ISSN 1512 – 2344

საქართველოს განათლებისა და მეცნიერების სამინისტრო
საქართველოს ტექნიკური უნივერსიტეტი
ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
გარემოს დაცვის ეკოცენტრი

VII საერთაშორისო სამეცნიერო-ტექნიკური კონფერენცია
„წყალთა მეურნეობის, გარემოს დაცვის, არქიტექტურისა და
მშენებლობის თანამედროვე პრობლემები“
შრომების კრებული
25-27 აგვისტო, 2017

MINISTRY OF EDUCATION AND SCIENCE OF GEORGIA
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VII INTERNATIONAL SCIENTIFIC AND TECHNICAL CONFERENCE
„MODERN PROBLEMS OF WATER MANAGEMENT, ENVIRONMENTAL PROTECTION,
ARCHITECTURE AND CONSTRUCTION“
COLLECTED PARERS
August 25-27, 2017

МИНИСТЕРСТВО ПРОСВЕЩЕНИЯ И НАУКИ ГРУЗИИ
ГРУЗИНСКИЙ ТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ
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ОХРАНЫ ОКРУЖАЮЩЕЙ СРЕДЫ, АРХИТЕКТУРЫ И СТРОИТЕЛЬСТВА“
СБОРНИК НАУЧНЫХ ТРУДОВ
25-27 Август, 2017

თბილისი, საქართველო / Tbilisi, GEORGIA / Тбилиси, ГРУЗИЯ. 2017

VII საერთაშორისო სამეცნიერო-ტექნიკური კონფერენცია — VII INTERNATIONAL SCIENTIFIC-TECHNICAL CONFERENCE — VII МЕЖДУНАРОДНАЯ НАУЧНО-ТЕХНИЧЕСКАЯ КОНФЕРЕНЦИЯ

ISSN 1512-2344

საქართველოს განათლებისა და მეცნიერების სამინისტრო
საქართველოს ტექნიკური უნივერსიტეტი
ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
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VII საერთაშორისო სამეცნიერო-ტექნიკური კონფერენცია "წყალთა მეურნეობის, გარემოს დაცვის, არქიტექტურისა და მშენებლობის თანამედროვე პრობლემები"

შრომების კრებული

25-27 აგვისტო, 2017

MINISTRY OF EDUCATION AND SCIENCE OF GEORGIA
TSOTNE MIRTSKHULAVA WATER MANAGEMENT INSTITUTE
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ECOCENTER FOR ENVIRONMENTAL PROTECTION

VII INTERNATIONAL SCIENTIFIC AND TECHNICAL CONFERENCE
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COLLECTED PAPERS

25–27 AUGUST, 2017

МИНИСТЕРСТВО ПРОСВЕЩЕНИЯ И НАУКИ ГРУЗИИ
ИНСТИТУТ ВОДНОГО ХОЗЯЙСТВА ИМЕНИ ЦОТНЕ МИРЦХУЛАВА
ГРУЗИНСКОГО ТЕХНИЧЕСКОГО УНИВЕРСИТЕТА
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VII МЕЖДУНАРОДНАЯ НАУЧНО-ТЕХНИЧЕСКАЯ КОНФЕРЕНЦИЯ
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СБОРНИК НАУЧНЫХ ТРУДОВ

25–27 АВГУСТ, 2017

თბილისი, საქართველო / Tbilisi, Georgia / Тбилиси, Грузия
2017

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ISSN 1512-2344

ტირაჟი: 150

VII International Conference on

"MODERN PROBLEMS OF WATER MANAGEMENT, ENVIRONMENTAL PROTECTION, ARCHITECTURE AND CONSTRUCTION"

25–27 August 2017, Tbilisi, Georgia

Conferences	Date	Place (Location)
I	**18-22 August, 2011**	**Qobuleti, GEORGIA**
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III	**29 july – 4 August, 2013**	**Tbilisi - Borjomi, GEORGIA**
IV	**27 – 30 September, 2014**	**Tbilisi, GEORGIA**
V	**16 – 19 July, 2015**	**Tbilisi, GEORGIA**
VI	**22–25 September 2016**	**Tbilisi – Telavi, GEORGIA**

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22–25 September 2016










Earth sciences

МИКРОЭЛЕМЕНТЫ КАК ФАКТОР ЭКОЛОГИЧЕСКОЙ ОЦЕНКИ ПОЧВ БАССЕЙНА РЕКИ КАТЕХЧАЙ

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Аннотация. Проведены исследования для определения экологической оценки почв с учетом баллы почв по содержанию микроэлементов. Наряду высотой местности, сумма осадков и эффективных температур, биоклиматической потенциал, гумус, реакция почвенной среды, баллы бонитета учтена также баллы почв по содержанию микроэлементов. С целю оценки по количеству микроэлементов была составлена оценочная шкала на основании который почвы бассейна реки Катехчай оценивались по баллам.

Ключевые слова: экология, бонитировка, почва, балл, микроэлементы, содержания.

MICROELEMENTS AS A FACTOR OF ENVIRONMENTAL ESTIMATION OF SOILS OF THE KATEHCHAY RIVER BASIN

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Annotation. Studies have been carried out to determine the ecological assessment of soils, taking into account the soil scores for the content of trace elements. Along with the altitude of the terrain, the sum of precipitation and effective temperatures, bioclimatic potential, humus, soil environment reaction, bonitet score, soil scores for microelements content are also taken into account. With the purpose of estimating the number of microelements, an evaluation scale was drawn up on the basis of which the soils of the Kachtechai river basin were estimated by points.

Key words: ecology, bonitiration, soil, grade, microelements, content.

Для определения экологической оценки почв, нами проводились исследования по вопросу изучения содержания таких микроэлементов, как марганец, молибден, медь, цинк, кобальт, ванадий, свинец, никель и кадмий в почвах бассейна реки Катехчай. Этот объект был выбран в связи тем, что бассейн р. Катехчай охватывает значительно количество различных типов почв распространенных на территории Большого Кавказа.

Современные исследования требуют большей информации о возникших экологических вопросах, в том числе и о региональных особенностях содержания микроэлементов в почвообразующих породах и почвах, накоплении их в растениях, концентрации в водах и т.д.

За последние 50 лет ученые Азербайджанской Республике А.Н.Гюльахмедов (1986), Б.К.Шакури (2011), Н.А.Агаев (1994), О.Г.Мамедов (1989), А.Б.Ахундова (2004) и др. посвятили ряд

работ изучению роли микроэлементов в плодородие почв, питании растений повышении урожайности сельскохозяйственных культур и улучшении качества продукции [1,2,3,4].

Следует отметить, что по мнению В.И.Вернадского (1964) и А.П.Виноградова (1962) и др. в XX столетие внимание ученых все более и более привлекал к себе присутствие в почве в незначительных количествах редких химических элементов, не только было найдено большое число этих элементов но и выяснилось, что почва должна содержать вообще все элементы. Значение этих «бесконечно малых» элементов для биологических процессов делает необходимым определение их в почве которая является единственным источником редких и рассеянных элементов. Также исследованиями этих ученых в первые показан что живым организмам свойственно иметь в своем составе не только макроэлементы но и микроэлементы содержание которых не превышает $1 \cdot 10^{-2}$ % [5,6].

Степень распространения микроэлементов в почвах различна и это можно объяснить разнообразием почвообразующих пород, которые являются основным источником микроэлементов в почве. Важными источниками микроэлементов являются также атмосфера, метеориты, космическая пыль, океан и др.

Исследованиями выявлено, что различные почвы не могут быть одинаково пригодным для всех растений. Экологические особенности растительных организмов крайне разнообразны в отношении требований к почвенным условиям: к реакции среды, физическим свойствам, гранулометрическому составу и даже к богатству органическим веществом и элементами питания.

Учитывая то, что почва чувствительна к любому изменению почвообразовательных факторов, учет содержания микроэлементов в экологической оценке почв является новым подходом к этой проблеме в нашей республике. При экологической оценке почв были учтены высота местности, сумма осадков и эффективных температур, биоклиматический потенциал, реакция почвенной среды, а также баллы бонитета почв [7].

В настоящее время при экологических исследованиях результаты определения содержания химических элементов в том числе и микроэлементов выражаются в различных величинах. Такой подход принят в агрохимических исследованиях, поскольку без определения количество микроэлементов в почвах невозможно оценивать плодородие почв.

Баллы бонитета были рассчитаны на основе сравнения показателей плодородия почв с эталонными почвами. В наших исследованиях горно-луговые дерновые почвы (площадью 395,1 га) взяты как эталон. В соответствии с методикой при бонитировке почв используются поправочные коэффициенты. Так, строится основная бонитировочная шкала и на ее основе находят баллы бонитета почвы [8].

Наряду с указанными факторами учтены и баллы почв по содержанию микроэлементов. С целью оценки почв по количеству микроэлементов 0-30 см слое почв бассейна реки Катехчай была определена исследуемые нами элементы. Валового количества микроэлементов определяли атомно-абсорбционным методом («Шимадзу-6800» производство Японии).

Полученные нами аналитические данные показали, что содержание микроэлементов 0-30 см слое почв колеблется: марганец - 550-996 мг/кг; молибден - 0,5-1,7; кобальт - 5,2-6,5; цинк - 14,0-44,3; медь - 14,9-27,4; никель - 15,2-26,9; ванадий - 15,0-23,2; свинец - 8,4-21,6; кадмий - 0,2-1,2 мг/кг (Табл. 1).

На основании содержания микроэлементов в 0-30 см слое, почв бассейна Катехчая составлена оценочная шкала, на основании которой почвы бассейна оценивались по баллам.

Таблица 1

Оценочная шкала по содержание микроэлементов почв бассейна реки Катехчай

Микроэлементы		Mn	Mo	Co	Zn	Cu	Ni	V	Pb	Cd
Кларк, мг/кг		850	2	8	50	20	40	100	10	0,5
Фон, мг/кг		750	1,8	7,5	33	18	18	25	11	0,5
Баллы	100	750-850	1,8-2,0	7,5-8,0	33-50	18-20	18-40	25-100	11-10	0,07-0,5
	80	750-650	1,8-1,5	7,5-6,5	33-28	18-16	18-16	25-20	11-15	0,5-0,8
	60	650-550	1,5-1,2	6,5-5,5	28-23	16-14	16-14	20-15	15-19	0,8-1,1
	40	550-450	1,2-0,9	5,5-4,5	23-18	14-12	14-12	15-10	18-23	1,1-1,4
	20	<450	<0,9	<4,5	<18	<12	<12	<10	<23	<1,4

На основании оценочной шкалы по содержании микроэлементов почвы бассейна оценивались по баллам. Самый высокий бал рассчитан для горно-луговых дерновых почв, самый низкий характерен для аллювиально-луговых засоленных почв. Почвы бассейна реки Катехчай получили баллы в пределах 57-88 (Табл. 2).

Таблица 2

Оценка почв по содержанию микроэлементов

Называние почв	Микроэлементы									Бал
	Mn	Mo	Co	Zn	Cu	Ni	V	Pb	Cd	
Лугово-орошаемые	100	80	100	80	100	80	60	60	60	88
Аллювиально-луговые	100	80	80	100	100	80	60	80	60	82
Горно-лесная бурая	60	60	60	80	80	80	60	20	20	57
Аллювиально-лугово лесные	100	80	80	100	100	100	80	80	60	88
Горно-лесо луговые	60	20	100	20	80	80	60	100	100	68
Горно-луговые	60	20	80	20	100	80	60	100	100	68

После составления бонитировочной шкалы проводится экологическая оценка почвы. Бонитетные баллы и экологическая оценка почв проводится по методу на основе подхода разработанного Г.Мамедовым и С.Мамедовой. На основе этого подхода проведена экологическая оценка почв бассейна реки Катехчай. При нахождении экологических баллов этих почв был использован ряд экологических показателей: сумма, осадков в зависимости от высоты местности, pH, содержание гумуса и микроэлементов в почве (Табл.3).

Таблица 3

Экологические параметры почв бассейна реки Катехчай

Называние почв	Параметры среды				Микроэлементы									БМ	ББ	ЭБ
	B	O	Гумус, %	pH (H_2O)	Mn	Mo	Co	Zn	Cu	Ni	V	Pb	Cd			
Лугово-орошаемые	600-700	600-700	2,6	8,2	100	80	100	80	100	80	60	60	60	88	75	81
Аллювиально-луговые	200	250-300	2,6	7,3	100	80	80	100	100	80	60	80	60	82	68	75
Горно-лесная бурая	700-800	850-900	6,3	6,6	60	60	60	80	80	80	60	20	20	57	51	54
Аллювиально-лугово лесные	250	250-400	3,0	7,0	100	80	80	100	100	100	80	80	60	88	67	77

Горно-лесо луговые	1500	1200-1400	8,1	5,5	60	20	100	20	80	80	60	100	100	68	58	63
Горно-луговые	1700	1200-1400	9,2	4,6	60	20	80	20	100	80	60	100	100	68	57	62

Примечание: В – высота в метрах; **О** – осадки в мм; **«Микроэлементы»** - (марганец, молибден, кобальт, цинк, медь, никель, ванадий, свинец, кадмий); **«БМ»** – бал микроэлементов; **«ББ»** - бал бонитета; **«ЭБ»** – экологический бал.

Резюмируя наши исследования по содержанию микроэлементов в почвах бассейна Катехчай следует указать что, содержание их независимо от типа почв выражается, значениями в пределах кларковых величин для почв. Наибольшим содержанием микроэлементов для большинство типов почв отмечается верхние гумусированные горизонты. Также отмечается общая закономерность прямой зависимости распределения микроэлементов по почвенному профилю от содержания органического вещества в почвенной толще и механического состава. В метровом слое почв бассейна так же было определено фоновые содержания исследуемых элементов.

Отметим что на основе 0-30 см слое почв по содержанию микроэлементов их можно расположить в следующей ряд: аллювиально-луговые (Fluvisols) < лугово-орошаемые (Irragri Qleysols) < аллювиально-лугово лесные (Fluvisols) < горно-лесная бурая (Cambisols) < горно-лесо луговые (Phaeozems) < горно-луговые (Leptosols Umbrisols).

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MILITARY CONFLICTS AND DAM SAFETY: CASE STUDY

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Annotation. This article is devoted to the comparative study of earthen dam destruction risk assessment and vulnerability analyses in Kura river basin, in peacetime and during military conflicts. In the introduction noted, that the advisable management and protection of critical hydro-technical infrastructure, essentially as earthen dams is relevant to safety of the population. Firstly, analyzed earthen dam destruction risks in peacetime. As common risk factors shortly characterized wear and tear of the hydro-technical systems; earthquakes; sludge settling of reservoir; prolonged periods of heavy rains and flooding; "domino" principle dam destructions; animal intrusions and probability of piping. Secondly, described such threat scenarios of explosions: over a dam body; over the water reservoir; on slopes of hillside adjacent to dam and terrorist act (explosion) in a dam body. In each considered case, on the basis of the analysis of a direction of explosive physical forces carried out modeling of the crater formation in dam body. In the conclusion mitigation measures stated.

Key words: earthen dam, risk assessment, vulnerability, explosion, terrorist act, Kura River.

INTRODUCTION

World practice shows that the sustainable development of each country substantially depends on rational management of its natural resources. Fresh water turns to the most important among natural resources. Therefore, the dynamic, balanced management of water resources, in regional, also in global scale is an actual problem. The basic tools of successful management of water resources are elements of a critical infrastructure, such as dams, water reservoirs and intakes, etc. In turn, the advisable management and protection of critical infrastructure, essentially as earthen dams is relevant to safety of the population. A destruction of any huge dam, e.g. Mingecevir earthen dam could have serious ramifications on downstream Kura-Araz lowland communities in the 8000 km^2 area lived 3.5 million population. The direction of 16 km^3 water mass along the Kura River valley may cause flash flooding, raze to the ground all infrastructure, including oil- and gas-pipelines, roads, bridges, high voltage and communication lines, etc. [1].

This article is devoted to the comparative study of earthen dam destruction risk assessment and vulnerability analyses in Kura river basin, in peacetime and during military conflicts.

Earthen dam destruction risks: Peacetime

Wear and tear of the hydrotechnical systems. All of the earthen dams in Kura River basin in South Caucasus were built in period, before the independence of these republics (e.g. Mingecevir cascade in Azerbaijan, Khrami cascade in Georgia and Vorotan cascade in Armenia). The large majority of earthen dams are working over 60 years continuously and in case of it considers as "old dams" [2]. There are many common risk factors for all earthen dams over the Kura river basin. The basic criterion of technical realization of such projects those years was the principle of their minimal cost. Thus issues of strategic risk, ecological safety and other, as a rule, at all did not take seriously. Water leak supposition is rising of dam by

getting older of earthen dams. Unfortunately, for the existence Soviet period the dam inspection, evaluations, modifications and upgrades of the earthen dams were never spent. To this end, there is a need for more adequate legal frameworks for dam operation. All these listed factors actualizes the prognosis of dam destruction risk at peacetime and the development of forecasting measures plan and analyses for military conflicts period.

Wear and tear of the hydro-technical systems, absence of due supervision of safe exploitation make substantial the crevasse of water reservoirs and holding lagoons of runoffs that can result in catastrophic consequences.

Earthquakes. Kura River basin covers all the South Caucasus region, which is the active seismic earthquake area. For example, on the seismic activity maps Mingecevir dam is an eight-mark-ball zone. Earthen dams respond to earthquake vibrations. Shaking an unstable slope that has been weakened after saturation by rises in ground water levels may produce a landslide into the reservoir. The powerful earthquake can cause a huge wave which can get over the dam, destroy it and lead to catastrophic consequences.

Sludge settling of reservoir. Kura river receives the great quantity of mud from basin systems. As a result of the mud accumulation the reservoirs lose net volume (available storage). For example, after putting in operation (1953) the maximal depth of the Mingecevir reservoir has decreased from 83 meters up to 63 meters. The decreasing of available storage excludes an opportunity of the flood management.

Prolonged periods of heavy rains and flooding. Flooding is a yearly occurring phenomenon in Kura River. It may be induced by heavy rains or extreme snowfall. Flood warning and forecasting system in Azerbaijan and Georgia is in a very poor condition. No uniform standards relating to flood mitigation and no schemes for reducing potential damage and improving protection have been developed.

Rivers of the Kura basin has extremely irregular discharge throughout a year. Sometimes, the ratio of extreme discharge to average is 1.63-6.67, which makes sometimes difficulties to overcome its negative impact [3].

"Domino" principle dam destructions. Peacetime, heavy flooding on basin and/or dam failure, for some reason, in upstream are enough for catastrophic "domino" destruction of all the downstream earthen dams. For example, the peacetime disruption of Shimantan dam in South China in 1975 August caused the disruption of other 22 dams due to "domino principle" [4].

Animal intrusions and probability of piping. Small animals can cause big problems for earthen dam. Earthen dam environment is near a water source and can contain a variety of vegetation; given these characteristics, dam environments can be naturally conducive to use by wildlife. Through their natural desire to create dens, search for food or escape predators, wildlife burrow, graze, root, and traverse the embankment as if it were natural field or forest. These activities cause a host of damages to the dam and can even lead to piping and dam failure. In general, there are three main serious effects that wildlife activities can have on earthen dam: hydraulic alteration, structural integrity losses, and surface erosion.

Thus, the summarizing of the above mentioned risk factors and consideration of stated below statistics once more shows topicality of dam destruction issues in South Caucasus (list not exhaustive):

- ✓ 14 May, 1987. Earthen dam-break event happened in neighbor Georgia. 11.9 meters dam of Cghneti dam near Tbilisi city destroyed.
- ✓ Summer, 1987. Earthen dam-break event happened in neighbor Armenia. 20 meters dam on Bazar River damaged, The flash floods damaged villages of Gubadli district of Azerbaijan.
- ✓ May, 2010. The bank protection embankment of Sarisu lake in Azerbaijan damaged.
- ✓ 30 October, 2016. 17.5 meters Goytepe dam has damaged. Flash floods damaged houses and bridge in the Privolni village in Djalilabad district of Azerbaijan.

Last accident happened in the small Goytepe dam in Azerbaijan, actualized the issues of identifying of dam destruction risks in time and developing of forecasting measures. According to the President's Order dated 14 November 2016, the State Commission has been made in order to learn and improve the exploitation conditions of large reservoirs in Azerbaijan [5].

Dam safety during military conflicts

There have been various bomb attacks on dams [6, 7]. Most of these attacks occurred during military conflicts. A review of literature indicates that most of the attacks have been against both earthen and concrete dams. While a localized failure will not necessarily lead to breach of a concrete dam, the localized failure of an earthen dam has a potential to develop into full dam destruction through overtopping.

During the conflict in the Balkans, the Serbian forces planted high tonnage explosive (Trinitrotoluene) on the Peruca Dam located in Dalmatia, Croatia, in January 1993. The dam was repaired and brought back into operation in 1996, three years after the damage caused by the Serbian forces [8].

In August, 2014 terrorists occupied the largest Mosul Dam on the Tigris River, in Iraq. As a result of the military conflict the dam has been partially damaged and can collapse at any moment.

Absence of dialogue and trust between the conflicting parties the critical infrastructure of water resources management turns to the tool of pressure to the enemy. The basin states located on river upstream have a favorable geographical location and by all means during the military conflicts want to use this advantage. This is acute problem for Azerbaijan.

After the al-Qaeda attacks 9/11 September 2001 many developed countries and international agencies are taking measures to reduce this possibility through risk and vulnerability analyses and security measures. However, studying of the scientific and technical literature shows that the given problem for earthen dam has not yet been developed. The presented paper is first attempt of numerical or computational analyses of the impacts of explosive attack scenarios for the Kura River basin earthen dams.

Unlike a peacetime, in the conditions of military conflicts, it is necessary to analyze risk and vulnerability to bombing explosions. Such blast-assessment is spent taking with a glance of dam type and aiming point of bomb explosion.

As a rule, earth dams on Kura River basin were built of inhomogeneous soils with different grain-size composition.

In the report will be considered various scenarios of explosions:

- ✓ over a dam body;
- ✓ over the water reservoir;
- ✓ on slopes of hillside adjacent to dam;
- ✓ act of terrorism (explosion) in a dam body.

In each considered case, on the basis of the analysis of a direction of explosive physical forces carried out modeling of the crater formation in dam body.

In the conclusion mitigation measures will be stated.

MITIGATION MEASURES

If earthen dam is found to be vulnerable to the impacts of an explosive blast or terrorist attack, mitigation measures should be implemented to reduce the risk of adverse consequences to acceptable levels. This is consistent with general geotechnical dam safety assessments in which mitigation measures would be designed and implemented if the risk over global stability failure, piping or seismic stability were concerns.

For the above described threat scenarios, some mitigation measures are possible (site access, operational protocols and structural improvements). These measures will be discussed in the slide presentation.

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SIMPLIFIED REGULARITIES BETWEEN PARAMETERS OF THE FLOW CROSS SECTION UNDER CONDITIONS OF COMPLIANCE WITH THE BALANCE OF SEDIMENTS

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Annotation. Dependences between hydraulic parameters of the cross-section of channels are often used in the system of equations in solving problems of the channel process, including bed-formation phenomena. When replacing the average speed of the wetted perimeter and the area of the effective cross-section through the width and depth, complex expressions are obtained. The use of their differentials, especially in motion equation, creates serious inconveniences and difficulties for the solution. On the basis of the carried out investigations, under conditions of observing sediment balance, simple expressions for the depth, average velocity and area of the effective cross-section were obtained. The applicability and reliability of the proposed dependencies for the practically possible cases of channel erosion is justified by an analysis of the results of numerical calculations.

Key words*:* flow, cross-section, width, sediment balance, parameter.

INTRODUCTION

Dependences between hydraulic parameters of the cross-section of channels form an integral part of the system of equations which are generally used to solve many problems of channel process, the more channel-forming phenomena. Using these dependencies, the average velocity, wetted perimeter and area of the effective cross-section are replaced by the depth of the stream and the channel width. However, even for a rectangular cross-section, the functions
h = f (A, χ) and b = f (A, χ), and even more so their differential forms are rather cumbersome and inconvenient for use in differential equations of nonuniform motion and deformation of the channel [1, 2].

OBJECTIVE OF THIS WORK

The purpose in view is to derive simple relationships between the hydraulic parameters of the cross section under conditions of observing sediment balance along the flow length.
RESULTS OF THE STUDY. For the rectangular cross-sectional shape of the channel, the area, the wetted perimeter and the average velocity of the effective cross-section in the dimensionless form are determined by the following dimensionless dependencies:

$$\overline{A} = \beta_0 \cdot \overline{b} \cdot \overline{h} \tag{1}$$

$$\overline{\chi} = \frac{\beta_0}{\beta_0 + 2}\left(\overline{b} + 2\overline{h}\right) \tag{2}$$

$$\overline{V} = \frac{1}{\overline{A}} \tag{3}$$

where the coefficient $\beta_0 = \frac{b_0}{h_0}$, and for dimensionless values we have

$$\overline{h} = \frac{h}{b_0}, \quad \overline{b} = \frac{b}{b_0}, \quad \overline{A} = \frac{A}{A_0}, \quad \overline{\chi} = \frac{\chi}{\chi_0}, \quad \overline{V} = \frac{V}{V_0} = \frac{1}{\overline{A}}, \quad \overline{Q} = \frac{Q}{Q_0} = 1. \tag{4}$$

Here, the linear dimensionless scale assumes the width of that section of the channel b_0, where, due to the maximum loading of the stream, the sediment does not have bedding. It follows from Eq.(2) that

$$\overline{\chi} = \frac{\beta_0}{\beta_0 + 2}\,\overline{b}\left(1 + 2\,\frac{\overline{h}}{\overline{b}}\right) = \frac{\beta_0}{\beta_0 + 2}\,\frac{\beta + 2}{\beta}\,\overline{b}, \tag{5}$$

where the coefficient $\beta = \overline{b} / \overline{h} = b / h.$

Under conditions of observing sediment balance, a qualitative and quantitative analysis of numerous forms in calculation of the sediment carrying capacity of the flow was carried out in the work [3]. As a result, the following dimensionless regularity is obtained between the area of the effective cross-section and the wetted perimeter

$$\overline{\chi} = \overline{A}^{a} \tag{6}$$

According to the analysis of [3], the indicator a for mountain streams varies in the interval 3 4. Then, taking into account the dependence (6) from (5) after simplifications, we get:

$$\overline{h} = \left(\frac{\beta + 2}{\beta_0 + 2}\,\frac{\beta_0}{\beta}\right)^{1/a} \cdot \frac{1}{\beta_0}\,\frac{1}{\overline{b}^{a-1/a}} \tag{7}$$

Let us denote the following by

$$\mathrm{M} = \left(\frac{\beta + 2}{\beta_0 + 2}\,\frac{\beta_0}{\beta}\right)^{1/a} \tag{8}$$

The obtained Eq.(7) is transcendental (implicit), since thector β is represented by the relation $\overline{b}$ and $\overline{h}$. To simplify solution of Eq.(7), we will perform a quantitative analysis of the M value. Many full-scale studies of the morphometric parameters of rivers show that a large range of variation of coefficients β or β_0 is possibly 1 to 12 [4, 5]. Against the background of these values, a numerical calculation of the M parameter was performed. The results are listed in Tables 1, 2 and 3. The analysis of the obtained values of this parameter shows that the greatest deviation from unity (more than 10%) is observed in cases where the coefficients $\beta_0 = b_0 / h_0$ and $\beta = b / h$ differ from each other more than 3 times. This means that the width of the natural bed in the transition area is narrowed by as many times. The practice of constructing bridge footings and dams, bank protection structures and other transitions shows that the narrowing of the channel is usually made within $1{,}2 \le b_0 / b \le 1{,}5$ [6, 7]. Proceeding from the above facts, it can be concluded that the parameter M for practical problems of channel erosion can be taken equal to unity without significant deviations. Then, instead of (9), we get

$$\overline{h} = \frac{1}{\beta_0}\,\frac{1}{\overline{b}^{a-1/a}} \tag{9}$$

With this in mind, in particular, for the average value of the exponent a, equal to 7/2, the dependence expressed by Eq.(9) takes the following form

$$\overline{h} = \frac{1}{\beta_0}\,\frac{1}{\overline{b}^{5/7}} \tag{10}$$

Table 1. The values of the parameter M as a function of the coefficients β and β_0 for a = 4

β \ β_0	2	3	4	5	6	8	10	12
1	1.11	1.16	1.19	1.21	1.22	1.24	1.26	1.27
2	1.00	1.05	1.07	1.09	1.11	1.12	1.14	1.14
4	0.93	0.97	1.00	1.02	1.03	1.05	1.06	1.06
6	0.90	0.95	0.97	0.99	1.00	1.02	1.03	1.03
8	0.89	0.93	0.96	0.97	0.98	1.00	1.01	1.02
10	0.88	0.92	0.95	0.96	0.97	0.99	1.00	1.01
12	0.87	0.91	0.94	0.96	0.97	0.98	0.99	1.00

Table 2. The values of the parameter M depend on the coefficients β and β_0 for a = 7/2

β \ β_0	2	3	4	5	6	8	10	12
1	1.12	1.18	1.22	1.24	1.26	1.28	1.30	1.31
2	1.00	1.05	1.09	1.11	1.12	1.14	1.16	1.17
4	0.92	0.97	1.00	1.02	1.03	1.05	1.07	1.07
6	0.89	0.94	0.97	0.99	1.00	1.02	1.03	1.04
8	0.87	0.92	0.95	0.97	0.98	1.00	1.01	1.02
10	0.86	0.91	0.94	0.96	0.97	0.99	1.00	1.01
12	0.86	0.90	0.93	0.95	0.96	0.98	0.99	1.00

Table 3. The values of the parameter M depend on coefficients β and β_0 for a = 3

β \ β_0	2	3	4	5	6	8	10	12
1	1.14	1.22	1.26	1.29	1.31	1.34	1.36	1.37
2	1.00	1.06	1.10	1.13	1.14	1.17	1.19	1.20
4	0.91	0.97	1.00	1.02	1.04	1.06	1.08	1.09
6	0.87	0.93	0.96	0.98	1.00	1.02	1.04	1.05
8	0.85	0.91	0.94	0.96	0.98	1.00	1.01	1.02
10	0.84	0.90	0.93	0.95	0.97	0.99	1.00	1.01
12	0.84	0.89	0.92	0.94	0.96	0.98	0.99	1.00

Proceeding from expression (10), instead of dependences (1) and (3), we will have:

$$\overline{A} = \overline{b}^{2/7} \tag{11}$$

$$\overline{V} = \frac{1}{\overline{b}^{2/7}} \tag{12}$$

Thus, rather simple dependences are obtained for determining the hydraulic parameters of the flow cross section for those channel processes in which the sediment balance takes place. We note that the regularity (9) agrees very well with the calculated expressions proposed for determining the maximum deformations of the under-bridge bed, provided that the sediment flow rate is constant. The generalized form of these expressions is represented by the following dependence [7]

$$h_{\cdot} = H_{b.}\left(\frac{Q}{Q_{b.}}\right)^{\alpha} \cdot \left(\frac{\mathrm{B}_b}{b_m}\right)^{\beta} \tag{13}$$

where H_b and B_b are the depth and width in the natural section of the channel in the natural state, Qb is the total flow rate, Q is the portion of the flow that flows between the two support holes.

On mountain rivers, one-span bridges are mainly built, and therefore these costs are equal. For many authors, the value of α is close to unity, and the average value of β is 2/3 [7]. It is easy to verify that, for a = 3, expressions (9) and (13) completely coincide in qualitative terms.

CONCLUSION

The obtained regularities in calculating the depth, average velocity and area of the effective cross-section can be used in the problems of predicting the parameters of the stabilized stage of channel transformations, including the hydraulic calculation of bridge transitions.

The research was performed under scientific theme 11-30/15TSCSRA.

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Water management

THE FUNDAMENTAL RESEARCH OF DRINKING WELL WATER POLLUTION

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Annotation. For assessment quality of well water used for drinking by rural population, have been researched seven municipality of west Georgia, particularly Samegrelo region, where main sources of drinking water is well water. It has been determinate as chemical pollutants also microbiological conditions. For make fulfill conclusions researches is going.

Key words: well water, drinking water, pollution, rural population.

INTRODUCTION

The water resource has significant importance for maintains favorable living conditions of population, normal functioning of the economy and maintaining the environment. Providing population, industry, energy and agriculture is one of the priority tasks for the normal functioning of the countries.

The supply of good quality drinking water to the country's population remains an unsolved problem. The sanitary-hygienic and technical condition of water pipe, individual wells, natural springs and small power village type water pipes not satisfactory, the drinking water does not treats with chlorine, or this process is violated. This promotes: intensively pollution of water supply sources, especially surface sources. Most of the rural population does not receive the normative quality of drinking water [2].

To management of drinking water quality has big importance to use new technologies of water cleaning and protection of quality standards. Recently, in Georgia only a small part of the population is provided safe water supply. Rural situation is worse than in cities.

The source of contamination of water bodies is the modern agricultural production, as a result, a significant number of pesticides are found in the water environment. As a result of natural environment pollution, in the water may fall significant amount of organic substances used as pesticides and fertilizers [1].

The ground water mainly is messed up by industrial, household and agricultural activities. Especially, danger is pesticides, which remain in water and in environment for a long time, which is toxic and ability of migration on the far away. The ecological condition of ground water is depend on the locations and protection of the watershed , where they are formed [3].

In the villages of Georgia approximately 100 percentage supply by spring water or well water ,,well or spring water is fit and safe to drink " this view can often be erroneous.

MAIN PART

All the above mentioned is important to be studded the ecological condition of ground water use for drinking, especially in such region where is not water supply system.

To accomplish this, scientific- workers of Tsotne Mirtskhulava Water Management Institute of Georgian Technical University were sent to seven municipalities of Colchis lowland on the Spring 2017 for determining chemical pollutants in the wells water used for drinking by rural population.

Below is presented wells used for drinking by rural water nearby agricultural lands (see photos 1, 2, 3), of which around implemented using as fertilizer so pesticides in order to improve plant productivity.

Photo 1

Photo 2

Photo 3

The analyzes of well water were been making on the site by the mobile chemical laboratory (CEL Advanced Drinking Water Laboratory), the results of the research are given in table 1.

Table 1

The results of chemical analyzes of wells water used for drinking by rural population

CONCLUSION

Sampling place	Coordinates		Depth, m	PH	Common microbio-logical pollution	Nitrite, mg/l	Nitrate, mg/l	Phos-phate, mg/l	Iron, mg/l
Abasha vil. Sabokuchao	4213328	4210794	5	7,15	1	0,026	0,58	4,8	0,072
Abasha vil. Sabokuchao	4213363	4210819	5	6,85	4	0,01	0,5	1,72	0,14
Senaki vil. Nosiri	4215076	4208415	7	7,22	5	0,024	1,36	5,02	0,07
Khobi vil. Pirveli maisi	4220393	4151785	8	7,3	3	0,03	0,78	2,01	0,011
Zugdidi vil. Chkaduashi	4235392	4200774	4	6,45	2	0,003	2,05	1,2	1,58
Tsalenjikha vil. Phabrika	4236693	4202189	7	6,42	3	0,0036	1,75	1,85	0,11
Tsalenjikha vil. Nakifu	4236314	4205849	6	6,8	2	0,0032	1,25	1,4	0,028
Chkhorotsku vil. Patara chkhorotsku	4229871	4206914	8	6,45	8	0,0045	1,34	1,2	0
Chkhorotsku vil. Qveda chkhorotsku	4229271	4206841	7	6,76	1	0,004	2,66	1,37	0
Chkhorotsku	4231398	4207784	6	7,2	0	0,0075	2,44	1,66	0,02
Chkhorotsku	4236287	4207108	5	6,89	6	0,01	2,06	2,4	1,47
Chkhorotsku vil. Qveda chkhorotsku	4236692	4206707	7	6,6	2	0,022	1,68	1,8	1,32
Chkhorotsku vil. Qveda chkhorotsku	4229271	4206843	6	6,12	3	0,03	1,75	1,2	1,1
Martvili vil. Nakharebavo	4224086	4221836	5	7,11	2	0,008	2,5	1,19	0,04
Zugdidi vil. Kakhati	422927	462124	7	6,99	77	0,002	22	1,3	0,08
Zugdidi vi. Darcheli	422603	414202	3	6,54	1	0,001	4	1,6	1,0
The maximum admissible concentration mg/l					10	0,2	50	3,5	0,3

According to of analyzes results, nitrite containing of wells water chosen for analyzer is in range 0,001 - 0,03 mg/l/, nitrate 0.5-22 mg/l, phosphate – 1,19-5,02 mg/l, results were compared with data of technical regulations for drinking water, according to these phosphate content in some cases higher than the MPC. During field works fixed some cases tinted waters, because in selected wells water were determined iron too, according to the results show that the iron content in only one case was higher than the MPC, it is about 4 times more. It certainly can not be considered a normal phenomenon and requires a pollution source survey [4;5].

Because every chosen wells water are used for drinking, the results of the processing time also used health Requirements for bottled drinking water quality, according which nitrite containing don't be more the 0,005 mg/l. From our selected 16 analyzing wells nitrite containing are more the 0,005 mg/l in 7 well [6].

What about microbiological pollution of well water its has been determine by fast tester of ULTRA SNAP, according to it value from 0 until 10 is suitable of pour water, from 10 until 30 is needed attention, and above 30 is pollution. As we can see from the results, only in 1 well discovered water pollution, that is not normal and requires reesearch of pollution sources

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Environmental protection

DETERMINATION OF KEY PARAMETERS OF TRIBUTARIES TENDING TO TURN INTO MUDFLOWS AS IN THE CASE OF THE RIONI RIVER WITH A VIEW TO TAKING MUDFLOW PROTECTION MEASURES

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Annotation. With a view to implementing mudflow protection measures key geometrical, hydrological and hydraulic parameters of the Rioni River's water channels tending to be affected by mudflows were investigated and assessed.

Key words*: m*udflow, catchment basin, slope of water channel, runoff coefficient.

Water channels being prone to mudflows drastically differ from normal mountain rivers by both their hydrological and hydraulic regime and negative impact on the environment. The water channels of this kind are distinguished by highly unusual nature of impacting on facilities as well as hardly predictable movement through the river bed. These flows can stop even at the transit zone of a water channel and at the same time continue their movement until the alluvial cone and even up to the confluence of a main river. Such movement of mudflows significantly prevents us from taking effective measures against them regardless of whether they are needed at the river head, transit zone or nearby the alluvial cone [1,2]. In this regard priority is given to safety measures to be provided first for the population residing at the surrounding area and then for the communication facilities, such as: railway network, motorways, high voltage lines and water management system.

Based on the view provided above, the drastically distinguished water channels being prone to mudflows, such as: the Duruji River, Telavi Gulley, Antoki Gulley as well as separate tributaries of the Aragvi River Valley those of Dusheti Gulley, Chokhelt Gulley, Nadibaant Gulley, Arakhveti Gulley and Mleta Gulley require special attention; including as well Laskandura Gulley and Kheledula Gulley in Kvemo (Lower) Svaneti and Nagvarevi Gulley and Skhalta Gulley in Mountain Adjara.

In order to mitigate mudflow activity in the water channels mentioned above (as to make them completely safe is not even considered) various capital as well as palliative and contemporary measures are applied that requires key geometrical, hydrological and hydraulic parameters of these water channels to be identified and evaluated. Successful implementation of mudflow protection measures mostly depends on correct selection of these parameters that include an area of water catchment basin of the water channel, difference in maximum and minimum levels of the water channel, length of a river bed, average slope, average annual volume of solid runoff, disposition of existing hydro-facilities, etc. [5,6,9].

It should be noted that if anywhere around the world it is required to apply mudflow protection measures in the regions tending to be affected by mudflows, one of the most vulnerable areas in this regard is Georgia. However, mudflow protection structures located in our country are not enough to cover all danger zones in order to prevent or mitigate emergency situations that might be caused by this natural disaster.

The analysis of literature sources and scientific research conducted demonstrated that on the territory of Georgia the Racha region and the tributaries of the Rioni river that inflict great damage on both the population (resulting even in the deaths of people many times) and agriculture and communication network are less studied in this regard.

With a view to alleviating a mudflow activity in the water channels mentioned above it is necessary to investigate, select and evaluate those key geometrical, hydrological and hydraulic parameters that significantly ensure a successful implementation of mudflow protection measures. These parameters include an area of a water channel's catchment basin, difference in maximum and minimum levels of a water channel, a river bed's length, average slope, average annual volume of solid runoff, location of existing hydraulic structures, etc.

It should be noted that in the regions tending to be affected by mudflows it is required to carry out mudflow protection measures. In Georgia mudflow protection measures are implemented in separate basins.

With the aim of assessing mudflow situations in the country as well as developing relevant protection measures Table 1 was offered where the names and geometrical, hydrological and hydraulic parameters of main water channels tending to be effected by mudflows are provided. Identification and prediction of these parameters will allow us to reduce a destructive effect of expected mudflows for separate facilities at least to some extent (see Table 1, Table 2, Table 3).

Table 1

Factors determining mudflow runoff

1.	Name of water channel (left, right)		
2.	Area of catchment basin Ω		
3.	Area of spots originating mudflows		
4.	Slope of water channel (average) I		
	4.1	i_1 of heading spot	
	4.2	i_2 of transit zone	
	4.3	Alluvial cone i_3	
5.	Average precipitation H (mm)		
6.	Runoff coefficient $\alpha = f(t, \tau)$		
7.	Liquid runoff volume per unit area $W = 100 \cdot \alpha \cdot H$ m^3		
8.	Erosion coefficient $\Psi = 1 - \ell^{-0.07 \cdot}$		
9.	Liquid runoff volume W(m3) $W = 100 \cdot \alpha \cdot H \cdot \Omega_{m3}$		
10.	Solid mudflow deposit S md $S_{zR} = \psi \cdot W$ (m^3)		
14	Upper level of confluence zone ∇_3		
15	Lower level of confluence zone ∇_4		
16	Lower slope of confluence zone $i = (\nabla_3 - \nabla_4)/\ell_3$		
17	Average gradient of tributary $i = (\nabla_1 - \nabla_2)/\ell$		

Table 2

Key hydraulic parameters of tributaries as well as their separate spots (upper, transit zone and lower zone with alluvial cone) tending to be affected by mudflows

#	Tributary Left	Basin area F (km2)	Total length of tributary L (m)	River head level ∇_1 (m)	Confluence level ∇_2 (m)	Average slope $i = \frac{\nabla_1 - \nabla_2}{L}$	Length of zone $L_1 =$	Upper level of zone $\nabla_1 =$	Lower level of zone $\nabla_2 =$	Zone slope $i = \frac{\nabla_1 - \nabla_2}{L_1}$
1	-	131	25 000	2400	800	0.064				
1.1							Upper zone			
							5000	2400	1860	0.108
1.2							Transit zone			
							9000	1860	1330	0.058
1.3							Lower zone with alluvial cone			
							1000	330	800	0.048

Apart from physical and mechanical as well as rheological properties mudflows comparing with normal water flows are characterized by anomalous velocity of 11-20m/min, 5-10m depth and what is more important large size (50-90m) stones having destructive force (2,4).

Table 3

#	Tributary right	Basin area F (km2)	Total length of tributary L (m)	River head level ∇_1 (m)	Confluence level ∇_2 (m)	Average slope $i = \frac{\nabla_1 - \nabla_2}{L}$	Length of zone $L_1 =$	Upper level of zone $\nabla_1 =$	Lower level of zone $\nabla_2 =$	Zone slope $i = \frac{\nabla_1 - \nabla_2}{L_1}$
1	-	37	11000	2300	800	0.136				
1.1							Upper zone			
							3300	2300	1700	0.181
1.2							Transit zone			
							3700	1700	1200	0.135
1.3							Lower zone with alluvial cone			
							4000	1200	800	0.100

While making hydrological and hydraulic calculations of mudflows it is extremely important to lay down parameters including an initial resistance of flow, its depth, a configuration of a riverbed itself in a plan as well as slope values on separate zones of riverbed. In case when the flow resistance is more than the product of flow volume ratio, riverbed slope and the existing depth of the flow at the moment of its stoppage, basic principles of hydraulic calculations of mudflow protection structures drastically differ from traditional methods. Therefore, before making calculations of this kind it is necessary to define values of the parameters provided above.

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Environmental protection

FORMATION OF COHERENCE/SUBSEQUENT MUDFLOWS IN EROSION SPOTS

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Annotation. Method formation of free survey curve for hyperconcentrated by the sediment debris flow at the constantly discharge lengthways of natural non-prismatic river beds is offered.

Key words: Debris flow, formation of stream, uniform motion, non-uniform motion

Coherence high-concentrated mudflows are mostly formed in erosion spots of high mountain regions, on the bare slopes of high gradient near mountain river heads following the long spell of drought. In this case, nearly the whole surface of an erosion spot is covered with a thick layer of dust that becomes water-resistant and during the period of torrential rains it streams down as a debris flow snatching large-size rocks on its way [1].

The debris flow of this kind consists of rocky fractions, grit, plant waste and muddy components hiding its rocky ingredients. Its 80-90% (in weight) consists of solid material and its 10-20% is water (in coherence condition), mixture density is 1.8-2.3t/m^3 and a driving environment is a mud-rock plastic conglomerate of solid body that represents a body of rheological properties [1, 2].

This kind of nature of the flow can be described by the Shvedov-Bingham model [2, 3]:

$$\tau = \tau_0 \pm \mu \frac{du}{dy} \ , \tag{1}$$

where, τ _ is a value of tangential stress for a flow depth; τ_0 - is an initial resistance of a flow for shear; μ – a dynamical coefficient of a mass viscosity; u - flow velocity for y depth.

(1.) Based on the dependence it can be concluded that the body of this type starts travelling under the condition as follows:

$$2 > 3\frac{\tau_0}{\rho g H i}, \tag{2}$$

Where, ρ - is flow density; g - is acceleration of gravity; H - is a full depth of a flow; i -is a gradient of a river bed.

i.e., when

$$\tau_0 < \frac{2}{3}\tau b_{bed.}, \tag{3}$$

since $\tau_0 = \gamma\, h\, i$, in case of existence of the so-called h - heart of the flow depth, the body normally starts moving, i.e.

$$h < \frac{2}{3}H\,. \tag{4}$$

where H - is a full depth of the flow.

Considering the model mentioned above, it is reasonable the integration to be implemented within the space of a gradient layer and not along the whole depth of a flow as a velocity within the borders of the heart of the flow is constant. Then, in order to calculate a flow rate we use the following:

$$Q = \frac{BH^2}{\tau_{bed}^2}\int_{\tau_{bed}}^{\tau_0}\frac{\tau(\tau_0-\tau)}{\mu}d\tau\,,$$

i.e. taking into account the dependences $\tau_{ფს.} = \gamma\, H\, i$ and $\tau_0 = \gamma\, h\, i$, after the integration we receive the following:

$$Q = \frac{BgiH^3}{\nu}f(\beta), \quad (5) \text{ where } f(\beta) = \frac{\beta}{2}(\beta^2-1) + \frac{1}{3}(1-\beta^3) \quad (6) \quad \beta = \frac{h}{H} \quad - \text{ is a relative depth.}$$

Thus, based on the dependences we received, a **coherence** (structural) flow starts moving from the erosion spot under the condition as follows:

$$\frac{H}{3}\left(1-\frac{h^3}{H^3}\right) > \frac{h}{2}\left(1-\frac{h^2}{H^2}\right), \quad (7) \qquad \text{i.e.} \quad h < 0{,}9H\,. \quad (8)$$

If we use symbols $Q_{ნ.}$ and $Q_{ან.}$ for Newtonian and non-Newtonian liquid rates respectively, then as a result of comparing the dependences (1.2) and (1.5) we receive the following:

$$Q_{not.N.} = 3Q_{N.}f(\beta) \tag{9}$$

Thus, based on (1.9), non-Newtonian liquid rate ($Q_{ან.}$) can be expressed by a Newtonian liquid rate $Q_{ნ.}$. In this case, the proportionality coefficient

$$K_3 = 3f(\beta)\text{, i.e.} \quad Q_{not.N.} = K_3 Q_{.N.} \tag{10}$$

of specific values of the function $f(\beta)$ can be taken from the table provided below.

Table 1

$\beta = h/H$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
$f(\beta)$	0.333	0.283	0.234	0.187	0.14	0.1	0.069	0.04	0.018	0.0

Spots producing mudflows are usually placed at the heads of water channels tending to form mudflows. Due to the wind influence as well as washing capacity of a water flow (heavy rain, intensive snow melting, etc.), mountain rocks are being permanently destructed on the slopes of high gradient. Mudflow masses of such origination accumulate at the heads of water channels in the deepened areas of erosion spots.

Let's consider a micro mudflow motion from one of the representative mudflow spots. If we take a friction coefficient of a "portion" of the mudflow "flowed down" from the spot as a constant value and its depth as equal to $`h_{ღვ.}$~, then the well-known continuity equation for the given concrete wave (in the direction of motion with alternating mass) will be expressed in the following way:

$$q'_n = \frac{dh_{debr.}}{dt} \tag{11}$$

where q'_n – is an intensity of rate alteration per length and width unit; flow height; t – is time.

Let's assume that $q'_n = const$. Then the integration of (2.1) gives the following:

$$h_{debr.} - h_o = q'_n(t - t_0) \tag{12}$$

Index "0" corresponds with the initial conditions of the task.

It is common knowledge that a wave velocity $V_{ტალღ.} = 3V$, where V is an average velocity of the "portion" of a mudflow while the stream motion is uniform, then considering that $V = Q/\omega$ we will have the following:

$$V_{wav.} = \frac{3gih^2_{debr.}}{\nu_{debr.}} f(\beta) \tag{13}$$

i _ is an averaged slope of the spots of high gradient where elementary "portions" of a mudflow mass are directly formed at the velocity of:

$$\frac{dx}{dt} = \frac{3gih^2_{debr.} f(\beta)}{\nu_{debr.}} \tag{14}$$

If we merge (2.1) and (2.4), we will receive:

$$\frac{dh_{\text{Rv.}}}{dx} = \frac{dh_{debr.}/dt}{dx/dt} = \frac{q'_n \nu_{debr.}}{3\text{gih}^2_{\text{debr.}} f(\beta)}, \tag{15}$$

After the integration of which we will have:

$$\frac{(h^3_{debr.} - h^3_0) gif(\beta)}{\nu_{debr.}} = q'_n (x - x_0). \tag{16}$$

(16) The equation characterizes a profile trajectory of the wave surface.

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HYDROTECHNICAL CONSTRUCTION IN THE CHOROKHI RIVER BASIN AND GEOMORPHOLOGICAL PROCESSES IN THE BLACK SEA REGION OF ADJARA

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Annotation. The purpose of this work is to review geomorphologic processes triggered as a result of hydraulic engineering construction (dam) on the Chorokhi River and its tributaries that pose a great threat to the Adjara region, and in particular, the Adlia-Batumi segment as its coastline might be washed away. In the work it is studied and analyzed the factors of bank formation.

The view has been expressed that a solution to the existing problem must be basically sought in pumping ashore by artificially spreading inert material.

Key words: waves, coastline, dams' cascade, river solid deposits, geomorphological processes.

INTRODUCTION

Natural or artificial change in hydrological regimes of sea waves and river runoffs has a decisive effect on formation of a coastline of seas and oceans as well as on its geomorphological and ecological processes causing a delta formation at the river mouth, coastline erosion processes and major changes in regard to environment protection as well the elimination of which requires significant investments and many years.

With the purpose of a morphological investigation of a coastline it is necessary to identify the amount of bottom as well as float deposits brought into the sea by a river. The Rioni, Enguri and Chorokhi Rivers deposits play a crucial part in formation of the Black Sea region coastline the amount of which was significantly changing over the last century as a result of hydraulic constructions carried out on these rivers and various human interventions in riverbed processes. These factors were followed by lots of problems that currently remain unresolved and that are being now studied by a number of project and scientific research organizations operating both within Georgia and beyond it. A special contribution to this activity was made by *Institute of Energy and Hydrotechnical Constructions of Georgia*, *Tbilhydroproekti, Saktskalproekti, Institute of Water Management and Engineering Ecology of Georgia, Georgian Technical University, LEPL Tbiltskalgeo, GAMA Consulting LLC, Bank Protection/Napirdatsva LLC* as well as other organizations.

MAIN PART

The Chorokhi River originating in Turkey in the Okus-Badatsagi Mountains situated at 2700 meters above sea level flows into the Black Sea to the south of Batumi in 6km away. The total length of the river is 438km (26km – within Georgia). At the river mouth it divides forming islands (Fig.1).

Fig. 1. The Chorokhi River Mouth

Out of the rivers of the Black Sea basin of Georgia the Chorokhi River has the largest water catchment basin with an area of 22100km^2 (including 2090km^2 – within Georgia).

The river basin is distinguished as well by gradient on average 30‰. River fall on the territory of Georgia amounts to 56m. The width of the riverbed ranges between 48m and 900m (at the river mouth); the depth ranges from 1,5m to 5m; while average velocity of flow ranges between 0,7m/sec and 2,5m/sec.

When affected by the storms of west direction dominating in this region the Chorokhi River deposit travels along the Batumi coastline towards the north and reaches the Natanebi River mouth.

Based on the 1832 cartographic materials, two main branches of the Chorokhi River used to discharge into the sea, to the south – nearby the contemporary confluence and to the north – in Adlia, at the confluence of the Mejini River. Both river branches that were forming wide deltas divided into channels demonstrate that the Chorokhi River at that time was quite abundant with an active hydrological regime. On the map of 1890 the north branch is cancelled – at that moment the north branch had already lost its connection with the main system of the Chorokhi River and it was replaced by the Mejinistskali River mouth [3,5,6,7].

The Mejini River bank that had been moving towards the sea over the last 150 years retreated by approximately 400m, washing-away pace in 1880-1926 was 5,2m per year on average and in 1926-1980 it reduced to 2,2m per year.

The Chorokhi River discharge concentrated at the confluence of the south branch significantly changed the litho-dynamics of the sea coastline. At the confluence area deep canyons and underwater alluvial fan were formed that is intruded into the sea up to 30 km in length.

On the Chorokhi River, near the confluence of the Adjaristskali River, by the village of Ergesi a Hydrological Watchtower had been operating until 1992. Near this watchtower the maximum fluctuation of river level was 6,9m and average annual flow was ranging between 159m^3/sec and 409m^3/sec. It was at that time when according to the data of Prof. R. Diakonidze 1% occurrence flow reached 4210m^3/sec [2].

Coastline dynamics depends on wave regimes. Flow velocity along the coastline on the territory of Adjara is 0,3-0,5m/s on average but when there is a strong wind it reaches 1m/sec. According to wave directions, west waves amounts to 57%, north-west waves – 18%, south-west – 15%. Parameter values of waves and their frequency are provided in Table 1. In 1997-2007 strong storms ratio drastically increases in their total amount.

Table 1. Values of wave parameters along the coastline of Adjara region

Storm power (magnitude)	Average values of wave parameters			Wave frequency according to direction, Day/year					
	Height $\overline{h}$, m	Duration $\overline{\tau}$, sec	Length $\overline{\lambda}$, m	S/W	W	N/W	N	N/E	Calm
0	_	_	_	_	_	_	_	_	91
1	0,06	1,4	3,0	5,1	23,8	16,7	17,2	3,7	_
2	0,23	1,8	5,0	8,5	50,0	27,0	18,0	5,6	_
3	0,46	2,6	10,8	6,35	32,4	11,2	6,95	1,28	_
4	0,74	4,0	25,5	2,42	16,6	4,8	1,78	0,15	_
5	1,25	5,6	50,0	1,3	9,6	1,27	0,73	0,11	_
6	2,15	6,8	75,0	0,22	1,9	0,22	0,36	_	_
7	3,3	8,5	115,0	0,07	0,4	0,07	_	_	_
8	4,45	9,8	155,0	0,04	0,04	0,04	_	_	_

In the 70's along the left branch of the Chorokhi river mouth with a view to protecting agricultural lands against flooding an earth dam was arranged that made its confluence at the headwater of the underwater canyon. Since this same period an inert materials factory started operating in the Chorokhi riverbed the capacity of which amounted to approximately 0,5mln m^3/year (basically, coarse fraction material to form a coastline was extracted). As a result of this along the coastline of the Adlia-Batumi segment a heavy deficit of deposit supposed to form a coastline occurred. Totally, in 1930-80 along the Adlia-Batumi coastline more than 40ha area was washed away [3,5].

Based on the 1978 data out of 30mln m^3 solid deposits brought into the Black Sea by the rivers from the territory of Georgia on average, the significant share with the amount of 17mln m^3 falls on the Chorokhi River only, which is 57% of the total amount of deposit [2].

In 1982-1990 from the washed-away areas of the coastline with the purpose of filling the deficit of deposits, under the project of SPA (Scientific-Production Association) "Sakzgvanapirdatsva" a great amount of coarse fraction material (6,3 mln m^3 in total) was extracted from the Chorokhi River mouth (that was filled during the floods and freshets). Out of the amount of the coarse fraction material mentioned above, approximately 1,3 mln m^3 was spread along the coastline of the Adlia segment. This material during the previous years was being lost in the underwater canyon leading to erosion of canyon slopes and correspondingly, resulting in its activation. As expected the material spread along the Adlia segment supposed to form a beach being affected by the storms of dominating directions was moving towards Batumi where it was forming beaches of full profiles.

In the 90's in the upper part of the Chorokhi River hydraulic constructions being widely spread across the territory of Turkey drastically changed a hydrological regime of the river. From 1998 the construction of the Derineri arch dam with a height of 249m started (Fig.1.23). The dam was being constructed in stages was finally completed in 2013.

Fig. 2. Derineri Arch Dam on the Chorokhi River (Turkey)

According to the 2017 data, on the Chorokhi River within the territory of Turkey 27 dams are planned to be constructed in total (Fig.3.) that constitutes a major threat to the coastline of the Adjara region. Out of the dams mentioned above except for Derineri dam, six dams including Muratli, Borchkha, Artvini, Arkuni, Giulbaghi and Tortumi have already been constructed and put in operation.

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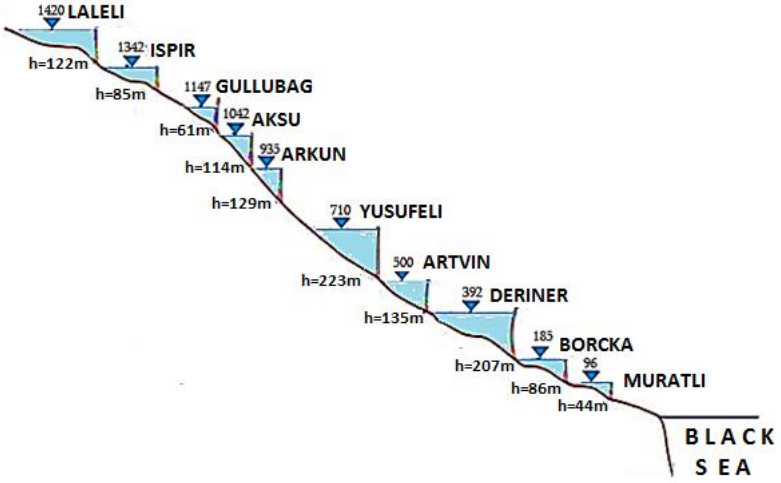

Fig. 3. Schematic section of the dams being in operation or under construction on the Chorokhi River within the territory of Turkey

Width of the washed-away zone of the coastline along the left bank of the Chorokhi River mouth amounted to 180-185m in 2007. And, only as a result of the bank protection works conducted in 2007-2011 it became possible to increase beach width up to 50-55m.

Meanwhile, in 2001-2007 the right bank of the river mouth was washed away more frequently, along the Adlia segment the beach with a width of 125m was washed away. With the purpose of protecting a beach in 2009-2012 inert material with the amount of 100 thousand m^3 was brought into the above mentioned area from the Chorokhi riverbed as a result of which the beach width increased up to 30-50m.

More to the north, Batumi beaches increased only up to 2-7m. But, as this material is extracted from the Chorokhi riverbed with almost no deposits remained in it significant activation of erosion processes is expected at the water areas of the river mouth.

Besides, a collapsing situation has been emerged again near the Batumi Boulevard the most part of which was washed out and destroyed (Fig.4).

Fig. 4. Collapsed promenade near Adlia (2016)

Dynamics of the Gonio coastline is not homogeneous. In particular, if in 1984-2001 the width of a washing zone near the Chorokhi River mouth amounted to approximately 60m while in 2001-2007 it reached 33-35m, in 2007-2011 beach width in the south and central part of Gonio increased by 4-10m. On this segment the condition of beaches does not cause concern as yet. Although, after comparing the materials of various periods it appeared that in this area washing-away processes are still being implemented [5].

For the time being liquid flow in the Chorokhi river basin within the territory of Georgia constitutes 200m^3/sec on average per year. Average annual flows of the two tributaries of the Chorokhi River – the Adjaristskali River and Machakhela River – that relatively constitute 52m^3/sec and 18m^3/sec discharge into the Chorokhi river basin as well. The total volume of deposit of these tributaries supposed to form a beach does not exceed 80 thousand m^3 per year. However, even these deposits cannot reach the sea as the river has no capability to transfer deposits any more. The deposits settle in the Chorokhi riverbed and form islands at the confluence area.

Within the territory of Georgia on the Chorokhi River Kirnati, Khelvachauri 1 and Khelvachauri 2 Hydro Power Plants (Fig.5) are being constructed while on the tributary of the Chorokhi River – the Adjaristskali River – Shuakhevi, Koromkheti and Khertvisi Hydro Power Plants are planned to be constructed (Fig.6).

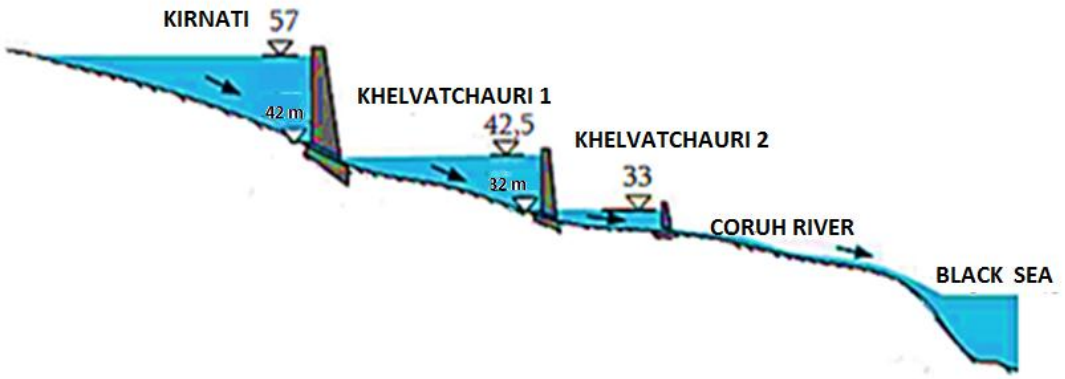

Fig. 5. Dams being under construction on the Chorokhi River within Georgia [6]

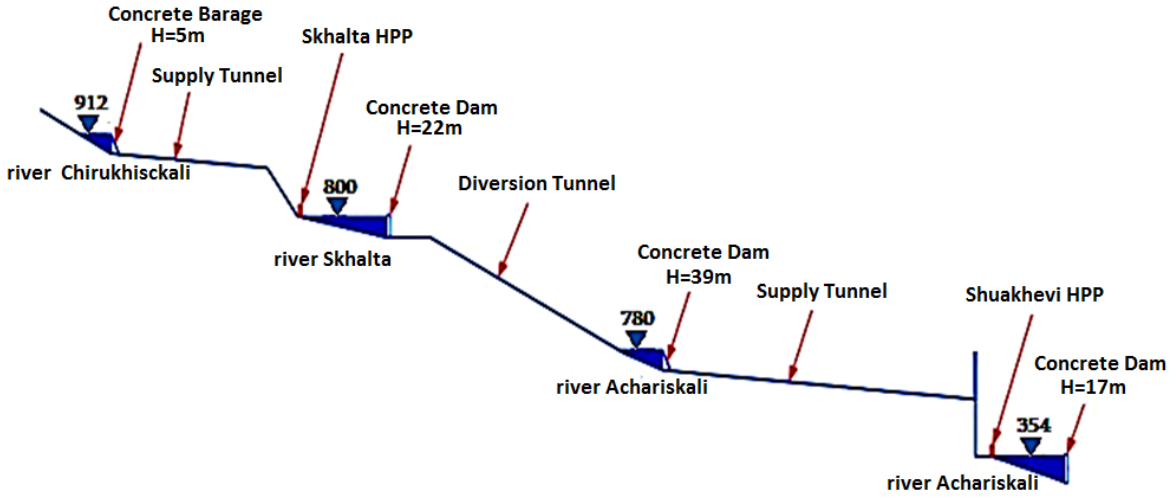

Fig. 6. Design Hesses on the Adjaristkali River [8].

In the very near future after the Hydro Power Plants mentioned above are put in operation, the Chorokhi River will stop to provide the Adjara coastline with the deposits that are intended for forming a beach for over the next 300-350 years.

REHABILITATION MEASURES FOR THE COASTLINE OF THE ADJARA REGION

Following the regulation of the Chorokhi River a new extremely different stage of formation of banks has started in the Black Sea region of Adjara that is determined by the factors as follows:

- A natural renewable source of the material forming a beach does not exist any longer as solid deposits in significant amount are not brought to the Chorokhi River mouth;
- A sea coastline washing-away process at the river mouth became irreversible that will continue until this coastline has a frontal shape against dominating waves and dynamical balance profile of a beach is not determined by new fractional composition of deposits;
- Impact of an underwater canyon on the coastline will be reduced to minimum. A great amount of deposits that was seized by this canyon is not brought by the river any longer. It is quite hard to predict a geomorphological change caused by this occurrence;
- Along-the-coastline flow of deposits is formed at the expense of washing-away products of a river mouth and adjacent transit zone.

Due to the lack of information regarding the operation of existing and planned dams as well as volumes of deposits to be gained in future, the predictions made in this regard are quite provisional. In this case the peak (flood) flows that will be released from the dams being in operation on a periodic basis, will take on particular significance for deposit transportation.

In spite of the fact that there exists a prediction for the Adlia-Batumi coastline zone development up to 2025 as well as several schemes [4] for bank protection measures, we suppose that currently all these options need to be proved in more reasonable manner. These measures should be implemented by taking into account natural and anthropogenic factors. First of all it will be necessary to achieve a balance of deposits intended to form banks artificially on separate areas of the coastline. And only on those areas where bank strengthening will be impossible or less effective to implement by solid deposits, various types of bank protection and deposit-directing constructions should be used.

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Агромелиорация

ОСОБЕННОСТИ ФОРМИРОВАНИЯ И РАЗВИТИЯ АНТРОПОГЕННЫХ ЛАНДШАФТОВ РАВНИННЫХ РАЙОНОВ АЗЕРБАЙДЖАНСКОЙ РЕСПУБЛИКИ

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Аннотация. В статье анализируются особенности формирования и развития антропогенных ландшафтов в различных естественных комплексах. А также планомерное урегулирование, создание агроирригационных, садово-плантационных и богарно-земледельческих ландшафтов, путем оптимизации хозяйственной нагрузки на равнинных регионах Азербайджанской Республики.

Ключевые слова: агроирригационные ландшафты, рациональное планирование, мелиорация, оптимизация, урегулирование.

Agromelioration

FEATURES OF FORMATION OF ANTROPOGENIC LANDSCAPES THE REGION OF PLAIN OF THE REPUBLIC OF AZERBAIJAN

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Annotation. The article analyzes the peculiarities of antropogenic landscapes in different natural complexses. As well as the creation of the planned settlement agroirrigation, garden and plantation-and rainfed agricultural landscapes through the optimization of the economic burden on the lowland regions of Azerbaijan

Key words: agroirrigation landscapes, rational planning, reclamation, optimization, settlement.

