Ministry of Education and Science,
Youth and Sport of Ukraine
National University of Water Management
and Nature Resources Use

# INNOVATIVE TECHNOLOGIES IN WATER MANAGEMENT COMPLEX



Collected articles of young scientists

**23-25 April**

**Rivne – 2012**

Ministry of Education and Science, Youth and Sport of Ukraine

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# Innovative technologies in water management complex



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Part II

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The collection of science works includes the research materials of young scientists of Ukraine, Germany, Poland, Uzbekistan. They reflect the most topical problems of water management today, available achievements and shows the possible directions of their development.

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*In conditions of increasing anthropogenic loading on natural environment, development of public production and growth of financial requirements emerges the necessity of development and suport for the special rules of using water resources, their rational use and ecologically directed protection.*

Water Code of Ukraine
Verkhovna Rada of Ukraine

*Code of Ukraine, Law*
*Code from 06.06.1995 №213/95 VR*

## EDITORIAL SCIENTIFIC COMMITTEE:

# HYDROAMELIORATION, HYDROTECHNICAL INGINEERING AND RATIONAL NATURE RESOURCES USE

## USING COSMIC VIEW FOR RECULTIVATING WATERED LAND OF "QIZIL RAVOT" (RED RABOT) MASSIF ON THE BANK OF AMU DARYA

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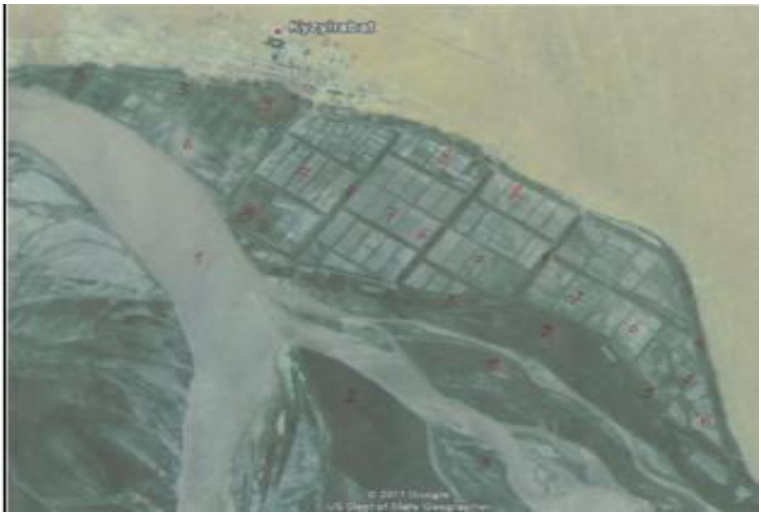
It's known that Bukhara province, Romitan region "Red Rabot" is situated on the bank of Amu Darya's terrace. It consists of pasture used in irrigating farm, swampy and different kinds of salty soils. It was learnt less by researchers because cultivated lands in this massif are situated further (240 km) than the lands in Bukhara. That's why opening of barren land as the factor of appearing natural soil is not learnt. As a result hydrotechnic and hydromeliorative actions were not planned and enough done. So it is observed that during 2-3 years under the influence of the flood of Amudarya, water overflowed from built dam to the opening barren land, as a result productive lands were under the water.



The scheme of "Red Rabot" massif's land ameliorative structure.

1. Amudarya
2. The place full of thickets
3. Land and thickets place is under water
4. Channels and irrigation canals
5. Dam
6. Lands are under water
7. Swampy
8. Pasture watered and salty land

Changing natural river stream, land is observed in the picture.

It's known that, it is taken a picture of 1000 $km^2$ areas in a short time from orbit, in other words in 5 minute from orbit. The important feature of cosmic views is its quickness, it forms the condition of agriculture crops in one time. It is taking a picture of changing dynamic condition of salinity and soil erosion from a distance and the anthropogenic influence on the structure of land shaft, water reservoir, channels, river banks, the condition of ice by the method of doing decoding the cosmic view information given above done by the suggestion of U.Tojiev and KH Namozov.

Watered land of learnt massif is near 950 hectors nowadays, used land in the farming is 60 hector. Other lands are underwater. In addition underground subsoil waters in productive land are placed near the surface of earth (30-35 m). As a result the conditions are not enough for using agrotechnical plans and taking care of crops. So agricultural lands are turning useless and to thickets place. It seems to us that recultivating the land and increasing its economy we should design to build dam in this massif the length of which is near 10 km and height is 5-6m.

If this design comes true it will be good. The aim of our research is to rich quantity and quality the meaning of the research of the Uzbekistan subject and technology centre number 01-76, and to attract land providing the resources with water and innovations to assimilate them.

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## INFLUENCE OF SHAHRUD CHANNEL ON SOME PROCESSES OF SOIL FORMATION AND SALT ACCUMULATION IN SOILS OF BUKHARA OASIS OF UZBEKISTAN

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The purpose of researches - to study turbidity, mechanical and mineralogical structure, and also chemical properties of the suspended particles of channels waters and sprinklers of the Shahrud channel and sprinklers of the Bukhara oasis of Uzbekistan and to establish their influence on soil formation, in particular on processes of salt accumulation.

Researches were carried out on soils of the Bukhara oasis where are extended by the different prescription of an irrigation for meadow alluvial soils. In researches the following, widespread in genetic soil science methods of researches were applied:

- field route-forwarding researches, allowing to study the development of various soils of genetic-geographical origin;
- chemical-analytical, allowing to establish the structure and properties of soil deposits in channels, sprinklers. In analyses of waters and soils widely known methods are used: [1], [2], [3], [4].

The Shahrud channel till 1975 was the basic irrigational construction of the river of Zarafshan in the Bukhara oasis, turbidity water was on the average 3.04 g/l [5]. Now the Shahrud channel begins from the Kuimazar reservoir where water turbidity of this channel makes up 3.27 g/l thanks to which to the irrigated lands of the Bukhara oasis annually arrive about 12-18 million tons of clay particles. Results of our researches show the natural change of quantity of the suspended particles in various parts of irrigation system [6]. So, in headwaters of the Shahrud channel water turbidity equals 2.78 g/l, in the Hayrabad main sprinkler, 2.43 g/l and in sprinklers near villages Ehson and Kasari these indicators decrease accordingly to 2.30 and 1.17 g/l. The same regularity is observed on the average in a channel current, except for a sprinkler of Gulobod (turbidity 3.14 g/l) that, probably, speaks of emission to it of building materials. Thus, with the inflow of water from the channel to an irrigated field it is besieged on the average to 37-50 % of the suspended deposits or on cultivated fields during the vegetative period irrigation waters bring 12-18 t/hectares of deposits that cause the gain of an arable layer on 0.5-1.0 mm a year.

In mechanical structure in the suspended particles of headwaters of the Shahrud channel 47.90 % of physical clay are contained. In a sprinkler Hayrabad

located on the average current this indicator equals 50.52 % that leads to weighting of mechanical structure of old irrigated grass farming -alluvial soils. Such regularity is traced also in averages and in the bottom of currents of other sprinklers. So, in waters of sprinklers Gulistan, Navmetan and New Navmetan, the content of particles in the size less 0.01 mm increases from 58.08 to 75.04 %. In headwaters of the channel content of $Fe_2O_3$ is 4.5-6.5 %, and in the bottom current the quantity of its oxide increases to 9.23 %. Under content of $Al_20_3$ the suspended particles of the Shahrud channel differ a little from particles of the river of Zeravshan (7.54-16.79 %). The phosphorus content in the weighed deposits makes up 0.18-0.55 %, and the quantity of SaO and MgO accordingly in top and in bottom currents fluctuates in limits from 3.17-3.19 till 1.83-0.93 and from 5.64-6.04 to 1.66-2.12. Potassium is kept in order 1.73-3.47 % and exceeds sodium (0.51-2.62 %) a little. Correlation $SiO_2$:$R_2O_3$=5.73-12.03.

The nitrogen content in the suspended particles of Amu Darya, Zeravshan and Shahrud channels doesn't exceed 0.040-0.063 %, and ratio C:N equals 7.5-10.6. The suspended particles of the Shahrud channel contain on the average only 16-24 mg/kg of active phosphorus and 120-136 mg/kg of exchange potassium. Thus, muddy waters of the channel positively influence the fertility of the soils especially newly mastered. The content of $CaCO_3$ in the suspended particles of the Shahrud channel makes up 12-17 % that by 1.5-3.0 times is more than in waters the Kura-Araksinsky oasis of the Republic of Azerbaijan. It is probably connected with structure of rocks and conditions of their aeration. Because, the mineralogical structure of the suspended particles of the Shahrud channel basically consist of illite (62 %), chlorite (17 %), kaolin (13 %) and quartz (8 %).

Results of researches show that under the influence of a centuries-old irrigation meadow alluvial soils have lost the natural morphological shape instead of which in a soil profile following genetic horizons were generated: $Aa_1$-$Aa_2$-$Aa_3$-$Aa_4$ $B_1$-$G_1$-$G_2$.

The irrigation turbid water differently influences mechanical structure of soils extended in the Bukhara oasis [6]. So horizons of $Aa_1$ and $Aa_2$ soils are located at the distance of 100-500 m from the channel, consist of easy loam (physical clay of 27.3-28.3 %), in soils developed at the distance in 500-1000 m and 1000-2500 m the increase of the the content of fraction of physical clay accordingly 29.6 and 33.2 % is observed.

Depending on remoteness of channels and sprinklers, a structure average and a microrelief, mechanical structure, depth bedding ground waters and on the degree of their mineralization, irrigated soils of the Bukhara oasis also are subject in various degrees to processes of salinization.

The total area of the studied soils makes up 20666 hectares, of them not salted – 9.9 %, less salted – 28.3 %, average salted – 38.1 %, hard salted – 15.9 % and saline soils occupy 7.8 % of the area. In soils of the channels extended in headwaters and sprinklers in a layer of 0-100 cm, the average content of the chlorine and sulfate of ions are accordingly 0.230-0.360%, 0.010-0.024 % and

0.021-0.015 %. On the average a current of the channel and sprinklers processes salting in soils increases. At the distance of 1000-2000 m from the channel and sprinklers the quantity of the dry remnant, chlorine and sulfate ions accordingly increases to 1.234, 0.027 and 0.104 % that in turn causes occurrence of spotty forms of hard salted soils and places of saline soils. In the bottom of the current of the channel and sprinklers in irrigated soils the content of the dense remnant, chlorine and sulfate ions reaches a maximum, so these indicators increase to 3.142, 0.664 and 0.945 %. Vegetative and washing waterings deduce from these hard salted soils and saline soils readily soluble salts in deep layers, but because of bad outflow of ground waters, at salt evaporation rise back in the top layers of soils and processes salt accumulation in soils become often not reversible that promotes formation of steady constant forms salting on the irrigated lands.

The research results have a great importance concerning the increase of soil fertility. Accumulation and distribution of suspended particles on profile lets choose the proper agro-meliorative and agro-technical measures.

It can be used for increasing the fertility and improvement of meliorative conditions of irrigated soils of Bukhara oasis, in soil research works, in education process at high and special schools.

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## TO THE QUESTION OF ECONOMIC SECURITY OF WATER MANAGEMENT ENTERPRISES

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Speaking about economic security of water management enterprises we understand the current functioning of sustainable enterprise that counteracts the effects of threats of internal and external environment under conditions of maximum risk-free use of water resources and opportunities, targeting the basic objectives and strategies, with such consequence as build-up of high potential development of the water complex.

Economic security of water management enterprise is a complex multidimensional category, which is characterized by strong interconnection and interconditionality of its separate functional components. And then, the flaws or errors in compliance of some options of economic security immediately affect others and their entire population.

That's why while making management decisions is sorely needed to take into account all the factors that affect one or another effective measure, their relationship and interconditionality, to determine the specific consequences of the implementation of certain measures. The economic activity of the water management enterprise is influenced by a large number of external and internal factors, that is first of all due to variety of connections and relationships that water enterprise has. In the course of material, financial, information, personnel, and other connections in which sharing takes part, consumption and moving raw materials, equipment, investments, technology, money, etc. All these connections arise in the actual political, socio-economic, climate and other conditions that have formed as at the scale of the whole country, and at the level of a particular region. This situation in one or another region, where basin enterprise operates, can significantly affect the results of his economic activity.

The process of ensuring the functional components of the economic security of the water management enterprise may be defined as a set of activities to achieve the maximum level of solvency of the enterprise, the most effective modeling the structure of capital, improving the quality of planning and implementation of financial and economic activities in all areas of strategic and operational planning and management of technological, intellectual and personnel potential in order to maximize revenue and ensure stable development of water management enterprises.

Analysis of the level of economic security of the water management enterprise is carried out on the basis comparison, obtained as a result of the calculation of the value of cumulative criterion of economic security of the enterprise with the earlier values this criterion for the entrepreneur measures that is analyzed, as well as, possibly, appealed to compare meanings of this criterion for similar enterprises in the water industry. In addition current and past assessments of partial functional criteria are compared and the degrees of influence changes in functional

components on changing the value of the cumulative criteria of economic security of the enterprise are identified. After this calculation it's necessary to conduct functional analysis of measures to maintain the required level of functional components of economic security of water management enterprise. [3]

Methodological approaches to assessing the level of economic security in the whole and its separate components should include definition of the criterion of economic security, the choice of certain indicators, defining their values, monitoring indicators, comparison of actual values of certain parameters with threshold values, determining the extent of economic security, the analysis of the obtained results, prediction of critical groups of indicators.

The main goal of economic security — to ensure the most efficient functioning of operating system and economic use of water resources, ensuring a certain level of working life of the workers and quality of business processes of the enterprise, as well as the constant stimulating the growth of the existing potential and its stable development [1].

Management of the economic security of the enterprise should provide: full characteristics of external and internal threats that water management enterprise can face; the definition and monitoring of factors, restorative or destructive to the stability of its socio-economic position in the short and medium term; building a system of indicators that allow evaluating the effect of these factors on the potential of the basin enterprise; building criteria and marginal values, which form the most important indicators of the level of economic security; the development of economic policy aimed at increasing the degree of economic security; the development of measures to compensate or minimize the negative impact of possible threats [2]

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## OPERATION OF IRRIGATION SYSTEM

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In order to increase harvesting of crop yields and regulation of water-air regime it is necessary to conduct irrigation. Irrigation water is supplied to the plants as an additional to the natural sediments; it prevents periodical droughts, stimulates and regulates the growth of plants. With the help of irrigation yielding has increased approximately in 1.5-2 times, and in years of drought in 5 times or more.

Surface irrigation methods, drip irrigation and rainwater are the most widely used in Ukraine. Depending on irrigated crops there is surface irrigation which is used in bands, in furrows or in full flooding.

Irrigation system is widely used. Paying attention to operating and capital costs, the usage of wide irrigation systems are the most cost-effective. One of the vivid measures of irrigation system quality and plants are the size of rain drops layer. The best conditions for soil moisturing and maintaining of its structure when rain drop not more than 1 ... 2 mm, and a rain layer for heavy soils - 0.1 ... 0.2 mm /min for medium loamy soils - 0.2 ... 0.3 mm / min and for light soils - 0.5 ... 0.8 mm / min. In such conditions water is completely absorbed by the soil (it does not form puddles).

Recently, the economy with an area of irrigation over 1,000 ha use foreign irrigation machines which are offered by such prominent firms as „Bauer" (Austria), „Valley", „Lindsay" (USA). For the area irrigation from 5 to 30 hectares hose-tube irrigation installations are used, and areas from 50 to 200 hectares use broad-catching irrigation machines.

Irrigation systems are used for irrigation of various crops. They are commonly used for irrigation of vegetable crops, orchards and berry fields. As a rule broad-catching irrigation equipment is typically used for irrigation of fodder and grain, technical and other crops.

Modern irrigation machines work both the closed and open irrigation networks. Closed network could provide machine work in their moving as well as in a circle and in frontal motion. Water collecting is done from closed irrigation network or from place to place; using flexible pipe the length of which is 120 m. Supplying water irrigation into a closed irrigation system is used with the help of fixed or mobile pumping station.

Water into irrigation systems is pumped from natural sources as lake, river and other open water bodies. To provide continuous and qualified machine irrigation work a number of measures like cleaning of irrigation water from solid particles is conducted.

Water quality significantly affects the productivity of irrigation machines and there is a significant factor which affects the determination of irrigation norms during the season. With the deterioration of water quality such as grade, flowering, etc., the loss of pressure in the irrigation system what leads to lower level of productivity and significantly affects the quality of energy and irrigation increases.

The experience of using „Centerstar" collective farm in „Russia" (Zaporizka region) while working on very dirty channels especially in summer blooming, the protective effect of safety nets and gravel filters are low. As a result small particles

of water impurities penetrate into closed irrigation network. These particles, getting into the machine, cause unexpected changes in local resistance, which cause changes in distribution of rainfall along the irrigation pipeline irrigation system „Centerstar". As a result, the design features of machinery as sprinkling nozzles are suspended at the bottom of the tubes. They work on clearing rather hardworking and time consuming. Therefore, in order to improve the quality of irrigation of supplied water to the pressure pipe irrigation machines it is recommended providing of additional purification. In this case it is recommended to install a filter at the central tower irrigation system or on the touring pumping station. The filter should provide qualified cleaning of irrigating water and the effort and complexity of work on his recovery should be minimal.

Floating impurities removed from the liquid mainly using mechanical ways as filtering through the porous walls or assertion.

Cleaning of irrigating water is the most common technology of filtering fluid with negligible content of solid phase on the continuous mesh settings. Net filter is used in water supply purification systems of water containing algae and other floating impurities. Therefore, it is extremely necessary to use mesh filters which require less cost to restore the filter element.

The use of vibration in the process of filtering significantly increases the period of filter cycling and streamlines the process of mesh fabric regeneration. Therefore vibration filters have a wide application in various fields.

## ESTIMATION OF THE STATE OF SMALL RIVER OF IKVA

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To the small rivers in Ukraine take small rivers long to 2000 km$^2$ [1]. For last half of age as a result of making progress negative anthropic influence on natural

ecosystem in the small rivers, shall owing, oppression of hydrophilic flora and fauna, worsening of quality of water, happened and on occasion them complete degradation.

For the real estimation of the state of water resources of Ukraine attaching of our state was initiator Ministry of guard of natural environment to Water Scope Directive of European Union, in fact our water problems are near after the degree of decision to European, that was instrumental in introduction of requirements of the mentioned directive at the study of the state of the river of Ikva.

River of Ikva – one of many small rivers of Ukraine, where the large upcasts of muddy flow waters are registered. Are these up casts exceeded by a 1 million $m^3$/year and are 91% all volume of flow waters. The primary purpose of description of the river is its dividing into expressly certain water objects which can be examined as objects for water control.

The river of Ikva takes beginning from ascending sources in the district of v. Chernicya Brodi the district of the Lviv area is on Podil'skiy sublimit. The river of Ikva belongs to the river of Stir basin, being it by the right influx of the first order. In riverheads the valley of the river is narrow, washtub similar, with steep slopes. Within the limits of Lvov it flows on a 23 km in to sublatitudinal direction with a narrow one-sided back-water which gravitates to the south bank. A river-bed poorly winding, breadthways 2,5 – 4,0 $m^3$, in 0,5 – 1,7 m. depth absolute mark of water on included Ikva in the Ternopil area – 267 m. the first right influx of Ikva in the district of v. Lukashi, second – v. Tetetl'kivci [2].

A river basin is located in a forest and forest-steppe area. Length of the river is a 148,8 km, the area of pool makes 2250 $km^2$. Territory of water collapsible territory is strongly dried for the use in agriculture, especially in the district of m. Dubno. First 15 kilometres upwards down stream named the drainage system Ikva. There is one large dike, which forms Mliniv storage pool, and a few dikes, in the district of c. Dubno.

Substantial contamination is three cleansing buildings of water channel which throw down a flow water. These cleansing buildings are old enough and conduct cleaning of organic materials, but not cleaning, from P or N. The networks of the centralized overflow-pipe and sewage system do not have a village. In relation to industry, a sugar-house is most contamination in a region. Substantial contamination is three cleansing buildings of water channel which throw down a flow water. These cleansing buildings are old enough and conduct cleaning of organic materials, but not cleaning, from P or N. The networks of the centralized overflow-pipe and sewage system do not have a village. In relation to industry, a sugar-house is most contamination in a region. It completed oxidization of organic earths and creation of meadows of salts to more deep aquifers horizons. A section from the epiphyses of salt resulted in the compression of salts. In some parts of pool obtain peat which influences on lees of water and content of guminovikh matters.

River of Ikva and its pool part on 9 water objects. 4 from them is considered natural water objects, while other 4 considered strongly changed through human interference. Two overhead down stream water objects Ikva have good ecological status. The analogical is consider an area below for flows from Mliniv of storage pool. In middle part of the river water objects have satisfactory ecological status. Such description is conditioned influence of contamination, drainage system, system of dikes and straightening of the river. Mliniv a storage pool is considered a water object with satisfactory ecological status. These three water objects (two basic parts of the river, three influxes and lake of Mliniv) are considered such which fall under the risk of achievement of good ecological status in accordance with the requirements of VSD of EU. Other are considered out of risk.

Conclusions. Lead through of research in the pool of the small river of Ikva are the first in Ukraine and can exemplify and by basis for organization of management a water pool. The high detailed of the different study testifies to the presence of ecological problems for proceeding in natural operating of the small rivers conditions in our state. Water Scope Directive of EU is a basic document which regulates a lead through on unique method of works on preparation of control system by water pools.



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## INFLUENSE OF CONFINING LAYER ON DRAIN DRAINAGE DRAINAGE-MODULE SYSTEM

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Under conditions of deep laying of water-resisting layer, drains of drainage module practically do not influence the flow of each other. It is caused by the

horizontal movement of water, which is in the limits of space between bottom of drains and surface of water-resisting layer, is faintly revealed on the character of flow formation across shallow or deep drains of drainage module.

However by shallow laying of water-resisting surface space for horizontal transference of soil water flows under level of drains laying is considerably less than in the case of deep laying of water-resisting layer.

In this case calculation of drainage module parametres must be fulfilled taking into account the fact that deep drain in certain spaces of time influences substantially shallow drain flow.

Under conditions of soil nutrition, when drainage flow is being formed only due to soil water (infiltration of water from surface is absent), hydrodynamic net shows a bit greater amount of water passes to deep drain than to shallow. Besides it duration of water passing to deep drains is a little longer than to shallow ones.

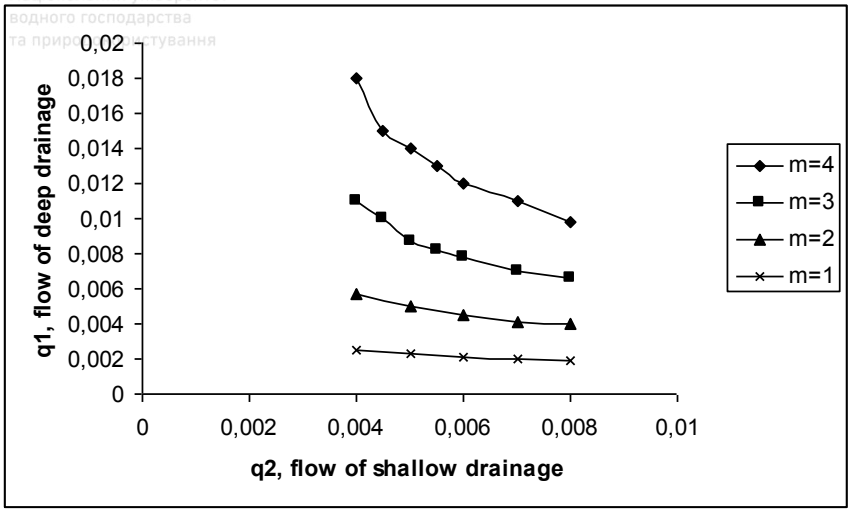
Having analyzed formula for computation of distance between perfect by degree of aquiferous layer opening by drains under condition of soil nutrition and substituting data

$$B_{i\bar{a}} = \frac{\sqrt{k}}{2}\left[\sqrt{\frac{\text{[illegible]}_0^2 - m_1^2 - h_{01}^2}{q_1}} + \sqrt{\frac{\text{[illegible]}_0^2 - m_2^2 - h_{02}^2}{q_2}}\right]$$

where $q_1$ *i* $q_2$- rate of water influx to drains, according to deep and shallow;
$h_0$-maximum level of soil water
k- coefficient of soil filtration

We can make the graphic of deep drain dependence on flow of shallow under different distances from water-resistant layer to deep drain.

Having analyzed given dependence we can say that by soil nutrition with increase of shallow drain flow the drainage of deep one decreases.




Sceme 1. The graphic of deep drain flow dependence on shallow flow

Having analyzed dependence we can say, that by soil nutrition with increase of shallow drain flow the drainage of deep decreases. And also increase of distance from water-resisting layer to deep drains ( in limits 1…4 m) leads to more substantial advantage over work of shallow in the work of drainage-modular system work. Hereby overfall between drains does not change (in our case it is 0.5 m), deepness of water-resisting layer remains unchangeable , and distance from drainage module to soil surface decreases because of distance increase from water-resisting layer to deep drain (from 1 m. to 4 m.).

Having analyzed graphic of flow distribution between shallow and deep drains under conditions of overfall between drains we can make a conclusion , that flow of deep drain exceeds shallow one, the biggest exceeding of deep drain flow over shallow is observed by overfall between drains in 0.4 m., we can see decrease of flow difference between deep and shallow drains with increase of overfall between deep and shallow laying (more than 0.4 m.)

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# METHODS AND WAYS OF THERMAL MELIORATION OF SOIL

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One of the most important tasks in developing Ukraine's economy is to increase the efficiency of agricultural production. To solve this problem it is necessary to ensure high qualityl of land. An effective way to achieve this goal is to improve the hydrothermal regime of soils which is known to play an exceptional role not only in soil formation but also directly affects the growth, development and plant productivity.

The agricultural use of land may comprise such economic conditions when obtaining early and guaranteed yields of crops requires purposeful engineering measures to improve and control not only water but also the thermal regime of soil. Improved thermal conditions (thermal reclamation) can be directed at both raising the temperature of soil and surface air and their reduction. There is no standard definition of thermal melioration in literary sources.

The necessity of adjusting thermal regime of soil follows from the biological laws of irreplaceableness and equivalence of environmental factors in plant life. Under these laws, no factor needed for plant development (light, heat, moisture, mineral nutrition and space) can be replaced by another one.

The temperature of the soil as one of the main factors has a significant influence on germination, growth and development of plants, especially in the initial period of their lives. During the germination of plant, soil should be sufficiently warmed up to the so-called "critical" temperature of germination. If soil temperature is below the "critical" point the seed does not germinates but rots.

Under *heat reclamation* we understand the system of organizational and economic and technical measures directed at radically improving the natural thermal regime of land in accordance with the requirements of plants with the purpose of efficient agricultural use.

Heat reclamation is generally based on three basic fundamental methods:

• the change of the soil heat balance structure by strengthening or weakening the flow of heat to the soil or its discharge from the soil;
• changes in heat physical properties of soil;
• heating or cooling the soil and surface air by various heat sources and technical measures.

There are the following main ways to influence the thermal regime of the soil taking into account the above mentioned methods of thermal melioration:

1. Redistribution of natural short-and long-wave radiation that reaches the active surface of the field from the atmosphere. It is achieved by the change of the reflected short-wave energy to that which came or by redistribution of heat balance components. It is performed by darkening the soil surface with mulching.

In contrast, covering the soil surface with translucent pellicles - covers leads to the redistribution of the components of heat balance and to the reduction of spending heat consumption during evaporation and heat exchange with the atmosphere.

In thermal melioration practice polyethylene, polyamide, polyvinylchloride, acetate pellicles, thin plastic, wide-spread transparent plastic pellicle of 0.1-0.2 mm thick are being widely used.

2. Increase (decrease) and redistribution of moisture that enters the soil surface or deeper layers soil which, in turn, causes change in the structure of heat balance and redistribution of heat energy (water melioration). Heat regime of soil on drained lands can be adjusted by changing the water level on irrigated land - by watering, especially with warm waters of industrial plants or geothermal waters.

3. Changing the microrelief of soil surface and the use of special agricultural technology. The most common thermal melioration techniques are: cutting combs, shafts, deep plowing, loosening or compaction of soil, sowing plants with high stem and the creation of special protective wings with their help, growing plants in the ditches. To regulate the thermal regime on limited areas, polymeric blowing materials that form steady heat protective layer on the ground are used. Perspective is the application of liquid foams that freeze at low temperatures and do not lose their shape. Such coatings are used to combat plants freezing.

4. Change of thermophysical properties of the soil by changing its structure - density, porosity, aggregate structure and opportunities to absorb and hold thermal energy. Sandy and sandy loam soils are known to warm up faster than clay and loamy ones.

The reduction of heat capacity is achieved by moisture reducing and increasing the number of large mineral particles in soil (crushed stone, gravel, sand). Stony material has low heat capacity: it quickly heats up and gives its accumulated heat to fine particles of soil.

5. Changing the heat entering the soil by artificial heating or cooling the soil and surface air. It is achieved by creating special heat melioration system heating or cooling the soil and requires additional sources of heat energy. In some cases providing the desired thermal conditions on limited areas can be carried out by use of infrared heating and electric heating installations.

6. Change of thermal regime through the change and transformation of the wind regime of land by a wind screen, artificial increase of the area airing with the help of additional forest belts, special fences, buildings and use of forced ventilation.

7. Change of thermal regime by changing humidity and evaporation in a particular area (microclimate) with the help of sprinkling, moisturing, creating

water areas, reservoirs, ponds, waterfalls, fountains, creating artificial clouds or in contrast scattering clouds.

8. Increase or decrease of snow cover in the cold season which changes the intensity and character of the processes of freezing and thawing of soil, runoff of melt water and redistribution of moisture in the soil. Snow protects the soil and wintering plants from severe frosts and replenishes soil moisture reserves.

All of the above-mentioned methods influence the thermal regime of soil, which are used in the management of thermal regime, can be divided into passive and active.

The energy basis for passive methods is solar heat and technological basis is an artificial change in heat transfer in the soil surface and heat transfer in the soil itself.

Active thermal reclamation requires additional sources of heat and special technical means of transportation and transmission of energy into the environment "soil - plant –air ground-level layer."

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## THE MELIORATIVE SORPTION MATERIAL APPLICATION RATES SUBSTANTIATION IN THE COMPLEX OF ENGINEERING LAND RECLAMATION MEASURES FOR MUNICIPAL WASTE DISPOSAL

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**At the moment**, the problem of environmentally friendly conservation of municipal solid waste (MSW) is extremely complicated and relevant [1-4].

The research conducted by A.I. Golovanov, S.S. Dushkin, D.V. Stalinskiy, A.M. Kasimov, V.V. Batishchev, A.I. Kyashkin, S.O. Dovgan, M.S. Slobodyanyk, M.V. Yatskov, I.V. Varnavska, C.A. Coles, R.N. Yong, P.A. Brown, W.R. Wilmarth and other scientists indicates that wastes accumulation in sanitary landfills and dumps causes unpredictable physical, chemical and biochemical processes. As a result, the toxic chemical compounds in various states of aggregation set conditions for environment pollution [2, 3].

The use of sorption treatment methods is to be promising and the most appropriate for pollutants removal in solid, liquid and gaseous states of aggregation. The artificial sorption materials, such as activated carbon, synthetic zeolites *NaA*, *CaX*, *CaA* etc. have the limited scope of use basically because of their high price. Thus, relatively inexpensive materials of natural origin, such as peat, clay minerals, lateritic, limestone soils, natural zeolites etc. attract scientists' and manufacturers' attention [3-6].

In Land Reclamation subject area the above mentioned materials, along with traditional ameliorants (lime, gypsum) are often used to improve hydro-physical and physical-chemical properties of "soil – ground water" system [5].

**The objective of our research** is the prevention of environment pollution with MSW dumps and landfills by means of Engineering Land Reclamation Measures Complex (ELRMC) application. Within the ELRMC we have to solve the certain scientific problems and one of them – is to work out the method of meliorative sorption material application rates for waste and leachate flow harmful compounds accumulation and neutralization [1].

It is zeolite tuff, as a meliorative sorption material, an industrial waste and a by-product of basalt mining that is being proposed for resolving of the above-mentioned problem of our research.

The scientific novelty of the approach to environmentally friendly conservation of MSW consists in the substitution of conventional *passive insulating* material used for MSW landfilling (soil, clay, etc.) for another local *meliorative adsorptive* material – zeolite tuff.

Because of complex character of the issue that is being displayed, we consider the meliorative sorption material application rate value as an integral characteristic and the following equation is being used for its estimation

$$M_C = \sum_{i=1}^{3} M_i, \ kg/year \quad (1)$$

where $M_C$ – the total annual zeolite tuff application rate for the whole MSW storing site;

$M_1$ – the constituent part of the total annual zeolite tuff application rate, that is necessary for chemical compound $\psi, \psi = \overline{1, n_\psi}$ ($CH_4$, $CO_2$, $PBT$, $NMO$ etc.) absorption from biogas (biogas clarification/accumulation);

$M_2$ – the constituent part of the total annual zeolite tuff application rate that is being applied into waste dumps;

$M_3$ – the constituent part of the total annual zeolite tuff application rate for the pollutant substance $\varphi, \varphi = \overline{1, n_\varphi}$ adsorption from the "leachate – ground-water" flow solution.

Having analyzed literature sources data [6, etc.] that disclose the questions concerning zeolite tuff adsorption properties, the $M_1$ value can be estimated by the improved expression, based on [7]

$$M_1 = \sum_{\psi=1}^{n_\psi} M_{1_\psi} = 10 \cdot Q_\psi \cdot \left( \frac{Mr_\psi \cdot 1atm}{R \cdot 1000 \cdot (273+T)} \right), \ kg/year \quad (2)$$

where $M_{1_\psi}$ – the annual zeolite tuff application rate for the harmful compounds $\psi, \psi = \overline{1, n_\psi}$ adsorption from the biogas;

$Q_\psi$ – the volume of chemical compound $\psi, \psi = \overline{1, n_\psi}$ formation;

$Mr_\psi$ – the molecular weight of the substance $\psi, \psi = \overline{1, n_\psi}$, that is being absorbed by the meliorative sorption material;

$R$ – Gas constant, $8{,}205 \cdot 10^{-5} \frac{m^3 \cdot atm}{mol \cdot \hat{E}}$;

$T$ – biogas temperature.

In turn, the $M_3$ application rate calculation is based on the G. Freundlich method (plotting the adsorption isotherm), that is usually being used in anthropogenic geochemical landscapes analysis, as it is considered to be the most authentic when describing a multilayer sorption and sorption on heterogeneous surfaces [4].

Thus, to estimate the annual zeolite tuff application rate $M_3$, the equation that should be used is

$$M_3 = \sum_{\varphi=1}^{n_\varphi} M_{3_\varphi} = \frac{W_{Ih} F C_\varphi}{1000 \cdot a_\varphi \cdot C_\varphi^{1/\lambda_\varphi}}, kg/year \quad (3)$$

where $W_{Ih}$ – the annual amount of leachate formation per unit area;

$F$ – the area of the waste storing site;

$C_\varphi$ – the equilibrium concentration of substance $\varphi$, $\varphi = \overline{1, n_\varphi}$ ions in leachate – ground-water flow;

$a_\varphi$, $1/\lambda_\varphi$ – empirical parameters of the G. Freundlich equation.

The $M_2$ value can be estimated, based on the use of "environmental principle of 10%" [8] as a sum of the corresponding annual application rates $M_1$ and $M_3$, notably

$$M_2 = 0{,}1(M_1 + M_3) \quad kg / year \tag{4}$$

Conclusions:

The meliorative sorption material (zeolite tuff) application rate for the entire MSW storing site can be calculated as an integral characteristic. This is because of differences in waste dumps and sanitary landfills constructions, as well as the presence of multicomponent and multiphase pollutants flows within the anthropogenic landscape of wastes placement.

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## MATHEMATICAL MODELING OF MOISTURE TRANSFER IMPACT ON THE STABILITY OF SOIL SLOPE

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Landslide is epy displacement of rocks, earth mass down the slope under its own weight, surface and groundwater, as well as the influence of atmosphere. The practical significance of the forecast of velocity displacement is especially important because the arrangements for landslide avoidance in the present state of technologies are expensive and their use isn't everywhere economically justified. Measures that prevent landslides are often more simple and cost much cheaper than measures for fixing landslides that already exist and systematically moving.

Landslide is not only economic and environmental threat, but also a danger to human's life. Their greatest danger is in transience of their moving process. Therefore, the main task is in forecast and early prediction of stability of such areas. One of the methods of investigation of such problems is mathematical modeling.

Work [1] is devoted to the study of landslides in terms of physics and mechanics of their origin and development.

Problems of stability appear during building of civil, water management and hydraulic engineering objects on the slopes. One must check in advance the stability of the array of soil to ensure normal conditions of construction and to avoid significant material losses.

In general, to determine the stability of soil slope you need to solve several problems. First, determine its stress-strain state. Second, when adopting a condition of failure one needs to determine the possible destruction surface. The problem of determination of the stress-strain state is a difficult task. Besides its mathematical model includes the equation of rheological state of the soil medium, which is also a hypothesis and generalization of experimental research. Therefore, in this paper is made an attempt to calculate slope stability based on mathematical modeling of the saturation of the soil medium without the stress-strain state by engineering method of circular cylindrical sliding surfaces. This procedure reduces the computer time calculations.

There are many engineering methods to test the stability of the soil [2, p. 280-294]. Each has its own characteristics and conditions for use. Among the most popular methods one can find methods of Shahunyants, Mozhevitinov, Kreya, Maslov-Berrera etc., and among sliding surfaces the method of circular cylindrical sliding surfaces is often used.

For calculations with method of circular cylindrical sliding surfaces it is supposed that the stability loss occurs as a result of the rotation of the soil medium relative to some center in point O. Sliding surface is the arc with the corresponding radius and center in point O.

One of the factors of stability loss is the change of its moisture content. It changes the strength characteristics of soil that are the angle of internal friction and cohesion.

We consider the two-dimensional problem of infiltration on the slope which consists of homogeneous isotropic soil under the influence of rainfall. The change of moisture in soil is described by Richards' equations [3, p. 4]. The unknown function is function $s$ that showed the degree of liquid saturation of porous medium. Then the mathematical model of this process can be described by the following boundary value problem:

$$\frac{\partial s}{\partial t} = \frac{\partial}{\partial x}\left( D(s)\frac{\partial s}{\partial x}\right) + \frac{\partial}{\partial z}\left( D(s)\frac{\partial s}{\partial z}\right) + \frac{1}{n-\theta_r}\cdot\frac{\partial}{\partial z}K(s), \qquad (1)$$

$$s(x,z,0) = 0, \quad (x,z) \in \overline{\Omega}; \qquad (2)$$

$$s(x,z,t)\big|_{\Gamma_1} = s_1(x,z,t), \quad (x,z) \in \Gamma_1, \quad t > 0; \qquad (3)$$

$$\left(\overrightarrow{q_s}, \vec{\mathbf{n}}\right)\Big|_{\Gamma_2} = Q(x,z,t), \quad (x,z) \in \Gamma_2, \quad t > 0, \qquad (4)$$

where $s(x,z,t)$ – a function of the degree of liquid saturation, $s = \dfrac{\theta - \theta_r}{n - \theta_r}$, $0 \le s \le 1$;

$\theta$ – volumetric liquid content;

$n$ – soil porosity;

$\theta_r$ – residual liquid content in the porous medium which exists practically always on walls of solid skeleton of a porous medium due to molecular forces;

$D(s)$ – nonlinear diffusion coefficient;

$K(s)$ – hydraulic conductivity of an unsaturated porous medium;

$\overrightarrow{q_s}$ – flow of soil moisture;

$\Gamma_1 \cup \Gamma_2 = \Gamma$ – a boundary of the domain $\Omega$, where $\Gamma_1 \cap \Gamma_2 = \varnothing$; $s_1(x,z,t), Q(x,z,t)$ – given functions.

To calculate the nonlinear functions $D(s)$ and $K(s)$ the following empirical dependences of R. H. Brooks and A. T. Corey [3, p. 5] was used:

$$K(s) = K_F \cdot s^{\frac{2+3\lambda}{\lambda}}; \qquad D(s) = D_0 \cdot s^{2+\frac{1}{\lambda}}, \qquad (5)$$

where $D_0 = -\dfrac{K_F \cdot \psi_b}{\lambda(n-\theta_r)}$;

$K_F$ – filtration coefficient;

$\lambda$ – the pore size distribution parameter; $\psi_b$ is the bubbling pressure.

For the numerical solution of the boundary value problem (1)-(4) meshless method of radial basis functions [4-7] was used.

The test of slope stability depends on determination of safety factor $k_s$ that is equal to the relation of retaining forces (cohesion and friction) to the shear forces [8, p. 62-73]

$$k_s = \frac{\sum M_{R.F.(s)}}{\sum M_{S.F.}(s)}. \quad (6)$$

It is supposed that the sliding surface is calculated by circular cylindrical sliding surfaces method.

Research in this paper is a trial step for further development and improvement of methods for calculation the stability of soil slopes and for prediction and prevention of dangerous situations in building construction.

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## CALCULATIONS OF PROFILES OF FREE SURFACE OF UNDULAR JUMP

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During the designing of hydrotechnical buildings it is necessity to predict hydraulic regimes and calculate profiles of curves of the free surface, which can arise during exploitation of these buildings. In this article we will make the analysis of calculation methods for carves of free surface of undular jump. Undular jump is type of near-critical flow. It can arise during the transition from supercritical to subcritical flow. This jump is characterized by undulations of the water surface without a surface roller in other words by gradually damped waves on the free surface (Fig. 1). One of the calculation methods of free surface profile is its simulation as the summation of solitary and cnoidal waves [1-3].

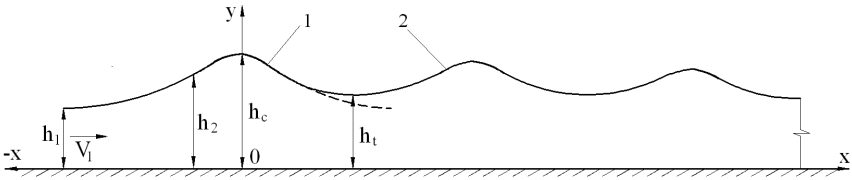


Figure 1. Undular jump: 1 – solitary wave, 2 – cnoidal waves

**Methods by recommendations of VNIIG** [2]. In this method the free surface of flow is described from initial section to the first crest wave by solitary wave equation:

$$\eta = \frac{h}{h_1} = 1 + \left(Fr_1 - 1\right) sch^2\left(\frac{1}{2}\frac{x}{h_1}\sqrt{3\frac{Fr_1 - 1}{Fr_1}}\right), \qquad (1)$$

where h – depth of any point, $h_1$ is depth in initial section; $Fr_1 = V_1^2 / g h_1$ – Froude number in initial section, $V_1$ – velocity of flow, g – constant of gravity, sch(φ) – function of hyperbolic secant, x – abscissa of any point.

Downstream flow free surface described by cnoidal wave's equation (Fig. 1):

$$\eta = \frac{h}{h_1} = \eta_t + \left(\eta_c - \eta_t\right) cn^2\left(\frac{x}{\lambda}, k\right), \qquad (2)$$

where $\eta_c$ – comparative depth under first crest wave, $\eta_c$ – comparative depth under first trough wave, cn(φ) – the Jacobi elliptic-function amplitude of cosine, λ – length of cnoidal waves, k – elliptic integral of second kind.

**Rybenko's method** [3]. This method the following system of equations for calculation of curve of the free surface:

$$\left.\begin{aligned} h_c &= \frac{h_1}{2}\left[\frac{4s_1-1}{3}+Fr_1+\sqrt{\left(\frac{4s_1-1}{3}+Fr_1\right)^2-4Fr_1}\right], \\ h &= h_1\left[1+(\eta_c-1)\,cn^2\left(\frac{x}{\Delta},k\right)\right], \\ \Delta &= 2\cdot h_1\sqrt{\frac{\eta_c\cdot Fr_1}{3\cdot(\eta_c^2-Fr_1)}}, \\ k &= \sqrt{\frac{\eta_c(\eta_c-1)}{\eta_c^2-Fr_1}}, \end{aligned}\right\} \quad (3)$$

where $s_1$ – non-hydrostatic coefficient, it influences on depth under the wave crest and wave length.

**Hager-Hutter's method** [4]. It based on steady flow equation:

$$H = h + z + \frac{q^2}{2gh^2}\left(1+\frac{2hh''-h'^2}{3}+hz''-z'^2\right), \quad (4)$$

where H – head, z – position of the considered point above the comparative plane, q – specific discharge, h', h'' – the first and the second derivatives from depth (first derivative gives slope of free surface, and second gives curvature of flow stream), z', z'' – the first and the second derivatives from z.

After some calculations one can get the following differential equation:

$$\left(\frac{dh}{dx}\right)^2 = \frac{3}{Fr_1}\left[-\frac{h^3}{h_1^1}+(2+Fr_1-Fr_1\gamma)\frac{h^2}{h_1^2}-(2+2Fr_1-2Fr_1\gamma)\frac{h}{h_1}+Fr_1\right] \quad (5)$$

Upon integrating of this equation, one can get a profile of free surface.

In order to compare and analyze these methods we'll calculate the curve of free surface according to H. Chanson's experimental data [5]: discharge $Q = 0.007$ m$^3$/s, channel width $b = 0.25$ m, initial depth of undular jump $h_1 = 0.035$ m, Froude number in initial section $Fr_1 = 1.864$. As the result of these calculations we'll get the following profile of free surface of undular jump (Fig. 2).

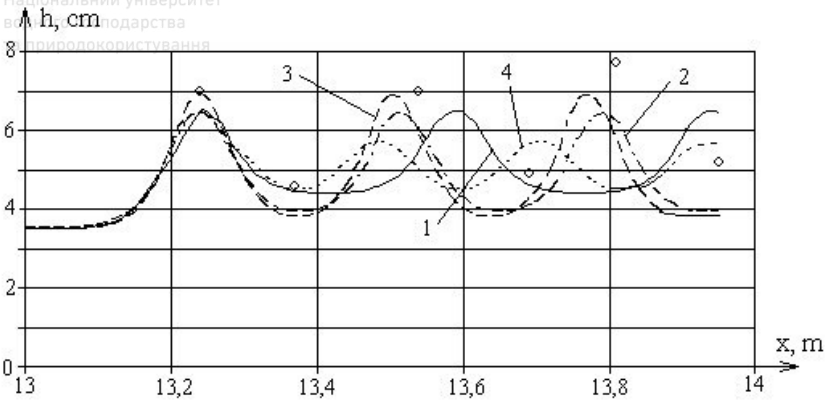


Figure 2. The profile of free surface of undular jump: 1 – by recommendations VNIIG, 2 – by Ryabenko's method ($s_1 = 1.0$), 3 – by Ryabenko's method ($s_1 = 1.05$), 4 – by Hager-Hutter's method, ○ – experimental data

Conclusions:

1. As we can see from the Figure 2, all methods give very similar profiles of solitary wave.

2. Profiles of cnoidal waves, which were calculated by these methods, are different in wave length, besides that this length difference becomes larger when Froude number increases.

3. Hager-Hutter method predicts, that amplitude of cnoidal waves will be smaller then amplitude of solitary wave.

4. All these methods give smaller depths to according experimental date, because they don't take into account the non-hydrostatic coefficient $s_1$. If we take this coefficient into account we'll get very close results to experimental date (Ryabenko's method $s_1 = 1.05$).

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# BUKHARA PROVINCE "VARAKHSHA" AREA RECLAMATION OF LAND'S MELIORATION AND ECONOMICAL COSTS

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Nowadays our Republic's agriculture reclamation of using lands is agriculture farms the salty lands that consist of 50% but in Bukhara Province it organizes 88%. As you see, In Bukhara Province it is the most culmination to get productive economical result is getting well the meliorative condition of land-arrangement and land –cadastre science. The president of Uzbekistan Islam Karimov said: "before there were not any plans and works in emit radiation, that's why the wind and the water effect have showed its negative result in fruitfulness. There more than 2 mln hectare land fields in the Republic, all of the watering lands scarcely had stayed half of the watering lands became as in spoil condition." 1997.

It seems, watering lands fertileness of salty sands and it is also to be played in erosion progresses. As the result of it the fruitfulness of lands are lessened. There were opened many factors to increase the fruitfulness of watering lands in Bukhara province. They researched how to improve the meliorative condition of lands, but they were not researched it completely the meliorative condition of lands in VARAKHSHA area, however there not enough plans how to increase the condition of lands.

In Jondor region of Bukhara province watering lan fields consists of 27825.

"Varakhsha" is situated in the east of western part of Jondor region. In this area some new reclamation lands area consist of 3003 hectare. From these the ploughing lands 2551 hectare. Nowadays the meliorative condition of this area is not satisfactory causes of here are the following explaining:

- From the old the watering lands are middle become civilized, less salty soils is – 8 hectare, but middle salty land area – 56 hectare;
- From the old the watering middle civilized, light, less salty soils is – 710 hectare, strong salty area – 175 hectare;
- From the old the watering middle civilized, middle salty soils area – 145 hectare
- From the old the watering less civilized, light and middle salty soils area– 79 hectare, strong salty soil area – 43 hectare
- From the old the watering less civilized, middle salty soils area – 47 hectare
- From the new watering less civilized, light sandy middle salty soils area– 124 hectare, strong salty lands area – 480 hectare
- From the new watering less civilized salty soils area– 387 hectare,

- From the new watering less civilized, middle sandy, strong salty soil area – 168 hectare,

As you see from the following information reclamation of the area is adopted the salty lands especially:

- Less salty land area – 718 ha (28.1 %)
- Middle salty land area – 447 ha (17.5 %)
- Strong's salty land area – 999 ha (39.2 %)
- Salty land area – 387 ha (15.2 %).

We can determine the characteristic of the lands of the area with this formula:

$$B_{middle} = \frac{B_1 \cdot M_1 + ...B_p \cdot M_p}{M_1 + ...M_p}, \quad (1)$$

where:

$B_{middle}$ – middle marking

$B_1$, Bp – the fields of some plants,

$M_1$, Mp – crop planted field.

On the base of following formula the reclamation lands productive middle ball is marks 48. The productiveness of area is marks 33-34 centner/hectors even it can be lessened.

On the base, Bukhara province of Varakhsha Massive lands economical productivity it must be watered from the salt, fertilize, to work out and agrotechnic works and e.t.c. If these works are being as a demand, the fretfulness will increase in the best way. There will manifold the fruitfulness and productiveness of crops. Especially it can lessen the compactness of sands, the condition of its structure is gets well. The food stuffs of plants changes in positive side, it will lessen the saltiness of sands, it improves the grooving of crops too.

## INFLUENCE OF PHYTOREMEDIATION PLANTS ON SOIL SALTS

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**Introduction:** Bukhara region has been selected to conduct this field research as the problem of secondary soil salinization is highly threatening agricultural crop productivity (See Fig. 1 for the location). Soil and climate conditions of the Bukhara region differ from other regions of Uzbekistan. The region's soil is heavy and very salty. The groundwater level is close to the surface leading to waterlogging problems. The climate is considered to be a continental with cold dry winter and very hot summer. For instance, during summer period the temperature may go as high as $+47^0$C (e.g. observed in July, 2005) and during winter as low as $-29^0$C (e.g. noted in January, 2008). In some instances, due to the freezing of lower layers of soil horizons, which happened in 1969, 1976, 1984 and 2008 , it caused difficulties in conducting agro-technological activities in due time, which delayed the starting of vegetation period. The region's annual precipitation is determined as 120-140 mm, which falls mostly outside of growing season in autumn-winter period. Local potential evapotranspiration is about 2000 mm/year greatly exceeds rainfall. Thus, large scale irrigation for cultivated crops is essential to this area.

**Importance of the topic:** Uzbekistan has been practicing the application of water (i.e. leaching) to remove soil salts for the past couple of decades. Each year, excessive water is applied to leach cotton and wheat fields. Generally, this practice does not solve the salinity issue. In autumn, after harvesting cotton and wheat the problem again comes out.


Figure 1. Location of Study Region

**Study objectives:** With this research, we investigated phytoremediation technique – environmentally clean and friendly – to remove soil salts and to conserve water resources. Using agricultural plants, after harvesting wheat in summer, we conducted the potential of corn and cartamus tinctorius to remove soil salts.

**Methodology:** On the experimental field, after harvesting wheat, Sorghum was planted in order to improve soil amelioration condition and to obtain higher crop productivity. The experiment took place in 2010 and 2011 during summer and autumn periods. In the wheat field, Sorghum and cartamus tinctorius were sown to observe soil salt uptake. It was also aimed at investigating water usage. Soil salt contents were measured to see the effect of corn and cartamus tinctorius for salt removal.

It is observed that after harvesting wheat, the field was rather wet and the salt content in the soil was very high. In order to understand soil moisture dynamics

and to identify salt contents, soil samples were taken from the layers of 0-20, 20-40, 40-60, 60-80, 80-100 cm. Salt contents of soil as well as plants were subject for laboratory analysis to determine $HCO^{-}_{3}$, $Cl^{-}$, and $SO_4$.

**Results and discussions:** In 2010, when experiment was conducted the natural soil moisture showed on average 11,6-12 % in 1m soil layer in the beginning of June. However, when sample was taken in autumn, the value increased up to 14.9-16.8%. In contrast, salt content was lessened during this period in both experimental fields. For instance, in cartamus tinctorius field, the chlorine content in the soil was 0.036% at the beginning of vegetation and 0.031% at end. In the case of white corn, the chlorine content in the soil was at 0.036% at the start of the vegetation and 0.022% at the end.

The same experiment was conducted in 2011. In experimental land when after autumn wheat was planted white corn, soil moisture was higher than in cartamus tinctorius field. For example, during wheat harvesting, soil moisture was at 11.2–11.8 % in 1m layer. Soil salt content was also reduced during the vegetation period. Prior to planting the cartamus tinctorius, the quantity of chlorine in the soil was 0.033%. At the end of the vegetation, the measurement showed 0.029%. While in white corn, soil chlorine content was at 0.033% in the beginning of vegetation period and 0.021% at the end.

Generally, Sorghum field had higher soil moisture content than cartamus tinctorius field. At the end of experiments, soil moisture content for cartamus tinctorius was at 11.8-12.9%. In the meantime, in the field of Sorghum it was 15.1-16.3%. In both cases, soil salt content decreased expeditiously.

**Conclusions:** Bukhara region experiences high soil salts and frequent droughts. This research was investigated to study salt removal potential of Sorghum and cartamus tinctorius after the harvesting of wheat. The results reveal that investigated crops removed soil salts and can be incorporated into crop rotation programs. The calculations showed that cartamus tinctorius removed about 74.6 c/ha salts from the soil whereas, Sorghum about 390 c/ha. Further research is needed to verify these findings.