ВВЕДЕНИЕ

Анализ ландшафтно-мелиоративных условий орошаемых регионов Кура-Аразской низменности показывает, что мелиоративные условия здесь крайне неблагоприятны и обусловлены значительной площадью засоленных почв тяжелого механического состава с низкими фильтрационными свойствами. К антропогенным факторам, ухудшающим мелиоративную обстановку, относится неудовлетворительное состояние ирригационной сети, неспланированные орошаемые участки, чрезмерная протяженность необлицованных каналов и т.д.

ОСНОВНАЯ ЧАСТЬ

В аридных регионах Азербайджана и в частности Кура-Аразской низменности устойчивые агрофизические свойства почво - грунта и высокое плодородие наблюдаются под тутовниками, виноградниками и лесными насаждениями. Это объясняется заметным накоплением в них органического вещества, мощным развитием биомассы. Особенно в предгорных наклонных равнинах, в естественно-дренируемых участках, где почво - грунт имеет высокую фильтрационную способность, формируется своеобразный агроирригационный горизонт. Мощность этого горизонта определяется не только природно-хозяйственными условиями, но и давностью орошения. Исследования показывают, что на основных агроландшафтах: Муганской, Мильской, Ширванской и Гарабахской равнин самые благоприятные условия в формировании и развитии экологически устойчивых агрокомплексов, создаются на незасоленных почвогрунтах (уровень грунтовых вод- более 1,5 м) при содержании водопрочных макроагрегатов (более 0,25 мм) около 60-80%, микроагрегатов (менее 0,25 мм) около 30-40% при влагоёмкости (от максимальной молекулярной до полевой) около 1,0-1,5 г/см^3. В аридных условиях с целью улучшения и урегулирования агрофизических свойств почво - грунта, а также повышения эффективности мелиорации засоленных и солонцеватых почв тяжелого механического состава необходимо повышать водопрочность почво - грунта, способность накопления и сохранения почвенной влаги путем обработки в вегетационный период и промывки засоленных участков, создавать систему полезащитных лесных полос и вводить почвенные севообороты, регулировать применение минеральных и химических удобрений, широко распространять противоэрозионные мероприятия и химическую мелиорацию, направленную на борьбу с процессом засоления почв.

Обработка многочисленных данных показывает, что продуктивность агроирригационных ландшафтов во многом зависит от нормального обеспечения орошаемых полей зелеными насаждениями. На Ширванской равнине каждые 100 га агроландшафта имеют в среднем 0,07 га, а в Муганской и Сальянской степях, а также в Юго-Восточной Ширвани-0,04-0,05 га лесных полос. В отдельных массивах Кура-Аразской низменности и других аридных регионах республики этот показатель колеблется в пределах 0,01-0,11 га. В полупустынных и сухостепных агроландшафтах для сохранения относительного равновесия между естественными и искусственными биоценозами необходимо увеличить существующие площади лесных полос в 10-15 раз, а в богарно-земледельческих массивах - в 3-5 раза. По нашему мнению, на каждые 100 га пахотных земель следует создать минимум 1,2-1,5 га лесных полос.

Интенсивно используемые агроландшафты охватывают неорошаемые, орошаемые полевые, садово - плантационные комплексы. Они широко распространены вдоль рр. Кура, Араз, Гейчай, Турианчай, Тертер и др., а также крупных каналов (Верхне-Ширванского, Верхне-Гарабахского, Среднемуганского, Сабирского и др.). В аридных условиях Азербайджана формирование агроирригационных ландшафтов зависит от степени искусственного увлажнения. Именно этот фактор определяет основные тенденции эволюции оазисных ландшафтов. За последние 20 - 25 лет площадь интенсивно используемых ландшафтов Кура-Аразской низменности увеличилась в 2,5 раза, соответственно площадь нерегулярно используемых ландшафтов значительно уменьшилась. Благодаря чего, коэффициент антропогенности отдельных естественных типов ландшафта составляет около - 0,8 - 0,9 [3].

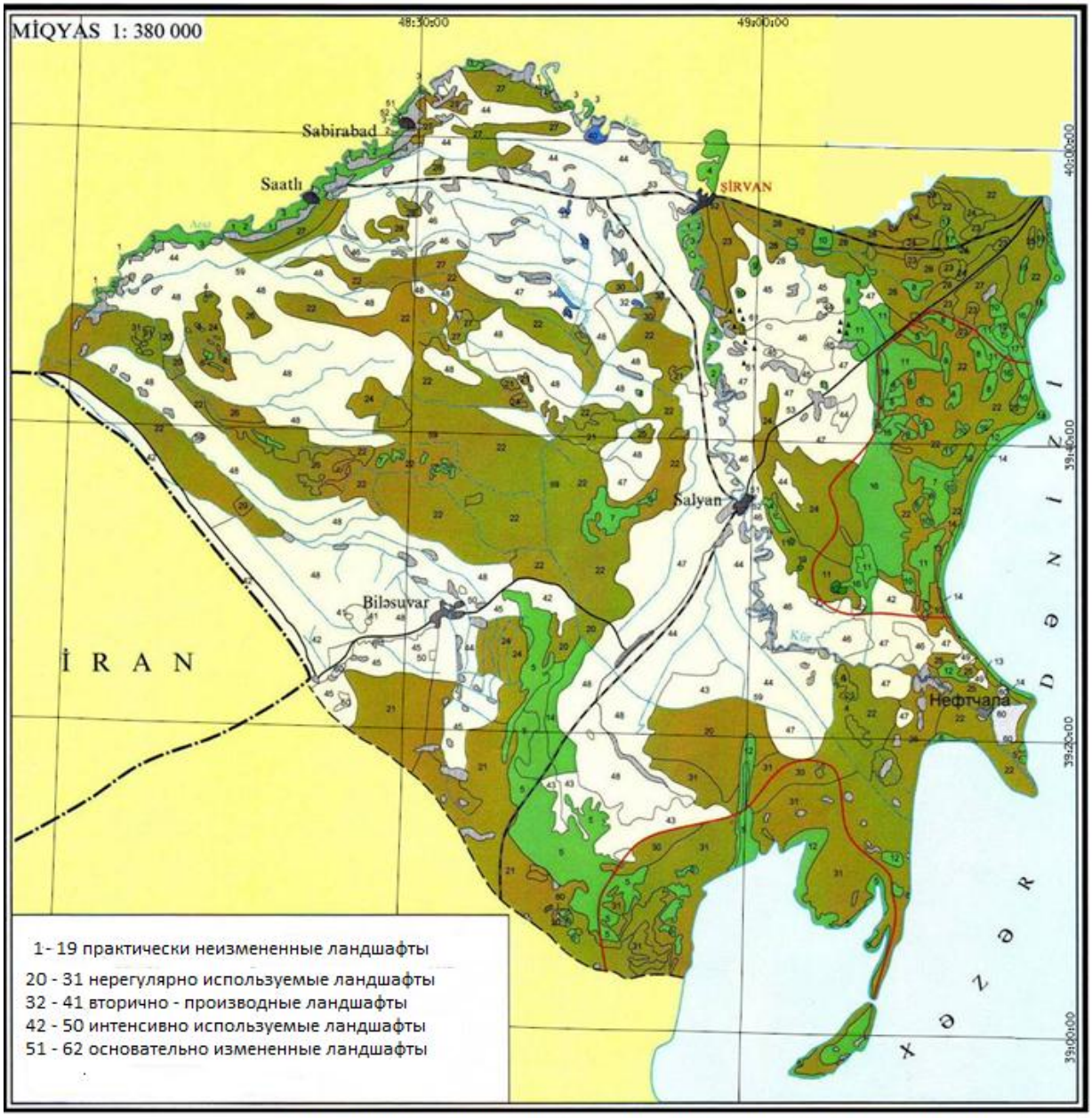

Рис. ! Современные антропогенные ландшафты Нижне Куринской равнины (Я. А. Гарибов)

Интенсивно используемые агроландшафты с момента своего формирования превращаются в управляемую систему и находятся под регулярным воздействием человека. Ежегодные распашки, бронивание, корчевка, орошение, внесение органических и минеральных удобрений, сенокошение сельскохозяйственных растений и т.д. обновляют вторичные фитоценозы, возникает мощный агроирригационный горизонт (0,5-1,5м), а также возникает ряд нежелательных процессов, таких как ирригационная эрозия, вторичная засоленность и заболоченность (3).

На орошаемых агроландшафтах Муганской, Ширванской, Гарабахской, Мильской равнин и Юго-Восточной Ширвани годовая амплитуда колебания уровня грунтовых вод достигает 1,5-2,0 м, а неорошаемых полупустынных - не выше 0,5 м.

В высоко-антропогенизированных (0,8) сухостепных, аридно-редколесных, лесо-кустарниковых, полупустынных ландшафтах предгорных, низкогорных и низменных районов Азербайджана под влиянием орошения, распашки, фитомелиорации формируются разнообразные

вариации агротехногенного происхождения. Здесь на волнистых, холмисто-грядовых, сильно расчлененных равнинах каштановые, сероземные, луговые, сероземно-луговые, серо-бурые и др. почвы формируются гидроморфные признаки, и мощные агроирригационные горизонты.

Искусственное увлажнение почво - грунта на древне орошаемых частях конусов выноса рек и межконусных понижениях рр. Турианчай, Гейчай, Гирдыманчай, Тертер, Ахсу, Кенделанчай и др. усиливает гидроморфизацию ландшафта. Повсеместно на сероземных, сероземно-луговых, светло-каштановых, сероземно-бурых и др. почв образуются культурно-гидроморфные горизонты, вместе с одновидовыми агроценозами развиваются вторичные сорные заросли, состоящие из негофитных и галофитных сообществ.

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Исследования по изучению Земли

ВЛИЯНИЕ ГЕОДИНАМИЧЕСКИХ ПРОЦЕССОВ НА СТАБИЛЬНОСТЬ ГЕОДЕЗИЧЕСКИХ ПУНКТОВ В АЗЕРБАЙДЖАНЕ

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Аннотация: В данной статье приведены сведения о тектоническом положении территории Азербайджана, интерпретации результатов повторных нивелировок на Апшеронском полуострове, грязевых вулканах, распространенных в прибрежных районах Каспийского моря и сейсмической ситуации в Республике. В целях изучения геодинамических процессов в наиболее сейсмоактивных зонах АР созданы шесть геодинамических полигонов. В статье описаны их особенности создания и влияния на стабильность геодезических пунктов.

Ключевые слова: геодезическая сеть, тектоника, сейсмичность, Апшеронский полуостров, геодинамические процессы.

Studies of the Earth

THE INFLUENCE OF GEODYNAMIC PROCESSES ON STABILITY GEODETIC POINTS IN AZERBAIJAN

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Annotation. This article provides information about the tectonic situation of the territory of Azerbaijan, the interpretation of the results of repeated leveling on the Absheron Peninsula, mud volcanoes common in coastal areas of the Caspian sea and seismic situation in the Republic. In order to study geodynamic processes in the most seismically active areas AR created six geodynamic polygons. The article describes their create features and influence on the stability of geodetic points.

Key words: geodetic network, tectonics, seismicity, Absheron Peninsula, geodynamic processes.

ВВЕДЕНИЕ

Государственная геодезическая сеть, если её систематически не обновлять и не совершенствовать, постепенно стареет, утрачивает часть пунктов, теряет точность в отдельных

её частях, особенно из-за современных движений земной коры.

Основными очагами современных движений земной коры на территории Азербайджанской Республики (АР) являются явления тектонического характера, высокая сейсмическая активность, наличие очагов землетрясений и грязевулканических извержений, различные воздействия на формы рельефа, вызванные техногенными и антропогенными процессами.

Работа выполнена в рамках гранта **EIF-KETPL-2-2015-1(25)-56/27/2-M-16** Фонда Развития Науки при Президенте Азербайджанской Республики.

1. Тектоническое положение Азербайджана

Тектоническое положение Азербайджана в общей структуре Кавказа и сопредельных складчатых областей определяется основными структурными комплексами: мегантиклинорами Большого и Малого Кавказа (восточные окончания) и разделяющим их Куринским межгорным прогибом [1,2]. Эти структуры уходят под новейшие отложения меридиальной депрессии Каспия.

Каспийское море расположено на стыке крупных разнородных геоструктурных элементов Северного Прикаспия, Кавказа, Закаспия (Казахстана, Туркменистана) и Северного Ирана. Каспийская впадина состоит из двух впадин: Средне-Каспийской и Южно-Каспийской, разделенных Апшероно-Прибалханской зоной молодых поднятий.

Анализ геологического строения Азербайджана показывает, что ныне наблюдаемые разломы глубокого заложения имеют значительную протяженность и, простираясь в основном с северо-запада на юго-восток и с северо-востока на юго-запад, рассекают всю территорию Республики (рис.1).

В Малом Кавказе современные движения носят дифференцированный характер и, если в крайних горных зонах происходят поднятия со скоростью 4-5 мм/год, то во внутренних зонах, наоборот, опускания 0,1-1мм/год[2]. На Кура-Араксинской низменности в целом происходит опускание, и его скорость доходит до 0,5-5 мм/год, на Миль-Карабахской наклонной равнине общая скорость составляет 2-3 мм/год. В Аджиноурской зоне происходит дифференциальное поднятие со скоростью 4-6 мм/год. Ганых-Агричайская зона, расположенная между Аджиноуром и Большим Кавказом, также является зоной поднятия (4 мм/год). Отмеченные тектонические процессы оставляют свои отпечатки в пространственных положениях геодезических пунктов.

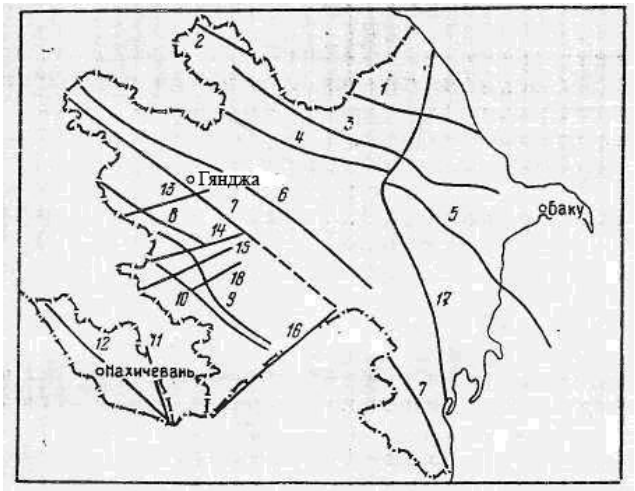


Рис. 1. Схема расположения глубинных разломов в АР [1]
1 - Сиазанский; 2 - Главнокавказский; 3 - Кайнарско-Зангинский; 4 - Северо-Аджиноурский; 5-Аджичай-Алятский; 6 - Куринский; 7 - Предмалокавказский; 8 - Мровдагский; 9 - Карабахский; 10 - Башлыбельский; 11-Анкаван-Сюникский; 12 - Нахичеванский. Поперечные: 13 - Хандар-Хачбулакский; 14 - Мровдаг-Зодский; 15 -Тертерский; 16 - Нижне-Араксинский;

2. Интерпретация результатов нивелирования

Результаты повторных нивелировок показывают, что на Апшеронском полуострове происходят значительные движения земной поверхности. Анализ инструментальных данных, морфоструктурных особенностей и геодинамики полуострова, позволил установить, что эти движения имеют тектоническую природу. В то же время, опускание локальных участков, связанных с наиболее старыми нефтепромыслами в Сабунчах, Сураханах, Раманах и Бибиэйбате (за период с 1912 г. по 1962 год общее опускание земной поверхности на Сураханском месторождении достигло

2450 мм), были интерпретированы как результат длительной добычи нефти и газа, т.е. как проявление техногенного фактора на фоне чисто тектонических движений[3,4,5].

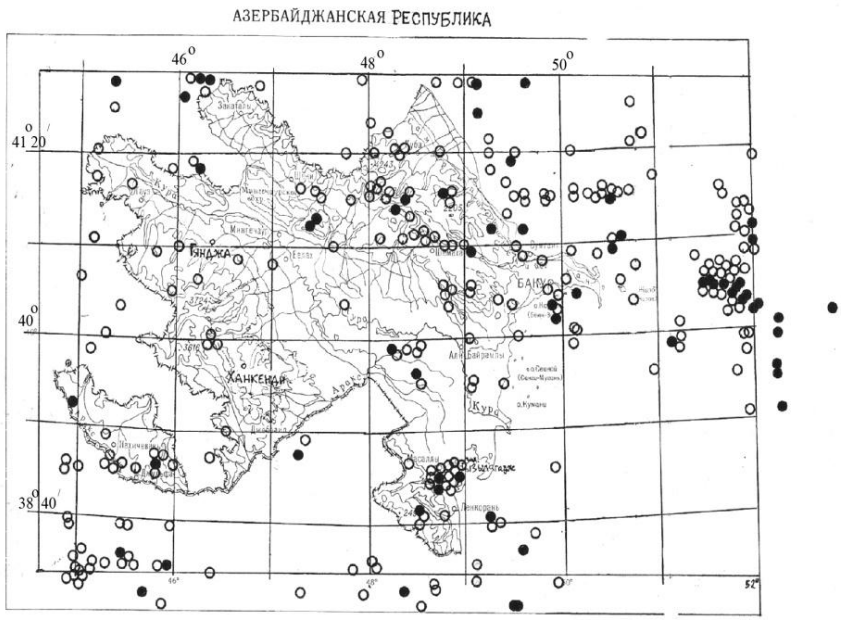
Азербайджан с прилегающей акваторией Каспийского моря представляет обширную область распространения грязевых вулканов. В регионе Юго-Восточного Кавказа насчитывается более 200, в том числе около 30 действующих грязевых вулканов.

3. Сейсмичность территории Азербайджана

Территория Азербайджана издавна отличается высокой сейсмичностью. Так, район г. Шемахи – наиболее сейсмоактивный пункт Кавказа. Очаги землетрясений в АР разбросаны почти по всей территории Республики. За последние 25 лет произошли землетрясения значительной силой – 7-балльные по шкале Рихтера: Каспийское (май 1980 г.), Исмаиллинское (ноябрь 1981 г.), Каспийское (март 1986 г.), Ленкоранское (октябрь 1987 г.), Каспийское (сентябрь 1989 г.), на границе с Ираном (февраль 1997 г.), Лерикское (июль 1998 г.), Бакинское (ноябрь 2000 г.)[6].

На рис.2 приведена карта эпицентров землетрясений на территории АР, составленная по данным американского геофизического общества. За последних 22 года число землетрясений с силой три и более баллов – 372, общее количество толчков – 1515 (в среднем за год: $\frac{кол-во \quad земл-й}{кол-во \quad толчков} = \frac{17}{69}$), из них землетрясений силой пять и более баллов – 75 с количеством толчков 242 (в среднем за год $\frac{3,5}{11}$). Шемахинская эпицентрическая зона на фоне других выделяется с 9-балльной изосейтой, 8-балльные изосейты: в Шемахинской, Нахичеванской зонах, на севере Апшеронского полуострова, в Нагорном Карабахе, Ленкоранском районе и в пограничной зоне с Ираном.

Анализ распространения землетрясений показывает высокую сейсмичность Каспийского моря, причем подавляющее большинство эпицентров землетрясений расположено в западной полосе[7].



●- 5 и более баллов ○ – 3-5 баллов

Рис. 2. Карта эпицентров землетрясений на территории Азербайджана

Для Баку и некоторых районов Азербайджана (Хызы, Шемаха и др.) характерны также периодические оползневые процессы с охватом значительной площади (в Баку в 1998 году произошли оползни с площадью около 100 га и глубиной примерно 30 м), приводящие также к деформациям геодезических сетей в отмеченных районах.

4. Геодинамические полигоны на территории Азербайджана

В советское время в целях изучения геодинамического режима в наиболее сейсмоактивных зонах АР было создано шесть геодинамических полигонов (ГПД): Апшеронская спецсеть-80, Шемахинский геодинамический полигон, Прикаспийский ГДП, ГДП «Шеки-Кюрдамир», Техногенный полигон Апшерона, ГДП Азербайджанской АЭС (рис.3)[7].

Дадим их краткое описание.

Апшеронская спецсеть-80. Используя результаты повторных нивелировок в различные годы, исследованы колебательные движения земной поверхности Апшерона многими учеными: А.А. Изотовым, Д.А. Лилиенбергом, И.Н. Мещерским и др. Результаты повторного нивелирования показывают, что поверхность Апшеронского полуострова повсеместно испытывает неравномерную деформацию. В центральной части зарегистрировано максимальное опускание со скоростью – 48 мм/год, а на периферических участках полуострова - оно сменяется иногда поднятием [3].

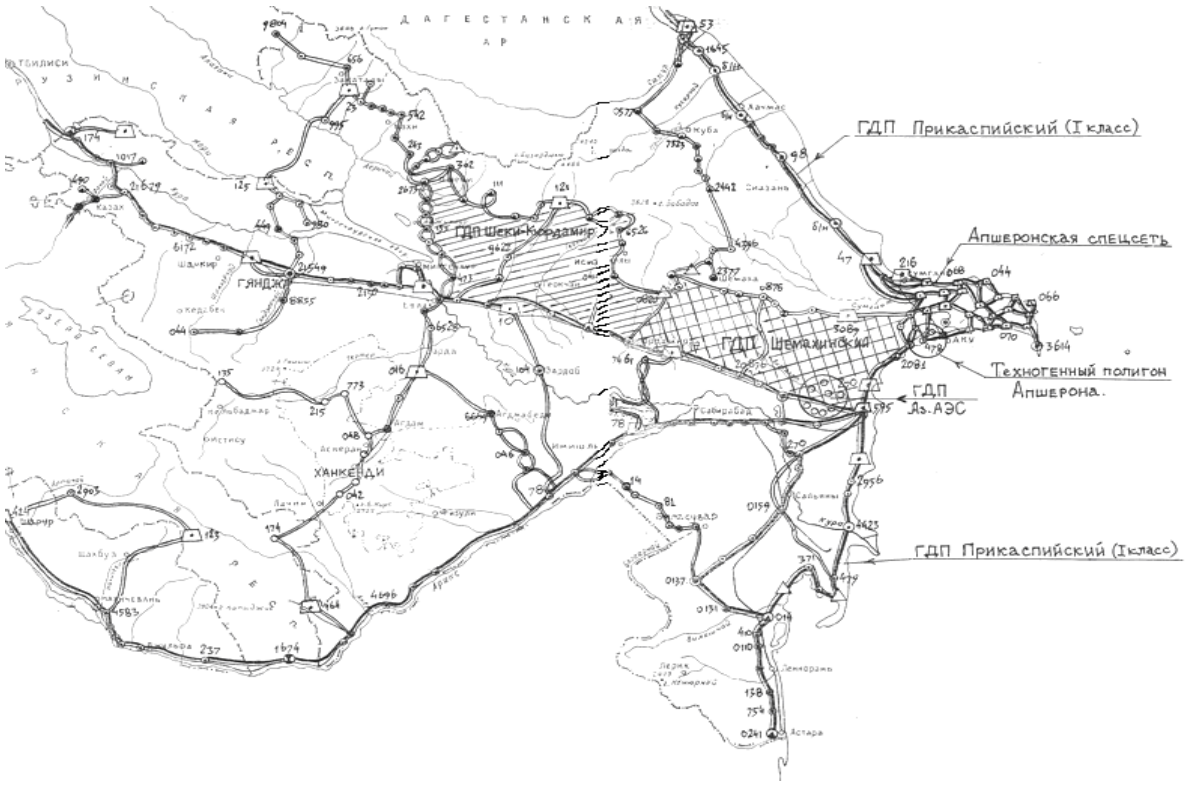


Рис. 3. Схема расположения геодинамических полигонов

Шемахинский геодинамический полигон – создан в 1974 году в юго-восточной части Большого Кавказа. За последние 150 лет здесь зарегистрировано более 200 значительных землетрясений, среди которых особо выделяются катастрофические землетрясения 1859, 1869, 1872 и 1902 гг., практически полностью разрушившие город Шемаха и приведшие к гибели многих десятков тысяч людей.

Геодезической основой инструментальных измерений современных тектонических движений на полигоне являются повторное нивелирование и повторная триангуляция. Полигон состоит из каркасной нивелирной линии I класса Баку-Кюрдамир и трех линий нивелирования II класса: Кюрдамир-Ахсу, Гаджиево-Мараза и Мараза-Дуванный, а также линейно-угловая сеть, расположенная на территории Шемахинского района для изучения горизонтального движения на данной территории.

По согласованию с Институтом Геологии и геофизики Национальной Академии Наук Азербайджана (НАНА) Предприятие №16 (ГУГК) с 1975 года по 1985 год регулярно выполняло высокоточные геодезические измерения на этом ГДП в трех циклах линейно-угловых измерений I класса, нивелирования I и II классов. При этом ставились также цели обнаружения возможных предвестников землетрясений. Результаты сравнения измерений из разных циклов показывают, что на Шемахинском ГДП происходит интенсивное движение земной коры, как в высотном, так и плановом положениях. В течение последних десятилетий на полигоне повторные геодезические измерения не производились.

Прикаспийский геодинамический полигон создан в 1981 году вдоль западного побережья Каспийского моря от Махачкалы до Астары на территориях Дагестанской АР и Азербайджанской Республики. В ход нивелирования I класса были включены гравиметрические пункты с объекта "Гравиметрические пункты геополигонов". В полигон вошли также нивелирные линии, проложенные в 1950 г., 1971 г., частично в 1912 г., 1936г., 1940-1944 гг., 1976 г. Последние геодезические измерения на этом полигоне выполнены в 1982-1986 гг. На общем фоне имеются резкие чередования в направлении движения земной коры по линиям Махачкала-Астара.

Геодинамический полигон «Шеки-Кюрдамир» создан в 1982-1984 гг., на юго-восточном Кавказе (районы: Агдаш, Ахсу, Габала, Геокчай, Евлах, Исмаиллы, Огуз, Кюрдамир, Уджар, Шеки) с целью выявления предшествующих землетрясению деформаций земной поверхности. Полигон состоит из линейно-угловой сети первого класса, нивелирных линий I и II классов. В 1985 году выполнены еще два цикла (7 и 8 циклы). Результаты измерений дают основание предполагать, что на участке полигона происходят горизонтальные и вертикальные движения земной коры колебательного характера.

Техногенный полигон Апшерона расположен в районах добычи нефти и газа Локбатан, Пута, Кушхана Апшеронского полуострова. В 1986 году выполнен I цикл измерений по нивелированию I и II классов. В 1987 году осуществлен II цикл измерений нивелирования I и II классов.

Главной научно-прикладной задачей при организации этого полигона явилось изучение влияния интенсивной добычи нефти и газа на перемещения земной поверхности и установление соотношений последних с медленными вертикальными движениями.

Геодинамический полигон Азербайджанской АЭС расположен к северу от станции Наваи в Пирсагатской долине. В 1985 году было заложено 11 глубинных и 143 грунтовых репера. Проектировалось нивелирование I класса по существующей линии нивелирования I класса Алят-Хашури. В 1985-1987 гг. было выполнено три цикла (с промежутком между циклами в 1 год) нивелирования I класса и II класса. Целью создания этого полигона являлось изучение сейсмичности данного района, где проектировалось строительство Азербайджанской АЭС. В настоящее время повторные измерения на полигоне прекращены в связи с приостановкой строительства АЭС.

ВЫВОДЫ И РЕКОМЕНДАЦИИ

По результатам анализа геодинамических процессов, происходящих на территории Азербайджана и их влияния на стабильность положения геодезических пунктов, можно сделать следующие выводы и рекомендации.

1. Для решения многочисленных научных и научно-технических, инженерных задач очень важно сохранение в рабочем состоянии Государственной геодезической сети, а это требует её систематического обновления, совершенствования и развития из-за современных движений земной коры.
2. На Апшеронском полуострове происходят значительные движения земной поверхности, и эти движения имеют тектоническую природу. В то же время, опускание локальных участков интерпретируются как результат длительной добычи нефти и газа, т.е. как проявление техногенного фактора.
3. Высокая сейсмичность, а также оползневые процессы также являются источниками деформаций в геодезических сетях на территории Азербайджана.
4. После долголетнего перерыва необходимо возобновить геодезические наблюдения на геодинамических полигонах Азербайджана. Это помимо обнаружения возможных предвестников землетрясений, изучения геодинамических процессов, послужит также к цели реконструкции и развитию геодезических сетей. Об этом и других связанных с ним вопросах, будем информировать в следующих наших публикациях.

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Environmental protection

PROBLEM OF CALCULATION OF NORMS OF PERMISSIBLE RECREATIONAL LOADS ON BELARUS WATER RESERVOIRS

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Annotation. The recreational use of water reservoirs as one of the types of economic activity can lead to adverse consequences in relation to the water object - environmental risk and the degradation of the ecological condition (status) of the reservoir. The article represents the methodological approaches to the integrated assessment of environmental risk and the calculation of norms of permissible recreational loads on Belarus water reservoirs.

Key words: water reservoir, recreation, load norm.

Recreational use of water reservoirs as a kind of economic activities can lead to adverse consequences for water bodies - deterioration of its environmental condition (status), and as a result to the decrease of its recreational attractiveness.

According to the legal system of the Republic of Belarus, the use of water objects for recreational purposes is currently limited in terms of correspondence with hygiene regulations of water safety, which include:

- maximum permissible concentration of chemicals in the water bodies;
- approximate permissible levels of chemicals in the water bodies;
- organoleptic indicators;
- microbiological indicators;
- radiation safety indicators.

However, legal documents do not establish the scale or possible degree of impact of recreational activities on water bodies.

In order to develop the methodology for integrated assessment of environmental risk and calculate the norms of permissible recreational loads in recreational areas on Belarusian reservoirs, as well as in the framework of the assignment of State Research Program "Nature Management and Ecology", the scientists carried out the analysis of modern approaches to the assessment of the recreational use of water bodies [1]. The researches show that the following factors are necessary to consider when calculating admissible recreational loads:

– load norms shall not exceed the admissible volumes of recreational use. The norms shall be determined not separately, using different criteria, but by their correlation and finding the optimal value from the point of view of peculiarities relating to a certain type of recreation, psycho-physiological comfort and stability of a water body (reservoir) in terms of anthropogenic loads;

– the norms of permissible one-time recreational load are of key importance: seasonal, annual, and established for longer periods;

– the permissible volumes of recreational use of water bodies shall be determined taking into account the impact of other (non-recreational) activities.

It is proposed to assess the degree of possible recreational load on the water body on the basis of the algorithm that takes into account the initial state of the reservoir, sources of impact on it and its assimilating capacity.

The use of this algorithm presupposes the conduction of the complex of studies, including the following basic elements:

– collection of initial information about the water body (reservoir), which includes the assessment of natural conditions and existing anthropogenic impact;

– identification of existing sources of anthropogenic impact and background characteristics of the reservoir;

– calculation of load for the planned types of recreational use;

– comprehensive analysis of the degree of impact of proposed types of recreational use on the overall environmental condition of the water body;

– determination and analysis of reservoir assimilative capacity;

– in case if the assimilating capacity is exhausted, the use of this reservoir as a recreation facility is impossible without additional research and rehabilitation measures;

– in case if the assimilating capacity is not exhausted, we make the choice among possible types of recreational use of this water body;

– drawing up the regulations for the recreational use of a water body and the measures ensuring the conservation of the water body and improving its environmental state.

The collection of initial information includes the generation of basic data on the following criteria: morphometric, climatic, hydrochemical, hydrological, hydraulic, biological, and organoleptic.

When analyzing the existing anthropogenic impact, we determine the composition of water users, the degree of their impact on the quantitative and qualitative characteristics of the water body.

The determination and analysis of the reservoir assimilative capacity makes it possible to establish the ability of a water body to take a certain mass of substances per unit of time without violation of water quality standards in the controlled section or water use point.

The choice of possible types of recreational use of a water body is carried out taking into account the recreational criteria that can be recommended for a particular water body.

The calculation of permissible recreational load is carried out in accordance with the requirements for a certain type of recreational use and the capabilities of the water body according to the correspondences stated in this methodology, as well as on the basis of expert estimations.

During the phase of complex assessment of the influence of recreational use of a water body, we are to determine the total impact of the proposed composition of recreational species on the hydrological, hydrochemical, hydrobiological, sanitary and hygienic indicators of water resources and the limits of their use in order to prevent the excess of maximum permissible concentrations of pollutants and the density of the water area and coastal area.

In accordance with the received information, we make the general expert assessment of reservoir condition on the basis of morphometric, climatic, hydrochemical, hydrological, hydraulic, biological, and organoleptic criteria for the purpose of its recreational use.

The calculation of load for each type of recreational use of a water body (reservoir) is carried out in accordance with allowable values and the corresponding characteristic of the water body.

The algorithm is the base for developing the methodology of the integrated assessment of environmental risk and calculating the norms of permissible recreational loads on the reservoirs of Belarus.

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Гидрология и метеорология

ДИНАМИКА ИЗМЕНЕНИЯ ГОДОВОГО И МАКСИМАЛЬНОГО СТОКА РЕК АЗЕРБАЙДЖАНА

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Аннотация. В статье для анализа колебаний годового и максимального стока рек Азербайджана применен метод линейного тренда. Этот анализ позволяет выявить динамику изменения направления в многолетних колебаниях. С этой целью были использованы данные о максимальных и годовых расходах воды за 1960 - 2014 гг по 29 гидрологическим пунктам наблюдений. Было выявлено, что на большей части территории Азербайджана имеет место уменьшение максимального стока рек, что с большой долей вероятности вызвано современными изменениями климата. Лишь в 2-х регионах тренды обобщенного годового стока являются статистически значимыми: для рек южного склона Большого Кавказа - тренд положительный, а для Ленкоранской природной области - отрицательный.

Ключевые слова: годовой сток, максимальный сток, линейный тренд, изменение климата, антропогенные факторы, статистическая значимость.

Hydrology and meteorology

DYNAMICS OF ANNUAL AND MAXIMUM RIVER FLOW IN AZERBAIJAN

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Annotation. In this article, the linear trend method was used to analyze the long-term fluctuations of the maximum and annual runoff of the rivers of Azerbaijan. This analysis makes it possible to identify directional changes in multi-year fluctuations. For this purpose, were used maximum and annual discharges dates for 1960 - 2014 years for 29 hydrological observation stations.It was revealed that in most of the territory of Azerbaijan maximum flow of rivers are decreased, which is probably caused by modern climate changes. Only in 2 regions the trends of the generalized annual runoff are statistically significant: for the rivers of the southern slope of the Greater Caucasus, the trend is positive, and for the Lenkoran natural area, the trend is negative.

Key words: annual runoff, maximum runoff, linear trend, climate change, anthropogenic factors, statistical significance.

ВВЕДЕНИЕ

Многолетняя изменчивость гидрологических характеристик обусловлена действием природных и антропогенных факторов.

Природные и, прежде всего, климатические факторы могут выражаться в виде многолетнего изменения режима поступающих на водосбор атмосферных осадков и приземной температуры воздуха. В результате этого нарушаются условия формирования речного стока на водосборе и гидрологический режим на реках становится нестационарным. Нарушение стационарности гидрологического режима на реках европейской части России, вследствие климатических изменений, не вызывает сомнений (Шикломанов, Георгиевский, 2007; Водные...,2008; Агальцева и др.,2011; Евстигнеев и др.,2012; Современные…,2014; Болгов и др.,2017).Происходит также изменение гидроэкологических функций рек (экологической, ландшафтной, рекреационно-эстетической и др.) (Фролова, 2012).

В Азербайджане средняя годовая температура воздуха за 1991-2014гг. по сравнению с предшествующим периодом (1961-1990гг.) возросла на 0,7°С. Причем, повышение температуры происходит по всем высотным поясам страны. Динамика изменения атмосферных осадков по высотным зонам носит более сложный характер. Во втором периоде по сравнению с первым, по всему Азербайджану годовая сумма осадков увеличилась всего на 11мм или 2,8%. В многолетнем разрезе минимальные зимние расходы воды рек Азербайджана увеличиваются, а максимальные уменьшаются (Махмудов, 2017).

Ранее было установлено, что во всех регионах Азербайджана максимальные расходы воды уменьшаются, а тренды годового стока являются разнонаправленными (Иманов, Гасанова, 2008). Также было выявлено, что для 18% рядов максимальных расходов воды гипотеза случайности и стационарности опровергается, и они характеризуются значимыми внутрирядными связями (Иманов, Гасанова, 2009).

К 2010 году годовой сток р. Куры в замыкающем створе (Сальяны) уменьшился на 50% или 13,4 км^3 по сравнению с его нормой, а годовой сток р.Аракс в замыкающем створе (Саатлы) снизился еще больше, т.е. на 54% или 4,95 км^3 (Иманов, 2016; Иманов, Вердиев, 2016). Приток в Каспийское море рек Ленкоранской природной области составил 65% от нормы годового стока (Фатуллаев, 2002).

ИСХОДНЫЕ ДАННЫЕ И МЕТОД АНАЛИЗА

Анализ многолетних колебаний годового и максимального стока рек Азербайджана был выполнен методом линейного тренда. Этот анализ дает возможность выявить направленные изменения в многолетних колебаниях. Были использованы данные по среднегодовым и максимальным расходам воды за 1960 - 2014 гг. по 29 гидрологическим пунктам наблюдений. Для рек юго-восточного склона Малого Кавказа и Нахчывана тренды рассчитаны по 1998г, что связано отсутствием данных наблюдений за последующие годы.

Наличие статистически значимых линейных трендов в ходе многолетних колебаний гидрометеорологических характеристик свидетельствуют о том, что имеет место статистическая неоднородность во времени.

Значимость линейных трендов оценена по величине коэффициента парной корреляции (R), с учетом его стандартной ошибки (σ_R).Тренд считался значимым, если выполнялось условие $R/\sigma_R \geq 2$, что соответствует 5%-му уровню значимости или 95%-му доверительному интервалу (Методические…,2010; Сикан, 2007).

ОБСУЖДЕНИЕ РЕЗУЛЬТАТОВ

Анализ линейных трендов среднегодовых и максимальных расходов воды рассматриваемых рек показали, что они являются разнонаправленными (табл.1.).

Учитывая вышесказанное, наряду с анализом линейного тренда по отдельным рекам, были рассчитаны линейные тренды осредненного модульного коэффициента рассматриваемых характеристик стока, обобщенные по различным регионам Азербайджана (рис.1). Пропуски в рядах наблюдений годового и максимального стока были восполнены их среднемноголетними значениями (к=1).

Таблица 1

Количество разнонаправленных линейных трендов в рядах годового и максимального стока рек

№	Регионы	Годовой сток			Максимальный сток		
		Знак тренда			Знак тренда		
		ПТ	ОТ	ТО	ПТ	ОТ	ТО
1	**Северо-восточный склон Большого Кавказа**	1(1)	1	1	1(1)	1	1
2	**Южный склон Большого Кавказа**	5(3)	2(1)	1	0	7(2)	1
3	**Северо- Восточный склон Малого Кавказа**	2(1)	1(1)	2	0	5(1)	0
4	**Юго- восточный склон Малого Кавказа и Нахчыван**	5(3)	4(2)	0	2(2)	4(2)	4
5	**Ленкоранская природная область**	1	2(2)	1	3	1	0

Примечание. *В скобках приведены число статистически значимых коэффициентов корреляции при 5%-ом уровне значимости; ПТ-положительные тренды; ОТ-отрицательные тренды; ТО-тренд отсутствует.*

Линейные тренды осредненных модульных коэффициентов годового стока рек по регионам Азербайджана приведены ниже на рисунке.

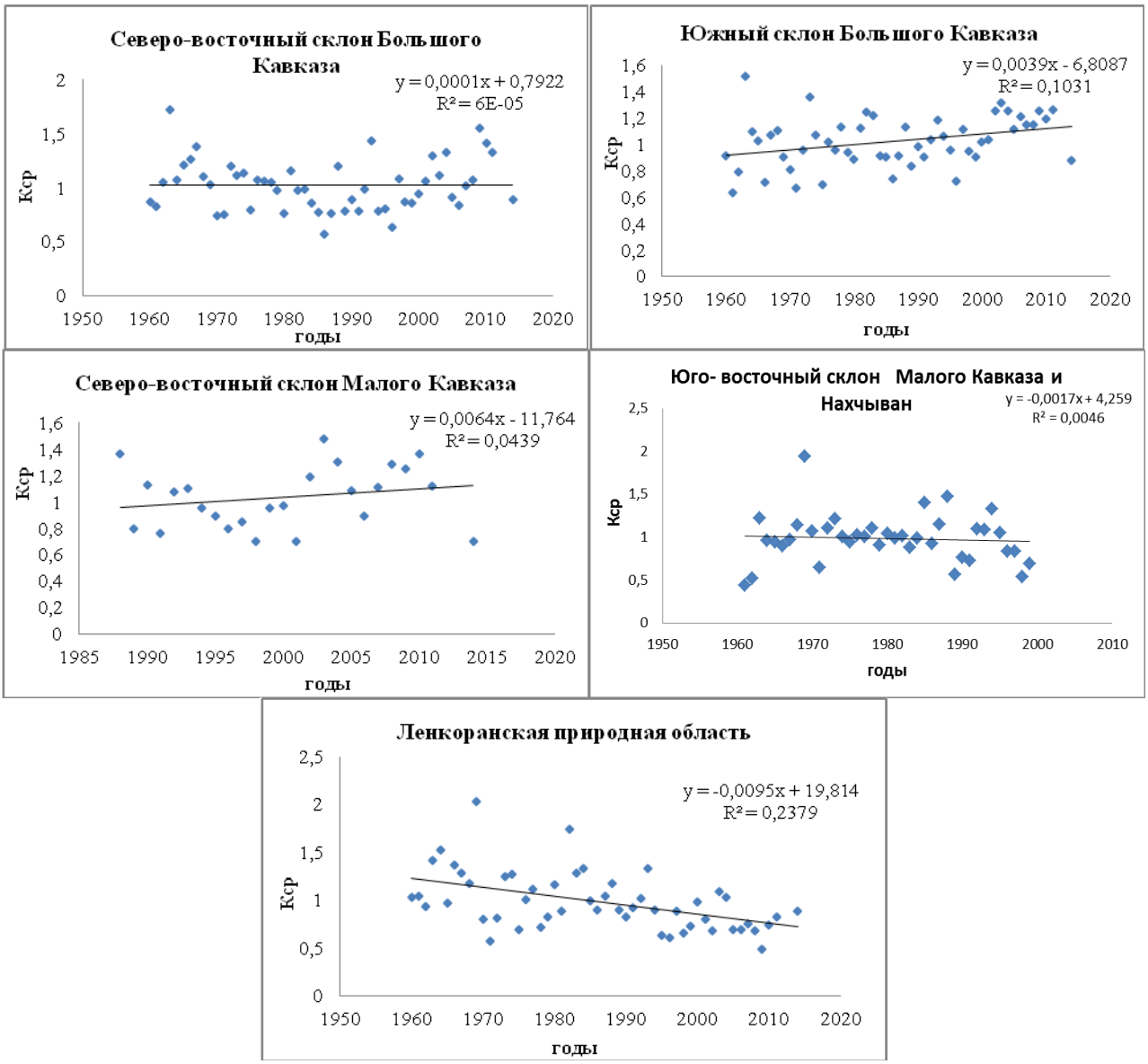

Рис.1. Линейные тренды осредненных модульных коэффициентов годового стока рек по регионам Азербайджана

Результаты оценки значимости линейных трендов осредненных модульных коэффициентов среднегодовых и максимальных расходов воды по регионам Азербайджана представлены в таблице 2.

Таблица 2

Результаты оценки значимости линейных трендов осредненных модульных коэффициентов годовых и максимальных расходов воды по регионам Азербайджана

Регионы	Период	Годовой сток				Максимальный сток			
		Знак тренда	R^2	R	$б_R$	Знак тренда	R^2	R	$б_R$
Северо-восточный склон Большого Кавказа	1962-2014	ТО	0,0001	0,008	0,139	ОТ	0,095	**0,31**	0,115

Южный склон Большого Кавказа	1961-2014	ПТ	0,1031	**0,321**	0,124	ОТ	0,072	**0,27**	0,116
Северо-Восточный склон Малого Кавказа	1958-2014	ПТ	0,0187	0,137	0,136	ОТ	0,237	**0,49**	0,105
Юго-восточный склон Малого Кавказа и Нахчыван	1960-1998	ТО	0,0046	0,068	0,161	ОТ	0,111	**0,33**	0,141
Ленкоранская природная область	1960-2014	ОТ	0,2379	**0,488**	0,106	ОТ	0,016	0,13	0,133

Примечание. *Жирным шрифтом обозначены статистически значимые коэффициенты корреляции при 5%-ом уровне значимости.*

В 2-х регионах из 5-ти, выделенных на территории Азербайджана, тренды обобщенного годового стока являются статистически значимыми. Для рек южного склона Большого Кавказа обобщенный тренд является положительным, а для Ленкоранской природной области - отрицательным.

Во всех регионах Азербайджана обобщенные линейные тренды максимального стока являются отрицательными и в 4-х из них - статистически значимыми (табл.2).

ВЫВОДЫ

1. На большей части территории Азербайджана имеет место уменьшение максимального стока рек, что большой долей вероятности вызвано современными изменениями климата.
2. Лишь в 2-х регионах тренды обобщенного годового стока являются статистически значимыми: для рек южного склона Большого Кавказа тренд положительный, а для Ленкоранской природной области - отрицательный.

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Hydrotechnics

GRAPHOANALYTICAL METHOD OF FORECASTING THE TRANSFORMATION OF ABRASION BANKS OF HIGHLAND WATER RESERVOIRS

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Annotation. The article provides the results of field and theoretical research carried out for assessing and forecasting the transformation of abrasion coasts of highland water reservoirs of Georgia depending on wave energy, erosion of rocks and duration of erosion process. The calculations are quite accurate. It has been established that the process of transformation of abrasion banks of highland water reservoirs has a general nature being only distinguished by quantitative differences.

Key words: highland water reservoirs, transformation of banks.

INTRODUCTION

The issue of forecasting the transformation of banks of highland water reservoirs is significant not only for the reservoirs being designed but also for those ones which are already existing. Georgia is a mountainous country and highland water reservoirs constructed on its territory as early as in the middle of the last century are already distinguished by significant consequences of bank transformation processes. For the time being there is no guidance on calculation of bank transformation process of **highland water reservoirs**. The present work provides a simple method of forecasting the transformation of an abrasion bank that with an adequate accuracy for practical calculations allows to evaluate the scale of this process. The work summarizes a large number of theoretical materials and observations on the banks of **highland water reservoirs of Georgia.**

MAIN PART

The study of the issue being considered for lowland water reservoirs has started since the middle of the last century when reservoirs were widely constructed throughout the world. Doctor of technical science, prof. N. Varazashvili – a pioneer and forward of the investigations for studying highland water reservoirs of Georgia – highlights their key differences for the first time (table 1).

Table 1

Average quantitative indicators of water reservoirs of various types

№ Item num-ber	Key indicators	Symbols	Unit of measure	Quantitative indicators		
				Lowland water reservoir	Piedmont reservoir	Highland water reservoirs
1	Mountain terrain indicator	"a"	-	1,0÷0,6	0,6÷0,29	0,29÷0,1
2	Morphometric feature	H^2/F	-	$9\cdot10^{-9}\div2\cdot10^{-7}$	$9\cdot10^{-7}\div2\cdot10^{-5}$	$9\cdot10^{-4}\div2\cdot10^{-3}$
3	Amplitude of water level variation	A	m	Less than 6	6÷20	More than 20
4	Volume utilization	$W_{act.}/W_{tot.}$	-	0,4÷0,6	0,5÷0,7	0÷0,95
5	Volumetric gain on 1m pressure	W_{act}/H	mln.m^3/m	500÷2000	50÷500	1,0÷50,0

6	Correlation between volume and water-surface area	W_{tot}/F	$mln.m^3/km^2$	5÷15	20÷50	50÷120
7	Correlation between flooded area and effective capacity	$S_{pond}/W_{act.}$	$km^2/mln.m^3$	150÷120	110÷50	46÷25
8	Flooded are on 1m pressure	S_{pond}/H	km^2/m	250÷65	50÷3	0,25÷0,08
9	Percent of area of shallow waters from the total water-surface area at flood-control storage level	$F_{fleetwater}/F_{tot}$	%%	20÷15	10÷6	6÷4
10	$A_в$=f(a)	$A_в$	-	0.010	0.014	0.016-0.018

Based on the calculations **four** basic types of slopes are distinguished:

- formed by sandy non-cohesive soil;
- formed by cohesive clay rocks;
- formed by half bed-rocks with relatively weak cohesion;
- formed by solid rocks of high density with tight structural coherence.

Following the investigations of various authors a new method of forecasting erosion of abrasion coasts for a certain type of water reservoir was developed (table 2).

Table 2

Forecasting groups for a certain type of water reservoir in Georgia

№	Group of water reservoir	Amplitude of water level variation (*A*), m	Movement rate of water line (V_{front}), m/day	Morphometric feature H^2/F	Mountain terrain indicator (average) "α"*)
1	Quasistationary	Less than 6 m	Up to 0,03	$8\cdot10^{-9}\div3\cdot10^{-7}$	0,84
2	Unstable	6÷20	0,03÷0,08	$3\cdot10^{-7}\div3\cdot10^{-5}$	0,57
3	Average drawdown level	20÷50	0,08÷0,50	$3\cdot10^{-5}\div3\cdot10^{-4}$	0,36
4	Quick-operating	50÷100	0,50÷1,5	$3\cdot10^{-4}\div8\cdot10^{-3}$	0,27
5	Intensive-operating	More than 100	More than 1,5	Less than $8\cdot10^{-3}$	0,12

*) The value of mountain terrain ratio "a" (table 2) depends on the capacity (W), water surface area (F), depth (H) of water reservoir (Fig.1.)

It is widely accepted that erosion of abrasion coasts of highland water reservoirs depends on the following factors: wave energy at the coast of the certain area, level regime, capability of the earth material of the coast to be exposed to erosion as well as duration of erosion.

There are two main positions that stick out: - with the level movement when an amplitude is no more than 6,0m; and, with the level movement when an amplitude is more than 6,0m;

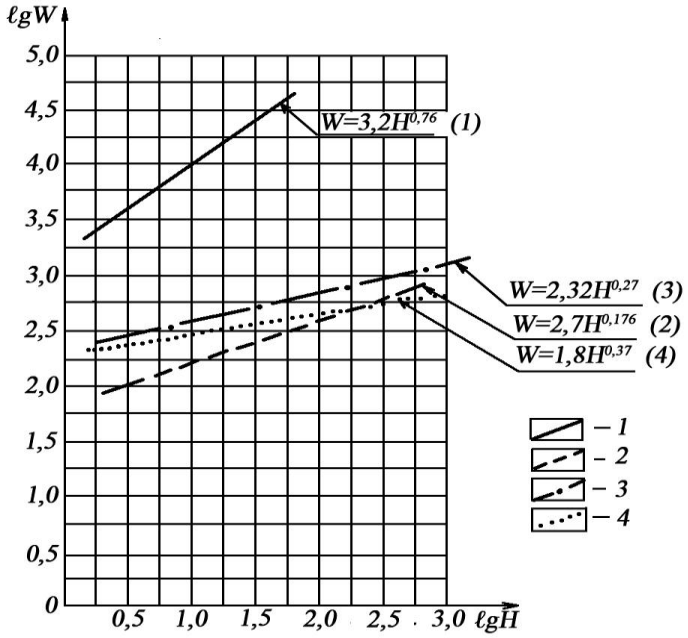

Fig. 1. Dependence of water reservoir capacity *(W)* on the depth of water admission *(H)* when the terrain indicator *"a"* and *"K_w"* has different values. 1. – Volume curve for lowland water reservoirs (a = 0,76, K_W = 3,2); 2. The same for piedmont water reservoirs (a = 0,37, K_W = 2,7); 3. The same for mountain water reservoirs (a = 0,27, K_W = 2,32); 4 – the same for high-mountain water reservoirs (a = 0,176, K_W = 1,8).

In view of the first position of the calculation (when the variation of water level is no more than 6,0m) a design level is considered to be the level of water with no less than 60% occurrence. With a view to forecasting the transformation of abrasion coasts an energetic method is used during which a level of destruction is determined from the following formula, [Kachugin E.G., 1975]:

$$Q = EK_{\text{eros}}K_{б}t^{в}, \qquad (1)$$

where Q – is a capacity of erodible earth material along the 1m length of the coast, in m^3; E – is a long-term annual average wave energy occurring on 1m length coast, tm.; K_{eros} – is a coefficient of erosion of rocks in m^3 on tm. of wave action; $K_{б}$ – is a coefficient considering a bank elevation; t – is a number of years of erosion; в – is a degree value. Values of coefficients (K_{eros}) and ($K_{б}$) are provided in table 3.

Table 3

Values of coefficients K_{eros} and $K_{б}$

№№	Class of geological material	K_{eros}, m^3/ever.m	$K_{б}$
1	Very easily erodible earth materials	0,0065÷0,003	0,03
2	Easily erodible earth materials (sand, loam soil, sandy loam)	0,003÷0,001	0,035
3	Earth materials of average erodibility (heavy loam, lake clay, etc.)	0,001÷0,0005	0,04
4	Hardly erodible earth materials (gravel, sandstone, marine clay)	Less than 0,0005	0,05

The value of indicator "*в*" ranges between 0,45 and 0,95. An average value of "*в*" equals to 0,7. In the case of alluvial coarse sand with gravel and pebble *в* = 0,5; in the case of moderately coarse sands with gravel *в* = 0,6; in the case of bouldery glacial clay loam *в* = 0,7; in the case of alluvial fine and dust sand, cover loessoid sandy loam and clay loam *в* = 0,8; in case of cover loamy light sand *в* = 0,9. Shapes of

erosion are delineated on the engineering-geological profile considering upper and lower borders of erosion.

Design levels are considered to be normal (upper) headwater elevation (FRL) and lower level of maximum drawdown (MRL). Major elements of the calculation are: - erosion boundaries – upper (a_1) and lower (a_2); – outlines of abrasion bench lands and their change over time, an average angle of safe cut m = ctgα; – timeframe and duration of separate stages of the process.

A projected profile is constructed along with the movement of water level in the reservoir for a design elevation. On each design elevation a profile produced during the previous cycle of abrasion is considered to be initial. The final (integral) profile of erosion is constructed through the integration of its private changes.

In view of the second position of the calculation (when the variation of water level is more than 6,0m) for forecasting the transformation of abrasion coasts of mountain water reservoirs a method of grapho-analytical construction is used. When the movement of water level in the water reservoir is variable and soil is homogenous, the ultimate width (S) of erosion is determined in the following order (fig.2):

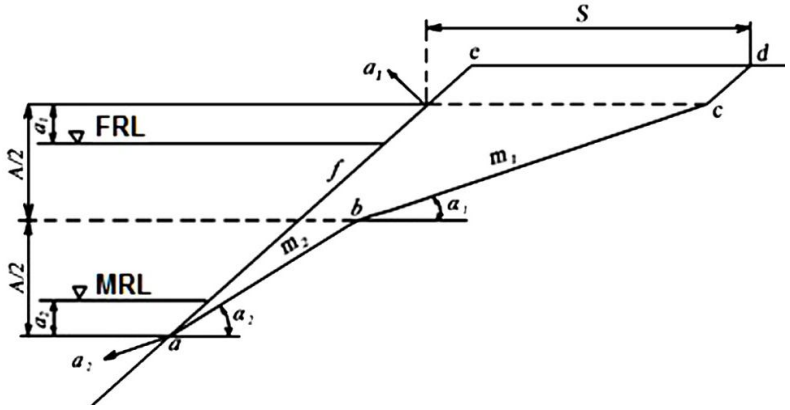

Fig. 2. Determination of ultimate width of erosion of rocks from homogenous soil when the water level of reservoir is variable

- **Upper erosion boundary** according to the slope profile (a_1) on abrasion coasts depends on the height of wave setup ($h_{\text{run up}}$), wave ($h_{\text{wave setup.}}$) and wind ($h_{\text{wind setup.}}$) setups aslope:

$$a_1 = h_{\text{run up}} + h_{\text{wave setup.}} + h_{\text{wind setup,}} \text{ m,} \tag{2}$$

where, – $h_{\text{run up}} = 1{,}1h_{\text{deep,1\%}} \cdot k_{\text{r}} \cdot k_{\text{run}}$, m [I.Iordanishvili, 2012]; – $h_{\text{wave setup.}} = 0{,}5h_{deep,1\%}$; – $h_{\text{wind setup.}} = 0{,}001h_{\text{deep,1\%,}}$ m – value of wind setup on mountain water reservoirs in the conditions of short length of wave fetch (D ≤ 10 km); – $h_{\text{wind setup.}} = 0{,}001h_{\text{deep,1\%,}}$ m and for practical calculations its value can be neglected; – $h_{\text{deep,1\%}}$, $\lambda_{\text{deep,1\%}}$ (m) – the height and length of waves in deep water of 1% occurrence, in case of absence of statistical data $h_{\text{deep,1\%}}$ is calculated according to dependence - $h_{\text{deep.1\%}} = \bar{h}_{\text{deep.}} \cdot P_{1\%}$, where $\bar{h}_{\text{deep.}} = A_b \cdot V_c^{1,2} \cdot D^{0,4}$ (m);

– design curves $\bar{h}_{\text{deep.}} = f\left(A_b, V_c, D\right)$ provided on fig. 3: $A_b = 0{,}010 \div 0{,}018$, depending on the terrain indicator (a) provided in table 1; V_c – wind velocity m/sec; D – wave fetch (km); $P_{1\%} = 1{,}1$ – coefficient depending on o1% occurrence of wave;

– (k_{run}) – dependence from the angel of slope to the elevation ($\alpha°$) equals to: $k_{\text{run}} = 1{,}2$ when $\alpha° = 18° \div 6°$; $k_{\text{run}} = 0{,}5$ when $\alpha° = 5° \div 3°$; $k_{\text{run}} > 2$ when $\alpha° < 13°$;

– (k_{r}) – coefficient of surface roughness of bank side (Table 4).

- **Erosion lower boundary** (a_2) is determined depending on a type of soil:

for non-cohesive soils:

$$a_2 = 0{,}08\lambda \cdot arcsh\left[\frac{0{,}16\gamma\, n_u h^2}{m_p \gamma_1 d_{mean} \cdot \lambda}\right], \text{ m} \tag{3}$$

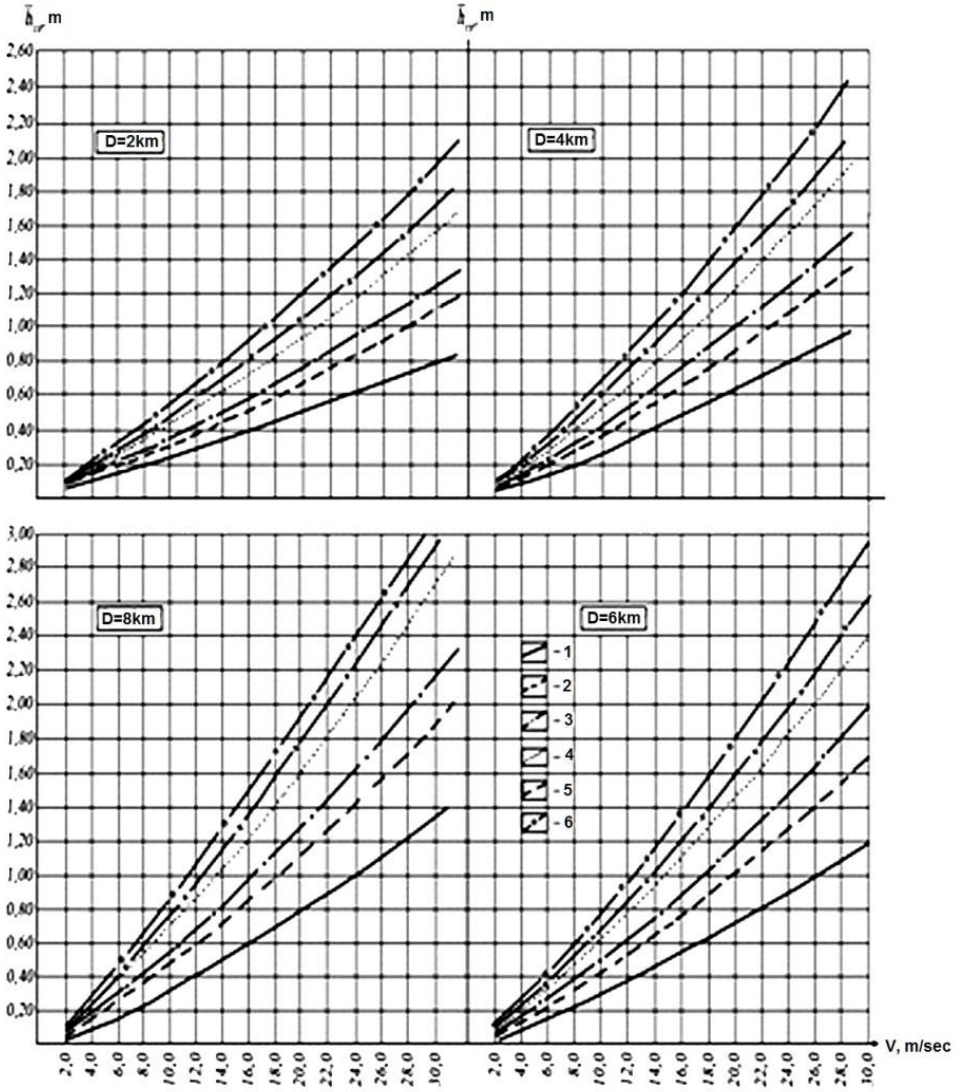

Fig. 3. Dependence of average height of wave ($\overline{h}_{\text{deep.}}$) from wind velocity (Vc), acceleration distance (D) when coefficient Ab has various values:

$$\overline{h}_{\text{deep.}} = f\left(A_b, V_c, D\right)$$

(1 – Ab = 0,01; 2 – Ab = 0,014; 3 – Ab = 0,016; 4 – Ab = 0,020; 5 – Ab = 0,022; 6 – Ab = 0,025)

Table 4

Coefficient of surface roughness (k_r) of a slope

№	Type of slope protection	Coefficient of roughness, k_r	Coefficient of roughness according to Gangilie and Kutter, n	Lineal roughness, ε, mm
1	Concrete plates	1,0÷0,95	≤0,014	<1,0
2	Clay-gravel slope	0,94÷0,90	0,015÷0,020	1,0÷1,1
3	Talus of rounded stone	0,89÷0,76	0,020÷0,025	1,1÷6,0
4	Talus of crushed stone	0,75÷0,71	0,025÷0,030	6,1÷50,0
5	Concrete bricking	0,71÷0,5	≥0,030	>50,0

for cohesive soils:

$$a_2 = 0{,}08\lambda \cdot arcsh\left[\frac{0{,}825\gamma\, n_u h^2}{m_p \lambda\left(\gamma_1 d_{mean} + 1{,}25K_0 C_y^H\right)}\right], \text{m} \qquad (4)$$

where γ_1 and γ – is relative weights of soil and water; n_u – is an overloading ratio, $n_u = \frac{V'_{\Delta\max}}{V'_{\Delta}}$, for wavy flows, n_u=0,4; m_p – coefficient of the conditions of work, (Table 5); d_{mean} – average diameter of soil, in mm; K_0 – coefficient of uniformity of clay soils (on average $K_0 = 0{,}4$, Mirtskhulava T.E. 1974); h and λ – height and length of waves in control station; C – design soil adhesion for clay soil C = 0,01÷0,06; C_y^H – standard endurance strength of clay soil: $C_y^H = 0{,}035C$, $C_y^H = 0{,}00035 \div 0{,}0021$.

Table 5

Coefficient of the conditions of work (m_p)

Cohesive soils **Conditions of work**	m_p	**Non-cohesive soils** **Conditions of work**	m_p
Existence of deposits in a colloidal state more than o,1kg/m^3	1,30	Slopes formed by sand $d = 0{,}25 \div 0{,}10$ mm	1,30
		The same, where $d = 1{,}0 \div 3{,}0$ mm	1,50
Existence of deposits of coarse grain	0,75	Slopes formed by gravel $d = 3{,}0 \div 10$ mm	1,40
Bottom and slopes are occupied by vegetation	1,10	The same, where $d = 10 \div 30$ mm	1,20
Moisturizing when water level is varying in the areas with dry climate	0,20	Slopes formed by pebbels	1,10
The same in the areas with humid climate	0,60	Rubble slope	1,00

The calculation (a_2) for cohesive soils according to the formula (4) is facilitated by using fig.4.

A predicted slope when a water level varies during the movement and soil is homogenous is constructed in the following way (Fig.2.): straight c ctg$\alpha = m_2$ found in (Table 6) for the given soil, is drawn from point (a) to point (b) on the horizontal line dividing the vertical distance in halves between the design levels of normal headwater elevation (FRL) and lower level of maximum drawdown (MRL). Straight ctg$\alpha = m_1$, corresponding with (h_1), is drawn from point (*b*) to point (*c*), straight (*cd*) is drawn in parallel with a slope (*ef*) and the width of coast transformation is determined by horizontal distance (S).

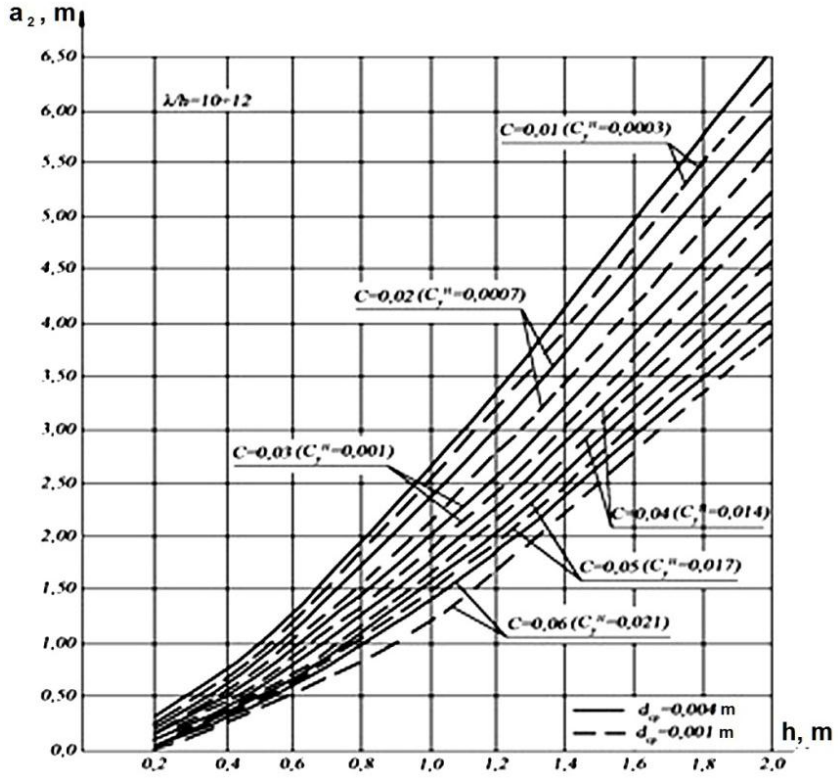

Fig.4. Change in size of the erosion lower boundary of cohesive soils (a_2) depending on: wave height (h), coherence of coast soils (C), soil diameter (d_{mean}) (1 – d_{mean} = 0,04 m, 2 – d_{mean} = 0,01 m) and on relative flatness of waves λ/h = 10÷12.

Steepness of **overwater slopes** is taken to be equal to depositional gradient of soil in water-saturated condition while steepness of **underwater slopes** is taken by comparison with analogues (table 6).