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## ELECTRONIC LEARNING MODULE ON INTEGRATED WATER RESOURCES MANAGEMENT

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*Background*

The paradigm of Integrated Water Resources Management (IWRM) has been generally accepted nowadays as the basis for the water sector. However, the implementation of IWRM is still lagging behind. Therefore, sustainable water resources management has to be aligned with capacity development (Leidel et. al 2011).

One possibility to support the worldwide implementation of IWRM is to improve respective education. This is why IWAS (International Water Research Alliance Saxony), together with the German IHP/HWRP (International Hydrological Programme of UNESCO and Hydrology and Water Resources Programme of WMO), has developed an electronic learning module (IWRM E-Learning) that is supposed to complement to classical learning options for instance at universities.

*The Concept of Integrated Water Resources Management (IWRM)*

IWRM is rather a conceptual framework than a concrete manual at the operational level. There have been several definitions of IWRM, whereas all of them including to a greater or lesser extent equity, efficiency and sustainability. According to the widely-used definition from the GWP (2000), *"IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."*

For implementation of IWRM, the respective society needs capacities, in order to start such processes and keep them running. Capacity Development (CD) can be understood as the *"process through which individuals, organizations and societies obtain, strengthen and maintain the capabilities to set and achieve their own development objectives over time"* (UNDP 2008). Thereby, it is often distinguished between different levels of CD-measures, namely between the individual level (education and training of human beings), the institutional level (development of institutions) and the enabling environment, i.e. the improvement of the societal and political system (cf. van Hofwegen (2004) and Alaerts (2009)).

However, this paper will focus on the individual level, namely on education and training through an electronic learning module on IWRM.

*E-Learning module on IWRM*

39 most relevant topics have been chosen to fit in a comprehensive representation of current water issues. Respective academics from various universities and research institutions, as well as practitioners have been selected in

order to videotape their lecture. Those electronically available lectures are divided into six categories: Water and the physical environment, technical measures, water governance, economic instruments, tools, IWRM implementation and case studies.

The special feature of this E-Learning concept on IWRM is that the individual lectures are interlinked. Thematic correlations (e.g. climate change) of the module components are shown, thus allowing the user to switch from one lecture to the next, hence following the integral approach of IWRM. Those linkages are helpful, since none of the lecturers can cover all issues in IWRM- there will be always interfaces to other topics- and those interfaces need to be identified and made available. Therefore, the additional value of this E-Learning concept is that the complexity of Integrated Water Resources Management can be conveyed to persons interested in this topic.

Target groups of the module are graduating students in water-related fields, decision makers, water related professionals and administration staffs primarily in developing and transition countries.

The module will be available in the world wide web (http://www.iwrm-education.org/) as well as on DVDs and USB flash drives. It is sponsored by the German Federal Ministry of Education and Research and the Federal Ministry for the Environment.



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## ECOLOGICAL AND ECONOMIC BASES OF EFFECTIVE SOIL MELIORATION

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The regulation for the distribution of land has expanded the sphere of melioration activities. They include not only agricultural land improvement but also water land fund, forests, urban areas, industries and development of recreation territories. Therefore, the object of nature-use tenure should be not separate environment elements or territories but landscapes which are complete natural systems.

It is obvious that indicators of effective land use assessment should be widened not only with melioration regime of drained and irrigated lands evaluation. They should include criteria of landscape evaluation as a whole system. Ecological stability index (ability of landscape to maintain its basic characteristics such as entirety, performance and dynamics to external influence) belongs to ecological criteria. It takes into account the structure of biotic and abiotic landscape components and defines their importance:

$$K_c = \frac{\sum_{1}^{n} f \cdot k_1 \cdot k_2}{\omega}, \quad (1)$$

where $K_c$ – landscape ecological stability index; f – area of biotic and abiotic component in landscape; $k_1$ – comparative coefficient of ecological significance of component; $k_2$ – relief geomorphologic stability coefficient; ω – landscape area.

Ecological stability determination is based on following scale: $K_c$<0.33 – unstable; 0.34-0.5 – insufficient stability; 0.51-0.66 – moderately stable; >0.66 – stable. Coefficient $k_1$ depends on type and productivity of vegetation cover, physical, chemical, microbiologic land properties. It varies from 1.0 (foliage forest), 0.79 (natural waters), 0.68 (grassland), 0.62 (hayfield), 0.43 (gardens, bushwood), 0.38 (forest belt), to 0.14 (tillage). These numbers are general for the country and don't take into account soil and climatic conditions.

The aim of our research was to define ecological stability index on the territory of drained lands of Volyn region in Ukraine. Our calculations show that drained lands as ecosystem element are unstable, because ecological stability index is 0.26. It is determined by the number of factors: losses of biomass with harvest and water, deterioration of soil as a biochemical barrier. It is very important from agricultural point of view that grasslands and hayfields have high ecological value.

Thereby, during landscape structure substantiation in melioration management demands preserving ecological stability and minimization of negative effect of agricultural activities on biodiversity . On the other hand, the need of agricultural production should be considered. In other words, landscape structure optimization is in a high demand. Odum and Reimers as optimization criteria took maximum account of ecological, social and economic effect. This effect is provided when

intensively used lands make up 40% of total area. Nowadays, total arable area of the melioration territories is 58%, grasslands occupy 16% of the area, hayfields – 18% and 6% is covered with forests. We can see that distribution of these elements is not balanced. Consequently, according to recommendations the area for tillage should be reduced to 18% (574.4 thousand hectares), this land should be changed according to natural conditions and economic value of biotic elements.

The above given recommendations about landscape structure normalization and keeping sustainable agrocenosis should be taken as limitations for agricultural activities. Ecological stability index should be not smaller than 0.51-0.66. Land-use system should include not only landscape structure optimization, technical system optimization, technologies and technical means, but also ecological, economic, social and political factors.

Economic effect of agriculture is determined by maximum production that is needed for the society with consumption of less possible labour and resources for a unit. The main criteria of land-use economic effect is production yield growth with the lowest labour and resources consumption for a land unit. There is a question, if the scale of land usage influences general labour consumption that is needed for the production of certain produce.

Significant effect on agriculture after intensive crop-growing system, chemicalization and melioration has taken place during 15 years. For this period of time the growth of gross production was 21%. During the next 15 years raising the level of crop yield was not observed, but prime costs were grown (cereals – to 42%). It means that comes the period with less fertility and high ecological resistance of soil and an effort for recovery is not compensated.

In our opinion ecological activities such as production should have economic evaluation. For that purpose economic criteria for ecological measure can be the value of prevented losses. The value of prevented losses shows actual or possible losses in natural territory potential due to environment deterioration and depends on various factors. Sales proceeds should be not smaller than expenses of growing crops and ecological losses compensation:

$$V_{pr} \times C_{pr} \geq E_{cr} + L_{ee} \quad (2)$$

where $V_{pr}$ – production amount, ton/centner; $C_{pr}$ – product costs, UAH; $E_{cr}$ – growing crops expenses, UAH; $L_{ee}$ – ecological and economic losses from soil degradation. UAH.

Of he most dangerous impact is agriculture intensification with the help of chemicals, products of cattle-breeding, negative effect of machinery on the soil and environment. The amount of specific ecological and economic losses from soil degradation is determined:

$$L_{ee} = C_{sr} + P_d + E_{hem} + x \quad (3)$$

where $C_{sr}$ – costs for recovery of soil fertility, UAH; $P_d$ – costs of less received agricultural products due to degradation and defertilization, UAH; $E_{hem}$ – expenses from chemical soil pollution; x – costs of other factors that are to be recovered.

The amount of limitation factors of sustainable agricultural development is bigger, that is why the mentioned factors of ecological and economic losses are not final and can be added.

The formation of special nature protection resources should be done at the stage of project planning. The principle of payments for land-use and water consumption is used for this purpose. The procedure is done though payments for:

- exploration of natural resources in the system of agrolandscapes (soil, water, mineral wealth, vegetation and animals, natural reserves and recreation resources);
- pollution and contamination of environment in melioration systems: - breach of the nature protection law.

Almost all payments are made by means of regional and local taxes and as the fine for nature pollution. These actions are regulated by law "About Environment Protection" and should be based on size of damnification.

Ecological and economic land-use effectiveness in agriculture is an economic result of ameliorative activities and crop yield increasing according to the point of view of major scientists. From another point of view, ecological and economic land-use effectiveness is the result of agricultural produce with taking into consideration ecological influence on environment (and soil especially) of human activities and also it can be determined by economic affect of ecological expenses.

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## CONTROL REGULATION

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The aim of control regulation is improvement of control regulations which must provide with guaranteed power any time of the year, to determine water rest in

water reservoir to decrease excess water discharges and soften the duration of hitches in water supply in the least water periods beyond the calculation capacity.

For improvement of control regulations from data of forty years observation, we choose four years with the most minimal expenses and make hydrograph of river flow for each year separately.

With the help of hydrograph of river flow and radial scale, we build integral curve of flow ICF, and without taking into consideration volume, we build equidistant curve. We make integral curve of consumption W=f(t) for ideal regulation with the help of ICF and equidistant curve.

In order to make control regulations, integral curve of ICF of consumption must be built, providing with constant capacity during given period.

For this purpose graphic W= f(t) is divided into intervals of three months.

The first interval is determined from the end of the last month and is marked with the point $A_1$. In defined point $A_1$ we find consumption $Q_A$. Having consumption $Q_A$, along with curve of connection Q = f ( Ztw ) we find mark of water level in tail water Ztw. After this we find volume $W_A$ in point $A_1$. Along the curve of connection, W = f (Zhw), with the help of volume $W_A$, we find mark in head water Zhw.

Having found marks in the levels of water in tail and head water, we determine statistic pressure with formula:

$$H_{st} = Zhw - Ztw, \quad (1)$$

where Zhw – mark of water level in head water;

Ztw – mark of water level in tail water.

We determine capacity $N_{a.d.c}$ (average daily calculation) from graph of average daily powers with probability P = 95 % - $N_{a.d.c.}$=19000 kWt.

Since for determination of consumption all values are known, then with formula $Q = \frac{Na.d.s}{9{,}81 \cdot H \cdot \eta_a}$ find consumption in $B_1$.

Having found consumption in point $B_1$- $Q_h$, make segment.

The rest of calculations are made analogously, in Table form (1.a,b,c,d)

Table 1.a

1906year

| point | Q,$m^3$/s | $Z_{tw}$,m | W, $km^3$ | $Z_{hw}$,m | $H_{st}$,m | $N_{a.d.c}$, kWt | Q,$m^3$/s |
|---|---|---|---|---|---|---|---|
| A | 14.25 | 26.0 | 0 | 132.0 | 106.0 | 19000 | 16.0 |
| B | 16.0 | 26.5 | 0.0015 | 133.0 | 106.5 | 19000 | 17.0 |
| C | 17.0 | 26.75 | 0.004 | 134.5 | 107.5 | 19000 | 18.0 |
| D | 18.0 | 27.0 | 0.005 | 135.0 | 108.0 | 19000 | 19.0 |

Table 1.b

1929year

| point | Q,$m^3$/s | $Z_{tw}$,m | W,$km^3$ | $Z_{hw}$,m | $H_{st}$,m | $N_{a.d.c}$, kWt | Q,$m^3$/s |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | 14.5 | 25.0 | 0 | 132.0 | 107.0 | 19000 | 15.0 |
| B | 15.0 | 26.75 | 0.001 | 132.5 | 105.25 | 19000 | 18.0 |
| C | 18.0 | 26.8 | 0.0035 | 133.5 | 106.7 | 19000 | 18.5 |
| D | 18.5 | 27.0 | 0.004 | 134.0 | 107.0 | 19000 | 19.15 |

Table 1.c

1919year

| point | Q,$m^3$/s | $Z_{tw,}$m | W,$km^3$ | $Z_{hw,}$m | $H_{st,}$m | $N_{a.d.c,}$ kWt | Q,$m^3$/s |
|---|---|---|---|---|---|---|---|
| A | 19.83 | 16.45 | 0 | 132.0 | 104.5 | 19000 | 19.0 |
| B | 19.0 | 15.1 | 0,001 | 132.5 | 105.7 | 19000 | 18.5 |
| C | 18.5 | 14.8 | 0,002 | 133.0 | 106.25 | 19000 | 17.5 |
| D | 17.5 | 14.7 | 0,003 | 133.5 | 107.5 | 19000 | 17.3 |

Table 1.d

1939year

| point | Q,$m^3$/s | $Z_{tw,}$m | W,$km^3$ | $Z_{hw,}$m | $H_{st,}$m | $N_{a.d.c,}$ kWt | Q,$m^3$/s |
|---|---|---|---|---|---|---|---|
| A | 23.0 | 26.5 | 0 | 132.0 | 105.5 | 19000 | 17.0 |
| B | 17.0 | 26.75 | 0.004 | 134.5 | 107.75 | 19000 | 17.5 |
| C | 17.5 | 26.0 | 0.008 | 136.5 | 110.0 | 19000 | 16.0 |
| C | 16.0 | 25.0 | 0.102 | 138.0 | 113.0 | 19000 | 15.8 |

Having made integral curves of consumption ICF of consumption for every fours years, control regulations can be built.

For this purpose we take in every period of water rest left in water reservoir ICF- ICF of consumption and leaving it on the curve of connection W = f ( $Z_{hw}$), get the mark $Z_{hw.}$ It is done for every period and every year. After what we make graphs of control regulation.

After building of curves, we make bending curve of wear (violet line), with some storage, which fixes regulation water storages in water reservoir on every data, that provides with condition N > $N_3$ during wear of water reservoir. This generalizing curve is called control regulation of water reservoir wear.

If during the operation of the last on the beginning of flood period the condition $N_3$=const was preserved, and then the level in water reservoir occupied the position above control line, and then in water reservoir there is excess of volume on this data contrary to control line, which can be used with more intensive wear of water reservoir and get larger power than $N_{3.}$

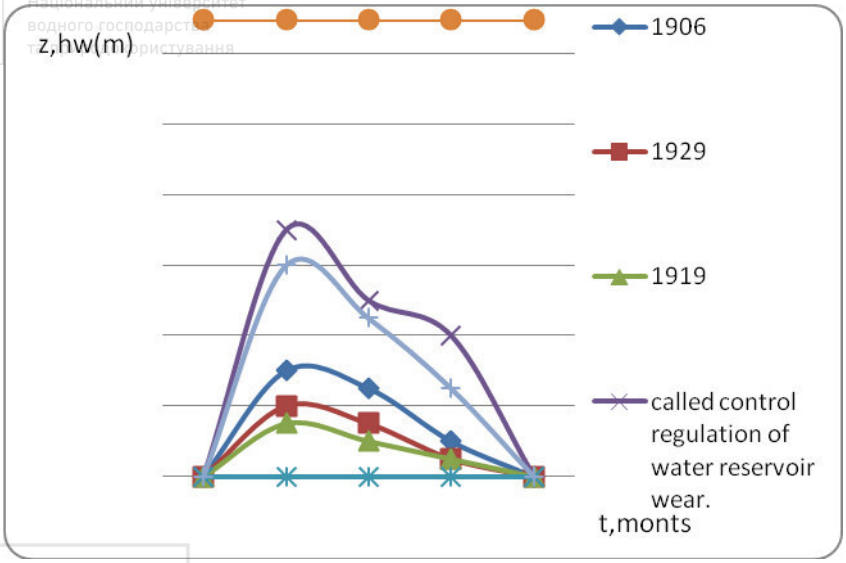


Figure 1. Control Regulation Chart



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## EVALUATION OF HUMAN PRESSURE ON WATER RESOURCES IN URBAN AREAS IN CONTEXT OF SUSTAINABLE DEVELOPMENT

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The basis for achieving sustainable balanced development of any area is the presence not only of certain amount of water, but also of its quality. Within the urban areas most exposed to human impact are surface waters, which in recent decades increasingly act as receivers of untreated waste water. In order to assess

the impact of urban areas on the state of water resources and identify key priorities for sustainable development of urboecosystem, we conducted the research on the use of groundwater and surface water exemplified by Dubno, Rivne region and by Ikva which flows through this town.

Analysing the anthropogenic impact on surface water we found that river Ikva is also the source of water supply and receiver of domestic and industrial discharges. We analyzed the dynamics of water intake from the river Ikva since 1990 and selected two phases: from 1990 to 2004 - the water intake gradually decreased (by 0.4 million m3), and since 2004 - is growing and in 2007 is 0.6 million m3 .

We established that the main polluters of the river are: utilities, industry, energy, agriculture, fisheries and tourism. In recent years the tendency to reduce discharges of water reverse SCE "Housing and utility" and most polluting rivers and equipment PDE "Dubnovodokanal" and, after a gradual reduction of discharges during the previous years, dramatically increased the amount of sewage in the company of "Dubnoremtransservis" which is associated with restoration of its production without paying due attention to environmental measures. However, despite this, the main contaminant of the local river is automated PDE "Dubnovodokanal." Discharge of such volumes of water untreated this now due to outdated treatment facilities, which overloaded the city wastewater (design capacity of urban sewage treatment plants is 4.2 m3/day, and actually received 6.2 m3/day). To pollutants discharged wastewater treatment plants cities are: suspended matter, sulfates, chlorides, ammonia nitrogen, iron, phosphates

To assess water quality in the river Ikva we used the method of "Comprehensive expertise ecosystems basins", whose results are presented in Table. A. Thus, as shown in Table 1, the water in the river Ikva on the verge of Rivne and Ternopil regions, as well as outside the settlement zones Dubno corresponds to the third class quality, after discharge of urban sewage treatment plants is characterized by class IV. Currently the river is used for the purposes of recreation in the city, due to the bad condition of coastal areas, lack of accommodation and disparity of the river recreation rules.

Table 1

**Qualitative assessment of environmental surface waters of the river Ikva**

| Index | Create 1* | Create 2** | Create 3*** |
|---|---|---|---|
| $_1$ | 2 | 3 | 4 |
| $I_A$ | 1 | 1 | 1,2 |
| limit indicator | mineralization | mineralization | sulphates |
| $I_B$ | 10,97 | 4 | 7 |
| limit indicator | nitrite nitrogen | nitrite nitrogen | nitrite nitrogen |
| $I_C$ | 1,5 | 10 | 20 |

| limit indicator | iron | copper | copper |
|---|---|---|---|
| $I_E$ | 4,49 | 5 | 9,4 |
| Class of water quality | III | III | IV |
| Condition of Water Protection | satisfactory | satisfactory | transitional |

Create 1a * - at the entrance to the settlement zones Dubna,

Create 2 ** - below the town of Dubno, 0.7 km above the discharge of sewage treatment plants and equipment PDE "Dubnovodokanal"

Create 3 ** - within the village Ivanne Dubensky district, 3.2 miles below the discharge of sewage treatment plants and equipment PDE "Dubnovodokanal″

To date, industry and drinking needs of widely used water from the underground levels. There Dubno into three tiers (aquifers). Pressure water third tier used for central water Dubno. Abstraction from underground aquifers was: in 2003 - 2.158 million m3 in 2004 - 1.996 million m3 in 2005 - 1.936 million m3 in 2006 - 1.8 million m3 in 2007 - 1.7 million m3. Annual water is raised 1.6 million m3, the amount designated waste - 2.2 million m3.

After analyzing the security of the population with water, found that the actual average daily consumption in the city is about 100l/dobu per capita, which corresponds to hygiene and household and drinking needs.

Sanepidemstantsii conducted studies of drinking water for sanitary-chemical and microbiological indicators of water supply, the results are presented in Table 2. The largest percentage of non-compliance samples as in sanitary-chemical and microbiological parameters set in the departmental water.

Table 2

**Drinking water quality in city water**

| Sources of centralized water supply | | | | Municipal water | | | | Departmental water pipes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Only selected samples | | does not meet the MCL,% | | Only selected samples | | does not meet the MCL,% | | Only selected samples | | does not meet the MCL,% | |
| 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 |
| With health and chemical indicators | | | | | | | | | | | |
| 61 | 60 | 16,3 | 11,7 | 198 | 120 | 1,5 | 0,8 | 16 | 13 | 6,2 | 23,1 |
| For microbiological parameters | | | | | | | | | | | |
| 70 | 68 | 2,1 | 1,5 | 225 | 139 | 0,4 | 1,4 | 20 | 10 | 1,4 | 21,3 |

Thus, we can conclude that the provision of water industry as well as residents with drinking water in full, but there are problems with its quality. Go to the priorities for improving water quality in the river and achieve sustainable human settlements development should include: the creation of clear boundaries of water protection zones of water bodies, the elimination of natural landfill in the protection zone of the river, preventing plowing, farming, within the water protection zones of clearing river, improving water quality r. Ikva through prevention and control discharge of untreated and unrefined water in the river, install warning signs on the Prohibition of washing vehicles and equipment in water protection zones of water bodies, improving the efficiency of water supply and sanitation.



## REMOTE SENSING BASED ON CROP ROTATION DETECTION IN WESTERN BUG RIVER CATCHMENT, UKRAINE

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One part of the research project "International Water Research Alliance Saxony" (IWAS) is dealing with the water balance of the Western Bug River catchment in the past and also in the future. The water balance is simulated with different kinds of models such as BROOK90 or SWAT together with ArcGIS applications. These models need different input parameters like precipitation, several soil parameters as well as land-cover attributes. The land-cover type with the highest annual and inner annual variability is cropland. The crop and with it the different land cover attributes can change every year. Therefore, it is crucial to know typical crop rotations with their spatial allocation in the Western Bug catchment. Since it is nearly impossible to get all the necessary data for the study site, the following described method is used.

Different crops have different patterns of Normalized Differenced Vegetation Index (NDVI) during a year, depending on their growth state (phenology). Itzerott and Kaden (2005*)* detected these patterns for different crops in the federal state of Brandenburg in north eastern Germany. The climatic situation in the Western Bug catchment is not equal but similar to the region where the patterns of NDVI were detected.

The next step is to detect the NDVI of different arable land units. For that, information of the past is needed. Remote sensing provides data for a long time period, partly from the 1970$^{th}$. For example, the data from the Landsat missions are available in 30 meter resolution since 1984. Hence, this meso scale geometric resolution is available with a temporal resolution of about one month. In principle, this is enough to detect different crops after calculating the NDVI. But half of these scenes are not suitable for analyses because of the cloud cover. However, to detect crop rotation, at least 3 successively years with high quality data are necessary. In the Western Bug catchment these conditions could not be fulfilled. So the Landsat data are not suitable because of their low temporal resolution. Another remote sensing mission that can be considered is the MODIS mission with its satellites TERRA and AQUA. Though, a handicap of these data is their low geometric resolution of 250 meters. But their advantage over the Landsat data is the excellent temporal resolution. The satellites pass every point of the earth surface twice a day. One of the passing is during the night and one during the day, so daily data is available. To get data without cloud cover influence, the MODIS products are offered as 8- or 16-days products. NDVI data are offered with a 16-day temporal resolution that is suitable for the above mentioned task. Subsistence farming, of course, cannot be mapped with these data, but it is possible to analyse larger patches of arable land. Therefore, the next step is to identify large arable land units with the help of a Landsat band 1, 2, 3 true color picture. After assigning the mean NDVI to every arable land unit at every available time step with a GIS tool, the result is a table with the NDVI-trend for every detected arable land unit. The crop classification takes place while calculating the square error between the calculated and the tabulated patterns of NDVI from Brandenburg for every time step and every arable land unit. The crop with the minimal sum of the square error is assigned to the arable land unit. In Western Bug catchment with 29 detected arable land units and its assigned crops. One remaining problem is to validate these results. There is no information about the crops of a specific arable land unit. The only data that are available are statistics. In table 1 there is an overview of different crops and their proportion to overall farming compared to remote sensing results. The greatest problem is the low geometric resolution of 250m. Furthermore, there is a great influence of mixed pixels. To solve this problem it is necessary to use data with a high temporal and geometric resolution like f. i. RapidEye. With its resolution of about 5 days and 5 meters the method, that is in principle shown here, can be applied to get better results.

Table 1

Comparison of results with statistics

| | 2008 no. | 2009 no. | 2010 no. | sum | rate of results remote sensing [%] | rate statistical data [%] |
|---|---|---|---|---|---|---|
| winter rye | 0 | 2 | 1 | 3 | 3.45 | ? |
| winter wheat | 12 | 12 | 7 | 31 | 35.63 | 33 |
| sugar beet | 0 | 0 | 1 | 1 | 1.15 | 5 |
| spring crop | 3 | 3 | 0 | 6 | 6.90 | 24 |
| rape seed | 5 | 7 | 5 | 17 | 19.54 | 7 |
| maze | 7 | 4 | 14 | 25 | 28.74 | 8 |
| vegetables | 2 | 0 | 0 | 2 | 2.30 | 1 |
| oil fruits | 0 | 0 | 2 | 2 | 2.30 | 4 |

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## IMPROVEMENT OF WATER REGULATION AT DRAINAGE MODULES WITH DIFFERENT DEPTH USING HYDROREGULATORS

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Most existing drainage systems had been constructed over 30 years ago, therefore, are imperfect concerning the present-day level of knowledge. The systems are often unable to dispose of excess water and in some cases overdrain the land resulting in the sharp decreasing of the agricultural crops yield.

Presently, the urgent problem remains of building new, reconstruction and modernization of old ameliorative systems, of developing and introducing into practice progressive technologies for managing water regime of soils [1].

A new, the most perfect technical solution for regulating of ground water level in the zone of sufficient and unstable humidification of Ukraine is considered to be the use of drainage modules. Such method is suggested to be used in the humid zone on highly water pervious soils with filtration coefficient $K\phi > 0.5$ m/day, under atmospheric soil type of water supply with land surface slopes $i < 0.003$ [2].

An issue is important of deepening scientific studies in the direction of developing and creating more technically perfect constructions of drainage module systems. In particular, we suggest improving the regulation network of such systems at the expense of arrangement in the mouths of deep drains of lock-up armature (regulators) [3].

In the laboratory of the department of hydroamelioration of NUWMNRU we conducted experimental researches of the efficiency of using hydraulic regulators on drainage modules.

The aim of researches is the analysis and evaluation of the joint operation of the drainage module and hydraulic regulator placed on the deep drain and also the determination of the accumulation capability of the drainage module with the operating regulator.

Researches were carried out on the experimental installation (large filtration flume) with 6.4 m length, 1.1 m height and 0.8 m width.

To obtain valid values data had been taken 3-4 times and as the calculation the average head value had been accepted.

On the basis of experimental data the calculation scheme was compiled (Fig.1):

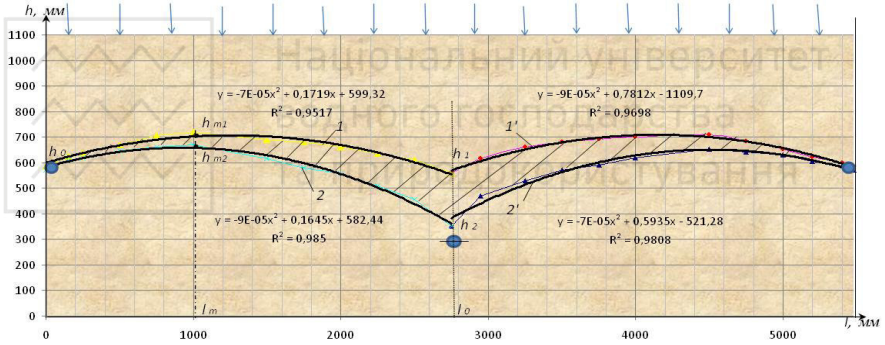


Figure 1. Calculation scheme for determining the accumulation capability of drainage system (module):

*1*, *1'*– depression curves with operating drainage module and hydroregulator; $R^2$=0.9517 and $R^2$=0.9698 respectively for curves *1*, *1'*.

*2*, *2'*– depression curves for operating drainage module without hydro-regulator; $R^2$=0.985 and $R^2$=0.9698 respectively *2* and *2'*.

On the scheme such designations were adopted:

$h_0$ – head above shallow drain, m; $h_1$, $h_2$ – heads above deep drain, m;

$h_{m1}$, $h_{m2}$ – maximum heads, m;

$l_0$ – distances between shallow and deep drains, m; $l_m$ – distances between shallow drain and the largest head value, m.

The increased productivity of the drainage-modular system with the operating hydraulic regulator at the deep drain was 12.8%.

The approximation was carried out by way of the tabular processor Microsoft Excel, by the method of the least squares. As a result we obtained lines of trend,

the evaluation of the reliability of trend lines concerning factual data was carried out by determination coefficient $R^2$.

**Conclusions:**

The application of hydraulic regulators will improve the operation of the network of drainage modular systems which will permit to increase the yield of grown crops, to improve the ameliorative and ecological condition of agricultural lands and environment.

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## TECHNOLOGICAL ASPECTS OF BUILDING DRAINAGE MODULES WITH FILTER ELEMENTS

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The moral and physical wearing out of the drainage systems requires the application of new effective measures both for their planning and building.

The regulative network of hydroreclamation systems are anthropogenic influenced , mainly, by water and air regime on the drained lands. That is why its perfection is the pre-condition of the effective work of drainage system [1, 2].

The innovative method of regulating ground water level in the zone with excess moisture of the drainage modules as a quality the regulative network of the hydro reclamation systems is used. These modules were developed in the National University of Water management and Natural resources Use under the guidance of doctor of technical sciences, professor M.M. Tkachuk [3]. Their novelty consists in the possibility of creating two operational modes of regulative network. The drainage module is a contour in which within the limits of two deep drains one or more shallow drains can be laid out..

The comparative analysis of regulative network and traditional network represented by drainage modules testify to the effective work of the drainage modules. Presented regulative network with greater distance between drains gives an accelerating access to soil water . Also the use of given drainage modules allow to substantially decrease the amount of the taken ground-water on condition of

stopping water feed. The increase of hydrological efficiency of the drainage modules, the use in drains of the shallow laying of filter elements can be attained [4]. It will crease soil water excess at the edge periods of work of the hydro reclamation system (floods and thundershower rains).

The introduction of new effective constructions of drainage is impossible without perfect technology. The technology of building of drainage modules includes processes and facilities which are used for building horizontal drainage [5, 6]. Filter element arranging of the drain of shallow laying increases the amount of technological processes iin building regulative network. Also it increases the expenses of resources for building. At the same time it is necessary to specify requirements for the technology of drainage modules arrangement connected with filter elements.

A list of technological processes for building drainage modules:

1) realization of drainage lines;
2) drainage path preparation;
3) conveyance of expended materials for building drainage along the drainage path;
4) digging of drainage ditch for later laying of drain;
5) drain pipes laying;
6) drain protecting from silting-up;
7) filter element laying;
8) reverse trenches filling up;
9) buildings arrangement in the closed network.



Transferred technological processes can be united and combined, depending on the choice of material for drains (plastic or tile drainage, drain with the protection from a silting-up or without and others), to the method of arranging drainage ditches (trench, narrow trench, without trench) and later drainage (mechanized, made by hand).

The simultaneous arrangement of drains of shallow laying with simultaneous filter element arrangement is foreseen.. Simultaneously with the conclusion of drain arranging of filter element is executed the previous filling up of drain to its height . Due to this the strengthening of filter element is possible by the soil of previous filling up. It will allow not to use additional devices for fastening and maintenance of filter element.

In the development of the technology of building presented regulative network the drainage module with filter element it is necessary to take into account the features of compatible work of the latter with drains of the shallow laying. Basic conditions of which are the following

1) hydraulic filter elements connection with drain or with the protection from a silting-up;
2) vertical position of filter element;
3) laying of filter element by the whole length of drain.

The technology of drain building of the shallow laying with a filter element includes the cycle of the combination of technological processes such as arranging of drainage ditch, insetting of drainage line, installation of filter element as a previous filling up of trench. It allows accelerating considerably the rates of drainage modules arranging, decreasing the cost of their building, and avoiding intensive hand labour.

The laying out of drains of the drainage module can be executed by the known methods [5, 6], taking into account changes and additions predefined by insetting of filter element.

Devices for the conclusion of filter elements in building drainage on soils with the coefficient of filtration of $K_f$=0.5 meters/days are known [5]. The features of their structure depend on the material of a filter element and method of laying drain .

The construction of passive working devices for insetting filter elements as plane materials is proposed by us [7]. This construction allows sending a filter element to provide its conclusion simultaneously with hydraulic connection with drain and its fixing. The parameters of device allow changing the range of thickness of filter elements due to the change of gap width between guiding plates. Simplicity of construction of device provides reliability of its exploitation. Also it enables to assemble this device for different modifications of drain layer.

Combinations of technological processes of laying drain, filter element and reverse filling up of drainage ditch, allow executing mechanical fixing of filter element without additional technological operations.

During critical periods of work of the hydro reclamation systems in the zone with the excess or changing moisture (flood, thundershower rains) it is needed to take off superfluous ground-water from the epiphases of soil as quickly as possible. For the decision making of this burning issue we offer the arranging of filter elements on drains of the shallow laying of the drainage modules as the regulative networks of the drainage systems. It will allow to increase hydrological shallow laying efficiency of drain of . Technological solutions for arranging the drainage modules simultaneously with filter elements there can be the technologies used for the development both of building and reconstructions of the drainage systems .

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## USAGE PROBLEMS OF WATER RESOURCES IN SIVERSKY DONETSKY BASIN AUTHORITY OF WATER

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Water supplies play a key role both in maintaining the process of production of economic agents in national economy and in guaranteeing people's work capacity and protectability. In general, the question of quality of water supplies and their sufficiency does not only concern the field of socio-economic relations but it also applies to the sphere of national security of the state or its separate regions. Therefore, the tasks of uninterrupted supply of water, ensuring its quality and avoiding or minimizing its pollution take on special significance.

Investigating scientific publications on questions the rational water consumption of water resources, as a necessary element of development of society, are devoted many proceedings.

Investigating scientific publications on questions the rational water consumption of water resources, as a necessary element of development of society, many prominent ecologists and economists, both in Ukraine and abroad, dedicated their scientific publications to the problem of efficient usage of water supplies. Among the scientists, there are the names of A.Achkasova, A.Hordiychuk, K.Hofman, M.Loiter, A.Mintz, S.Strumilina,T.Khachaturova and others. However in water management area, the question was not given proper consideration. Therefore thorough investigation of the condition of water supplies in a definite region deserves attention as it might serve a determinative factor for the water management development.

The object of the theses is to define the main problems of water management and to evaluate the managing efficiency in terms of economic activity in Siversky Donetsky basin authority as well as to elaborate some suggestions on improving the existing approach to managing water supplies.

The results of the conducted analysis indicate that the water management system in the region covering Kharkiv, Donetsk and Luhansk oblasts proves to be unsatisfactory with the following facts pointing to that.

First of all, our task was to define the needs for water supplies in different fields in 2010. The biggest water volume was used for the industrial needs, its figure constituting 70 per cent of the whole volume of the sea and fresh water used. Besides, the considerable part of the fresh water usage went to household and drinking needs reaching 23 per cent. Four per cent was due to the water supply use in piscine and fishing industry. The least volume of water supplies was recorded in regular irrigation, farming and other fields, the figure going up to 1 per cent. It should be pointed out that the collection of surface water and underground sources was carried out to satisfy the need in water supplies for the needs mentioned above.

In general, during 2007 – 2010 the water usage in both industry and agriculture reduced. Yet, the decrease in water use in 2007 – 2009 was evident. However in 2010 those fields registered the growth in production volume which led to a slight increase in the use of water resources. Losses of water in industry and agriculture were rather considerable and ranged at 67 per cent. In the field of communal services, the situation is slightly different (see Fig. 1). In the period between 2007 and 2010, the volume of water intake was 52 per cent up, the reason for that being the redistribution of quantitative measures caused by the 2008 final transition of some enterprises from the field of industry to the field of communal services. Water usage in that field went 9 per cent down in the period under consideration.

Speaking about the losses of water in communal services we should admit that during four years they slightly reduced, going one per cent down.

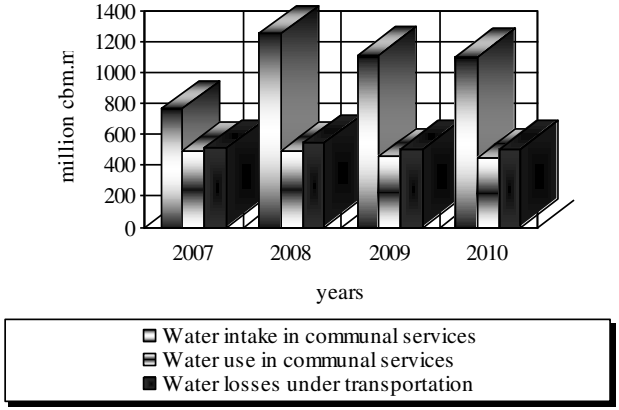

Figure 1. Dynamics of main indexes to water intake, usage and losses in communal services

The basic percentage of losses in the field was attributed to the emergency state of sewerage systems which dramatically needed repairing but repair works were financed insufficiently. A considerable part of existing water supply systems was physically worn out and technologically outdated. In some population aggregates, conduits for drinking water supplies had exceeded the amortization terms. More than 40 per cent of water supply systems needed immediate substitution or reconstruction.

The analysis of quantitative measures for the return water discharge into the surface water bodies by the enterprises of the key industries in 2010 indicated that the main percentage went to the return water discharge from the enterprises in industry and communal services constituting 75 and 24 per cent correspondingly. The main water pollutants appeared to be coal industry, ferrous metallurgy and chemical and petrochemical industry.

One of the principal problems in water supplies, drainage system and their influence on the environment concerned the quality of water resources. The index had considerably fallen since treatment facilities designed to purify water resources fail to function at full capacity. Overall performance of the ecological condition of surface water was carried out according to the following factors: biological oxygen demand, chemical oxygen demand, phosphates, ammonium nitrogen, nitrites, nitrates and others. The least polluted region proved to be Kharkiv oblast while Luhansk oblast had water resources with 33 pollutants in them.

Kharkiv oblast is the most pollution-free region within SDBAWS since according to both the structure and the methods of evaluating the water quality it was defined as moderately polluted in 2010 though polluted water resources could be spotted in some businesses in previous years.

Donetsk oblast was the most polluted region; according to the impurity index it was estimated at mark 6 as being “polluted”. The waters in Luhansk oblast had various water pollutants in them, and yet, according to the impurity index, this region was the most pollution-free area with the impurity index fluctuating within the bounds of polluted and moderately polluted water resources.

Thus, caused by the low level of providing the population with qualitative water resources environmental issues and problems of drinking water supplies become first priority. To improve the condition of water bodies, we find it necessary: to decrease discharge of pollutants into water bodies; to increase investment attraction of the region; to accomplish the construction and reconstruction of treatment facilities, water supplies and drainage systems making use of new materials and equipment which are supposed to have reliable corrosion and cavitational protection and long-term durability; to improve water protection zones and coastal strips; to carry out clearing the beds of small rivers; and to solve the problem of providing the private sector population with centralized water supplies and street stand-pipes.

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## REMOTE MONITORING AS A COMPONENT OF OPERATIONAL CONTROL BASED ON SELF-CONTAINED MODULES OF DRAINAGE AND IRRIGATION SYSTEMS

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In contrast to traditional concept that is focused only on the maximum yield, in current market conditions agricultural production should maximize revenue with minimum cost and adhere to environmental constraints [1, 2]. Thus, the main practical problem of crop production sector can be formulated as a problem of decision making, i.e. selection of alternatives and the best options, while meeting the requirements of environment protection.

In land reclamation decision support system includes optimizing simulation models and information system that provide storage and preparation of data for calculating the object of research. It should be emphasized that the validity of the right solution choosing is determined by the accuracy and reliability of the objective source information obtained by monitoring.

Because of the special features of land reclamation systems operation (large dispersion, seasonal tilling, crops growth on managed modules, etc.) it is appropriate to use wireless networks as communication systems. The rapid development of GSM-network and VHF/UHF transceivers opens prospects for their use in monitoring and control systems.

A system for regime technological parameters monitoring on drainage and irrigation systems autonomous modules (Fig. 1) that provides for monitoring the level of water-table (LWT), soil moisture and meteorological characteristics was proposed in the paper.

Technical means of humidity measuring (suction pressure) within the control system are implemented based on fixed moisture meters that are being placed on representative areas of land reclamation systems autonomous module. The tensiometers with automatic refueling are being used [3] that improves their

performance and the microprocessor system for information processing and transmitting by radio or GSM channel [4].

The calculation of root zone moisture deposits is being conducted using the designed method [5]. While tensiometers using, the humidity values were calculated by the following expression:

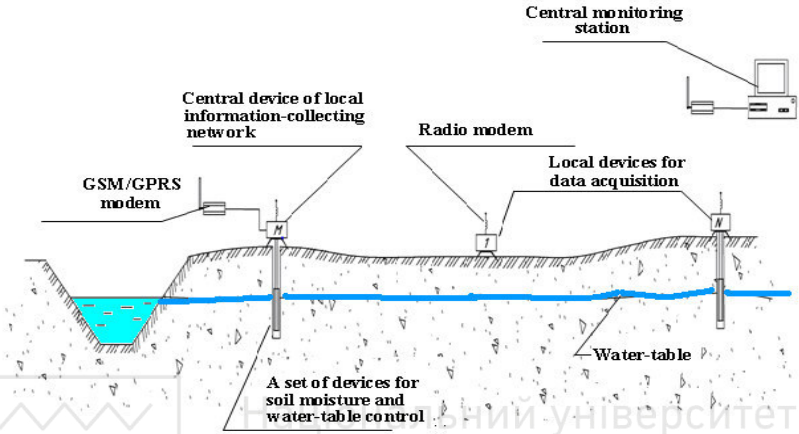


Figure 1. The scheme of regime-technological parameters monitoring on autonomous modules of drainage and irrigation systems

$$\theta = (\theta_{0.33} - \theta_{15}) \cdot (arcctg(\psi + c) - d) + \theta_{15}, \quad (1)$$

where $\theta_{0.33}$ and $\theta_{15}$ soil moisture under pressure at 15 atm and 0.33 atm respectively (experimental data of the main hydrophysical characteristics for studied soils in the range from low to high humidity values are being used).

The practical significance of the methodology in solving land reclamation problems consists in the possibility of ground water dynamics calculations.

Based on the information received and using the appropriate control algorithms, the management system synthesizes control data which by radio or GSM channels actualizes operating, providing a resource saving regimes of water regulation.

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## THE HYDRAULIC CHARACTERISTICS CHANGING OF "T-TAPE"DROPPERS DURING ITS OPERATION

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Drip irrigation systems related to melioration systems, for which the design stage is a particularly important role in ensuring the performance systems caused by the fact that these systems of each plant receives individual irrigation rate, therefore the uniformity of distribution flow in the system should be high enough.

Same time, the amount of water that is every plant is a random variable, which depends on the following mains projects and exploitations factors: technological spread flows; hydraulic characteristics of droppers and distribution pipelines, water quality, regime of exploitation, length of water supply cycles, regularity flushing pipelines and droppers [1, 2, 3].

Field research on change of hydraulic characteristics droppers in service are carrying out in 2010-2011 in the area of drop irrigation «Domaine Azzouz Abdallah EAC 33" in Zeralda Algeria city.

55 droppers of T-Tape were studied of not compensated types [4, 5, 6, 7]. The research was conducted in operational mode: with washing and addition of fertilizer at operation pressure of 1.05 bar, with an average turbidity 2.25 NTUta average temperature Tav = 20 ° C, droppers worked against-tion 660 hours.

Flushing regime droppers held the opening end caps irrigation pipes after every irrigation at 15-20 min.

To plan observations of reliability droppers T-Tape the plan was used [NUT] [7, 8].

The following hydraulic parameters were determined at constant pressure [8, 10]: the average flow $q_c$, coefficient of flow variation $v_q$, coefficient of technological flow uniformity $k_p$, coefficient of decrease in the average flow $K_e$.

The results showed, that the stable area of the system can be seen in the first year of exploitation of drip irrigation, where the system is stable and storage area, which starts with a significant deterioration of the hydraulic parameters (hydraulic parameters significantly changed from 28% to 82% for the coefficient technological uniformity of flow $k_p$, from 28% to 70% for the average flow $q_c$ from time t = 360 to 660 hours) drippers.

Hydraulic characteristics in the process of exploitation change: the average flow $q_c$= 1.44 l/h to $q_c$ = 0.44 l/h, coefficient of technological flow uniformity $k_p$= 0.95 to $k_p$= 0.32, the coefficient of decrease in the average flow $K_e$= 1.00 to $K_e$= 0.30, but increases the coefficient of variation of flow $V_q$= 0,036 to $V_q$= 0.68, for the experiment.

Reliability of droppers described connection coefficient technological uniformity of flow $k_p$ and the distribution function reliability drippers T-Tape with confidential probability $\beta = 0.90$ of regime - flushing with the addition of fertilizers from the pressure of 1.05 bar for the Weibull distribution that depends on operation times. When comparing the graphs there is a limit, after passing which, the system becomes unable to operation state, ie the reliability of the system is broken, this limit is the point of intersection of two graphs.

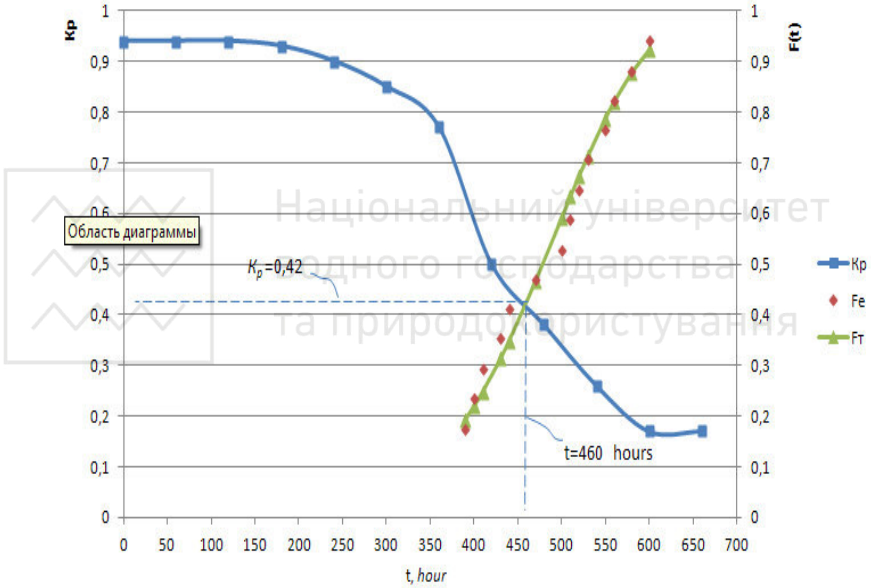


Figure 1. Graph of the coefficient technological uniformity of flow $k_p$ and reliability of the distribution function of droppers of T-Tape with regime - flushing with the addition of fertilizers, depending on operation times

Figure 1 shows that with decreasing the coefficient technological uniformity of flow $k_p$ increases distribution function of reliability of refusal droppers. Intersection graph shows the limit at which the system become not performance, ie at $K_p = 0.42$ and $q_c = 1.30$ l/h, $K_e = 0.50$, $V_q = 0.72$ system refuses at time t = 460 hours.

Refusal droppers because turbidity in the water for irrigation pipe or content of fertilizers in the water, there is complete blockage droppers.

**Conclusion:** The field research has shown that perfectly work droppers "T-Tape" by mode - flushing with the addition of fertilizers, which meet the allowable values $q_c = 1.01$ l/h, $K_e = 0.70$, $K_p = 0.75$, $V_q = 0.16$, took 370 hours to first refusal.

Droppers "T-Tape" are stable only eighteen months of operation. Its operation depends on the quality of irrigation water and filter. Therefore you can install the following recommendations for improving efficiency "T-Tape" droppers: average turbidity of water should be between 2.25 to 60 NTU in case of increasing the length of flushing irrigation pipeline three times higher than proposed, or used for flushing device of irrigation pipeline [9], that was used in laboratory researches and showed the effectiveness of flushing.

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**ANALYSIS OF MODERN TECHNICAL EQUIPMENT OF**

# WATER LEVEL MEASURING IN CHANNELS OF HYDROMELIORATIVE SYSTEMS

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For controlling the distribution of water-courses and use of water of importance is the presence of technical equipment for water accounting. The modern arsenal of facilities for measuring water levels includes both simple measuring devices of water and the highly automated measuring devices and sensors.

The choice of facilities for measuring levels is regulated by requirements for exactness and authenticity of results of measuring, and also possibilities of its realization.

The problem of choice becomes complicated by the necessity of energy supply for electronic devices of measuring water, sensors and warners of levels. In Table 1 technical data on devices are brought for measuring water level, suitable for application on reclamative systems. The basic producers of these facilities are firms of countries of European Union, Russia, USA, Germany.

Table 1

Facilities for measuring and controlling water level

| Type of device (country of origin) | Measuring range | Measuring error | Initial information | Electro-consumption |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| A. Discrete control of level | | | | |
| A rail is level portable GR - 116 (Russia) | 0-0.1 | ± 0.002 | Visual | - |
| A rail is marine hydrometric GM-4 (Russia) | 0-0.4 | ± 0.01 | Visual | - |
| Water-level rail G1 (Germany) | 0-0.1 | ± 0.01 | Visual | - |
| B. Continuous control of level | | | | |
| 1 | 2 | 3 | 4 | 5 |

| | | | | |
|---|---|---|---|---|
| A device for measuring water level by means of float GR-116 (Russia) | 0-20,0 | ± 0,01 (m) | Registration on the ribbon of variplotter | - |
| Multichannel recorder variplotter LGraph2 | 0-20,0 | ± 0.01 (m) | Registration of analog signals | - |
| A device for measuring water level by means of float RUPT-A | 0-16,0 | ± 0.01 (m) | Registration of analog signals | - |
| C. Measuring of level | | | | |
| Pneumatic measuring of level by a sensor «NIMBVS» (Germany) | 0-13,0 | ± 0.01 (m) | Registration on variplotter. The analog signal 4-20 mA | Permanent voltage of 12V |
| Bubble measuring of level «Orphimedes" (Germany) | 0-13,0 | ± 0.01 (m) | Digital information | Permanent voltage of 6V |
| Sensor of level of capacity EMA-M (Russia) | 0-6,0 | ± 2.5 (%) | Frequency 2-1 kHz signal | Permanent voltage of 24V |
| The sensor of level is acoustic «Kalesto» (Germany) | 0,5-30,0 | ± 0.01 (m) | Digital information | Permanent voltage of 12V |
| Sensor of level «Honeywell» USA | 0,5-20,0 | ± 0.0001 (m) | The analog signal 0-5 mA | Permanent voltage of 12V |

The analysis showed that most simple and reliable here are hydrometric rails and acoustic sensors of water level in exploitation. With correct application they do not need periodic verification.

## LEGISLATIVE INITIATIVES TO SETTLE LAND RELATIONS FOR RENEWING EFFECTIVE USE OF RECLAIMED AREA IN HUMID ZONE OF UKRAINE

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The drained lands are in the zone of excessive moisture. Providing the effective operation of reclamation network is insurance fund and indispensable guarantor of sustainable agriculture, establishing a strong forage base for livestock development and food security, regardless of climatic conditions and social problems of the population.

During reforming agrarian sector it is lead to division and privatization of the drained grounds. The internal network of reclamation is transferred to balance of local self-government institutions. Owing to such changes efficiency of the use of reclaimed grounds has essentially decreased. The share of use in agricultural production was reduced and the productivity of the basic agricultural crops almost twice decreased.

By results of the lead inspections according to technical condition of some meliorative systems humid zone it is established that by 65-70 % of the drained grounds the water mode mismatches requirements of agricultural crops. First of all because of inefficient operation of the internal network of drainage canals, impossibility of operative management of regulation processes of water mode and absence of water sources for humidifying during the droughty periods.

It is established that technological level of the internal network of drainage canals by 25-30 % of the areas is good, by 40-45 % is satisfactory, and by 30- 35% is unsatisfactory. Channels, hydraulic engineering constructions, pump stations of intereconomic network which are served by the water-economic organizations, spend on repair works practically by 85% of the areas that are in good and satisfactory condition.

The modern condition of existing ground attitudes and the use of the reclaimed grounds demands cardinal reforming of state policy in the field of rational use of water and ground resources in a zone of superfluous humidifying. The drained soils should be considered as the integral component of complete natural-technological complex which demands an ecological substantiation, estimations of a real condition of the drained grounds with the purpose of development of regional models of conducting agrarian manufacture, accomplishment of agricultural landscapes, substantiations of expediency and volumes of reconstruction and denaturalization landscapes, measures of rational use of ground resource potential of the reclaimed grounds humid zone of Ukraine.

For formation and realization of the state program in direction of maintenance of highly effective use of the grounds of land reclamation fund humid zone

priorities is modification and additions in existing normative and legislative documents in the field of land reclamation, ground attitudes, namely:

- Development of scientific principles of consolidation of water and land resources;

- Restoration of technological integrity of reclamation systems in conditions of reforming of ground attitudes;

- Amendments to acts concerning returning an interfarm reclamation network from municipal in the nation-wide property on balance of public service of operation State Agency of water resources of Ukraine;

- Amendments to acts concerning increase of the responsibility of land users for preservation and reproduction of fertility reclaimed soils, as important element of maintenance of food safety of the state, strengthening of a role of local authorities in control;

- Creation of the State program of a gradual conclusion drained peat soils and unproductive reclaimed land from agricultural use and their translation in natural reserve fund;

- Strengthening system of the state control over use the reclaimed grounds and creation of the program of the state encouragement introduction of new systems of reclamation agriculture, rational land treatment and improvement actions.

For the account of interests of all interested parties and maintenance of peak efficiency from introduction offered above legislative initiatives in their development and perfection structural divisions of the Ministry of an agrarian policy and the foodstuffs of Ukraine, the Ministry of ecology and natural resources of Ukraine, State Enterprise "Centre of State Land Cadastre" and others.

Realization of the offered positions will allow providing at the certain state support an essential gain of manufacture of agricultural production due to effective utilization of the reclaimed grounds, receiving the increase in crop on the cores grown up cultures more than 30 % that 4-5 billion grn. is equaled the annual national income of the country.

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## RESULTS OF EXPERIMENTS ON APPLICATION OF AUGER BUCKET

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The task of conducting the experiment included a study on the application of auger bucket, changes in volume weight in the composition of soil, leveling of field surface.

The results of the volume weight and substance of the soil hitched in the speed of the unit are shown in Tables 1 and 2.

As is shown by research, increasing the speed of planning unit causes reducing volume weight of soil. Table 1 shows changes in volume soil weight, depending on the speed of the auger working body.

According to the result of the experiment from table 1 it can be said that increasing the driving speed of unit reduces volume of soil weight. In table 1 are given the results (data) obtained with ground speed 0.69 …2.08 m/s which are most satisfactory, concerning agricultural requirements as compared with data from the other vehicle speeds. The difference in changing volume weight of soil between the minimum and maximum speeds of the scheduler in the slice consist in the following:

For the layer 0-5 cm - 0.179 g/cm$^3$ or 12.8 %, for the layer 5-10cm - 0.137 g/cm$^3$ or 9.7 %, for the layer 10-15 cm - 0.123 g/cm$^3$ or 8.34 %.