Table 6

Angles ($\alpha°$) of safe slopes of deposits

№№	Deposits	Conditions	
		Overwater	Underwater
1	Gravel-pebble	30° (m = ctg$\alpha°$ = 1,73)	25° (m = ctg$\alpha°$ = 2,1)
2	Coarse and fine sand	26°÷28° (m = ctg$\alpha°$ = 2,1÷1,9)	15°÷20° (m = ctg$\alpha°$ = 3,7÷2,7)
3	Sand clay and loam soil	15°÷23° (m = ctg$\alpha°$ = 3,7÷2,4)	6°÷14° (m = ctg$\alpha°$ = 9,5÷1,1)
4	Clay	>20°	5°÷10°

A number of years (T_{max}) during which a final transformation of coast will occur equals to:

$$T_{\max} = 2\frac{S_k}{V_{\max}},\ \text{year}, \tag{5}$$

where, $V_{\max}$ – maximum velocity of coast erosion in m/annually (Fig.5).

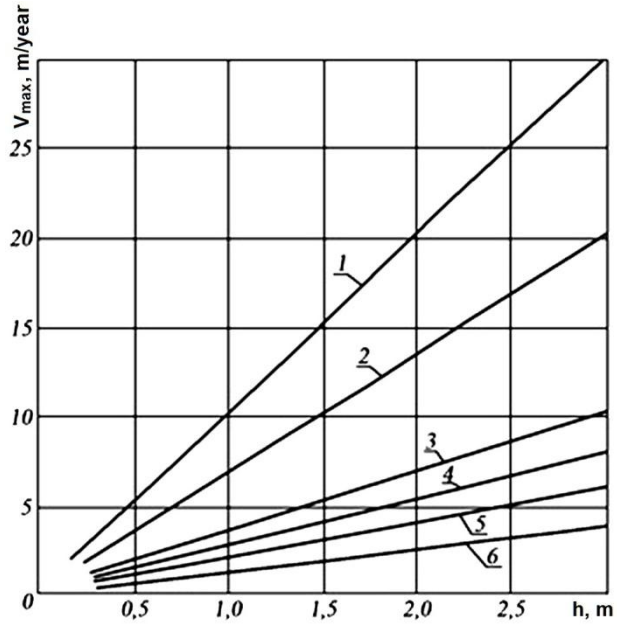

Fig.5. Diagram $V_m = f(h)$

1 – loess; 2 – fine sand; 3 – medium sand; 4 – loam soil; 5 – clay; 6 – coarse sand with boulders

In the preliminary calculations the connection between the upper boundary of erodible slope formed by **loam soil** (a_1) and a wave height (h) is given by $a_1 \approx h$; and, the lower boundary of erosion is given by – $a_2 \approx 1{,}3h$.

An example of graphoanalytical construction of an abrasion bank profile of the Tbilisi water reservoir is given on table 7.

Table 7

Calculation of upper (a_1) and lower (a_2) erosion boundaries of a coast of the Tbilisi water reservoir (Gross section 1) (λ/h = 10, d_{mean} = 0,004 m, C = 0,06)

A_b (Table 1)	Maximum length of wave fetch under NW wind direction, D, km	Wind velocity under NW direction, $V_{C,max}$ m/sec	$\bar{h}_{deep}$, Fig. 3	$P_{1\%}$	$h_{deep,1\%}$	K_r (Table 4)	K_{run} when, α=12°	$h_{run\ up}$ m	$h_{wav.set.}$ m	$h_{wind.set.}$ m	a_1 (f-la 2), m	a_2 (Fig. 4), m	Angle of natural grade (overwater) a^0	Angle of natural grade (underwater) α°
0,014	3,5	37,0	1,4	1,1	1,54	0,9	1,2	1,83	0,77	0,001	2,6	2,7	20°	10°

An extent of erosion in diagram form is determined as an area confined within the line of an initial slope as well as the line of a predicted profile (fig.8).

CONCLUSIONS

Key distinctive features of mountain water reservoirs: moderate-size water surface; significant depths (up to 200m) and drawdown level (20÷100 m) and intensity of water level movement; variability of geomorphological factors of coast slopes; producing significant wind velocity (up to 40m/sec); small lengths of wave fetch and significant steepness of coast slopes (15°÷45°).

With a view to forecasting the transformation of abrasion coasts of mountain water reservoirs it is reasonable to use a graphoanalytical method of construction. However, forecasts are provisional they are quite useful for practical calculations. Only in a crucial situation for the purposes of correcting forecasts, the calculations can be made more precise based on quite serious investigations according to the results of hydrological and engineering-geological observations.

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Water management

WATER RESOURCE MONITORING IN THE RECLAIMED LANDS

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Annotation: At the present the effective agricultural production and the agricultural imports ensuring is possible on the basis of the land reclamation development taking into account both reconstruction of the existing and construction of a new land reclamation projects.

As a result of the research, a technology for monitoring of the reclaimed lands has been developed, taking into account the improved monitoring principles, modern methods of collecting, processing, storing and transferring of information; the use of GIS technologies. Recommended new instruments and equipment for observation can provide the maintenance of the hydrogeological, hydrological and ecological observations in an autonomous automatic mode. To analyze and systematize monitoring data, it is recommended to use the ArcGis software system.

Key words*:* water resource, land reclamation, environmental monitoring, groundwater, surface water bodies, soils, ameliorative systems.

At the present the effective agricultural production and the agricultural imports ensuring is possible on the basis of the land reclamation development taking into account both reconstruction of the existing and construction of a new land reclamation projects.

Currently, the area of reclaimed agricultural land in the Russian Federation is 9.1 million hectares, including 4.3 million hectares of irrigated land, and 4.8 million hectares of drained land. Unfortunately, a considerable part of the reclaimed lands (over 3.5 million hectares) is in unsatisfactory conditions now. More than half of the irrigation systems (2.4 million hectares) require reconstruction and technical re-equipment to improve safe operation and other activities. To provide normalization of the situation, the Federal Targeting Program "Development of Land Reclamation of Agricultural Land in Russia for 2014-2020"

(Approved by resolution of the Government of the Russian Federation of October 12, 2013 N 922) has been developed.

The State Ecological Monitoring of agricultural land including reclaimed land) is the main source of information for the decision-making at the development of land reclamation as well as construction and reconstruction of land reclamation systems. Researches and works on the development of monitoring of the reclaimed land are being carried out in VNIIGIM named after A.N. Kostyakov, long term works in this direction having been carried out at the Institute during 1970s-1980s. (D.M. Kats, N.I. Parfenova, V.E Raynin). In the past decades, significant changes in the economy as well as in the reclaimed areas of agriculture occurred. Tools and equipment were actively developed in the fields of observing, collecting, storing and processing of the received information. In this regard, it is necessary to improve and to update the methods for the conducting of the environmental monitoring in the reclaimed lands.

The objects of the environmental monitoring are: groundwater, surface water bodies, soils, and irrigation and drainage systems. When carrying out environmental monitoring of reclaimed lands, it is necessary to use data (if available) for monitoring soil fertility of agricultural land held by state centers and

agrochemical stations, as well as monitoring of water bodies, subsoil conditions, and hydro-technical monitoring.

The main objectives of environmental monitoring in drained lands are [3,4,5]:

- moisture storage and the humidity in the root layer of the soil during the growing season, including the optimal time of the additional watering, or excess water removal;

In the case of sub-surface irrigation:

- the pattern of the atmospheric precipitation;
- capillary feeding of the aeration zone;
- total evaporation (water consumption) of the cultivated crops;
- drainage flow, including optimal time and water discharges from the drained areas, including the period of sub-irrigation;
- the pattern of the groundwater levels;
- the quality of surface, groundwater and drainage water for determining the degree of their contamination with mineral fertilizers and pesticides to determine the possibility of drainage flow re-using;

In the case of surface irrigation:

- temperature characteristics of the soils;
- the amount of run-off, its change in time and distribution over the territory;
- the status of drainage systems and hydraulic structures, including the development of erosion of banks of the canals, their overgrowing and silting, deflation and subsidence of peat, etc.;

-estimation of the volume and quality of water used for drinking water supply to the population and irrigation within the land reclamation systems;

- estimation of the volume and quality of waste and drainage flow;
- estimation of the drainage efficiency and other ameliorative measures as well the possibility of drainage flow re-use for irrigation purposes;

In drained irrigated lands:

- the hydrological pattern of the surface water bodies (which are used for water supply, irrigation, drainage flow discharge, etc.);
- the pattern of the underground water and the water in the pressure (sub-pressure) aquifers;
- the degree, character and dynamics of soil salinity, the complexity of soils, changes in their water-physical properties;
- factors determining the ameliorative status of the irrigated lands;

At the final stages of the monitoring in the irrigation and drainage zone:

-estimation of the ameliorative status of the irrigated and drained lands;

-conducting of the special studies in the experimental plots to determine the parameters of the saturated and unsaturated zone for the hydro-geochemical and hydro-geodynamic forecasts of groundwater, water and salt pattern of the aeration zone, soils; to perform organization of the observations of the filtration losses from the canals and filtration losses in the fields; to provide efficient operation of the collector-drainage network, etc.

- flood control in the populated areas as well as the forecast of the emergency of any unfavorable engineering and geological processes;
- the forecast of changes in the groundwater pattern in the hydro-ameliorative systems and adjacent lands; the status of the water bodies used for domestic and drinking water supply, irrigation, water supply for the livestock farms, discharge of collector-drainage water (if necessary - with the involvement of research and design institutes of the Russian Academy of Science and the Ministry of Agriculture of the Russian Federation);

- estimation of the reliability of the soil-hydrogeological forecasts and land reclamation (if necessary - with the involvement of research and design institutes of the Russian Academy of Sciences and the Ministry of Agriculture of the Russian Federation);

-development of the proposals for the prevention or elimination of adverse ecological processes in the agricultural and the adjoining lands, as well as in the water bodies;

- providing the necessary information for the operational management in the reclaimed lands;

- development and annual submission of the data for the Register of the Reclamation Systems and the Reclaimed Lands, preparation of targeting programs in the field of land reclamation, reconstruction of irrigation and drainage systems to ensure the fertility of soils of agricultural land at the Federal, regional, district and economic levels.

As a result of the research, a technology for monitoring of the reclaimed lands has been developed, taking into account the improved monitoring principles, modern methods of collecting, processing, storing and transferring of information; the use of GIS technologies. Recommended new instruments and equipment for observation can provide the maintenance of the hydrogeological, hydrological and ecological observations in an autonomous automatic mode. To analyze and systematize monitoring data, it is recommended to use the ArcGis software system.

The technology is a system of stages, processes, methods and software and hardware that determine the procedure for the reclaimed land monitoring.

The implementation of the technology ensures the collection of information on the status of the reclaimed lands as well as their changes, the processing of information and the provision of collected data in the form of an comprehensive model (a set of sub-models such as cartographic, mathematical etc.) which is sufficient to estimate the ecological and ameliorative conditions, to forecast dynamics and to make management decisions on the land reclamation status in order to minimize environmental risks, to maintain a favorable ecological conditions, to provide efficient use of water and land resources and to get high yield of agricultural crops.

The technology includes the following stages: the determination of the object of research, the setting of works, the monitoring program, the identification of funding sources for monitoring, the organization of observations, the organization of special observations (pilot production plots), the observation, the establishment of a primary information bank, the creation of graphical models reflecting the current status of the reclaimed lands, the estimation of the status of reclaimed lands and the risks of the development of the unfavorable processes, the adoption of the operational decisions to reduce the environmental risks, scenario studies of the dynamics of the development of the land reclamation status using the mathematical models, the choice of planned measures to improve the land reclamation status; information transfer to the operation service, federal executive bodies, interested parties. At the each stage processes and algorithms of the necessary actions, methods of conducting work, actual software and technical support are determined depending on the monitoring object (groundwater, soil, surface water bodies, land reclamation systems),

The novelty of the research is the orientation of developments on the technology of monitoring in the reclaimed lands basing on the wide application of GIS-techniques and software products. To analyze and systematize monitoring data, the ArcGis software system of the Agricultural Land Monitoring System in the Ministry of Agriculture of Russia is used.

To adapt the use of ArcGIS support for monitoring of the reclaimed lands the following works have been done:

• a draft database structure for storing information on environmental and land reclamation indicators was created;

• geo-information layers have been created on observation points and reclamation objects in the Ryazan region in accordance with the list;

• a list of visualized input information based on the data structure and tools of the geo-information environment of the system was developed;

• additional tools have been created to work with input databases on natural indicators;

• decision support services with information on the environmental status of facilities have been created in case of a risk of the reclaimed lands deterioration.

In the addition to the database on the development of the adopted reporting format in the system of the Ministry of Agriculture of Russia on the environmental indicators of reclaimed lands status were given.

Studies have shown that the economic efficiency of the reclaimed land monitoring can be determined through the gross income of the agricultural production in the cadastral valuation of land. The procedure of the reclaimed land cadastral value determining is considered, taking into account the monitoring data. The estimation of the gross income of the agricultural production on the basis of the monitoring data of the reclaimed lands under their current condition as well as the restoration of a favorable land reclamation status make it possible to determine the economic efficiency of the investments into the restoration of the land reclamation fund.

In accordance with the completed studies, the economic part of the reporting forms which is submitted to the Department of the Land Reclamation and Agricultural Water Supply was proposed and the accepted form of the estimation of the planned yields should be changed. This will make it possible to increase the validity of the proposals of the Department in the development of Land Reclamation which will increase the Productivity of Agricultural Land.

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Агромелиорация

УРЕГУЛИРОВАНИЕ ПРОЦЕССОВ ФОРМИРОВАНИЯ АГРОИРРИГАЦИОННЫХ ЛАНДШАФТОВ АЗЕРБАЙДЖАНСКОЙ РЕСПУБЛИКИ

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Аннотация. В различных естественных ландшафтах Азербайджана планомерное урегулирование создания агроирригационных, садово-плантационных ландшафтов имеет огромное значение. Однока до сих пор ряд вопросы закономерностей формирования агроирригационных ландшафтов практически не изучены. Это относится, в основном, к орошаемым регионам республики, где во многих местах мелиоративная обстановка неблагоприятна, и без учета этой обстановки невозможно рациональное планирование формирования различных антропогенных ландшафтов.

Ключевые слова: агроирригационные ландшафты, рациональное планирование, мелиорация, агротехника, рентгенодифрактометрический анализ, дифрактограмма.

Agromelioration

THE PECULIARITIES OF THE REGULATION OF THE FUNCTIONING PROCESSES OF AGROIIRRIGATION LANDSCAPES OF THE AZERBAIJAN REPUBLIC

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Annotation. In various natural landscapes of Azerbaijan creating of systematic regulation of the agro-irrigational, cultivated-plantational landscapes have a tremendous significance. Many questions of the appropriateness of the formation, functioning, regulation of the agro-irrigational landscapes in various regions of Azerbaijan have already been practically learned. It mainly concerns to the irrigational regions of the republic, where in most areas land-reclamation situation is unfavourable, without which it is impossible a rational planning of the formation of various anthropogenic landscapes.

Key words: agroirrigation landscapes, rational planing, meliorative, agrotechnic, rentgenodifraktometrical analysis, difraktogramma.

ВВЕДЕНИЕ

Урегулирование агроирригационных ландшафтов – длительный и очень сложный процесс, охватывающий большой комплекс мероприятий, в том числе мелиоративных, инженерных, агротехнических, экологических, санитарно-гигиенических и т.д. Многие вопросы формирования, функционирования и урегулирования агроирригационных ландшафтов в различных экологических условиях Азербайджана не изучены.

ОСНОВНАЯ ЧАСТЬ

В результате анализа гумуса, механического состава, водно-физических и химических свойств различных почв, а также грунтовых и речных вод Кура-Аразской, Самур-Девечинской, Ленкоранской, Гусарской наклонной равнины установлены основные тенденции формирования и развития агроирригационных, богарно-земледельческих, селитебно-садовых ландшафтов и их связи с окружающими практически неизменными ландшафтами.

На основе рентгено-дифрактометрического анализа рассмотрено влияние мутных вод рек на формирование агроирригационных ландшафтов предгорных равнинах Юго-Восточного Кавказа в пределах Азербайджанской Республики [2].

В аридных условиях Азербайджана формирование агроирригационных ландшафтов во многом зависит от степени искусственного увлажнения. Именно этот фактор определяет основные тенденции эволюции оазисных ландшафтов. За последние 20 лет площадь интенсивно используемых ландшафтов Кура-Араксинской низменности увеличилась в 2,5 раза, соответственно площадь нерегулярно используемых ландшафтов значительно уменьшиласъ.

Оросительная вода, увеличивая влажность почвы и принося с собой растворимые и взвешенные вещества, оказывает существенное влияние на характер почвенных процессов и способствует образованию агроирригационных (культурно-поливных) ландшафтов [1].

Впервые с помощью рентгенодифрактометрического метода всесторонне изучен минерально-кристаллический состав взвешенных наносов оросительных вод Гусарской наклонной равнины и Самур-Девечинской низменности, а также их влияние на формирование агроирригационных ландшафтов [4]. В данной работе с помощью указанного метода анализируются агроирригационные ландшафты предгорных равнин Юго-Восточного Кавказа.

Для анализа образцы воды и взвешенные наносы были взяты из р. Самур, Турианчай, Геокчай, Ахсу, Гусарчай, Гарачай, Гудиалчай, Агчай, Вельвеличай и др, а также из 3-х постов Самур-Абшеронской оросительной системы. Анализы проводились в Аналитическом центре Института геологии НАН Азербайджана в рентген-аппарате ДРОП-II. Для каждой реки составлены отдельные дифрактограммы [2], где указаны цифрами расстояния между плоскостями атомов кристаллической решетки минералов (рисунки 1–2).

Установлено, что в дифрактограмме р. Вельвеличая преобладают кальций ($CaCO_3$), кварц (SiO_2), полевой шпад, глина, аморфные структуры, а в р. Гусарчайе Ca, Mn, Mg, CO_3, также кутнагорит, кальцион и другие минералы. Указанные соотношения минералов благоприятно влияют на формирование зерновых, огородово-бахчевых и других агроирригационных комплексов. Поэтому в этих районах целесообразно увеличить территории данных комплексов.

В дифрактограмме р Гудиалчая содержатся селикатные и карбонатные минералы, особенно кварцит, кальций, полевой шпат, и т.д. Они очень положительно влияют на производительность виноградно-плантационных и орехово-плантационных комплексов. Однако, до сих пор в этих районах преобладают зерновые, огородово-бахчевые агроирригационные комплексы.

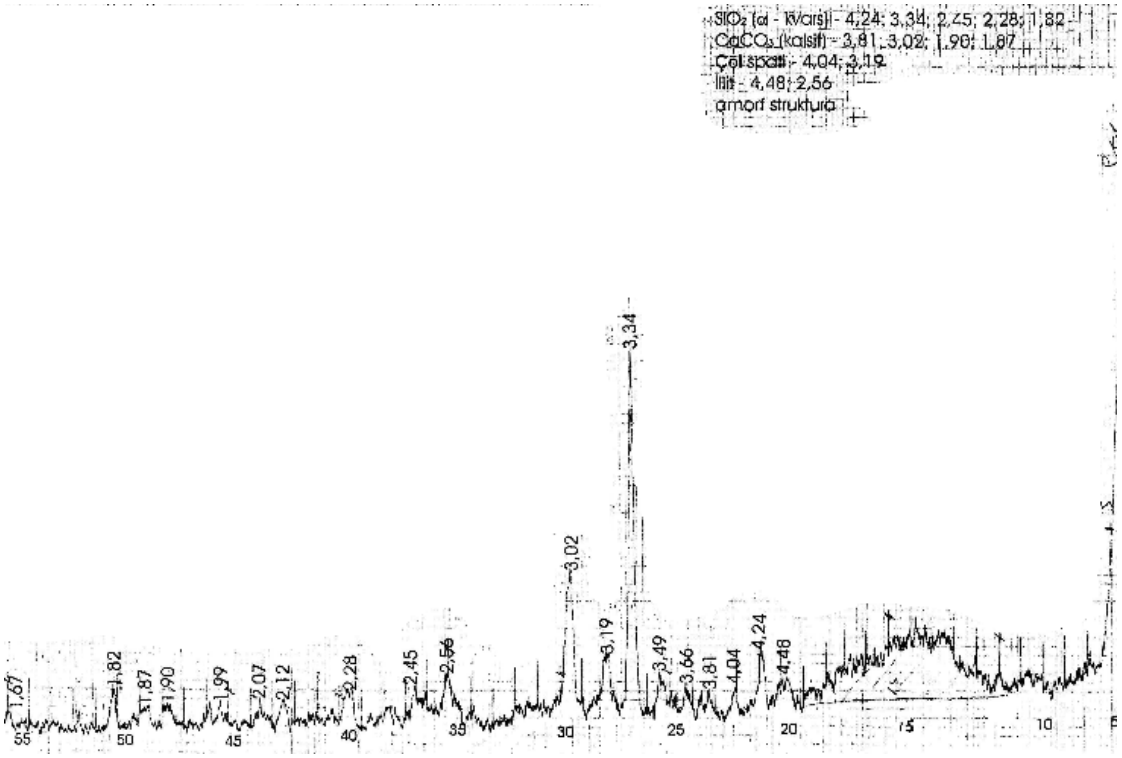

Рис. 1. Дифрактограмма р. Гудиалчая

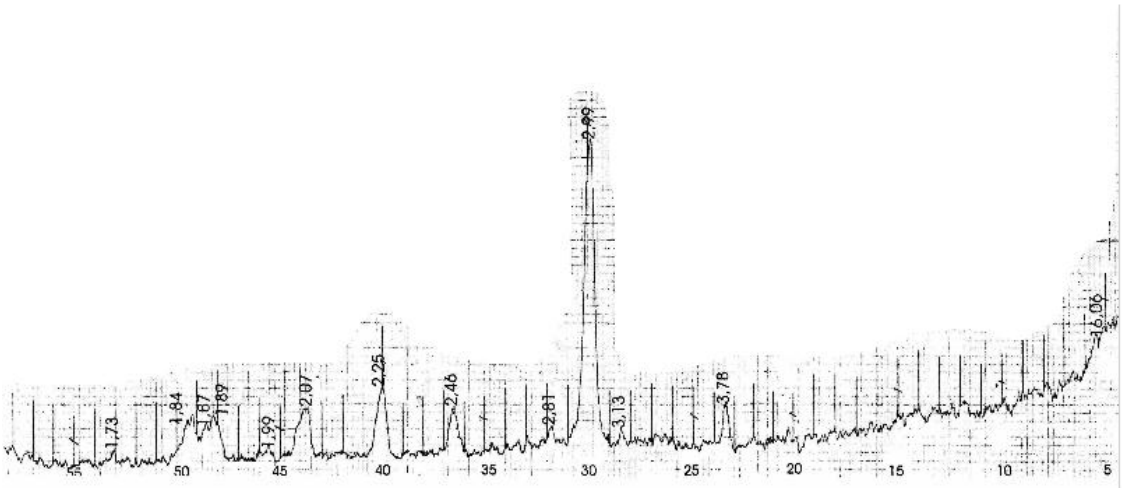

Рис. 2. Дифрактограмма р. Гусарчая

Самур-Абшеронский канал характеризуется наиболее сложными дифрактограммами. Воды этих источников слабо минерализированны (0,25–0,48 г/л), преимущественно гидрокарбонатные, относительно богаты кальцием. В минералогическом составе преобладают мусковит, кварцит, каолинит, кальций, аморфные структуры (Al_2O_3, Si_2O_5) и др. Поэтому в данном районе почвообразующие породы состоят из аллювиально-делювиальных карбонатных суглинков, подстилаемыми на глубине 2,5–3,0 м, аллювиально-пролювиальными мелкоземисто-галечниковыми отложениями.

Таблица 1

Состав речных вод Северо-Восточного Кавказа (Анализы проводилась в Институте геологии НАН Азербайджана).

№	Водные объекты	Мг/ л					
		Валовой азот	$CaCO_3$	P_2O_5	K_2O	P_h	Гумус
1	Самур-Абшеронский кан.	0,58	120	0,68	32,4	7,01	0,21
2	р. Гусарчай	0,82	850	0,38	182,5	7,60	0,06
3	р. Гудиалчай	0,56	180	0,42	129,5	7,30	0,04
4	р. Гарачай	0,28	182	0,42	125,6	6,74	0,16
5	р. Агчай	0,51	886	0,34	31,4	7,20	0,02
6	р. Алпанчай	0,84	170	0,32	28,5	7,14	0,24
7	р. Вельвеличай	0,39	744	0,75	134,4	6,80	0,37
8	р. Джагаджугчай	0,52	178	0,40	130	7,20	0,02
9	р. Шабранчай	0,38	740	0,70	130,5	6,70	0,35

Мутность поливных вод р. Гусарчая, Гудиалчая, Гарачая, Самура колеблется в пределах 2000–4000 г/м^3, а Атачая, Гилгильчая, Шабранчая, Тахтакерпучая – 400–1000 г/м^3 в год.

Ирригационные наносы данного района достаточно богаты питательными элементами и минералами. По нашим анализам они содержат в среднем 0,21–0,34 мг/л гумуса (или 1,25–1,85%), 0,28–0,34 мг/л валового азота (или 0,08–0,12%) 129–182 мг/л обменного калия.

Нами рассчитаны количества питательных элементов во взвешенных наносах, поступающие на орошаемую территорию Самур-Девечинской низменности. На орошаемое поле поступает в среднем 280–350 кг/га гумуса, в том числе 0,96 кг/га воднорастворимого гумуса, валового азота 18–24 кг/га, подвижного фосфора 0,30–0,53 кг/га, карбонатов 900–1100 кг/га, обменного калия 6,50–7,76 кг/га (таблица 1).

На орошаемые поля с поливными водами ежегодно поступают 2,35–2,80 т/га солей, преимущественно гидрокарбонатно-сульфатного состава [2].

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Environmental protection

NEW NON-CONVENTIONAL WATERPROOFING MATERIALS

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Annotation. Given article describes the content, behavior, fabrication method and using of new non-conventional waterproofing materials**.**

Key words: woven and nonwoven materials, bentonite, polyelectrolyte, steep, waterproofing.

Water proofing is one of the basic elements of all constructions. In spite of large number of existing ones, it is still a very difficult task to find new, easy to process and cheap waterproofing materials.

As a result of the study, we have developed a new, easy to make and cheap waterproofing on a base of woven and nonwoven materials [1,2].

Fabrication method is easy and consists from the following operations:

- Preparation of 10% aqueous suspension of bentonite;
- Mixing of the suspension of bentonite and the polyelectrolyte solution to obtain a homogeneous mass (working mixture);
- Impregnation with a working mixture of any woven or non-woven material and drying at any temperature up to 1000C (700 ml of solution per 1 m^2 of a basis with a thickness of 1 cm).

The optimal thickness of base material is providing an effective waterproofing of 0.5 3.0 cm.

After drying, impregnated mixture turns into highly swelling composite (up to 5000% of the volume), Contacting with water it increases in volume and covers the pores of the base, making it totally waterproofing.

The composite is resistant to temperature, microbiological, chemical and radiation effects and it is environmentally friendly.

Waterproofing effect of materials does not decrease when exposed to high water pressure.

Materials are flexible enough and they can be fitted on the surface of any configuration.

Period of validity of this waterproofing material depends on the period of validity of the base material.

The cost of materials depends on the price of base as the cost of impregnated mixture for 1 m^2 of the base with thickness of 1 cm does not exceed 1 cent.

The proposed materials can be successfully used to create anti-filtration screens on canals, ponds, reservoirs, slopes of dams, etc. It can also be used for growing seedlings, lawns, mushrooms, etc.

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Строительство и архитектура

МАТЕРИАЛ И ФУНКЦИЯ: О СПЕЦИФИКЕ ФОРМООБРАЗОВАНИЯ В СОВРЕМЕННОЙ АРХИТЕКТУРЕ

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Аннотация: В статье рассматривается проблема сохранения идентичности архитектурного творчества и его внутренних смыслов и ценностей в условиях эволюции постиндустриального общества. Архитектурное формообразование как процесс накопления и трансляции опыта свободного пространственного конституирования анализируется с точки зрения изменения соотношения «материала» и «функции» в контексте развития массового производства и культуры. Оцениваются перспективы развития структурно-функционального подхода к выработке принципов независимой архитектурной теории.

Ключевые слова: архитектурная форма, пространство, структура; функция, массовая культура, стандартизация.

Construction and architecture

MATERIAL AND FUNCTION: ON THE SPECIFICS OF FORMATION IN MODERN ARCHITECTURE

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Annotation. The article considers the problem of preservation of architectural creativity and its internal meanings and values within the evolution of post-industrial society. Architectural shaping as the process of accumulation and transmission of spatial experience free of Constitution is analyzed from the point of view of changing the ratio of "material" and "function" in the context of the development of mass production and culture. Evaluates the prospects of development of the structural-functional approach to the development of architectural principles independent of theory.

Key words**:** architectural form; space; structure; function; mass culture; standardization.

Актуальность темы предлагаемой статьи и ее главная исследовательская проблема прямо связаны с современным этапом развития архитектурной мысли как на Западе, так и в нашей стране. В условиях диффузии предметных границ опыта архитектурной деятельности, выступающей моментом в общей цепи деструктивных тенденций нашего времени, остро встает вопрос о том, что составляет внутренний предел продуцирования архитектурного «продукта». Иными словами, можно ли сегодня с полным правом говорить о том, что основания автономности и свободы архитектурного *творчества* остались непоколебимыми. Остался ли сегодня архитектор художником? Мастером? В каком-то смысле поэтом, сказывающем в пространственных формах и камне свое уникальное слово.

Архитектурное творчество как процесс ближайшим образом рождения новой формы сегодня как раз лишено своих оснований в «материале», «технологии» и целях деятельности. Современная архитектура практически не создает структуры пространственно означенного опыта, которые бы заключали в собственном развертываемом имманентно потоке принципы «чтения», метафоризации и кодификации. Очень трудно сегодня найти архитектурный проект или его готовую реализацию, который бы своим «текстом» создавал особый мир значений. Любое современное строение «читается» по правилам вовсе не архитектурной имманентной грамматики. У него практически полностью отсутствует своя уникальная герменевтика, круг интерпретаций и референций. Оно не в силах само себя *рассказать*, повествовать о самом себе. Эту функцию утилитарной «экзегетики» выполняет само постмодернистское потребительское общество.

Безусловно, доминирующим в архитектурной мысли новейшего времени способом объяснения сущности как архитектуры вообще, так и архитектурной формы, в частности, стал формалистский структурно-функциональный подход. Это вполне понятно и логично в условиях социокультурных трансформаций общественной жизни и самого человека в эпоху развития крупномасштабного производства, массовых стандартизированных алгоритмов и шаблонов деятельности, мысли, поведения и коммуникации, тотального разрушения сакрализованных смысловых пластов коллективного антропологического опыта и культивирования научно-технического прогресса. «Современный процесс стандартизации … нас выхолащивает и подчиняет себе, – отмечает Ф. Л. Райт. …Стандартизация стала уже неизбежной необходимостью, а как враг или друг – можете выбирать… Механизация и стандартизация уже лишили жизни ремесло во всех его проявлениях… Меня беспокоили, – подчеркивает при этом Райт, – новые формы как выражение новой системы машинного производства» [8, с. 54].

Еще в 30-е годы позапрошлого столетия французский автор и архитектор, создатель библиотеки Св. Женевьевы и нового читального зала Национальной библиотеки в Париже, А. Лабруст писал: «…я объясняю им [своим ученикам], что прочность зависит скорее от того способа, которым материалы соединены, чем от их количества, и… я говорю им, что они должны исходить из самой конструкции при выборе вида отделки… Я часто повторяю им, что искусство обладает властью делать все прекрасным, но настаиваю на том, чтобы им было абсолютно ясно, что в архитектуре форма должна всегда соответствовать функции, для выполнения которой она предназначена» [1, с. 185].

Архитектура фактически утратила связь с обрядово-символической стороной социального бытия, определявшей каноны строительства на протяжении всей ее многотысячелетней истории существования, начиная со времен сооружения Пирамид и Стоунхенджа и вплоть до Первой Мировой Войны. Исторически архитектура была неотделима от трансцендентного измерения культуры. Любое строение, не обязательно даже прямо связанное с религиозными практиками (храмовые комплексы, Соборы и т. п.), в традиционном обществе, будь то восточные цивилизации (Китай, Индия, Персия, Синтоистские культурные очаги) или классический Запад, рожденный на берегах теплого Эгейского моря, всегда было сориентировано структурно и пространственно таким образом, что в своей морфологии, геометрии, композиционном решении отвечало общим для данного времени и его «Духа» требованиям закрепления отношений между единичным носителем культуры, простым индивидом и всеобщими целостными уровнями, властью, культоотправляющими социальными группами, элитами.

Также как и искусство в целом архитектура всегда выполняла важнейшие аксиологические и целерегулятивные функции. Но, кроме того, выходила также за рамки простого выражения творческой воли и технических знаний своих создателей, выступая формой закрепления знаково-символического единства культуры, общества, способом или методом объективирования

сверхфизического измерения опыта и последующего соотнесения с ним конкретных носителей-субъектов данного конкретного уровня цивилизационно-исторического развития.

Уже со второй половины XIX столетия, когда активным участником социального обмена в общества, коммуникативных процессов стала техника, *машина*, строительство в Европе, США, России и других регионах планеты, причастных к прогрессу на базе рынка и науки, перестало ориентироваться на метафизические леса жизни. «Особую роль в архитектуре играют изменения, обусловленные духом времени; новые задачи, поставленные перед строительством, на транспорте и в промышленности и возможность новых конструктивных решений при применении новых строительных материалов: стекла – стали – бетона» [4, с. 306]. Техническая мощь просто избавила человека от необходимости *творческого* освоения и опосредованного подчинения жизненного пространства.

Кроме того, социальные коллизии, революции и прочие процессы в обществе и самом сознании привели к актуализации ранее неведомого фактора культурной эволюции – всплывшей многомиллионной массы людей. Урбанизация, слом патриархальной иерархической структуры, десублимирование коммуникативных практик, их деэстетизация, существенное упрощение, максимальная прагматизация массовое производство заставили как-то «принять», ассимилировать некогда молчаливое большинство населения, вовлечь в орбиту идентифицируемого социального субъекта (например, национального или государственного). Процессы урбанизации, тенденции разрастания городов, подчинения ими всего пространства как «места» бытования индивида неотделимы от эволюции массового сознания и его главного носителя. Видимо, прав отечественный ученый В. Л. Глазычев, когда пишет, что «объективный процесс всеобщей урбанизации неумолим. Разумеется, попытки уходы индивидов или небольших групп как можно дальше от влияния городов будут продолжаться, но этот вариант эскапизма обречен на то, чтобы быть сугубо маргинальным явлением. Мир движется к тому, что все его население будет городским. Мир уже таков: природные заказники, заповедники, национальные парки будут, надо полагать, увеличиваться в числе и в размерах, но это происходит именно потому, что в их рекреационных возможностях все более заинтересованы те, чья основная деятельность осуществляется в городской среде» [2, с. 7]. Современная массовая культура – это культура жителя большого города, тоталитарно подавляющего всякое индивидуальное кодирование жизненного мира.

Для этого непосредственно потребовалось создание принципиально отличных от традиционных форм условий проживания, перемещения и хабитуализации жизненной среды. И главное требование, которое сформулировал уже век XX – новая архитектура должна удовлетворять текущие *массовые* потребности и желания обустройства масс, лишенных трансцендентного небосвода и корней. При этом, как считает Вальтер Гропиус, «ошибочно предполагать, что архитектура ухудшится из-за индустриализации конструкций жилого дома. Напротив, стандартизация элементов здания окажет благотворное влияние на создание единого характера новых жилищ и предприятий» [3, с. 343]. Единый характер архитектуры фактически превращает ее в простое производство, создающее свой готовый продукт в промышленных масштабах. Иначе удовлетворить актуальные социальные потребности будет крайне сложно. Точнее, вовсе невозможно. Заметим, что современная ситуация с решением жилищного вопроса в России и многих других странах Старого и Нового света во многом сохраняет еще это требование – строить дешевле, больше и быстрее, догоняя пропорцию демографического роста, с одной стороны, и необходимости жесткой экономии ресурсов (в то числе интеллектуальных, необходимых для символического освоения новой среды), с другой.

Толкование сущности архитектурной формы стало исходить из необходимости поиска новых каналов социальной циркуляции и лифтинга, чего не знала ни архитектура, ни искусство вообще в

классическую эпоху. Характерно в этой связи высказывание Луиса Салливена, архитектора и автора конца XIX в., который попытался теоретически обосновать «новую» эстетику, в которой красота как ощущение есть результат удовлетворения потребностей и имеет также функциональную природу. «Будь то орел в стремительном полете, яблоня в цвету, ломовая лошадь, везущая груз, журчащий ручей, плывущие в небе облака – и над всем этим вечное движение Солнца – всюду и всегда форма следует за функцией» [9, с. 44-45]. Ему словно вторит Э. Мендельсон: «Формы всех шедевров начального этапа развития самобытных архитектур определены четкостью положенного в основу конструктивного принципа; конструкции и материалы обусловили также облик всех тех произведений мирового значения, по которым можно безошибочно проследить историю развития человечества» [6, с. 309].

В связи с этими насущными веяниями само отношение в обществе к архитектуре стало сугубо прагматическим, опирающимся на соображения экономии и расчета, критерии эффективности использования доступной среды и ландшафтов, максимизации полезности. При этом ограничивать круг аргументации таких критериев только развитием науки и технологий было бы явно неверно и исторически не точно. Дело в том, что сами по себе технологические новации, применение знаний, полученных экспериментально, опытно, всегда сопровождали обустройство жизненного мира, освоение природной среды (например, при строительстве древнейших городов, военно-оборонительных сооружений, храмов, дворцовых комплексов и т. д.).

Величайшие памятники древнегреческой и римской архитектуры, грандиозные готические Соборы средневекового Запада, наконец, масштабные стройки Ренессанса и барокко, прежде всего, основывались на тончайших и сложнейших математических расчетах, на глубоком специализированном знании состава материалов, способов их обработки и сочетания в комплексах зданий и храмов. В этом отношении верно подмечает немецкий исследователь Курт Зигель: «Всякий архитектурный замысел осуществляется определенными техническими средствами. С помощью техники архитектура принимает ту или иную форму и становится материальным выражением своей эпохи. Техника всегда оказывала влияние на архитектурные формы. Во все времена техника и новые строительные материалы служили архитекторам источником творческого вдохновения. Не будь техники – не было бы ни Парфенона, ни готики» [4, с. 8]. Еще ранее аналогично высказывался и Ле Корбюзье: «Технические средства предшествуют и являются условием всякой стройки… они определяют архитектурные формы, а иногда и вызывают радикальную эстетическую перестройку» [5, с. 76].

С этой точки зрения архитектурная мысль, насколько глубоко мы можем судить по истории цивилизации вообще, всегда выступала в авангарде интеллектуального вооружения общества. Выдающиеся мастера, зодчие, архитектуры, проектировщики были крупнейшими учеными своего времени, энциклопедически совмещавшими знания в самых разных областях и очень тонко чувствовавшими духовный ритм своего времени. Поэтому влияние научного прогресса на развитие архитектуры в новейшее время, несомненно, знаково и симптоматично. Но сущность произошедших трансформаций и тенденции, определяющие характерные черты развития архитектуры уже сегодня далеко не ограничиваются только внедрением новых материалов, технологий и расчетных систем моделирования.

Анализ и сопоставление трактовок именно архитектурной формы как раз и позволяет лучше всего понять, что общемировоззренческий сциентистский настрой новейшего времени, влияние науки выразились в ином. А именно: метаморфозы телеологии оформления пространства, символической и смысловой градуировки и ранжирования. Именно через эти свои «качества» архитектура и выражает не только и не столько уровень материально-технического прогресса общества, сколько способ самопостижения, самоидентификации, самодвижения единого

социокультурного организма. В архитектурной форме считывается ментальное укоренение субъекта, создающего и созерцающего то или иное сооружение. Форма не только ограничивает или очерчивает архитектурную массу, но и существенным *определяющим* образом закрепляет *различие* как метод конституирования особого перцептивного субъекто-стремительного подчиняющегося пространства (и времени).

Структурно-функционалистские аспекты потому и получили в индустриальном и постиндустриальном обществе ведущую роль в подходе к изучению и продуцированию архитектурной формы, что как раз именно такой фокус позволяет избавиться от «лишнего» бремени метафорики, малопонятной и практически не нужной массовому потребителю метафизики смысловых и символических векторов тектонического корневища проектов.

В архитектурологических штудиях нашего времени все больше превалируют подмены концепта «форма» различными эрзацами конструктивизма и, соответственно также, выхолащивается самодовлеющее имманентное качество аффирмативности формы и ее саморепрезентативности, остается пустой формализм и *факторный анализ формообразования*. Которые, конечно же, вызывают множество нареканий и скептических взглядов в свою сторону. Что уже одно лишь только само по себе свидетельствует об отсутствии надежного собственного предметно-методологического пристанища теории архитектуры. Не способной в сложившихся весьма не простых условиях противопоставить нечто содержательное и прочное натиску операциональной конструкционистской идеологии последнего времени, пользующейся очевидностью доводов научно-ориентированного мировоззрения и отсутствием, с другой стороны, прагматической весомости и полезности, удобоваримой потребительской привлекательности у бывших в классической культуре смысловых «узлов» пространственных решений и полей напряжения точек присутствия созерцающего «Я», субъекта. В классическую эпоху сознания архитектура представляла собой пространственный пластический *образ реальности*. Метаморфозы новейшего времени поставили под сомнение фундаментальную стратегию подобного формообразующего пространственного конституирования. Классические принципы архитектурного формообразования приводили к включению физического пространства как объективной предпосылки человеческого обитания в поток самого сознания как его *иное*; в мире современной архитектурной формы человек себя почти не узнает.

Если рассматривать архитектуру только как некий *продукт* общественного производства (пусть даже в самом широком смысле слова, том, на которое указывал Маркс в своем знаменитом пассаже о сравнении «хорошей» пчелы и «самого плохого» архитектора), обладающий специфическими предпосылками собственного развития, изменения принципов деятельности, планирования и проектирования, то естественно, что именно факторный анализ должен давать ответы на основные вопросы о сущности архитектуры в конкретной культурной среде.

Этот же подход полностью укладывается в методологические контуры позитивистского научного осмысления того или иного предмета. А в XX веке не только природные объекты стали его предметом, но прежде всего сам человек, его мышление, исторические развитие культуры, язык, психика, коммуникация, коллективные представления и цветущие побеги индивидуального самосознания (мифы, поэтика, религия, искусство, философия). Не исключение и архитектура. С этой точки зрения любой предмет, в данном случае произведение архитектуры, расчленяется на осязаемые компоненты, фактически редуцируется и предстает в виде *конфигурации* или *структуры*, изменения которой обусловлены сменой факторов, их динамикой и качественным ростом, а также изменениями общественных ожиданий и заказов.

Архитектурная форма вследствие такого «генетического» проникновения в предмет оказывается всецело исчерпанной процессами *оформления* архитектурного объекта, его *формообразования*, то есть, иными словами, его построения или конструирования. И дело в данном

случае не столько даже в процессуальном характере такого измерения формы. Ибо сам по себе такой характер еще ни о чем не говорит. Форма как имманентный метод самоорганизации образа архитектурного произведения через процесс предстает пока еще только как абстракция, требующая восстановления целого ряда опосредствующих звеньев. Форма как оформление архитектурного объекта действительно *всецело обусловлена*. Малейшие передвижки в ней или структурные различия лишь *отражают* в себе эволюцию факторов. Данным положением следует оперировать предельно аккуратно. И вот почему.

Любой артефакт человеческой культуры (по крайне мере, достоверно известный нам), любой социокультурный феномен, явление или процесс в первую очередь есть «дитя» своего времени, грань «духа эпохи», включающего уровень развития материальной производственной базы социума как основы антропокультурогенеза. Архитектура здесь не просто пример, а один из наиболее показательных аспектов роста и прогресса «неестественного» (Маркс) продолжения «естественного» тела человека.

Далеко не случайно классический греческий ордер, ставший образцом для всей западноевропейской культуры, почти на три тысячи лет полностью отражает мерность человеческого тела, его симметрию и асимметричные пропорции [7, с. 12-13]. Или: активное использование в барочных итальянских постройках и скульптурных произведениях XVII-XVIII веков мрамора (Ватикан и бессмертные шедевры Дж. Л. Бернини, королевская резиденция неаполитанских Бурбонов в Казерте близ Неаполя (проект архитектора Луиджи Ванвителли, середина XVIII в.) и другие характерные виллы) конечно же, было не в последнюю очередь обусловлено наличием в Италии богатейших месторождений этого красивейшего и ценнейшего природного камня.

Гуляя по бульварам и авеню Парижа, или пребывая в вековой тиши Руанского Кафедрального Собора, Реймсского или Шартрского, Амьенского или Собора Парижской Богоматери, рассматривая из под сени парковых деревьев замок Шеверни или Амбуаз, Во-ле-Виконт или Фонтенбло, везде и всюду глаз скользит по практически одноцветной серо-песочного оттенка поверхности стен, объемов фасадов, изумительных по красоте вырезанных фигур. И это тоже не удивительно, а находит свое прямое объяснение массовой распространенностью песчаника на территории бывшей Римской Галлии. Этот естественный природный строительный материал поддается обработке, резке, фактурной огранке гораздо легче, чем многие другие камни. И вместе с тем он удивительно прочный. Мастера резчики и скульпторы смогли в песчанике, например, передать не просто лицо героев евангельских сюжетов на стенах Реймсского Собора, но подчеркнуть их особый въедливо-саркастический взгляд, намекающий (именно намекающий!) на великое богооткровенное знание, разоружающее любую горделивую человеческую сокрытость и земную эмпирическую психологию. Со временем песчаник темнеет, но это лишь усиливает особую метафорику строений и замковых пропорций, аккумулирует смыслы времени.

Вершина всей классической западноевропейской культуры, ставшая возможным достоянием человеческой культуры и самого *Духа* благодаря развитию именно барочной архитектурной формы, знаменитая Зеркальная Галерея Версальского дворца в пригороде Парижа на период своего создания (1676-1684) выразила не только высочайшую метафизику и символизацию абсолютной субъективности, но также и экономическую мощь Франции, развитие промышленности. Производство зеркал в то время требовало специфических знаний в области химии, тепловой физики и обработки материалов, умений и развитых дорогостоящих технологий.

Стремление подчеркнуть внутренний союз православной веры и самодержавной власти императора нашло свое, пожалуй, лучшее выражение в таком природном материале как гранит, который добывали близ Петербурга по берегам Карельских и Финских озер, и из которого создавали колоннады Исаакиевского Собора, Посольской лестницы Зимнего Дворца (после пожара 1837 года

колонны из искусственного розового мрамора заменили на монументальные колонны, высеченные из серого сердобольского гранита) и такой важнейший архитектурный памятник, доминанту всего центра Петербурга как знаменитую Александровскую Колонну на Дворцовой площади, а также многие другие строения и оформления фасадов и интерьеров, создававшие облик северной имперской столицы. Тут же вспоминаем и другой такой характерный пример: после пожара 1837 года в Зимнем Дворце проводились тотальные реконструкционные работы. Сильнейший пожар оставил от императорской резиденции один черный остов. В ходе фактического воссоздания заново в решении главного – Георгиевского Тронного – зала дворца (созданного еще при жизни Екатерины Великой в 1795 году архитектором Дж. Кваренги) впервые в таких больших архитектурных объектах были применены по решению архитектора В. П. Стасова металлические фермы для создания крепления и перекрытия потолка вместо дерева и каменных сводов. Данные металлические конструкции были созданы на Александровском заводе инженером М. Е. Кларком. Тем более что Зимний Дворец в основе своей строение кирпичное, а не каменное, и требовал для завершения больших объемов особых технико-технологических приемов. Примеры эти можно продолжать еще и еще.

Переводя свой взор на минувший и трагический XX век, мы видим аналогичное. Господство стекла и бетона, металла и синтетических материалов, объясняется развитием производства, опирающегося на наукоемкие инженерные разработки. К. Зигель дает следующую характеристику архитектуры XX века: «Современные каркасные конструкции появились в результате применения в строительной практике стали и бетона. К характерным чертам каркасных конструкций относятся уменьшение размеров сечения несущих элементов до минимума, соответствующего статическим расчетам, и четкое функциональное разграничение несущих и ненесущих элементов. Каркас состоит из жестко соединенных между собой ригелей и стоек. Преимущества его применения в наибольшей степени проявляются в многоэтажном строительстве. Большая несущая способность новых строительных материалов позволяет возводить все более высокие сооружения в соответствии с возрастающими современными требованиями. Для облика наших крупных городов характерным в основном каркасные здания из стали и бетона точно также, как для средневековых городов – фахверковые здания» [4, с. 13]. Таким образом, соотношение формы, функции и материала в современной архитектуре, равно как и в прошлом, выступает одним из основных факторов становления целостного облика (образа) архитектурного произведения. И поэтому проблема самоопределения смыслового измерения пространственных структур остается актуальной и в условиях совершенствования технологической и материальной базы архитектуры.

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Hydrology, Hydrochemistry

WATER QUALITY ANALYZE IN RIVER VERE

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Annotation. The problem of pollution of c. Tbilisi is one of the most urgent issues, study and analyze of which have the most important role in further development of our city. To solve this task, since 1990 TSU Hydro-meteorological School Laboratory has been identifying the content of some standard elements (copper, zinc), biogenic substances and hydro-chemical properties of the river. Within the past 27years period, to reveal the expedient changes in the chemical content of riv. Vere, taking samples and chemical analyze was held in three stages in three sections.

Analyze of the chemical elements taken at the first stage showed that their motion is asynchronous against the river discharges.

The comparison of the analyzes made in 1990-1992 showed that the solid residues (accordingly mineralization) in 1990 was relatively high (0.9-1 g/l). In 1992 it started reduction and in May, 1992 reached the minimum value (0,034g/l), which might be explained by the reason that since 1991, the enterprises closely located to riv. Vere did not function any more due to the instable state in the country. Since 2000s, after starting the functioning of enterprises, mineralization increased and exceeded the data of 1990 in the samples taken in 2008.

In the samples taken in 2017 down to the Napetvrebi ravine, the nitrates are found - NO^-_2- 0,50mg/l and NO^-_3 - 3.90 mg/l, where no ammonium ion is presented, which indicates that the water was polluted previously and self-cleaning process was in course in the water. As for the sample taken at the same time to the outfall of riv. Mtkvari – down to the Zoo, here, in contrary, ammonium ion is presented - NH^+_4 - 3.50 mg/l and no nitrates and nitrites are observed, this shows that the pollution of the water with organic substances occurred recently. The ammonium content in this water is higher than Threshold Limit Value (T L V - 2mg/l). Accordingly, the degree of oxidation, 44, mg/O_2/l is relatively increased in this water in comparison with others; furthermore, this water had a heavy odour of hydrogen sulphide (H_2S).

Based upon the above given conclusions of the chemical analyze of the river; the annual monitoring should be inevitably established as for riv. Vere as for other tributaries of river Mtkvari in c. Tbilisi areas.

Key words: macro-elements, biogenes, solid residue.

INTRUDUCTION

Water is one of the most important natural resources, it is a mostly spread chemical compound. The eminently universal role of water in nature is explained by its distinctive and, mostly, anomalous, physical and chemical properties. By these properties water determines all of the processes being in course in water objects, as well as a lot of peculiarities of the climate, meteorological and geomorphologic process. It is

widely applied as drinkable water, for domestic, industrial, energetic, agricultural needs, water transports, recreational, tourism and other public necessities complying with the requirements set forth in the laws. In case of water shortage, a lot of countries might not deal as with food as energetic crisis.

Water is the renewable resource on the earth. Despite, in a number of regions, water suffers from very heavy anthropogenic load due to which the water objects are intensively polluted which has the catastrophic character sometimes. Exactly this property of water serves as the reason that the problem of fresh water became one of the urgent and tickler social-economic problems today, this problem is not caused due to lack of water but due to its unplanned predatory using which results in reduction of water reserves and the heavy worsening of water quality.

There are the various sources of pollution of water objects. In a lot of regions on the earth, the polluted substances are fallen in the water objects through bringing the radiation dust (Chernobyl – 1986, Japan catastrophic tsunami – 2011, etc.) or other chemical substances over the earth surface by impact of atmospheric precipitations which causes degeneracy of flora and fauna, by flowing down the treated waters of chemical plants, marine and land transport, huge catastrophic phenomena of the earth, wars, etc. which results in the worsening human health and disorder of the functioning of ecosystem.

Discharge waters always contain some quantity of solid particles and solved substances. Such particles are observed in water as floating, rolling-creeping, as well as solved substances. Study of the soluble chemical substances taken out by river water gives some possibility of observance at the impact on environment. It should be noted that the study of the flown down soluble substances has the great scientific and practical importance for solution of a number of geological, geochemical and hydro-chemical or other problems.

One of the basic tasks of the study of water content is identification of ion contents. Ionic or macro-element part (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, CI^{-}, SO_4^{2-},HCO_3^{-}, CO_3^{2-}), microelements (Cu, Zn, Mn, Cd, Pb, etc), biogenes (NH_4^{+}, NO_2^{-}, NO_3^{-}, PO_4^{3-}), organic substances and mineral colloids are implied in the chemical content of the solved materials. Analyse is based upon the specific properties of every ion and identifies their concentration in water.

The common ionic part of the substances solved in water consists of 90-95% of the basic part of water.

In surface waters, biogenic substances belong to the most variable components. The powerful, fast biological and biochemical factors are added to the abovementioned numerous factors providing the chemical content of water, which ensures the regime and content of biogenic substances. Basically, the content of the biogenic substances in lakes and reservoirs is profoundly studied in contrast to river waters.

MAIN PART

The problem of pollution of c. Tbilisi is one of the most urgent issues, study and analyze of which have the most important role in further development of our city. To solve this problem we need inevitably study of water quality at every water object located in our city. From this point of view, riv. Vere is our research object, the aim of which is the identification of the content of hydro-chemical properties, biogenic substances and some standard elements (copper, zinc) in riv. Vere. For this purpose, from November 1990 to 1992, inclusive, Hydro-meteorological School Laboratory of Iv. Javakhishvili Tbilisi State University actively started taking samples and chemical analyze of water samples at riv. Vere within different stages of water content regime. Further, to show the expedient changes in chemical content of the river, the mentioned works have been held episodically in 2009 and 2017. Furthermore, it should be noted that the everyday observances at floating debris in riv. Vere has been carried out from 1963 to 1990s, the measurements were held episodically according to the water content regime of the river to identify the bottom debris flow, according to which the debris flow of riv. Vere was established which averagely equals to 96 thousand tons annually (fl. 74+bot.22).

The chemical property of the river depends on a lot of factors, it is very variable value and its chemical flow depends on the complicated complex of the physical-geographical factors of a basin, within the last years it is added by the economic activity of a human which sometimes has the decisive role in formation of the chemical flow of riv. Vere, so in order to get the reliable and objective information, the long-term and systematic observances are required.

The hydro-chemical observances at the water of riv. Vere are held in three sections: 1. adjacent to the conjunction of Napetvrebi ravine – down to it; 2. In the section of TSU hydro-meteorological laboratory; 3. To the outfall of riv. Mkvari – down to the Zoo.

At the first stage, the analyze of the chemical elements obtained in the observance period showed that their motion is asynchronous against the river discharges. For example: during low water level (21.11. 1990 Q=0.31m^3/s.) there are high values of Cl^-,Ca^{2+}და Mg^{2+} concentrations (1,68; 1,0; 0,36) , and during high waters in Spring (31.04.1991, Q=4,07) is low (0,55; 0,55; 0,12), which is the sign that during high water level, the river has the self-cleaning ability.

According to macro-element content the samples do not differ either according to seasons or to areas, they are moderately mineralized (appr. 0,9 g/l) sulphate-calcium waters of the second group, are characterized with high hardness (11-12 mg/eq.), the samples taken down to the Zoo have comparatively low mineralization (appr. 0,6g/l), like mineralization, the hardness is comparatively lower in the samples taken to the Zoo (appr. 9mg/eq.).

The comparison of the analyzes made in 1990-1992 showed that the solid residue (accordingly mineralization) in 1990 was relatively high (0.9-1 g/l). In 1992 it started reduction and in May, 1992 reached the minimum value (0,034 g/l), which might be explained by the reason that since 1991, the enterprises located near to the basin of riv. Vere, especially the carpets' factory functioning for a long time, by the impact of which the river has different colour from time to time, did not function any more due to the instable state in the country and the water mineralization was lower than in 1990. Since 2000s, after starting the functioning of enterprises, as well as in the result of the construction works being in process in 2-3 km above High building of the university and disposing construction and household wastes at the river slopes from the different places of the city, mineralization increased and exceeded even the data of 1990 in the samples taken in 2008. The relatively high concentration of calcium ions in the top first section (8.0 mg/eq) with its high content in soil and in the middle, laboratory section (8.2 mg/eq) should be noted, which might be explained by flowing down the treated waters from the marble sawmill of Saburtalo cemetery located in 2km above the laboratory in the river, further, in the lower section it is sharply reduced (6,40 mg/eq) due to the self-cleaning property of the river water.

Except for macro-elements, in the samples of 2008 (13.11.08; Q=1,1m^3/s), biogenic substances (nitrites, nitrates, ammonium), ferrum, phosphates and some microelements, in particular copper and zinc, have been identified. Copper content varies from top to bottom accordingly within 14,5-7, 0mkg/l, i.e. to the bottom it is reduced due to the self-cleaning property of the river, zinc is increased within 20-28mkg/l, ferrum Fe^3 is reduced from 0,50to 0,15mg/l. According to our data, NO_3^- nitrate is quite high in the top first section (6,60 mg/l). Under the impact of the above mentioned anthropogenic factors, afterwards it is quite reduced due to the self-cleaning property of the river (1,90mg/l), and downwards, basically by the impact of the Zoo, it is quite increased (8,80mg/l). It should be noted that, no of the biogenic substances identified by us exceeded the threshold limit value.

As for organoleptic properties, everything was within the norm excluding the samples taken down to Napetvrebi on 13.11. 08 having a heavy odour of hydrogen sulphide i.e. it contains S^{2-} ion.

In comparison with the analyzes made previously according to the macro-element content, in the samples taken in 2017 some changes might be observed, in particular, the concentration of calcium ions is

reduced (from 0,180-0,160 g/l to 0,068 g/l), furthermore, present (2017) waters are less fresh ones (was 11,6-9,0mg/eq, now within 3,0-4,0mg/eq).

Accordingly, the salty content formula of the waters as well as water group, class and type have been changed, – was $S^{Ca}_{//}$, now - $S^{//}_{Na}$..

In one sample (2017, down to Napetvrebi ravine), nitrates - NO^{-}_{2}- 0,50mg/l and NO^{-}_{3}- 3.90 mg/l are found where no ammonium ion is presented which indicates that the water was polluted previously and self-cleaning process was in course in the water. As for the sample taken in another area (2017, to the outfall of riv. Mtkvari – down to the Zoo), here, in contrary, ammonium ion is presented - NH^{+}_{4} - 3.50 mg/l and no nitrates and nitrites are observed, this shows that the pollution of the water with organic substances occurred recently. The ammonium content in this water is higher than threshold limit value (T L V - 2mg/l). Accordingly, the degree of oxidation 3,44 ,mg/O_2/l is relatively increased in this water in comparison with others but it does not exceed TLV which equals to 4 mg/O_2/l , furthermore, this water had a heavy odour of hydrogen sulphide (H_2S).

It should be noted that before the heavy, catastrophic flooding of 13-14 June, 2015 resulting in loss of human life (21 dead persons, two missing persons) and in huge damage to the population of c. Tbilisi, there was huge impact of anthropogenic factors those resulting in the sharp changes in the chemical content of the river water in the river basin, the heavy flooding of 2009 (Q_{max}=133m^3/s), might be cited as an example , which broke the sewage pipe of Tskneti-Bagebi (1200 cm) in the beginning of Vake-Saburtalo pass way which was totally flown down in the river till 2013 (the laboratory was giving the monthly report), the similar cases occurred in otter sections of the river as well. After the mentioned catastrophic flooding Q_{max}=511m^3/s), the river destroyed all of the polluting focuses, including Tamaz Elizbarashvili Dogs' Shelter (250dogs. 10 bears), which was sharply positively reflected on the further chemical content of the river, for example on the analyze taken by us at the river on 31.03. 2017, except for the abovementioned impact of the Zoo, where the content of biogenic substances is increased. For this reason, the central catchment of faeces flown down into the river with cleaning equipment should be arranged at the territory of the Zoo.

CONCLUSION

In the result of the study held by us, we might conclude that river Vere is not technogenically polluted excluding some exceptions – in particular, down to the Zoo, in a tunnel where the impact of the Zoo is observed and in the result the content of the biogenic substances (ammonium and nitrite ions) is increased. The rest components (hardness, pH, sulphates, chlorides, and oxidation) are within the norm. Hence that river Vere crosses c. Tbilisi at quite large place and taking into consideration the conclusions of the abovementioned analyzes, the annual monitoring over river Vere should be established.

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Агромелиорация

ЭНЕРГЕТИЧЕСКИЙ ПОДХОД К ИЗУЧЕНИЮ БИОСФЕРНЫХ ПРОЦЕССОВ

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Аннотация. В статье с позиции энергетики почвообразования представлены данные фитопродуктивности, составлен энергетический баланс агрофитоценоза озимого ячменя, величина радиационного баланса и полноты использования радиационной энергии агроценозом в условиях Сальянской степи. Проведена множественная и парная корреляционная зависимость между приростом растительной массы, радиационным балансом и влажностью почв и в отдельности.

Ключевые слова: агрофитоценоз, фитомасса, радиационный баланс, гранулометрический состав, гумус.

Agromelioration

ENERGETIC APPROACH THE STUDY OF BIOSPHERIC PROCESSES

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Annotation. The article deals with the information about biological productivity of barley agrophytocenosis under the condition of Salyan plain from soil formation energetic standpoint, compiling of the agrocenosis energetic balance, establishment of multinominal and separate nominal correlation dependence between the productivity and radiation balance and soil humidity.

Key words: agrophytocenosis, phytomass, radiation balance, granulometric structure, humus.

ВВЕДЕНИЕ

Рациональная интенсификация сельскохозяйственного производства, способная обеспечить плодородие почв и получение стабильного и устойчивого урожаев сельскохозяйственных культур, представляет собой глобальную проблему нашего времени.

В соответствии с долговременной комплексной программой развития аграрного сектора экономики Азербайджана, меняется и совершенствуется его структура, получают широкое развитие новые формы организации производства – сельскохозяйственные и агропромышленные предприятия и объединения. Наряду с дальнейшим наращиванием техногенной базы сельского хозяйства (техники, удобрений, пестицидов, орошения и др.), намечено обеспечить более эффективное использование почвенно-климатических ресурсов, биологических средств труда (видов, сортов пород, агроценозов и др.), прогрессивных технологий, новых форм планирования и организации производства, достижений мировой науки и практики.

ОСНОВНАЯ ЧАСТЬ

Исследование круговорота веществ и энергии в природе является одним из важных вопросов биосферы. Однако, полнота изученности этих двух главных составляющих процессов развития

компонентов природы, оказывается несоразмерно различной. Основные усилия исследователи уделяли изучению круговорота веществ, энергетическая же сторона природных превращений оставалась малоизученной, при том что о необходимости исследования именно вещества и энергии говорилось повсеместно. На важность учения о биосфере указал еще В.И. Вернадский, установивший взаимодействие между живой, неживой биосферой, геологическим фактором и связи их с космическим фактором – приходящей лучистой энергии солнца, а также учение В.И. Сукачева о биоценозах, определившего новые пути в познании процессов материально – энергетического взаимодействия биосферы.

Во всех этих областях проведены обширные исследования, однако картина общего взаимодействия в процессах превращения вещества и энергии на земной поверхности все еще остается во многом не выявленной. При системном подходе к изучению природных объектов становится особенно необходимым использование энергетических (термодинамических) критериев и данных. Изучение процессов превращения и миграции веществ сопряжено с выявлением и описанием чрезвычайно сложных систем, поскольку вещественный состав растений, животных, почв, грунтов и др. представлен многообразными химическими соединениями. Даже переход в исследования превращений веществ к использованию только элементного состава лишь в некоторой мере уменьшает трудность этой проблемы.

В переходе при изучении биосферных процессов к использованию энергетических представлений и критериев мы, прежде всего, получаем возможность описывать протекающие в биосфере процессы в их самом общем виде, в их главном существе и оценивать в единичных количественных единицах, скажем, калориях или джоулях. Затем, что еще более значимо, мы оказываемся способными обнаружить новые аспекты в процессах экосистемы. Уместно напомнить здесь, о впервые установленном Лотке и Макфедьеном каскадном характере переноса энергии и круговорота веществ, когда вещество может повторно в каждом новом цикле возвращаться в экосистему, каждая же порция энергии проходит через нее лишь однажды и на каждой ступени пищевой пирамиды необратимо теряется.

Помимо этого, при энергетическом подходе оказывается возможным обнаружить и количественно исследовать такие явления и процессы, которые на вещественном уровне остались нераскрытыми. Опираясь на законы термодинамики, мы оказываемся в состоянии определить общую направленность вещества и энергии, определить решающие звенья в этих потоках и в конечном итоге наиболее полно обосновать рациональные методы управления этими процессами. Но для осуществления этого требуется раскрыть потоки энергии во всей совокупности сопряженных компонентов биосферы.

Сельскохозяйственные системы могут рассматриваться как агроэкосистемы, в которых человек является неотделимым компонентом. Они могут быть также рассмотрены как жилищно-инженерные процессы над контролем человека, в которых солнечный свет, углекислота, азот, фосфор, генетическая информация и т.д. используются для образования углеводов и других питательных материалов. Однако, все более становиться ясным, что необходимо переходить к новой стратегии, которую можно сформулировать как требование обеспечить наиболее полное и полезное использование энергии солнечного луча. «Фотосинтез, в процессе которого образуется растительное вещество – решающее звено в этом процессе» [1]. Поэтому понятно, что в работах по научным основам программирования высоких урожаев сельскохозяйственных культур, первой задачей стало обеспечение условий возможно наиболее полного использования солнечной энергии, аккумулированной в растительной массе урожаев сельскохозяйственных культур в процессе фотосинтеза. Вместе с тем, ФАР не раскрывает полностью картины энергетических превращений в агробиоценозах, так как принимается во внимание только использованное ФАР в процессах

фотосинтеза, которыми утилизируется только доли процента от ФАР. Поэтому появилась необходимость в более полном освещении превращений энергии в процессах создания биомассы.

Аккумуляция энергии, поступающей из окружающих источников, негенртопии и информации для постоянно прогрессирующей экосистемы, характерно уменьшение энтоптии, что в свою очередь определяет пути развития почв, агрофитоценозов и экосистемы в целом.

Целью наших исканий является определение показателей приходящей солнечной энергии, составление энергетического баланса и выявление величины полноты использования радиационной энергии агрофитоценозом озимого ячменя, а также выявления зависимости между продуктивностью растения с факторами среды. Исследованиям энергетики почвообразования в различных почвенно-климатических зонах, а также подстилающей поверхности, посвящено достаточно работ [2].

На современном этапе особую актуальность приобретает проблема исследования ресурсов биосферы, в частности, определение действительной и потенциально возможной первичной биологической продуктивности фитоценозов, в целях сохранения и восстановления высокопродуктивных растительных сообществ и повышения урожайности сельскохозяйственных культур. Выявление основных закономерностей качественного и количественного распределения и воспроизводства органического вещества в интересах наиболее рационального использования продукции Земли человеком, является одной из основных проблем современной биологической науки, решением которой занимались многие советские и зарубежные ученые [3].

Наряду с этим, динамика фитомассы агрофитоценозов изучена в относительно меньшей степени. При этом биологическая продуктивность фито- и агрофитоценозов, в основном, изучена без учета энергетических ресурсов, основное усилие исследователей была направлено изучению круговорота веществ в биогеоценозе. Энергетическая же сторона природных превращений оставалось мало изученной, хотя на важность данного вопроса указал еще Дояренко А.Г. [5]. В основном, энергетика почв фито- и агрофитоценозов обобщена в работах Волобуева В.Р. [6], Керимова А.М. [7,8], Между тем, без знания энергетики природных явлений, представления о них будет неполной. Академик Ферсман А.Е. писал: «Энергетический подход к анализу динамически развивающихся процессов природы является конечной целью наших исканий. Мы должны перейти на единое мерило определения хода процесса, причем таковым может быть или калория или киловатт» [9]. Радиационный и тепловой балансы деятельной поверхности являются важными факторами в жизнедеятельности растений, под непосредственном влиянием которых протекает жизнь и развитие растений и формируется урожай.