The average to a depth up to 15 cm the difference can be 0.146 g/cm3 or 10.2 %.

Table 1

Changing volume soil weight, depending on the speed of the auger working body

| Layer, sm | Soil moisture, % | Volume weight soil, g/cm$^3$ | | | | | |
|---|---|---|---|---|---|---|---|
| | | Before passage | After passage | | | | |
| | | | Ground speed, in m/s | | | | |
| | | | 0.69 | 1.05 | 1.44 | 1.8 | 2.08 |
| In the slice | | | | | | | |
| 0-5 | 12.48 | 1.121 | 1.400 | 1.349 | 1.270 | 1.262 | 1.221 |
| 5-10 | 14.80 | 1.155 | 1.412 | 1.315 | 1.314 | 1.303 | 1.275 |
| 10-15 | 16.18 | 1.265 | 1.473 | 1.406 | 1.381 | 1.399 | 1.350 |
| The average to a depth of up to 15 cm | 14.49 | 1.180 | 1.428 | 1.357 | 1.322 | 1.321 | 1.282 |
| At the two graders | | | | | | | |
| 0-5 | 12.48 | 11.21 | 12.70 | 12.50 | 12.21 | 11.95 | 11.90 |
| 5-10 | 14.80 | 11.55 | 13.15 | 13.20 | 12.90 | 12.89 | 12.74 |
| 10-15 | 16.18 | 12.65 | 13.81 | 13.92 | 13.53 | 13.40 | 13.29 |
| The average to a depth up to 15 cm | 14.49 | 11.80 | 13.22 | 13.21 | 12.88 | 12.74 | 12.64 |

As can be seen from this analysis (Table 1) the difference of changes of volume weight of soil between maximum and minimum speeds with the increase in depth decreases.

The same phenomenon with the change in volumetric soil weight, depending on the speed of the flows to graders. The difference in the change of volumetric soil weight between the minimum and maximum speeds for the graders is: For the layer 0-5 cm, 0.80 g/cm3 or 6.3 %, for the layer 5-10cm - 0.4 g/cm$^3$ or 3.12 %, for the layer 10-15 cm - 0.52 g/cm3 or 3.77 %.

The average to a depth up to 15 cm difference is 0.058 g/cm3 or 4.38%.

It is known that the unit structure of the soil is one of the main qualitative indicators of the work of agricultural machine. Increasing forward speed can result in excessive soil dispersal, and the latter may cause soil erosion.

Table 2 shows the change in the nature of the soil, depending on the speed of the auger working body of scheduler.

The change in the composition of soil depending on the speed auger working body

| The speed of act | The contents of the factions, % size in mm | | | |
|---|---|---|---|---|
| | 100 +50 | 50 + 10 | 10 + 0,25 | < 0.25 |
| Before pass unit | | | | |
| | 28.62 | 50.82 | 19.42 | 1.72 |
| After pass unit | | | | |
| 0.69 | 28.41 | 48.38 | 20.25 | 2.59 |
| 1.05 | 26.81 | 48.81 | 24.36 | 1.92 |
| 1.44 | 19.76 | 47.73 | 30.17 | 2.21 |
| 1.8 | 16.00 | 50.72 | 30.25 | 3.05 |
| 2.08 | 13.41 | 47.98 | 34.99 | 3.69 |

As can be seen from the table increasing the speed of auger working body large lumps (Ø100 … 50mm) are crushed, medium-sized lumps (Ø 50 … 10mm) almost do not change - this is the transition large lumps in the medium-sized and medium-sized to small. A valuable structural unit (Ø 10 …0.25 mm) is increasing.

Table 3 shows the difference in changes of the factions in the soil between the minimum and maximum speeds: Large lumps Ø 50 … 10mm - 52.8 %, the average lumps Ø 50 … 10mm - almost without changes in quantitative composition. Valuable units size of Ø 10 …0.25 mm increases to 72 %. The composition of the factions size of Ø<0.25 mm as can be seen from the table increases slightly within the range of inspection requirements.

Above described results of the study will favourably affect the winter crops condition background to contains ammoniacal and reduce costs for the use of guns for chopping large and medium-sized lumps seeding background.

Improvement of the quality of leveling of longitudinal profile is one of the main and crucial factors in the study of the work of technology planning units.

Table 3 shows the extent of flattering in the longitudinal direction, depending on the speed of the unit.

Table 3

Changing the extent of equalizing depending upon the speed of the unit

| Drowing indicators | Speed, m/s | | | | |
|---|---|---|---|---|---|
| | 0.69 | 1.05 | 1.44 | 1.8 | 2.08 |
| $\sigma_{\partial}$ | 9.94 | 11.05 | 10.80 | 10.30 | 10.10 |
| $\sigma_{\text{п}}$ | 7.89 | 8.27 | 7.32 | 6.82 | 6.84 |
| K (%) | 20.6 | 25.1 | 32.2 | 33.8 | 32.2 |

where $\sigma_{\partial}$ – rms deviation from height one decimal place bumps up to pass scheduler, sm; σп – the same after passage scheduler, see; K – the degree of uniformity in percentage.

Apparently from table 3 data, with increasing speed of progress of the scheduler with working body degree of uniformity of a planned site increases. It occurs at the expense of crushing large lumps of soil which are promoted by work of two units which rotation is directed at every way. On speeds of movement 1.8 … 2.08 km/s uniformity degree above in comparison, than on other speeds of movement. It speaks of steadier course of working body on the raised speeds. Besides, the increase in speed of movement in the specified limits promotes crushing of large and average lumps of soil in a drawing prism much more. Work of two augers allows uniform distribution of soil on width of pass, the last also improves quality – of a lay-out.

Conclusion and offers.

1. With increase in speed of movement of the scheduler with working body from 0.69 to 2.08 km/s reduces volume weight of soil, and the modular structure of soil improves.

2. Increase of forward speed of movement to 2,08m/ improves quality of a lay-out in a longitudinal direction.

3. It is necessary to devote further researches to studying parametres of working body and its arrangement in a ladle of the scheduler.

## ESTIMATION OF USING WATER RESOURCES IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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One of the basic tasks of sustainable development is forming safe ecological terms for people existence which includes the balanced use of water resources in particular. The evaluation of this process is realised with the use of the most ponderable indices which are presented by the aggregate indices of surface-water pollution and underground-water provision . The aggregate index of surface-water pollution consists of three aggregate indicators: chemical pollution of water resources; the upcast of not enough cleared waters; the upcast of unrefined waters. [1].

The purpose of the research is the estimation of water resources usage in Rivne area.

The object of the research are indices of water resources usage in the affected zone of Rivne.

The subject of the research is the system of indices which estimate the state of the water resources usage of the territory under investigation.

It is established that on this territory an agricultural complex industry is one of the most active users and polluters of water (table.1). The majority of water after the use in the process of production goes back into the rivers and lakes as flow waters. In the composition of these waters there are 39 million m³ normatively cleared waters, 0,8 million m³ unrefined waters , 9,1 million m³ not enough cleared waters, 61,5 million m³ normatively clean without cleaning waters. The normatively cleared reverse waters were deficated at the cleansing plants of bioscrubbing, physical and chemical cleaning and mechanical cleaning.

Contamination of waters in the process of agricultural production happens as a result of the intensive use of mineral fertilizers and chemical facilities for plants protection, water providing for stock-raising farms and complexes, and also in the process of water-reclamative measures. Municipal consumer flow waters are 15–20% of all volume of flow waters. However, if it is possible to avoid the volumes of industrial and agricultural flow waters and amount of contaminents there by the reverse water-supply, the change of production technology , the observance of norms and terms of the chemical process in agriculture, but service-utility flow waters are characterized by permanent growth of their volumes. It is predefined by the growth of quantity of population, the increasing of water consumption, the improvement of sanitary-hygenic terms of life in cities and other settlements[2].

Table 1

Use and uptake of waters by the enterprises of economy industries, million

| Industry of economy | Used water | For: | uptaken reverse waters in superficial water objects |
|---|---|---|---|

| | | domestic-drinkable necessities | production necessities | Sum total | muddy | unrefined |
|---|---|---|---|---|---|---|
| Electroenergy | 51,78 | 0,77 | 51 | 13,84 | - | - |
| Chemical and petrochemical industry | 10,77 | 0,72 | 10,04 | 18,75 | 0,36 | 0,36 |
| Engineering | 0,17 | 0,13 | 0,04 | 0,02 | 0,02 | - |
| Housing public utilities | 22,68 | 20,72 | 1,92 | 20,45 | 8,89 | - |
| Agriculture | 66,96 | 0,12 | 19,370 | 45,77 | - | - |
| Food industry | 1,84 | 0,11 | 1,74 | 0,11 | 0,11 | 0,02 |
| Transport | 1,03 | 0,74 | 0,06 | 0,25 | 0,017 | - |
| Industry of building materials | 2,23 | 0,26 | 1,97 | 10,33 | 0,47 | - |
| Other industries | 1,54 | 0,273 | 1,278 | 0,88 | 0,01 | 0,42 |
| Sum total | 159 | 23,84 | 87,41 | 110,4 | 9,88 | 0,79 |



As a result of supervisions superficial water objects sustain the most anthropogenic influence :

- r.Horyn' The water research of the river is carried out in 14 permanent sampling stations, from 65 investigations for sanitary chemical indices of water tests, 14 tests were not conformed to sanitary norms, in particular for BPK5 and general iron.

- r.Zamchys'ko(Kostopil' district) sampling is carried out from 4 sampling stations. In the investigation of 16 tests disparity was marked for BPK5, BPK20 by general iron, cut-in oxygen, oil products, formaldehyde, oxidation.

- r.Styr (Mlyniv district) 6 sampling stations, from 38 researches, 6 tests were dissatisfied sanitary norms , namely for suspended matters, general iron, BPK5.

- r.Ustia lake Basiv Kut.There were investigated 9 permanent sampling stations, from 103 tests in 19 cases water was not conformed to norms for general iron , BPK5, suspended matters[3].

The calculation of the generalized aggregate index of underwater supply was conducted on the basis of three aggregate indicators – prognosis supplies of underwaters, ratified supplies of underwaters and quality of drinking-water. Calculations revealed that the probed territory is rather unevenly part for descriptions of underwater supply. Together with the quantitative indices of supplied underwaters, one of the most essential indicators is the high-quality state of drinking-water which is consumed by population. In a regional plan the changes of chemical composition of underwaters register on territories with low

afforestation, relatively high technogenic loading, enhanceable introduction of mineral fertilizers, stipulate the certain problems for self-cleaning of waters. The considerable sources of contamination of underwaters are industrial enterprises and, mainly, flow waters that accumulated in accumulating ponds, settlers on drainfields, cleansing stations from which they get in ground water and enter more deep aquaferous horizons.

Compositions of lacking amenities of chemical pesticids and fuel-oil materials are of considerable danger, dumping grounds, settlements which do not have sewage networks. The potential sources of contamination of underwaters are the started mining holes or mining holes which broke ranks and subject to the technical plug-back, mining holes without well-organized areas of technical mode, especially, when they are placed directly near the sources of contamination and do not have the permanent pressurizing. For the rural population there are considerable ecological risks from the consumption of off-grade drinking-water.

Thus, for forming the sustainable development of water resources of the probed territory it is necessary to decrease the anthropogenic loading on superficial and underground water.

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## EFFICIENCY OF HEATING SOIL BY WARM-EXCHANGERS IN THE WEST OF UKRAINE

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Problem of getting early and permanent yields of agricultural cultures, particularly of vegetables and berries; getting packaging of flowers is one of major

socio-economic problems in agriculture of many countries. Change of climate and weather conditions which become unforeseeable, yet more stress actuality of this problem. In generally to accepted tendency of global warming specialists pay regard to even possibility of local cold snaps' appearance on certain territories, protracted cold periods in spring, considerable oscillation of weather conditions.

Studying of possible climatic and weather changes' influence on development and productivity of agricultural cultures and development of measures preventing the negative climatic and weather phenomena become actually in agriculture not only for researchers but also for experts.

One of the variants of this problem's solving can be creation of soil's areas, which are heated by special facilities of thermal land-reclamations using of thermal wastes from industry. Attractive free thermal energy sources can be charged hot water (heat-exchange water) from industrial and power objects which have temperatures of 20-40$^0$ C and geothermal water. Their attractiveness consists in that pre-eminently such temperatures are optimal for development of most vegetables.

In 80th of the last century long-term efficiency's researches of the use of charged hot waters of atomic power stations and thermal power stations for heating of soil by the pipeline systems were conducted in many developed countries of the world, in the USA, France, Germany, former Soviet Union, particularly at our university. The pipeline systems showed its sufficient efficiency in increasing of the productivity of separate agricultural cultures and in harvesting on a few days earlier. However their thermal efficiency in relation to the ground layer of air appeared low (0.5…1.5 $^0$C), that did not allow them to come into wide use as effective heating land-reclamation's method, except for separate engineering tasks (cooling of water in soil, accumulation of warmth in soil, heating sporting grounds and others like that).

One of the perspective and effective methods of thermal land-reclamation of soil's local areas can be as superficial heating of soil by warm water with temperature parameters of within the limits of 25…35 $^0$C. The working scientific hypothesis is that the maximal thermal effects of water use with such temperatures are necessary to expect at direct water-courses' direction to the area of plants' dwelling. Transmission of thermal resource in the limits of 15…20 $^0$C in the environment «soil - air» in theory will allow displacing the transition through 10$^0$ C at the end of February - beginning of March (see Figure 1).

Figure 1. General view

Using shelters of tunnel type soil's heating with the water temperature 25…30 $^0$C promote creation of all temperature conditions in warm-exchangers necessary for the change of vegetation period and early growth of agricultural cultures, in average from one month to two depending on the type of culture.

Thus, the use of superficial heating by warm-exchangers influences on the substantial rank of the temperature condition of soil and air of ground layer. It appears in the change of temperatures' distributing on the ground type, in the considerable increase of temperatures of soil and air, in the change of heat exchange of soil with the ground layer of air.

Using of the tunnel shelters soil's heating with the temperatures of warm-exchanging agent of 25…30$^0$ C promote creation of all necessary terms in warm-exchangers for displacement of vegetation period extra early growing of agricultural cultures, in average on 1-2 months depending on the type of plants. It allows conducting earlier sowing and planting of thermophilic cultures, getting the harvest earlier than in ordinary terms, increasing the amount of plant-grower products and also improving its quality.

## ON QUESTION OF EVALUATING INNOVATIVE POTENTIAL OF WATER ECONOMY ENTERPRISES

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The specifics of innovation management of water economy enterprises is a management innovative potential, existing in some organizations, as part of the functional aspects of management (planning, organization, motivation, etc.).

Innovative capacity is the ability of the economy (in general) or entity (such as) to produce new knowledge - based products that correspond to the requirements of the market (especially of the world) and include [1]:

− production capacity for the manufacture of means of production;
− professional and technical staff;
− powerful experimental base related to the preparation of new production;
− possibility of introducing innovations and their control.

To each state of the enterprise it's possible to offer special innovative strategy that is most acceptable for it. This strategy will allow it to organize the innovative activity of the water economy enterprise in the most effective direction for innovative building conditions to optimize the correlation of water economy enterprises with market demand. That is, to bring the system to a certain period of time to equilibrium.

The combination of possible market demand with three kinds of provision of innovative resources will allow discovering the nine most common situations in which water economy enterprise may be.

P1:D1. The status of "eliminating" the liquidation strategy, i.e., sale of products, equipment, buildings, facilities and other resources. Most often this can occur in the procedure of bankruptcy. A positive way out of this situation can be found at the expense of the attraction of foreign investment. In these conditions, any innovative conversion, backed by financial resources, increases the innovative potential of enterprises and, as a rule, gives a positive effect.

P1:D2. Low market demand and a lack of innovative capacity drive the water economy enterprise to "crisis" situation. Innovative strategy of this is performed by cutting costs because they can't be accompanied by attracting investments. In this regard, the spread of managerial innovation may appear.

P1:D3. The status "waiting for" is characterized by high demand for the products of the water economy enterprise, and therefore high market potential that causes the state of relax condition and doesn't encourage management for active transformations, the more so that the existing enterprise innovative potential is low. Such passive strategy situation can develop in different scenarios: 1) toward the loss of market positions by the enterprise in case of aggressive policy of strong competitors; 2) accumulation of own resources to increase innovation potential; 3) attracting external investors.

P2:D1. "Diversification inside the branch" describes the situation where the enterprise has a limited capacity to implement innovative integrated activity. The solution for the current situation can be the introduction of market innovative technologies that allow to find new market segments and to implement

diversification inside the branch.

P2:D2. In "survival" situation with limited capacity takes place the so-called imitation innovation accompanied by improvement of production and management structure. However, limited innovation capacity allows driving innovation in small increments, as a result, the complexity is lost and water economy enterprise has no full effect from the innovation.

P2:D3. Situation of "stabilising" occurs under conditions of high market demand for the products of the enterprise. The company has limited innovation potential, so is eager to hold on the popular market segments. Strategy of stabilizing the position does not provide for the introduction of integrated innovation projects.

P3:D1. Diversification inter-departmental – occurs in situations of high innovative potential of water economy enterprises with the low demand for its products. In these conditions, enterprises make valuable diversification, turning to release products for other industries with a large-scale innovative conversion.

P3:D2. In a situation of "improving" the innovative potential allows focusing on product innovation at the expense of technical updates, improving its quality, extending the range with the aim of increasing market demand.

P3:D3. "Welfare" situation allows the enterprise to realize large-scale innovative activities. Its field is very large for such enterprises due to the selection of the various strategic alternatives. Development strategy envisages either independent research or funding for this aim specialized scientific and research institutions.

So, optimal development of enterprises can be the following:

1) development and implementation of measures to increase own innovative potential of water economy enterprises in which it is at a low level;

2) directing the innovation activity on the implementation of measures related to the increasing market demand for products - for water economy enterprises, with low market demand.

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## CORRELATION ANALYSIS OF PHOSPHORUS CONCENTRATION TIME SERIES FOR BUG RIVER WATER BODY

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The high content of phosphorus compounds in natural and waste waters is now one of the main environmental problems of the European Union and Ukraine, problems of its monitoring, mathematical modeling of spatial and temporal dynamics of migration in natural systems and the transition from one form into another is the prospect of research in this field [1, 3].

Western Bug River belongs to the Baltic Sea basin and to the main Transboundary Watercourses between Ukraine and European countries. That's why this object is of increased interest of the representatives of practical and theoretical ecology in Ukraine and abroad [2].

The processes of accumulation of phosphorus and nitrogen compounds group (nitrites, nitrates and ammonium salt) lead to the manifestation of one of the most environmentally hazardous natural phenomena man - eutrophication of water bodies as process of water nutrient enrichment, which stimulates the growth of phytoplankton [3]. Eutrophication is primarily a problem of standing fresh and marine waters. So according to the Swedish Environmental Protection Agency (Swedish Environmental Protection Agency, SEPA) in 2005 were observed significant algal blooms in the Baltic Sea. To date, SEPA and other environmental organizations are conducting intensive and thorough knowledge of discharges of nitrogen and phosphorus compounds, and their impact on the ecological status of waters of the Baltic. On the other hand, accumulation in natural waters of some compounds, particularly compounds of phosphorus (adverse effect on the human body is basically proved) makes a danger to human populations.

Water pollution in the Ukrainian part of the Western Bug River, Baltic Sea and Lake Zehzhynske, which is the source of water supply for the capital of Poland - a major modern environmental problem in Europe, not directly related to phosphoric regime of the Western Bug River [1].

There are 21 water treatment facilities in the Western Bug basin, which state deemed unsatisfactory. Four of them are located in the Volyn region, and seventeen in Lviv. These treatment plants do not carry out an effective treatment even according to Ukrainian quality standards, not to mention the requirements of the Water Framework Directive.

**Correlation analysis of time series:**

The correlation analysis of time series of phosphate concentration was conducted according to hydrochemical monitoring provided by the Western Bug river basin management in order to study the basic patterns of phosphorus, the water regime Bug. Initially, we used analysis of the nature of phosphates fluctuations only even values of the correlation coefficient between the levels series, which certainly can not be perfect and complete. The main results are presented in two tables - the correlation matrix (Table 1) and analytical table (Table 2).

Table 1

Correlation matrix for time series of phosphates in Western Bug river

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | | | | | | | | | |
| 2 | 0.66 | 1.00 | | | | | | | | |
| 3 | 0.54 | 0.61 | 1.00 | | | | | | | |
| 4 | 0.31 | 0.54 | **0.79** | 1.00 | | | | | | |
| 5 | -0.36 | -0.22 | 0.30 | 0.47 | 1.00 | | | | | |
| 6 | ***0.67*** | ***0.78*** | ***0.73*** | ***0.70*** | 0.04 | 1.00 | | | | |
| 7 | 0.66 | 0.66 | 0.47 | 0.37 | -0.13 | **0.86** | 1.00 | | | |
| 8 | ***0.70*** | ***0.81*** | ***0.75*** | ***0.61*** | -0.09 | ***0.77*** | ***0.83*** | 1.00 | | |
| 9 | 0.56 | 0.41 | **0.87** | 0.53 | -0.07 | **0.72** | 0.59 | 0.56 | 1.00 | |
| 10 | 0.51 | 0.07 | 0.45 | 0.34 | -0.09 | 0.50 | 0.57 | 0.32 | **0.98** | 1.00 |

Note: The numbers of posts set in the direction from source to mouth, see the Table. 2. Value allocated substantial and significant correlation.

As the correlation matrix, only few rows can be considered correlated. Among the distinguished ranks for post number 3 (Sokal) and number 4 (v. Lytovezh), № 6 (v. Ambukiv below, the Huchva) and number 7 (Ustilug city above, the Grasslands), № 9 (v. Novouhruzke) and number 10 (Zabuzzya village) to high (up to 0.98) correlation coefficients, which seems logical, as mentioned areas are contiguous. On the other hand, the 10-year series of observations in the widths of number 9 (v. Novouhruzke), for unknown reasons by now that closely correlate with the remote from them geographically ranks number 3 and number 6. Another interesting fact arises obviously (see Table 1). Data obtained in widths of number 6 (v. Ambukiv below the confluence, the Huchva) and number 8 (Ustilug city below the confluence, the Meadows) is closely correlated with all rows except row number 5 (v. Ambukiv above the confluence, the Huchva). We can assume that this situation reflects the fact that the river Luga and Huchava likely are typical in the Western Bug basin on the flow of phosphates, and plot to take water, the Suceava (post number 5) is the ultimate in upper part of the basin Bug, and therefore unique. In general the data statement needs clarification and verification during special studies. Also found pattern dynamics for the widths of 6 and 8 are extremely important because it creates conditions for the operational control of phosphorus hydrochemical regime of the Western Bug basin with possible adjustment of the monitoring program in the basin, but also opens new perspectives of mathematical modeling (especially statistical) phosphate runoff. Table 2 presents the analysis of correlation between time series of dynamic content phosphate conjugate areas of the Western Bug.

Table 2

Analysis of correlation between time series dynamic content phosphate conjugate areas of the Western Bug

| № | Post | Length of series | Distance from the mouth, km | $k$ | $k_z$ |
|---|---|---|---|---|---|
| 1 | Kamyanka Buzka city | 25 | 704 | 0.67 | 0.51 |
| 2 | Dobrotvorsky reservoir. (downstream) | 25 | 689 | 0.62 | 0.07 |
| 3 | Sokal city (downstream) | 9 | 637 | 0.79 | 0.45 |
| 4 | village Lytovezh | 15 | 631 | 0.47 | 0.34 |
| 5 | village Ambukiv (upstream river Huchva) | 11 | 585 | 0.04 | 0.09 |

| | | | | | |
|---|---|---|---|---|---|
| 6 | village Ambukiv (downstream river Huchva) | 15 | 584 | 0.86 | 0.50 |
| 7 | Ustilug city (upstream river Luga) | 10 | 570 | 0.96 | 0.57 |
| 8 | Ustilug city (downstream river Luga) | 10 | 569 | 0.56 | 0.32 |
| 9 | village Novouhruzke | 10 | 483 | 0.98 | 0.98 |
| 10 | village Zabuzzya | 25 | 468 | | 1 |

Note: k – coefficient of correlation between numbers obtained in the relevant and the next upstream post; $k_z$ – coefficient of correlation between this number and the number Zabuzzya village.

**General conclusions:**

1. These hydrochemical monitoring of surface waters in the basin of the Western Bug is a source of reliable information on the ecological condition of streams and pools in general.

2. The availability of flow of the river reservoirs (reservoirs, ponds, lakes, etc.) makes a positive impact on the treatment of surface water from surplus phosphorus compounds. Significant impact on the phosphorus mode waters Bug of Dobrotvorsky and Sokal reservoirs, which act as filters and effects to be simulated and investigated.

3. The concentration of phosphate in the waters of the Western Bug River decreases downstream due to activation of self-purification processes in aquatic ecosystems.

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## THE HYDRAULIC PLANE FLUME PROBLEM'S SIMULATION

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**The actuality** of this work is evident from the fact that there are many practical problems that require plane currents calculations, for example - in the theory of river-bed processes, in many fields of hydro engineering, also in many other cases.

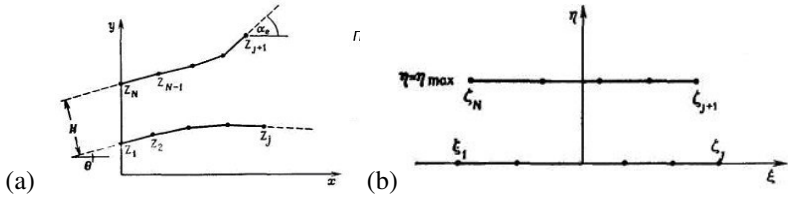
**Scientific novelty** of this work is that hydrodynamic grid (HG) was built for the channel of complex geometrical form with sufficient accuracy taking into account the geometric shape of the channel in plane and also in its cross-section.

The method of conformal mappings can recreate HG and correspondent flow that occurs in the region of any geometry. Let's imagine river-bed of rectangular form typical for real rivers. We'll try to use the method of conformal mappings in order to solve the problem of some canonical region (upper half-plane) transformation in the interior of an arbitrary polygon. This method can be applied if the flow within this river is potential (without separation zones and also essential screw torrents and vortices). The well-known Schwarz–Christoffel mapping is one of conformal transformations of the upper half-plane in the interior of a simple polygon.

Applying Christoffel-Schwarz integral we'll try to describe transformation of the channel given in the plane $Z$ to the plane $W$. It has the form

$$\frac{dZ}{dw} = \frac{M}{w}\left(\prod_{j=1}^{N}(w-b_j)^{-\alpha_j/\pi}\right)w^{-\alpha_e/\pi} \quad . \tag{1}$$

where $\alpha_j$ – angles of rotation during the transition from each angular point to another (in counterclockwise direction), $b_j$ – unknown position points beyond on the real axis in converted the plane, three values $b_j$ can be selected arbitrarily.




(a) (b)

Fig 1. Schemes for the real river-bed (a) and transformed rectangular domain (b)

Two subsequent transformations are to be performed. It should make first transformation which regards the first (lower) boundary of river-bed, then a second one, which transforms the upper half-plane into the plane sub-domain of a straight channel parallel to the real axis in the (Fig. 1b) Practical calculations [1] are to be performed by the expression (2)

$$\frac{Z_{k+1}-Z_k}{\zeta_{k+1}-\zeta_k}=\frac{-\pi M}{w_{k+\frac{1}{2}}^{\alpha_e/\pi}}\prod_{j=1}^{N}\frac{(w_{k+1}-b_j)^{1-\alpha_j/\pi}-(w_k-b_j)^{1-\alpha_j/\pi}}{(1-\alpha_j/\pi)(w_{k+1}-w_k)}. \qquad (2)$$

Note that the potential flow in the channel determined by the expression the complex potential

$$\varphi+i\psi=\zeta, \qquad (3)$$

where $\varphi$ – flow velocity potential, $\psi$ – flume function and module of velocities is equal to one.