Базилевич Н.И. и Родин Л.Е [10] пишут, что связи биологической продукции с условиями увлажнения носит различный характер в зависимости от количества тепла. При высокой теплообеспеченности (более 35-40 ккал/см^2 год) важнейшим фактором, регулирующим биологическую продуктивность, является влага, при низкой теплообеспеченности (до 35-40 ккал/см^2 год) избыток влаги снижает производительность фитоценозов.

Исследования проводились на сероземно-луговых почвах Сальянской степи, входящий в Кура-Аразскую низменность, граничащей с запада р. Аккуша, с востока Каспийским морем и с севера Гызылагадским заливом общей площадью 149 тыс га, среди которых 46 тыс га приходиться на долю сельскохозяйственных насаждений.

Территория представлена аллювиальными отложениями рек и морских отложений IV периода Кайнозойской эры. Рельеф местности равнинный и возвышается от -26 м до 200 м над уровнем моря.

Климат полупустынный и сухостепной с жарким сухим летом. Средняя температура воздуха 14,6°С, средняя температура самого жаркого месяца 26,2-26,4°С (июль-август), самого холодного месяца 2,2-4,0°С (январь-февраль). Среднемноголетнее количество осадков 187-309 мм, а относительная увлажненность 62-81% [11].

Глубина залегания грунтовых вод наиболее близка к поверхности и простирается узкой полосой по побережью Каспия, а в с. Сейидсадыхлы, Гушчу, Аджалы, Арбатан, Дайыкенд и Шорсулу опускается ниже до 2-3 м. Растительность представлена ксерофитными формациями полынно-эфемерового сообщества и гидрофильными в заболоченных территориях.

Почвы представлены сероземно-луговыми, лугово-сероземными, лугово-болотными, солончаками и песками и по гранулометрическому составу характеризуются глинистыми, суглинистыми и супесчаными фракциями. Количество гумуса колеблется 1,2-2,8%, постепенно понижаясь к нижним горизонтам.

Реакция среды оказывает значительную роль в питании растений и интенсивности протекания биологических процессов в почве. pH орошаемых сероземно-луговых почв объекта исследований указывает на щелочную среду, составляя в пахотном слое (0-25 см) 8,0, понижаясь на 25-50 см слое до 7,4-7,6. $CaCO_3$ также подвергается изменению с увеличением глубины от 20,14 до 23,14%, оцениваясь по градации Мамедова Р.Г.[12] как средне карбонатные.

По гранулометрическому составу сероземно-луговые почвы средне суглинистые, с содержанием физической глины 47,60-47,84%.

На орошаемых сероземно-луговых почвах в комплексе поглощенных оснований доминирует Ca (68-76%), Mg несколько меньше (25-22%), а показатели Na составляют 1,11-1,17% от суммы, в верхнем пахотном слое (0-25 см) он соответствует 3,99% - несолонцеватые, а с увеличением глубины 25-50 см достигает до 6,61% - слабо солонцеватые.

Сумма поглощенных оснований в комплексе 27,79-28,79 мг/экв и оцениваются удовлетворительным. По данным литературных источников запасы фитомассы суши составляет $2{,}4x10^{12}$ т (в океане $2x10^{8}$ т); запасы подстилки и торфа на порядок ниже общего количества фитомассы на планете и соответственно составляет $1{,}9x10^{11}$ и $2{,}2x10^{11}$т, годичная продукция Земли ровна $2{,}3x10^{11}$т и на 74% определяется надземными растительными сообществами [13].

В Азербайджане первые исследования по определению запасов фито-продуктивности также изучены в достаточной степени. Щипанова И.А. [14] отмечает, что в субтропической зоне Азербайджана общая биомасса (надземная и подземная) включая растительные остатки, семена, труху, органическую пыль, углистые остатки, зоомассу, экскременты, увеличивается от полупустынных биогеоценозов (168-284 ц/га) к степным (193-460 ц/га) и далее к лугово-степному (358-738 ц/га), в лесо-луговом сильно остепненном и на поляне в лесу она составляет 272 ц/га. Подземная часть биомассы в субтропических безлесных биогеоценозах преобладает над надземной, с колебанием в полупустыне от 2,9 до 9,8 раз, в степе - от 12,7 до 21,5 раз, в луговой степи от 2,7 до 11 раз, в травянистом покрове лесо-лугового сильно остепненного биогеоценоза до 8,1 раза.

В наших исследованиях в 2016 г. изучена фитопродуктивность агрофитоценоза ячменя на 4,0 га площади, в двух вариантах- N150 P150 K 100 и N200 P200 K150, на примере фермерского хозяйства с. Ашагы Гараманлы, где наряду с физическими, химическими и физико-химическими свойствами сероземно-луговых почв, характеристика которых изложено выше (Рис.1).

Рис. 1. Фаза восковой спелости и жатва

При этом, за вегетационный период общая фитомасса агрофитоценоза составила при дозе удобрений N_{150} P_{150} K_{100} и N_{200} P_{200} K_{150} соответственно 391,6 и 346,3 ц/га. Известно, что для оценки роли фитомассы (естественных сообществ) в почвообразовательных процессах огромное значение имеет определение годичного прироста (спада) надземной и подземной массы растения.

В литературе многие исследователи на основании косвенных показателей условно принимают, что прирост и разложение корней (за год) в степных сообществах ровна 1/3 от общей массы. Другие же предлагают метод разностей, третьи - метод последовательного суммирования положительных разностей [15].

В наших исследованиях мы оценивали величины прироста по методике предложенной Волобуевым В.Р.[16] – дифференциального анализа кривой динамики растительных веществ в биогеоценозе, с помощью которого на основе экспериментальных данных можно определить прирост растительного вещества для каждого месяца. В данном случае установлено, что действительный прирост растительного вещества агрофитоценоза ячменя в данных условиях за вегетационный период соответственно вариантам N_{150} P_{150} K_{100} и N_{200} P_{200} K_{150} составил 129,3 и 129,5 ц/га.

Для выявления количества энергии, аккумулированной в приросте растительного вещества, необходимо знать данные о теплоте сгорания растительной массы. По данным калориметрических определений установлено, что в растительной массе ячменя в среднем (стебель, корни, листья, опад) аккумулировано 3957 кал/г сухого вещества [17].

Исходя из этих данных и темпов прироста растительной массы, можно охарактеризовать динамику накопления и расхода энергии во времени. Выявлено, что за вегетационный период накопление энергии в массе ячменя составила 517,2 и 518,0 кал/см^2 (соответственно вариантам). При этом, наибольшее накопление энергии приходиться на фазу восковой спелости 242,0 и 240,6 кал/см^2, а наименьшее на фазу всходов- 8,4 и 9,2 кал/см^2 (Таблица 1).

Для составления энергетического баланса необходимо рассчитать энергетические затраты на суммарное испарение. Исходя из средних значений величины затрат энергии на скрытую теплоту парообразования в 580 кал/см^3, определен общий расход энергии на испарение за 2016 г. в размере 29806 кал/см^2. При этом наибольший расход энергии на суммарное испарение приходиться на фазу полной спелости 5881 кал/см^2, а наименьшая к фазе всходов –928 кал/см^2.

Исходя из данных энергии аккумулированной в чистой первичной продукции и расход энергии на суммарное испарение, была определена основная величина затраты тепла на почвообразование, что в данном случае составила 30323 кал/см^2 (Таблица 1).

Сопоставив изменение величины энергии, расходуемой в агрофитоценозе ячменя на построение растительного вещества и испарение с величиной радиационного баланса, установлено, что в сумме за вегетационный период, агрофитоценозом использовано 0,67 (или 67%) всей наличной радиационной энергии, при радиационном балансе 51,92 ккал/см^2, рис.2.

- радиационный баланс, ккал/см^2
- полнота использования солнечной энергии агроценозом

Рис.2 Полнота использования радиационной энергии

Таблица 1

Энергетический баланс на основе данных по динамики растительной массы и суммарного испарения на агроценозе ячменя, орошаемых сероземно-луговых почв при дозах удобрений N150 P150 K100 (2016г.) N200 P200 K150

N	Показатели	1	2	3	4	5	6	7	8	9	10	11	12	Год
1.	Динамика растительной	24,3	28,5	32,7	37,8	114,4	153,9	-	-	-	-	-	-	391,6
	массы (надз. и подз., ц/га	22,2	26,7	30,0	35,8	96,2	135,4							346,3
2.	Прирост растительной	2,1	3,2	4,5	8,7	60,5	50,3	-	-	-	-	-	-	129,3
	массы, ц/га	2,3	4,0	6,1	6,4	60,2	50,5							129,5
3.	Накопление энергии в	8,4	12,8	18,0	34,8	242,0	201,2	-	-	-	-	-	-	517,2
	раст. веществе, кал/см^2	9,2	16,0	16,4	25,6	240,8	202,0							518,0
4.	Осадки, мм	30,6	17,2	43,5	23,4	21,8	3,7	0,0	0,0	2,4	9,8	22,5	28,7	203,6
5.	Суммарное испарение по													
	водному балансу, мм	16,0	29,3	46,0	67,4	91,0	101,4	60,2	32,4	20,9	19,3	16,3	13,7	513,9
6.	Расход энергии на сумм.	928	1699	2663	3909	5278	5881	3492	1879	1212	1119	945	795	29806
	испарение, кал/см^2													
7.	Затраты энергии на поч-	906	1712	2686	3944	5520	6082	3492	1879	1212	1119	945	795	30323
	вообразование, кал/см^2	937	1715	2684	3935	5519	5962	3492	1879	1212	1119	945	795	30324
8.	Относительная доля	0,90	0,75	0,67	0,68	4,38	3,31	-	-	-	-	-	-	1,71
	энергии от затрат	0,98	0,93	0,61	0,65	4,36	1,35							1,71
	энергии на почво-													
	образование, аккум.													
	в раст. веществе,%													

На основе данных по радиационному балансу и суммарному испарению предыдущих исследователей, включая и наши экспериментальные данные, также построена интегральная кривая полноты использования радиационной энергии агроценозом озимого ячменя. Следует отметить, что эта типовая среднемноголетняя величина на пространстве Кура-Аразской низменности за год составляет 0,55, при радиационном балансе 52,50 ккал/см^2. Обозначив общий расход энергии в агрофитоценозе ячменя на процессы, связанные с почвообразованием через Q и R – радиационный баланс, можно написать:

$$\mathbf{Q = 0{,}55\ R}$$

Опираясь на результаты вариационной статистики на агрофитоценозе ячменя, коэффициент корреляции между приростом растительной массы, радиационным балансом влажностью почв, составляет r = 0,94. В данном случае ошибка коэффициента корреляции составила mr = 0,17. Установлено, что для формирования агрофитоценоза ячменя влияние этих двух факторов достаточно высока (r^2=0,88%). Коэффициент корреляции (r) на агрофитоценозе ячменя определена для интервала влажности почвы в пределах от 22,7% до 26,3% (Таблица 2).

Таблица 2

Множественная и парная корреляционная зависимость между приростом растительной массы, радиационным балансом и влажностью почвы на орошаемых сероземно-луговых почвах Сальянской степи

Уравнение регрессии	r	mr	tr
У= 1,56X + 6,29 Z –176,83	0,94	0,17	5,53
Корреляционная связь между приростом растительной массы и радиационным балансом			
У= -3,71+2,76 R	0,89	0,23	3,87
Корреляционная связь между приростом растительной массы и влажностью почвы			
У = 9,75-11,24 Z	0,89	0,23	3,87

X – радиационный баланс, Z – влажность почвы, r- коэффициент корреляции, mr – ошибка коэффициента корреляции, tr – критерий существенности коэффициента корреляции.

При парных корреляциях между приростом растительной массы и радиационным балансом коэффициент корреляции r = 0,89, а mr = ±0,23, а при оценке зависимости продуктивности от влажности почв коэффициент корреляции также составил r = 0,89, при mr = ± 0,23.

ВЫВОДЫ

1. Установлено, что рост и развитие агроценоза озимого ячменя на 88% зависит от радиационного баланса и влажности почв, а оставшиеся 12%? Вероятно? зависят от физико-химических свойств почв, агротехники и др. факторов. А также для полного использования радиационных резервов, можно использовать земли для получения дополнительного урожая под сорго, рапс и кукурузы на силос.
2. Выявлено, что при увеличении доз минеральных удобрений и? соответственно технологических затрат, относительная доля энергии на почвообразование, аккумулированной в растительном веществе в обеих вариантах составила 1,71%, что? в свою очередь? уже может служить предпосылкой для внесения минеральных удобрений в дозе $N_{150}P_{150}K_{100}$ и уменьшению технологических затрат.

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Irrigation

CRITERIA FOR SOLAR RADIATION AND DEPENDENCE FACTORS DURING VEGETATION PERIOD FOR PROGRAMMING CORN CROP

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Annotation. As a result of the long-term supervision on Mukhrani meteorological station we had established parity between total solar radiation and the growing sums of active temperatures by results of researches, the parameters of solar radiation during the vegetative period fluctuate in the following limits: the sum of active temperatures 3245-3731^0 C, on the average 3731C. Radiation balance 46472-102651C kcal/sm^2, photosynthetic active radiation of the sun of 40200-46091 kcal/sm^2, on the average within the limits of 66286 kcal/sm^2.

These parameters quite provide the reception of a potentially possible top yield not only of corn, but also of other agricultural crops. It is necessary to note, that in some years April appeared in sufficient warm, but the high temperature mode of October has provided power balance during the vegetative period.

Key words: climatic factors, solar radiation, radiation balance, corn.

Climatic factors – solar radiation, radiation balance, solar photosynthesis active radiation (phAR), air temperature, sun of active temperatures, atmospheric precipitation provide reception of a potentially possible top yield not only for corn but also for other agricultural crops in Mukhrani District.

It's well known that an agricultural crop productivity is closely connected with the effective application of climatic factors, which in its part, requires reliable definition of its relevant complex (indices) indicators. Among climatic factors especially significant are: Solar radiation, radioactive balance, active radiation of the solar photosynthesis (phAR). Air temperature, the sum of active temperatures, atmospheric precipitation and so on [1,2].

It is also well know, that calculation of solar radiation and radiation balance is based on the meteorological observation data, obtained through measuring direct and dispersed radiation.

Direct and dispersed radiation belongs to the short wave part of the spectre. Common sum of the solar radiation input consist of direct and dispersed radiation [3].

There is certain parity for the ray energy input and outlet on the earth surface for any moment if time. According to our analysis difference of the energy or radiation balance can be expressed as the following:

$$R = Q_p + Q_g - Q_{an} - E_{at} - E_g \quad (1)$$

Where Q_p and Q_g are respectively direct and dispersion radiation Q_{an} – reflected radiation; E_{at} and E_g respectively atmospheric and earth long wave radiation.

According to the parity of inlet and outlet radiation, radiation balance can be positive or negative.

We have determined the dependence between the sum of Solar radiation and increasing sum of active temperature in Mukhrani Meteorological station through many years observation:

$$\sum R = a \sum t > 10^0 C + b \quad (2)$$

Link with the increasing sum of radiation balance and summed radiation is shown with analogue dependence,

$$\sum R = C\sum Q + a; \sum Q = \frac{\sum R - d}{C} \quad (3)$$

where a, b, c, d are empirical coefficients.

Reconsiling second and third equation we get:

$$\sum Q = \frac{a\sum t > 10^0 C + b - d}{C} \quad (4)$$

It's well-known from reference sources that phAR is 43% of direct radiation and 75% of dispersed radiation or approximately 50% of the total radiation.

Taking into consideration this, we can write:

$$phAR = \frac{a\sum t > 10^0 C + b - d}{2C} \quad (5)$$

We can also give phAr as the function of radiation balance.

$$phAR = \frac{1}{2}\sum Q = \frac{1}{2}\frac{\sum R - d}{C} = \frac{\sum R - d}{2C} \quad (6)$$

According to the carried out research phAR during vegetation period indices of Solar radiation fluctuates in the following ranges: sum of active temperatures 25÷30^{0}C, on average 30÷35^{0}C.

Tab. 1. Multi annual average data during vegetation period for the evaluation of Solar radiation and its depending factors on programming corn productively

№	Indices/Months	IV	V	VI	VII	VIII	IX	X
	1	2	3	4	5	6	7	8
1	Sum of active temperatures $t > 10^0 C$	374,4	508,8	588,9	689,0	659,3	530,1	368,6
2	Sum of radiation R	6856,8	11962,8	12904,7	131778,7	12224,5	9216,4	5472,7
3	Sum of phAR	6040,6	7156,2	28119,8	8463,9	7213,1	5399,6	3893,1
4	Increasing sum of active temperatures. $\sum t > 10^0 C$	374,4	883,2	1472,1	2161,1	2820,4	3350,5	3713,0
5	Increasing sum of radiation balance. $\sum R$	6856,8	18819,3	31724,0	44902,0	57126,5	66342,9	71815,6
6	phAr increasing sum.	6040,6	13196,8	41316,6	49760,5	56993,6	62393,2	66286,3

These indices completely provide not only corn to yield but also of other agricultural crops in the district. It is necessary to note, that sometimes April is not sufficiently warm, but the high temperature mode of Octomber provides power balance during the vegetation period.

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Охрана окружающей среды

ПОЛЕВЫЕ ИССЛЕДОВАНИЯ ИНТЕНСИВНОСТИ ЭРОЗИОННЫХ ПРОЦЕССОВ ПОЧВОГРУНТА НА УЯЗВИМОМ СКЛОНЕ В ДОЛИНЕ РЕКИ ГЛДАНИСХЕВИ И ЭФФЕКТИВНОСТИ СОВРЕМЕННЫХ ПРОТИВОЭРОЗИОННЫХ МЕРОПРИЯТИЙ

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Аннотация. В работе рассмотрены полевые исследования, проведенные на исследовательском интегрированном полигоне, в результате которых было установлено, что на контрольном участке протекают активные эрозионные процессы, что негативно отражается как на данном склоне, так и на экологическом состоянии водосборного бассейна реки Глданисхеви.

Иссследования, проведенные на опытных участках исследовательского интегрированного полигона показывают, что геоковер "Luffaeromat" более эффективен, чем геоковер "Jute Mat". Это подтверждается сравнением количества эрозированной массы твердого стока соответвующих опытных участков, а также динамикой роста растений, проросших на гековрах.

Ключевые слова: эрозия, исследовательский интегрированный полигон, геоковер.

Environmental protection

FIELD RESEARCHES FOR INTENSITY OF EROSIV PROCESSES OF SOIL AT VULNERABLE SLOPE OF GLDANISKHEVI RIVER VALLEY AND FOR EFFECTIVENESS OF MODERN ANTIEROSIV MEASURES

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Annotation. In the article are presented field researches implemented carried out at the investigated integrated polygon, as a result of which ascertained that at the controlled section active erosive processes take place, that negatively reflect as at the very slope, so at the ecological state of Gldaniskhevi River catchment basin.

Researches carried out at the experienced sections of investigated integrated polygon show that geo mat "Luffaeromat" is more effective than geo mat "Jute Mat". This is confirmed by comparison of quantity of masses sediment runoff washed out at the correspondent investigated sections as well as plants growth dynamic at the geo mats.

Key words: erosion, investigated integrated polygon, geo mat.

ВВЕДЕНИЕ

Для оценки уязвимости эрозионных участков (эрозионно-селевых очагов) в долине реки Глданисхеви и с целью разработки эффективного противоэрозионного геоковра были проведены полевые экспедиции, в результате которых был выбран сильно эрозированный склон необходимый для устройства исследовательского полигона.

ОСНОВНАЯ ЧАСТЬ

На выбранном склоне были взяты образцы грунта. Были проведены лабораторные исследования образцов грунта с целью определения его химических, физических и механических свойств.

В результате химического анализа установлено, что почвогрунты опытного полигона сильно эрозионной тенденции.

Также были определены физические и механические свойства почвогрунтов и их гранулометрический состав.

Результаты лабораторных исследований указвыают на то, что склон, сложенный из быстро набухающих грунтов, должен быть защищен от формирования поверхностных потоков во время интенсивных осадков.

На выбранном нами уязвимом склоне был устроен исследовательский интегрированный полигон для определения интенсивности эрозии почв и эффективности противоэрозионных мероприятий (см. фото 1).

Фото 1. Общий вид исследовательского интегрированного полигона

На I опытном участке исследовательского полигона на поверхности эрозированного почвогрунта укладывается геоковер „Jute Mat", изготовленный из натурального материала. Поверхность почвогрунта, расположенная под геоковром засевается семенами райграса.

На поверхности эрозированного почвогрунта II опытного участка укладывается, предложенный нами геоковер „Luffaeromat" [13], в волокнисто-лабиринтном слое которого помещается смесь почвы и семян райграса толщиной 0,5 см, после чего орошаются высеянные в оба геоковра семена.

С технической точки зрения геоковер „Luffaeromat" можно использовать на склонах с уклоном до 60^0 против эрозии почвы и для восстановления биомногообразия.

В середине полигона устраивается контрольный участок для изучения динамики эрозии почвы. На нем проводятся исследования для изучения интенсивности эрозионных процессов (изменение параметров промоин, смытая со склона эрозионная масса).

Возможности исследовательского интегрированного полигона, предложенного нами, уникальны, так как на нем одновременно исследуется динамика эрозии почвы, а также протвоэрозионная эффективность и возможность восстановления биомногообразия двух различных геоковров.

С помощью плювиографа регистрировалось количество, продолжительность и интенсивность осадков.

Твердый и жидкий сток, сформированный на опытных и контрольном участке, стекает через наносоприемник, трубы в небольшие резервуары, вставленные в большие резервуары. Объем стока измеряется специальными измерительными цилиндрами.

После измерения объема твердого и жидкого стока, сформированного на исследовательском полигоне производится отделение твердого стока, высушивание в специальной сушилке 4 часа при температуре 105^0C, потом взвешивание и соответственно определение веса эрозированного почвогрунта.

Кроме определения веса эрозированного с контрольного участка почвогрунта, фиксировалась динамика роста растений на геоковрах непосредственными измерениями.

Исследования на исследовательском интегрированном полигоне проводились с 19 марта по 30 июня 2017 г. (104 дня) и были получены данные об эрозионных процессах, протекающих на контрольном участке, а также об эффективности геоковров, смонтированных на опытных участках.

На фото 2 отчетливо видно, что на геоковре „Jute Mat" растений взошло меньше, чем на геоковре „Luffaeromat", а также масса твердого стока, с I опытного участка больше, чем со II опытного участка, что на данном этапе подтверждает эффективность протвоэрозионного геоковра „Luffaeromat" и соответственно его возможности восстановления биомногообразия на уязвимом склоне.

Для подтверждения надежности проведенных исследований полученные данные были сравнены с данными, полученными в результате расчета по зависимости, определяющей количественные показатели эрозии почв, разработанной академиком Ц.Е. Мирцхулава [7].

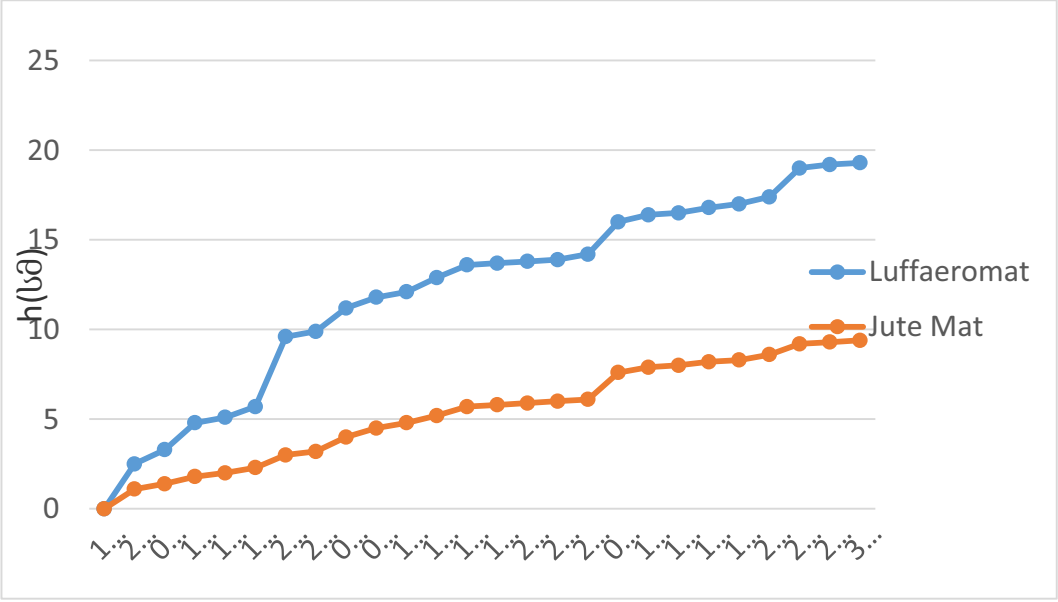

График 1. Динамика роста растений проросших на геоковрах

Фото 2. Вид исследовательского полигона через 104 дня после монтажа

Количество почвы, смытой с участка, ширина и длина которого от водораздела склона до конца эрозированной части составляет определенную величину, которую можно рассчитать по следующей формуле[1]:

$$q_{x_2 T} = 11 \cdot 10^{-3} \gamma \omega d \left[\frac{308 (\sigma n_0)^{0,6} i^{0,7} m_1^{1,4} I^{0,6} x_2^{1,6}}{V_{\Delta доп}^2} + \frac{13 \cdot 10^{-6} V_{\Delta доп}^{3,32}}{(\sigma n_0) i^{1,16} m_1^{2,32} I} - x_2 \right] \frac{T}{x_2}$$

где γ – объемный вес почвогрунта в полном водонасыщенном состоянии, т/м^3;

d – средний размер агрегатов (оторванных отдельностей), м; [1].

$V_{\Delta доп}$- допускаемая неразмывающая донная скорость водного потока м/с;

ω – средняя частота скорости пульсации, которая определяется по числу Струхаля რომ ω=0,73 V:H (V- средняя скорость склонового стока, H- глубина стока). При отсутствии данных специальных исследований ω=10 I/c;

I – средняя интенсивность осадков, м/с;

T – продолжительность избыточных осадков или время в с., в течение которого слой выпавших осадков больше слоя инфильтрации;

σ – коэффициент стока;

n_0 - коэффициент гидравлического сопротивления (коэффициент Маннинга);

i – средний уклон поверхности, равный отношению разности уровней к заложению откоса;

x_2 – расстояние от водораздела склона до конца эрозированной части склона, м;

m_1 - коэффициент, учитывающий отклонение характера склонового стока от принятого в расчетной схеме движения прямого слоя воды по А. Н. Костякову [8], коэффициент, характеризующий бороздчатость поверхности склона, концентрацию стока.

Таблица

Данные полевых исследований и соответственно величины, полученные по зависимости определяющей количественные показатели эрозии почв, разработанной академиком Ц.Е. Мирцхулава

№	Даты экспериментов	Данные полеых иссследований, твердый сток, кг	По формуле Ц.Е. Мирцхулава, твердый сток, кг
1	19.03.2017-30.06.2017	**∑ 1,182**	**∑ 0,862**

[1] для установления общего количества смыва, полученный результат нужно умножить на площадь склона (x_2b), где b - ширина склона

Из таблицы видно, что данные полевых экспериментов и величины, полученные в результате расчета с достаточной точностью приближены, на основании чего можно заключить, что иссследования, проведенные на устроенном нами исследовательском интегрированном полигоне надежны.

ВЫВОДЫ

В итоге, можно заключить, что на контрольном участке исследовательского интегрированного полигона протекают активные эрозионные процессы, что негативно отражается как на данном склоне, так и на экологическом состоянии водосборного бассейна реки Глданисхеви.

Иссследования, проведенные на опытных участках исследовательского интегрированного полигона показывают, что геоковер "Luffaeromat" более эффективен, чем геоковер "Jute Mat". Это подтверждается сравнением количества эрозированной массы твердого стока соответвующих опытных участков, а также динамикой роста растений, проросших на гековрах.

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Hydraulic engineering and irrigation

APPROACH TO IRRIGATION ADDAPTATION UNDER CLIMATE CHANGES IN RUSSIA

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Annotation. The mean annual air temperature in Russia has increased by 1° C over the past 100 years and by 0.4° C in the last decade of the 20th century. According to forecasts of The Main Geophysical Observatory, the increase in temperature by 0.6°C should be expected in the South of Russia by the end of the XXI century (http://rosnauka.ru/publication/844). In the case of aggressive anthropogenic scenario (RCP 8.5) the average-temperature in all parts of our country will be increased by 5-8°C. Climate change directly affects agriculture and it is one of the most serious risks to the prosperity of the country. Temperature growth will result in increased areas of agricultural land, and drought and consequent reduced yields of some crops. The increasing frequency of extreme weather events leads to lower yields and decreases agricultural sector in GDP.

To ensure the adaptation of agriculture and reclamation under changing climatic conditions water availability for irrigation plays a significant role. Irrigation was developed in the South of the European part of Russia with the aim of providing the population with rice, vegetables, cereals and fodder crops. However, since the early 90-s the reduction of irrigated area was caused by the processes of the national economy restructuring. According to the Ministry of Agriculture, the irrigated area has decreased by 32%. This was caused by the deterioration of the technical condition of irrigation systems and land reform. Only large irrigation facilities and systems belong to the Federal account balance, while on-farm network passed to the subjects of the Russian Federation and some farms that were not ready to use reclaimed lands as well as to operate the drainage network efficiently.

In productive years more than 20% of all agricultural commodities of Russia are produced in the Southern Federal district (SFD), a major part of the irrigated lands being located there too. Water consumption in agriculture is stable and ranges from 30 to 55% of total water consumption in the country over the last 15 years, which should be considered when evaluating water availability and water pollution caused by drainage flow and runoff from irrigated agricultural lands. Therefore it is important to estimate the impact of the global warming and especially the adaptation of agriculture and irrigation under changing climatic conditions in this region. This requires valid prediction of changes in water availability of the territory on the basis of existing models of soil – climatic zoning and the possibility of crop productivity control for major crops.

Key words: global climate change scenarios, humid, arid, precipitation evaporation ratio, productivity, irrigation, drainage.

INTRODUCTION

Agricultural production obtained in the irrigated land which occupies 17% of the arable land provides with food almost half of the world population. In the late 80s 15-17% of the gross output of crop production was obtained within the reclaimed land, which comprised 7, 9% of the arable land In the Russian Federation. Most of the agricultural land of the Russian Federation is located in the area of risky agriculture - about 80% of arable lands are located in the zone of insufficient moisture, and more than 10% are in the zone of

excessive moisture. In dry years it is almost impossible to realize the potential of high-yielding crop varieties, intensive agricultural technologies and adaptive-landscape systems of agriculture without carrying out hydr-otechnical reclamation. The situation is dramatized by the frequent natural disasters in the form of droughts and extreme temperatures that have been observed in the recent years. Global warming is the most obvious in the territories between 40-70 degrees of the northern latitude (Ivanov, 2003; Kiselev, 2011). According to some climatic models global warming by 1.4 to 5.8°C is expected by 2100 (IPCC, 2007). Global processes are accompanied by the changes in precipitation, which may cause deteriorated moisture mode in the soil and more frequent droughts in Russia (Ivanov 2003).

According to the observation data of the Russian meteorological stations, average annual air temperature has increased by 1° C in the last 100 years and by 0.4° C in the last decade of the 20th century (it is significantly higher than the world average). According to the forecasts if the growth of the temperature remains the same the climate of Russia will become warmer by nearly 2 degrees by the middle of this century. There is an increase in the number of days with abnormally high rainfall (> 10 mm) in winter, and on the contrary their reduction in summer in most parts of the North Caucasus and southern Federal districts in Russia. The number of days without precipitation in winter is increasing in most parts of the country (Natural Resources of Russia, 2014).

While, the growth of the average annual temperature is common to all regions of Russia, climate change is uneven for different regions and seasons due to the large territory and the diversity of the natural conditions. Average mean annual air temperatures in Russia are shown in the figure 1.

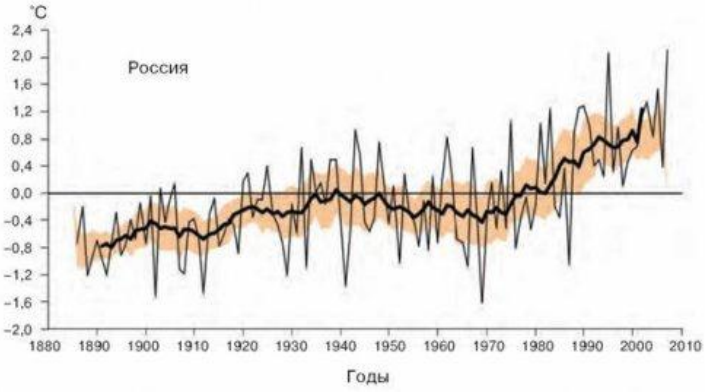

Figure 1. Averaged anomalies of mean annual air temperature in Russia (http://rnns.ru/176117-anomalnoe-leto-2010 beda-tolko-nachinaetsya.html)

The change in the average annual surface air temperature in Russia is shown on the chart. The thin line shows the results of observations, the thick line - a gradual course of the air temperature. There are considerable inter-annual fluctuations in average temperature against the background of a steady rise in temperature over the past 35 years.

Forecast of the climate changes in Russia [A1FI scenario (HadCM3 model], proposes fast increase of CO_2 in the atmosphere. The duration of the vegetation will be prolonged by 26 days; some climatic parameters will be increased: precipitation - by 26 mm, evaporation - by 40 mm, evapotranspiration - by 141 mm. Regional climate scenario on the Main Geophysical Observatory in St. Petersburg describes the possible climate changes according to the humid scenario (model MRK GGO). The difference in the air temperature increase in January is 0.40 ^{o}C for the compared scenarios, whereas the increase in the July temperatures is 5.1 - for the arid scenario and it is 1.30^{o}C - in the case of the humid scenario.

Climate change has a direct effect on the agriculture. The increasing frequency of the extreme weather events leads to the lower yields and the weaken role of agricultural sector in GDP. In 2010 during the unprecedented drought a decrease in production led to the slowdown in the development of the rural

economy in Russia. A total 895 areas in 43 regions in Russia suffered. Crops were damaged over more than 13, 3 million hectares (Mha), which are 29 % of the area of crops in these regions. Production of grain fell by 35 %; the country lost almost 15 M tons of grain, fodder - 36 M tons of feed units (hereinafter - t. f. u.), 1.9 M tons of vegetables. At the same time, fodder crops productivity under irrigation has decreased by 12 % only.

Irrigation and drainage projects play an important role in providing planned crop yield. Nowadays reclamation and water economy of Russia is presented as: 9.1 Mha of reclaimed land, including 4.3 Mha of the irrigated and 4.8 Mha of drained land. Reclaimed land occupies only 5% of the total arable land; they produced 70% of vegetables, more than 20% of coarse and succulent fodder, all rice, a significant amount of other plant products. The distribution of the reclaimed lands in the administrative districts of the Russian Federation is shown in the Figure 2.

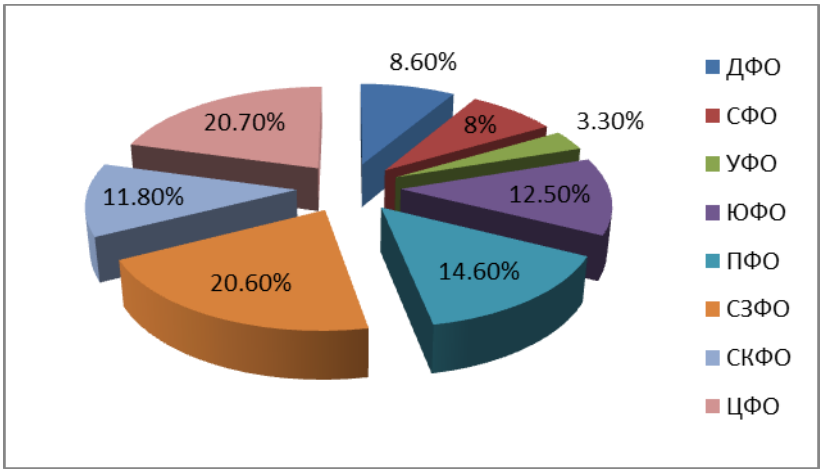

Figure 2. The distribution of the reclaimed land in the territory of the Russian Federation [5] (ДФО - Far Eastern Federal district; СФО - Siberian Federal district ; УФО - Ural Federal district ; ЮФО - Southern Federal district; ВФО – Volga Federal district; СЗФО - North-Western Federal district; СКФО – North Caucasus Federal district; ЦФО - Central Federal district)

The objective of the study is to estimate the probable climate changes, their impact on crop productivity, agricultural sector adaptation to the climate changes and the role of reclamation in the ensuring of food security in the changing climatic conditions.

Figure 3 shows a diagram of grain yields from 2000 to 2012 in Russia as compared to other countries in the world.

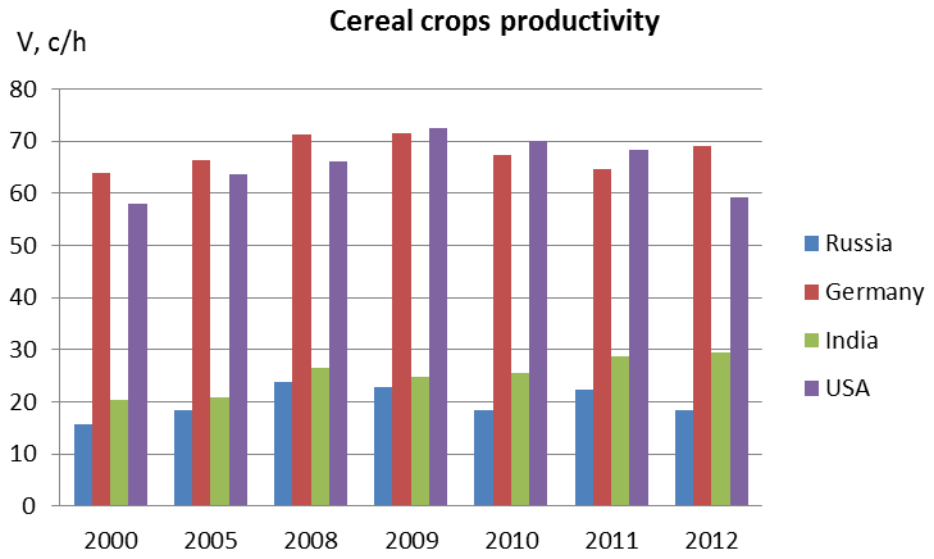

Figure 3. Yield of grain crops in Russia in comparison with other countries of the world [Department of Amelioration, 2013, Russian Academy of Agric. Sciences, 2014.]

The diagram shows that the yield of grain crops in Russia is lower than in many countries in 1.5-2 times in average. Climatic changes may deteriorate the existing status.

METHODS

Mathematical models and approaches on the accounting of the climatic factors when estimating requirements in land reclamation development

The technology has been proposed to estimate possible climate changes and the probability of the requirements in the development of land reclamation. Figure 4 shows the block diagram of the used models, which allows carrying out the above estimations.

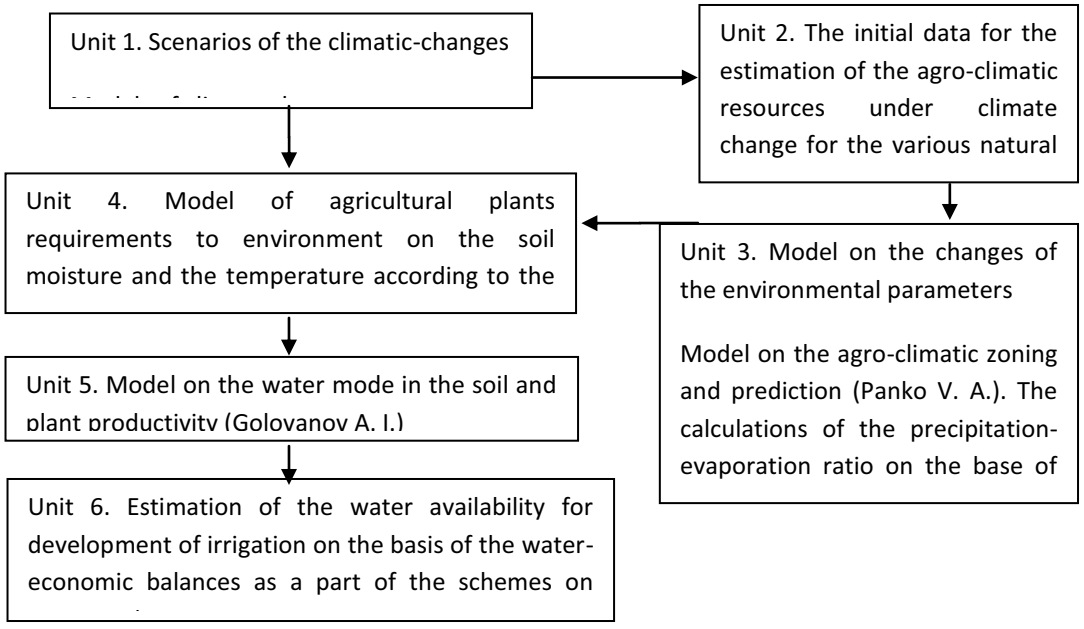

Figure 4. Block diagram of the applied models on accounting climatic parameters to estimate the necessity of the land reclamation development [8,11]

Calculation of the productivity of agricultural crops depending on the soil moisture to according the phases of plants development

At the first stage the change in the productivity of agricultural crops depending on the soil moisture according to the phases of plant development on the model of Shabanov V. V. is calculated. [11]

$$U_W = U_{\max} \sum_{i=1}^{n} \alpha_i k_{W_i} \ , \tag{1}$$

where: UW – crop productivity at the given soil moisture; Umax – maximum possible crop productivity at the optimum moisture content in the root zone; - contribution of the ten-day period into crop productivity (depends on the stage of crop growth); n – the number of the ten-day periods in the vegetation period; - coefficient, determining productivity reduction due to soil moisture deviation from the optimum moisture content in the given ten-day period i:

$$k_{W_i} = \left(\frac{\theta_i}{\theta_{opt_i}} \right)^{\gamma_i \theta_{opt_i}} \left(\frac{1-\theta_i}{1-\theta_{opt_i}} \right)^{\gamma_i \left(1-\theta_{opt_i} \right)} \tag{2}$$

where

$$\theta_i = \frac{W_i - W_Z}{m - W_Z}; \ \theta_{opt_i} = \frac{W_{opt_i} - W_Z}{m - W_Z}$$

W_i – mean soil moisture in the root-inhabited zone for the given ten-day period ; W_{opt_i} - optimum moisture content in the root zone; m – soil moisture which is appropriate to the total moisture capacity; W_Z - wilting point; γ - coefficient , taking into account crop reaction to the soil moisture deviation from the optimum.

The requirement in the different types of land reclamation is defined using the bio-climatic technique based on the comparison the need of agricultural plants for soil moisture over the phases of development of plants in the estimated years for the different scenarios of climate change.

Techniques on the estimation if the precipitation-evaporation ratio

The second step is estimation of the moisture ratio (Ky), which is one of the main criteria affecting the productivity of agricultural land. The areas of land reclamation under climate change are defined using this ratio. Precipitation-evaporation ratio is the ratio between the amounts of precipitation falling in a given area which is divided by evaporation or air temperature, which determines evaporation. [8]

$$Ky=O/ E*To, \tag{3}$$

where O – sum of the precipitation for the period of crops vegetation mm; To – sum of the average daily temperatures (above 0o C); E - empirically determined coefficient 0,177 using to convert heat energy into evaporativity (degrees of temperature into mm of evaporativity).

Precipitation-evaporation ratio is calculated in relation to the climatic optimum which corresponds to the maximum productivity of the grass-forb crops in chernozem soils, or to the relative optimum in agriculture, corresponding to the maximum productivity of agrocoenosis.

Productivity of the zonal soils and crop yields, expressed in the grain equivalent (t. g.u/ha) are calculated at the nest step by the formula (Ponko, 2012):

$$V = K_t \cdot K_{фар}\left(e^{\pi \cdot k_o \cdot k_y} - 1\right), \text{если } k_y < 1,$$
$$V = K_t \cdot K_{фар}\left(e^{\pi \cdot k_o \cdot (1/k_y)} - 1\right), \text{если } k_y > 1 \quad (4)$$

where Kt– heat provision factor weighted with the factor of the photosynthetic active radiation Kfar; Kh – humidity factor relatively to the natural optimum, which corresponds to the maximum natural soil productivity at Kh =1,0; constants e = 2,718…, = 3,14…; coefficient of development ko which equals 1,0507 or (1,0166) (Ponko, 2012).

The change in the precipitation-evaporation ratio according to the scenarios of the climate change for the southern part of Russia calculated by different techniques as well as production potentials of crops are given in table 2.

Table 2. The estimated and forecast values of the precipitation-evaporation ratio for the South of Russia

Estimation techniques	Without climate changes	Humid scenario of the climatic change	Scenario of climatic change
Technique 1 (Ponko V.A., 2012)			
Ky	0,6-0,8	0,73-0,97	0,52-0,7
V, t.g.u. /ha	3,6	3,63	2,03
Technique 2 (Ivanov A.L., 2003)			
Ky	0,6	0,62	0,42
V, t.g.u. /ha	3,2	3,6	1,99
The required value of the precipitation-evaporation ratio	1,4-1,5		
The required production potential, t.g.u. /ha	6,2		
Actual mean productivity of cereals 2006 по 2014	2,15		

Note: V –production potential, Ky – precipitation-evaporation ratio, t.g.u. /ha (tons of grain units per hectare).

As can be seen from the table 4, forecast values of precipitation-evaporation ratio and the productivity of cereals, which were calculated by the model of Ponko V. A, and by the formula of Ivanov A. L., are decreased in the arid scenarios of climate change. In arid scenarios of climate change the precipitation-evaporation ratio is reduced by 12-36%, while the productivity of grain is reduced up to 37% compared to the current level.

RESULTS

Productivity of crops and probability of the necessity of the land reclamation development

Calculations of productivity of agricultural crops were carried out for two scenarios of climate change according to the phases of plant development. To estimate the necessity for land reclamation the corresponding values of soil moisture were shown on the integral curves of the normal distribution of soil moisture, both actual and projected for the arid and the humid scenarios of climate change. The calculations were fulfilled for the Southern part of Russia.

Arid scenario

The results obtained on the estimation of the probability of reclamation development in the case of arid climate change scenario are shown in table 3.

Table 3. The probability of the optimal conditions and the need for reclamation for the current conditions (P1) and the arid scenario (P2) according to the phases of plant growth and in average for the vegetation period

Phases of the plant growth		1	2	3	In average
Optimal	P^1_{opt}	22	57	32	37
	P^2_{opt}	11	47	39	32
Irrigation	P^1	78	28	0	35
	P^2	89	46	8	48
Drainage	P^1	0	15	68	28
	P^2	0	7	53	20

When estimating the probability of the optimal conditions and the reclamation the probability of the optimal conditions is reduced (up to 11 %), the probability of irrigation development is increased (up to 18 %), however, the probability of drainage is reduced (up to 15 %). This may change the water-economic balance, because the frequency of irrigation, and therefore volumes of the water withdrawals will be increased.

Humid scenario

To estimate humid scenario of the climate change actual data which correspond to the expected Ky in the Central part (Station Kaluga) 0.87 were taken. Appropriate statistical analysis of the meteorological parameters (precipitation, air temperature, air humidity deficit) and evaporation for 47-year period (1966-2012.) were done. (Poddubskii, 2015).

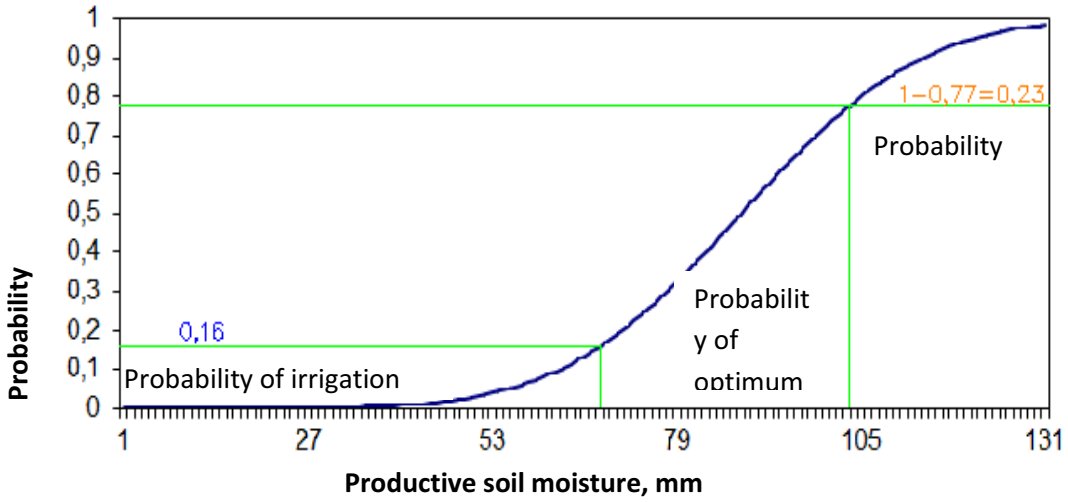

Figure 5. The Integral curve of probability change of the reclamation requirement in the cultivation of grain crops in the humid scenarios of climate change

At minimum optimal level of productive moisture in the soil probability of irrigation is 16%, while the maximum values in the optimal range of greater than 89 mm drainage probability is 23%. Irrigation probability for spring wheat is up to 16...22%. In average at the cultivation of spring wheat the probability of irrigation is 19...22%, and drainage is 6-10% according to the humid scenario of the climatic changes.

Substantiation of the required levels of moisture for different zonal-provincial soils of the Southern part of the Russian Federation

Having calculated the probability of the irrigation development in the arid scenarios of the climate change and the decrease in grain crops productivity depending on the precipitation-evaporation ratio the required soil moisture for the different zonal-provincial soils in the Southern part of the Russian Federation was estimated (Fig.6).

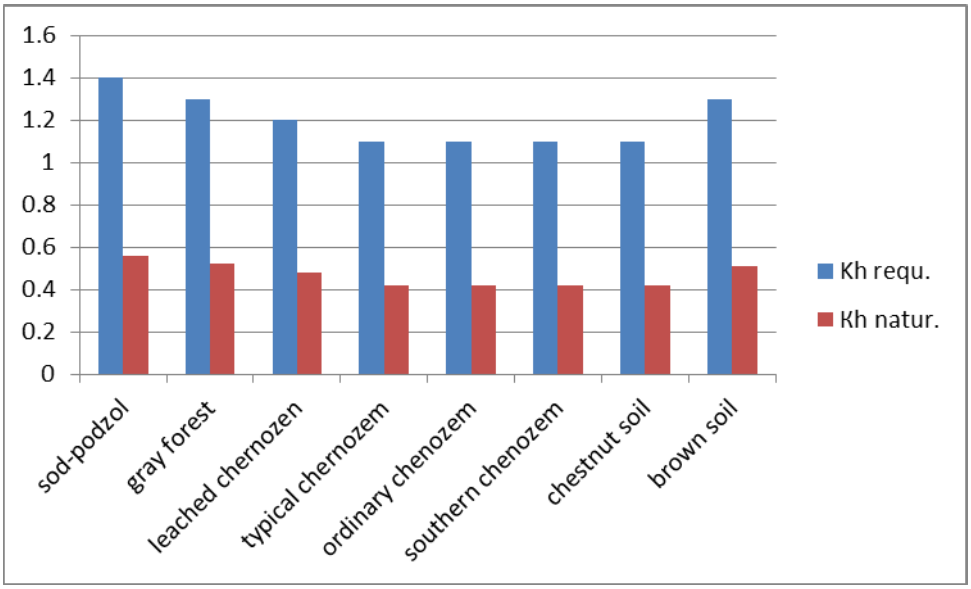

Figure. 5. The required values of precipitation-evaporation ratio in the zonal soils of the Southern part of the Russian Federation (note: Kh nature. – humid scenario , Kh req - required values

In the case of climate change in the Southern part of Russia according to the arid scenario, it will be necessary to increase the area of irrigated land up to 213940 hectares, which is by 18% more than the existing area – 180924 hectares.

RESULTS AND DISCUSSION

To ensure food security of Russia in conditions of climate change under different scenarios the development of land reclamation is required. The Government' Program on land reclamation is aimed at solving the issues of creation adaptive conditions in the agricultural fields through integrated land reclamation to provide efficient and sustainable use of agricultural lands and natural resources regardless of climate change and anomalies.

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Water management

THE MAIN DIRECTIONS OF THE WATER SUPPLY IMPROVEMENT FOR THE AGRO INDUSTRIAL COMPLEX

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Annotation. The basic effects of climate change on agricultural water supply in some regions of the country are considered. The possible ways of water supply improvement and rational use of water resources are suggested.

Key words: water resources; agriculture; global climate change, irrigation, potable water supply.

Water resources are very important for planning and development of the regions as well as solving social and environmental problems.

According to the forecasts, global climate change will lead to aridity in the south of the European part of Russia and in the Western Siberia.

One of the main issues is to provide the security of the population and regional economies, including agricultural production, water quality and the volumes of water supply.

The computer simulations, having been considered in the framework of the fifth assessment report of the intergovernmental panel on climate change with the participation of Russia (IPCC), showed that the average global temperature will be increased under all scenarios of radiation exposure in the 21st century.

Russia is the world region where the climate warming will greatly exceed the average global rates in the 21st century [1].

Changes are expected in the all components of climate: radiation, temperature, hydrological modes, etc.

According to the forecasts, during the 21st century a steady tendency to the increase in precipitation both in winter and in summer is expected, however the forecast precipitation decrease can reach up to 25% in the southern regions of Russia by the end of the century.

The forecast climate changes have already confirmed by the long-term field studies [2].

The underground feeding of the rivers and the increased river flow are detected in the European part of Russia (EPR) in winter, as well as the trend of increasing aridity in the south.

It is required to note significant changes in the river flow of the Don: its discharge was by 40% lower in 2012 than it was in 2008 [3].

Nowadays, according to expert estimates, the water resources of the most rivers of the European part of the country – the Don, the Kuban, the Samur, the Volga, the Ural, etc. – are almost completely exhausted, while the river flow of the Sulak, the Terek, the Irtysh (in the Asian part) are used by three quarters or more. About 6.3 million people live in the areas with local water shortages.

The increasing water supply of the territories, including agricultural purposes, and the regional climatic changes are the reasons for the specific measures development.

A positive role in situation stabilization belongs to the reservoirs with seasonal or multi-year regulation of the river-flow, which accumulate a significant portion of the river flow of the major rivers in the country.

However, the long lifetime of the most of them has led to their significant sedimentation, reduction in the capacity, loss of the efficiency [4].

At the same time, in the last three decades, the annual inflow to the reservoirs of the Volga-Kama cascade was increased by 8-26% in summer, and by 70-120% - in winter due to the increased precipitation in the Volga basin.

To ensure rational use of the water resources the restoration projects of the capacity and the revision of the principles of water management of the reservoirs are required, where primary importance is to be given to energy generation [5].

In this case, favorable conditions can be created, especially to increase drinking water supply, water availability of the agricultural land, power engineering and shipping [6].

Environmental aspects of agricultural water supply are of great socio-economic importance.

Issues on drinking water supply of normative quality for the rural population are acute in many regions now.

According to the state monitoring of the water bodies 16% of the rural population use drinking water with mineralization from 1 to 5 g/l and hardness - from 7 to 15 meq/l or higher, and 19% - underground water which contains iron and manganese exceeding the maximum permissible concentration (mpc) without proper treatment in Russia in 2014. 16.4% of underground water and 36.8 % of surface drinking water sources did not meet sanitary-epidemiological standards [4].

The sustainable drinking water supply in agriculture should be based on the development of the centralized water supply and sanitation.

Urgent provision of water purification systems and water treatment plants to supply the population with drinking water is required.

To use of water treatment in rural areas is determined not only by the possibility of anthropogenic pollution of surface water, but also by the extensive development of the territory in the zones of the anomalous chemical composition of groundwater due to the chemical composition of water bearing rocks and ion exchange processes in the system "water-rocks".

A number of major administrative regions of Russia, including Novgorod, Yaroslavl, Astrakhan, Volgograd, Kurgan, Omsk, Tyumen district, a large part of the Rostov district, Stavropol region, the Republic of Adygea, etc. are not provided with conditioned fresh groundwater in sufficient volumes for these reasons. [4].

In many regions, however, groundwater must be an additional source of water supply [5,6].

However, at present, the degree of the groundwater resources use remains low - about 15% in the country as an average.

To stabilize the situation it is necessary to conduct works on groundwater prospecting and exploration development in the new areas, which of course is associated with certain, but necessary economic costs.

In connection with the strengthening of water shortages in the southern regions a rational redistribution of the river flow is required to ensure, first of all, drinking water supply.

The total amount of existing and proposed water transfers in the world is about 595 billion m3/year for 35 countries.

The background for the redistribution of the part of the river flow is necessary to overcome the shortage of water resources of the adequate quality, to improve social conditions, to increase employment of population in the Rostov, Astrakhan, in Volgograd district, in the Republic of Kalmykia, in the Republic of Crimea and in many other regions of the Russian Federation. [7].

The detailed scientific and technological study of the issue may determine the necessity and sufficient conditions as well as environmental constraints to justify the redistribution of the river flow taking into

account that the guaranteed provision of population with quality drinking water is one of the priority public policy.

Climate change in Russia he have already had different effects on the agricultural production in different regions in the period from 1976 to 2012.

Favorable factors caused by climate warming, are increase in the heat provision of the agricultural crops, increase in the average temperature during the cold period of the year. Global relative rate of photosynthesis has increased by 5-10% as the result of O2 increase in the atmosphere.

The duration of the growing season has been increased; the primary productivity of the plants being increased at a rate of 1.17% per year in Northern Eurasia in the 1982-2000[1].

The efficiency of water use in agriculture is of particular importance.

Unfortunately, as a result long-term inefficient water use due to large seepage losses from canals, high irrigation rates and on-field infiltration losses, etc. more than 70% of irrigated land is under unsatisfactory condition now. [6].

According to estimates of the further warming the present moisture and level of soil fertility should lead to increased bioclimatic potential and productivity of grain crops in Russia by the middle of 21st century.

To maximize the use of bioclimatic potential, the necessary adaptation of agriculture to the new conditions, and accordingly, changes in the principles of water use in agriculture are required.

Warming leads to the need for an increase in the agricultural areas in the Central and the North-Western part of European Russia, which will require rational water supply, irrigation of lands through the use of modern drainage and irrigation systems as well as improving techniques and technologies of irrigation with focus on water conservation.

First of all one must restore the reclamation fund, improve farming systems and the structure of crop rotation in relation to the new climatic conditions, development of a system of measures to combat pests and plant diseases and other measures.

Water conservation is one of the key directions in the water management in agriculture [8].

More than half of irrigation systems (2.4 million hectares) need reconstruction and technical re-equipment, taking into sustainable use of water resources [9]. The improvement of the irrigation and drainage systems, water supply and sanitation, increase in drainage water reuse and others are among the priority tasks.

Measures include upgrading the main production funds, including protection and rational use of water resources.

The degree of depreciation of the main production funds in the water industry is practically unknown (no statistics), but it is estimated to be about 50%, depreciation of irrigation and drainage systems is up to 70% [9].

For the development of the water probability in agriculture and other sectors of the economy in the coming economic and climatic conditions at the international level, it is necessary to determine forms of cooperation in the field of transboundary river basins water use, to synchronize the legal aspects of the water use, to ensure integrated management of water resources based on the existing experience.

In general, to determine the principle directions of water sector development in the country it is necessary to consider the development of the General schemes of integrated use and protection of waters of the Russian Federation on the basis of basin schemes (SIWRM).

In the short term period some of the above mentioned issues are to be settled in the implementation process of relevant policies and targeted programs [9, 10].

Successful implementation of water management measures is determined by the scientific and practical validity of decisions, which involve the necessary scientific research of the appropriate level, raising the issue of actually required funding for scientific research works.

Thus, among the directions of water sector development and measures to improve water availability in APK the following objects are considered:

-adjustment of the principles of water use in agriculture in relation to adaptation to climate change in the regions;

- revision of the principles of water management for the reservoirs with a priority of drinking water supply and agricultural water supply;

- strengthening measures to ensure agricultural water supply, water treatment to provide drinking water supply to the population regardless of the water quality in the water source, the development of the centralized water supply and sanitation;

- strengthening the role of water conservation and efficient water use in agriculture due to the upgrading of drainage, water supply and sanitation systems, increase in drainage flow reuse etc.;

-consideration of alternative water sources in regions with water scarcity, including desalination of sea and underground saline water, the rational redistribution of the river flow;

- the revival of the General schemes of the integrated use and protection of waters in the Russian Federation;

- identify forms of cooperation in the field of transboundary river basins, to synchronize the legal aspects of water use, to ensure integrated water resources management, based on the expertise

It is not possible to plan the increase in the efficiency of agriculture, as well as high production of the main crops regardless of natural conditions without the above and other important measures application.

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Environmental protection

THE EFFECT OF THE BOUNDED MUDFLOW ON THE REGULATORY BARRAGES

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Annotation. The expected risks of mud flow impact on constructions confirm that there are both a loss of flow stability and a change in its hydraulic regime. An excited zone and a wave against the current are created.

For the case of a tied-up flow passage in a mudflow duct with rectangular cross section, theoretical formulas of the calculated parameters determining the breakthrough of the flow stability are derived. In addition, their changes, graphic illustrations in connection with the rheological characteristics are given. The distance between the counter-mudflow barrages has been determined; Theoretical calculated dependences under the conditions of the appearance of a wave against the flow and downstream were derived.

Key words: hydraulic regime, flow, mudflows.

INTRODUCTION

Under the influence of the tied-up mudflow on natural or artificial barriers, the change in its movement regime differs significantly from those having analogous parameters of sediment flows and water flows.

Due to the great destructive force, it becomes necessary to transfer such flows into a calm flow regime, which is associated with the holding of reinforcing measures of quite significant areas against the deformation of the channels. Based on this, for the purpose of switching the flow mobility to a quiet regime, very often artificial solutions are used, in particular, to the construction of barrages. After this action, a jump or wave is created, where a significant loss of energy takes place and this process is directed to suppress excess energy of the stream. Based on this, the problem is also interesting from the point of view that those calculation parameters that have a special role in the correct arrangement of the counter-mudflow constructions in the planned scheme would be determined.

In general, when assessing the impact of such flows on hydraulic engineering, the determining criterion is the average speed. Possible risks of stability loss as a result of changes in traffic are fully ignored.

Based on the above, among the flows the tied-up mudflows are characterized by considerable transportability. In the case of an impact on the opposing barrier, it is very interesting what form the counterbalancing inclination in the head and tail water of the duct will take. When the balancing inclination is on the inclination of the free surface of the moving stream, there will be an overflow to the construction and vice versa.

The abovementioned circumstance has a significant influence on the solution of problems in the planning of counter-mudflow measures.

THE MAIN PART

The expected risks of mudflows and the peculiarity of the impact on various types of objects are related to the defining characteristics of the possibilities of stopping their formation [1, 2, 3, 4, 5].

Depending on what objectives the protection from mudflows sets, in the process of issue resolving, a special place is given to the tasks: determining the magnitude of the propagation of the perturbed zone arises in the flow, formed by construction, which functions on the dynamic load; Determination of the inclination balancing of the flow free surface.

Since each of the specific questions here depends on the type of mudflows, when their energy is attenuated, a special attention is given to the type of construction.

Existing approaches prove that, when regulating mudflows by the engineering measures a loss of its stability due to flow on the construction takes place; the hydraulic regime of the flow changes.

By uprising of a direct or inverse wave, the free surface of the stream takes a characteristic shape and it is known as a balancing inclination; i.e. under the influence of construction on the flow, a loss of stability of the flow and the wave formation takes place.

Arises in the result of the counter-mudflow barrier with a rectangular section the impulse of the wave force on the basis of the equation of momentum can be expressed by the following dependence:

$$\Delta P = \frac{\gamma Q V}{g} \cdot \frac{\alpha'\left(2\sqrt{a}+a\right)}{a+2\sqrt{a}+4} \tag{1}$$

Force impulse with respect to the outer zone:

$$\Delta P = \left(\rho c V + \rho V^2\right)\omega \tag{2}$$

Where γ is the volumetric weight of the mudflow (N/m^2); Q - consumption of mudflow (m^3/sec); V - flow motion velocity (m/sec); α' - speed correction factor $(\alpha' = 1{,}05 \div 1{,}08)$;

a is a coefficient and depends on the rheological characteristics, when the equivalent depth corresponding to the tie-up factor is h_0, the depth of the flow is equal to h and φ is equal to the angle of internal friction $a = \varphi\left(1 - h_0 / h\right)$

By equalizing (1) and (2) equations, the wave velocity caused by the force ΔP gets the form:

$$C = \alpha' V \frac{2\sqrt{a}+a}{2\sqrt{a}+a+4} \tag{3}$$

In the wave form moving flow, when the continuous wave is ahead of the dynamic wave and a violation of the regime of constant advance takes place, the speed of the wave front V_c caused by the force ΔP will be

$$V_c \geq C + V \tag{4}$$

By specifying the value of the wave velocity c in (4), we obtain:

$$V_c = \alpha' V \frac{4\sqrt{a}+2a+4}{2\sqrt{a}+a+4} \tag{5}$$

A change of the mobility mode in any flow causes a continuous or stepwise change in the flow rate, depth and speed. The possibility of stopping the reverse wave appears when the following condition is satisfied:

$$\alpha' V \frac{4\sqrt{a}+2a+4}{2\sqrt{a}+a+4} = V + C \tag{6}$$

i.e.

$$C = V\frac{(2\alpha'-1)\left(a+2\sqrt{a}+2\right)-2}{a+2\sqrt{a}+4} \tag{7}$$

Since the velocity of the mudflow

$$V = KC^*\sqrt{hi} \tag{8}$$

And the velocity of propagation of the tied-up mudflow

$$C = K\sqrt{gh} \tag{9}$$

Considering relations (8) and (9) in (7), we obtain:

$$C^*\frac{(2\alpha'-1)\left(a+2\sqrt{a}+2\right)-2}{a+2\sqrt{a}+4} = \sqrt{\frac{g}{i}} \tag{10}$$

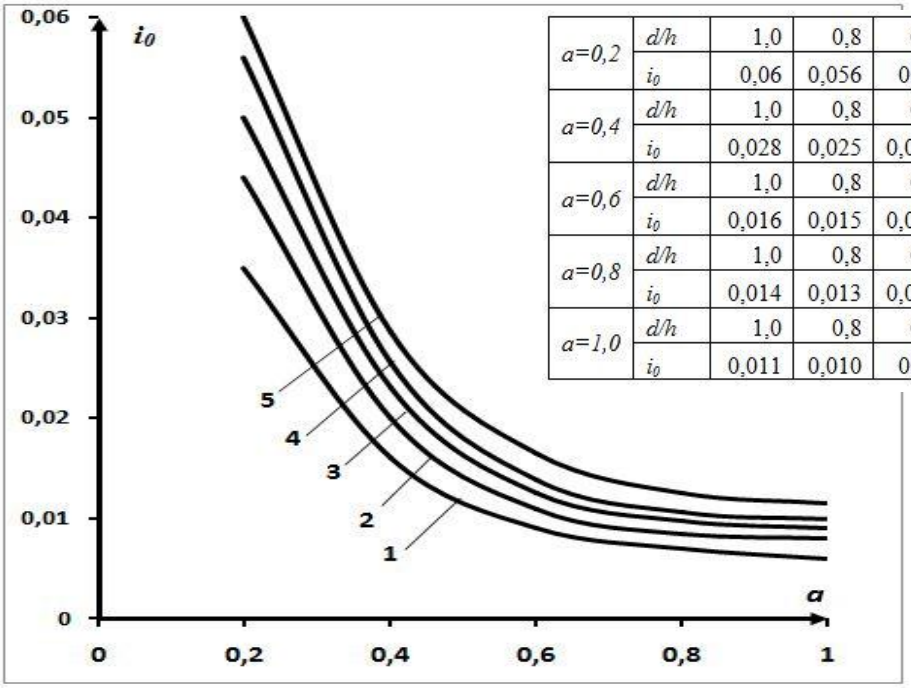
If we include the value of $\alpha' = 1.1$ and $a = 1$ to (10), in the case of water it coincides with the result of Academician O. Natishvili.

$$C^* = 2\sqrt{\frac{g}{i}} \tag{11}$$

Taking into account the value of the mudflow velocity coefficient, in (11) we have:

$$i = 0{,}002686\sqrt[3]{\frac{d}{h}}\frac{\left(2\sqrt{a}+a+4\right)^2}{a^{0{,}333}\left[(2\alpha'-1)\left(2\sqrt{a}+a+2\right)-2\right]^2} \tag{12}$$

For clarity, we give a graphical dependence $i = f\left(a,\frac{d}{h}\right)$ linking with the mudflow rheological characteristics for different values of $\left(\frac{d}{h}\right)$.



a=0,2	d/h	1,0	0,8	0,6	0,4	0,2
	i_0	0,06	0,056	0,05	0,044	0,035
a=0,4	d/h	1,0	0,8	0,6	0,4	0,2
	i_0	0,028	0,025	0,035	0,002	0,06
a=0,6	d/h	1,0	0,8	0,6	0,4	0,2
	i_0	0,016	0,015	0,013	0,012	0,0094
a=0,8	d/h	1,0	0,8	0,6	0,4	1,0
	i_0	0,014	0,013	0,012	0,01	0,08
a=1,0	d/h	1,0	0,8	0,6	0,4	1,0
	i_0	0,011	0,010	0,09	0,008	0,0064

1. d/h=0,2; 2. d/h=0,4; 3. d/h=0,6; 4. d/h=0,8; 5. d/h=1,0

Fig. 1 dependence graph $i = f\left(a,\frac{d}{h}\right)$

The barrages, located in the mudflow channels, whose function is the complete or partial stop of the mudflow, dramatically change the flow regime; Following the next task to be solved in the practice of mudflow regulation - for example, complete stopping of the flow or overflow through the ridge, it is necessary both to estimate the length and motion of the wave propagation by the balancing inclination, and the definition of the reverse direction. Based on this parameter, for an approximate construction, it is possible to estimate both the number of constructions and the distance between the constructions.

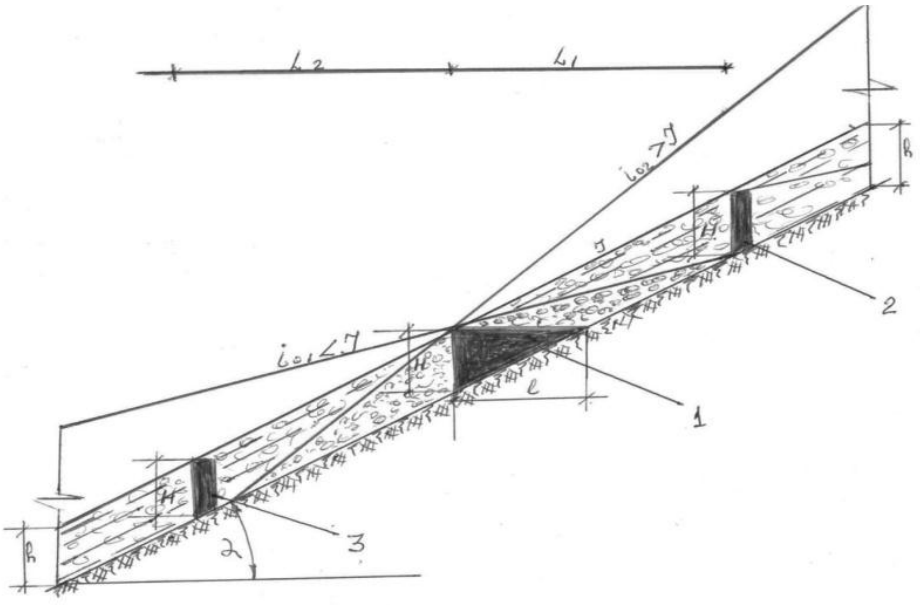


Fig. 2. Cross-section of the barrages location in the mudflow channel.

1. Approximate construction; 2. Separation of the design construction from the approximate construction in the upper pool, when i_{01} <I. 3. Separation of the design construction from the approximate construction in the upper pool, when i_{02} >I.

Based on the above, on the basis of the construction location in the channel on the scheme (Fig. 1, 2), if we denote the propagation length of the wave in the direction opposite to the original motion by L_1, then we get:

$$L_1 = \frac{H}{I\left(1-\frac{i}{I}\right)} \tag{13}$$

Where i_1 is a balancing inclination in the opposite direction from the approximate construction. H — height of construction (m); I — angle of inclination to the mudflow channel.

Considering (12) in (13) we get:

$$L_1 = \frac{H}{I}\frac{3\sqrt{a}\left[(2\alpha'-1)\left(2\sqrt{a}+a+2\right)-2\right]^2}{\sqrt[3]{a}I\left[(2\alpha'-1)\left(2\sqrt{a}+a+2\right)-2\right]^2 - 0{,}002686\sqrt[3]{\frac{d}{h}\left(2\sqrt{a}+a+2\right)^2}} \tag{14}$$

When the overflow through the threshold of construction takes place, then the location of the building structure from the approximate construction along the flow stream will be:

$$L_2 = \frac{\sqrt[3]{a}\left[(2\alpha'-1)\left(2\sqrt{a}+a+2\right)-2\right]^2}{0{,}002686\sqrt[3]{\frac{d}{h}\left(2\sqrt{a}+a+2\right)^2} - \sqrt[3]{a}I\left[(2\alpha'-1)\left(2\sqrt{a}+a+2\right)-2\right]^2} \tag{15}$$

The obtained results confirm that by a constant slope of the mudflow channel for mudflows with the same rheological characteristics (in the case of a decrease in the ratio of the stone inclusions diameter to the flow depth), the amount of the balancing inclination decreases. Following from here, the distance between the constructions increases; And in the case of rheological characteristics increasing, when the ratio of the stone inclusions to the mudflow height does not change, we observe the same picture of the change of the distance between the constructions.

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ENERGY EFFICIENCY OF BUILDINGS AS AN INDICATOR OF ENVIRONMENTAL PROTECTION

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Annotation. The paper presents European Union strategy and documents connected with increased energy efficiency and also polish requirements in thermal protection of buildings. The aim is to estimate predicted energetic and ecological effects of activities that adapt existing residential buildings to the requirements for the thermal protection of buildings in Poland. The energy demand for heating buildings at 60-70 kWh (m^2rok) has been adopted. The calculations show that as a result of this adjustment, the energy demand for heating in residential buildings may decrease by an average of around 67% compared to 2011. Such actions will reduce the overall emissions of air pollution from households by reducing the energy requirement for heating apartments from about 30% to about 67%, depending on the type of pollutant.

Key words: energy consumption, energy efficiency; pollutants emissions to atmosphere; policy and strategies, buildings.

INTRODUCTION

The contemporary world is very dependent on various forms of energy. The exhaustive resources of conventional energy resources and the impact of energy production on the environment make energy effectiveness and energy savings should be given special attention and activities in the economy.

Finding the greatest savings and energy efficiency opportunities should be in the sectors with the highest energy consumption. One of the largest consumers of energy is the building sector and associated buildings. The largest groups of buildings are residential buildings. Buildings account for an average of around 41% of total energy consumption in the European Union. This energy consumption also translates into the emission of hundreds of millions of tons of CO_2 and other air pollutants. Due to the high share of total energy consumption, the building sector has significant potential to reduce the energy intensity of the building's operation, increase the share of RES and thus significantly reduce air pollutant emissions.

Buildings existing in Poland, both residential and public are characterized by a great potential in terms of energy and ecological efficiency. The greatest possibility in the implementation of energy and ecological efficiency activities creates a saving of media consumption: heat, natural gas, coal fuel, electricity, water. One of the ways to increasing energy effectiveness of existing buildings and reduction of emissions are the thermal modernization activity, which adapts existing buildings to present and future energy requirements. Due to the constant global increase in energy demand, it's considered that its saving and efficient use will become an alternative and important source of energy (Fig. 1).

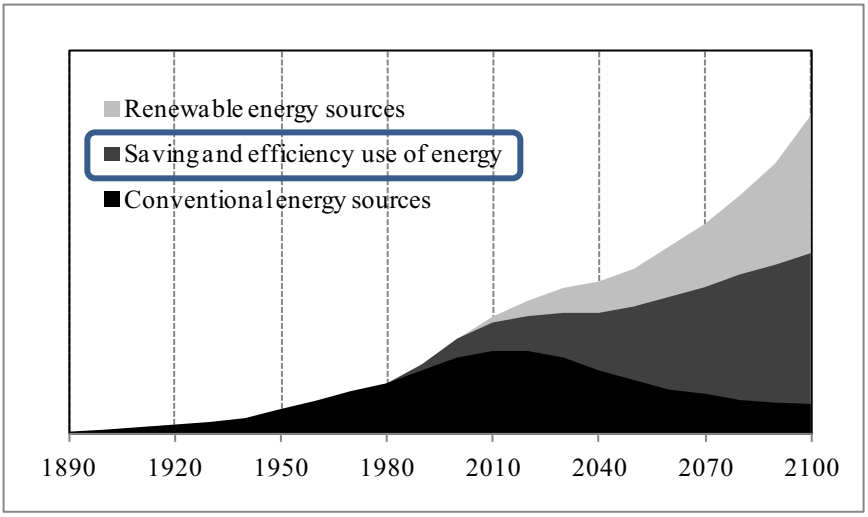

Fig. 1. Growing demand for energy and sources of its coverage over the years [1]

1. ENERGY EFFICIENCY IN THE BUILDING SECTOR

The energy efficiency is a ratio between an output of performance, service, goods or energy, and an input of energy. Presently the energy efficiency is a widely addressed issue in strategic documents determining the development direction of the European Union. The impulse for action in this direction was depletion of natural energy resources, increase in fuel prices, increased dependence on energy imports and high environmental pollution by combustion products contributing to changes in the Earth's climate. Energy efficiency is a valuable means to address these challenges. It improves the Union's security of supply by reducing primary energy consumption and decreasing energy imports. It helps to reduce greenhouse gas emissions in a cost-effective way and thereby to mitigate climate change. Shifting to a more energy-efficient economy should also accelerate the spread of innovative technological solutions and improve the competitiveness of industry in the Union, boosting economic growth and creating high quality jobs in several sectors related to energy efficiency. The priority role of energy efficiency in the European policy was emphasized in a document specifying a general EU development strategy up to the year 2020 - "EUROPE 2020. A strategy for smart, sustainable and inclusive growth" [2]. One of the targets identified in the strategy is to increase the energy efficiency by 20%, to reduce greenhouse gas emissions by at least 20% compared to the 1990 levels and increase the share of renewable energy sources in our final energy consumption to 20%. Up to 2050 the European Union plans a reduction of CO_2 emissions of up to 95%. In order to support the execution of the above-mentioned targets the Energy 2020 project has been launched [3]. A top priority of the project is to create a common energy market. One of the initiatives of the Europe 2020 Strategy is the flagship resource-efficient Europe adopted by the Commission on 26 January 2011. This identifies energy efficiency as a major element in ensuring the sustainability of the use of energy resources.

The European Union has consistently implemented the objectives of climate and energy package, the priority of increasing the energy efficiency expressed in subsequent statement and directives of European Parliament [4-7]. One of the important directives on energy efficiency was the directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services [4]. The aim of this Directive was not only to continue to promote the supply side of energy services, but also to create stronger incentives for the demand side. Directive 2006/32/EC imposed on Member States the obligation to achieve an overall national indicative energy savings target of 9% for the ninth year of application of this Directive. In 2011 the European Commission confirmed that the Union is not on track to achieve energy efficiency target, associated with a package 3x20%. It was necessary to update the Union's legal framework for energy efficiency with a new Directive pursuing the overall objective of the energy

efficiency target of saving 20% of the Union's primary energy consumption by 2020, and of making further energy efficiency improvements after 2020. Therefore, in 2012 it was prepared the Directive 2012/27/EU on energy efficiency [7]. Each Member State shall set an indicative national energy efficiency target, based on either primary or final energy consumption, primary or final energy savings, or energy intensity, establish a long-term strategy for mobilizing investment in the renovation of the national stock of residential and commercial buildings, both public and private, and set up an energy efficiency obligation scheme. The development of energy efficiency indicators adapting statistics to changing economy conditions and present needs is realized on the level of European Union and International Energy Agency. Joined actions of Eurostat and Member States aim to create the statistical indicators system to assess trends in the field of energy efficiency [8]. According to the Directive 2012/27/EU established a polish energy efficiency target for 2020, shown in Table 1.

Table 1

Energy efficiency target for 2020 [8]

Energy efficiency target	Energy consumption in 2020	
Reducing primary energy consumption for 2010-2020	Final energy consumption	Primary energy consumption
Mtoe		
13.6	71.6	96.4

The provisions of the directive impose on the member countries an obligation to elaborate national, long-term strategies supporting the various activities covering the specification of optimal ways for improving energy efficiency of buildings and specification of instruments mobilising these activities. Thermal protection of buildings in Poland is based on the provisions of the Polish Construction Law [9] and on the technical and construction conditions [10]. Issues relating to energy efficiency refers whereas the act of 15 April 2011 on energy efficiency [11] and to the energy performance the act of 29 August 2014 on energy performance of buildings [12]. Important documents defining energy efficiency policies in Poland are also Polish Energy Policy until 2030 and National Action Plans on energy efficiency.

2. ENVIRONMENTAL PROTECTION

Furthermore, the implementation of energy efficiency has a significant importance for the process of reducing the emissions to the atmosphere of pollutants from fuel combustion process. The energy efficiency pointed out in the European Directives constitutes also an important basis for reduction of greenhouse gas emissions. Poland's membership of the EU entails a wide array of environmental-protection requirements. Some have been satisfied by Poland to a greater extent than required, e.g. as regards greenhouse gases emissions. In 2014 Poland achieved a reduction of 34% in the emission of greenhouse gases, expressed as a carbon dioxide equivalent, in relation to the base year (1990), in particular, the emission of carbon dioxide dropped by 35%, methane by 46%, and nitrous oxide by 32 % [13]. The reduction in greenhouse gas emissions achieved by Poland has therefore considerably exceeded the level required under the Kyoto Protocol. The highest increase in greenhouse gas emissions in EU countries between the base year and 2014 occurred in Spain (14%), Portugal (7%) and Ireland (5%). The biggest decreases in this period were recorded in Lithuania (62%), Romania (61%) and Bulgaria (57%). It has been estimated that the potential for reducing CO_2 emissions in operation of buildings up to 2030 is 3,7 Gt. Percentage share in each region is shown in Figure 2.

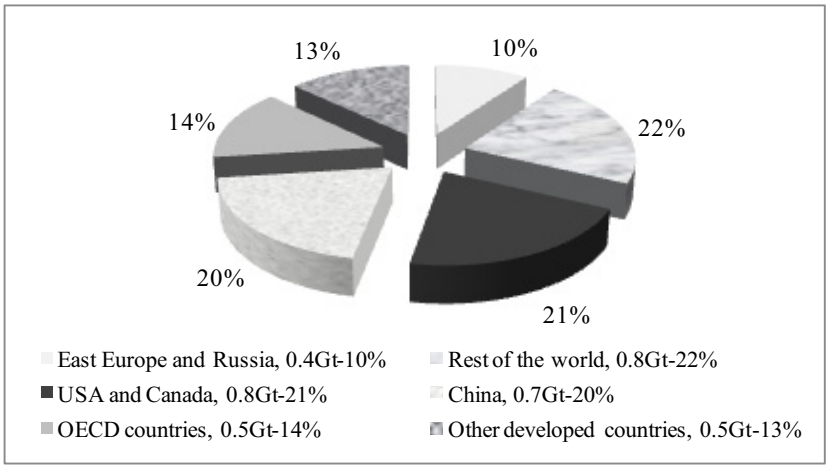

Fig. 2. The potential for reducing CO_2 emissions in operation of buildings up to 2030 [14]

In 2014 there was a drop in emissions of sulphur dioxide by 53%, ammonia by 8%, nitrogen oxides, dusts by 14%, and carbon dioxide by 3% compared to 2000. During this period, total carbon monoxide increased by 2% non-methane volatile organic compounds by 3% [13]. The largest share of emission of dust, sulphur and coal dioxide in Poland was, among others local boiler houses and fireplaces. In the last decade Poland has made huge progress in environmental protection, reducing the dependence of economic growth on a number of environmental pressure factors. However, further limitations on resource exploitation and on the amounts of substances and energy emitted into the environment, still pose a challenge to implementing the principles of sustainable economic development and to strengthening efficiency oriented trends.

Starting from 2021, all newly constructed buildings will be required to have very low energy consumption, covered mainly by the renewable energy resources. Therefore, it is necessary to promote and implement environmental friendly technologies based on the renewable energy resources and to increase the application of these energy resources. Prepared and sent to the European Commission document "National Plan Activities in the field of energy from renewable sources" stems directly from the provisions of Directive on promotion of energy from renewable sources [5]. This document included forecasts achievements by Poland in 2020 year 15% share of energy from renewable sources in gross final energy consumption. Poland is one of the biggest primary energy producers in the European Union (8.9% in 2012) [15]. Relation of renewable energy to total energy consumption has been growing both in Poland and in the European Union during recent years. Share of renewable energy in gross final energy consumption is shown in Figure 3.

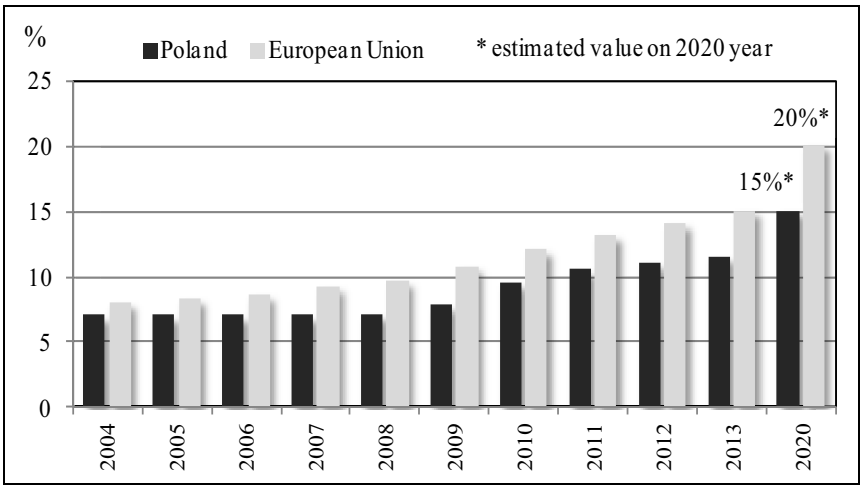

Fig. 3. Share of renewable energy in gross final energy consumption [16]

In Poland production of energy from biomass and wind has been increasing, while use of water and geothermal energy has stabilized [17]. Structure of energy production from selected renewable sources is shown in the Figure 4.

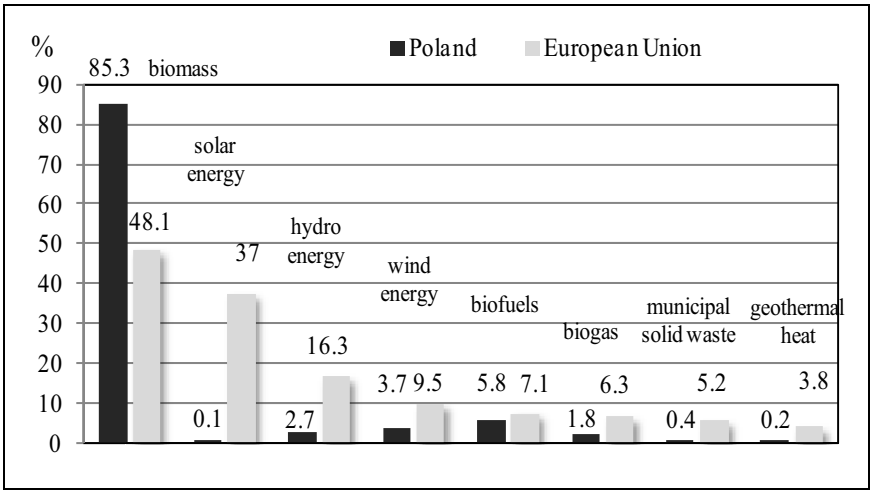

Fig. 4. Structure of energy production from selected renewable sources [17]

3. RATIONALIZATION OF ENERGY CONSUMPTION IN BUILDINGS

Issues concerning the rationalisation of power consumption constitute nowadays one of the main trends in planning, construction and exploitation of buildings. Factors which influence the structure and dynamics of heat consumption for a building can be divided in two groups. The first group should include factors conditioned by the location of a building in a given climate zone and by the season of the year, and which are beyond human control; such as: the temperature of external air, wind rose, solar energy, precipitation and cloudiness. The second group should include factors connected with the intended building type and its location in a given area, and resulting from man's decision taken on the basis of the current state of knowledge of designing buildings. These factors may include architectural and builder's solutions, material and constructional solutions, energy characteristic of a building, its purpose and the manner of exploitation, holding suitable values of parameters of microclimate, quantity of air exchanges through a ventilation system, parameters of heating system and the technical condition of a building.

Building stock of European Union covers about 200 million buildings, out of which 6 million are located in Poland. In accordance with the Polish National Energy Conservation Agency the energy consumption in Poland is at the level of around 120÷300 kWh/m^2/ year while other European countries reach 50 kWh. The heat consumption in Poland has shown a slight declining tendency in the recent years. The largest heat consumers in Poland in 2015 were in the households - about 64% [15]. The structure of energy consumption in residential buildings according to different directions of use in recent years is shown in Figure 5.

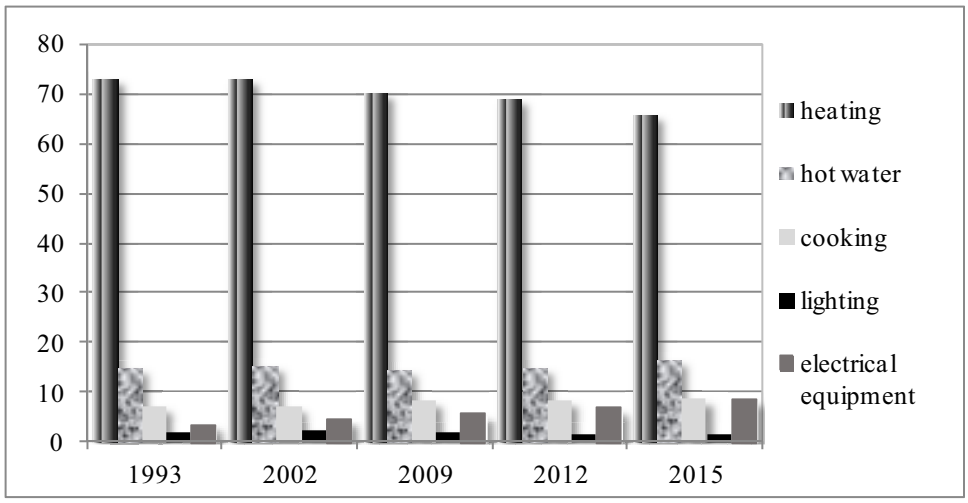

Fig. 5. The structure of energy consumption in residential buildings sector [8, 18]

That is why, in order to limit the energy consumption on heating and ventilation one should look for areas for its rationalisation. The main direction of activities aimed at limiting energy consumption on heating buildings is sealing a building coating and the modernisation of ventilation and heating systems.

Pursuant to the EU directive up to the year 2020 all new buildings shall have nearly zero energy consumption. One of the elements of rationalization of energy consumption in buildings and reduction of emissions are the undertakings related with thermal modernization of buildings. The introduction of innovative technologies and solutions, and the gradual adaptation of existing resources to energy-efficient building standards, combine energy and economic effects with reducing the negative impact of buildings on the environment. It's estimated that the annual energy savings, achieved through thermal modernization, can reach around 26% of 2013 consumption by 2030 [19]. The estimated potential for energy savings from the thermal modernization of buildings under individual activities is presented in Table 2.

Table 2

Potential of energy savings from individual thermal modernization activities [20]

Type of thermal modernization activities	Savings
Improvement of thermal insulation of transparent partitions	14÷20%
Improvement of the thermal insulation of the walls	33÷60%
Modernization of the ventilation system	16÷21%
Regular inspections and repairs of boilers	10÷12%
Modernization of the domestic hot water system using RES	50÷80%

4. RATIONALIZATION OF ENERGY CONSUMPTION IN BUILDINGS AND REDUCTION OF POLLUTANT EMISSIONS

As prepared in 2011 National Census of Population and Apartments in Poland is 6 047 100 buildings with at least one apartment, of which 5 542 600 are single- and multi-family residential buildings [21]. The average usable area of the apartments was 78.2 m^2. The highest number of apartments was in the usable area of over 100 m^2 (20.5%), then in the range of 41÷50 m^2 (18.5%) and least in the range of 61÷75 m^2 (13.6%). The highest number of apartments was in multi-family buildings (55.5%). Individual heating predominates in the heating of rooms. Network heat consumed 41.7% of all households. Of net heat consumers, 72% also used it for water heating. Approximately 67% of apartments had hot water heated locally, and 30% used district heating [18].

Among residential buildings, over 404 000 were built before 1918. They represent 7.3% of the total number of inhabited buildings. There were about 1.2 million apartments, which accounted for 9.0% of total apartments in Poland [22]. The age structure of residential buildings located in Poland is presented in in Figure 6.

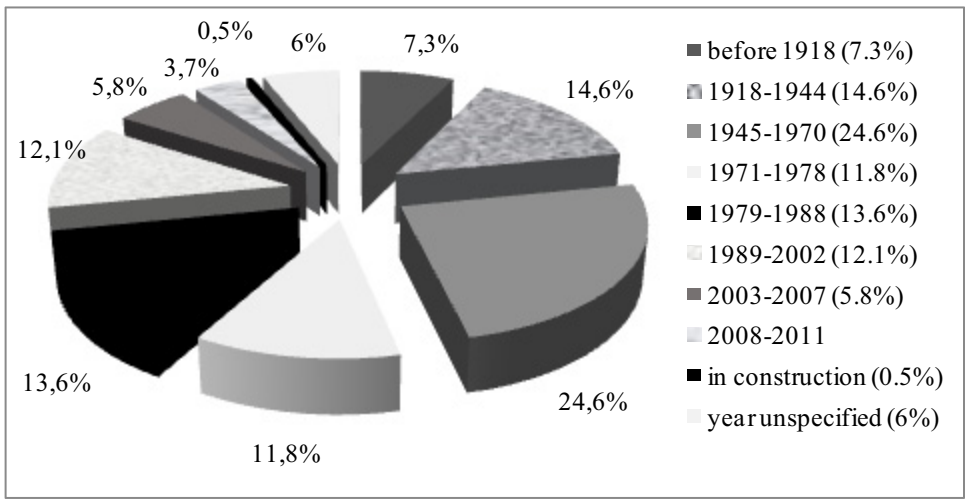

Fig. 6. The age structure of residential buildings in Poland [8, 18]

About 85% of residential buildings are characterized by high energy intensity [21, 22]. That's why these buildings have the greatest potential for energy savings. An analysis of the possibilities to reduce the energy demand for the heating of residential buildings which was exploited in Poland in 2011 to the value 70 kWh/(m^2year) for multi-family buildings and 60 kWh/(m^2year) for single-family buildings was conducted. The potential energy savings by reduction the energy demand for heating to accepted values is shown in Table 3 [23, 24].

Table 3

The potential energy savings by reduction the energy demand for heating to 70 kWh/(m^2year) for multi-family and 60 kWh/(m^2year) for single-family buildings

The building construction period	Heat demand for heating		Reduce the energy demand for heating			
	single-family	multi-family	single-family		multi-family	
	kWh/(m^2year)		kWh/(m^2year)	%	kWh/(m^2year)	%
before 1918	367,66	264,31	297,66	81,0	199,31	75,4
1918-1944	306,10	191,31	236,10	77,1	126,31	66,0
1945-1970	265,22	172,74	195,22	73,6	107,74	62,4
1971-1988	230,25	156,52	160,25	69,6	91,52	58,5
1989-2010	183,36	125,67	113,36	61,8	60,67	48,3

Saving on energy demand for heating for the whole building structure is shown in Table 4.

Table 4

Reduce the energy demand for heating for all buildings [23, 24]

Reduce the energy demand for heating				Reduce the total energy demand for heating	
single-family		multi-family			
TWh	%	TWh	%	TWh	%
84,2	71,3	38,0	60,3	122,2	67,5

Savings in energy demand was around 67%. It is also estimated to reduce the pollutants emission to the atmosphere as a result of reducing the energy demand for buildings heating. Ecological effect of reduction the energy demand for the heating of residential buildings which was exploited in Poland in 2011 to the accepted values is shown in Table 5.

Table 5

Reduce of pollutants emissions [13, 25]

Analyzed pollutants	Pollutants emission resulting from the apartments heating in 2011	Reduce of pollutants emissions as a result of reduced demand for energy for apartments heating
	thou. of tons	
Carbon dioxide (CO_2)	49 440,568	33367,16
Nitrous oxide (N_2O)	0,906	0,61
Methane (CH_4)	120,873	81,58
Nitrogen oxides (NO_x)	67,506	45,56
Sulfur oxides (SO_x)	219,180	147,92
Ammonia (NH_3)	0,510	0,34
Non-methane volatile organic compounds	102,769	69,36
Carbon monoxide (CO)	1 622,308	1094,89
Particulate matter PM_{10}	103,756	70,02
Particulate matter $PM_{2,5}$	61,348	41,40
Dioxins and furans (g i-TEQ)	134,9	91,04
Hexachlorobenzene (HCB)	2,8	1,89
Polychlorinated biphenyls (PCB)	0,0004353	0,00
Polycyclic aromatic hydrocarbons (WWA)	0,1230266	0,08

Reduction in energy demand for heating will reduce pollutants emissions, burdensome for the environment, especially particulate matter and greenhouse gases.

SUMMARY

Energy efficiency is key to ensuring a safe, reliable, affordable and sustainable energy system for the future. Buildings existing in Poland, both residential and public are characterized by a great potential in terms of energy and ecological efficiency. An analysis of the possibilities of reducing the energy consumption for heating of residential buildings and the emission of pollutants to the atmosphere generated during its production in relation to energy use in buildings clearly indicates the greatest potential for activities undertaken in the area of rooms heating. The calculations show that, as a result of adjusting the energy demand for residential heating to 60-70 kWh (m^2rok), the demand for existing residential buildings can be reduced by an average of around 67% compared to 2011. Taking these activities will reduce the air pollutant emissions from about 30% to about 67%, depending on the type of pollutants.

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Earth sciences

EVALUATION OF CONDUCTED COMPREHENSIVE THERMAL MODERNIZATION AT AN ANGLE OF ENERGY SAVING AND REDUCTIONS POLLUTANTS

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Annotation. The article presents the real results of the thermal modernization activity based on the monitoring of their effects conducted in selected educational building from 2011 to 2015 which was a representativ4e of the evaluated group of buildings. The analysis includes energy consumption for heating, ventilation and domestic hot water preparation and electricity consumption in chosen building. The monitoring of the results from conducted thermal modernization showed significant energy reduction effect and therefore also fuel consumption and exploitation costs of this building.

Key words: comprehensive thermal modernization, energy consumption, energy saving.

INTRODUCTION

One of the ways to energy rationalization of existing buildings is the thermal modernization activities. Through the comprehensive thermal modernization activities of an average building in accordance with the currently valid regulations up to 40% of energy may be saved. Buildings existing in Poland, both residential and public are characterized by a great potential in terms of energy efficiency. The greatest possibility in the implementation of energy and ecological efficiency activities creates a saving of media consumption: heat, natural gas, coal fuel, electricity, water. Presently the energy efficiency is a widely addressed issue in strategic documents determining the development direction of the Union Member States. The impulse for action in this direction was depletion of natural energy resources, increase in fuel prices, increased dependence on energy imports and high environmental pollution by combustion products contributing to changes in the Earth's climate. Energy saving is a valuable means to address these challenges.

In Poland thermal modernization activities have been increasingly intensified for over twenty years and at the beginning they were mostly focused on renewal and elimination of defects in the buildings built by industrial technologies. After implementation of the act regarding support of thermal modernization activities, new opportunities to execute such operations in a systematic way, basing on an algorithm of technical and economic analysis of an investment, have emerged. These regulations provided legal background for comprehensive complex thermal modernization.

The analysis of the real effects of the thermal modernization activities in educational building is based on monitoring of media consumption from 2011 to 2015. The analysis includes energy consumption for heating, ventilation and domestic hot water preparation and electricity consumption. For analysis was chosen educational building similar in the technical characteristics to other buildings of this type in Poland. Building has undergone comprehensive thermal modernization in 2010, and the obtained results are representative for the monitored educational building group.

ENERGY CONSUMPTION IN POLAND

Indigenous production of primary energy carriers declined in Poland in 2014 and amounted to 2853.8 PJ. Consumption of primary energy was higher than production by more than 50% and amounted to 4320.5 PJ in 2014 [1]. Building stock of European Union covers about 200 million buildings, out of which 6 million are located in Poland. Energy used in buildings accounts for a significant percentage of a country's total energy consumption. This percentage depends greatly on the degree of electrification, the level of urbanization, the amount of building area per capita, the prevailing climate, as well as national and local policies to promote efficiency. Realization and exploitation of buildings involves in European Union in the period 2009-2013 about 42% of total energy consumption, bat in Poland, this value is higher at about 7% [1, 2, 3]. Buildings consume more energy than transport and industry and use also about 25% of global water.

Energy consumption in buildings is divided into heating, ventilation, cooling, hot water, lighting and electrical equipment. Structure of energy consumption in the period 2009-2012 in residential buildings according to its destiny in Poland is shown in Fig. 1.

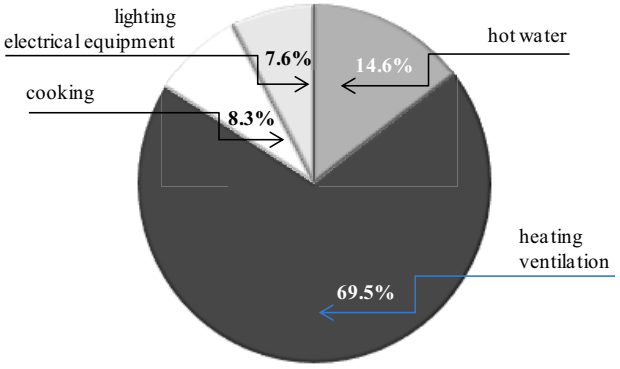

Figure 1. Energy consumption in residential buildings in Poland in the period 2006-2012 [4, 5]

The public utility buildings have a bit different structure of energy consumption (Fig. 2). In this structure is the energy consumption for cooling. The energy consumption for hot water is significantly lower.

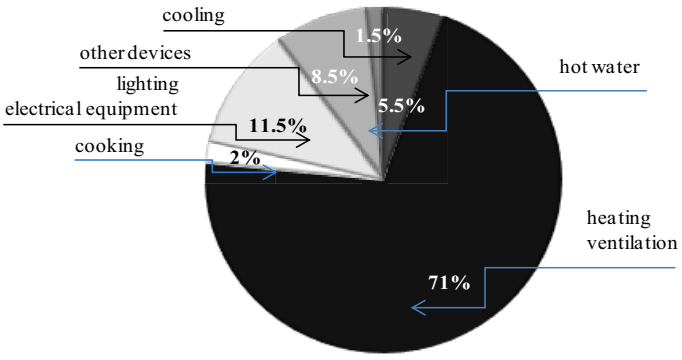

Figure 2. Energy consumption in public utility buildings in Poland in the period 2006-2012 [4, 5]

In European Union the share of energy consumption for heating and ventilation is lower than in Poland especially in public utility buildings but they consume more energy for hot water (Fig. 3 and 4).

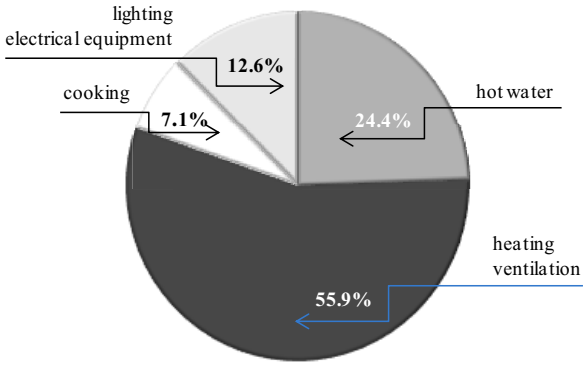

Figure 3. Energy consumption in residential buildings in EU in the period 2006-2012 [6, 7]

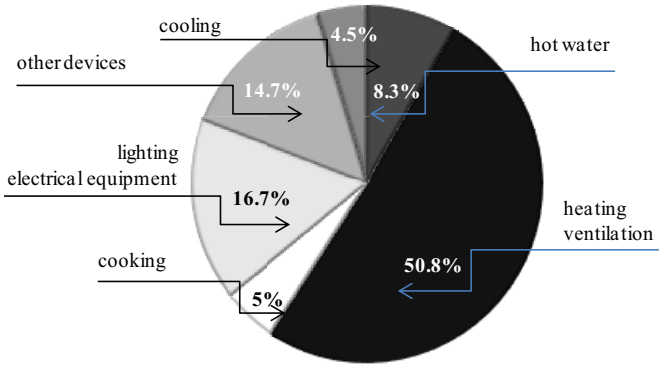

Figure 4. Energy consumption in public utility buildings in EU in the period 2006-2012 [6, 7]

The structure of primary energy carriers consumption in Poland did not change significantly during last years. Recently in Poland production of hard coal, lignite, crude oil, natural gas and others energy carriers decreased. The most important energy carrier produced is hard coal, which share amounted to 61.0% in 2014. The second important energy carrier is lignite with share of 18.2%. The share of natural gas amounted to 5.5% and crude oil to 1.4% [1]. The most important energy carrier consumed is hard coal which share amounted to 40.4%. The share of crude oil amounted to 23.8% and the share of natural gas to 14.1%. Consumption of lignite amounted to 12.0% of total consumption [1].

Starting from 2021 all newly constructed buildings will be required to have very low energy consumption, covered mainly by the renewable energy resources. The strategy for the development of renewable energy sources in Poland and European Union assumes increase the share of renewable energy sources in our final energy consumption to 20%. Therefore, it is necessary to promote and implement environmental friendly technologies based on the renewable energy resources and to increase the application of these energy resources. In Poland share of renewable energy in gross final energy consumption increases and in 2014 year was 11.4% [8, 9].

COMPREHENSIVE THERMAL MODERNIZATION OF CHOSEN BUILDING

The school was built in 1964 using the traditional technology. The lack of thermal insulation in partitions caused that the building failed to comply with thermal protection requirements and was not energy efficient therefore generating considerable energy losses. The school building before thermal modernization is shown in Fig. 5.

Figure 5. The school building before thermal modernization in 2006

In 2010 was performed the thermal modernization of this building in a complex manner and in accordance with the guidelines resulting from the energy audit. The thermal modernization activities included the thermal insulation of the external barriers and replacement of some equipment of the buildings. The school building before thermal modernization is shown in Fig. 6.

Activities were aimed at improving the efficiency of the energy use for heating and preparation of the domestic hot water. Thermal modernization works performed in research building aimed at improving the energy performance of the building, increasing its energy efficiency, reducing its negative impact on the environment and improve the interior microclimate. The effects of conducted thermal modernization were monitored since 2011.

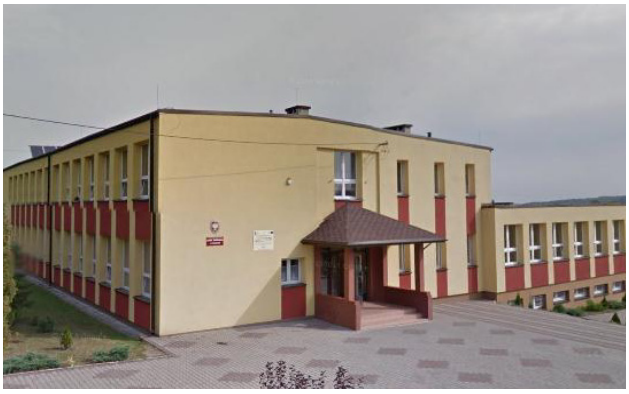

Figure 6. The school building after thermal modernization

After the thermal insulation significantly improve the heat transfer coefficients of school building partitions (Table 1). Spite of the high value of heat transfer coefficients for the floor on the ground this partition couldn't be insulated due to technical reasons.

Table 1. Heat transfer coefficients of partitions before and after thermal modernization of school building

Partitions	U_C, W/(m^{2}K)		U_{Cmax}, W/(m^{2}K)	
	Before	After	2010	2016
External walls	1.40	0.22	0.30	0.25
Flat roof	0.68	0.16	0.25	0.20
Floor on the ground	0.63	0.63	0.45	0.30
Wooden windows	3.00	1.40	1.80	1.30
PCV windows	2.60	1.40	1.80	1.30
External doors	3.50	2.50	2.60	1.70

The heat transfer coefficients of walls and roof are also in accordance with the current requirements. Insulation of partitions and the replacement of windows and doors caused a large decrease in heat loss.

Replacement of coal boiler by new gas boiler and the creation of collective water heating systems with a water use meter were associated with improvement of the heating and hot water system efficiency (Table 2).

Table 2. Efficiency of heating and hot water system before and after thermal modernization of school building

Efficiency of:	Heating system		Hot water system	
	Before	After	Before	After
- heat generation	0.65	1.00	0.97	1.00
- heat transfer	0.90	0.98	0.85	0.96
- heat accumulation	0.93	0.97	0.67	0.86
- heat regulation and utilization	0.85	0.98	1.00	1.00
- total system	0.46	0.93	0.55	0.83

Energy demand indicators of the building before and after thermal modernization, determined on the basis of the energy audit analysis are presented in Table 3.

Table 3. Energy demand indicators before and after thermal modernization of school building

Energy demand indicators	Before	After
	kWh/(m^{2}year)	
EU	285.7	142.4
EK	526.0	149.4
EP	578.6	164.3

EK is demand indicator for the final energy and EU for usable energy. According to the national legislations in the field of energy saving [10] the maximum value of EP indicator defining yearly calculated demand for non-renewable primary energy for heating, ventilation, domestic hot water preparation, cooling and lighting is calculated by the following formula:

$$EP = EP_{H+W} + \Delta EP_C + \Delta EP_L$$

where:
EP_{H+W} – maximum value of a partial indicator of the EP for the heating, ventilation and the preparation of domestic hot water, kWh/(m^2year);
ΔEP_C – the maximum value of the partial indicator of EP for cooling, kWh/(m^2year);
ΔEP_L – the maximum value of the partial indicator of EP for lighting (only for public utility, commercial, warehouse and production buildings), kWh/(m^2year).

Presently required partial maximum values of the indicator EP for heating, ventilation, hot water, cooling and lighting for educational buildings are presented in Table 4.

Table 4. Partial maximum values of the indicator EP for heating, ventilation, hot water, cooling and lighting for educational buildings [10]

Partial indicator of EP for:		**kWh/(m^2year)**
- heating, ventilation and the preparation of domestic hot water	E_{PH+W}	65
- the maximum value of the partial indicator of EP for cooling	ΔEP_C	$25 \cdot A_{f,C}/A_f$
- lighting	ΔEP_L	for $t_0 < 2500$ $\Delta EP_L = 50$ for $t_0 \geq 2500$ $\Delta EP_L = 100$

In the table were used the following parameters:
$A_{f,C}$ – the usable cooled area building, m^2;
A_f – the heating area of building, m^2;
t_0 – the duration of lighting during the year, h/year.

The monitored school building doesn't have a cooling system, therefore ΔEP_C=0 kWh/(m^2year). The duration of lighting during the year for school buildings amounts 2000 h/year, therefore ΔEP_L=50 kWh/(m^2year). Maximum value of EP indicator for investigated school buildings amounts 115 kWh/(m^2year).

Despite the significant reduction in final energy demand the EP indicator obtained in 2010 is too high according to current requirements. A good solution in this case would be the use of renewable energy in monitored school building.

THE ENERGY SAVING RESULT OF CONDUCTED THERMAL MODERNIZATION

After comprehensive thermal modernization in chosen school building its various effects were analyzed. Basic advantages of thermal modernization are related to economic aspects, i.e. reduced consumption of fuel resulting from reduced heat consumption. In research building components of media consumption (coal, gas, water and electricity) and associated with this consumption costs were monitored. Energy consumption for heating, ventilation and domestic hot water preparation was estimated. The year 2010, when the thermal modernization was carried out, was transitional year which is not included in the analysis.

The monitoring of the results from conducted thermal modernization showed significant effect in reduction of energy consumption for heating, ventilation and the preparation of domestic hot water (Fig. 7).

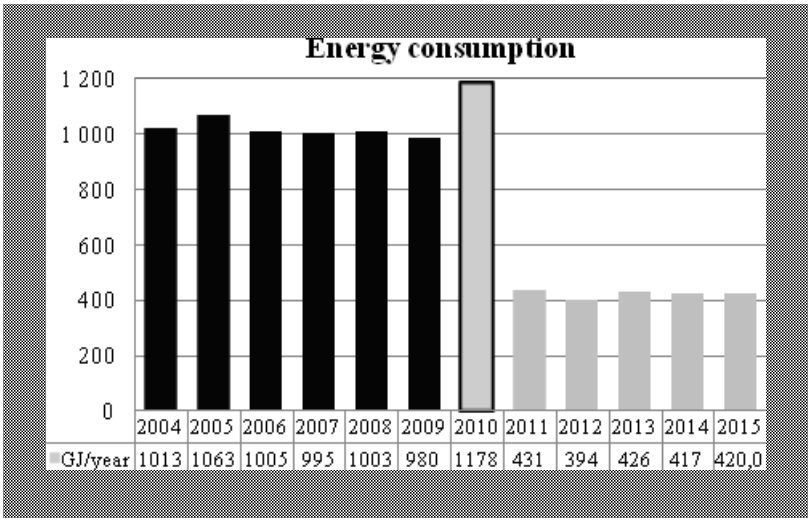

Figure 7. Energy reduction effect after thermal modernization

Before thermal modernization the average energy consumption was about 1000 GJ/year, and after the thermal modernization dropped to 420 GJ/year. Average energetic effect was about 58%. A distinct downward in final energy consumption in monitored period is associated with improvement of the the heating and hot water system efficiency.

After thermal modernization cost per 1 GJ of energy was increased because the conversion of coal to gas was made but compared to 2010 decrease in the cost of heat consumption was occurred. Finally they achieved the level of costs close to the level of 2008-2009. Performed thermal modernization works practically set off the increase in gas prices which was in the period from 2011 until 2015. The cost of energy consumption before and after thermal modernization is presented in Fig. 8.

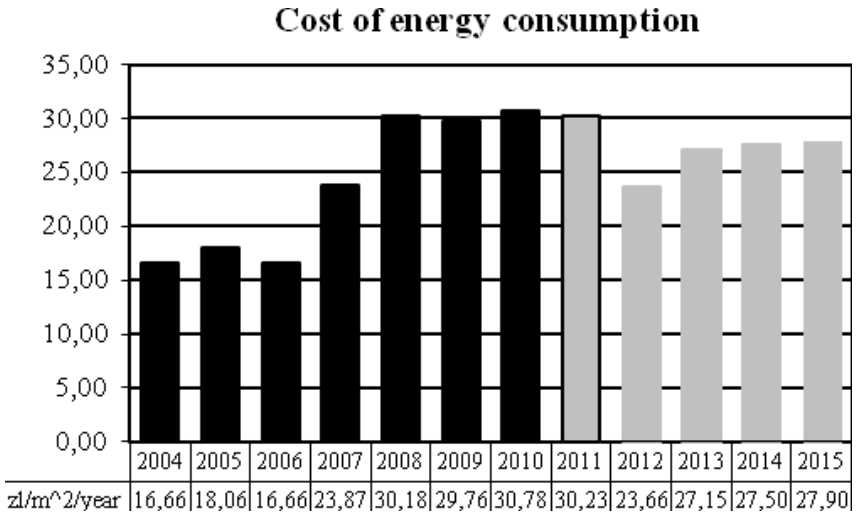

Figure 8. Energy consumption cost of heating and hot water preparation per 1 m^2 of heated surface

The decreases in the heat cost for heating and hot water preparation is not so significant as the decrease in energy consumption due to increases in prices for 1 m^3 of gas from 1.15 to 3.23 zl in the analyzed period.

Use of electric power decreased in the building was observed too. Electricity reduction effect is presented in Fig. 9.

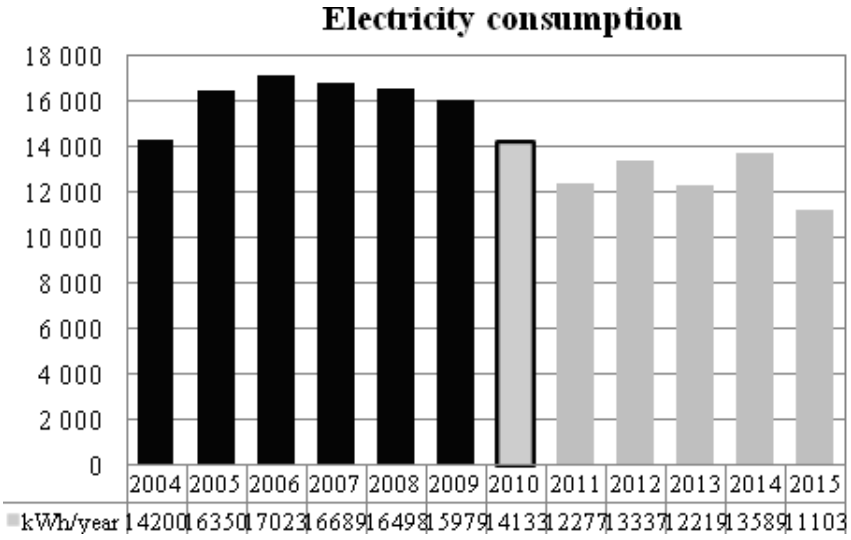

Figure 9. Electricity reduction effect after thermal modernization

Before thermal modernization the average electricity consumption in the analyzed object was about 16 100 kWh/year, and after thermal modernization dropped to 12 500 kWh/year. After thermal modernization a decrease by about 35% of the annual electricity consumption was observed. The decrease in consumption also results from the fact that before the thermal modernization of about 45% of hot water were prepared using electric heaters. Increase in electricity consumption in 2011 was caused by the conducted thermal modernization works.

In 2012 reduction the annual payment for electricity by about 17% was achieved. The cost of electricity consumption per 1 m^2 of heated surface is shown in Fig. 10.

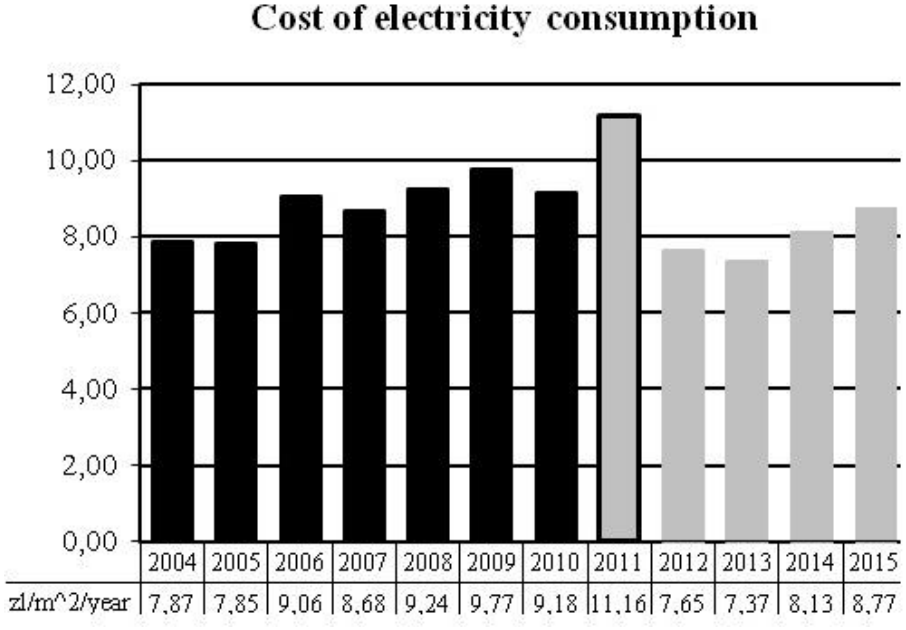

Figure 10. Electricity consumption cost per 1 m^2 of heated surface

In the period 2004-2015 also the increase in electricity prices was occurred. The average electricity price in the analyzed school institution increased from 0.46 zl/kWh to 0.78 zl/kWh.

SUMMARY AND CONCLUSIONS

The rationalization of energy consumption is a widely addressed issue in strategic documents determining the development direction of the European Union. One of elements identified in the European Union strategy is to increase the energy efficiency by 20% until 2020. Realization and exploitation of buildings involves in European Union almost 40% of total energy consumption. Around 70% of energy is consumed for heating and domestic hot water preparation. The European Union directives impose an obligation, inter alia, to elaborate national, long-term strategies supporting the modernization investments covering the specification of optimal ways for improving energy efficiency of buildings and specification of instruments mobilising the investments.

In the last decade Poland has made huge progress in environmental protection, reducing the dependence of economic growth on a number of environmental pressure factors. However, further limitations on resource exploitation and on the amounts of energy and substances emitted into the environment, still pose a challenge to implementing the principles of sustainable economic development and to strengthening efficiency-oriented trends. The energy efficiency of the Polish economy is about three times lower than in most developed European countries and about two times lower than the average in the EU. Additionally, primary energy consumption in Poland, based on the number of population is almost 40% lower than in the in most developed European countries, which indicates the great potential in range of energy saving in Poland.

One of the ways of increasing the energy efficiency of buildings and reducing the environmental impact of buildings are the activities related with thermal modernization of buildings. It has been estimated that through the modernization of an average building in accordance with the currently valid regulations up to 40% of energy may be saved. The thermal modernization activities in Poland have been conducted for more than twenty years, the implemented provisions constitute a basis for performing these activities in a complex manner and cost-effectively, considering the investment and utilization expenses.

The article presents the improving the energy efficiency of the chosen school building. Thermal modernization activities conducted in this building included a wide scope of improvements. The monitoring of the results from conducted thermal modernization pointed out a number of benefits resulting from this type of activity:

1. properly conducted thermal modernization considerable contribute to the improvement of the energy performance of the building,
2. comprehensive thermal activities of a buildings brings the greatest effects and the shortest time of return on invested capital,
3. average energy reduction effect in thermal modernized school building by approximately 58% was observed,
4. there was occurred reduction of electricity consumption at about 35%,
5. fluctuations in energy consumption within the following years were partially related with temperature conditions in respective settlement periods,
6. appropriate building energy performance influences on the reduction of buildings operating costs,
7. reduction the annual payment for electricity by about 17% was achieved,
8. the decreases in the energy consumption cost is not so significant as the decrease in energy consumption due to increases in prices in the analyzed period,
9. due to the increase in the prices of fuel, water and electricity is not always possible to achieve economic results planned in the audit.

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Hydro technique and reclamation

THE INFLUENCE OF A SEASONAL CHANGE OF THE CLIMATE ON THE SOIL OF THE SOUTHERN PART OF THE EAST GEORGIA (TARIBANA, NATBEURI)

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Annotation.The influence of the climate change on the soil and productivity on the territory of Natbeuri and Taribana of the Southern part of the East Georgia has been considered in the present work.

The necessity of arranging of irrigation system by means of surface waters has been represented since in these soils the capillary contact between the ground waters and soil humidity is disrupted.

Key words: ground, salted soil, atmospheric sediments.

INTRODUCTION

The topic of our present report is the influence of the climatic change on the soils of the Southern part of the East Georgia (Taribana, Natbeuri) for the cold and warm periods of the year. This place belongs to the zone of desert fields and represents a sub-region of chestnut and too salted soils. As for the relief they represent a wide depression. This territory is nearly lacking of the water artery. The ground water is in deep (deeply) (15-20 m. and more) and frequently is strongly mineralized. These soils are being developed in conditions of semi-desert dry and hot climate, with the smallest number of the atmospheric sediments (200-300 mm), having the high mean annular temperature (15^{0c}c–16^{0}c) and with a great deficit of the humidity, especially in summer months.

MAIN PART

A great part of this deficit (80-90%) comes on the summer months. This time it occurs the greatest expenditures of humidity by evaporation and transpiration

Table 1. Physical property of the chestnut soils

Soil	Depth with the cm	The volume weight	specific weight	Humidity capacity		Coefficient of filtration	
Dark	0–18	0,97	2,48	total	limited	sm/sc	
chestnut,	35–43	1,28	2,50				
Yagslluja	70–88	1,36	2,53				
The	0–15	1,21	2,67	56.10	53.06, marginal	0.0006	
Chestnut	20–35	1,24	2,70	45.53	45.73	0.0003	m^3/h
Natbeuri 81	45–55	1,26	2,70	45.06	41.80	0.0003	

According to the climatic conditions this zone of the East Georgia is characterized by hot summer and at minimum, twice per year.

Table 2. The mean air temperature

City	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Sagarejo	0.4	0.9	5.0	10.0	15.0	19.0	21.8	21.6	17.2	12.2	6.4	1.9	10.9
Gurjaani	0.0	1.4	6.2	11.0	16.2	20.0	23.1	22.4	18.0	13.2	7.1	2.8	11.8
Melaani	1.1	3.0	7.8	12.9	18.0	21.8	25.0	25.1	20.2	14.7	8.7	3.6	13.4
Tsnori	6.4	2.0	6.7	11.7	16.8	20.4	23.5	23.7	18.7	13.3	7.8	2.9	12.2

The brought numbers show us that the mean temperature of the hottest months of summer is 20-23^{0}c; End by the data for the last 10 years the mean temperature is 25-26^{0}c and even more. In particular, the maximum of the temperature in summer months reaches to37–38^{0}c. In winter it is relatively warm here too. The number of frosty days does not exceed 50-60 days. The number of atmospheric sediments in this very zone is quite fluctuating, too.

Table 3. A mean numbers of the sediments (mm)

City	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Sagarejo	20	30	43	73	141	108	74	57	62	51	48	37	744
Gurjaani	19	28	41	68	129	96	68	52	54	47	47	35	683
Melaani	20	29	43	62	112	87	62	48	49	43	48	37	640
Tsnori	26	26	36	54	101	72	44	36	52	57	39	21	574

By the numbers it is shown that the maximum of the sediments comes on May and June and then on autumn months. And the minimum of sediments comes on January and summer months. Besides, it should be indicated that for Kakheti it is characterized a strong hail.

Together with the air temperature and the number of sediments it is necessary as well the data of evaporation and relatively the water balance, too.

For the practical aims it is very interesting to know the anomaly sedimentary and non-sedimentary months and years.

Table 4. The number of the greatest and the smallest sediments

City	Sediments	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sagarejo	The greatest	84	102	127	173	187	218	252	146	139	220	127	64	1337
	The smallest	0	0	6	16	18	8	2	1	4	3	1	0	489
Gurjaani	The greatest	96	106	113	160	235	192	221	175	188	250	106	66	1100
	The smallest	0	0	6	8	41	6	6	0	9	3	0	0	262
Melaani	The greatest	68	27	88	130	198	220	175	203	179	139	126	83	767
	The smallest	0	0	1	5	5	3	1	0	1	4	1	0	241
Tsnori	The greatest	42	59	70	97	169	145	129	106	111	151	85	49	655
	The smallest	0	0	0	2	11	9	0	0	0	1	0	0	212

As from the data shown in the Table it is clear that the smallest number of sediments came for a month in the lower parts of Georgia fluctuates within rather great limits. It is not so random such a year when during any month there was only 1-2mm of sediments or no sediment at all (mainly in winter and summer).For the last period there was indicated (1010-12ts,) much lesser that the norm of sediments the smallest indicator (within the limits of 0-48 mm) in this part during the plenty-sediment years there is the sediment at 650800mm).

During the relatively dryyears it is quite lower (up to 200 mm). These fields are not insured, guaranteed, more precisely, there are often droughts. In comparison to the sediments occurred during the cold period of the year, the snow is not laid for a long time on the indicated fields and, correspondingly, the humidity gathered in the soil in frequent cases does not satisfy the requirements of the agricultural cultures. The observation was realized (spring, autumn), as it is called the first (IV-VI months) and the second (VII-X months) halves of the vegetation period. It is cleared up that in the first part of the vegetation period the sediments are changed within the 120-500mm. On the background of all this the melioration measures to be carried out on the objects of our observation should envisage by all means the balance the humidity of soil-ground. And the latter is not determined only by the number of the sediments. Of great interest is the expenses which express the total number of the humidity expenditure of those which had been accumulated as a result of physical evaporation from the soil, percolated into deep layers, or transfused from the surface or by other phenomena, as a result it should be realized the melioration and agro melioration measures.

On the given field (Taribana-Natbeuri) the ground water is located deeper and the capillary contact between the soil humidity and underground water is established only periodically during the great rains. This mode of humidity is characterized by vacillatingbalance. It depends on the number of atmospheric sediments which is exceeded by the number of evaporated water, the coefficient (ratio) of humidity is less than 1 (0.70), the ground water, as we have indicated is lower than 15-20mm and the capillary contact between the ground water and the soil humidity is terminated. By leakage of the atmosphere water only the upper layer of the soil profile becomes wet and it does not reach deeper because of small quantity. The capillary water of the soil here is always in the capillary dependant state. The soil is always distinguished by great deficit of water and it needs to be carried out the melioration measures of watering character.

CONCLUSION

As a consequence of our present state on the indicated territory these measures can't be performed (carried out). The zone is declared as a desertification. With allowance that traditionally on this territory there was a great harvest of wheat, barley, popcorn, oats and sunflower and even for today there are carried out to sow-cultivate, grow the cultures indicated here, the results totally depend on the weather.

For today, the population of the Municipalities of Dedoplitskaro and Sighnaghi are supplied by the surface waters. It might be found out the ways to use these waters for irrigation too.

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Hydraulic engineering and irrigation

LAND RECLAMATION IN BREST REGION (BELARUS): STATE, PROBLEMS, PROSPECTS

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Annotation. The article presents a historical background of land reclamation in Brest region, Belarus. It also describes a current state of land reclamation in the area and specifies some aspects of professional training of qualified experts in the sphere.

Key words: land reclamation, Belarus.

INTRODUCTION

Brest region enjoys an advantageous location in the Republic of Belarus. Better supplies with soil moisture and warmth create favorable conditions for agriculture in the region. Nevertheless, both excesses and shortages of moisture and warmth are often observed in cultivated soils due to instability of natural irrigation. Today, water and heat regimes of soil are regulated with ameliorative facilities predominantly. Agronomic soil properties, natural soil fertility, and natural irrigation only cannot guarantee high and steady crop yields. It is also essential to create a productive air-water and heat regimes on cultivated areas, although that might not be enough to solve the problem. Another requirement necessary for sustainable agriculture is considered a balance of gases, minerals, and organic fertilizers. That is why amelioration is regarded today as engineering activities (facilities and technologies) which provide optimal air, moisture, temperature, and nutrition regimes in soils.

HISTORY

Land reclamation in Brest region has a long history.

Considerable growth of population, social and industrial development in the 16th century resulted in the necessity to cultivate new and virgin lands and improve them. Land reclamation began to develop then. A few melioration canals were built in Kobrin district after Queen Bona Sforza ordered to start reclaiming her lands (1549 – 1557). The biggest one has survived until now. It is called the Bona Canal to honor the Queen. The canal is 29 km long. Its catchment area is 261 km^2.

After Queen Bona's contribution to land improvement the practice was continued by the Dutch who settled near Brest in the 17th century. They drained bogs for agricultural purposes of their own.

At the end of the 18th century Polish government of King Stanislaw August Poniatowski started to erect a navigable canal between the Dnieper River and the Bug River watersheds. The canal, which was called the Royal Canal, connected the Pina River with the Mukhavets River. Today it is called the Dnieper-Bug Canal although a part of the canal in Kobrin district still remains with its original name. After the war of 1941-1945 the canal was restored. Today it is used for navigation, fishing, recreation, and as a water intake reservoir of the local melioration system. The total length of the Dnieper-Bug water system is 196 km of which 105 km is the canal itself. It comprises 12 hydro-engineering structures with navigation locks, 28 flow-through dams, 14 water outlets, 5 earth-fill dams, 3 drop structures, 64-kilometer dams. In fact, the Dnieper-Bug Canal connects the basins of the Baltic and the Black Seas [1].

Alongside with the Dnieper-Bug Canal another canal called the Oginski was built at the end of the 18th century. Its length is 47 km. It connects the Shchara and the Yaselda Rivers and as a result the Baltic and the Black Seas. During World War I the canal was greatly destroyed so it lost its original importance. The canal bed, some hydro-engineering facilities, and the revetments built in the war years have remained until now. Today the canal silts up. It operates only as a water intake reservoir of the nearby polder melioration system.

The biggest land reclamation work was the so-called Western Expedition organized by Russian general I.I. Zhilinski at the end of the 19th century. Land amelioration was performed according to a governmental plan to reclaim Polesie marshlands that is why the project was well designed and financed. From 1874 to 1897 the Expedition managed to construct 4360 km drainage canals, 549 bridges, 30 canal locks. 127 km of river beds were cleared of weeds and grass. Many of them were built so profoundly that they have remained up to now.

Amelioration in Brest region almost stopped in the first half of the 20th century, which is explained by political changes (revolution and wars), and as a result, poor funds. But in the mid-1950s the work proceeded again and soon a hector of ameliorated area started to produce 18-19 hundredweight of rye, 20-27 hundredweight of oats, 200-300 hundredweight of potatoes, 250-400 hundredweight of root crops, 400-500 hundredweight of corn for silage.

In 1971 irrigation systems started to be built alongside large-scale drainage practices. There appeared water reservoirs and ponds, pump stations, network hydro-technical facilities, diversion dikes, roads, bridges, communication lines and power transmission lines. At the top of land reclamation activity the productivity of drained agricultural land was 33-38 hundredweight of fodder unit, and specifically, reclaimed soils produced 43-53 hundredweight of fodder unit. Gross output of crop production was 45%, including fodder up to 60%. Reclaimed areas of Polesie were put into cultivation by new farms (sovkhoz). They also tried to develop social services such as industrial and residential areas, public buildings and shops, recreational areas [1].

CURRENT STATE

According to the latest data (01.01.2017), 23% of the total area and 48% of the agricultural area in Brest region is drained. Today over 80 % of the land in need of amelioration is drained. The most ameliorated districts of Brest region are Ivanovo district (35%), Kobrin district (35%), Zhabinka district (34%), and Drogichin district (32%). The least ameliorated districts are Baranovichi (8%) and Kamenets (14%). 372,900 ha of Brest region land are drained with subsurface drainage systems, which is about 50% of all the drained area. Ceramic drainage is being replaced with the plastic one in the systems under reconstruction. It already accounts for about 5%.