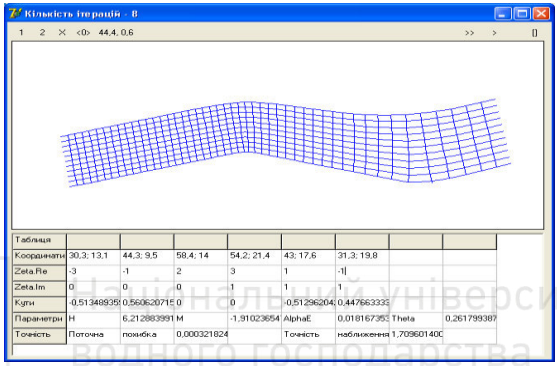



Fig 2. The scheme of river-bed plane with HG showing flow character

The flow character, equal potentials (isolines of $\varphi$) – and stream functions $\psi$, are shown in Fig 2.

Considering real bed form in any cross section is to be done in two ways:
the first way is the simplified hydraulic method, and the second – the simulating one. Approximate method involves well known Shezy formulas of hydraulic resistance [2]:

$$v=C\sqrt{R\cdot I};\quad Q=v\cdot\omega,\ R=\frac{\omega}{\chi},\ C=\frac{1}{n}R^{y}$$

$$y=-0{,}13+2{,}5\cdot n^{0,5}-0{,}75\cdot\left(n^{0,5}-0{,}1\right)\cdot R^{0,5} \qquad (4)$$

To consider the cross-sectional shape of the channel one may use the known approximate method by Velikanov MA.[1]. The idea of it is that the traditional equation Shezi and all formulae (4) are to be used to any vertical of this cross-section. Let $b$ be a cross-sectional coordinate, then using the above idea:

$$v(b)=C(b)\sqrt{R(b)\cdot I};\quad dQ=v(b)\cdot d\omega.$$

$$R(b) = \frac{d\omega(b)}{d\chi} = \frac{h(b)\cdot db}{d\chi} = \frac{h(b)}{\sqrt{1+\left(\frac{dh}{db}\right)^2}} \qquad \chi = \int_0^B \sqrt{1+\left(\frac{dh}{db}\right)^2}\, db \qquad (5)$$

So, formulae are obtained to calculate velocities *v* and discharges *Q (b)* as functions with b [1].

Another one is the simulating method which uses the idea of marker cells (or knots) moving with the averaged flow, effluation of Brownian particles from each knot and estimation of hydraulic resistance in any local zone of flume with their density. The intensity of Brownian particles diffusion regulates with the given approximate information of the turbulence level.

Simulating process and local turbulence structure setting are equivalent to those described at [3]. So, two-phase flow imitating process includes previous approximate approach to autocorrelation functions and also to distribution of pulsating velocities character and so is the density field. The second step of such imitation is more exact approximation. Thus, the stable, convergent and convenient instrument is achieved to predict two-phase flow modeling.

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## INVESTMENT AND INNOVATION PROCESSES IN THE WATER COMPLEX

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The development of innovation and widespread use of innovative developments must be made foremost in those areas and sectors of the economics that produce consumer goods and provide productive or non-productive services. However, almost everything depends, on the one hand, on economic and investment policy of

the State and behavior of subjects of economic activity, the volume and structure of investment, opportunity to concentrate them on the most recent and effective prior areas and on the other from the stability of the political, socio-economic situation and a favourable investment climate in the country. Difficult financial-economic and social situation of the water complex of Ukraine, despite his prior socio-economic and strategic importance for the development of the society, stimulates subjects of entrepreneurial activity to invest costs in its innovative development [1].

Subjects of the investment process in the water complex can be either State, or agricultural enterprises, domestic and foreign investors, investment and venture funds, private pension funds, leasing companies, insurance companies, and other legal and physical persons, etc. During the current economic situation of the country, the State budget is unable to finance the considerable costs in scientific development. To create a market of innovative products in the water complex, we need to establish a system of legal, organizational and financial-economic mechanisms to regulate the relationships between the producers of scientific-technical and innovative products and its customers in all branches and sectors of this complex.

While reforming the economic mechanism of stimulation of investment and innovation processes in the water complex of Ukraine is appropriate, firstly, to make the necessary changes in the already existing methodology base of economic instruments, secondly, to introduce new, more efficient water use regulators [2]. Economic mechanism of stimulating the innovations in water complex should provide incentive funding tools and instruments of scientific developments. Tools of stimulation the implementation of innovations are realized by using the following levers as: payments for the use of water resources; payments for dumping pollutants; fines for environmental violations; ecological tax; quotas on pollution. For the purpose of economic stimulation of investment in innovation activities of water protective measures, organizing sources of their financing and lending and reimbursement of national economic losses, caused as a result of pollution of surface waters, as well as underground horizons. Important value has the application fee for dumping pollutants in aquatic objects. This should increase the size of the rate of payment for the use of pollutants in the manufacturing process, which is particularly harmful to the health of the population. A rate payment for pollution, differentiated on the toxicity of pollutants or their potential environmental hazards also require review.

Tools of financing the innovative water management projects will be performed by: payments of ecological funds; the system of environmental benefits; the system of soft loans; state financing of investment projects of basin; payment for ecosystem services; environmental insurance.

According to the economic conditions prevailing today, the role of environmental funds is exacerbated as quite reliable off-budget source of accumulation and use of costs for investment and innovative nature conservative

needs, which are formed on the enterprises due to the introduction of elements of concessional lending.

Conclusions: activity of the water industry in modern conditions should be based on ecological and economic principles, namely resource economy, resource saving and resource recovery of water potential of the country. Thanks to a combination of innovation and investment activity, the growth of investment in modern innovative technologies and the production of innovative environmental products should take place. Namely environmental innovations should be seen as the most important precondition for efficient and sustainable development of the water complex of Ukraine. The reformed system of water management based on environmental innovation, will ensure the improvement of social living conditions and state water supply in general, and reduce losses from adverse effects of the harmful effects of polluted waters.

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## HYDRAULIC REGIMES IN THE UPPER RESERVOIR OF DNIESTER PSP AND THEIR FIELD RESEARCH

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The operation, reliability and safety of hydropower objects are closely related to the different conditions of their work, including hydraulic regimes. The pumped storage power station has two characteristic modes: pump (filling the upper reservoir in times of power load failure) and turbine operation (emptying the reservoir in times of peak loading). A specific feature of operation PSP reservoirs in comparison to reservoirs HPS is more intense mode of their use. This is a

regular periodic change of the main hydrophysical fields (level of the surface and flow velocity) by changing operating modes. Therefore both in the design stage of the object, and in the stages of its construction and operation it is very important to understand the dynamics of processes in the reservoir. The special case is critical modes with possible catastrophic consequences: the overflowed reservoir, water overflow through the dam as a result of wave processes, washout of the bottom, etc.

It is necessary to take into account the parameters of wave's movement when specifying the marks of pressure front crest and protecting water receptacles structures of the upper reservoir and forebay, selecting the type and size of fixture slopes, designing strength and stability of buildings [1].

Methods of numerical calculations of the free surface outlines of flow are based on solving one-dimensional and two-dimensional Saint Venan equations, three-dimensional Reynolds equations in the hydrostatic approximation. In solving the problem are used the original numerical algorithms, adaptive three-and four square meshes. This problem is very complicated because it takes into account the parameters of working units, depth and configuration of a particular reservoir, many other existing factors and correction factors.

The geometry of the upper reservoir PSP (Fig. 1) is characterized by considerable excess of its horizontal size over the vertical one. It stretches along one of the horizontal direction and has a low change of field depths. During calculations reservoir is broken into separate sections. Other important parameter of calculations is a process time which is set by the duration of the filling and wear-out of the reservoir. It is important to take into account the geometry of the enclosure dam and dynamics of the free surface [2, 3].

The elongation of the reservoir allows at the previous stage to carry out calculations for one-dimensional model of Saint Venan It has a higher degree of hierarchy of approximate hydraulic models and allows in one-dimensional statement to take into account the effects of changing the width of the channel.

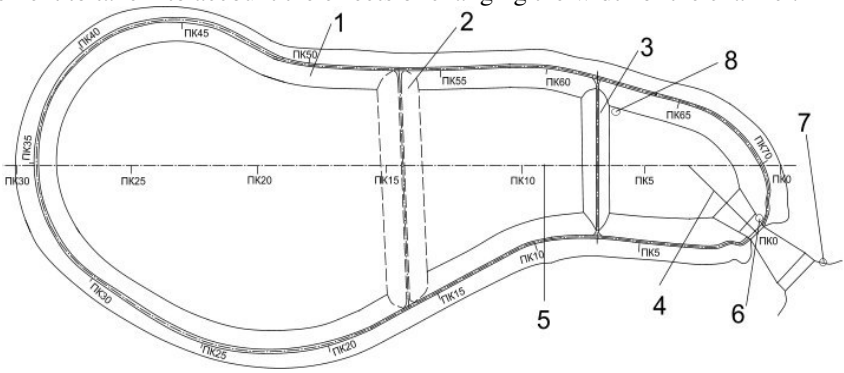


Figure 1. Stages of construction of the upper reservoir of the Dniester PSP:
1 – enclosing dam, 2 – temporary dam at the PC-15,

3 – temporary dam at the PC-7, 4 – axle of water intake, 5 – axis of reservoir, 6 - location of existing pressure sensor in the upper stream, 7 - location of existing pressure sensor in downstream, 8 – location to install additional pressure sensor in the upper reservoir

The conditions imposed on the model:

• cross components of velocity are low in comparing to longitudinal, centrifugal effect not taken into account;

• low river bottom gradients;

• it is considered that the total effect of friction and turbulence can be taken into account as some power of resistance.

Under these conditions equation Saint Venan takes the form [3, 4]:

$$\begin{cases} \dfrac{\partial Q}{\partial t} + \dfrac{\partial}{\partial x}\left(\alpha \dfrac{Q^2}{A}\right) + gA\dfrac{\partial \eta}{\partial x} + g\dfrac{Q|Q|}{C^2 AR} - vq\cos\varphi = 0, \\ \dfrac{\partial A}{\partial t} + \dfrac{\partial Q}{\partial x} = q, \end{cases} \quad (1)$$

where $A$ – cross sectional area, Q – consumption, $\alpha$ – Bussineska coefficient, C – Shezi coefficient.

In a more complete statement, the problem can be considered in three-dimensional form of the potential motion of an ideal fluid with free surface. This task is to determine the potential speed and function, describing the free surface.

The nature research of the condition of wave regime in the basin includes installing hydrometric posts in places where the regime of water levels can have special features.

In conditions of the basin of the Dniester PSP were analyzed next three variants of water gauge devices: as a sloping rail posts that are placed on the basin slope, in a vertical rail posts held by special beams, as a pressure sensor.

The first two versions have major drawbacks associated with both the terms of the accuracy of measurements and the conditions of the ice regime in the reservoir. It can interfere with the accuracy of research results, and destruction of beams, which keeps the rail in the vertical position.

During the test of the upper reservoir of the Dniester PSP at working unit number 1 in the turbine and pump modes are found wave movement. The most pronounced they were in the pump mode and in marks close to the NDP. The largest wave of movement was recorded at a stopped unit in pump mode. It was found that this oscillatory process is damped and has a long time. At the time of the stopped unit wave height was about 22 centimetres, which was measured by pressure sensor, located on the left riser forebay. The location of this sensor in the riser allows to measure hydrodynamic pressure without consideration of wind processes and reduction of the irregularity distribution of velocities and pressures. We can assume that the waves in the reservoir is higher are result of the imposition of wind along the reservoir [4].

In conditions of intensive construction of PSP the question of calculations of outlines of free surface flow in the upper reservoir and the outlet channel during the work of these stations in the pump and turbine modes is very important. Existing models in most cases are true in specific spaces. To improve the reliability of such calculations and designing appropriate structures of special importance is the research of basic characteristics of flow in the pump and turbine modes of PSP at existing objects in the natural environment.

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## FINANCIAL ECONOMIC ASPECTS OF INNOVATION DEVELOPMENT OF WATER MANAGEMENT COMPLEX OF UKRAINE

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The present-day economic development of any country is impossible without investments and innovation. Unfortunately, unfavourable investment climate remains for Ukraine. During 20 years water management complex of the country is actually declining. In general, investment innovation development of Ukraine is determined on the part of scientists, politicians and authorities.

On the background of the country's negative innovation investment component a number of research studies have been presented. However, the investment innovation component in water management sphere is investigated comparatively less than in other branches of Ukrainian economy.

Among foreign scientists research results in this direction are rather substantial. Let us point out M. Li [1], O. Zurabov, V. Samasyuk [2]. Ukrainian scientist M. Kozishkurt, M. Romashenko and V. Bezruk [3] pay their attention mainly to the

problem of modernizing drainage-irrigation system and to the automation of sprinkling irrigation.

Thus, the innovation aspects of water management are being worked out, but only in a narrow, predominantly technical direction. Besides, in amelioration the strategic vector is the modernization of present-day acting ameliorative schemes. There, the research objective is the economic characteristics of innovation investment aspects of development of Ukrainian water economy and the evaluation of its development potential.

The problem of the innovation development of water economy is under the guidance of the government, in 2009, respectively "General state purpose-oriented programme of water management development for the period up to 2020" had been adapted. It is necessary to stress, however, that since 2002 "General state purpose-oriented programme of water management development up to 2011" was being effected bur there had been no cardinal improvement of the condition of Ukrainian water resources and of the drinking water quality because of the insufficient purpose-oriented state financing. Analysing the next Programme up to 2020 we should point out that the optimal variant for the development of state water management policy in this branch which should be oriented, first of all, at improving the mechanism of state control of water management complex.

The financing of this Programme is traditional as in the previous one, that is, from all and from everything a little for water management complex. Thus, no clear-cut sum and no day-today volume of financing have been determined, and, respectively, the efficiency of the adopted Programme will be equal to the previous one with high probability.

In this period very actively are loans borrowed from the International Bank of Reconstruction and Development. First off all, these loans are directed at large megalopolises: Kyiv, Lviv, Donetsk, Zaporizhzhya. In general, during 2012 it is envisaged to attract 400 mln. dollars USA for developing the Programme of housing and communal services of Ukraine [4].

Thus at present the investment innovation component for developing the Ukrainian water economy is primarily directed at attracting bank credits and searching for a foreign investors [5]. However, the state financing is oriented predominantly at protective economic measures. And the result of this policy is the gradual price-raising for rates in water supply ad water disposal without significant improvement of the quality of services.

Unfortunately, in Ukraine no costs are allowed for carrying out fundamental studies in water management complex. It is necessary to form the innovation park by the principle of business-incubator. That is, to provide for the respective infrastructure, conditions, laboratories, probably on the bases of some leading water management institutes, here the state budget should cover expenses for communal services, electric power and the upkeep of infrastructure itself, and the legislation guarantees the creation of tax-free zone. Only at the cardinal solution is possible of protracted «chronical» problem of Ukrainian water economy which will

lead to price-lowering of corresponding services and to providing for their mass and large-scale introduction.

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## ADEQUACY OF CALCULATIONS OF GRADUALLY-VARIED FLOW PROFILE BY THE KRISENKOFF'S METHOD

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In the paper [1] was present analytical method of computation of a gradually-varied-flow profile offered by N.I Krisenkoff [2]. In this article different ways of computations compares with Krisenkoff's method for the example 10-7 from [3]. A trapezoidal channel having width $b$=6,096 m (20 *ft*), section factor $Z$=2, channel bottom slope $i$=0,0016, roughness $n$=0,025 carries a discharge $Q$= 11,32674 $m^3/s$ (400 $ft^3/s$). The backwater profile created by a dam computes by direct step method (another named Charnomsky's method), Bakhmeteff's method and Krisenkoff's method.

A Charnomsky's method (direct step method) is characterized by dividing the channel into short reaches and carrying the computation step by step from one end of the reach to the other. By Bakhmeteff's method and Krisenkoff's methods, the length of flow profile consider between two consecutive sections 1 and 2.

The results of flow profile computation are consists in table 1.

Table 1

Coordinates of the M1 flow profile computed by the Charnomsky's, Bakhmeteff's

and Krisenkoff's methods for example 10-7 from [3].

| Depth | | Length $L$ | | | |
|---|---|---|---|---|---|
| | | by Charnomsky | | by Bakhmeteff | by Krisenkoff |
| $h$, ft | $h$, m | $L_{Ch}$, ft | $L_{Ch}$, m | $L_B$, m | $L_K$, m |
| 5 | 1,524 | 0 | 0 | 0 | 0 |
| 4,8 | 1,46304 | 155,245064 | 47,3186955 | 47,184709 | 47,2244487 |
| 4,6 | 1,40208 | 317,8340914 | 96,8758311 | 97,894385 | 96,9263997 |
| 4,4 | 1,34112 | 490,6692002 | 149,555972 | 149,632057 | 146,841307 |
| 4,2 | 1,28016 | 678,5513322 | 206,822446 | 207,051948 | 201,143064 |
| 4 | 1,2192 | 890,2460326 | 271,346991 | 271,710064 | 260,709484 |
| 3,8 | 1,15824 | 1144,394534 | 348,811454 | 349,323562 | 329,762828 |
| 3,7 | 1,12776 | 1300,859607 | 396,502008 | 397,101227 | 370,901305 |
| 3,6 | 1,09728 | 1494,842979 | 455,62814 | 456,447155 | 420,622917 |
| 3,55 | 1,08204 | 1616,782676 | 492,79536 | 493,711805 | 451,16265 |
| 3,5 | 1,0668 | 1768,11857 | 538,92254 | 540,002579 | 488,596324 |
| 3,47 | 1,057656 | 1882,730419 | 573,856232 | 574,782488 | 516,648825 |
| 3,44 | 1,048512 | 2028,027123 | 618,142667 | 618,092049 | 552,206991 |
| 3,42 | 1,042416 | 2154,516035 | 656,696488 | 654,102799 | 583,285047 |
| 3,4 | 1,03632 | 2324,599456 | 708,537914 | 698,620231 | 626,014993 |

The flow profiles thus computed are practically identical with that obtained by Chow (table10-4, p. 264 [3]). The difference of calculation results by Charnomsky's method (direct step method) can be explained the computer calculation accuracy.

Check of adequacy of mathematical model of N.I.Krisenkoff to data of mathematical models of Charnomsky and Bakhmeteff is carried out by the *F-tests.* Here the F-test in one-way analysis of variance is used to estimate, whether the expected values of a quantitative variable within several predetermined groups differ from each other. In my case the ANOVA (analysis of variance) F-test can be used to assess whether any of the mathematical models is on average superior, or inferior, to the others versus the null hypothesis that all three models yield the same mean response. This is an "omnibus" test, meaning that a single test is performed to detect any of several possible differences. If the F-test is performed at level $\alpha$=0,05 I can state that the Krisenkoff's analytical method is adequate to others authors methods.

The coordinates of M1 flow profile computed by the three mathematical models in the thirteen sections selected according to data computed by Krisenkoff's method are considered for the ANOVA F-test (fig.).

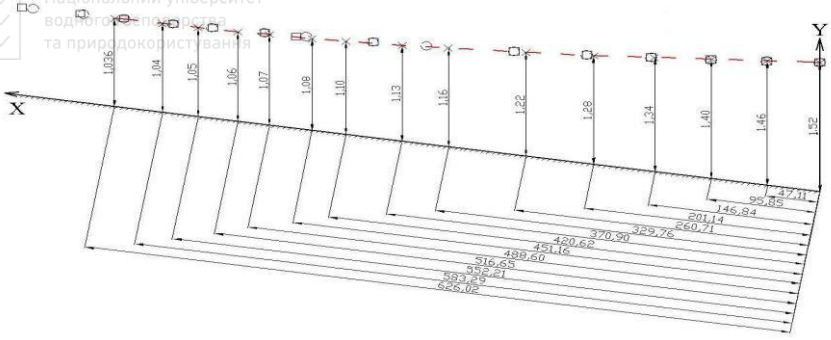


Fig. An M1 flow profile computed by the different methods:
□ — by Charnomsky's method; ○ — by Bakhmeteff's method;
-×- — by Krisenkoff's method

The formula for the one-way ANOVA F-test statistic is

$$F = \frac{explained variance}{unexplaind\ variance} \quad or \quad F = \frac{between\text{-}group variability}{within\text{-}group variability} = \frac{MS_b}{MS_w}, \qquad (1)$$

were the "explained variance", or "between-group variability" is

$$S_b = \sum_{i=1}^{n} n_j \left( \bar{h}_j - \bar{\bar{h}} \right)^2 \Big/ \left( k - 1 \right) \qquad (2)$$

and the "unexplained variance", or "within-group variability" is

$$S_w = \sum_{i=1}^{n} \sum_{j=1}^{k} \left( h_{ij} - \bar{h}_j \right)^2 \Big/ \left( n - k \right). \qquad (3)$$

Follow designations denotes: $\bar{h}_j$ is the sample mean in the $j^{th}$ group of each method data, $n_i$ is the number of coordinates of free surface profile in the $j^{th}$ group, and $\bar{\bar{h}}$ is the overall mean of the data; $h_{ij}$ is the $i^{th}$ coordinate in the $j^{th}$ out of $k$ groups and $n$ is the overall sample size. This *F-ratio* (6) follows the *F-distribution* with $k-1$, $n-k$ degrees of freedom under the null hypothesis.
The data of *F-ratio* computation are consists in table 2.

Table 2

Computation of *F-ratio* for the three mathematical models

| Length $L$ № *section*/ $L_K$, m | | Depth $h_{ij}$ | | | $\left( h_{ij} - \bar{h}_j \right)^2 \times 10^{-2}$ | | | $\sum_{j=1}^{k} \left( h_{ij} - \bar{h}_j \right)^2 \times 10^{-2}$ |
|---|---|---|---|---|---|---|---|---|
| | | by Charnomsky | by Bakhmeteff | by Krisenkoff | | | | |
| 1 | 0 | 1,524000 | 1,524000 | 1,524000 | 9,301228 | 9,292461 | 9,897723 | 28,491412 |
| 2 | 47,244 | 1,463159 | 1,462854 | 1,462905 | 5,960344 | 5,938452 | 6,426806 | 18,325602 |
| 3 | 96,9264 | 1,402020 | 1,401919 | 1,400765 | 3,348869 | 3,339917 | 3,662304 | 10,351089 |
| 4 | 150,2664 | 1,340330 | 1,340415 | 1,337145 | 1,471591 | 1,470166 | 1,632044 | 4,573800 |
| 5 | 208,4832 | 1,278636 | 1,278718 | 1,272286 | 0,355397 | 0,354661 | 0,395546 | 1,105603 |
| 6 | 273,7104 | 1,217141 | 1,217456 | 1,206861 | 0,000353 | 0,000292 | 0,000641 | 0,001287 |
| 7 | 352,044 | 1,156029 | 1,156359 | 1,141155 | 0,396797 | 0,394455 | 0,465650 | 1,256902 |
| 8 | 400,5072 | 1,125440 | 1,125793 | 1,108759 | 0,875737 | 0,871826 | 1,012731 | 2,760294 |
| 9 | 461,772 | 1,094536 | 1,094926 | 1,077347 | 1,549648 | 1,543523 | 1,743629 | 4,836800 |
| 10 | 500,1768 | 1,079327 | 1,079678 | 1,062802 | 1,951437 | 1,945652 | 2,148908 | 6,045997 |
| 11 | 547,7256 | 1,064284 | 1,064613 | 1,049528 | 2,394349 | 2,388620 | 2,555699 | 7,338668 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 12 | 584,3016 | 1,055251 | 1,055451 | 1,042243 | 2,682056 | 2,680215 | 2,793930 | 8,156201 |
| 13 | 626,015 | 1,047118 | 1,046958 | 1,036320 | 2,955059 | 2,965512 | 2,995445 | 8,916016 |
| Σ | | 1,219021 | 1,219165 | 1,209394 | 33,242866 | 33,185750 | 35,731055 | 102,159671 |

The overall mean of the data is $\overline{\overline{h}}$ =(1,219021+ 1,219165+ +1,209394)/3=1,215860.

The between-group degrees of freedom is one less than the number of groups $f_b$=3-1=2 and the within-group degrees of freedom is $f_b$=k(n-1)=3(13-1)=36. According to (7), the "between-group" sum of squares is $S_b$=13*(1,219021-1,215860)$^2$ + 13*(1,219165-1,215860)$^2$ + 13*(1,209394-1,215860)$^2$ = 0,00815445. So the between-group mean square value is $MS_b=S_b/f_b$=0,00815445/2=0,000407723. At last the within-group mean square value is $MS_w=S_w/f_w$=1,0215967/36=0,0273777 and the F-ratio is $F= MS_b / MS_w$= =0,000407723/0,0273777=0,0144.

The critical value is $F_{crit}(f_b, f_w)=F_{crit}(2,36)$ = 3,259 at α = 0,05. In this computation $F$ = 0,0144 < 3,254, the results are significant at the 5% significance level. It is possible to accept the null hypothesis, concluding that there is strong evidence that the expected values in the three groups of M1 flow profile coordinate are equal.

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## ECONOMIC EFFICIENCY OF THE ECOSYSTEMS FUNCTIONS OF BIODIVERSITY

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*Actuality of the work.* The maintenance of biodiversity is pre-condition of the biosphere's sustainable state that forms the necessary terms of human physical existence on Earth and socio-economic system's functioning. Biodiversity is the major component that forms the productivity and efficiency of economic systems functioning. Because the economic efficiency estimation of biodiversity's ecosystems functions is the main objective of these investigations.

*Formulation of a problem.* Maintenance of biodiversity is a result from the action of economic mechanism that provides functioning of the socio-economic system. Biodiversity determines quantitative and quality composition of ecosystems, predetermines pre-conditions of biosphere's firmness. For example, bogs clear water, the forests product oxygen for maintenance of vital human functions, plants used as medications. It shows that functioning of ecosystems is

productive and economically advantageous for society. However, the economic evaluation of ecosystems functioning efficiency is conducted. Such natural value of ecosystems must be taken into account in the national accounts of every state. It is defined the necessity of realization of this research.

*Main part.* The main of biodiversity's maintenance methods are presented in Figure 1.

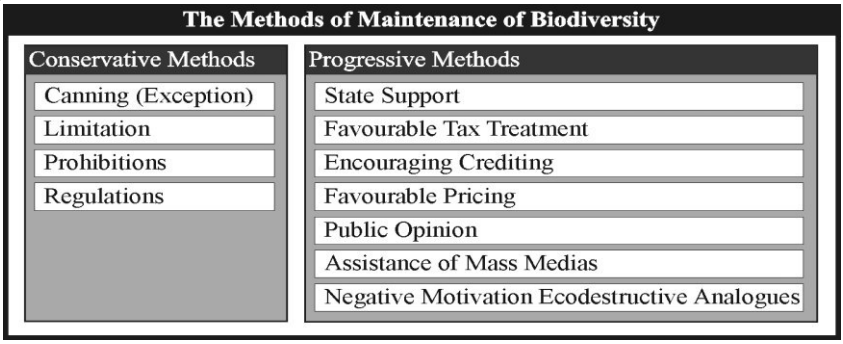


Figure 1. The main of biodiversity's maintenance methods

The role of biovariety in development of the economic systems is determined after few directions:

1) biodiversity is the productive factor of a number of industries of economy, in particular rural and forest economy. Among similar functions – pollination of agricultural and wild plants, elimination of organic wastes, decomposition of chemical contaminations, water and soil treatment;

2) components of biodiversity are the means of defence of bioproductive factors of the economic systems. For example, one gene of the Ethiopian barley protects now from a yellow midget virus the harvest of all Californian barley by a cost in 1160 million dollars of the USA in a year;

3) biodiversity is the source of facilities of defence of human health. Pharmaceutical facilities are created or directly from the logical substance of plants and animals, or informative principles adopt them. In 1960 for children that suffered on leukemia, was only one of five chances to survive. On this time such patients children have four chances from five due to treatment medicinal facilities that contain the active substances of pink periwinkle that meets in the tropical forests of Madagascar. The cost of medications that is produced in the world from plants and natural foods makes about 40 milliards of dollars every year;

4) biodiversity is the information (ideas, know-how) generator for the improvement of the productive systems. Wild-life was and remains a huge informative resource, from where a man ladles ideas for creation of mechanisms, machines, productive processes, building constructions.