37% of the ameliorated area (283,200 ha) is controlled by a two-way regulation (drainage and subirrigation) of water regime. But, in fact, it is hard to use as a lot of the retaining structures (19%) in the double-acting (drainage and subirrigation) systems are in poor condition.

Amelioration systems of water rotation type operate on the area of 40,400 ha. Drainage of 227,800 ha is performed with the use of pump stations. Polder systems occupy most of the area, which is a peculiarity of land reclamation in Brest region. Winter (non-flooded) polders occupy 208,000 ha.

The irrigated area has decreased significantly over the past decades. Today it accounts for 4,400 ha, which is less than 1% of all the ameliorated area. The reason for this decrease is current financial problems, and as a result, poor maintenance of the equipment.

The total length of meliorative drainage network in Brest region is 164,200 km, including 41,300 km of an open network. The network consists of diversion dikes (2,800 km), inspection roads (6,100 km), field-protecting forest belts (2,100 km), 291 pump stations, 364 locks, 7662 pipe-regulators, 794 bridges, 13304 conduit passes, 2411 pedestrian bridges, 7670 wells in a closed collector-drainage network, 83909 drain outlets, 728 wells for observing groundwater level.

PROSPECTS

Over the past decades land reclamation in Brest region has been conducted according to the State Program for preserving and using ameliorated lands. The Program is developed and adopted for every five years. Its main goal is to improve soil fertility by meliorative practices and drainage of highly fertile lands. In order to reach the goal, the Program requires providing optimal air-water regime on ameliorated lands through appropriate maintenance. Today, worn-out and outdated equipment of the melioration systems or their particular elements are being replaced, failed systems are being restored. A lot is being done to provide technically efficient maintenance of the system and its elements.

Although most of the ameliorated land in Brest region is mineral soils (70%), there is a problem of preserving drained peat bogs. Agricultural use of peat-bog soils inevitably results in their degradation. Brest region has peat-bog soils up to 1 m deep. Almost a third of them has mineralized and transformed into organic-mineral and human modified soils. Inefficient agricultural use of peat-bog soils causes soil erosion. About 30% of the peat-bog soil is used for tillage. Thermo-physical properties of the ameliorated peat-bog soil have changed significantly, which aggravated a problem of ground frost and fires [2]. The double-acting (drainage and subirrigation) systems that function on the peat-bog soils cannot solve the problem as their equipment is in poor technical condition and they are badly maintained.

Scientific support to implement the State Program for preserving and using ameliorated land is provided by scientific research establishments of the Department of Agrarian Sciences of the National Academy of Sciences of Belarus. In particular, RUE Institute for Land Reclamation is a leading scientific establishment which provides scientific support for over 4.3 million ha of farmland of which 2.9 million ha is drained. The Institute develops technologies and design decisions for reclamation of wetlands and bogs of Polesie.

In Belarus professional training for specialty "Land Reclamation and Water Management" is conducted at Belarusian State Agricultural Academy and Brest State Technical University.

CONCLUSION

Although the scale of land reclamation has reduced considerably lately, Belarus is developing and implementing the State Program for preserving and using ameliorated lands. Brest region is the country's leader in this sphere. In order to provide professional staff for this branch of national economy, higher educational establishments coordinate their work with the industry.

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Water management

SLOPE DEPTH OF THE GROUND WATERS AND THEIR MINERALIZATION IN THE ZONE WHERE THE BTC (Baki-Tbilisi-Ceyhan) OIL PIPELINE PASSES

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***Annotation*:** The article provides detailed information on the level of groundwater deposition and changes in mineralization around the Baku-Tbilisi-Ceyhan oil pipeline. According to the research, a map of their mineralization has been compiled.

***Key words*:** qranulometric composition, ground water, ground water stage, the soil special weight.

INTRODUCTION

The main factor which will be able to create a danger for the oil pipeline is a slope depth of the ground waters and mineralization of this zone. Let's pay attention to the subsoil waters in which depth they are situated and how their mineralization changes. The subsoil waters are situated in much deeper place (>10m). That's why not depending on their mineralization to be high and low there can't be an effect of the subsoil waters on oil pipes in this part.21 hydrological wells have been drilled from 31st km till 242nd km of the second part of the pipeline (Shirvan). (6, 8, 11, 15, 17, 20, 21, 23, 25, 27, 28, 29, 30, 31, 32, 34, 36, 37, 39, 163, 164) and samples of the subsoil waters have been taken from them. The whole water weight analyses have been carried out in the samples taken from 8 wells, but dry residue has been defined in the samples taken from 13 wells. The well places have been selected so that a correct notion can be created about mineralization of subsoil waters in the different places of this part of which length is 211km. We paid attention to salinity of the soil samples taken from the cuts which we put in order to define it, and to grass plant that cover its around. The places of the hydrological wells have been defined depending on grass plants of different kinds and salinity of the soil samples. To tell the truth, paying attention to abovementioned, the wells have been built on the soil cuts. Such approach to the solution of the problem gave a chance to define both mineralization of the subsoil waters and soil salinity at the same point. It has been done because a notion about subsoil mineralization can be created in the places where the near marks of the salt quantity are observed in the soils spreaded in the zone of the oil pipeline [1,2,3].

MAIN PART

The consequences which we have carried out in the different regions of the Kur-Araz Lowland show that there is a close relation between mineralization of the subsoil waters and soil salinity in the natural-climatic condition which posses the same physical-chemical features. The mineralization parameters of the subsoil waters are low or on the contrary in the places where the salinity indices of the soils is low. For. Ex. The 8th cut was put in 55th km of the pipeline. A quantity of the salts was 0.714% on 0-100cm of layer, but it formed 1.66% increasing on 100-200cm of layer of the soils in the place where this cut was put. The mineralization of the subsoil water taken from a hydrological well on this cut was 16.55g/l. The soil salinity

is 0.14% in the cut put on 116th km. The mineralization of the subsoil waters in the place of this cut formed 2.8g/l (Fig. 1).

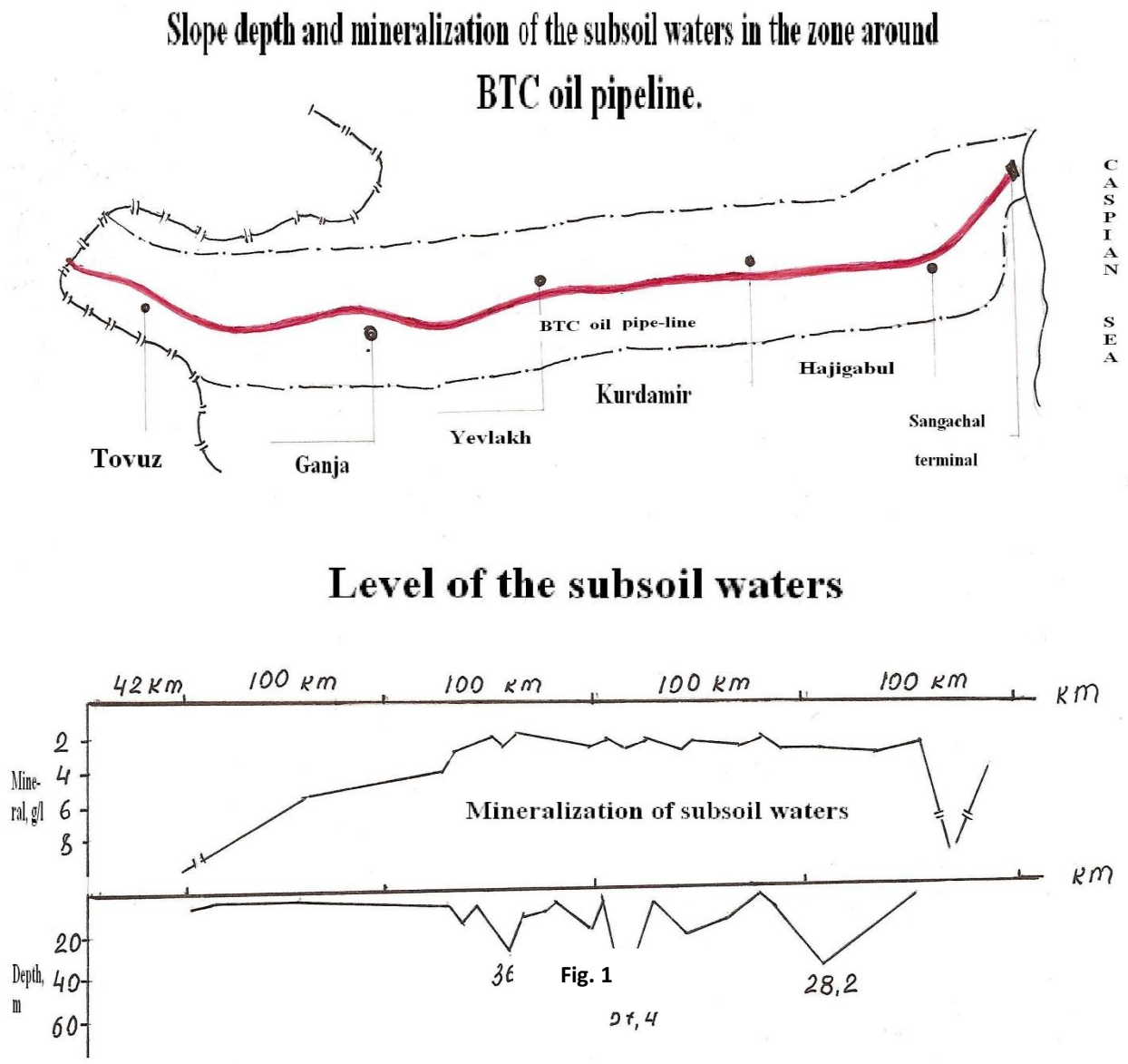

Fig. 1

So, if soil salinity is known in every point of the "Shirvan" part of the pipeline, enough information can be got about subsoil mineralization (5-10% outside) [4,5,6]. Let's investigate how the ion structures of the salts change from the low values of mineralization upwards in the total water weight analyses of the subsoil waters. It is obvious from Table 4.1. that the lowest value of the mineralization of the subsoil waters was observed in cut of K-17 (116km).Mineralization of the subsoil waters forms 2.8g/l here. The subsoil waters at the distance from 277 km till Great Cut are situated in a larger depth than 5.0m from the soil surface and their mineralization changes by 2.0-4.5g/l.

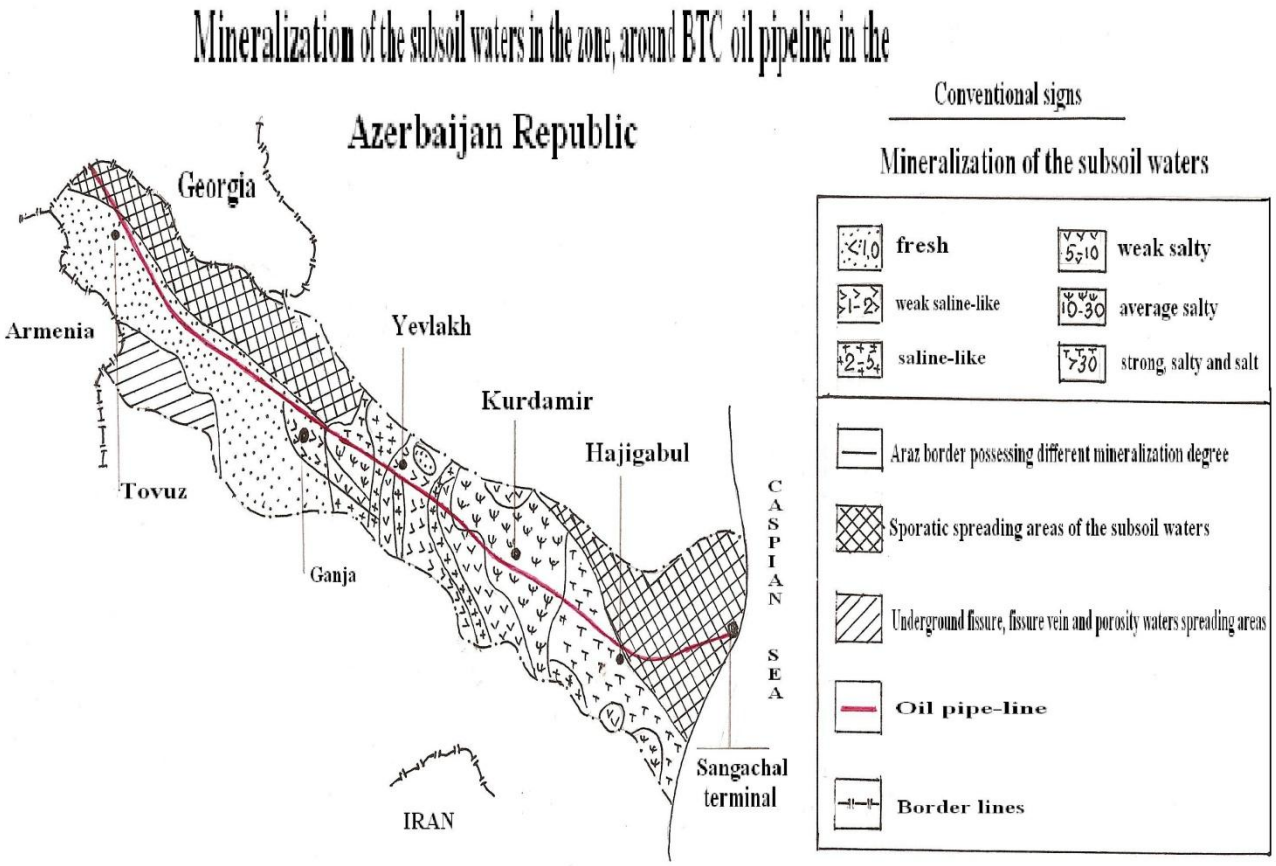

Fig. 2

The highest mineralization of the subsoil waters is observed in Cut K-30 and 31. Mineralization of K-30 of subsoil waters forms 57.4g/l. SO_4 ion is superior-16.5g/l in the anion composition of salts. Cl-ion is in the second place-12.6g/l. Here HCO_3-ion quantity isn't little-6.2g/l. Na^+K (difference) ion is superior in cation structure of the salts-12.7g/l. Ca and Mg-ion quantity is high and in accordance forms 5.21 and 3.2g/l. The salt type is sulphatic-cloridic-hydrocarbonatic. It is obvious from the investigation that anion and cation compositions of the salts change while increasing mineralization of the subsoil waters. The high mineralization of the subsoil waters in the zone of the pipeline of Ganja-Gazakh is observed (41,43,45) in the salinized zones which form little areas near Ganja and in the zone of Goranboy. Mineralization of the subsoil waters changes by 0.5-2.50g/l in the next part of 265km of the pipeline. It is necessary to note that the subsoil waters of this part are situated in 3.0-9.0m from the surface, that id, lower from oil tubes. Therefore a negative effect of the subsoil waters can't be on oil pipeline in this part of the pipeline (length is 177km).

CONSEQUENCES AND PROPOSALS

1. The danger which will be created by subsoil waters and their mineralization. The danger which will be created by the torrent waters formed during a strong earthquake and atmospheric rainfalls.
2. The soil salinity along the zone of the pipeline is more in upper 0-100cm of layer of some places, in low layers of some places. In two states, being more quantity of salts can create a corrosion danger for the tubes of the pipeline. Therefore the waters leaking into soil during strong atmospheric rainfalls will create solution

by solving the salts in both upper and low layers. Mineralization degree of the salty solution can be from 10-15g/l till 100g/l (in which soils the salinity is high) depending on salt quantity in the soil. Undoubtedly, accelerating corrosion process in the oil tubes the salty solution formed in the soils possessing high salinity can be a reason for their earlier destruction.

3. The showing figures are for the subsoil water depth of which level is 2.0-2.5m from surface. The part of the rainfalls that feed the subsoil water in the places where a level of the subsoil water is less than 2.0-2.5m from the surface is more than abovementioned figures, but they are less in the places where a level is more than 2.0-2.5m. The salt which will be able to create a corrosion danger for oil pipeline can be taken 1.0-1.5%. This quantity of the salt and mineralization of the solution which is occurred during atmospheric rainfalls can from 15-20g/l till 25-30g/l. Mineralization of the subsoil water in such places can change from 16-18g/l till 25g/l. The places, where a very strong influence of the soil salinity (3.0-4.0%) and subsoil water mineralization (50-60g/l) is on oil pipeline corrosion. Such places are observed in 85, 158, 185 and 186th kilometer.

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Агромелиорация

АКТУАЛЬНАЯ И ПОТЕНЦИАЛЬНАЯ АКТИВНОСТЬ ФИКСАЦИИ АЗОТА В РИЗОЦЕНОЗАХ НЕКОТОРЫХ ТИПАХ ПОЧВ АЗЕРБАЙДЖАНА

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Аннотация. В представленной статье рассматривается сезонная и суточная динамика азотфиксации микроорганизмами в ризоценозах, на серо-коричневых почвах Гянджа-Газахской наклонной равнины, серо-бурых почвах Кура-Аразской низменности, серо-бурых почвах Абшерона и серо-коричневых почвах Малого Кавказа.

Ключевые слова: ризоценозы, микроорганизм, азот, бактерия.

Agromelioration

ACTUAL AND POTENTIAL OF NITROGEN FIXATION IN RHIZOGENOUS OF DIFFERENT TYPES OF SOIL

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Annotation. In proposed article analysis of Spring and summer season dynamics in daily actual and potential activity of microorganisms which perform nitrogen fixation in rhizogenous in grey brown soil Ganja Gazakh plain, grey-meadow soil of Kura-Araz coast, gray-brown soil of Absheron and grey-brown soil of lowlands of Small Cuacasus was performed.

Key words: rhizogenous, microorganism, nitrogen, bacterium.

ВВЕДЕНИЕ

Рациональная интенсификация сельскохозяйственного производства, способная обеспечить плодородие почв и получение стабильных и устойчивых урожаев сельскохозяйственных культур, представляет собою глобальную проблему нашего времени. Наряду с агрофизическими и агротехническими приемами, способствующих увеличению плодородия, огромное значение имеет почвенное население в виде различных представителей мезофауны, участвующих в обогащении почв гумусом так азотфиксирующие бактерии.

ОСНОВНАЯ ЧАСТЬ

Запасы азота на нашей планете достаточно огромны, основная масса которого находится в атмосфере в молекулярной форме [1]. Эта форма азота химически инертна и может усваиваться лишь ограниченной группой микроорганизмов – бактериями, которые именуются азотофиксаторами. Связанный ферментами бактерий азот, являясь биологическим и, циркулируя в биосфере, формирует биогеохимический цикл азота, круговорот которого происходит поглощением диазотрофами атмосферного азота и образуя аммиак, который в свою очередь служит круговороту азота в природе.

Белки растений и животных разлагаются с помощью бактерий – аммонификаторов с образованием аммиака и ионов аммония, после чего в процессе микробной нитрификации образуется молекулярный азот, превращение которого происходит с непосредственным участием микроорганизмов.

Азотфиксирующие бактерии, в основном, подразделяют на две группы – свободноживущие (ассотиативные) и симбиозные (клубеньковые) [2].

Свободноживущие бактерии, обитая в ризосфере, обладают нитрогеназной активностью, в значительной мере заменяя минеральный азот высокой антибиотической активностью. Фиксация этими бактериями азота имеет достаточно важное значение в балансе азота в почве, которое осуществляют свободноживущие и симбиотические микроорганизмы: бавкерии, актиномицеты, цианбактерии, наиболее распространенным среди которых является Azotobacter Clostridium.

Azotobacter Chroococcum фиксируют азот в аэробных условиях, на агаре образуя слизистые колонии. Являясь подвижными, они теряют свою подвижность в процессе развития. В качестве источника углерода азотобактер использует моно - , дисахариды, спирты и соли органических кислот, в том числе и бензойной, в неблагоприятных условиях образуя цисту.

Clostridium Pasteurianum – является облигатным анаэробом. Необходимую энергию для ассимиляции азота и в целом жизненно важных процессов, они получают за счет маслянокислого брожения. Азотфиксирующие цианбактерии относятся к родам Nostoc, Anabaena и являются фотоавтотрофами, аминоавтотрофами, аэробами и образуют специальные клетки - Гетероцисты, которые защищены специальной оболочкой от окисления кислородом. Способность к фиксации атмосферного азота обусловлена наличием сложной системы ферментов – Нитрогеназой, кодированными 17 генами и подразделяющихся на молибдобелок и железобелок [3].

Симбиотическая азотфиксация осуществляется многими микро-организмами в симбиозе с бобовыми растениями, как люцерна, сорго, соя и др. Среди этих азотофиксирующих бактерий наиболее изученной является Rhizobium в симбиозе с бобовыми. Представители их рода бесспоровые палочки, имеют жгутики, которые при старении теряют свою подвижность, накапливая жировые включения.

Микроорганизмы, вызывающие аммонификацию белков (мине-рализацию азота), выделяют в окружающую среду протеолитические ферменты, под действием которых белки гидролизуются до аминокислот. Последние поступают в клетку и в ней дезаминируются с образованием аммиака, органических кислот и других продуктов. Возбудителями процесса служат гнилистые бактерии [4].

В наших определениях объектом исследования служат серо-бурые почвы Абшерона, сероземно-луговые почвы Кура-Аразской низменности, серо-коричневые (каштановые) почвы наклонных равнин и горно- коричневые почвы предгорий и низкогорий Малого Кавказа.

Развитие и физиолого-биохимическую активность азотофиксирующих сообществ в различных почвенно – климатических условиях, регулируются экологическими факторами, которые влияют на интенсивность процесса биологической фиксации азота.

Таблица 1

Актуальная азотфиксирующая активность различных типов почв

Почвы	**Количество фиксированного азота, в среднем за сутки, мкг N_2/ кг почвы**				**Средняя**	**За вегетац. период, кг N_2/га**
	Май	**Июнь**	**Июль**	**Август**		
Серо-бурые	96,6	118,5	110,6	85,7	103,1	37,7
Серо-коричневые	72,7	88,4	83,4	70,5	79,0	28,4
Сероземно-луговые	88,4	95,6	93,7	80,5	89,5	32,2
Горно-серо-коричневые	56,4	67,5	63,2	50,1	59,4	21,3

Как следует из таблицы 1, количество актуального фиксированного азота за весенне-летний период изменяется не только в течении суток, но и по типам почв, имеющие различные условия почвообразования.

Наибольшее их значение приходится на серо-бурые почвы, особенно на июнь, составляя 118,5 мкг N_2/кг, а значительное угасание на август – 85,7 мкг N_2/кг почвы. Высокими значениями выделяются сероземно-луговые почвы 95,6 мкг N_2/кг почвы в июне и минимальные 80,5 мкг N_2/кг в августе. Почти в два раза активность азотфиксации низка в горно серо-коричневых почвах, составляя 67,5 - максимум и 50,1 мкг N_2/кг почвы – минимум в августе. Такие резкие отличительные показатели между горной и равнинной местностью, вероятно связаны с гидротермическим режимом почв.

В целом обогащение почв трофическим субстратом активизирует азотофиксацию во всех исследуемых почвах, из чего следует заключить, что представленные типы почв имеют достаточно высокий азотофиксирующий потенциал, где деятельность бактерий лимитировано за счет недостаточности энергетического субстрата.

Таблица 2

Потенциальная азотфиксирующая активность различных типов почв

Почвы	Количество фиксированного азота, в среднем за сутки, мкг N_2/кг почвы				Средняя	За вегетационный период, кг N_2/га
	Май	Июнь	Июль	Август		
Серо-бурые	520,8	821,0	760,0	595, 0	699,4	251,7
Серо-коричневые	480,3	524,6	710,3	448,4	548,0	222,1
Сероземно-луговые	652,8	865,5	708,6	615,5	709,7	255,4
Горно-серо-коричневые	328,5	464,3	577,2	376,3	629,0	132,0

Исследованиями выявлено, что нитрогеназная активность увеличивается в 10 – 50 раз при внесении в почву динамического источника углерода (Таблица 2).

Анализ таблицы 2 вновь констатирует высокое наличие фиксированного азота на серо-бурых и сероземно-луговых почвах 821,0 – 865,5 мкг N_2/кг почвы соответственно и значительно меньшую на горно серо-коричневых почвах, соответствуя при этом 464,3 мкг N_2/кг почвы.

ВЫВОДЫ

Установлено, что наличие диазотрофов в почве наряду с биологическими, имеют экологическое значение, за счет связывания ими молекулярного азота, практически во всех природных комплексах.

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Гидротехника

ИССЛЕДОВАНИЕ ДЕФОРМАЦИОННЫХ ХАРАКТЕРИСТИК ПЕСЧАНО-САПРОПЕЛЕВЫХ СОСТАВОВ ДЛЯ СТРОИТЕЛЬСТВА ПРОТИВОФИЛЬТРАЦИОННЫХ ЗАВЕС НА ВОДОХОЗЯЙСТВЕННЫХ СИСТЕМАХ

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Аннотация. Приведены результаты исследований деформационных характеристик различных песчано-сапропелевых составов для строительства противофильтрационных завес на водохозяйственных системах.

Ключевые слова: водохозяйственные системы, противофильтрационные завесы, песчано-сапропелевые составы, сапропель, водоподпорные сооружения, коэффициент пористости, коэффициент уплотнения.

Hydraulic engineering

RESEARCH OF DEFORMATION CHARACTERISTICS OF SAND-SAPROPELIC STRUCTURES FOR CONSTRUCTION OF ANTIFILTRATIONAL VEILS ON WATER MANAGEMENT SYSTEMS

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Annotation. Results of researches of deformation characteristics of various sand-sapropelic structures for construction of antifiltrational veils are given in water management systems.

Key words: water management systems, antifiltrational veils, sand-sapropelic structures, sapropel, water retaining constructions, porosity coefficient, consolidation coefficient.

ВВЕДЕНИЕ

Мелиоративные системы, отвечающие современным требованиям, представляют собой комплекс различного рода гидротехнических сооружений, большую часть которых составляют водоподпорные регулирующие сооружения, при строительстве которых на хорошо водопроницаемых грунтах возникает необходимость устройства противофильтрационных завес, что приводит к увеличению трудоемкости и стоимости сооружения.

Наиболее перспективным способом возведения противофильтрационных завес является способ «стена в грунте». Этот способ успешно применяется для строительства надежных противофильтрационных завес на крупных сооружениях. Для гидротехнических сооружений на мелиоративных системах, где размеры противофильтрационных устройств, сравнительно небольшие, применение метода «стена в грунте» по традиционной технологии экономически нецелесообразно.

Это объясняется главным образом, высокой стоимостью используемых материалов. Поэтому актуальность приобретает вопрос возведения противофильтрационных завес и поиск новых дешевых местных материалов для вышеуказанного способа, применительно к гидромелиоративным сооружениям.

В выполненных работах на кафедре гидротехнических сооружений и водоснабжения УО «БГСХА» Республика Беларусь, была выявлена возможность применения для строительства противофильтрационных завес методом «стена в грунте», современных отложений пресноводных водоемов Республики Беларусь – сапропелей. Также установлено, что для противофильтрационных завес сравнительно небольшой глубины (до 10…15 м), возводимых методом «стена в грунте», наиболее технически и экономически целесообразны следующие способы строительства завес:

1) проходка траншеи шнекоинъекционными машинами – перемешивание разрабатываемого грунта с тиксотропной суспензией в процессе проходки без извлечения смеси из траншеи;

2) разработка грунта траншеи бурофрезерными машинами с одновременным сбросом пульпы (разрабатываемый грунт и тиксотропная суспензия) обратно в траншею – обратный намыв смеси выбуренного грунта с тиксотропной суспензией. При этих способах строительства противофильтрационных завес образуется состав, состоящий из водопроницаемого грунта (песка) основания водоподпорного сооружения и тиксотропной сапропелевой суспензии.

Вопрос, какими деформационными характеристиками в дальнейшем, будут обладать вышеуказанные составы, представляет практический интерес и является, весьма актуальным, что крайне необходимо для определения несущей способности противофильтрационных завес.

ЦЕЛЬ И ЗАДАЧИ ИССЛЕДОВАНИЙ

Целью работы являлось исследование деформационных характеристик различных песчано-сапропелевых составов для строительства противофильтрационных завес на мелиоративных системах. Для достижения поставленной цели решались следующие задачи:

1. Определяли коэффициенты пористости.

2. Рассчитывали коэффициенты уплотнения.

С целью решения вышеуказанных задач выполнялись компрессионные испытания песчано-сапропелевых составов.

МАТЕРИАЛЫ И МЕТОДИКА ИССЛЕДОВАНИЙ

Материалами исследования являлись высокозольный сапропель взятый на объекте Лукомльского опытного «Озрыбхоза» Витебской области и песок мелкий. Физические характеристики исходных материалов приведены в табл. 1.

Таблица 1 – Характеристики физических свойств исходных материалов и ихсоставов

№ составов	Содержание сапропеля в составе песок + сапропель, %	Плотность твердых частиц γs, г/см^3	Плотность состава, γ, г/см^3	Плотность в воздушно-сухом состоянии γ_s,г/см^3	Влажность, W, %	Коэффициент пористости, e	Коэффициент неоднородности, η	Коэффициент водонасыщения
1	10,0	2,54	174	1,26	38,5	0,98	200	1,00
2	7,0	2,55	1,87	1,32	31,30	0,79	150	1,00
3	5,4	2,58	1,98	1,39	23,60	0,61	60	1,00
4	3,7	2,62	2,13	1,45	13,0	0,39	9,5	0,97
Песок	-	2,62	-	1,68	-	0,52	4,8	-
Сапропель	-	2,55	-	0,58	-	3,40	-	-

Компрессионные исследования выполнялись на приборах предварительного уплотнения грунтов ГГП-29 и обработка результатов исследования – по существующим методикам.

РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЙ И ИХ ОБСУЖДЕНИЕ

Результаты компрессионных исследований песчано-сапропелевых составов приведены в табл.2.

Таблица 2 – Результаты компрессионных испытанийпесчано-сапропелевых составов

Давление на образец, МПа	Коэффициенты пористости, e				Коэффициенты уплотнения, МПа$^{-1}$			
	Составы				Составы			
	№1	№2	№3	№4	№1	№2	№3	№4
0,000	0,980	0,790	0,610	0,390	22,53	16,87	9,13	0,40
0,015	0,642	0,537	0,473	0,384	9,20	5,70	4,30	0,40
0,025	0,550	0,480	0,430	0,380	1,20	0,80	0,80	0,80
0,050	0,520	0,460	0,410	0,360	0,80	0,4	0,4	0,3
0,100	0,480	0,440	0,390	0,345	0,24	0,36	0,18	0,22
0,150	0,468	0,422	0,381	0,334	0,20	0,24	0,14	0,20
0,200	0,458	0,410	0,374	0,324	0,16	0,12	0,08	0,12
0,250	0,450	0,404	0,370	0,318	0,14	0,08	0,04	0,08
0,300	0,443	0,400	0,368	0,314				

Анализируя таблицу 2, необходимо отметить, что коэффициент пористости для составов с большим содержанием сапропеля уменьшается под нагрузкой более значительно, чем с меньшим содержанием сапропеля.Также следует, что в интервале нагрузок до 0,05 образцы составов №1, №2 и №3 обладают сильной сжимаемостью. Коэффициент уплотнения изменяется от 22,53 до 0,8 МПа$^{-1}$.

С ростом нагрузки разница в сжимаемости образцов различных смесей снижается. При вертикальной нагрузке 0,10 МПа и более коэффициенты уплотнения всех смесей менее 0,5 МПа$^{-1}$, что характеризует их как среднесжимаемые.

При содержании сапропеля в смеси менее 4% (состав №4) сжимаемость образцов во всем

диапазоне нагрузок невелика.

Состав №3 с содержанием сапропеля 5,4% при нагрузках, больших 0,05 МПа, обладает лучшими показателями сжимаемости. При нагрузках 0,25-0,30 МПа этот состав обладает коэффициентом уплотнения, равным 0,04 $МПа^{-1}$, что позволяет отнести его к малосжимаемым и характеризовать как надежное основание для водоподпорного сооружения. Это обстоятельство можно объяснить тем, что по сравнению с другими составами он обладает более оптимальным содержанием сапропеля в песке, т.е. здесь достигается наиболее полное заполнение порового пространства песка сапропелем.

ВЫВОДЫ

1. С уменьшением содержания сапропеля в смеси сжимаемость уменьшается довольно значительно.

2. Состав №3 (содержание сапропеля 5,4%) относится к малосжимаемому, т.е. противофильтрационная завеса возведенная из состава №3 будет давать наименьшую осадку.

3. Учитывая, что запасы сапропелей в Республике Беларусь составляют более 2,6 млрд. $м^3$, применение их при строительстве противофильтрационных завес, позволит снизить стоимость строительства завес на 60-80%.

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Гидрология

МИНЕРАЛЬНЫЕ И ТЕРМАЛЬНЫЕ ИСТОЧНИКИ АЗЕРБАЙДЖАНА И ИХ ИСПОЛЬЗОВАНИЕ С ЦЕЛЬЮ ТУРИЗМА

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Аннотация. Эта статья, посвященная тепловым и минеральным водам в Азербайджанской Республике, и использующий эту воду в секторах экономики (отопление зданий, терапия курорта, здоровье и т.д.). Информацию о физической и химической структуре тепловых и минеральных вод, нагревая температуру показывают в этой статье.

Ключевые слова: минеральный, термальный, лечебный, геотермический, источник, рекреация.

Hydrology

MINERAL-THERMAL WATERS OF AZERBAIJAN AND ITS USING FOR TOURISM PURPOSES

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Annotation. This article dedicated to thermal and mineral waters in the Republic of Azerbaijan, and using this water in economic sectors (heating of houses, resort therapy, health etc.). İnformation about a physical and chemical structure of thermal and mineral waters, heating temperature are shown in this article.

Key words: mineral, thermal, social, region, chemical, temperature.

ВВЕДЕНИЕ

Территория Азербайджанской Республики богата природными ресурсами. Однако, эти природные ресурсы используются не на должном уровне. Среди этих ресурсов термальные и минеральные источники занимают особое место.

В государственных программах по социально-экономическому развитию регионов для каждого региона в отдельности определены пути решения эффективного использования природных территорий, туристско-рекреационных ресурсов, в том числе термальных и минеральных источников. Однако, эти проблемы еще не решены.

ОСНОВНАЯ ЧАСТЬ

Азербайджанская Республика обладает богатыми природными ресурсами. Одним из таких ресурсов являются термальные воды, термальные и минеральные источники Азербайджана широко распространены на территории Большого и Малого Кавказа. К сожалению, эти источники используются не на должном уровне. При разведочных работах на территории Азербайджана геологами было обнаружено около 1000 минеральных и термальных источников.

Особые заслуги в изучении минеральных и термальных вод Азербайджана имеют А.Н.Аскеров, М.А.Кашкай и А.Д.Асланов. Минеральные и термальные источники используются главным образом в Нахчыванском, Ленкарань-Астаринском, Губа-Хачмазском, Нагорно Ширванском районах.

При достаточном использовании термальных и минеральных вод возможно развитие новых отраслей хозяйства, создание курортно-оздоровительного хозяйства, лечебно-медицинских предприятий, туристско-рекреационных объектов, что оказывает положительное влияние на занятость, обеспечивая местное население рабочими местами. А также может способствовать расширению некоторых предприятий, увеличению потребности в продуктах питания прибывших в страну туристов и развитию сельского хозяйства.

По сравнению с другими странами в Азербайджане курортно-санаторная сеть слабо развита. Было бы целесообразным развитие в ближайшем будущем новых курортных центров в Нахчыване, Казахе, Товузе, Дашкесане, Астаре, Масаллы, Яламе, Худате, Хачмазе, Шемаха и Исмаиллы.

Водные источники Азербайджана состоят из 200 групп, в результате разведочных работ выявлено лишь 30 групп минеральных вод [1,3].

Исследования ученых показали, что температура вод существующих в Азербайджане термальных источников колеблется от 4ºС до 95ºС. Эксплуатационные запасы термальных вод составляет 248000 м ³/сут. Конечно, эта цифра относительная. В ходе исследования было выявлено, что запасы термальных вод в республике составляет 496000 м ³/сут.

В зависимости от геотермических особенностей района температура подземных вод меняется в широком диапазоне. Температура воды отражает тектоническую и гидродинамическую особенность данной территории. Температура оказывает влияние на химический состав воды и способность течения.

В природном состоянии подземные воды бывают очень холодными (<0ºС), холодными (<20ºС), термальными (20-100ºС) и очень горячими (>100ºС).

По международной бальнеологической классификации температура вод на земной поверхности дается в ниже следующем виде:

- холодные воды (ниже 20ºС)
- субтермальные – теплые воды (20-37ºС)
- термальные – горячие воды (37-42ºС)
- гидротермальные – очень холодные (больше 42ºС)

Находящиеся в Азербайджане минеральные воды Сираб, Бадамлы имеют холодную температуру (7-20ºС). Из высокотемпературных вод Азербайджана можно отметить Истису, Илыгсу, Готурсу, Аркеван, Бабазанан, Мешесу, Ибадису, Хашы, Халтан и др.

Минеральные и термальные воды республики используются в таких отраслях, как курортно-оздоровительные предприятия, химическая промышленность, оснащение питьевой водой, переработка электроэнергии, добыча природного газа, отопительная система зданий и т.д.

По вычислениям А.Д.Асланова, В.Д.Ахундова, О.М.Ахмедовой суточный дебит минеральных и термальных вод Азербайджана составляет более 200 млн л. Из них 50 млн л. приходится на долю минеральных вод с углекислым газом [2,8].

В результате проведенных научных и аналитических анализов выясняется, что термальные и минеральные воды экономико-географических районов Азербайджана изучены с геологической точки зрения, но проблемы комплексного исследования природно-ресурсных потенциалов изучены не полностью. Мысли и идеи Ш.Ф.Мехтиева, М.А Кашкая, А.Г.Аскерова, И.И.Тагиева, А.М.Бабаева, Н.А.Бабаханова и др. имеют большое значение при оценке с экономической точки зрения термальных и минеральных источников природно-географических территорий республики. История изучения термальных и минеральных вод еще раз доказывает, что использование термальных и минеральных вод в мировом хозяйстве является основным условием в туризме, рекреации и оздоровлении. В прошлом научные исследования термальных вод велись в геологическом и гидрогеологическом направлении. Сейчас же проводится, главным образом, в социально-экономическом, медицинском, курортно-оздоровительном направлении. Воды нефтяных скважин Апшерона, Сиязаня, Нафталана, Ширвана, Сальяна широко используются в лечебно-оздоровительных целях. На данных территориях построены санатории, где лечится большое количество больных.

Термальные и минеральные воды выходят на земную поверхность вместе с различными химическими элементами. Термальные и минеральные воды по своему химическому составу отличаются от простой воды. Эти воды выходят из глубины и обладают высокой температурой. Здесь встречаются, можно сказать, все известные в мире виды минеральных вод. В составе термальных и минеральных вод встречаются различные природные газы, органические и минеральные соединения. В минеральных водах имеется более 70 химических элементов в растворенном виде. В составе минеральных вод Азербайджана выявлено более 60 элементов. Состав минеральных источников Истису, Сираб, Бадамлы, Вайхыр (Нахчыванская Автономная Республика) и др. богат микроэлементами.

Минерализация воды – это количество солей растворенных в 1 литре воды.

При определении уровня минерализации используются классификации А.М.Овчинникова, В.А.Приклонского, Н.И.Толстихина, В.И.Вернадского и др. Однако, было бы целесообразней использование классификации по уровню минерализации термальных вод В.В.Иванова и Г.А.Невраева [3].

Минеральные воды в Азербайджане по своему химическому составу делятся на 10 групп. С целью эффективного использования минеральных и термальных вод подготовлены многочисленные проекты. Территориальная организация термальных вод и проблемы развития и их экономико-географическое изучение имеет научно-практическое значение. Ниже следуют наиболее распространенные экономические районы термальных и минеральных вод.

Апшеронский полуостров отличается от других регионов своими термальными источниками. Здесь находится около 183 термальных источников с высоким дебитом. В их состав входит большое количество метана, йода, брома, серы и др. компонентов [1,11].

В настоящее время на полуострове термальные источники широко используются в лечебных целях. Термальные воды Сураханов, Говсанов, Бибигейбата, Шыхова не отличаются от вод «Матеста».

Северо-Восточная часть Азербайджана богата нефтегазовыми ресурсами. В состав термальных и минеральных вод Галаалты, Халтан, Хашы, Джими и др. на территории Шабранского района входит азот и метановые элементы.

На территории Нагорно Ширванского региона имеется около 30 термальных и минеральных источников. Среди них можно отметить такие источники как Ваша, Хафтасов, Дияллы, Намазгях, Лагидж, Заргяран, Галагах Исмаиллинского района, сел Чаган, Авахыл, Галейбугурт, Бадов, Чухурюурт, Джабаны Шемахинского района находятся термальные и минеральные источники, где имеются перспективы развития курортного туризма.

Северо-западная часть Азербайджана богата термальными и минеральными источниками. Часто происходящие здесь природные катаклизмы разрушают источники термальных и минеральных вод и в результате усложняют использование данных природных источников. Однако, Кахский административный район широко использует туристско-рекреационные возможности.

Группа термальных источников Илису, минеральные источники Огланбулаг, Гызбулаг до сих пор не эксплуатируются в полной мере. Использованием термальных и минеральных вод региона и, тем самым, созданием курортно-лечебных объектов можно решить вопрос оздоровления населения, а также снижение безработицы в регионе, и привлечь в данный регион большое количество зарубежных туристов.

ВЫВОДЫ И РЕКОМЕНДАЦИИ

Т.О. необходимо провести учет имеющихся в Азербайджане минеральных и термальных источников, а также изучение химического состава, суточного дебита каждого термального источника и предпосылки использования этих источников в оздоровлении людей. Необходима оценка термальных и минеральных источников с точки зрения туристского хозяйства, а также определение и расширение в освоении территории с туристско-рекреационной целью.

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Environmental Protection

ECOLOGICAL STRATEGY FOR RATIONAL USE OF WATER RESOURCES

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Annotation. The article describes continuous intensive impact of human activity on the natural environment that increases the necessity to solve urgent problems of optimal control of various complex bioinert systems. To satisfy the needs, the modern society is compelled to create technical systems that are related to different technological cycles and perform certain public functions. Such systems, first of all, interact with the natural environment, consisting of various kinds of homogeneous and dissimilar natural systems and create so called Geotechnical System. One of the varieties of natural-technical systems is a water management system that is a totality of sources of water resources, means of their regulation and delivery to water users and means of environmental protection.

Reviewed methods of economizing of water resources are considered for the study of water problems - water resources protection and optimization of its planning and management.

Key words: water resources, bioinert systems, water management system, environmental protection, water pollution

INTRODUCTION

The continuous intensive impact of human activity on the natural environment increases the necessity to solve urgent problems of optimal control of various complex bioinert systems. To meet the needs, modern society is forced to create technical systems in the form of a combination of tools and means of labor, connected by some technological cycle and performing a certain social function. The most complex among them are systems that include techniques designed to extract resources from the natural environment and for purposeful impact on it.

Such systems, first of all, interact with the natural environment, consisting of various kinds of homogeneous and dissimilar natural systems. Set of technical and natural objects, forming a single integrity and purposefully functioning, forms a natural-technical system (Geotechnical System).

MAIN PART

One of the varieties of natural-technical systems is a water management system that is a totality of sources of water resources, means of their regulation and delivery to water users and means of environmental protection [1]. Consequently, within the framework of water management systems, the natural and socio-economic system is continuously interacting and the water management system itself serves as a mediator between nature and the economy.

The main task of further development of water management systems is to establish permissible loads on the natural environment so that the design of measures does not lead to a significant change or destruction of natural complexes.

In usage of water resources an important role plays the contaminants of anthropogenic origin entering the water bodies, which ultimately lead to a qualitative depletion of water resources. The main source of water pollution is waste waters from industrial and municipal utilities. Increasingly, they pollute the surface runoff from the territories of cities, industrial enterprises and especially from agricultural lands. In this case, water bodies are polluted with nutrients and pesticides. No less important source of pollution of water resources are cattle-breeding complexes and enterprises for processing livestock products.

The use on a large scale of Groundwater and their interconnection with surface waters predetermine the penetration of pollution into underground horizons, which are the most valuable sources of drinking water for the population.

The most common are chemical and bacteriological pollution of groundwater and they are "tied" to industrial areas.

The increase the use of water resources in the industrial and non-industrial spheres is accompanied by the expansion of water management capacities through the creation of Hydraulic Engineering and other Water Supply Facilities. The main core in the water management system is the reservoirs. On the use of water resources created reservoirs are mainly multi-purpose: for hydropower, irrigation, municipal services, industrial water supply, flood control, fisheries, etc. An important role in the water management system played channels which are ensuring the redistribution of the flow. They are used for irrigation, drainage, watering, water supply, Power engineer, etc.

Rational use of water resources in irrigation traditionally means the economical use of water with specified qualities. However, intensive human anthropogenic impact on the environment prompts the need to take into account and evaluate all the consequences of various environmental aspects, including the emergence of landscape-geomorphological and deformation-erosion processes that are especially pronounced in the course of functioning of complex natural-technical systems of irrigation [2].

At nowadays, the problem of water use is dominated by the emphasis on water consumption and almost completely ignored the environmental strategy to protect natural, in particular, the most unique mineral resources on earth - water resources.

In this regard, the reorientation of water use from the consumer position to the eco-water system should reflect the special role of water as an important component of the bioinert environment and an industrial and economic resource possessing indispensable unique consumer properties. At present, Georgia is working to improve the processes of rational use of water resources. An important role in solving this problem belongs to economic research on the development of bases for optimizing water protection activities, taking into account long-term socio-economic development.

The increasing demand of water resources and their scarcity (quantitative and qualitative) in certain regions of Georgia predetermine the particular urgency of implementing water protection activities on the necessary scale, protection and reproduction of water resources.

The main direction of rational use of water resources should be the improvement of technological processes from the standpoint of effective use of water. At the same time, it is necessary to reduce not only

the discharges of contaminated sewage, but also the intake of fresh water. The increase of water circulation in the industrial technological processes is the main direction in reducing the anthropogenic impact on water resources. Although this increases the irrevocable water consumption, but the water intake from the source is significantly reduced and what is most importantly stopped the pollution of a huge amount of water by sewage.

Water resources of Georgia are severely affected by agricultural activities and the use of artificial fertilizers. Surface waters are polluted by flushing fertilizers and pesticides. There is no precise data on the pollution of water resources by the agricultural enterprises. In rural areas, there are stocks of prohibited or under-used agrochemicals and pesticides that are stored in conditions that do not prevent their entry into surface and groundwater, which is an unknown threat to the sources of drinking water and consequently to human health [3].

To illustrate the great opportunities for implementing water conservation activities, we will consider the use of water resources in agriculture. At present agriculture, as was mentioned above, is one of the main water users and irretrievable water consumer, which makes 70-80% of the total volume of irretrievable water consumption in all sectors of the economics?

Obviously, one of the urgent issues of our time is the implementation of water conservation measures in irrigated agriculture aimed at savings of water. Among such activities, the main is the transition to new, progressive irrigation methods. The most promising here is drip and subsoil irrigation, in which moistening of the soil provided through special droppers. With such a method of irrigation, there is no loss of moisture due to evaporation and filtration and there is no rise of groundwater level and soil erosion. This method also allows adding fertilizers together with water.

A large reserve of water saving in agriculture is an increasing the efficiency of irrigation systems. Reducing the Coefficient of efficiency of irrigation systems to 0.85-0.9 makes it possible to significantly reduce water losses and at the same time significantly reduce the water logging and salinity of land.

CONCLUSION

The above reviewed methods of saving water resources predetermine the urgency of studying the problems of optimizing water protection activities and improving its planning and management.

Taking into account the current rate of population growth the UN predicts that by 2025 two-thirds of humanity will live in conditions of fresh water deficiency and the global water crisis is often simply a matter of life and death.

Therefore, water resources of a certain quality are the catalyst for optimal socio-economic development of states, regions, districts taking into account the quantification of water resources in technical, economic, environmental and legal aspects.

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Irrigation

REGULARITIES OF WATER AND EVAPORATION DYNAMICS IN THE ACTIVE LAYER OF SOIL

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Annotation. The article describes the physical image of the evaporation mechanism from the soil surface. It is estimated that the evaporation intensity is the function of the capacity of dried soil layer. The consideration of aerodynamic factors allows us to determine the intensity of capillary water intake, which is expressed in the quantitative definition of vacuum pressure in accordance with atmospheric pressure deficiencies.

Based on the proposed simulation model, a physical relationship between the speed and height of the capillary movement was established. This method can be used to quantitatively measure the productive humidity in the active layer of soil and irrigation mode.

Key words: evaporation rate, active layer of soil, productive water, meteorological factors.

INTRODUCTION

The first descriptions of the study of the evaporation process from the soil surface are derived from the beginning of the 20th century. The process of drying of certain soil layers by a number of authors was presented by means of three characteristic stages.

THE MAIN PART

The first stage of evaporation involves the starting momentum of atmospheric precipitation or ending momentum of artificial irrigation and evaporation intensity in this stage is determined mainly by the influence of meteorological factors. As for the dynamics of the water saturation in the active soil layer (aeration zone), we must estimate it in a manner similar to the seepage process occurring in a partially saturated porous and capillary body.

The second stage of evaporation is characterized by an intensive drying of surface layers of the soil during which the water becomes steamy not directly on the surface, but extends to a certain depth. At the same time, the evaporation intensity is determined by the velocity of water overflow at the evaporative zones and the separation surface is characterized by a slight change in humidity in the upper drain layer. Since the role of the meteorological factors is much more important than the capillary potential of water, it is usually thought that the process of intensification in the second stage of evaporation is entirely determined by the velocity of water in the vapor-transformation area.

The third stage of evaporation starts when in the area of vapor-transformation the upward movement stops and gradually starts the intensive dryness of the upper layers of the soil. Evaporation intensity at this moment is significantly reduced and in the first stage, it is determined by the complex of meteorological factors. The presented schematic model of the qualitative description of the physical picture of evaporation is used universal recognition both in the former Soviet Union and abroad.

Nevertheless, for the real natural geotechnical conditions, the variability of the meteorological properties complex within the day-cycle is characterized by certain specifications, therefore, the concept which is formed for the second stage of evaporation requires essential revision, which is of great importance to critical assessment of the existing models of evaporation of soil moisture, as well as the physical picture of the phenomenon to determine adequacy with them [1].

Let us consider the trivial case when in experiments the constancy of the main meteorological factors (solar radiation, air temperature, wind velocity, relative humidity and relative sun light) affecting evaporation are conserved, and the second of evaporation stage begins, which is limited by the continuous water flow in the evaporation zone. At this time the formation of the process of vapor-transformation is formed from the soil surface at a certain distance. After this, if we change the mentioned meteorological factors in such a way that potentially available evaporation will be significantly increased, then in the beginning the amount of water actually evaporated from the soil will be also increased, but after the transformation process will be completed, it will again equal to the rate of vapor-transformation and will depend on the capacity (thickness) of the dried layer of soil. When the water "inflow" mode is unchanged, then the evaporation rate will coincide with the initial intensity, even though the area of the vapor-transformation will be deeper into the depth. Meteorological factors, when they reach the initial values, can be assumed that the depth of the vapor-transformation zone (border) will remain unchanged due to the hysteria of the process.

In the proposed evaporation schemes, a paradoxical, but completely logical picture is observed, after the end of the first stage, the difficult transition process; this does not fall directly into the framework of the simple scheme of evaporation described above.

Evaporation from the soil depends on the potential of water flow, as well as the complex of meteorological factors. In terms of their variation in time, to describe a more laconic form of the process, we call the combination of complex of incoming factors as "evaporability" and at the same time consider that "evaporability" is evaporation from the surface of fully water saturated soil. It should be noted here that such a term is not accurate, but its use does not generate misunderstanding. However, we also need to note that evaporability is meant evaporation, when water is delivered in the entire section of the evaporation surface (the contact plane) continuously.

Description of the variability of the factors affecting the evaporation process during the day and their impact on the quantitative rate of evaporation was often a subject of some critical assessment for some researchers. As an example, for the evaluation of meteorological factors, analysis of the results of hypothetical experiments is used, according to which it is revealed that in the closed space the evaporation is higher than the possible potential velocity, that is equal to the potential velocity of water supplied from the bottom, then the evaporation velocity is equal to the fictitious velocity of supplied water. Increasing evaporation increases the duration of the vapor-transformation process. The proposed analysis aimed to evaluate quantitatively the impact of meteorological mono-factors on the evaporation in the case of determined local tests, which is obviously takes place in the case of different intensity in the formation of one and the same dried soil capacity in different times.

Such prerequisites are not enough to create a model that reflects the dynamics of evaporation process taking into account the physical essence of the hardest stochastic event. This is explained by the fact that all existing models are based only on the formal side of the process and are less aware of the capabilities of the capillary phenomena and, in particular, the exponential nature of the capillary rising, which completely

excludes the possibility of quantitative evaluation of the one or another potential on the finite contours in the given area. At the same time it is necessary to note that the model of dynamics of the capillary rising process is not based on the formal or mathematical symbolism, but on the magnitude of the gradient determining the velocity rate in the capillary fringe, which is dependent and tied to some or other hydrophilic and mineralogical characteristics of the soil.

The interpretation of the evaporation in the second stage by different authors is less clear and evident, since it is difficult to understand without any mechanical illustrative model. In order to overcome this difficulty, we have developed a model of velocity of capillary movement [2,3,4].

According to the design scheme, the gradient of the velocity of capillary movement is equal:

$$J = \frac{(H - \Delta H) - Z}{Z}, \tag{1}$$

where J is the gradient of the velocity of capillary movement; H - height of capillary rising, (m); ΔH - vacuum head, caused by wind velocity, (m); Z - coordinate of capillary meniscus, (m).

According to the above it becomes evident that one of the strongest meteorological factors in the second stage, namely, wind velocity increases the evaporation intensity and thus increases the capacity of dry soil. It is known that the increase in the depleted layer should lead to reduction of evaporation.

Conventionality and schematization of the description of the phenomenon is far from the actual physical picture of the process, however, it quite convincingly describes the synchronous mechanism of permanent supply of water in the depleted layer caused by the meteorological factor (wind velocity) [1,4].

At this stage of the study of the problem, we set the goal, according to the verified equation [4] proposed by us, to carry out a particular calculation of the velocity of the supplied capillary water, taking into account the aerodynamic pressure (vacuum effect).

For the ideal model of soils, the velocity of water movement in the vertical direction in capillary fringe can be calculated accordingly by means of the following [3]:

$$\frac{Z}{t} = \frac{Z}{\frac{n}{K} h_k \left(\ln \frac{h_k}{h_k - Z} - \frac{Z}{h_k} \right)}, \tag{2}$$

where Z is an application of the capillary fringe, (m); t - time of capillary rising, (s); n - porosity; $\eta = Z/h$ - relative coordinate; h_k - height of capillary rising, (m); K - seepage rate, (m/s).

If we consider that according to the design scheme Z varies from 0 to h_k and mark, that $\frac{Z}{h_k} = \eta$, which varies from 0 to 1, then we will get:

$$\frac{Z}{t} = \frac{\eta}{\frac{n}{K} \left(\ln \frac{1}{1 - \eta} - \eta \right)}. \tag{3}$$

If we take the following notation marks: $\frac{K}{n} = a$ and $\varphi(\eta) = \frac{\eta}{\ln \frac{1}{1-\eta} - \eta}$, then the average velocity of capillary movement will be described by the following equation:

$$V = a\varphi(\eta). \tag{4}$$

The differentiated assessment of the factors determining the vacuum pressure is not possible without special experimental and theoretical researches. In addition, it is noteworthy that the intensity of water supply at the certain stage of evaporation process does not depend on the distribution of the drying zone, although the air conductivity is obviously depending on the capacity of the drying zone.

CONCLUSIONS

Finally we can conclude that the model proposed by us will allow us to quantify the evaporation intensity in case of permanent supply of capillary flow, which will allow us to establish a productive water supply in the active layer of soil and thus irrigation mode in a certain interval of time.

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ASSESSMENT OF A CONTEMPORARY STATE OF SALINIZED SOIL OF THE ALAZANI VALLEY

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Annotation. The article describes the importance of salt soil of the Alazani Valley for agriculture development – one of the strategic directions of the country;

It provides as well performance indicators of salination of the Alazani soil according to the experimental observations made between 2005 and 2017 that are compared with existing data;

It has been established that a salination process on the Alazani soil is carried out in an appropriate manner and there is no threat of secondary salinization.

Key words: salinized soil, soil, salinization.

One of the main directions of agriculture development strategy of Georgia is an increase of melioration and soil productivity. Based on climatic conditions soil melioration as well as construction, operation and control of irrigation and drain systems is an important field that should ensure to provide a necessary background for an intensive and effective agricultural industry.

Georgia is a traditional agrarian country. A significant condition for its social-economic stability is to provide the population with food products and overcome poverty. The problem has become more crucial over the recent period.

Agricultural use of salt soils is the most significant agricultural problems that should be paid an appropriate attention. This problem is important today because the soils mentioned above occupy 18,7% of the area to be cultivated. In East Georgia salt soils cover 205 thousand ha including the Alazani Valley (occupying 31 ha) that is distinguished by its heavy clay saline-alkali and low-land alkali soils that are difficult to cultivate and meliorate. Non-availability of natural drainage turned the part of the Alazani Valley's plain into an accumulation zone of a geochemical underground flow running from the Tsivgombori Mountain that as a result of drastic reduction of flow velocity is accumulated from the tail into in the transitional zone of a plain and afterwards penetrates through the upper layers of soil. Intensive water evaporation helps salt to accumulate in the upper layers of soil, i.e. a soil-forming process of meadow alkaline soil occurs.

Salinized soils are situated on the right bank of the Alazani River as well as on the Iori Plateau, the Gardabani Plateau, the Eldari Valley, and Taribana. Cultivation of meliorated soils as well as desalinization of highly mineralized ground waters is quite a lengthy process.

Based on the longitudinal research carried out by the Sakhydroecology and the Alazani Probationary-Melioration Station a full cycle of melioration and cultivation of highly salinized and sodic, sodic-sulfite alkali soil is elaborated, approved and tested in progress that from 1970 was followed by a large-scale tillage of salinized deserted areas of East Georgia. Currently, the area of soils meliorated on the Alazani Valley approximately amounts to 17 thousand ha. [1,2].

Over the years on the areas mentioned above in parallel to soil cultivation, observations and industrial tests were being made in order to improve the technology of soil prewashing-down cultivation as well as to make the washing-down process perfect. During the cultivation process of the deserted areas it is very important to develop methods of irrigation that will ensure a heavy yield and further desalination of soil that

is implemented under the irrigation washing-down regime (operational washing-down and irrigation washing-down regime) [3,4].

During this period due to the high volume of work as well as existing condition in the country attention for the test-drainage segment diminished to some extent. Therefore, from 2005 monitoring observations were resumed with a more facilitated scheme.

The observations demonstrate that against the background of the existing parameters of the drainage-collector network and appropriate agro-technical measures, it is possible to intensively cultivate the soils mentioned above that is proved by the data provided in the tables below (Table #1) where it is clearly shown that through the years the dynamic of reduction in injurious salts is observed apart from certain exceptions that cannot make an essential impact on the whole picture of soil rehabilitation.

Table 1. Dynamic of soil-ground desalinization on the Alazani test-drainage segment

Depth in cm	Initial content of salts 1952	After washing down 1954	Years of observations – agricultural cultivation period						
			2005	2007	2009	2011	2013	2015	2017
1	2	3	4	5	6	7	8	9	10
0 – 25	1.09	0.032	0.240	0.180	0.190	0.120	0.140	0.130	0.156
25–50	1.55	0.51	0.400	0.240	0.250	0.220	0.240	0.210	0.230
50–75	–	–	–	0.350	0.340	0.320	0.330	0.300	0.330
75–100	2.19	1.24	1.04	0.820	0.800	0.785	0.790	0.760	0.810
Cl^*									
0 – 25	0.097	0.008	0.005	0.003	0.004	0.004	0.005	0.006	0.007
25-50	–	–	–	0.005	0.006	0.005	0.007	0.008	0.009
50–75	–	–	–	0.004	0.007	0.009	0.010	0.013	0.014
75–100	0.208	0.50	0.14	0.008	0.008	0.12	0.014	0.15	0.025
HCO_3^*									
0 – 25	–	-	-	0.027	0.032	0.034	0.034	0.50	0.057
25 – 50	–	-	-	0.023	0.032	0.040	0.042	0.044	0.045
50 – 75	–	-	-	0.025	0.045	0.045	0.047	0.048	0.048
75-100	-	-	-	0.050	0.060	0.070	0.071	0.080	0.085
SO_4^*									
0 – 25	–	–	-	0.90	0.95	0.106	0.110	0.115	0.128
25 – 50	–	–	-	0.101	0.103	0.107	0.119	0.125	0.139
50 – 75	–	–	-	0.310	0.310	0.320	0.350	0.380	0.406
75 – 100	–	–	-	0.500	0.515	0.520	0.550	0.590	0.626

It is also observed a slight increase in solid waste in a 0 – 100cm layer that is caused by the fact that over the recent period due to the full destruction of the irrigation network an irrigation washing-down regime does not work. In fact, over the past 10-15 years agricultural plants have not been irrigated. Not only the water intake collector requires a full repair but the whole irrigation network needs to be reinstalled that due to the existing situation in the country was placed in junk, and all this as you know requires high finance.

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THE DEVELOPMENT OF RATIONAL DRIP IRRIGATION SCHEDULE FOR APPLE SAPLINGS PRODUCED UNDER THE CLIMATIC CONDITIONS OF THE MOSCOW REGION

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Annotation.The article contains information about the main biometric characteristics used for quality estimation of nursery apple plants which are grown in different soil moisture ranges regulated by means of drip irrigation. The obtained results allow estimating various irrigation schedules and revealing the optimal ones that can be used for growing one-, two- and three-year old apple trees in nursery gardens of the Moscow region. Also application potential of differentiated drip irrigation schedule for growing two- and three-year old apple trees is outlined. The comparative analysis of irrigation schedules recommended for drip and traditional overhead sprinkler irrigation is provided in the article as well.

Key words: drip irrigation, apple saplings, differentiated irrigation schedule, irrigation dose, planting stock quality.

INTRODUCTION

Drip irrigation is proved to be one of the most effective water saving and ecological methods of plant watering.Moreover, such an irrigation system can be fully automated. Proper scheduling of irrigation is critical for nursery trees since they have no roots when planted [1]. Also irrigation schedule contributes to production costs and environmental safety when highly-profitable crops are cultivated. Drip irrigation enables to maintain the optimum soil moisture level in accordance with biological water requirements of an irrigated crop. However, these requirements vary greatly depending on plant species that is why it is necessary to do research on each crop in order to find out the optimal soil moisture conditions and to develop the ideal irrigation regime considering the specific climatic conditions of different areas. So, this article is devoted to the development of optimal irrigation schedule for apple sapling grown in nurseries of the Moscow region.

MATERIALS AND METHODS

The field experiment was conducted in the nursery on the territory of the Michurin Garden which belongs to the Russian State Agrarian University and lasted for 3 years. One of the most popular apple varieties - BeliyNaliv(which is widely grown in the Moscow region) was chosen as the object of the research. The soil on the experimental plot is characterized as the one of the sod-podzol type with middle loam texture on the covering silt. According to the results of agrochemical analyses the soil is well supplied with nutrients (NPK). The average field capacity (FC) of the plowed layer (0–30 cm) on the experimental plot amounts to 33 % of absolutely dry soil weight. Fertilizers were applied in all variants at the same rates in correspondence with the recommendations.

Four different irrigation treatments were used in the experiment, each being repeated three times, and every repetition included 25 average apple saplings.

Drip irrigation allows maintaining soil moisture in quite a narrow range, thus, the scheme of the experiment runs as follows:

1. I variant: soil moisture was maintained within the range 70–90% of FC, which means that watering of apple saplings started every time when the soil moisture content reduced to 70% of FC and ended up when it reached 90% of FC;
2. II variant: soil moisture was maintained within the range 60–80% of FC;
3. III variant – differentiated: in the 1st year of research – soil moisture was maintained within the range 70–90% of FC, in the 2nd and 3rd – soil moisture was maintained within the range 60–80% of FC;
4. IV variant (check) – without irrigation.

For the field experiment a special drip irrigation system has been designed and installed on the plot in the nursery garden. The drippers have a self-compensating system guaranteed by a silicon membrane that minimizes flow rate fluctuations when the working pressure changes. The flow rate of one dripper is 3.8 liters per hour. Besides, as plant roots grew the irrigated soil layer was increased, therefore, during the 1st year of experiment watering rates were calculated for 0–30 cm layer, during the 2nd year – 0–40 cm., the 3rd – 0–50 cm. Soil moisture content was controlled by means of tensiometers and moisture sensors calibrated on the basis of data obtained by gravimetric method.

RESULTS AND DISCUSSIONS

The obtained results on drip irrigation schedules were compared to the existing recommendations on traditional over-tree sprinkler irrigation used for watering saplings in nursery gardens of the Moscow region (table 1). In order to maintain soil moisture at the predetermined for each variant ranges the volumes of irrigation water applied were the following: I variant – 1665, 1481, 1463 m^3/ha in the 1st, 2nd and 3rd year of research correspondingly, II variant – 1362, 731, 748 m^3/ha, III variant – 1644, 725 and 741 m^3/ha (table 1). In the experiment the soil moisture after irrigation did not reach the level of 100% of FC, which helped to avoid infiltration of irrigation water down the soil profile into the layers underlying the root zone and to decrease its unproductive losses. So the volumes of water used which were mentioned the above were regularly applied at low irrigation rates, thus ensuring regular and equable humidification of the root zone. Irrigation doses increased along with the deepening of the root zone by 10 cm each year (from 30 to 50 cm for the three years of research) and on average amounted to 41, 47, 58 m^3/ha in the 1st, 2nd and 3rd year of research correspondingly. Overhead irrigation is performed by means of much higher irrigation doses 300-350 m^3/ha, in this case water losses through infiltration and evaporation are inevitable and quite significant.

Table 1

Comparative characteristics of different irrigation schedules and methods used for watering apple saplings

Characteristics	Drip irrigation									Overhead sprinkler irrigation
	I variant (70-90 % FC)			II variant (60-80 % FC)			III variant differentiated			
	Year of research									
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	
Irriga-tion demand, m^3/ha	1665	1481	1463	1362	731	748	1644	725	741	1500-2100
Average irriga-tion dose, m^3/ha	41	49	59	41	46	58	40	45	57	300-350
Irriga-tion interval, days	2	3	4	3	5	7	2	5	7	20-25

Irrigation intervals varied depending on weather conditions and irrigation schedule, in the I variant it fluctuated from 2 to 4 days, in the II variant –3 – 7 days, in the III variant – 2 – 7 days, which in its turn also provides more stable distribution of moisture during the vegetation period compared to overhead sprinkler irrigation, when irrigation interval is usually 20–25 days. Short irrigation intervals afford better meeting the biological requirements of young apple trees for water, plants do not suffer from excess of water immediately after irrigation and the lack of water at the end of irrigation interval.

It is necessary to outline the III variant (differentiated drip irrigation schedule) where savings of water for two years of research amounted to 777 m^3/ha andfor three years – 1500 m^3/ha.

As far as one and two year old apple trees cannot bear fruits, it is impossible to evaluate their quality by measuring the fruit yield, however, it is of greatest importance to use in orchards high-quality planting stock. The vigor of nursery trees directly depends on such parameters as stem diameter, plants height and leaf surface area [2]. Due to this fact during the investigation all above mentioned biological parameters characterizing the aboveground plant development as well as the quantity of appropriate standard planting stock were measured in order to find out the optimal irrigation schedule.

Table 2 represents information on biometric parameters of planting stock obtained in each variant of the field experiment.

Table 2

Influence of irrigation schedules on the development and yield of apple planting stock

Variant	Plantheight, cm	Stemdiameter, cm	Leaf surface area of one plant, cm2	The number of standard planting stock		Yield, kg/ha
				%	Thousands of plants per ha	
1st year						
I variant	135.8	1.78	1448	77	25.9	-
II variant	115.7	1.63	1181	68	22.9	-
III variant	139.9	1.72	1433	76	25.8	-
IV variant (check)	100.3	1.30	892	39	13.1	-
2nd year						
I variant	181.3	2.38	3997	75	25.3	-
II variant	156.6	1.91	3145	65	21.9	-
III variant	173.8	2.30	3715	74	24.9	-
IV variant (check)	146.3	1.55	2899	37	12.1	-
3rd year						
I variant	215.3	2.91	6033	75	25.3	154.4
II variant	181.8	2.49	5199	65	21.9	103.
III variant	213.7	2.88	5973	74	24.9	148.2
IV variant (check)	169.3	2.23	4182	37	12.5	69.7

The maximum plant height was recorded when soil moisture was maintained at the level 70-90 %FC: 135.8–139.9 cm (1st year), 181.3 cm (2nd year), 215.3 cm (3rd year). According to the results maximum stem diameters, which influence afterwards the yield of fruit trees in orchards [3], were also registered in variants where higher soil moisture range was maintained (I and III): 1.72–1.78 cm, 2.38 and 2.91 cm. The largest leaf area surface is typical of these variants as well 1433–1448 cm^2, 3997 cm^2 and 6033 cm^2 correspondingly. Moreover, it is important to note the differentiated variant where absolute values of biological parameters significantly exceeded the ones obtained in II variant setting aside IV (check) variant, despite reducing available soil moisture on the 2nd year of research to the interval of 60–80% of FC (table 2)

and were close to the ones obtained in the I variant. Minimal values were registered in the check variant. Besides, on the 3rd year of research young apple trees started to bear fruits, the maximum number of fructiferous plants was noted in the I and III variants – 18% and 17% respectively, where the highest yields were obtained 148.2–154.4 kg/ha. The check variant without irrigation showed minimal values of these characteristics. The highest number of one-year old standard planting stock was obtained in well moistened variants 70–90% of FCand amounted to 25.9 thousand plants per hectare, as for two- and three-year old apple saplings then the best results were registered in the I and III (differentiated) variants 24.9–25.3 thousand plants per hectare [4].

CONCLUSIONS

These data allows assuming that nursery trees are more demanding to soil water content in the first year after planting since they do not have developed root system yet and suffer from the lack of available moisture in the soil. So for growing one-year old nursery trees in the Moscow region the most favourable wetting conditions are recommended when soil moisture content is maintained within the range 70–90% of FC.

For obtaining two- and three-year old high quality planting stock the use of differentiated irrigation schedule is more reasonable, having formed under more intensive soil moistening in the first growing season young apple trees can grow properly even if the soil water content is reduced in the following seasons. At the same time such irrigation treatment allows saving resources, declining irrigation water requirements by 757 – 1500 m^3/ha.

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SURFACE WATERS DIVERSION BY USING DOUBLE-STAGE DRAINAGE

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Annotation. In the article is used existing practical filtration calculation methodic for upper tier of combined drainage, which is located at the water resistant. This type of the drainage may be use for protection of productive soils from the logging with atmospheric precipitation. For arise affectivity of the drainage is necessary to conduct measure for arise water permeability at the upper half meter layer of soil.

Key words: fissure drainage, combined drainage, filtration, soil.

INTRODUCTION

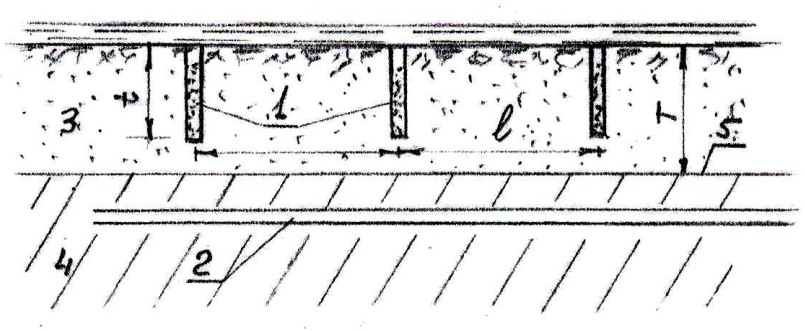
A practical task of the drainage amelioration is stating a distance between drains. For this purpose in a humid zone of European and the former Soviet Union countries, where a main reason of bogged soil is underground waters, filtration estimation of the regulating network were made considering provision of the necessary intensity of lowering of the underground water levels. Quite different situation is on The Colchian Depression. A reason of bogging-up of soils of heavy mechanical composition is plenty, long and intensive precipitations. So a main goal will be to decrease a period of flooding and water saturation of soil.

Irrigation and exploitation of such soils showed in practice of The Colchian Depression and Europe that at the time of plenty, long and intensive precipitations only the closed tubular drainage system can't create a necessary hydrological regime in soil. The growth of its effective action should be carried out by making the regulating network more frequent and using closed collectors. Besides from literature sources it is known that a combined-double-stage drainage systems are being tested in Sweden [1], Norway [2] and Russia [3], which is recommended for drying heavy clays, but implementation is delayed because of not having scientifically grounded parameters (the drainage distance between the upper and lower stages and filtration coefficient of the filling material).

MAIN PART

Combined double-stage drainage was tested on the experimental plot in Khobi region, where clayey soils of heavy mechanical composition and slight water permeability (with content of 60-80% clay and silt fraction) are spread. Signs of impermeability in these soils are seen from the depth of 15-20 cm, but from the depth of 50-80 cm an impermeable layer is started, saturated with attached water (Kf=0,00n m/day) and is water-resistant to the upper layer.

The main point of double-stage drainage is that right-angled crevices of 10 cm of the width and 60 cm of the depth are cut at right angle to the closed tubular collectors. (Picture 1). In this picture there is not shown a depth filter of broken stone of tubular collector, which is arranged up to the bottom of the crevices). The distance between the crevices is 3 m, which is filled with sand and gravel mix up to 10 cm from the earth surface in order to provide a hydraulic connection between surface waters and cervices. There was considered the necessary condition $K_g/K_f \geq 20$, where Kg is filtration coefficient of the surrounded clay ground and K_f - filtration coefficient of the filling material. So we have a combination of drains arranged on two levels: a lower stage from the ground surface – tubular closed collectors and an upper stage – crevassed drains with filler.



Picture 1. Doubled-stage drainage:
1 – crevassed drain; 2 – closed tubular collector (perforated plastic pipe - d>100 mm); 3- a water-permeable layer; 4 – a weakly water-permeable layer; 5 – water-resistant layer

Taking into account that the closed collectors of the lower stage arranged in the weakly water-permeable layer are acting factually as closed collectors and the distance between them is 4-6 times more than the distance between the crevassed drains of the upper stage, it can be admitted that diversion of the whole excessive water will be done by crevassed drains. Besides the water flow regime in the upper stage drains must meet the condition of the maximal water diversion, which depends on the possibility of water permeability of the interface of the upper and lower stage drains. However if the interface node and the depth filter of the generally closed collector are filled with crushed stone, the filtration coefficient of which is many times more than that of the sand-gravel mix, in our opinion it is not necessary to take into account the possibility of water permeability in hydraulic calculations.

Nowadays we don't have a satisfying method of diversion of waters seeped from the ground surface while flooding by a regulating network, which would allow us to estimate seepage. But in our case when surface waters are taken and diverted by the crevassed drains of the upper-stage of the two-stage drainage, we can use a hydro-mechanical solution of V.V. Vedernikov, which determines the maximum charges of tubular drains during flooding [4]. After that calculation methods of V.I. Aravin and S.N. Numerov and calculated formulae were reduced to approximate ones for sufficiently exact practical calculations [5].

From the above reasoning according to the calculation method the corrected specific discharge of each drain is calculated by formula [5]:

$$(q\ r)_{dr} = H/\phi$$

Where: H – current hydraulic pressure $H = t - 0.6a = 0.6 - 0.6 \cdot 0.2 = 0.48$m; a – thickness of the layer to be plowed; [6]

ϕ - Filtration resistance, which is calculated by the following formula:

$$\phi = 0.367 \log \frac{sn\left(\frac{K(4t-D)}{4T};\lambda\right) cn\left(\frac{KD}{4T};\lambda\right) dn\left(\frac{KD}{4T};\lambda\right)}{sn\left(\frac{KD}{4T};\lambda\right) cn\left(\frac{K(4t-D)}{4T};\lambda\right) dn\left(\frac{K(4t-D)}{4T};\lambda\right)}$$

where K is complete elliptic integral of first-order; λ - module of the complete elliptic integral of first-order; D – drain diameter, which in our case is D=0.56P, where P is a perimeter of the crevassed drain filled with sand-gravel, D=0.56· $1.2 = 0.672$ m; [7] t- crevice deepening from the ground surface (m); T – the thickness of the water permeable layer (m); sn, cn, dn – Jacob's elliptic functions, which can be determined by means of the following expressions: elliptic sinus - $sn(F,\lambda) = \sin\varphi$; elliptic cosines - $cn(F,\lambda) = \cos\varphi$; elliptic delta - $dn(F,\lambda) = \sqrt{1-\lambda^2\sin^2\varphi}$, where F - elliptic integral of first-order; φ -

its amplitude; θ – module corner (λ in radians to be turned into θ degree); unknown module λ can be found from the following equation: [5]

$$\frac{K}{K'} = \frac{2T}{\ell}$$

where K' - complete elliptic integral of first-order with an additional module: $\lambda' = \sqrt{1-\lambda^2}$; ℓ - the distance between the crevassed drains (m);

$$\phi = 0.367 \log \frac{sn\left(\frac{1.587(4\cdot 0.6 - 0.672)}{4\cdot 0.8}; 0.2\right) cn\left(\frac{1.587\cdot 0.672}{4\cdot 0.8}; 0.2\right) dn\left(\frac{1.587\cdot 0.672}{4\cdot 0.8}; 0.2\right)}{sn\left(\frac{1.587\cdot 0.672}{4\cdot 0.8}; 0.2\right) cn\left(\frac{1.587(4\cdot 0.6 - 0.672)}{4\cdot 0.8}; 0.2\right) dn\left(\frac{1.587(4\cdot 0.6 - 0.672)}{4\cdot 0.8}; 0.2\right)} = 0.19$$

So reduced specific discharge of each drain will be:

$$(q\ r)_{dr} = H/\phi = 0.48/0.19 = 2.\ 53\ \text{m}$$

The specific discharge of each drain:

$(q)_{dr}$= K $(qr)_d$ m^2/reduced=0,05•2,53=0,126m^2/day

or 0,126 • $\frac{1000}{86400\cdot}$ = 0,0014 l/sec.m.

K - Filtration coefficient of soil-ground, m/day;

Finally filtration discharge of drains from 1 ha area or drainage modulus of the drain will be:

$$QQ = 1000/l\ (q)_{dr}\ \text{l/sec. ha} = \frac{10000}{3} \cdot 0{,}0014 = 4{,}7\ \text{l/sec. ha}$$

Load upon the drain 4, 7 • 8.64=40.6 mm/day

In case when the crevassed drains of the upper stage are on the water-resistant layer ($T = t$), then filtration resistance $\phi$is calculated by the following formula:

$$\phi = 0{,}733 \log \frac{cn\left(\frac{KD}{4T}, \lambda\right) dn\left(\frac{KD}{4T}, \lambda\right)}{\lambda' sn\left(\frac{KD}{4T}, \lambda\right)}$$

Designations and calculation way are the same as above. Therefore

$$\phi = 0{,}733 \log \frac{cn\left(\frac{1.573\cdot 0.672}{4\cdot 0.6}, 0.077\right) dn\left(\frac{1.573\cdot 0.672}{4\cdot 0.6}, 0.077\right)}{0.997 sn\left(\frac{1.573\cdot 0.672}{4\cdot 0.6}, 0.077\right)} = 0.24$$

The reduced specific discharge of each drain will be:

$$(qr)_{dr} = \frac{H}{\phi} = \frac{0.48}{0.24} \approx 2.0\ \text{m}$$

The specific discharge of each drain:

$(q)_{dr}$= K (qr) m^2/day=0,05•2.0=0,1 m^2/day

or 0,1 • $\frac{1000}{86400 \cdot}$ = 0,0012 l/sec. m

The filtration discharge of drains from 1 ha area:

QQ = 1000/l $(q)_{dr}$ l/sec. ha. = $\frac{10000}{3}$ •0,0012 =4 l/sec. ha.

Load upon the drain 4,0 • 8.64=34.6 mm/day.

In the central part of the Colchian Depression the amount of precipitations per day in any season of the year is often 500 mm. As it is seen modulus of drainage flow, depending on whether crevices are located on the water-resistant layer or not, is in the range of 4.7-47 l/sec. ha, which is acceptable and quite real in the conditions of the Colchian Depression opposite to the former norm of 0.65-1.07 l/sec. ha [8]. Apart from this the regulating network of the existed parameters is able to move off 40.6 – 34.6 mm/day or 81.2% or 69.2% precipitations off the earth surface.

CONCLUSION

The usage of double-stage drainage on the heavy soils of the Colchian Depression has its certain perspectives, as compared to the other traditional systems along with the reliability it also allows to manage the water-air regime flexibly and effectively considering peculiarities of climate conditions existed in soil-grounds.

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Hydraulic engineering and irrigation

ANALYSIS OF FORMULAS FOR CALCULATING SILT-CARRYING CAPACITY IN MAINTENANCE SEDIMENT BALANCE ALONG THE LENGTH OF THE MOVEMENT

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Annotation. Qualitative analysis and comparison of many more or less well-known formulas by silt-carrying capacity definition of the thread held indirectly - on the background of sediment balance.

Consistency of silt-carrying capacity of the flow or sediment balance is quite acceptable concept, widely used in solving different tasks on thesediment movement, including the bridge hydraulics. It gives the opportunity to conduct a qualitative evaluation of existing formulas and establish the relationship between hydraulic parameters oftwo reaches of the channel. Moreover, one of the sections has known characteristicsand the parameters of the second are sought for.

Key words*:* silt-carrying capacity, sediment, flood, flow, parameter.

INTRODUCTION

While task solving of channel process related to a sediment balance are mainlypermittedthree inaccuracies:

- first, the flood of solid matter or silt-carryingcapacity of the flow uses the dependence of a large number of existing recommendations. Meanwhile, none of the existing formulas for calculating the amount of alluviums with a hint of shortcomings. Naturally, all shortcomings of this formula are automatically transferred to the new development;
- secondly, when using the sediment balance mainly are discussed channels with a rectangular cross section which allows to establish a simple connection between depth and width of the stream instead ofmore general connectionbetween the areaof passage and wetted perimeter;
- thirdly, in the preparation of sediment balance in the quality of the channel reach, where the flow parameters are known, taken that onewhich is directly before the section of the channel, for which areacceptedthe decisions.This approach is inappropriate, especially for watercourses of a mountain and foothill areas, as is taken as the initial section of the stream often moves with ultimate fullness of aggradations.

OBJECTIVE OF THIS WORK

Based on that was madean attempt toconsider more deeply those conditions, which are subject to the constancy of the marginal silt-carrying or transporting capacity. Thus, the results of analysis of formulas for the calculation of solid discharge and flow concentration (covering the diversity of the movement of sediment) allowed establishing a generalized relationship between the parameters of the water cross- section [1, 2]. The performed researches sufficiently simplify different tasks on the movement of sediment and debris flows greatly increasing the reliability of the final calculations.

It is known that the longitudinal gradient on the piedmont and especially mountain streams decreases quite sharply. And each section of the channel, depending on slope and other characteristics corresponds to a

certain value of marginal silt-carrying (transporting) capacity of *S*. In this case the calculated concentration of the $P_P$flow corresponds to its $Q_P$bed formation flow rate and has a specific value which is setwell-known hydrological calculations. Hence the obvious conclusion that transporting capacity on any section of the channel with sufficient accuracy corresponds to an estimated concentration of flow. In other words, at this point the stream will move with marginalsilt-carryingcapacity [2]. All parameters of this section hereinafter referred to as "marginal" denoted with"zero" index.

$$\text{Then}\, P_P = S_0 \quad (1)$$

The values of these parameters (slope i_O, transporting capacity *So*, cross-sectional wet areaA_O and others) play a critical role in the assessment and analysis of the state of motion silt-carrying capacity along the length of the watercourse and, therefore, establishing the type of natural stream bed, the hydraulic calculation of structures, etc.

Having considered silt-carrying capacityit is easy to see that the upper slopes, concerning marginalandreaches of the channel more than the slope i_o, and the bottom slopes– less i_o.

Choosing the "ultimate section" as the reference, we denote by $i_{b.1}, i_{b.2}, ..., i_{b.n}$ upper slopes of them, and after $i_{H.1}, i_{H.2}, ..., i_{H.n}$ the lower slopes of the river channel (Fig. 1). For the transportingcapacity of the flow, respectively, will have $S_{b.1}, S_{b.2}, ..., S_{b.n}$ and $S_{H.1}, S_{H.2}, ..., S_{H.n.}$

Keeping in mind that the calculated concentration of $P_P$flow at "marginal areais equal to its carrying capacity $S_{o,}$ it can be concluded that the magnitude of the limiting silt-carrying capacityof the upper sections of the river channel is more than the calculated concentration S_o, i.e.

$$S_{b.1}, S_{b.2}, ..., S_{b.n} > S_o. \quad (2)$$

For the lower reaches have the inequality

$$S_{H.1}, S_{H.2}, ..., S_{H.n} < S_o. \quad (3)$$

Specified gives reason to the following conditions ofsilt-carrying capacity along the entirewatercourse length:

- upper level movement occurs with concentration of P_P, with less transporting capacity $S_{b.n}$ *(n=1,2,3,...)*;
- movement to "marginal land" comes with a transportingcapacity;
- lower level movementin reaches occurswith concentrationP_P, with more transporting capacity of flow $S_{H.n}$ *(n=1,2,3,...).*

These considerations lead to the obvious conclusion that on the basis of the values i_o and S_o are possible to establish two well-known types of natural streambed at the entire watercourse length: the transit zone (upper plots) and sediment zone (lower areas) (Fig. 1).

Over time, with increasing of the predictedconcentration, "marginal land" moves up, and withdecreasing down. A gradual increase in the length of the transition zone occurs at a constant value P_P, because of the accumulation of sediments at the initial parts of the zone of the deposits, their grades and, consequently, transportinf capacity will increase.

In the channel construction of hydraulic structures on the appropriate locations of watercourses, disturbed the balance of natural channel process, so that near the target structures excited intense channel-forming loads of the phenomenon.Herewith, depending on the purpose of the structure and characteristics of flow, sediment, and river channels, in some cases, starts to develop a run of river erosion, in others, the sediment deposition (Fig. 1). After some time, reaching a certain level of development, these unsteady phenomena are fading, and the channel in this area takes on a new, almost stable shape of the longitudinal profile and plan. In most cases, under the new conditions the flow is uneven. Further received stream sediment transit pass through this area, i.e. the observed constancy silt-carrying capacity of flow (balance of sediments).

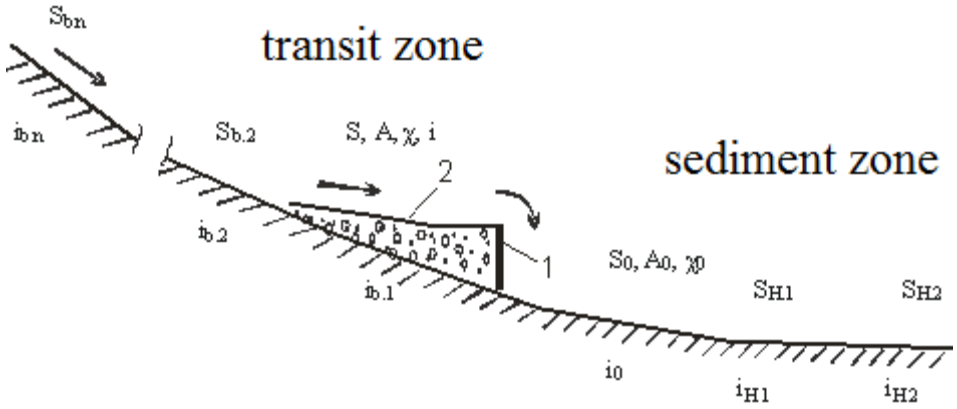

Fig. 1 Longitudinal profile of the stream diversion channel
1-mudflowcheck dam, 2 -stabilizedsurface deposition aggradation

A similar conclusion can come on the basis of known Exner-Velikanov continuity equation [3], which in the general case (non-stationary channel process), is as follows:

$$\frac{\partial A}{\partial t}+\frac{\partial Q_T}{\partial x}=0, \tag{4}$$

where Q_T is the sediment discharge in the flow, м^3/s; A – the cross-sectional wet area of the flowing channel $A=Z\,b$, m^2; Z is the height of wash away area. Obviously, at the completion of stream diversion channel and achievement of the stabilization period, longitudinal profile and transverse dimensions of the channel are the same, therefore $\partial A/\partial t=0$. Then, according to equation (4), we get:

$$P=const\ . \tag{5}$$

Therefore, solid flow rate (or silt-carrying capacity of the flow) and the length of the artificial channel are not changed.

From the above we can conclude thatthe diversion stream channel processassociated with the establishment of waterworks, originate such run-of-river conditions, which provide transit silt-carryingflow with the concentration of$P_P$through this area. All parameters here are denoted without an index. It is obvious that the entire length of this plot the flow, similar to the "ultimate site" is subject to the condition

$$S=P_P. \tag{6}$$

Taking into account specified for mountain streams the condition of a constant silt-carrying capacity (balance of sediments) is the equation

$$S=S_0, \tag{7}$$

where S_o is the transporting capacity of the stream to "marginal area" with a slope i_o.

Equation (7) is valid for any location of the structurein relation to "marginal area".

The sediment balance is often used in solutions of various tasks on aggravation motion, in particular, the hydraulic calculation of bridges, mudflow transporting channels and trays, mudflow check dams, etc. In this case equation (7) enables to establish the relationship between the hydraulic parameters of the cross section of two sections of the river channel: "ultimate" and the newly formed (accordingly A_o, χ_0 and A χ), using existing expressions for calculating the carrying capacity or solid flow.

There are many recommendations to determine silt - carrying capacity of the stream, which is analyzed in detail in the works of M.A.Velikanov [3], P.O. Baljyan [4]. From the analysis of these works it is possible to draw the following conclusion: none of the recommendations does not cover all the diversity of forms of movement sediment in lessor more saturatedflow, in deformable and rigid channels. Based on the

above and given the diversity of existing methods for calculation of the amount of sediment, an attempt is made to reveal functional dependence:

$$\chi = f(A, A_0, \chi_0) \tag{8}$$

Number of formulae can be reduced to the expression (9) [5]

$$S = \sigma \frac{V^3}{C^2 R \rho' W}, \tag{9}$$

this can be represented in the form:

$$S = const \frac{V \cdot i}{W \cdot \rho'}, \tag{10}$$

Show the transformation that allows conducting the comparative analysis. Given the Chezy formula replacing the hydraulic gradient, we get:

$$S = const \frac{V^3}{C^2 \cdot R \cdot \rho' \cdot W}. \tag{11}$$

Using condition (7) can be written:

$$\frac{V_0^3}{C_0^2 \cdot R_0} = \frac{V^3}{C^2 \cdot R}. \tag{12}$$

We introduce dimensionless quantities:

$$\bar{b} = \frac{b}{b_0}; \bar{h} = \frac{h}{h_0}; \bar{A} = \frac{A}{A_0}; \bar{\chi} = \frac{\chi}{\chi_0}; \bar{R} = \frac{R}{R_0}; V = \frac{V}{V_0} = \frac{1}{\bar{A}}; \bar{n} = \frac{n}{n_0}; \bar{C} = \frac{C}{C_0} \text{ etc.}$$

Thus, for example, for rectangular channel we have:

$$\bar{A} = \frac{b \cdot h}{b_0 \cdot h_0} = \beta_0 \cdot \bar{b} \cdot \bar{h}, \tag{13}$$

$$\bar{\chi} = \frac{b + 2h}{b_0 + 2h_0} = \bar{b} + 2\bar{h} \frac{\beta_0}{\beta_0 + 2}, \tag{14}$$

where $\beta_0 = b_0 / h_0$ is known as hydraulic ratio.

Equation (12) using the dimensionless quantities, is to mind:

$$\frac{\bar{V}^3}{\bar{C}^2 \cdot \bar{R}} = 1, \tag{15}$$

Replacing the dimensionless flow rate *V* and hydraulic radius $\bar{R}$ to the cross-sectional wet area and wet perimeter $\bar{\chi}$,and determining the ratio Chezy's Manning, will receive:

$$\bar{n}^2 \cdot \bar{\chi}^{4/3} = \bar{A}^{13/3}. \tag{16}$$

Under $n = n_0$ (i.e. $\bar{n} = 1$), according to the expression (16) we get the dependence of $\bar{\chi}$ and *A* for "marginal" and the newly formed areas in the form of:

$$\bar{\chi} = \bar{A}^{13/4}. \tag{17}$$

A under C=C$_o$and taking into account (2.23), we have:

$$\bar{\chi} = \bar{A}^4.$$

Similarly, with the use of a number of expressions for calculating the values$S$ и $Q_T$or all kinds of possibleconditions offlood

(silt-carrying capacity) was received on the appropriate balance between anddiffering from other values for the exponent under $\overline{A}$.

In cases where $n \neq n_0$ and $C \neq C_0$, the findings are used well-known expressions of Shtrickler Chang, nandigama speeds and others. Some results of these processing are presented in table 1.

The designationsare standardized in the formulas of various authors. At the same time those values whichdo not change in the considered conditions (the value of *g*, the density of the sediment and flow, solidfall diameter, etc.) included in the concept of "*const*".

Based on the analysis of theproceeding resultswe can conclude that despite the specificexpressions by definition of silt-carrying capacity (for suspendedload and bed silt, water and debris flows, hydraulic transport), as well as at the existing discrepancies between the results of calculations by these expressions (sometimes in several times), they are generalizing based on [2].

$$\overline{\chi} = \overline{A}^{a}, \tag{19}$$

In this expression the value of the exponent *a* represents a formula for calculation of silt-carrying capacityor the flow of sediment.Thus, despite the large quantitative discrepancy between the recommendations for calculation *S* or Q_T, the confidence range of the exponent *a* varies in the range from 2.5 to 4.5. This shows that the existing guidelines for determining of silt-carrying capacity significantly differ from each otherin quantitative as well asin qualitative characteristics.

Table 1

Research results-finding functions $\chi = f(\overline{A})$

№ n/n	Formulae	Nota bene	Transition $\chi = f(\overline{A})$	№ n/n	Formulae	Nota bene	Transition $\chi = f(\overline{A})$
1.	M. A. Velikanov and its analogues $S=const.V.i$	$C=C_0$	$\overline{\chi} = \overline{A}^{4}$	9.	M. A. Mostkov $S = const\frac{i}{1-2i}$	$C=C_0$	$\overline{\chi} = \overline{A}^{3}$
2.		$n=n_0$	$\overline{\chi} = \overline{A}^{3.25}$	10.		$n=n_0$	$\overline{\chi} = \overline{A}^{2,5}$
3.		$n \approx d^{1/6}$ $d \approx V^3/R^{1/2}$	$\overline{\chi} = \overline{A}^{3.67}$	11.		$n \approx d^{1/6}$ $d \approx V^3/R^{1/2}$	$\overline{\chi} = \overline{A}^{3}$
4.	I.V. Egiazarov $S = const\frac{R \cdot i^{3/2}}{d}$	$d=d_0$	$\overline{\chi} = \overline{A}^{4}$	12.	A. Shoklich $q_T = const\frac{q-q_H}{\sqrt{d}} h \cdot i^{3/2}$	$n=n_0$ $d=d_0$ $h=R$	$\overline{\chi} = \overline{A}^{4}$
5.		$n \approx d^{1/6}$ $d \approx V^3/R^{1/2}$	$\overline{\chi} = \overline{A}^{3}$	13.		$n \approx d^{1/6}$ $d \approx V^3/R^{1/2}$	$\overline{\chi} = \overline{A}^{4}$
6.	A. V. Karaushev $S = const\frac{V^2}{h}\frac{V}{V_{пов}}\Gamma$	$\Gamma = 1$ $\overline{h} = \overline{R}$ $\overline{V}/V_{пов} = 1$	$\overline{\chi} = \overline{A}^{3}$	14.	V.G. Sanoyan $\psi(S,d) = const\frac{(1+K_2 S)S}{V \cdot i}$	$\frac{\rho_T \rho}{\rho_c^2}(1-S) \cdot S \Delta \left(\frac{u}{W}\right)^2$	$\overline{\chi} = \overline{A}^{4}$
7.	V. S. Knoroz $q_T = const\frac{V^2(V-V_H)}{R^{2,25} \cdot d^{-0,75}}$	$d \approx V^3/R^{1/2}$	$\overline{\chi} = \overline{A}^{3}$	15.	author $S = const\left(\frac{V^2}{\Delta}\right)^{0,3} \frac{i^{1,4}}{\Delta^{1/6}}$	$C=C_0$	$\overline{\chi} = \overline{A}^{3,43}$
8.		$\overline{1} - V/V_0 = 1$ $d=d_0$	$\overline{\chi} = \overline{A}^{2,35}$	16.		$\Delta \approx d$ $\overline{d} = 1$	$\overline{\chi} = \overline{A}^{2,82}$

The proposed dependence (19) is applicable to all types of movement of sediment and shapes of channel cross sections, provided that there is consistency silt-carrying capacity of the flow. Passing to dimensional quantities, the expression (19) writes in the form:

$$\frac{\chi}{\chi_0} = \left(\frac{A}{A_0}\right)^a. \tag{20}$$

Here it is necessary to agree the cross-sectional wet area A_o and the wetted perimeter$_o$ of "marginal land" with a slope of i_o. It is obvious that without setting their values does not make sense to talk about the use of dependencies (19) or (20).

The calculation of their values for the given values of flow rate Q, the slope of the marginal section of the channel i_o, etc. is carried out according to the method of calculation riverbeds and channels, as described in Chapter 6. Meanwhile, the value of i_o is determined and by calculation according to the expression (13) (the inverse problem), and on the basis of surveys, as the slope of the plot above which is located a transit zone and lower are zone deposits. Naturally, it is better both ways with the aim of obtaining reliable values for the slope of the i_o. Both methods, naturally, are reliable for obtaining reliable values for the slope of the i_o.

For channels of rectangular shape generalized dependence (19) using expressions (13) and (14), is to mind

$$\bar{h}\left(\frac{\bar{b}}{\bar{h}} + 2\right)\frac{\beta_0}{\beta_0 + 2} = \left(\bar{b}\cdot\bar{h}\cdot\beta_0\right)^a. \tag{21}$$

After obvious transformations and defining

$$M = \left(\frac{\beta_0}{\beta_1}\cdot\frac{\beta_1 + 2}{\beta_0 + 2}\right)^{1/a}, \tag{22}$$

where $\beta_1 = \bar{b}/\bar{h} = b/h,$ will get

$$\bar{h} = \frac{M}{\beta_0\cdot\bar{b}^{1-1/a}}. \tag{23}$$

Practically, acceptable values of the ratios β_0 and β_1 are easy show that the cup product in brackets and even more the value of *M*is sufficiently close to identity.

$$\text{Then } \bar{h} = \frac{1}{\beta_0\cdot\bar{b}^{1-1/a}}. \tag{24}$$

Taking into account of practical calculations for channels with a rectangular cross section instead of independence(19) we can use (23) or (24).In confirmation of the saying consider the following example: substituting $1/a_{cp} = 1/3$ and *M=1*, according to the expression (23) we have:

$$\bar{h} = \frac{1}{\beta_0\cdot\bar{b}^{2/3}}. \tag{25}$$

Substituting the value of β_0 the ratio of b_0/h_0, and the dimensionless $\bar{h}$ and $\bar{b}$ to the dimensional, get

$$h = h_0\left(\frac{b_0}{b}\right)^{2/3}. \tag{26}$$

This dependence is well known in bridge hydraulics as a fairly reliable formula for calculating the depth of erosion under-bridge bed [6].

CONCLUSIONS

Based on the foregoing, it can be concluded that since none of the existing expressions for calculating silt-carrying capacity does not encompass the full rangeof sediment movements, for the solution of many practical problems, which observed the constancy of the carrying capacity, it is advisable to use a generalized relationship (19) or (24) with different values of the exponent and its confidence interval (2.5 to 4.5). As a final calculation result is necessary tochoose the most unfavorable. This approach will allow to avoid errors related to the use of one particular expression.

The research was performed under scientific theme 11-30/15TSCSRA.

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Earth sciences

SOME ISSUES OF CORRELATION BETWEEN TECTO-SEISMOGENIC LANDSLIDE-GRAVITATIONAL PHENOMENA AND EARTHQUAKES SYNERGIES IN THE CAUCASUS MOUNTAINS

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Annotation. Despite the large flow of information in the field of geomorphology, so far insufficient attention has been paid to the role of the earthquake as a relief-forming factor, and use of geomorphological methods in seismology, especially large landslide-gravity phenomena in established tectonic disturbances and regional distribution areas for strong earthquakes. Meanwhile, the study of tecto-seismo-gravitational formations at the proper level and the establishment of areas of their geographical distribution gives significant information about the possibility of earthquakes in those territories where data on earthquakes are still not available.

On the territory of Georgia, tecto-seismogenic landslide-gravity phenomena, which are directly related to earthquakes, there are more than one thousand. By the time of their formation, they are conventionally divided into three categories: 1. Geological period (i.e Pleistocene); 2. Holocene-Historical and 3. Modern (Last 300 years).

***Key words*:** Landslide, Geomorphology, Earthquake, Tectonics, Relief.

In today's understanding of Earth Science does not represent a new conceptual idea that modern tectonic movements in the young wrinkle mountain system occupy the leading position in the formation of relief and its geodynamic condition.

The Caucasus-Pontide Region is, first of all, the qualitative and quantitative transformation of alpine relief, the establishment of a new tectonic regime, the formation of basic morphological structures and the formation of hypsometric and barometric zones. At the same time begins to regenerate major tectonic disorders (especially prealpine deep faults) and new ones, mainly surface transverse disorders, faults, strokes and seismic dislocations. All this has led to the dismantling of large geo-structural units into separate lodges and karst-horst "mosaic" structures. All this led to the sharp increase of relief energy relief, formation of geophysical fields, activation of seismic processes and subareal volcanoes.

It is estimated that the speed of vertical movements in Caucasus Mountains in anthropogenic was 4-5 times higher than the average maximum speed of the whole neotectonic stage. Accordingly, the maximum amplitude in the central Caucasus segment comprises maximum amplitude of 4-5 km, and in the Lesser Caucasus - 3.0-3.5 km. At the same time, rates of the phase are significantly increased in the third - anthropogenic stage (the age of which is academic O. Milevsky defines 0.5 mln time), the Caucasus is estimated to be 1.0 km, and the Lesser Caucasus is determined by the first hundred meters. The maximum depth of the most recent sinks is in the Edge tub area: 2.5km in Kuban segment, 3.0-4.0km Tersk, 3.0km - Rioni, Mtkvari - 6.0-7.0km, and the Apsheron-Kobistan Pericline zone - 5.0-7.0km. These rates of vertical movements led to the block-break dislocation in the morphological structures of mountainous structures and the same stratigraphic block at different levels with different tectonic modes. In spite of the intense energy of deep erosion, the movements of the motion structures exceed the depths of rivers. Often the boundaries of

the boundary blocks and the different directions of movement are accompanied by live gaps that are accompanied by a gravity or compressive collapse that was subsequently filled with powerful alluvial-lacustrine-glacial sediments. Many geo-morphological discrepancies of this kind are set in the waters of the main rivers of the Caucasus - Tergi, Baksani, Teberda, Adjaristskali and Chorokhi (Turkey) basins (2). The uneven blockade, morpo-structures is morphologically defined by the depth of the river gorges, with the inclination of the bottom of the valley with the alluvial sedimentary factions and power. Frequently river gorges are a step in hard rocks, rather than a nearby neighborhood, with more concrete rocks built into erosion processes. This type of morphological nature of the same valley logically answers logically that there is a "live" disorder in the neighborhoods in the same river valley, though it is often not geologically inhospitable. Similar tectonic disorders include relief micro-props (slopes and terraced surfaces of the same age, flats, valves, waterfalls, landslide-rock avalanche events), and also indicate that we deal with micro-tectonic surface deformations. The modern seismic activity is most frequently seen in these tectonic disorders.

Although geo-morphological science has accumulated significant information on endogenous communication between tectonics and relief, there is still little attention to the role of earthquakes as a relief factor, and the use of geo-morphological methods in seismology. In this respect, it is especially important to assess the large-scale landslide-gravitational phenomena and their correlation between tectonic disorders and the possible spread of earthquakes in spatial areas in the context of relevant geological environment. Also, the effects of seismogenic factors are not yet fully understood in the formation of waste of gravitational deformation, rock reaction and slope stability. It does not argue that seismic events are directly related to tectonic movements and that the most striking representation of modern tectonic motions is earthquakes, but what is the place where individual morphological structures are still in the process of formation of seismic effect still needs to be understood. Due to different spheres of transformation of geodynamic regime, it is of principle important to determine the timeless and accurate parameters of modern tectonic movements, as well as the dissemination of spatial areas of significant constituent earthquakes and exodynamic gravitational processes noble Issues.

Although much of the land space of the Caucasus region belongs to the high-intensity earthquake detection zone, but still not properly established a correlation between the interdependence of the latest manifestations of tectonic movements on the playing field, morpho-structures block formation and seismic activity, and, most importantly, a great seismic and gravitational emergence of the events when it is known that the vast majority of earthquakes associated with the areas, which are located at depths of 5-20 km borders, which further increases the risk of landslide-gravitational tectonic-seismogenic nature. In central segment of the Caucasus mountain Kazbegi-Jimaraikhokhi alpine-nival zone in 2002 on the riv. Genaldoni and 2014 the riv. Amal-Devdorak basins formed catastrophic mudflows, which caused more than 10 victims and the hundreds of millions of dollars in economic losses.

In the study of modern geodynamic issues in the Caucasus, Elaboration of the rhythm of the vertical movements works processed by Lilienberg (3), Determine the rhythm of vertical movements of different types and rank modems - 1, 2-3, 5-7, 10-15, 20-25, 35-40, 50-60, 70-80, 100- For 120 years. According to the author, the rhythm of this kind in the XX century has suffered three times: two of these phases, one phase-sinking. In addition, it is important that the transition of the Caucasus and the Lesser Caucasus are not coincidental. Studies have shown that the agglutination periods of the South-East Caucasus earthquakes coincide with the general intensive phase (1950-1970).

With the growth of vertical movements that increase seismic events and the development of slopes-gravitational processes, it is practically approved on the Almaat geodynamic firing range, where the highest positive vertical movements (60 mm per year) were observed before large earthquakes (4).

Tashkent earthquake in 1966 as well as the example it has been determined that when an earthquake centers are located close to the surface, their energy low magnitude earthquakes may be even higher in intensity than the calculated data was provided. This view is completely revealed Spitak 1989 (Armenia), 1991 Racha, Phasanauri Barisakho-1992 (Georgia) and in Tbilisi 2002 earthquake caused landslide-gravitational deploy geodynamic analysis of the assessment. At the same time clarified that the focus of the shallow earthquakes impact the effect of geological structures in the upper floors of the tectonically ashlil react more strongly rocks relax process and residual deformations even arise from a weak earthquake, which made conditions for the next intensive and extensive development slope-gravitational events. For example, in the waters of the Black Sea in 1986, forming 5 magnitude intensity earthquakes in the highlands zone activated landslide destroyed more than 400 houses.

Thus, we can conclude that the morphogodiomic studies of the Caucasus are determined that all the strong earthquakes in the region must be caused by the motion structures that are in the area of the latest and revamped tectonic faults, and the large paleo - and modern seismic dislocations and slope-gravitational phenomena avoid the seismic tectonic zones, most of which retain some synchronization.

While the Caucasus geomorphologic and geological issues, researchers are paying attention to the important seismic-dislocations and seismic-gravitational assessment, which laid the foundation for the study of 20th century 60-ies professors V. Sololenko and V. Khromovskim (5), and in this time have accumulated a lot of information morpo-dynamics and seismic-tectonics and the majority of them are contradictory and insufficient seismic processes and the basic rocks of landslide-generated large volumes of rock-fall phenomena generating union. They should be all recorded event coding on the map of dynamic conditions and the possibility of the formation of the time and place, "GIS system" specializing tectonic-seismic-gravitational map. Surveys conducted in the Caucasus-Ponti and Central Asian Mountain regions assured us that the landslide and gravitational phenomena created in the main rocks (developed in hard rocks). Therefore, this kind of morphological phenomena is called "inside-slope-landslides".

Tectonic-seismogenic landslide-gravitational phenomena are conditionally divided into three categories: 1) the geologic stages of the Pleistocene period; 2) Holocene - a historical period; 3) Modern stage (the last 300 years period).

Today's level of knowledge allows only a certain probability to determine where and how strong earthquakes can occur if we have statistical information on the geographical space and the geological environment. But if we do not have this kind of information then we are forced to consider the possibility of seismic hazards of a given territory. But if we make the above-mentioned specialized tectonic-seismic-gravitational map, then this kind of geomorphologic phenomena as natural indicators of value to us is still unknown territory geographically within the palaeo- earthquakes and historical conditions and their expected return period risk determination, and, on the other hand, will help us to live Tectonic fault (especially local), which are geologically difficult to be mapped.

Tectonic-seismogenic phenomena according to the mechanism of origin are quite different from all other genetic types of landslides. Types of tectonic-seismogenic landslides are characterized by azonallocalization, such as the "regional misinformation" of the main ridge of the Caucasus and its co-wrinkle slope; "Surami-Gokhschuri-Chokhatauri", which separates each other from the Ajara-Trialeti fold system and the western slopes of the sloping zones; "Zhinvali-Orkhevi" thrust fault, which disassembles the Flisch-Terigenal sediments of the Eastern Caucasus from the Neogenemolasses structures. Special attention should also be paid to the tectonic zone of the Racha-Lechkhumi synclinic depression, mainly the barrier and the third-tailed marine sediments of the territorial sea carbonate rocks. There are several dozen villages (including Tsesi, Kvatskhuti, Kldisubani, Chorjō, Tola, Gadamashi, Chkvishi, Sairme, Orbeli, Chkhuteli, Surmush, Laila etc.), and most importantly in many of these last centuries; For example, the Kldisubani tectonic-seismic-gravitational landslide came into active dynamics in the XX century in 1926, 1942, 1956,

1960, 1972, 1977, 1987 and 1991. F. Sololenko and Khromovsky (5) link these Landslides to Achigvara 7-magnitude earthquake in 1957. The landslide-gravitational morphological forms of linearly located in the foothills of Samegrelo must be connected to the seismologically active zone of Poti-Abedagi.

Seismogenic gravitational effects due to the diversity of landslide-generated rock-fall processes should highlight the local seismic-generation tectonic fault effect, which is very impressive in Central and Eastern Caucasus Mesozoic flysch formation tectonically strongly disturbed.

At present, the area recorded several thousand tectonic-seismic-gravitational phenomena (Fig. 1). This kind of landslide-gravitational phenomena areas and volumes are mostly large, for example: village Gordi rock-avalanche-landslide, which is located in the riv. Tskhenistskali basin occupies more than 30 km^2, while Landslide developed in riv. Adjaristskali occupies 10km2 (area between Goderdzi pass and village Danisparauli), Gombori landslide occupies area of 15km^2. Large range of uncertainty as well as their deep deformations (two dozen meters to 250 meters) and volume -Several million from 250 m^3.

Impact of earthquake factors on the triggering of technogenic landslide-gravitational phenomena will be differentiated and depending on the degree of tension of tectonic slopes and dynamic conditions of its geological environment in the areas of disruptive zones.

1. Under conditions where the slopes are preliminarily determined by high tension of seismographs, they are instantly reacting to their sustainability as a "factor of power" and generate large landslides and rock-avalanches. There are classic examples of the 1991 Racha landslide in Sachkhere district of Khakhieti landslide when the whole village was buried (Fig. 2), in Oni district, Beloti landslide, such events are hundreds (2). In the second case, the seismic vibrations of various energy, related to geo-dynamically strained morpo-structural blocks, are constructed with different stratigraphy-lithological composition and physical-mechanical properties result in slopes from the marginal equilibrium and create real conditions for landslide-gravitational events intensive for activation. For example Danisaparauli landslide in Adjara, which was triggered by Spitak earthquake transit waves in 1989 (Fig. 3-4).

Fig. 1. Riv. Aragvi gorge (village Chiriki, Dusheti)

Fig. 2. Khakhieti Landslide (Sachkhere)

Fig. 3-4. Danisparauli Landslide (Khulo municipality)

The 1991 Racha earthquakes not only triggered hundreds of thousands of new landslides creation and activation of old landslides, but also slopes in such a critical tension that the dynamic activity of landslides has been observed every year.

It should be noted that in the Caucasus and in particular the regulation of seismogenic Geo-structures in Georgia, seismic intensity increase and the recovery of tectonics mesmerizing landslide events and their repeated reboots are observed from the 40s of the 20th century. Special danger is the seismic structural morphological units, which are occasionally regenerated with low seismic energy conditions. For example, Landslides in the Kvirila basin in Itskisi and Itavaza area (Sachkhere municipality), In riv. Rioni basin, the villages of Kldisubani, Lailashi, Tvishi, Chkhuteli and the Racha-Lechkhumi Syncine Boards.

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environmental protection

METHODS OF QUALITATIVE-CRITERIAL EVALUATION AND PREDICTION OF THE DEGREE OF WATER POLLUTION OF THE RIVERS OF THE BLACK SEA BASIN

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Annotation. The paper considers the methods of qualitative-criteria evaluation and prediction of the degree of water pollution of the rivers of the Black Sea basin and gives a flow chart of the ecological-ingredient system of the Black Sea with decision-making and regulatory functions. The methods given in the work consider the damage inflicted to the environment and public health for different levels of hazard of the environmental pollution risk: when d Є [0,20-0,37] - the Catastrophic, or "Situation of Ecological Disaster" or d Є [0,37-0,63] - the Critical, or "Critical Ecological State". The qualitative-criteria evaluation of the degree of water pollution of the rivers of the Black Sea basin can be identified by means of recommended methods given in complex, in line with the values of ingredients characterizing the pollution, based on the probability and descriptive modeling.

Key words*:* Black Sea, degree of pollution, ecological-ingredient system, risk of environmental pollution.

INTRODUCTION

The problem of protecting the river water ecosystems against the pollution shows certain opposition with the achievements of the technical progress. The development of the policy against the water quality deterioration plays a decisive role in the technical-economic and social-cultural achievements of any country. The water quality management needs solving such problems as guaranteeing the water quality in a given ecosystem at minimal expenses and development and realization of the action plan necessary for the realization of the former goal. The pollution of the river water means the deterioration of its biosphere and ecological functions. As the water gets polluted, its physical and organoleptic features change (seen in the changed transparency, color, odor and taste) evidenced by an increase in the content of sulfates, chlorides, nitrates or heavy toxic metals in water, decreased water-solved oxygen and presence of the elements of radioactive substances, viruses and various microorganisms causing diseases and other polluting ingredient-components. In general, water can be polluted with more than 400 substance-ingredients. Out of polluting ingredients, sanitary- epidemiological, sanitary-toxicological and other common sanitary indicators are notable. Even if one of them exceeds the maximum admissible concentration (MAC), the water is considered polluted. Polluting substances may be chemical, biological or physical. The most common type of chemical pollution occurs with the oil and oil products, as well as synthetically active substances, pesticides, heavy metals, dioxins, etc. Particularly hazardous is biological pollution, e.g. pollution with viruses and different microorganisms causing diseases.

MAIN BODY

On the background of the above-mentioned types of pollution, the monitoring of the ingredients is considered as an information system with multiple goals of observation and evaluation of the water ecosystems and decision-making (See Figure). The subject of study of this system is the multi-component objects of natural water, their structure and linked phenomena as a complex system, which studies and fixes the nature of dynamic change of natural, anthropogenic and technogenic pollutions [1]. Thus, ingredient monitoring means solving the problems of evaluation and prediction of the degree of the river water pollution with the aim to ensure the environmental safety. Therefore, the goal of construing the environmental-ingredient monitoring system can be generally formulated as an information system to prepare and support the managerial decisions about environmental safety and identification [2]. Fig. 1 shows the flow chart of the proposed ecological-ingredient system with decision-making and regulatory functions.

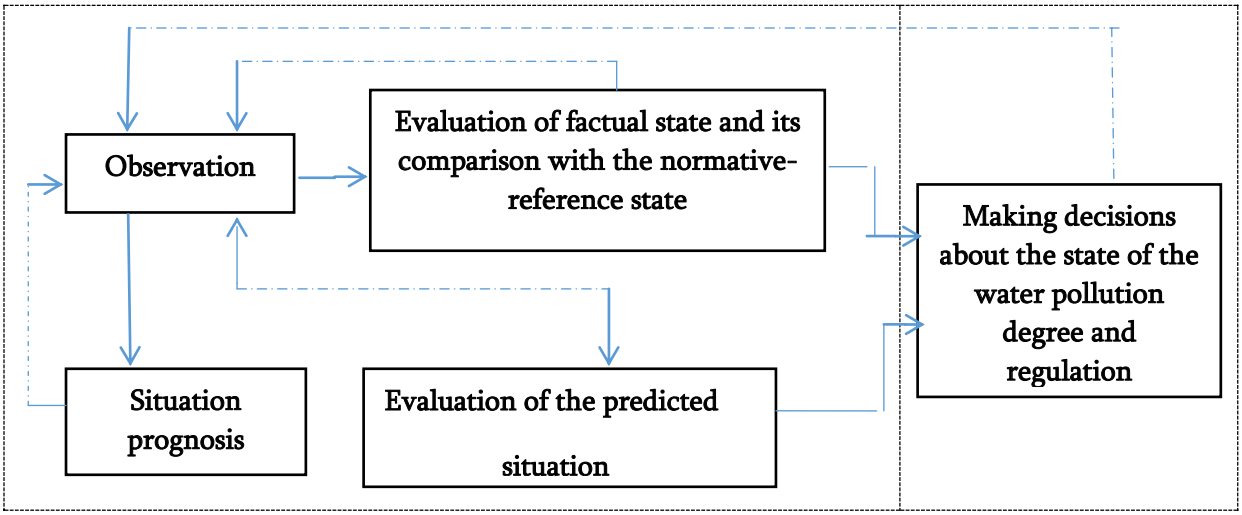

Fig. 1. Flow chart of the general environmental-ingredient monitoring system

The less the boundary value of the normative-ecological index of the ingredient pollution, the more the qualitative state of the water ecosystem is. Maximum admissible concentration (MAC) is the maximum concentration, at which an ingredient (component-substance) does not have either direct, or indirect impact on public health (when acting on a human body for the duration of life) and does not deteriorate the hygienic conditions of water use and at the same time, does not have an adverse impact on the sea biodiversity.

Maximum admissible concentrations of the polluting substances in the water ecosystem show the concentration of the substances, above which their use is unacceptable for one or more consumers. It is known that the level of hazard of an ecological state, in accordance with the degree of undesirability, can be classified as follows [3-6]:

- ✓ "More or Less Satisfactory State" when the index of concentration of harmful polluting substances does not exceed the MAC rated index.
- ✓ Critical, or "Critical Ecological State" when the concentration of harmful polluting substances exceeds the MAC index by 50 times or more, and
- ✓ Catastrophic or "Situation of Ecological Disaster" when deep irreversible changes occur in the eco-system.

As per the existing situation, out of the approaches of analysis to assess the degree of pollution of surface waters (rivers), the zones of "More or Less Satisfactory State", Critical, or "Critical Ecological State" or Catastrophic, or "Situation of Ecological Disaster" are identified by using a number of indicators to assess the degree of chemical pollution of the river-water (chemical pollution index (CPI-10) and others). It should be noted that the calculation of CPI-10 value needs the values of at least 10 chemical pollutants what can be considered as a disadvantage to use it in practice (making it impossible to use this method if less ingredients are known).

The proposed methods can be used to achieve the goal by using any combinations of the parameters of the ingredients in any quantities. With this purpose, in order to identify the chemical pollution of water, we recommend the use of a certain type of descriptive models allowing identifying the degree of water pollution by using Harrington's scale of dimensionless desirability in line with the degree of the ecological risk hazard [5-8], in particular, d Є [0,20-0,37] corresponds to the Catastrophic, or "Situation of Ecological Disaster" and d Є [0,37-0,63] corresponds to Critical, or "Critical Ecological State", and d Є [0,63-1.00] corresponds to "More or Less Satisfactory State". An advantage of the offered methodology is the possibility to do an integrated (general) qualitative assessment of water pollution in line with equally divided scale gradations with any number of combinations of D rivers (demonstrating the universal nature of this approach).

Qualitative-criteria evaluation of the degree of the river water pollution by using Harrington's scale of dimensionless desirability and descriptive modeling [7-9], in line with the degree of the ecological risk hazard is given in Table 1.

Tab. 1
Harrington's scale data of water pollution

№	**Gradations of Harrington's scale of dimensionless desirability**	**Qualitative-criteria evaluation of the degree of the river water pollution by using Harrington's scale of dimensionless desirability and descriptive modeling [5-8], in line with the degree of the ecological risk hazard**
1	d Є [0,20-0,37]	Catastrophic, or "Situation of Ecological Disaster" (can result in human mortality)
2	d Є [0,37-0,63]	Critical, or "Critical Ecological State"
3	d Є [0,63-1.00]	"More or Less Satisfactory State"

It should also be noted that there are no general methods to evaluate the environmental risk and in different cases, the elements of the probability theory can be used. Following the ecological reasons, the priority is given to the evaluation of the risk of the human health deterioration. The risk of certain events is associated with the expected material loss, while the risk indicator is associated with the human safety resulting from the impact of harmful factors of a human and surrounding environment. Some hazardous factors causing the pollution of the river water ecosystem are the deterioration of the physical, chemical and other properties of water. As a result of their harmful impact, "an emergent ecological state" is originated, or in extreme cases, "a situation of an ecological disaster" originates. In this connection, the indicator of an "ecological risk" can be formulated as the ratio of the value of the possible damage caused by an impact of adverse ecological factors for a certain time period with the rated values of the intensity of these factors. As it is known, human safety results from its scientific, technical and technological standing and developmental potential. Such standing has a stochastic nature and is determined by a number of causal events. We can make a similar judgment about the public health safety, and protection and environmental safety of the rivers. Besides, the pollution of these objects is associated with intense impact of anthropogenic and

technogenic factors, which, as mentioned above, in some cases lead to the severe degradation of human health (sometimes, with a lethal outcome) and esthetic damage.

Following the above-mentioned, it is expedient to determine the possible level of ecological risk hazard (as an alternative of CPI described above) by presenting it as a product of three probabilistic components:

$$R = R_1 \times R_2 \times R_3 \ , \tag{1}$$

where R is the possible level of ecological risk hazard, or the probability of inflicting certain damage to water ecosystem; R_1 is the probability of a phenomenon to occur causing the formation and action of harmful polluting factors; R_2 is the probability of formation of the concentration field of harmful substances caused by seasonal loads of human impacts and in different fields of biosphere; R_3 is the probability that the given loads and field of concentration of harmful substances will lead to certain damage.

Certain damage is understood as a negative outcome of adverse factors as well as a long-term environmental outcome. A negative outcome means the deterioration of human health, including a lethal outcome for fauna *inter alia*, etc. As for another kind of damage associated with a long-term outcome, it causes negative changes of the ecological environment (disharmony caused by the degradation of the ecological values, degradation of its vitality, extinction of some plant species, flora and fauna degradation, etc.).

Unfortunately, total ignorance of the connections between the dominant factors often causes ambiguity regarding the right kind of calculations to be done for the given kind of damage. In this connection, the kind of probabilistic calculation determines the concrete kind of technogenic or environmental damage.

Thus, the same source of technogenic safety can be evaluated with two probabilistic values: the technogenic risk and ecological risk. In identifying this value, the probabilistic parameters R_1 and R_2 in the formula given above will be common. As for probabilistic parameter R_3, its formulation is based on a certain expert opinion and peculiar methods of determination.

The given methods to assess and analyze the technogenic and ecological risk of surface water and other objects associated with the identification of R_1, R_2 and R_3 probabilistic parameters, is not universal with its essence, but will be acceptable in specific cases as an effective means of variant probabilistic calculation and analysis.

It will be expedient to apply the developed methods for probabilistic identification of the degree of the ecological risk hazard to the solution of problems of the environmental impact assessment (EIA), such as monitoring of the surface waters (rivers, lakes, water reservoirs, etc.) pollution, evaluation of impact of rivers on the sea pollution, protection of the sea coastline against washout, water-supply (water drainage and the like), in particular, 1) identification of the possible impact of rivers on the sea pollution, 2) planning and realization of the design and rehabilitation works of the water-supply and water-drainage (sewage) systems of cities and settled areas, 3) unfortunately, at present, due to the absence of the perfect treatment plants in a number of towns and settled areas, the domestic, economic and fecal water masses from houses are discharged into the water reservoir virtually untreated causing irreversible environmental damage to the adjacent flora and fauna and posing particular danger to the human health. In order to remedy the situation, a requirement for gradually designing and building discharge water treatment plants in every town and settled area, by considering the EIA factor for adjacent areas, is to be incorporated in the legislative document of environmental impact assessment (EIA) in a regulated manner. The methods to determine the level of "ecological risk" hazard for the objectives of the monitoring of the degree of the river water pollution can be recommended similarly.

CONCLUSION

As there are no single methods to evaluate the environmental damage caused by the river water pollution (and normative methods sometimes yield incorrect values), the damage inflicted to the environment and public health (with d Є [0,20-0,37] corresponding to the Catastrophic, or "Situation of Ecological Disaster" and d Є [0,37-0,63] corresponding to Critical, or "Critical Ecological State") can be identified by the methods recommended to use in complex, probabilistic and descriptive modeling, according to the ingredients characterizing the pollution.

In terms of sustainable regional development within the river water ecosystems, by observing the environmental standards in line with the environmental laws and normative documents will help:

- The reduction in the complex environmental pollution and maintenance of the biodiversity of the Black Sea.
- The ecological safety of people.
- The rational protection and use of water resources.
- The genetic maintenance of the human, flora and fauna funds.

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Environmental protection

PROMOTION OF ENERGY-EFFICIENT BUILDING AND POLLUTION REDUCTIONS WITH THE USE OF SOCIAL MARKETING

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Annotation. This following article discusses the problem of energy-efficient construction, which is generally more expensive than traditional buildings, so there are psychological barriers before deciding to implement them. Despite the significant increase in investor awareness in this area, the knowledge of the need and benefits of using such solutions should be constantly disseminated. The change in building standards is due to changes in building regulations, the use of various forms of financial support, the need to reduce CO_2 emissions and other pollutants. Various types of promotional and educational activities increase public awareness of the positive effects of building energy efficient buildings. Promoting energy-efficient constructions is intended to disseminate and disseminate the idea of energy conservation and its impact on local and global scale, as well as on the benefits of energy and the protection of the atmosphere. Promotional campaigns are being launched to promote passive buildings, energy-efficient buildings and the use of renewable energy sources. These campaigns are based on the creative idea of demonstrating that energy saving and the use of renewable energy sources can reduce the operating costs that can devote to many different consumer goods. It is assumed that this way of promotion will convince many investors to build their own home with the ability to take out a loan and repay the savings by minimizing the cost of living. The proposed action involving a wide range of tools affecting the public is part

Key words: energy-efficient constructions, social marketing.

INTRODUCTION

The prospect of a sharp worsening the construction standards for energy efficiency of buildings in future requires activation of all sorts of actions and activities aimed at the preparation of all parts of the investment process for a new challenge.

Various types of advertising, clarifying and educational activities increase the level of public knowledge of the population about the positive consequences of the construction and modernization of buildings, which should lead to significant improvements in energy efficiency construction. Today, in Poland there is gradually increasing interest in certification, confirming that the building is energy efficient and uses a minimal amount of energy or the media as opposed to traditional buildings. Promotion of energy-efficient construction consists of dissemination and promotion energy-saving ideas, which ultimately have a positive impact on the environment locally and globally, and show the advantages of not only energy, but also economic, environmental, including human health, and social areas.

The impact of construction on air pollution in Europe and Poland

Production of energy and above all the heat in the construction sector in Poland is responsible for air pollution very dangerous dusts and chemical compounds i.e., PM10. PM2.5, B(a)P.

The biggest impact on the level of air pollution with PM10 is generally low emissions from sources associated with the combustion of solid fuels for heating and household. Emissions from this source category have the largest share in the national emission 49%. Similarly, the situation with the issuance of PM2.5 into the atmosphere in Poland is shaped. The scale of pollutant PM2,5 emissions from different sources is shown in Figure 1. Approximately 56% of the air pollution of PM2.5 dust in Europe in 2014 comes from commercial, institutional and households' buildings.

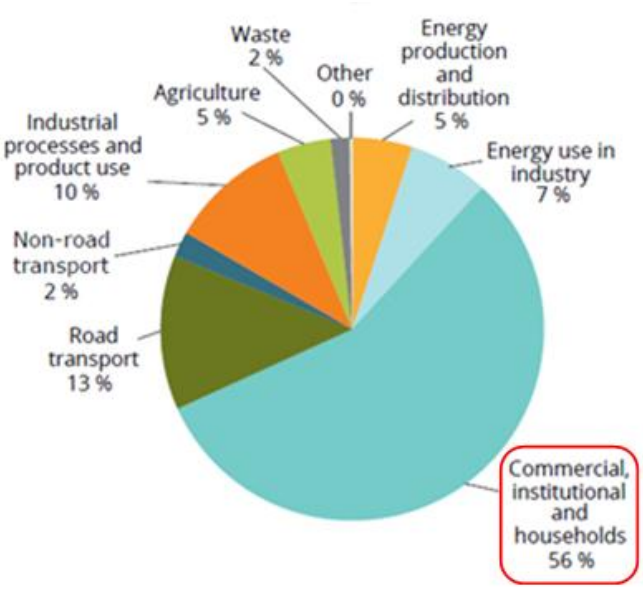

Figure 1. Emissions PM2,5 dust in the EU-28, share by sector group in 2014 [1].

It is affected by fuel combustion processes outside the industry. Emissions from these processes are approx. 50% of the total emission of dust from the area of the country. This category has the largest share of emissions from the municipal sector, including primarily related to the heating of buildings.

The main source of emissions of B(a)P to the atmosphere in Poland is individual heating of buildings. Emissions from these processes are approx. 78% of the total national emissions of B(a)P. The highest concentrations B(a)P are recorded in Poland (fig. 2) [2].

To reduce low emission communal household appliances (category: fuel combustion processes outside the industry) may result in a range of educational activities, administrative, organizational, tax, etc., including:

1) raise the level of ecological knowledge of the population to promote ecological behaviour;
2) promotion the replacement of furnaces and solid fuel boilers other heat sources less burdensome for the environment;
3) promotion the modernization of individual heating systems;
4) supporting the thermal insulation of buildings, among others, through financial support;
5) promoting energy-efficient construction and passive;
6) promoting the construction and use of renewable energy sources;
7) introduction of the ban on the use of solid fuels for heating buildings and water heating in selected areas with the simultaneous implementation of the system of financial support the reconstruction of the heating system;
8) introduction to the rules of public order ban waste incineration plant leaves grass clippings and weeds;
9) enforcement of the ban on waste incineration in furnaces domestic boilers, stoves, fire pits;
10) conduction of appropriate tax policies to encourage the use of less harmful fuels [3].

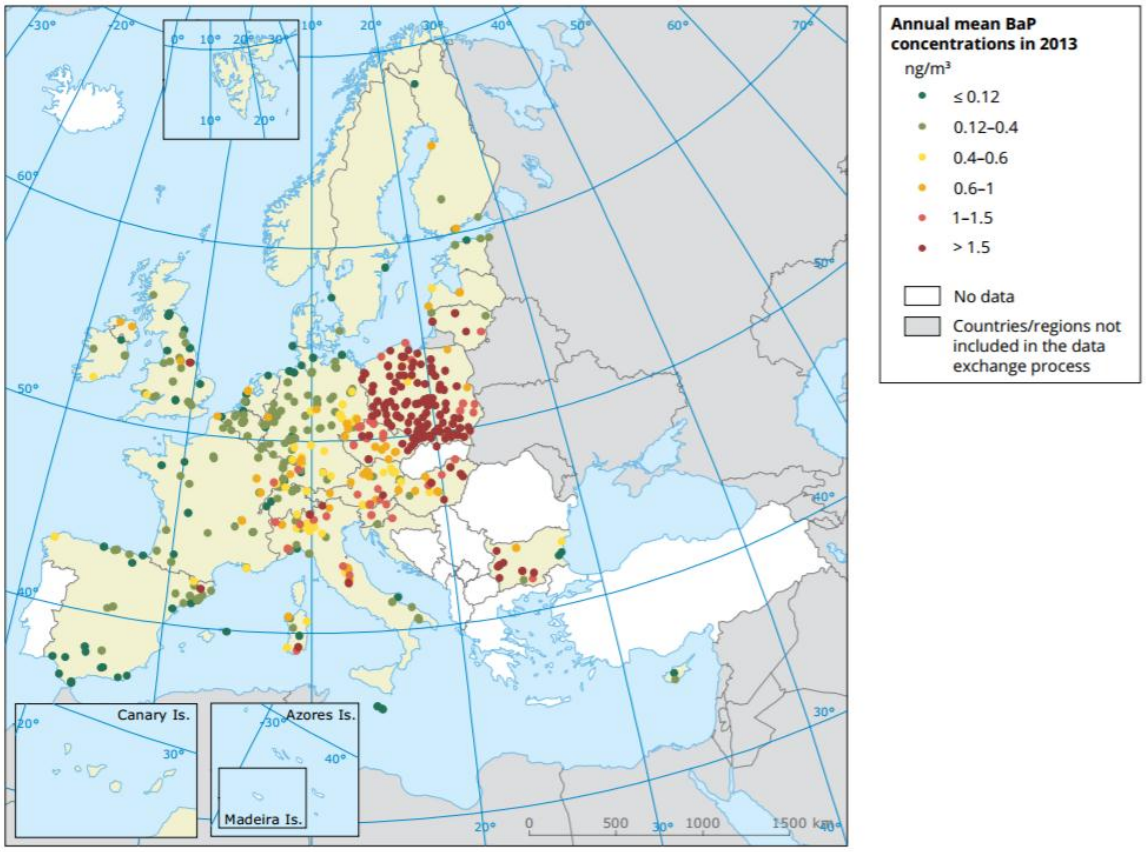

Figure 2. Annual emission concentration B(a)P in Europe in 2013 [2]

The buildings in EU use approx. 42% of all energy. In turn, approx. 85% of the energy consumed by buildings is the energy associated with heating and hot water preparation. If we add to this electricity associated with cooling the air in buildings, this value reaches approximately 90% [4]. It is assumed that by 2050 energy consumption in residential buildings will decrease by 29% and the public buildings by 18%, compared with 2010 [5].

Most of the residential buildings use boilers for solid fuels, coal and wood, for heating rooms and hot water (fig. 3, 4). This contributes to the emission of considerable amounts of B(a)P and other pollutants.

In Poland, the much higher proportion of the energy consumed by buildings and services is accounted for 49,1%, 24,4% in industry, 26,5% in transport [7]. The next planned change of technical regulations on energy efficiency of buildings, which will take effect on 1st January 2017 exacerbates the demand for energy efficiency – especially in the case of new single-family and public buildings. It must be emphasized that every year in Poland, there is introduced about 80-90 thousand buildings [8] that require a serious approach to the problem.

According to the latest changes requirements for determining the energy certificate of the building, except for the indicator of EP it is necessary to calculate the emissions CO_2 gas and the percentage of energy consumed from renewable sources. However, for the last two parameters of the building regulations do not specify limit values.