Having regard to all the stated higher the estimation of the productivity of forest and bog ecosystems has been conducted in this work. The main results of research have been presented in Table 1.

Table 1

Economic Efficiency of Estimation of the Productivity of Forests and Bogs

| № | Name of index | Result of calculation | | Together |
|---|---|---|---|---|
| | | Forest ecosystems | Weatlands ecosystems | |
| 1. | Economic effect from economy on acquisition of industrial cleansing options due to natural water treatment, million dollars | - | 85.8 | 85.8 |
| 2. | Producting of oxygen, million tons | 52.78 | 7.05 | 59.83 |
| 3. | Quantity of persons, vital functions of that provided by oxygen, million persons | 130 | 17 | 147 |
| 4. | An economic effect from cleaning of atmosphere, million dollars | 1583.4 | 211.5 | 1794.9 |
| 5. | A total economic effect from the natural functioning of ecosystems, million dollars | - | - | 1880.7 |
| 6. | Economic effect of functioning in a calculation on 1 hectare, dollars | 150 | 316.3 | 466.3 |
| 7. | A stake of natural capital is comparatively with the state budget, % | 4.4 | 0.6 | 5.2 |

*Conclusions.* In the process of research author came to such conclusions and produced such recommendations:

1) The biodiversity must get an adequate economic evaluation with the aim of reflection in GDP of the state, as national riches. After the conducted calculations the economic evaluation of functioning of the forests and bogs of Ukraine presents over 1.88 milliards dollars USA (2 % GDP, 5 % state budget). The economic account of these functions of biodiversity in GDP will allow forming in Ukraine the market of ecosystem services and to attract foreign investments in realization of nature protection activity.

2) The reflection of biodiversity economic efficiency in the national accounts of the state and taking into account of ecosystems services would allow to restructure external debt of Ukraine (104 milliards of dollars USA) during 15-20 years.

3) It is necessary to support functioning of forest and bog arrays of Ukraine in the natural state. Occupying only 19.1 % territories of the state one hectare of bogs brings for society blessing in a size over 316 dollars, forest – 150 dollars (does not take into account collection of side foods of the forest and medical plants).

4) The economic return of ecosystems in 9.4 times more than the public combined annual budgetary investments are in conservancy. Charges on maintenance of biodiversity must be distinguished by a separate line in the state budget.

5) To support bogs in the natural state. Important is a function of bog ecosystems as natural water filter, as society does not even begin to think, that due to it annually saves on establishment of water-purifying options to the amount of over 85 million dollars. It is besides impossible to take into account all ecological and social functions of forest and bog ecosystems economically, in particular it touches the amateur fishing, sporting hunt, rest, recreation, collection of medical plants, and also side foods. All of it is solid arguments in the reflection of ecological social economic value of functioning of forest and bog ecosystems in the national accounts of the state that confirms experience of the developed countries of the world.

6) Functioning of forest and bog ecosystems provides the vital functions of such quantity of persons annually, that three times anymore than own quantity of Ukraine's population (147 million persons). It has an enormous social value.

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## ECOLOGICAL AND ECONOMIC INNOVATION IN WATER MANAGMENT

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Water resources are an important component of national wealth and an essential condition for effective social development. Particularly acute is a problem of water supply, water use, and protection and use of water resources in Ukraine.

Due to large amounts of water resources attraction into economic circulation, increase of their exploitation intensity and their pollution by waste production, there is a growing conflict between traditional and rational ecologically balanced water use.

Taking into consideration the fact that water services in Ukraine are characterized by formed production capacity and limited possibilities of the new building, the main role in the future development must belong to the processes of reconstruction, modernization, and replacement of obsolete technologies and

systems for water purification by the new ones that will ensure environmentally balanced and resource-saving technology of water use [1].

Innovative development of water services, considering its extraordinary complexity, dependence on environmental factors and sectors of national economy should cover the following 3 types of innovations:

- Producing and technological: new ecologically safe technologies of processing, purification, feeding and transporting of water, equipment, etc.;
- Organizational and managing: new methods and forms of water supply organization aimed at reducing environmental hazards;
- Economic and socio ecological: new methods of implementation management of scientific and technological development of water use, planning functions, financing, etc.

All of these mentioned types of innovations can be implemented in practice through various forms of protection (patents, licenses, documentation for new technologies, innovative projects and programs, etc.). Taken together, the innovations should include the establishment of environmental technics to control water resources condition, modern purifying equipment and water-saving and environmentally friendly (clean) technologies and equipment that will put into practice environmentalizing logistics and will approach to implementing sustainability development model [4].

Since Ukraine is dominated by nature, energy, water, resource, and environmentally "dirty" production (index production resource usage in Ukraine is 8.7 units and by its number it is ahead of such countries as Russia, Moldova, and Poland), in the process of innovative and restructuring and technical and technological modernization of the material production branches, the priority attention should be focused on the creation of advanced eco-industry and its extensive infrastructure as an independent sector of national economy [2].

While developing areas, means, methods and mechanisms for upgrading and rendering technical and technological means for water services, one should adhere to the following principles [3]:

- Ecological approach to different environmental, organizational and economic conditions of production;
- Manufacturability, reliability and versatility of technical means when the capacity and performance indicators are high;
- Efficiency in economic industries that are the major water consumers;
- Automation and computerization of production processes in all areas of water use as the basis for higher productivity and a substantial reduction of resource use.

Among the measures to facilitate the implementation of modern technical, organizational, legal and socio-economic developments in water service complex of Ukraine, the following ones can be listed:

- Increase in innovation funding up to 2.5% of GDP;
- Initiation of state motivation system of water saving and water conservation developments;

- Economic motivation of water saving innovative enterprise activity (providing benefits to business entities that purchased the patent (license) for environmental innovation in water use area, and implemented water saving technologies;

- Introduction of innovative tax credit for enterprises that finance the development of environmental innovations in water sector in the amount of 25-100% of their expenditures for innovations in this area.

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# WATER SUPPLY, WASTE MANAGEMENT AND WATER TREATMENT

## DEVELOPMENT OF A COMMUNITY-BASED CONCEPT TO IMPLEMENT DECENTRALIZED WASTEWATER SYSTEMS ON A CASE STUDY IN WESTERN UKRAINE

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**Background and Objectives:**

The TU Dresden is a major player in the International Water Research Alliance Saxony [i](IWAS) [1]. This research project tries s to solve problems in water-sensitive regions all over the world. One of the focus regions is Ukraine. Specifically, water quality problems in the catchment area of the Western Bug should be remediated[ii] [2]. The sanitary situation in the villages of western Ukraine is inadequate due to the lack of structures in the area of sanitation and wastewater treatment. In many places, raw sewage is discharged directly into receiving waters and groundwater is impacted by private septic tanks and pit latrines. The drinking water is usually taken from private wells, which are often just a few meters away from septic tanks. This poses significant health risks. The aim of this study was to develop a concept for planning and implementing a pilot system of decentralized wastewater treatment in a case study in western Ukraine (in the towns Javoriv and Glyniany). The guiding principle was a community-based approach throughout the whole project.

**Planning process**:

This diagram shows - from left to right - the planning process. As a first step, it was important to identify different actors and analyze the situation. With the information from the first step it was possible to evaluate the system. By elaborating on the preferred solution, an adapted capacity development measurement was also integrated. A workshop and the presentation of the preferred solution are planned in the near future.

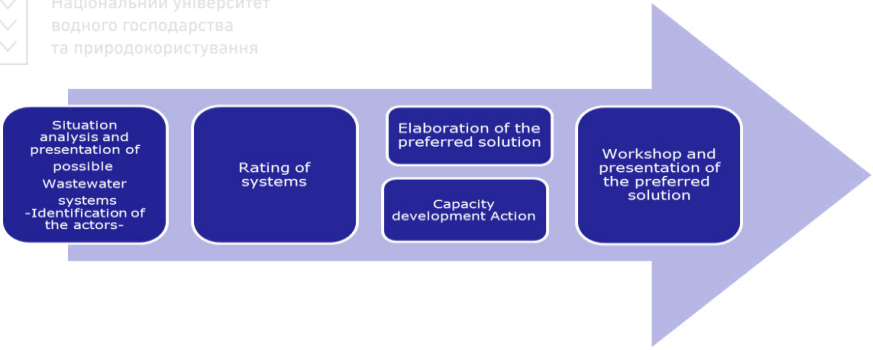


Figure 1. Scheme of planning process

**Results:**

During the planning process three options for sewage disposal were compared. As a first option, the possibility of maintaining the current system with the renovation of existing septic tanks and connections was analyzed. Furthermore the development of a separation system for gray water and black water (gray water purification by wetlands) was discussed. A constructed wetland with pre-treatment (three chamber septic tanks; Imhoff tank) and optional infiltration was identified as a third option.

**Preferred solution:** Constructed wetland


Figure 2. Scheme of constructed wetland[iii] [3]

The constructed wetland was identified as the best solution with regard to technical, environmental and economic aspects. The advantages for a constructed wetland are as follows:

- High cleaning power
- Works under different climatic conditions

- Low operating costs and maintenance, durability
- Landscape-compatible classification possible, good buffering effect by fluctuations in load
- Purified water can be saved and reused (irrigation purposes or rinse water) so water savings of up to 50% are possible

**Capacity development on-site**

Besides the technical solution, capacity development measures are integrated into the project. The aim of capacity development in this project is to show people a sustainable use of the natural resource water. A teaching unit[iv] provides an introduction to the topic and propagates the need of enhanced sanitation by involving pupils as multiplicators for other parts of society [4]. The pupils should realize that constructed wetlands are an innovative technology, where natural processes are used to clean wastewater. But the teaching unit is just one capacity development measurement. For the future it is also important to explain to the people on-site how to handle a constructed wetland.

**Learning goals:**

The teaching unit aims to give the pupils an understanding of the set-up of a constructed wetland and the way it works. They are meant to learn that constructed wetlands are a simple technology, where predominantly natural processes are used to clean wastewater (soil filter, degradation, microbial and plant uptake). The pupils will also build a model of the constructed wetland themselves and handle the technical equipment. This offers them an insight into the practical work.

To use the lesson anywhere in the Ukraine a video tutorial in Ukrainian, that also documents the construction of the model plant, was made.

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# IMPROVEMENT OF BIOFILTER BY USING VARIABLE HEIGHT OXYGEN REGIME

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At present there is an increase in number of small water consumers. This requires considering about the disposal and treatment of small sewage flow rates due to modern equipment of sewage systems.

The main features include:

- irregular arrival of sewage water by pollutants and discharge during the day, seasonal operation;
- absence of qualified operating personnel;
- little running or stagnant water reservoirs for sewage water outfall with low self-purification capacity;
- sensitivity to temperature changing because of small facility capacities.

The increase of concentration and expansion of contaminants range requires more effective treatment. It requires the implementation of additional measures of biological filters operation intensification.

The main directions for the improvement of biological filters are: replacement of the download, inflow recycling and improving the conditions of aeration.

The use of technological schemes with step or combination processes is effective for improving the quality of sewage treated water [1].

Most existing schemes are designed for operation in the aerobic mode, but the removal of many complex components requires the use of anaerobic sewage microflora. Since the existing facilities that operate only in the aerobic mode, cannot fully ensure the removal of nitrogen compounds , so it is reasonably to use the combined anaerobic-aerobic technologies [2].

The analysis of stages of biofilter operating indicates the presence of different groups of microorganisms in height, which differ both in species and quantitative composition and in activity.

Looking at the scheme and diagram changes of $BOD_5$ and nitrite changes there can be selected a zone of active organic pollutants removal and zone of intensive nitrification and post-treatment processes.

So, it is possible to make a clear division of a bed in height into zones with different processes and efficiency of pollution removal.

On the basis of the investigation of pollutants changing kinetics in biofilter height was proposed the construction with bed division into three layers: the first layer – zone where the removal of basic mass pollutants takes place. The second layer – zone where the oxygen absence or with small amount of it. This is a zone

for sewage treatment from certain pollutants. The last layer – zone of final treatment and saturation of the liquid by oxygen [3].

Treatment efficiency is determined by operation condition of every zone. It is important to determine parameters for every layer.

The achievement of aerobic-anaerobic processes alternation and regulation of the oxygen rate is possible by aeration conditions modifying in every layer. It can be achieved by using autonomous aeration system in every zone.

The multilayered biological filter was made for the laboratory researches. It consists of 3 parts interconnected by inserts, which are equipped with devices for sampling and controlling air arrivals to layers.

The filter beds during researches were made of materials: fibrous (number of threads per 1 $m^2$ nozzles 10000 pcs), of net-shaped (the cell diameter 5×5 mm parallel by screen cloth at the distance of 15mm) and block of plastics bed (with a height corrugation - 10mm, diameter of perforation 5 mm, specific bed surface area of 150 $m^2$ download)

This installation was placed at the main sewage pump station of Rivne sewage treatment plant. The influent sewage was a mixture of low of contaminated industrial waste water and domestic sewage from individual districts of the city.

The researches of sewage treatment on biofilters with aerobic-anaerobic zones showed that the processes of organic substrate oxidation and nitrification with active concentration strengthening of nitrites and nitrates were simultaneously observed in the first zone (H=1m). The decrease of ammonium nitrogen and active denitrification were observed in the second oxygen-free zone (H=0.5-1m). The processes of nitrification and the inhibition of denitrification with concentrations increase of dissolved oxygen and removal of gaseous nitrogen were observed in the third zone.

The relationships of sewage treatment efficiency from height of a bed, BOD, dissolved oxygen concentrations, hydraulic loading were the result of laboratory researches.

The operation of bioreactor was studied in conditions of excess and lack of oxygen.

We found that with excess of oxygen in the upper zone there is a significant increase in speed cleaning and nitrification. This biomass functions for increased rates of oxygen consumption when the concentration of dissolved oxygen in the liquid phase can be reduced to zero. The number of active sludge is reduced by 50-65% comparably to traditional high loading biofilter. Moreover, the part of biofilm that breaks away from the load has better sedimentation properties.

Introduction of anaerobic zones in the biofilter allowed improving the efficiency of removal of nitrogen compounds (75%) and other complex compounds (COD) by passing the intensive processes of denitrification.

The process of biological treatment in biofilter with different functional zones occurs more efficiently.

The content of total nitrogen in treated waste water after the first layer was 10-13 mg/l after the second and third layer of anaerobic and aerobic zones of 3-4 mg/l. The concentration of ammonia nitrogen in treated waste water after the first stage was 2.5-4 mg/l, and output settings with 0.5-2 mg/l.

However, removal of nitrogen was observed with intensive decrease in the concentration of organic contaminants in $BOD_5$ to the value of 7-10 mg/l, while the overall effect of treatment on $BOD_5$ is about 94%.

To improve the oxygen regime the air ventilation was proposed in each layer creating a separate autonomous air flow by installation of exhaust devices.

The relationship between the height of exhaust systems and the load parameters, the biofilter sizes, temperature of the liquid and air was determined.

To determine the height of exhaust devices the aerodynamic calculation of multi-aeration biological filter was conducted.

Using heat-balance and heat transmission equations the height of biofilter zone with exhausted aeration system is expressed as follows

$$H = \frac{Q_n^2}{2g} \cdot \frac{\zeta_{зав}}{Fp^2} \cdot \frac{T_p\left(e^{k_1 t} - 1\right) + T_n^з}{T_p - T_n^з\left(e^{k_1 t} - 1\right)}$$

where $Q_n$ – air discharge, $m^3/s$;

$F$– biofilter area, $m^2$;

$p$ – load porosity, m/m;

$\zeta_{зав}$ – coefficients of air movement resistance in the load;

$k_1$ – coefficient of heat flow velocity, $s^{-1}$;

$t$ – the time of air passing through the biofilter loading, s;

$\theta$ – equilibrium temperature, K;

$T_n^{поч}, T_t$ – initial temperature of air and temperature at time $t$;

$T_p^{поч}$ – initial temperature of liquid, K.

The basic parameters of biofilter design with combined zones for complete and incomplete sewage treatment were offered on the basis of research results.

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# EFFECIENCY OF ORGANIC IMPURITIES AND NITROGEN COMPOUNDS REMOVAL AT ANAEROBIC-AEROBIC BIOREACTOR

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The difficulty of organic impurities, nitrogen compounds and phosphorus removal is the problem of domestic sewage water treatment. The concentrations of pollutants are not so high, but however it is difficult to achieve the necessary concentrations at the outlet before disposal into the reservoir without damage.

The researches were conducted using continuous-flow sequential scheme on domestic sewage water with initial concentration of organic impurity by COD 250 - 300 mg/dm$^3$ [1]. The treatment facility has three anaerobic and three aerobic zones, one of which is transitional with anoxic conditions. Using this combination with anaerobic-aerobic conditions allows studying the necessary proportion between oxygen and anoxic conditions for domestic sewage water treatment. The research task was to determine the relationship between concentrations at inlet and outlet using different anaerobic-aerobic conditions achieving the desired efficiency of pollution removal. To improve the productivity and efficiency of facility operation each zone is equipped with carriers VIY for immobilization of microorganisms.

The organic impurity removal by COD is unequal at different oxygen conditions (Fig. 1). Considering the anaerobic conditions in three sequentially arranged bioreactors the maximum oxidation of pollutants is observed in the first one. The oxidation processes are less effective in two subsequent bioreactors. The maximum removal in aerobic conditions is observed in the second (reactor #5) aerobic bioreactor. The removal of organic impurities in the last one is hardly occurring. The efficiency of organic impurities removal by COD was 77% at the initial concentration of 300 mg/dm$^3$.

The influence of anaerobic-aerobic conditions on nitrogen compounds removal was studied at laboratory conditions, except for organic impurities removal (Fig. 2).

The process of nitrogen removal consists of two phases and is carried out by nitrification bacteria of *Nitrobacteraceae* family.

The first phase of the oxidation from ammonium salts to nitrous acid salts (nitrites) is carried out by ammonium-oxidative bacteria of *Nitrosomonas, Nitrosolobus* family and others. This process is observed in anaerobic conditions of reactors # 1, 2, 3 and partially in transitional reactor # 4 in anoxic conditions.

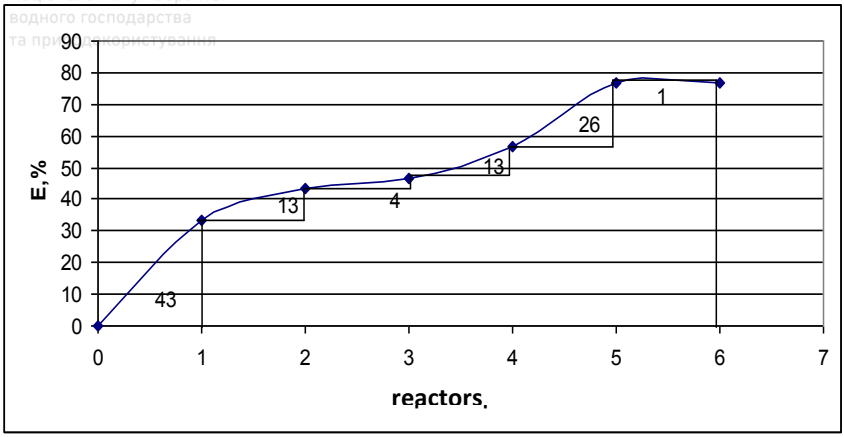


Figure 1. Efficiency (E) of organic impurities by COD removal
in reactors with anaerobic-aerobic conditions:
1, 2, 3 - anaerobic reactors, 4 - transitional reactor with anoxic conditions,
5, 6 - aerobic reactors, 43 - the percent of impurities removal in the reactor

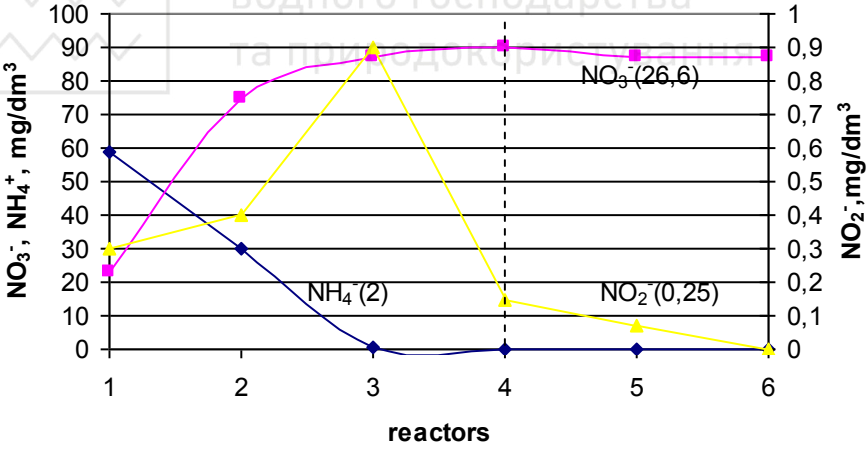


Figure 2. Influence of anaerobic-aerobic conditions
on nitrogen compounds removal:
where (2) - the pollutant concentration allowed disposing
into the water reservoirs

The second phase of oxidation from nitrite to nitrate which is observed after the third bioreactor under aerobic conditions is carried out by nitrite-oxidative bacteria of *Nitrobacter, Nitrococcus* family and others.

The results analysis shows that the organic impurities are mostly removed in the first anaerobic zone and practically there is no treatment in the last aerobic reactor. That's why the number of anaerobic zones can be reduced to two, and aerobic zone to one. Thus, the use of anaerobic-aerobic conditions with immobilized microorganisms with anaerobic processes at the first stage is reasonable for organic impurities removal in domestic sewage water when concentration by COD is not high (COD – 270-300 mg/dm$^3$, BOD – 200-250 mg/dm$^3$).

Conclusions:

1. It is possible to arrange a fiber loading of the VIYA type in bioreactors to increase the concentration of microorganisms in anaerobic and aerobic treatment plants. This loading is characterized by a large surface area and is able to attach a large quantity of microorganisms.
2. The use of attached biomass for biological sewage treatment allows stabilizing bioreactors operation. The changing of input parameters (pollution concentrations) and water discharge during prolonged operation time do not affect on the treated sewage water quality at the outlet of sewage treatment plants with selection and immobilization of microorganisms biomass.
3. Considering the received research results it is necessary to test the facility in order to make some corrections. It is proposed to use continuous-flow scheme with the following sequence of oxygen zones: anaerobic – anoxic –anaerobic – aerobic for domestic sewage water treatment.
4. The process of denitrification will take place in anaerobic conditions. The second phase of oxidation from nitrite to nitrate and the final oxidation of organic and biogenic impurities will take place in anoxic and aerobic conditions of bioreactor.
5. The use of anaerobic conditions at the first stage can significantly to reduce the air discharge for aeration, excess active sludge volumes, achieving the necessary treatment efficiency.
6. The sizes of treatment plants become less using facility with immobilized microorganisms because the concentration of immobilized biomass on the carriers VIYA higher than freely floating biomass.

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# COMPOSITION FERRITO–FERROMAGNETIC NOZZLE FOR PURIFICATION OF LIQUID MEDIA FROM FERROMAGNETIC IMPURITIES

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Fine purification of liquid media from ferromagnetic impurities is performed using the promising method of impurity precipitation in magnetized porous ferromagnetic filtering nozzles [1]. The suggested method is ecologically safe, because chemical reagents are not used. It is of high-speed, because the rate of a filtered liquid medium is 200–300 m/h and up to 1000 m/h when high concentration suspensions are filtered. The method allows liquid media at temperatures up to 500°C to be purified, and impurities with sizes of 0.01–10μm to be precipitated [1]. Ferromagnetic balls, steel shot, rods, perforated plates, and granules of special steel chips are used as ferromagnetic filtering nozzles [1]. When aggressive chemical media are purified, nozzles are coated with anticorrosion protecting layers or are prepared from special anticorrosion alloys [1, 2].

The suggested composition ferrito–ferromagnetic granulated nozzle for magnetic filters consists of ferrite and ferromagnet granules [3]. Ferrite granules are ground wastes of the production of ferrites, for instance, 2000NM, 2000NMS, 3000NMS, and others. Ferrites are chemical compounds of $Fe_2O_3$ iron oxide with other metal oxides. Ferrites are ferrimagnets that combine ferromagnetic and semiconductor properties. The specific resistance of certain kinds of ferrites is billions of times larger than the resistance of metallic ferromagnets. For this reason, eddy currents are almost absent in ferrites. The other component of a ferrito-ferromagnetic granulated nozzle is ferromagnet granules or balls. In this work, these were ShKh-15 steel balls.

The magnetic properties of nozzles were studied using a sectional solenoid. To decrease the influence of the demagnetizing factor, the sample geometric simplex $L/d$ value was set at $L/d > 10$. Measurements were performed by the pulsed induction method with the use of a millifluxmeter. We in turn studied porous granulated ferrite samples, porous ferromagnetic ball samples, and porous ferrito-ferromagnetic samples. The special feature of the magnetic properties of granulated ferrites is a sharp increase in the mean magnetic field induction $B$c and magnetic susceptibility μ values in low magnetic fields ($0–2.5\cdot10^4$ A/m). Compared with a sample of ferromagnetic balls, magnetic field induction in ferrite samples was higher by 12–15% in the same fields ($0–2.5\cdot10^4$ A/m). At the same time,

residual magnetization of ferrite samples is almost zero, which ensures effective regeneration when ferrite granules are used as a filtering nozzle in magnetic filters.

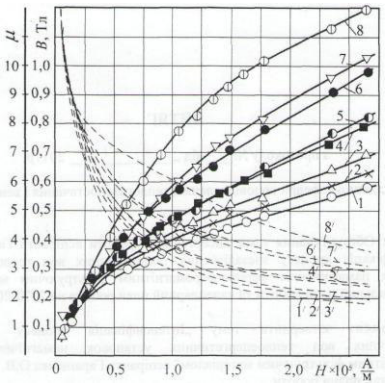


**Figure 1.** Magnetization curves of porous ferrito–ferromagnetic filtration material samples at various α coefficient values: (*1*) ferrite granules, (*2*) 0.214, (*3*) 0.44, (*4*) 0.869, (*5*) 1.669, (*6*) 3, (*7*) 5.49, and (*8*) ShKh_15 steel balls; (*1*')– (*8*') magnetic susceptibility curves

Effective regeneration without demagnetization is attained using the suggested composition ferrito-ferromagnetic nozzle [3]. Ferromagnetic balls of ShKh-15 steel 3 mm in diameter were mixed with 2000NMS ferrite granules with an equivalent diameter of 3–4 mm. The ratio between granules was determined by the $\alpha = m_b/m_f$ coefficient, where $m$b is the weight of ferromagnetic balls and $m_f$ is the weight of ferrite granules. When external magnetic field $H$ changed from 0 to $2.5 \cdot 10^4$ A/m (Fig. 1), the mean $B$c magnetic field induction values in the volume of granulated samples were, excepting curve *8*, commensurate with each other at various α coefficient values. At $H > 7.5 \cdot 10^4$ A/m, a substantial increase in $B$c was observed for filtering nozzles with $\alpha \geq 3$.