In the Directive EPBD and later in the construction regulations the definition of a building with almost zero energy consumption appears. This type of building should become the norm in beginning of 2021, and in the case of buildings occupied or owned by the state or local government should become norm in 2019. According to the Directive these are buildings with a very low or almost zero primary energy consumption. That energy must be generated to a large extent, from renewable energy sources. Based on this definition, a

building with almost zero energy consumption-technically means 0 kWh/(m^2a) rate of consumption of non-renewable primary energy EP [9].

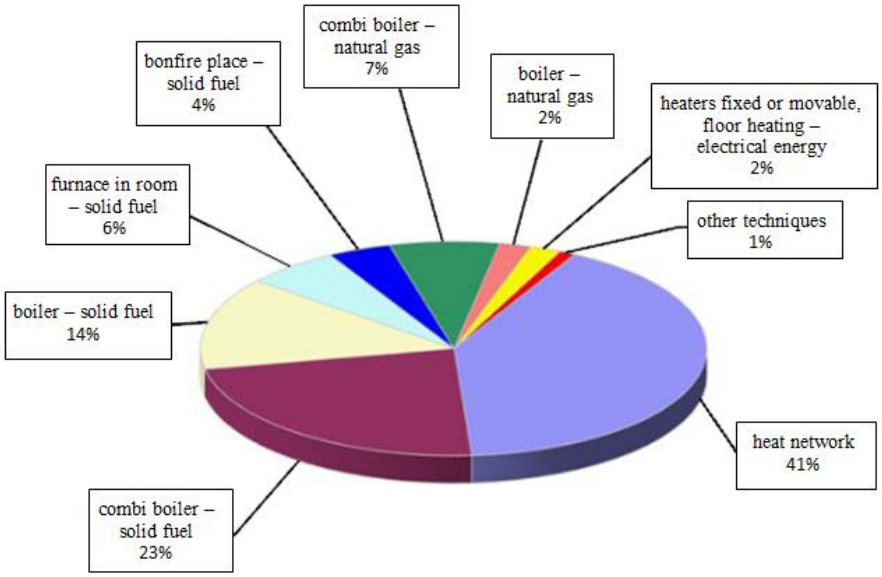

Figure 3. Heating systems in households according to heating techniques in Poland [6].

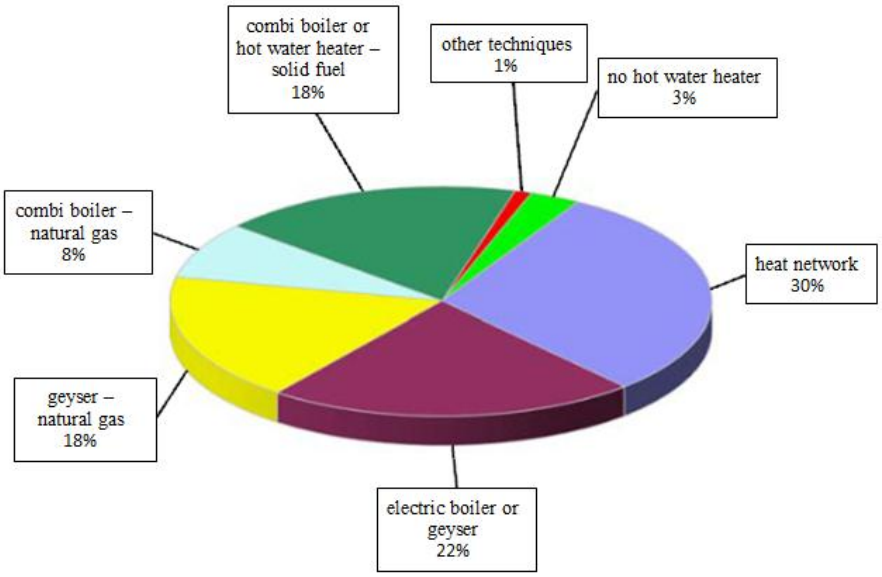

Figure 4. DHW heating in households according to heating systems in Poland [6].

In 2013, in Poland there was introduced the first program of subsidizing the construction of low energy houses in standard NF 40 and passive buildings in the standard NF 15. The symbols indicate the maximum level of final energy consumption for heating of 40 kWh/m^2a and 15 kWh/m^2a. Investors can get a grant in the amount of 30 000 and 50 000 PLN for single-family houses or 11 000 and 16 000 PLN for the apartments. To get a grant there is a need to fulfil a number of requirements, including insulation of external barriers of the building [10].

There has also been developed the document in the form of a national plan to increase the number of buildings with low energy consumption [11], indicating big business existing conditions and opportunities to achieve economically viable energy efficiency of buildings. In addition, the plan represents the actions of the

government in order to improve the design, construction and reconstruction of buildings to improve energy efficiency and increase the use of energy from renewable energy sources in new and existing buildings [11].

One of the characteristic trends of designing modern buildings called green buildings is the consideration of various environmental aspects. The energy efficient buildings which are close to green buildings with minimal consumption of energy generate a very low emission of fuel combustion products. According to a recent report [12] that represents the results of the analysis of the status and forecast of development of green building in 69 countries, over the next 2-3 years there will be a double increase in the number of buildings which are characterized by a minimal negative impact on the environment. Experts predict that in 2018 in more than 60% of building projects the green building features will be applied. It mainly concerns the new and modernized office and public buildings for which the investor tries to obtain a certain environmental certificate.

In the Polish construction there are mainly two systems of multi-criteria environmental certification used: the British Breeam and American Leed. As follows from the report [13], in Poland there were 249 certified office buildings in BREEAM or LEED. That's 60% more than in 2014. Most objects with an environmental certificate are located in Warsaw (126), Krakow (26) and Poznan (17).

The results of a survey of public opinion in the field of energy efficient construction

The results of surveys conducted in recent years on energy issues of buildings are very interesting. Most of Poles have rather low level of knowledge as far as energy is concerned. It mainly concerns the use of energy for the building in period of exploitation of the building and the influence of these processes on the state of the natural environment. Many people cannot properly assess how much of the energy is used for heating. From the public opinion survey «Poles about energy savings» in 2007, [14], we know that 71% of respondents indicated that most energy is consummated by industry and by buildings only 18%.

To the question, what percentage in consumption energy is the energy for heating the apartment/house, most of the respondents, 35% gave the answer that it's up to 20% of all energy consumed by the building. 23% of respondents did not answer this question. Approx. only 16% of respondents were close to the truth [15].

To the question what most affects the use of energy in the apartment/house: 32% of respondents indicated heating, 46% lighting and electrical equipment, 8% heating hot water, 7% fuel for cars and 7% were unable to give an answer [14].

Despite the growing awareness in the sphere of energy saving building the owner of the building rarely takes action associated with a reduction in energy demand for heating and ventilation.

Every tenth Pole has energy-saving equipment, and the most popular are relatively new, energy-saving televisions (68%), washing machines (65%), laptops (49%), kettles (49%) and the least popular are energy-saving components and heating systems (7%) [16]. From a report on the Polish energy sector, the majority of respondents (87%) say that they try to conserve energy, particularly electricity. As the main reason of its solutions they indicate the financial conditions [17].

The results of the survey in 2013 conducted in the framework of «Energy in my house», it follows that a relatively not many Poles approx. 19% of respondents indicates heating as the most energy-consuming operational process. 51% of respondents as the most energy-intensive indicated electrical appliances, 14% to heat water and 13% lighting. For comparison with earlier surveys it shows that the consciousness in this area has not changed significantly [18].

Public opinion survey «Energy Efficiency in my house» conducted in 2015 shows little progress, but still consciousness in the field of energy efficiency in buildings remains unsatisfactory. More than half of Poles do not know that the most energy in their homes is spent on heating (only 24% of respondents indicated heating), 46% of რespondents said that the most energy in their buildings is consumed by appliances [19].

Another survey which was conducted in the same year showed that 86% of Poles indicate that energy saving is only connected with the reduction of electricity consumption.

The use of social marketing to promote energy efficient construction

Many popular social-oriented strategy, although widely spread, has not received not only a single definition. Among them the increasingly popular tool of influence on public consciousness is the form of social marketing.

Social marketing involves the use of methods of commercial marketing for the analysis, planning, implementation and evaluation of programmes that affect intentional behaviour of selected groups of consumers, in order to enhance human wellbeing and the state of society. Social marketing uses planning process and applies the principles and methods of traditional marketing. It focuses on change of behaviour, and is designed to benefit the society. The concept of social marketing includes public service announcements and other besides advertising methods of influence. Mission of social advertising is to convince or dis-courage the audience to a particular idea or behaviour. Other activities are aimed at facilitating the implementation of new approaches and behaviour of the message recipient. Public campaign is the orderly in time operation using the tools of marketing, in particular advertising and Public relations affecting the changing attitudes and way of thinking. This, in turn, leads to the solution of social problems that block the achievement of the common good, defined as marketing goals.

The famous project promoting energy saving energy building has been carried out in Germany in Berlin. The title of the projects was «Dress warm your house» and Poland «Dress up your house». Advertisement is showed in the figure 5.

a) Germany - Berlin b) Poland

Figure 5. Example of social advertising in Berlin and Poland. [20]

Contrary to appearances, advertising pillars and buildings dressed in distinctive red hats is not an exhibition of large-size needlework, and part of an unconventional outdoor campaign, which has established itself on the streets of German cities. In this way, it urged the Germans to reduce carbon dioxide coal.

The aim of the campaign was to raise awareness of recipients, how important is the relationship between CO_2 emissions and heating in the house, and thus how to make home more energy efficient. This interesting – both visually and substantively – advertising campaign is a great idea for the unusual use of public space for advertising purposes. The initiative «dress» of the city met with a warm welcome from the locals.

Festive start of the campaign took place on one of the main streets in Berlin – Unter den Linden. Buildings «were dressed» in a red woolen cap, on which there was the inscription: «Verheizen Sie Ihr Geld

nicht: Ziehen Sie Ihr Haus warm an» («Don't waste money for heating: Dress warm your house»). The patronage of the campaign was covered by the German Ministry of Transport, Building and Urban Development (BMVBS).

Table 1. The basics of the marketing campaign «the House that saves me» [21]

Marketing challenge	The predominant target audience	Implementation
Stimulating the construction of buildings in passive technology, energy saving and use of renewable energy, by creating the conscious action of the profitability of this investment. This solution is more ex-pensive than standard, but it should quickly pay off due to lower cost of operation. The client was waiting for a bright, interesting proposals, which should stand out against other promotional materials	People planning the construction/reconstruction of houses or apartments over the next 3 years, at the age of 25-54 years, with a monthly household income of more than 5 000 PLN net. Analysis of studies shows a significant impact of women in taking decisions concerning the construction or modernization of the house / apartment	A key element of the campaign and the connecting element of the event was website www.oszczedzam-ener-gie.pl that contains database articles, tutorials, and graphic material. In or-der to read the content of the campaign in the Internet and the press the app AR for mobile devices was created. Users could create a passive or energy efficient house and com-pare annual savings compared to a traditional house. The campaign was supported by PR activities (including unintentional use of training for journalists and bloggers). The accompanying element was coffee served from a special food truck

One of the promotion tested in 2014 in Poland related to energy saving, was a campaign called «the House that saves me». [21]. Its purpose was to familiarize and convict all investors also in future in the construction of passive and energy saving buildings using renewable energy sources (tab. 1). It was directed and received a great response especially among the younger generation.

This action was based on creative ideas of selecting different construction solutions and calculating the resultant effects in the operation of passive or energy-efficient buildings, which is supposed to use renewable energy sources. Choosing different solutions there is possibility of achieving such an option that it allows to cut spending and gives the opportunity to save funds for other needs. It was assumed that this will increase the number of investors who want to build their own home with the help of a loan, with the possibility of redemption through saving costs.

The whole event with a variety of planned activities fits into the action characteristic of social marketing. The goal of social campaigns is the belief of the audience for which it is organized to accept changed or rejected certain beliefs, attitudes or behaviour. The proposed tools that have an impact on potential investors and the people from their entourage refer to activity within the framework of social marketing.

A key element of the campaign was the creation of website www.oszczedzam-energie.pl containing a database of technical and other data, database articles, tutorials, and graphics and video materials. To familiarize yourself with its contents the campaign in Internet and press was organized. It was also created a mobile app AR (Augmented Reality), in which the user can move the virtual process of design and construction of energy-efficient or passive houses. The user can change the size and rotate the display detail of the building, interact with it, modify its technical parameters, as well as obtaining additional information with a text description (fig. 6). The investor can also learn what is important while choosing the technology of construction and installation works, and is able to see how much can save on lowering the energy consumption for heating and ventilation.

The page also contains suggestions how you can use internal installation and what level of savings you can expect. The user can find answers to the following questions: On what to pay attention when designing energy-efficient or passive house? How to organize the construction? What is the process of construction?

What is the energy certificate of the building? How to get financial support? How to live in a passive house? How much can you save? This function performs a mobile 3D application that allows you to create a home concept, ensuring the adoption of appropriate projects solutions for energy-efficient or passive houses. It allows you to calculate the annual energy savings for heating and ventilation comparing to conventional building. Using the app it is possible to view a 3D model of this building. The program, which you can download from the Google Play store is available on iOS and Android devices.

Figure 6. The screen indicating the possibility of rotation of the building relative to the cardinal directions [21]

For a better acquaintance with the advantages of energy-efficient construction it was also suggested that communication through Face-book is possible. There were published three info graphics called «the House that saves me». Using Facebook peoples could learn where to receive coffee from the coffee truck which saves for me.

The campaign was supported by action in the form of Public Relations (including training, training for journalists and bloggers). During the distribution of coffee it was possible to receive a QR code to access the program (fig. 7). On the web page there is also a special calculator, which can estimate the amount of savings in standard energy-efficient or passive houses while comparing it to conventional houses.

Figure 7. The cup of coffee with a QR code to the calculator [21].

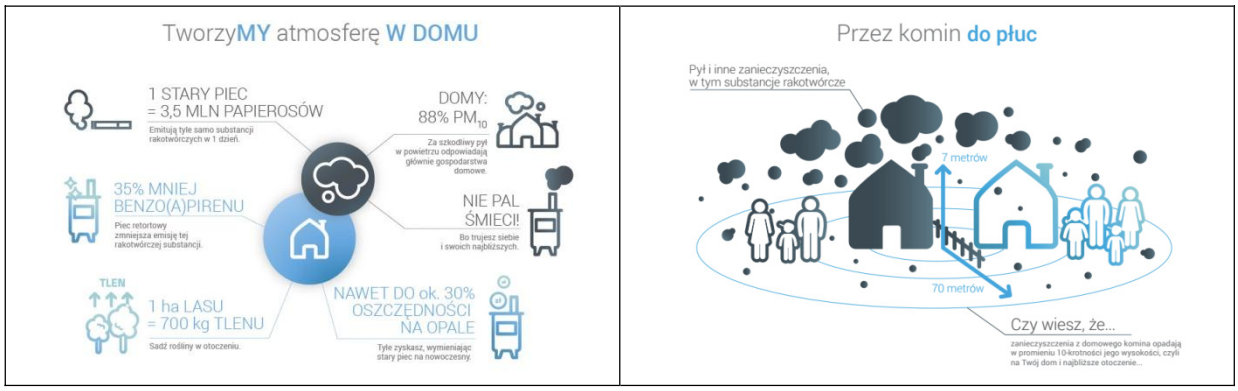

Figure 8. Posters of the campaign «Make the atmosphere in the house» and «Through the chimney into the lungs» [22]

There have been used all kinds of tools of communications online: website, mobile app (iOS, Android), AdWords, banners, video inserts, mobile campaign, mobile apps and advertising in the electronic editions of weeklies and magazines (articles, links, materials from the editors, sponsorship). In the press: print and promotional materials, in the most famous weeklies and magazines on architecture, construction and construction equipment – a total of 17 titles of journals, a model of a house with piggy Bank function etc. In just six weeks, the information was viewed on the popular Internet portals and on YouTube more than 400 thousand times, the log on page was approx 80 million times [22]. The main arguments underlying justification of the verdict of the jury was: interesting and unusual approach in creating positive motivation for environmental activities, witty symbolism and the choice of forms of communication and information transfer to social circles [23].

Similar actions have been done in many educational and promotional events in the area of energy efficiency and renewable energy, including environmentally friendly homes. Examples of outdoor advertising, social marketing [24, 25, 26] are also other campaigns: the project called «the House that saves me» won the main prize at the Competition of the Public campaign of the year 2014 in the category «Campaign for environmental issues».

There is also another interesting project addressed to the people and institutions responsible for the production and use of energy and heat in the construction industry and related air pollution. The name of the action is «Something is in the air», «Make the atmosphere in the house», «Mission - issue», « Quality air in Poland», «Before we suffocate from smog», «Clean air depends on you» and another. The following figure 8 presents the example of advertising posters.

CONCLUSIONS

In conclusion, it must be emphasized that the process of introduction of energy-saving, passive construction and pollution reductions is very complicated. The fact that the reduction of energy consumption in buildings in Poland varies very slowly is shown in the statistics. These changes have not yet significantly affected the reduction of pollutant emissions into the atmosphere.

The research also shows relatively low level of knowledge in the field of energy efficiency in construction and pollution reductions to the atmosphere. The creation of appropriate building regulations is not enough. It is necessary to conduct multilateral educational action in order to prepare for the realization of the different groups of the investment process for the construction and further operation of the standard buildings. An example of using social marketing for promotion of this idea is very interesting and should be developed in similar type of projects.

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QUANTITATIVE EVALUATION OF IRRIGATION IMPACT ON EFFICIENCY OF AGRICULTURE

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Annotation. The paper discusses quantitative evaluation of the share of input in the efficiency of agriculture in Georgia. There is reviewed dependence of the effectiveness of irrigation on the natural-climatic conditions in the particular regions of the country.

Key words: water management, economy, share of input, effectiveness of irrigation.

INTRODUCTION

Natural-climatic conditions of Georgia dictate necessity of wide application of irrigation being one of the most important factors of high efficiency of the agriculture. At the same time, it is necessary to mention that the currently effective system of payment for irrigation is significantly restricting further development of amelioration in the country. There appears the objective necessity of perfection of the system of payment for irrigation water, identification of new principles for its charging.

From this point of view, quantitative evaluation of the share of input of irrigation into the efficiency of agricultural industry on the irrigated lands of the country represents certain interest. Such kinds of indicators are given in the article in view of certain regions of Georgia.

BASIC PART

With the purpose of revealing quantitative values of impact of agriculture intensification factors (capital-area ratio, chemicalization and amelioration), there are calculated their shares of input into the efficiency of the country's agriculture. There is reviewed the following function:

$$E = f[\alpha_1 u_1(x_1) + \alpha_2 u_2(x_2) + \alpha_3 u_3(x_3)] \quad (1)$$

where E is the efficiency of agriculture, calculated as ratio of net value of revenues from agriculture to the value of gross product prime cost;

x_1 – capital-area ratio of agriculture, calculated as ratio of fixed industrial funds of agricultural purpose to the area of agricultural lands (thousand GEL/ha);

x_2 – value of the mineral fertilizer introduced to the active substance per ha of the agricultural lands (the area of pastures are excluded) (kg/ha);

x_3 – proportion of irrigated agricultural lands in total area of the agricultural lands (%);

$\alpha_1, \alpha_2, \alpha_3$ – the corresponding permanent coefficients.

Having applied the method of normalization of the variables of the formula of nonlinear regression, we have obtained the meanings of $\alpha_1, \alpha_2, \alpha_3$ for Kakheti region which are equal to 0,05, 0,34 and 0,73, formula of nonlinear regression, when coefficient of correlation R = 0,89, looks like:

$$E_1 = f[0{,}05u_1(x_1) + 0{,}34u_2(x_2) + 0{,}73u_3(x_3)] \quad (2)$$

The share of input of capital-area ratio, chemicalization and amelioration in the effectiveness of the agriculture turn out to be, correspondingly, 0,30, 0,30 and 0,40. All the factors under revision are effective.

For Kvemo Kartli region the meanings of $\alpha_1, \alpha_2, \alpha_3$ are 0,10, 0,27 and 0,68, correspondingly, the formula of nonlinear regression, when the coefficient of correlation is R = 0,97, looks like:

$$E_2 = f[0{,}10u_1(x_1) + 0{,}27u_2(x_2) + 0{,}68\, u_3(x_3)] \quad (3)$$

The share of input of capital-area ratio, chemicalization and amelioration in the effectiveness of the agriculture turn out to be 0,10, 0,21 and 0,69. All the factors under revision are effective.

For Racha-Kvemo Svaneti $\alpha_1, \alpha_2, \alpha_3$ are 0,20, 0,27 and 0,21, correspondingly, the formula of nonlinear regression, when the coefficient of correlation is R = 0,84 , looks like:

$$E_3 = f[0{,}20u_1(x_1) + 0{,}27u_2(x_2) + 0{,}21u_3(x_3)] \quad (4)$$

The share of input of capital-area ratio, chemicalization and amelioration in the effectiveness of the agriculture turn out to be, correspondingly, 0,25, 0,50 and 0,25. All the factors under revision are effective.

For Shida Kartli region the values of $\alpha_1, \alpha_2, \alpha_3$ are 0,26, 0,16 and 0,51, the formula of nonlinear regression, when the coefficient of correlation is R = 0,84 , looks like:

$$E_4 = f[0{,}26u_1(x_1) + 0{,}16u_2(x_2) + 0{,}51u_3(x_3)] \quad (5)$$

The share of input of capital-area ratio, chemicalization and amelioration in the effectiveness of the agriculture turn out to be, correspondingly, 0,24, 0,20 and 0,56. All the factors under revision are effective.

For Samtskhe-Javakheti region $\alpha_1, \alpha_2, \alpha_3$ are 0,69, 0,26 and 0,40, the formula of nonlinear regression, when the coefficient of correlation is R = 0,81 , looks like:

$$E_5 = f[0{,}69u_1(x_1) + 0{,}26u_2(x_2) + 0{,}40u_3(x_3)] \quad (6)$$

The share of input of capital-area ratio, chemicalization and amelioration in the effectiveness of the agriculture turn out to be, correspondingly, 0,45, 0,12 and 0,43. All the factors under revision are effective.

For Imereti region $\alpha_1, \alpha_2, \alpha_3$ are 0,31, 0,12 and 0,28, correspondingly, the formula of nonlinear regression, when the coefficient of correlation is R = 0,82 , looks like:

$$E_6 = f[0{,}31u_1(x_1) + 0{,}12u_2(x_2) + 0{,}28u_3(x_3)] \quad (7)$$

The share of input of capital-area ratio, chemicalization and amelioration in the effectiveness of the agriculture turn out to be, correspondingly, 0,50, 0,27 and 0,23. All the factors under revision are effective.

For Samegrelo region $\alpha_1, \alpha_2, \alpha_3$ are 0,71, 0,33 and 0,22, correspondingly, the formula of nonlinear regression, when the coefficient of correlation is R = 0,88, looks like:

$$E_7 = f[0{,}71u_1(x_1) + 0{,}33u_2(x_2) + 0{,}22u_3(x_3)] \quad (8)$$

The share of input of capital-area ratio, chemicalization and amelioration in the effectiveness of the agriculture turn out to be, correspondingly, 0,79, 0,11 and 0,10. All the factors under revision are effective.

For Ajara region $\alpha_1, \alpha_2, \alpha_3$ turned out to be 0,19, 0,39 and 0,32, correspondingly, the formula of nonlinear regression, when the coefficient of correlation is $R = 0{,}82$, looks like:

$$E_8 = f[0{,}19u_1(x_1) + 0{,}39u_2(x_2) + 0{,}32u_3(x_3)] \quad (9)$$

The share of input of capital-area ratio, chemicalization and amelioration in the effectiveness of the agriculture turn out to be, correspondingly, 0,30, 0,43 and 0,27. All the factors under revision are effective.

As it can be seen from the given data, the share of input of amelioration (irrigation) in the effectiveness of the agriculture according to the regions of Georgia are varying from 0,1 in Samegrelo to 0,69 in Kvemo Kartli. Such significant range of variation of the share of input of amelioration can be explained, first of all, by climatic peculiarities of the regions under investigation. Thus, in Kvemo Kartli, where the volume of average annual precipitation is 580 mm, the share of input of amelioration in the efficiency of agriculture equals to 0,69. In Samtskhe-Javakheti it is, correspondingly, 673 mm and 0,43; in Shida Kartli – 723 mm and 0,56; in Kakheti – 786 mm and 0,40, in Ajara – 1564 and 0,27; in Samegrelo – 1600 mm and 0.10.

The correlation equation of the link between the value of annual precipitations and share of input of amelioration in the effectiveness of agriculture looks like:

$$Y=0{,}58 + 0{,}11\,x - 0{,}25\,x^2 \quad (10)$$

where x is the value of annual precipitations, thousand mm/year.

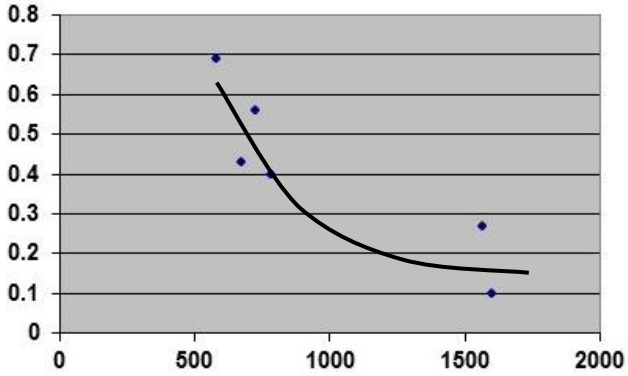

Fig.1. Dependence between average annual value of precipitations and the share of input in the effectiveness of agriculture

CONCLUSIONS

The give analytical calculations show the importance of such factors of intensification of agriculture in Georgia, as irrigation and capital-area ratio of agriculture.

The share of input of irrigation in the effectiveness of agriculture is, first of all, determined by climatic peculiarities of the regions – as drier the climate of the region as higher the impact of irrigation on effectiveness of agriculture.

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Hydrology and meteorology

ON THE TOPIC OF CHANGES IN THE NEMUNAS RIVER DISCHARGE

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Annotation.The forecast of the changes to Nemunas River discharge for the period from 2021 to 2050 were based on A1B andB1 CCLM regional climate models, using model of hydrological-climatic calculations based on simultaneous solution of the water and heat energy balance equations. The discharges in the Nemunas River were made using dataobtained from Kaunas (Lithuania) and Grodno (Belarus) meteorological and hydrological regime observation stations.

The results show the transformation of the Nemunas River discharge hydrograph of the discharge: a slight increase in the spring floods in the Belorussian part and spring floods will begin earlier than at the present time; the duration of flooding will remain the same in Lithuania part.

Key words: discharge, temperature, precipitation, Nemunas.

INTRODUCTION

Global climate change and associated impacts on water resources are the most urgent challenges facing mankind today and will have enduring societal implications for generations to come. Potential impacts may include the changes in watershed hydrologic processes including timing and magnitude of surface runoff, stream discharge, evapotranspiration, and flood events, all of which would influence other environmental variables such as nutrient and sediment flux on water sources (Simonovic and Li, 2004). The trends of precipitation extremes in Europe vary greatly and depend not only on the region but also on the indicator used to describe an extreme (Groisman et al. 2005). Climate change is altering the statistics of temperature and precipitation. More frequent and severer weather extreme events are anticipated to impose greater damages to ecosystems and agricultural systems (Wigley, 2009). Climate change projections may result in reductions of average annual runoff up to 50%, challenging the whole socio economic model which is based largely on water demanding activities: recreation, tourism and food production (Iglesias and Garrote, 2015).A number of studies have shown that under climate change annual river flow is expected to decrease in Southern Europe and increase in Northern Europe; changes are also expected in the seasonality of river flows with considerable differences over the European region.While some aspects of climate change such as increased precipitation may bring some localised benefits, therewill also be a range of adverse impacts, including reduced water availability and more frequent extreme weather (Arnell et al., 2011). A significant increase in the unevenness of precipitation distribution in summer is very likely. More intensive and prolonged droughts will be often followed by very short-lived but extremely intensive rains (Rimkus et. al., 2011). The main problems of the ecological status ofsurface waters in the Neman River Basin are:increased ammonium nitrogen contentis generally characteristic of Belarus; in Lithuania - high biological

oxygen demandconcentrations are common insome water bodiesand high total phosphorus andphosphate phosphorus content is characteristicof some water bodies(Korneev et al., 2015).

MATERIALS AND METHODS

The Nemunas (Neman) River basin is located at 56°15′- 52°45′ north latitude and 22°40′-28°10′ east longitude on the territory of Belarus (46.4 %, 45 450 km^2, Lithuania (47.7%, 46 700 km^2), the Russian Federation (Kaliningrad Oblast, 3.2%, 3 170 km^2), Poland (2.6% 2 520 km^2) and Latvia (0.1% 88 km^2). The total river length is 937 km, and its outfall comes to the Baltics Sea. The Nemunas River is covering about 75 % of the Lithuania territory (Aplinkos..., 2011) (fig. 1).

Fig. 1. NemunasRiver basin

The forecast of the changes to Nemunas River discharge for the period from 2021 to 2050 was elaborated using the Belarusian model of hydrological-climatic calculations based on simultaneous solution of the water and heat energy balance equations (Mezentsev, 1995; Volchek 1986). Long-term climate change forecasts for the Nemunas River were based on A1B andB1 CCLM regional climate models. The hypothesis of research experiment is based on the current long period data trends: the air temperature and the annual amount of precipitation will increase in the Nemunas River up to 2050.

Analysis and forecasting of the changes in climatic characteristics and discharge in the Nemunas River were made using data obtained from Kaunas (Lithuania, 54°53', 23°50', high - 76 m.) and Grodno (Belarus, 53°36'13", 24°02'39', high – 148 m.) meteorological and hydrological regime observation stations.

RESULTS AND DISCUSSION

The mean annual air temperature was about 6.8°C in the Grodno meteorological station from 1969 to 2019 at the mean annual precipitation 663.8 mm; and it was 6.82°C and 632.27 mm in the Kaunas meteorological station (fig. 2).

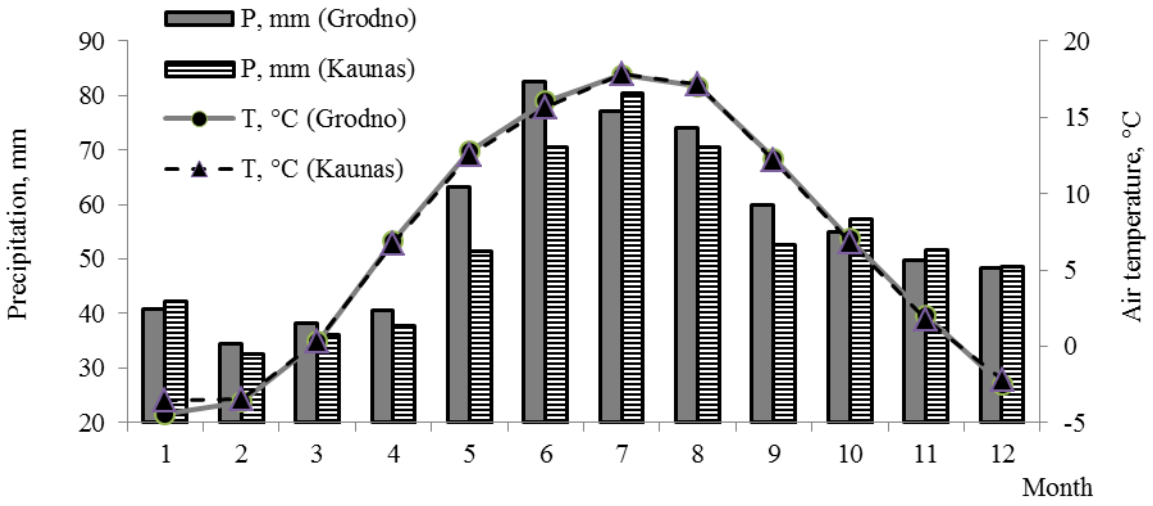

Fig. 2. The average air temperature and precipitation of month

The average temperature have tendency increased according Kaunas meteorological station data 1969-2016 (about 0.8°C), and the average quantity of average participation haveweak tendency increased (about 7% in the last 50 year, fig. 3).

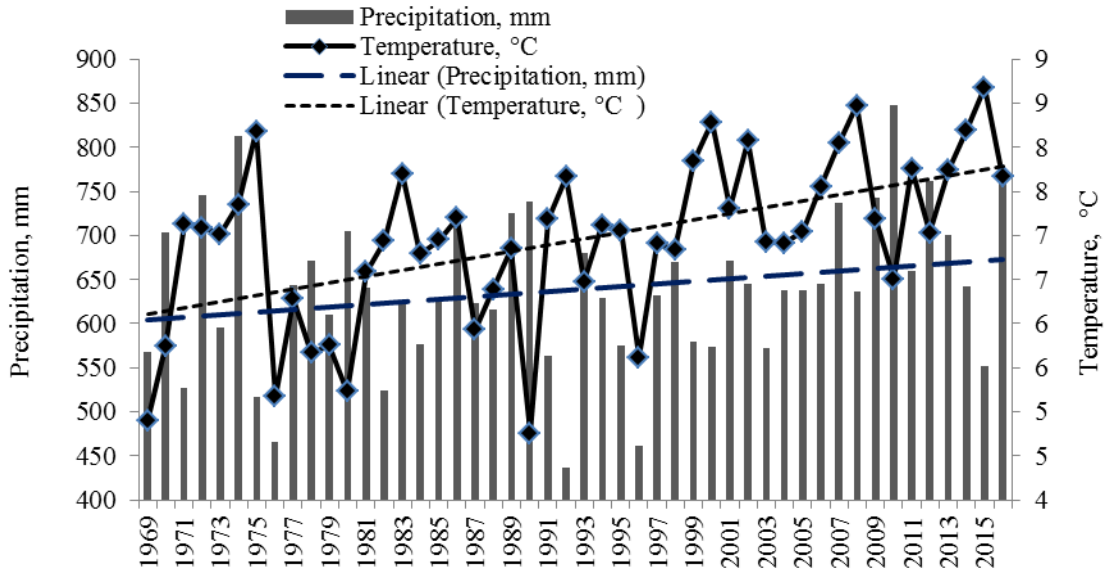

Fig.3. The average air temperature and precipitation of year (Kaunas, Lithuania)

The tendency for the air temperature to rise will also persist in the future (until 2050). The annual average air temperature is likely to increase by 1.4°C – 1.7°C in accordance with different climate change scenarios, assuming an increase by 2.0°C – 2.8°C in the winter season and by 0.7°C – 1.1°C in the summer season. Annual precipitation is also likely to increase in the Nemunas River

basin. More significant changes are expected in the first half-year, while in the summer and autumn seasons these changes will not be so significant. The air temperature is also expected to increase to the maximum in winter. The largest precipitation is forecast in the cold season of the year, while in the second half of summer and also at the beginning of autumn, the precipitation will actually remain unchanged or will even slightly decrease (the tendency 2015) (Korneev et al., 2015).

The results show the transformation of the of Nemunas River discharge hydrograph: a slight increase in the spring floods due to a shift in the beginning of the flood to earlier periods, and the maximum spring flood decrease in the Belorussian part.As the result of the growing winter temperatures and the growths of thaws, the amount of discharge will increase during the cold season with an increase in the minimum winter discharge. There are no significant changes in the discharge in the summer period (fig.4).

The forecast shows that amount of winter discharge will increase on the Nemunas River in Lithuania, and the minimum winter discharge will increase too. Spring floods will begin earlier than at the present time; the duration of flooding will remain the same, while the flood volume will decrease. No significant changes were found for the summer-autumn months (fig. 5).

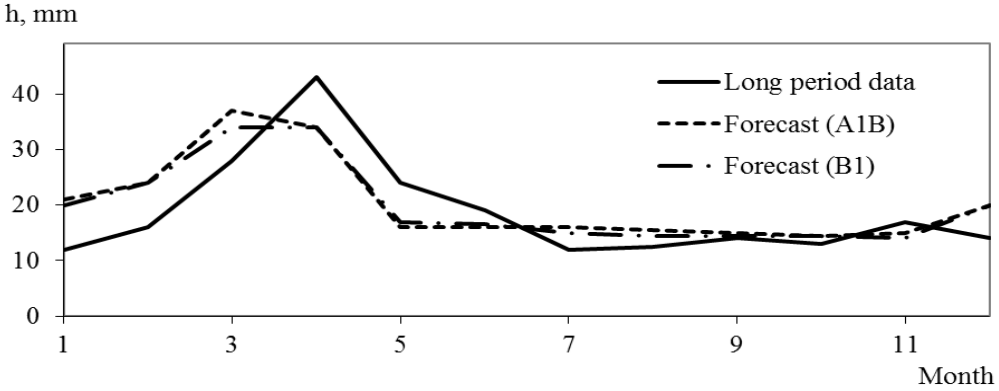

Fig. 4.Nemunas River discharge (Kaunas, Lithuania) (Aplinkos…, 2011)

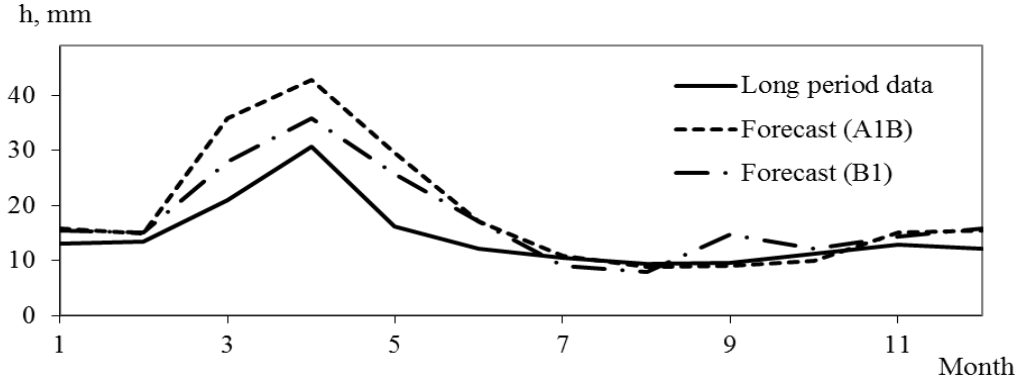

Fig.5. Nemunas River discharge (Grodno, Belarus)

According to the discharge change forecasts for the period 2021–2050, the tendencies for a slight increase in the average annual discharge throughout the Nemunas River basin spotted in 1961–2009, will persist. The increase in winter dischargetendency across a larger part of the Nemunas River basin area in discharge change was observed in the period of 1961-2009. The discharge may increase to the maximum in the winter season (up to 40%), mainly in January and February, due to increases in precipitation and the frequency of thaw periods.Climate change and the increased air temperaturemay result in watertemperature increases in surface water bodies. On

average, the water temperature is expected toincrease by 1 °C throughout the Nemunas River basin by the mid-21st century. This may leadto a reduction in the dissolved oxygen in surfacewaters by an average of 0.25 mg/dm^3 inthe summer season throughout the Nemunas River basin and it may become significantat low oxygen concentrations. The reductionin the dissolved oxygen content maylead to increased concentrations of biogenicpollutants and may also result in the deteriorationof hydro-biological indicators of surface waterquality. The water temperature rise may increasethe total mineralization by 3–10 % (Korneev et al. 2015).

CONCLUSIONS

The discharge may increase to the maximum in the winter season (up to 40%), mainly in January and February, due to increases in precipitation and the frequency of thaw periods.

The forecast shows that amount of winter discharge will increase on the Nemunas River in Lithuania (period 2021–2050), and the minimum winter discharge will increase too.

The transformation of the of the Nemunas River discharge hydrograph will slightincrease in the spring floods periods, and the maximum spring flood will decrease in the Belorussian part.

No significant changes were found in the summer months.

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Environmental Engineering
Ecology and Biotechnology

STOICHIOMETRY OF BIOLOGICAL NITROGEN TRANSFORMATION IN DENITRIFICATIONBIOREACTORS

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Annotation. The mechanisms of biological nitrogen transformations are very important for analysis, design, operation and optimal control of natural ecosystems or engineered systems for nitrogen removal. In general, the nitrogen compounds transformation direction and kinetics depended on bacterial metabolic activity and environmental (aqueous medium) conditions. The stoichiometric equations of ammonification, nitrification and denitrification have demonstrated that the nitrogen cycle in nature is rather complicated. In this study focus on denitrification process, this based on elements mass balance equation.

Laboratory scale tests have revealed that during the analyzed period of 235 days in bioreactor with deciduous woodchips the reduction of nitrate-nitrogen mass was reached 51% compared with the total amount observed in the inflow mass. During the same period the reduction of nitrate-nitrogen mass was reached, respectively, in the bioreactor with conifer woodchips – 64%, and with mixed woodchips filler – 63%.

Key words*:* stoichiometry,nitrogen transformation,denitrification bioreactor.

INTRODUCTION

„<...>All life on the planet is a chemical system, and life emerging is a chemical occurrence, which happens very quickly or does not happening at all."

Nobel-prize laureate Christian de Duve

Nitrogen is necessary for life to exist on Earth, it is an important the chemical element entering in biological the nucleic acid composition, which protected (in their chemical structure) the genetic information and transmit it from generation to generation, as well as transportation and performs information of functions by synthesis protein. Thus, the nitrogen atoms in the presence of complex biochemical processes in the body's growth and reproduction (Mažeikienė et al., 2012).

Nitrogen cycle is intricate process. Natural conditions nitrogen into nitrogen circuit inject of discharge power and via biological fixation. Nitrogen under an atmosphere migrate on diffusion, condensation, transpiration, erosion, infiltration, absorption, sedimentation, assimilation etc. physical processes. Biochemical processes of nitrogen ions can be in different chemical forms, each with its own characteristics and effects on the ecosystem (Tiškutė 2006; Carnicer et el., 2014).

Although the atmosphere contains are more than 78% gaseous nitrogen (N_2), but either animals or plants this form nitrogen can not to uptake. Plants absorbednitrogen compounds on ammonium (NH_4) and nitrate (NO_3) form, to addingprotein molecules. In addition nitrogen to soil entering with mineral and organic fertilizers. Not assimilated by plants, nitrogen compounds leaches to drains water and increased

inflow of nutriens into surface water bodies, leads to their eutrophication (Povilaitis et al., 2015; Dupas et al., 2014; Novotny, 2003).

Research results indicate (Deelstra et. al., 2014; Wesström et al., 2007) that the inflow ofnitrogen from tile drained agricultural areas is a significant source of this pollution.The solution of the above mentioned problem using purely agronomic or severe economic activity limitation measures often does not reach the expected results, due to the diversity of natural factors (e.g. flushy character of rainfall leading to high drainage runoff) and changeable climatic conditions. It is obvious that technological innovations in tile drainage systems design and implementation are necessary.

BIOLOGICAL NITROGEN REMOVAL IN DENITRIFICATION BIOREACTORS

The first attempts to apply biotechnologies for the removal of nitrogen in tile drainage water were started in the US (Cook et al., 2001). The main idea of these technologies is based on the direct installation of bioreactors into the trenches of tile drainage systems. The performance of bioreactors is driven by denitrification process which takes place under oxygen limited conditions in a specifically constructed trench filled with organic material where the tile water is diverted. At the time, the denitrifying bacteria utilize oxygen to process (oxidize) the available carbon and herewith converts nitrates being in a water into nitrogen gas (Povilaitis et al., 2011; Shaffer et al., 2008; Boyd, 2000).

Three rectangular shape (length – 130 cm, width – 35 cm, height – 70 cm) denitrification bioreactors (0.32 m^3 volume each) were installed in Drainage laboratory of Water Resources Engineering Institute at Aleksandras Stulginskis University (ASU) in Lithuania (Fig.1).

Fig. 1 Physical denitrification bioreactors models with different fillers (A – deciduouswoodchips; B – coniferous woodchips; C – mixed woodchips)

Bioreactor tanks were filled with woodchips made from local raw materials – deciduous and coniferous trees offal. The use of woodchips in bioreactors allows heterotrophic denitrifying bacteria to develop. Bacteria need organic material as a carbon source, therefore, a biofilm on the surface of woodchips is formed.Microbial biomass growth and activity is directly dependent on external factors: temperature, oxygen content, the hydrogen ion concentration, nutrient inflow and others, and the composition of the culture medium, enzyme (Tumas, 2003; Davis, 2010, Mažeikienė et al., 2012).

NITROGEN TRANSFORMATION

Soil bacteria, cyanobacteria and some fungi carries out biological fixation of nitrogen e.g. molecular nitrogen include the natural compounds. This process is regulated by the enzyme *nitrogenase*, which is *Nitrobacter* aerobic and anaerobic bacteria *Clostridium* media and algae (Povilaitis et al., 2011).Heterotrophic bacteria (uptake carbon from the organic compounds) and dividing the organic compounds containing in water or soil, organic nitrogen became inorganic into ammonification or mineralization process (1).

$$\text{Organic-N} + \text{microorganisms} \rightarrow NH_3^+ \rightarrow NH_4^+ \quad (1)$$

In the oxygen deficiency conditions *Pseudomonas Alcalignes, Paracoccus* bacteria and fungi to respiration reduced the oxygen from nitrate nitrogen compounds (Shaffer et al., 2008). Denitrification bacteria is reduced nitrate nitrogen to molecular nitrogen and returned to the atmosphere during denitrification process. The total process equation (2). The end products of denitrification include dinitrogen gas (N_2), carbon dioxide (CO_2), and bicarbonate (HCO_3).

$$4NO_3 + 5C + H_2O \rightarrow 2N_2 + CO_2 + 4HCO_3 \quad (2)$$

The HCO_3 is of interest because this release of alkalinity increases the solution pH.

The main product of interest is usually the gaseous phase nitrogen. While the main nitrogenous end product N_2, is stable due to its molecular triple bonds, denitrification can also produce nitrous oxide (N_2O), a potentially harmful greenhouse gas (Korom, 1992).

The environmental conditions of low pH, low temperature, high solution dissolved oxygen and low carbon to nitrogen ratio (C:N) may shift the final N_2O:N_2denitrification production ratio towards N_2O (Metcalf and Eddy, 2003).

Additionally, the microbiology of the bacteria may be important denitrifiers which lack the nitrous oxide reductase yet exhibit expression of the other denitrification genes may have reduced denitrification N_2O emissions. Unfortunately, nitrogen gas emissions in this work were not possible to determine due to the lack of suitable measuring equipment.

The mechanisms of biological nitrogen transformations are very important for analysis, design, operation and optimal control of natural ecosystems or engineered systems for nitrogen removal, and accurate stoichiometric equations can help in the maintenance of these environments.

In general, the nitrogen compounds transformation direction and kinetics dipended on bacterial metabolic activity and environmental (aqueous medium) conditions (Souza, 2009).

The stoichiometric equations of ammonification, nitrification and denitrification have demonstrated that the nitrogen cycle in nature is rather complicated (Fig.2).

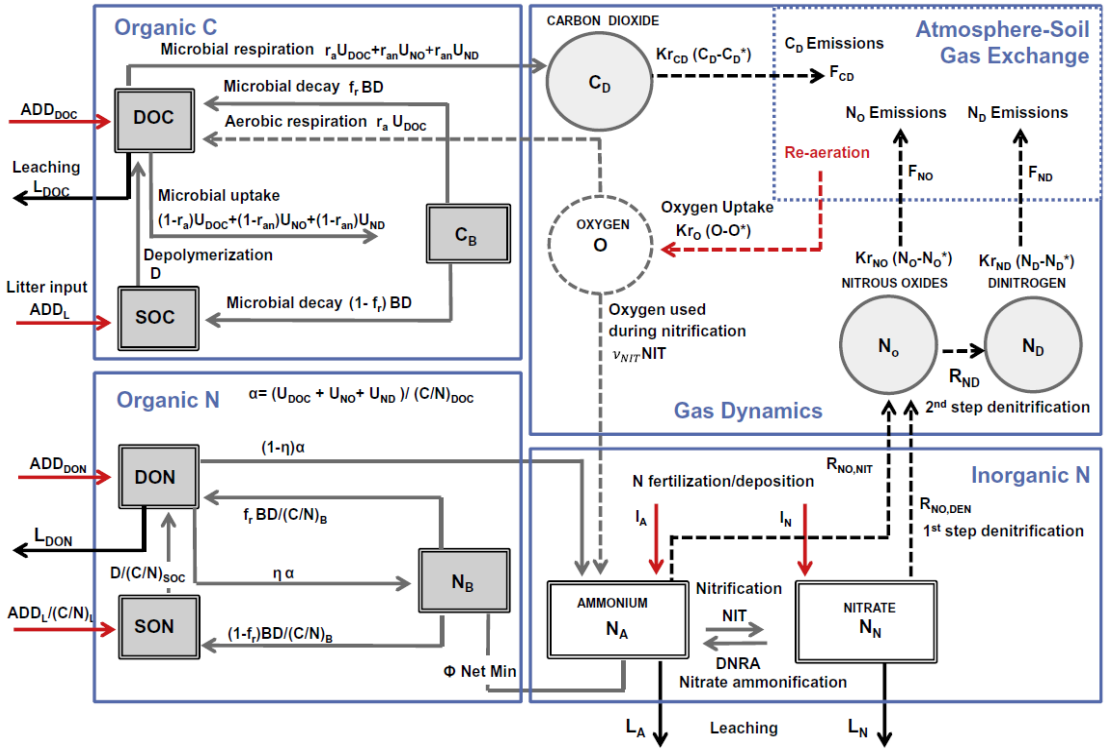

Fig. 2. Stoichiometry nitrogen transformation description (by Rubol et al., 2013)

where: DON/DOC – concentration of dissolved organic nitrogen/corbon, ADD_{DON}/ ADD_{DOC} – dissolved organic nitrogen/corbon inflow (system inlet), L_{DON}/ L_{DOC} – dissolved organic nitrogen/corbon outflow (system exit), SON/ SOC – organic nitrogen/corbon concentration of particles form, $ADD_{L(C/N)L}$/ ADD_L – nitrogen/carbon compounds inflow from the environment (decomposing organic materials, sediment) in system (system inlet).

In summary, analyzing nitrogen transformation (in water phases) and stoichiometry relations, focus on nitrate mass balance variation, mathematical law process description and influencing factors identication.

METHODS AND PROCEDURES

During the experiment the water samples were taken at irregular time steps according to water supply and water retention time characteristics. Nitrate nitrogen concentrations were determined in the inflow water, in the water of sampling wells and in the outflow. Variation of measured parameter values allowed to presume the ongoing nitrogen transformations in bioreactors.

Water inflow and outflow from the bioreactor readings were recorded with the help of water loggers.

Each bioreactor inside was equipped with additional water sampling wells where the water level was recorded. In all sampling sites, water temperature, pH, dissolved oxygen and NO_3-N concentrations were measured.

Nitrate nitrogen concentrations were determined by the means of Photometer MD600/MaxDirect system using a powder-like consistency reagent Vario Powder Pack. The dissolved oxygen amount was measured with a portable Eijkelkamp 18.28 oxygen meter and the pH values were measured by the portable WTW pH340i device, respectively. Inflow, outflow and inside bioreactor water temperatures were measured by the multifunctional portable system WTW Multi 350i.

Bioreactor fed NO_3 concentrations in the water tanks during the study period ranged from 4 to 35 mg/l. They were typical to the range of NO_3 values found in drainage water under field conditions. Nitrate mass change in bioreactors was calculated according to the equation:

$$\frac{dM}{dt} = \frac{d(M_{inflow})}{dt} - \frac{d(M_{outflow})}{dt} \pm R \quad (3)$$

where: $d(M_{inflow})$ – chemical elements inflow mass [g]; $d(M_{outflow})$ – chemical elements outflow mass [g]; dt - per time [h]; R – residual (sedimentation).

RESULTS AND DISCUSSION

In Laboratory, experimental with bioreactor with different woodchips filler (A, B, C) last 235 days. The graph 3,4,5 showed testing results, that the soaked woodchips facilitate reduction of oxygen, influencing pH, water temperature and further nitrate transformations in bioreactors.

The observed dynamics (Fig. 3; 4) of dissolved oxygen concentrations suggest that oxygen deficiency conditions are established and the balance of anaerobic environment stabilizes in there. The drop-off in dissolved oxygen amount confirms that it is actively consumed by heterotrophic microorganism.

The analysis of laboratory scale tests revealed that during each measuring event, water temperature in bioreactors increased ranged from 1 to 3 degrees (^oC). This corresponds occurs exothermic reaction in the bioreactor and an intense oxidation-reduction reaction,that denitrification process was active showed and soil increasedbicarbonate (HCO_3) concentration (TDS) in outflow water during all experimental time

It was determined that the amount of oxygen consumed by respiration, reaches the maximum (when the dissolved oxygen amount ranges from 0.00 to 1.00 mg/l) during the first 10 days of the startup of the reactor.

In the denitrification bioreactor with the deciduous woodchips filler (A), according equation (3) was determined 11,27 g of nitrate-nitrogen were removed within 235 days. This corresponds to 63% of the inflowing amount of nitrate-nitrogen. 5,40 m^3 of water have passed through the reactor during the period.

With conifer woodchips filler (B), 13,77 g, this corresponds to 64% of the inflowing amount of nitrate-nitrogen. 5,60 m^3 of water have passed through the reactor during the period. Over the same period in the denitrification bioreactor with mixed woodchips filler (C) 12,14 grams of nitrate nitrogen were removed and it makes up to 63% from the total inflow amount of nitrate nitrogen content.

The nitrate-nitrogen removal rates by event were calculated from the total amount of NO_3-N removed during an event divided by reactor volume filling with water and event step (Christianson et al., 2010).

The research tests revealed that nitrate removal rate in the bioreactor (A) has an average of 0,51 $g/m^3/h$. It ranged from 0,04 to 2,52 $g/m^3/h$. In the bioreactor (B) – an average of 0,54 $g/m^3/h$ and varied from 0,08 to 1,31 $g/m^3/h$. In bioreactor C – an average removal was 0,49 $g/m^3/h$, and it varied from 0,06 to 1,45 $g/m^3/h$.

The nitrate removal rate differences appeared due to the difference in bioreactor volume filling with water and the water retention time within which the biochemical degradation of nitrogen compounds ocurrs.

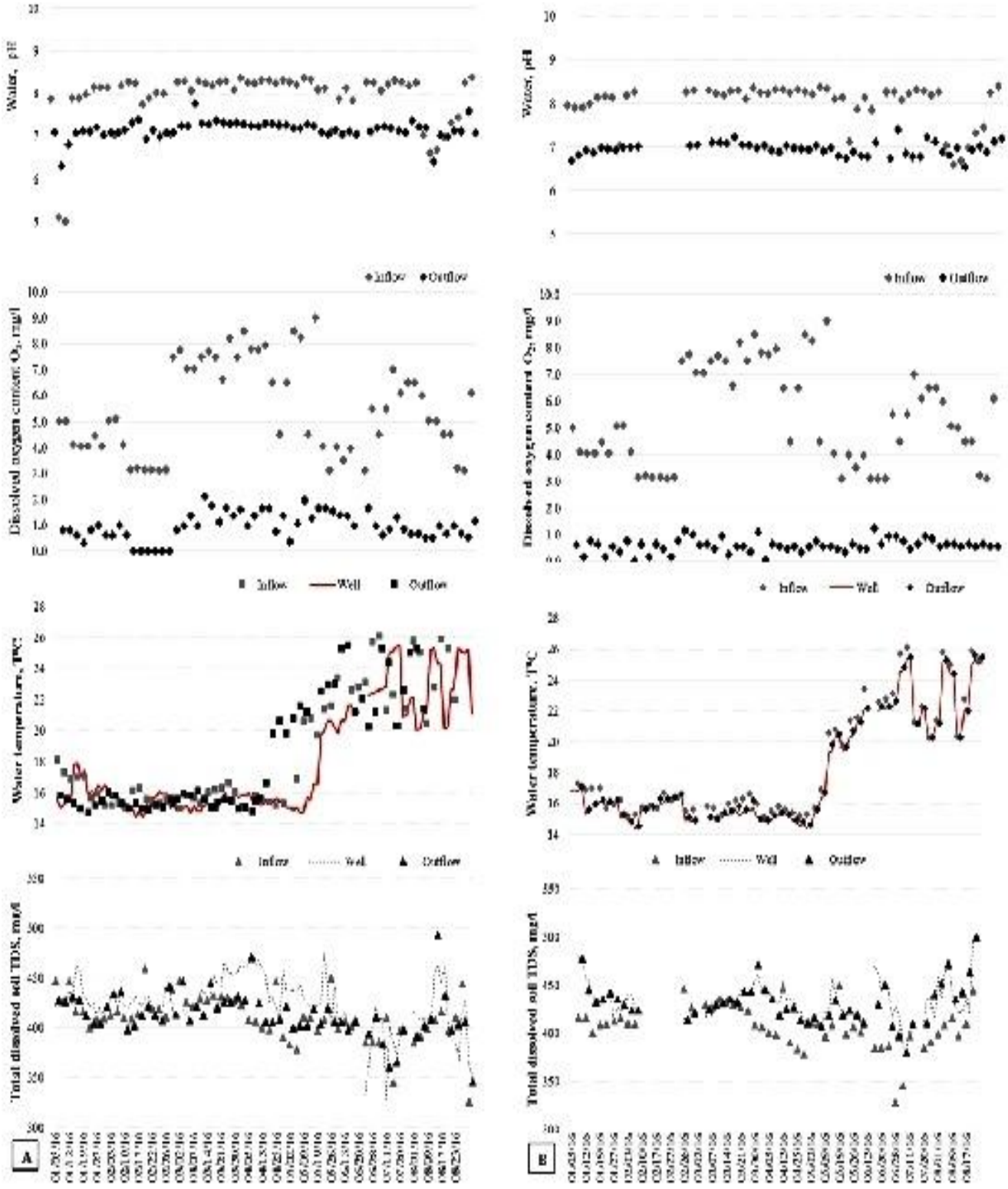

Fig. 3. The chemical elements concentration changes in denitrification bioreactors with deciduous (A) and coniferous (B) woodchips fillers. (Legend: Inflow – concentration in inflow; Outflow – concentration in outflow; Well – concentration in well)

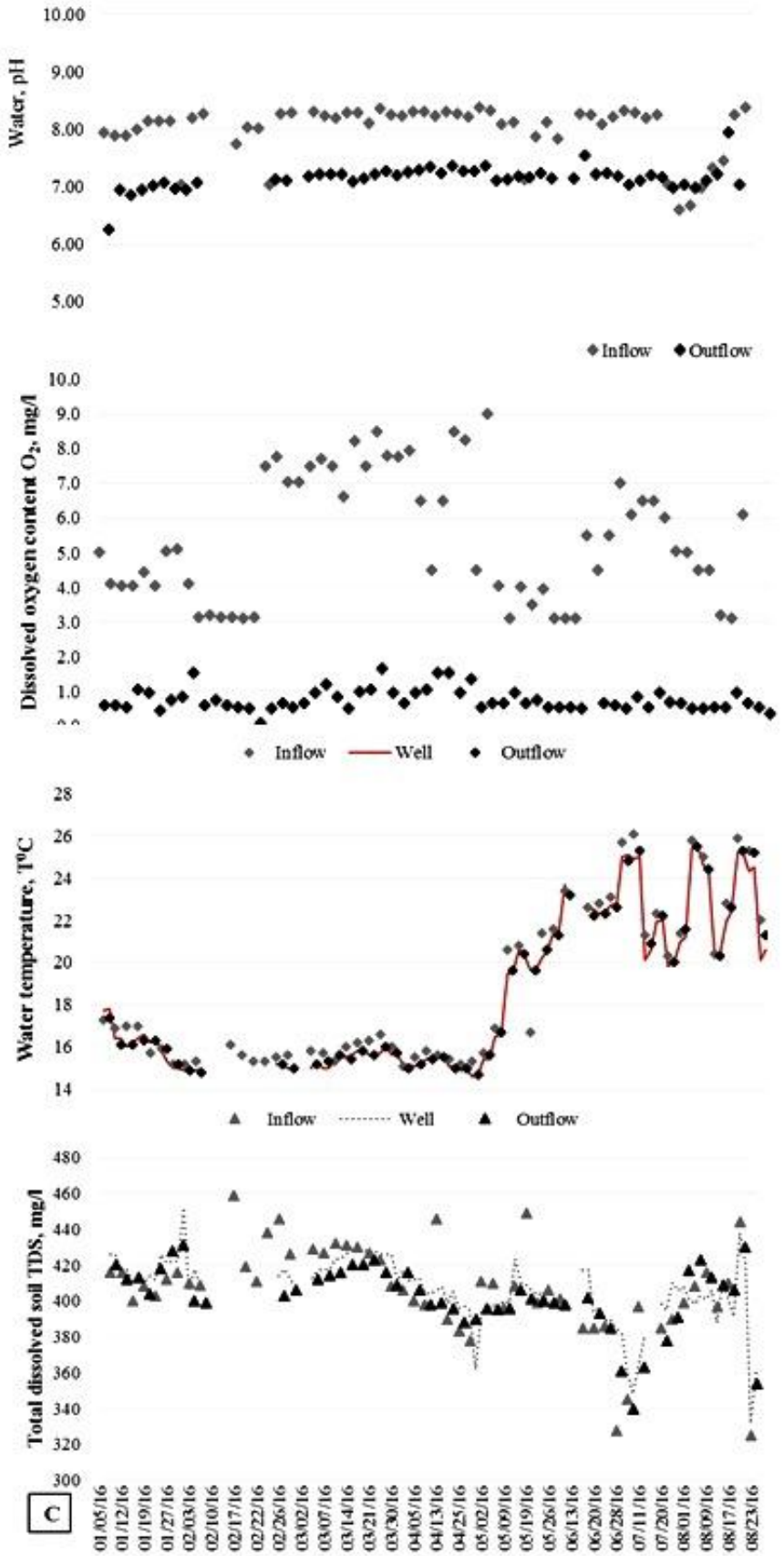

Fig. 4. The chemical elements concentration changes in denitrification bioreactors withmixed woodchips (C) fillers. (Legend: Inflow – concentration in inflow; Outflow – concentration in outflow; Well – concentration in well)

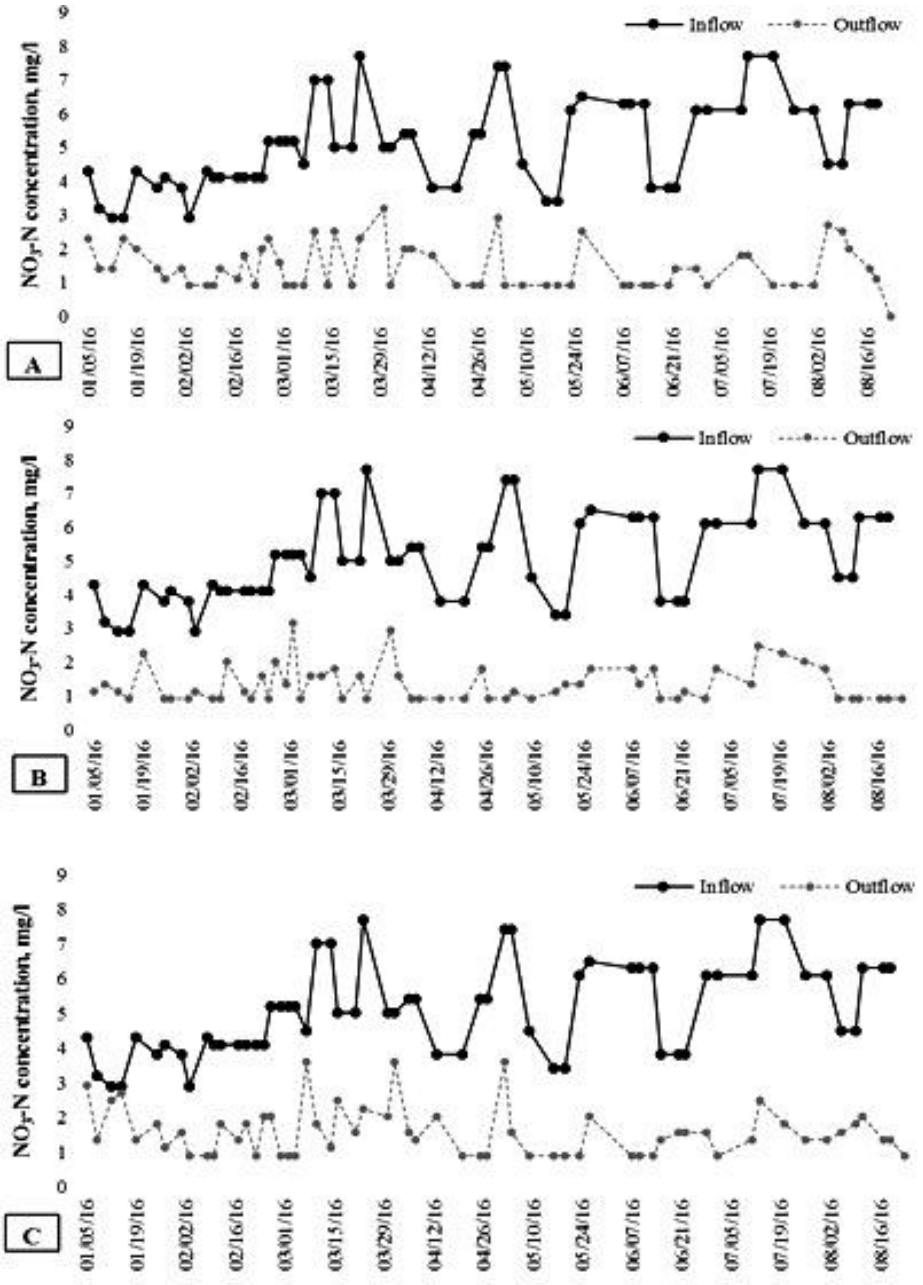

Fig.5. Dynamics of nitrate-nitrogen concentration in denitrification bioreactors withdifferent woodchips fillers. (Legend: Inflow – concentration in inflow; Outflow – concentration in outflow

Under oxygen deficiency conditions and the availability of NO_3, the microorganisms transform nitrates into gaseous nitrogen forms. The differences in nitrate concentrations at inflow and outflow clearly demonstrate (Fig. 5) that this process was intense.

Nitrate concentrations have ranged from 4.00 to 35.00 mg/l in inflowing water and from 4.00 to 13.00 mg/l in the outflow. It should be noted, that nitrogen removal efficiency dependent on nitrogen concentration in inflow. Nitrogen concentration inflow decrease shows in fig. 5 (A, B, C tests).

It is obvious, that biological nitrogen removal was going on in all bioreactors.

In general, stoichiometric relationships chemical elements, microorganism and environmental conditions (temperature, water pH, dissolved oxygen content and other) had possitive influence to efficiency of nitrogen transformation to gaseous form.

CONCLUSIONS

1. The stoichiometric equations of ammonification, nitrification and denitrification have demonstrated that the nitrogen cycle in nature is rather complicated. In this study focus on denitrification process, this based on elements mass balance equation.
2. Laboratory scale tests have revealed that during the analyzed period of 235 days in bioreactor with deciduous woodchips the reduction of nitrate-nitrogen mass was reached 51% compared with the total amount observed in the inflow mass. During the same period the reduction of nitrate-nitrogen mass was reached, respectively, in the bioreactor with conifer woodchips – 64%, and with mixed woodchips filler – 63%.
3. The results of nitrate-nitrogen removal rate were in bioreactor with deciduous tree woodchips it was 0,51 $g/m^3/h$, in the bioreactor with the conifer woodchips filler – 0,54 $g/m^3/h$ and in the bioreactor with mixed woodchips filler – 0,49 $g/m^3/h$. The nitrate removal rates differences appeared due to the difference in water retention time within which the biochemical degradation of nitrogen compounds occurs.
4. According to the experimental study results, stoichiometric relationships of chemical elements and environmental conditions were availability to microorganisms transform nitrates into gaseous nitrogen forms.

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