Conclusions:

1. Magnetization curves of ferrito–ferromagnetic filtering nozzles were measured experimentally at various mass ratios between nozzle components.

2. Depending on the type of the aqueous dispersed system undergoing purification, which can be high or low-concentration, and the type of impurities, which can be ferromagnetic, ferrimagnetic, or paramagnetic, the α value is used to select a ferrito–ferromagnetic filtering nozzle with the necessary magnetic and, accordingly, filtration and regeneration properties.

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## ADVANCED WASTEWATER TREATMENT

# METHODS AND TECHNOLOGIES

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Advanced or tertiary wastewater treatment is the additional treatment used to remove suspended, colloidal and dissolved constituents remaining after conventional secondary treatment. That is necessary in such cases as (1) need of meeting strengthened treatment requirements which are being grown in connection with continuous water resources pollution and cannot be met by two-stage treatment; (2) removal of specific contaminants that were not typical for wastewater in a period of available treatment plants designing and thus cannot be extracted because of technical incapability; (3) reaching needed water quality for further use in agriculture and reuse in industry what will allow to reduce wastewater discharges into water body; (4) extraction of certain substances from wastewater in order to reuse.

That is common to differentiate tertiary and advanced treatment for their application areas. **Tertiary treatment** is designed to remove the nutrients, total N (comprising Kjeldahl-N, nitrate and nitrite) and total P (comprising particulate and soluble phosphorus) from the secondary effluents. Additional suspended solids removal and BOD reduction is achieved by these processes. The objective of tertiary treatment is mainly to reduce the potential occurrence of eutrophication in sensitive, surface water bodies. **Advanced treatment** processes are normally applied to industrial wastewater only, for removal of specific contaminants. Where a high quality effluent may be required for reclamation of groundwater by recharge or for discharge to recreational waters, advanced treatment steps may also be added to the conventional treatment plant [1].

Existent advanced treatment technologies may be classified into 3 main methods: physical, biological and chemical (see Table 1). There do exist some water treatment processes which can be categorized as physical as well as chemical processes (e.g. carbon adsorption).

The effectiveness of each technology varies for different individual constituants. The latter can be grouped into four broad categories, which may be associated with a range of treatment technologies that are more effective for current category (see Table 2).

Table 1

Classification of advanced wastewater treatment technologies [1]

| Methods | Technologies used for | |
|---|---|---|
| | tertiary treatment | advanced treatment |
| **Physical**<br>treatment by use of naturally occurring forces (gravity, electrical attraction) or by use of physical barriers | Filtration | Membrane filtration<br>Electrodialysis<br>Flocculation<br>Ammonia stripping<br>Carbon adsorption |
| **Biological**<br>removing and oxidizing of organic pollutants by microorganisms | Nitrification<br>Denitrification<br>Biological P removal<br>Constructed wetlands<br>Aquaculture treatment | |
| **Chemical**<br>treatment by means of chemical reactions | Chemical precipitation<br>Disinfection<br>Chemical oxidation | Ion exchange<br>Oxidation<br>Detoxification<br>Coagulation |

Table 2

Unit operations and processes for removal residual constituents in treated wastewater [2]

| | |
|---|---|
| **Inorganic and organic colloidal and suspended solids**<br>▫ suspended solids, colloidal solids, organic matter | |
| Filtration (depth, surface, membrane) | |
| **Dissolved organic matter**<br>▫ total organic carbon, refractory organics, volatile organics | |
| Carbon adsorption | Chemical oxidation |
| Reverse osmosis | Electrodialysis |
| Chemical precipitation | Distillation |
| **Dissolved inorganic matter**<br>▫ ammonia, nitrate, phosphorus, total dissolved solids | |
| Chemical precipitation | Electrodialysis |
| Ion exchange | Distillation |
| Ultrafiltration | Nitrification |
| Reverse osmosis | Denitrification |
| **Biological constituents**<br>▫ bacteria, protozoan cysts and oocysts, viruses | |
| Disinfection | |

The degree of advanced treatment is not limited by the technology available and depends mainly on funds availability, political will and requirements set to effluent in accordance with further water reuse or disposal into water body.

Thus modern technology offers a broad variety of advanced wastewater treatment technologies, but there are still some of them that are most commonly used because of prevalence of certain pollutants that can be found in secondary treatment effluent more often or in higher concentrations, as well as easier maintenance and lower operation and investment costs.

One of the most common technologies of tertiary wastewater treatment is filtration for a range of advantages as simple operation, low initial and operation costs, reliability, high capacity, lower area requirements. The principle processes that run in this technology have being studied for more than century and a broad spectrum of theories exist now for them, but the research still goes on and new approaches, filter bed materials and combinations with other technologies are being developed.

Selection of the most appropriate operation, process or combination depends on (1) the use to be made of the treated effluent, (2) the nature of the wastewater, (3) the compatibility of the various operations and processes, (4) the available means to dispose of the ultimate contaminants, and (5) the environmental and economic feasibility of the various systems [2]. It should be noted that in some cases economic feasibility may not be a controlling factor in the design of advanced wastewater treatment systems, especially when specific constituents must be removed to protect the environment. Technologies that do not need adding excessive volumes of chemicals and produce easy degradable by-products should have priority. Modern approaches in the chosen technology should be balanced awareness of successive and prolonged application practice at full scale. Pilot-plant testing is also recommended for the development of treatment performance data and design criteria.

**Conclusions:**

1. Advanced wastewater treatment provides a high quality effluent allowing minimizing negative environment effect of wastewater disposal by extracting substances that may be reused or new harmful pollutants and subserve further reuse of treated water.
2. Advanced wastewater treatment technologies may be classified by application areas, methods and target pollutants.
3. Selecting technology a wide range of principles must be considered.

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# CONCENTRATION RATIO OF AUTOTROPHIC AND HETEROTROPHIC MICROORGANISMS IN ACTIVATED SLUDGE

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Different groups of microorganisms involved in the process of oxidation of dissolved in the water organic matter, nitrification and denitrification. Autotrophs and heterotrophs are the main microorganisms for implementing of these processes. It is necessary to select the concentration of alive microorganisms and know the concentration ratio of autotrophs and heterotrophs from the total mass of the sludge.

The heterotrophic biomass increase for aerotanks-mixer that performs oxidation of dissolved organic matters in the water under aerobic conditions will be expressed by the formula [1]

$$X_{H(C)0} - X_{H(C)e} = Y_H \left(S_{C0} - S_{Ce}\right) - b_H \cdot X_{H(C)e} \cdot T, \quad (1)$$

and the autotrophic biomass increase can be expressed as follows

$$X_{A0} - X_{Ae} = Y_A \left(S_{N0} - S_{Ne}\right) - b_A \cdot X_{Ae} \cdot T_N \ . \quad (2)$$

Installation of anoxic zone is provided in order denitrification process took place. The increase of denitrifying heterotrophic microorganisms is observed in this zone, which is determined by the following equation

$$X_{H(D)0} - X_{H(D)e} = Y_D \left(S_{D0} - S_{De}\right) - b_H \cdot X_{H(D)e} \cdot T_D \ . \quad (3)$$

The turbostatic process is considered in biological treatment systems in which the processes of organic matter oxidation, nitrification, and denitrification by mixed biomass took place. The concentration of certain groups of microorganisms in the total biomass of activated sludge is proportional to the increase of this group at this regime:

$$\frac{X_{Ae}}{X_{He}} = \frac{\Delta X_A}{\Delta X_H} = \frac{Y_A \left(S_{N0} - S_{Ne}\right) - b_A \cdot X_{Ae} \cdot T_N}{\left(S_{C0} - S_{Ce}\right) Y_H + \left(S_{D0} - S_{De}\right) Y_D - b_H \cdot X_{He} \cdot \left(T_N + T_D\right)}, \quad (4)$$

where $\Delta X_{Ae}, \Delta X_{He}$ – the increase of bacteria mass – accordingly of nitrificators and total heterotrophic biomass sludge by dry matter per unit purified liquid volume; $S_{N0}, S_{Ne}, S_{C0}, S_{Ce}$ – accordingly the concentrations of ammonia nitrogen and organic matter of inlet and purified water; $T_N, T, T_D$ – accordingly the average time of sewage water staying in the reactor for nitrification, oxidation of organic matter, and denitrification.

After some conversions, considering stationary conditions of the processes $dS_i/dt = 0$, we obtain the relationship between the concentrations of autotrophic bacteria and activated sludge:

$$\frac{X_{Ae}}{X} = \frac{Y_A \cdot \Delta S_N}{T_N \cdot X} \cdot \frac{\theta}{1 + b_A \cdot \theta}, \tag{5}$$

where $X$ – the concentration of activated sludge; $\Delta S_N$ – the difference of concentrations of ammonium nitrogen of inlet and purified water; $\theta$ – the age of activated sludge.

The alternate location of denitrification and nitrification zones and organic matter oxidation is provided in the aerotanks-mixers. The time of sludge mixture staying in these zones is usually different. Introduce the time of staying ratio $T_N = z_N \cdot T$, $T_D = z_D \cdot T$.

Then the relationship between autotrophic and heterotrophic biomass of activated sludge is expressed by the formula due to equation (4)

$$\frac{X_{Ae}}{X_{He}} = \frac{Y_A \cdot \Delta S_N \cdot z_N \cdot (1 - b_H \theta)}{(Y_H \cdot \Delta S_S + Y_D \cdot \Delta S_D \cdot z_D) \cdot (1 - b_A \theta)}, \tag{6}$$

where $Y_A, Y_H$ – accordingly the economic rate of auto- and heterotrophic biomass.

The fraction of heterotrophic denitrifying microorganisms which using nitrate and nitrite as a donor of oxygen, can be determined by the coefficient $\eta_D$. Thus, the concentration of denitrifying bacteria will be determined as follows:

$$X_{Di} = \eta_D \cdot X_{Hi}. \tag{7}$$

The adequacy of the obtained equation (6) was verified on the basis of researches of Turkish scientists Saziye Balku, Ridvan Berber [2] and Dutch scientists M.S. Moussa, C.M. Hooijmans, H.J. Lubberding, H.J. Gijzen, M.C.M. van Loosdrecht [3]. The determined values of the concentrations ratio of autotrophic and heterotrophic microorganisms additionally were compared with data obtained during researches of nitrification process at a pilot plant during 8 years in Copenhagen [4] by Harremoës P., Haarbo A., Windier-Nielsen M., Thirsing C.

It is necessary to accept the following economic coefficients of heterotrophic and autotrophic biomass: $Y_H = 0.7$ g/d; $Y_A = 0.2$ g/g and self-oxidation velocity for heterotrophic and autotrophic biomass accordingly $b_H = 0.2$ day$^{-1}$ and $b_A = 0.06$ day$^{-1}$. These values were accepted on the basis of the analysis of literature for purification of domestic sewage water from ammonium nitrogen, nitrate and organic matter

The results of comparison of the researches by Turkish scientists Saziye Balku, Ridvan Berber, Dutch scientists M.S. Moussa, C.M.Hooijmans, H.J. Lubberding,

H.J. Gijzen, M.C.M. van Loosdrecht and on the basis of equation (6) presented in Figure 1.

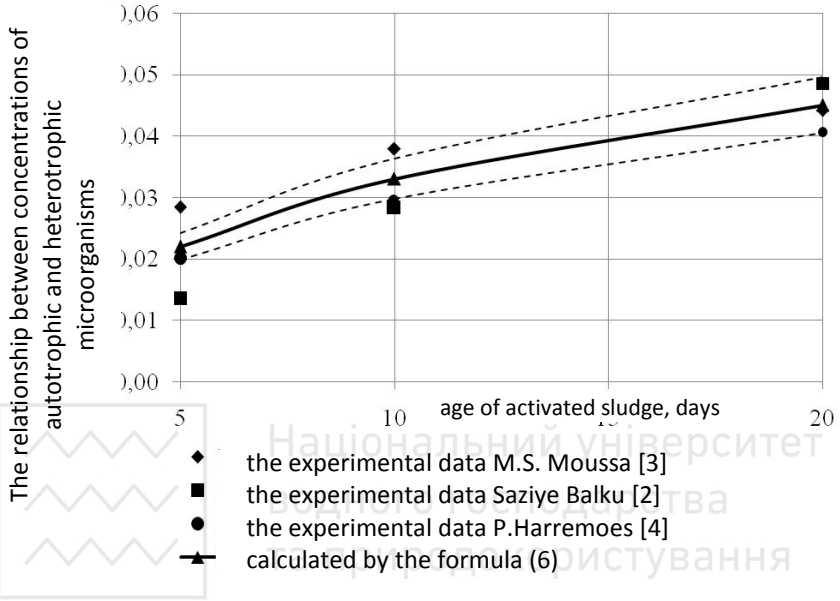


Figure 1. Comparison of the values of concentrations ratio of autotrophic and heterotrophic microorganisms from sludge age obtained analytically and experimentally.

Figure 1 shows the received approval of approbation at reasonable probability of the proposed equation (6).

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# THE WAYS OF OPTIMIZATION OF WATER TREATMENT FILTRATION PLANTS OPERATION

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Filtration is the most currently available effective and simple type of water treatment and purification. And it continues to be one of the most important stages in the whole technological process of water purification. Therefore optimization of filtration facilities operating is the issue specialists' attention should be focused on.

The objective function of optimization maximizes the effective performance, subjected to design constraints, and to achieve desired reliability level for meeting the prescribed effluent water quality characteristics [1]

$$W_{кор} = \frac{W_ф - W_{пр}}{t_ф + t_{пр}} \to \max, \quad (1)$$

where: $W_ф$ – water treatment plant output during filtration run; $W_{пр}$ – water losses through filter bed flushing; $t_ф$, $t_{пр}$ – accordingly duration of filtration run and flushing.

In general ways of optimization of parameters included into (1) should be targeted as presented by system (2)

$$\begin{cases} t_н \to \max; \ W_ф \to \max \\ t_{пр} \to \min; \ W_{пр} \to \min \end{cases}. \quad (2)$$

Plant output $W_ф$ depends on filtration flow velocity $V_ф$ and filtration run time

$$W_ф = V_ф \cdot S_ф \cdot t_н, \quad (3)$$

where $S_ф$ – filter bed cross section area.

Water losses through flushing (operational losses) depend on backwash rate (called backwash intensity) $q(t)$, which for conventional scheme of floating granular backwashing filter bed is variable, and flushing run time $t_{пр}$

$$W_{пр} = \int_0^{t_{пр}} q(t) \cdot S(t)\, dt, \quad (4)$$

where $S(t_{пр})$ – backwash water storage tank cross section area.

According to the wide-spread backwashing scheme of gravity floating filter bed is conducted by reducing flow of backwash water accumulated previously in above-filter tank. The whole of backwashing run can be considered as three-step process:

- water accumulation in above-filter tank. Backwashing start. Expansion of granular filter bed;
- sludge flushing out. Drawdown of flushing water accumulated in above-filter tank. Backwash flow rate is being gradually reduced;
- disposal of last portions of waste flushing water of filtration plant.

There are different requirements to backwash flow rate for pointed out steps. Required backwash flow rate for first step is presented as

$$q_1 = q_{осад} + q_{П/П}, \tag{5}$$

where $q_{П/П}$ – backwash flow rate for generating hydrodynamic force which is used for expansion of granular bed; $q_{осад}$ – backwash flow rate for generating hydrodynamic force which is used for overcoming adhesion and bonding forces in accumulated sludge deposits.

Since the backwash rate regulates the filter bed expansion ratio its required value for second step is

$$q_{пр1} \le q_2 \le q_{пр2}, \tag{6}$$

where $q_{пр1}$, $q_{пр2}$ – upper and lower backwash flow rate value needed to ensure optimal conditions for dislodging adhering contaminations. That is to say the backwash flow rate should be high enough to provide preset filter media expansion ratio and to separate sludge but not to cause media escape [2].

For gravity filter plants flow rate is determined by actual head

$$V = -\frac{dH}{dt}. \tag{7}$$

Practical experience of water treatment plants operating approves that it's often needed a considerable increase in the pressure gradient to extend clogged filter material [3], thus

$$q_1 >> q_{пр2}. \tag{8}$$

With inadequate head which is insufficient for generating $q_1$ backwashing could be resulted in imperfect bed cleaning. Due to incomplete recovery of filter media ability to retain contaminations duration of the next filtration run shortens [4] what does not meet conditions (2) .

$q_{П/П}$ value, which is the component of $q_1$, depends on physical-mechanical properties of filter bed only and is constant for same filter media material. $q_{осад}$ actually depends on mechanical strength properties of sludge deposited inside pores of filter media during filtration run and its amount. Those characteristics are determined by flow conditions (properties of suspension and filter media, flow rate) and filtration time and are variable $q_{осад} = f(t_ф)$.

To maximize the function (1) the following approach can be applied which is in choosing an optimum backwash interval or, taking into account conditions (2), in determination of optimum $t_ф$.

The problem of filtration process optimization as the issue of optimal filter run time detection was initially posed by Mintz [5]. Determining of filtration run time in order to meet both conditions at once: complete using of filter media ability to remove contaminations ($t_ф=t_з$, where $t_з$ – time period within which filter provides adequate contaminations removal) and actual head ($t_ф=t_н$ – the time period until built up head loss does not reach limit value), – is the central idea of this approach

$$t_ф=t_з= t_н, \quad (9)$$

or, taking into account sanitary reliability filtration plant operation

$$t_ф=t_з = (1,2…1,3)\ t_н. \quad (10)$$

The problem was solved by way of flow conditions optimization: both filter geometry (filter bed depth, granules size) and flow rate.

The basis for choosing the head as the controlling factor is in that parameter indirectly describes the amount of retained contaminations and its strength [6,7].

Under constant – flow rate filtration run is terminated for backwashing when the medium headloss development reached the maximum allowable level. Limit headloss value is stated on level 2..3 m.

In elaboration of that approach it's suggested to substantiate limit headloss value in accordance with filter bed clogging level in order to ensure complete recovery of filter media ability to remove contaminations under available by plant design head and in short backwash time.

Conclusions:

Analytical background of limit headloss value whereby filtration run should be terminated as a way of performance optimization of water treatment plants issue is suggested.

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# MEMBRANE PROCESSES OF NANOFILTRATION IN MODERN SYSTEMS OF WATER PREPARING

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The modern rates of developing building technologies do not always go in hand with the development of technologies of water preparing which modern building uses for sanitary and technically equipment. The application of obviously out-of-date technologies often creates hindrances to building. For example, the necessity of creating the stations of the additional cleaning of water in building compels to solve the questions of placing, installation and exploiting (servicing). Therefore, not only the quality of water but also sizes of construction depend on the chosen technology, expenses on installation and exploiting, taking into account volumes of effluents and water for own needs.

Traditional technologies which use pressure filters with loading of sand, coal and ions exchanged resins are unwieldy enough. They require expenses during their exploitation (to replace loading or their regeneration), form flows at their washing and regeneration.

Modern ecological situation assists in wider use of membrane systems. It is explained by, first of all, tougher requirements for the quality of drinking-water - in contents of chlorine-organical compounds, malignant bacteria, nitrates, ions of strontium and others.

The membrane processes of ultrafiltration and nanofiltration long ago attracted the attention of specialists in water-supply due to their possibilities to remove contaminations of different nature simultaneously: biological(bacteria and viruses), organic (humic acids and others), colloid, suspended, and also soluble in an ionic kind. Differences in membrane processes consist in the level of water cleaning (entry to clean water of one or other contaminations), depending on the size of pores of membranes.

Technology of nanofiltration is known long ago and already begins to be used in a drinkable water-supply due to the effective decline of maintenance of organic compounds (coloured, volatile chlorine organical compounds), iron, and also hardness.

However until now the method of nanofiltration is examined as a variety of the method of reverse osmosis with all its defects: the necessity of the careful pre-cleaning for preventing the formation of sedimentations of calcspar and sediments of organic and colloidal substances; high running costs related to the dosage of

pre-cleaning reagents. The high charges for reagents and other operating costs compel specialists to sceptically behave concerning the use of nanofiltration for preparing water of high quality on large water-treatment plants in spite of indisputable efficiency by comparison to " classic" coagulation and technologies of oxidizing and persorption.

Presently there is a wide scale of industrial introduction of the method of ultrafiltration that is used mainly at the sewage treatment plants of the municipal plumbings: from December, 2006 - in Moscow at the south-west station (and also at the water-treatment plants in Paris, London, Amsterdam, Singapore, in a number of cities of the USA, Canada).

Mainly the method of water treatment by nanofiltration is used for the distillation of water and removing from it all cut-in admixtures. However, this method can be used also in local sewage treatment plants. It is not recommended to be used in drinking water as nanofiltration, because all admixtures are extracted from water, including necessary for the human organism mineral substances and salts. Method of water treatment by nanofiltration is mostly used for receiving clean technical water that will be used in industry for different aims. So, for example, quite often nanofiltration of water is used in chemical industry, where the cleanness of water has a decisive value for one or another process. Options for nanofiltration are used in systems of heating, where unrefined water becomes the reason of the origin of scum and considerably reduces the efficiency of work of the system. Settings for nanofiltration have some distribution in the water supplying systems of different medical establishments, companies of pharmacy, oil-processing industry. On some occasions options for nanofiltration of water are used for cleaning sewage of some industries dangerous for environment. It is related with the high degree efficiency work of options for nanofiltration of water.

Modern membranes demonstrate indisputable efficiency and universality in water treatment from the different types of contaminations. Another main line of modern membrane technologies is their “ecological” cleanness. It means the absence of consumable reagents and, accordingly, dangerous for environment discharges and fallouts, creating the problem of their utilization. Modern developments of the systems of water preparing with the use of membrane technologies allow providing quality water for the engineering systems, in such a way providing the reliability and quality of their work.

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# ANALYSIS OF ABUNDANCES OF ORGANISMS WITHIN MORPHOLOGICAL-FUNCTIONAL GROUPS

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Bioindication is a method that provides important information about the state of the natural environment and environment transformed by human activity. Bioindication methods are often the suplement to physico-chemical analyses, because the physico-chemical analyses inform about the state of the environment at the time of sampling.

There are the classical bioindication methods and methods based on the structure of communities. Classical bioindication is based on a saprobes system, which was created by two German scholars Kolkwitz and Marsson. The result of their work was the division of natural waters into four saprobic zones [1]: polysaprobic zone - the most polluted waters; α-mezosaprobic zone - middling polluted waters; β-mezosaprobic zone - middling polluted waters; oligosaprobic zone - the least polluted waters.

Bioindication methods based on the structure of communities take into consideration the characteristics and properties of the organisms present in the test environment. The characteristics of organisms are, e.g.: their distribution in space, the number of organisms and species in communities. Methods which use lists of indicator organisms classified into species are complicated, time and labor consuming. Therefore, the morphological-functional groups are being used more frequently in latest researches connected with wastewater purification [2]. In turn, on the basis of m-f groups are defined the structure and changes of the groups sizes [3].

The paper presents examples of the abundances fluctuations of morphological-functional groups developed using the arithmetic average (1), standard deviation (2) and coefficient of variation (3) [4]:

$$\bar{x} = \frac{1}{n}(x_1 + x_2 + x_3 + \ldots + x_n) = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{1}$$

where $n$ – quantity of summed numbers, $x_i$ – summed numbers

$$s = \sqrt{\left(\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2\right)} \tag{2}$$

$$V = \frac{s}{\bar{x}}, \qquad \bar{x} \neq 0 \tag{3}$$

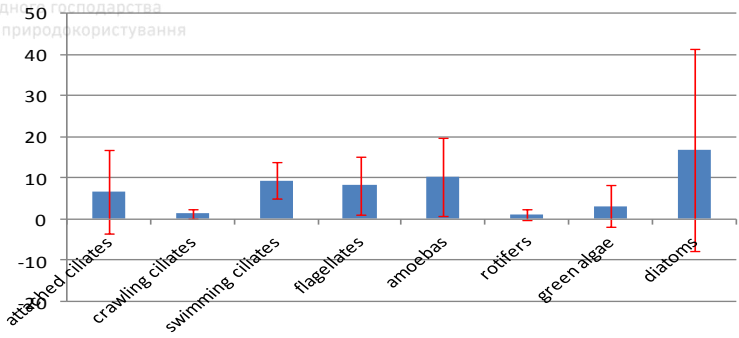


Figure 1. Standard deviation and arithmetic average of groups as on 4.11.2009

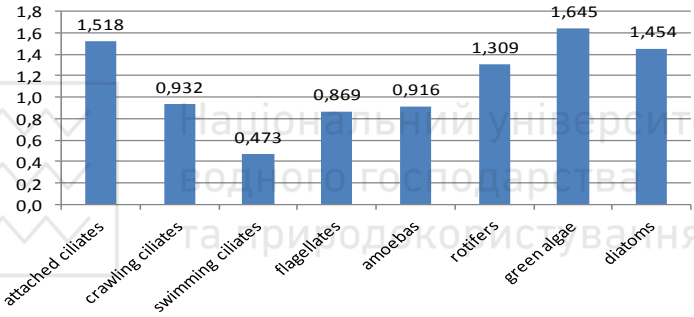


Figure 2. Coefficient of variation connected with number of groups inon 4.11.2009

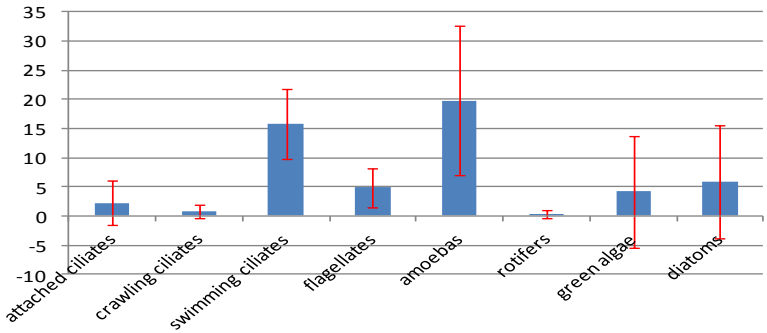


Figure 3. Standard deviation and the mean number of groups as on 25.11.2009

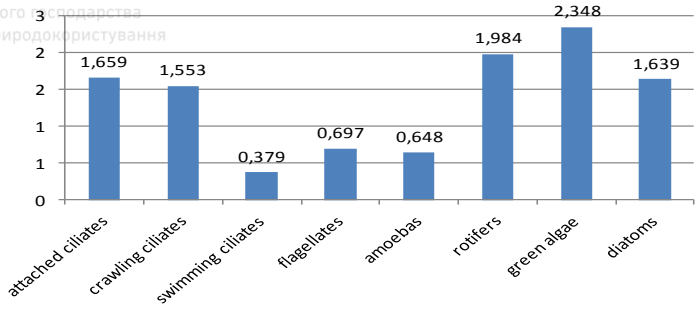


Figure 4. Coefficient of variation connected with number of groups as on 25.11.2009

The presented results are based on the number of m-f groups counted in biofilm and taken from the walls in the following sections of the biological part of Wastewater Treatment Plant (WWTP) Hajdów: I – outflow from the primary settler, II – outflow from the anaerobic chamber of bioreactor, III – inflow to the anoxic chamber of bioreactor, IV – inflow to the aerobic chamber of bioreactor, V – outflow from the aerobic chamber of bioreactor, VI – outflow from the secondary settler, VII – external recirculation conduit, VIII – outflow from WWTP. The coefficient of variation is related to the sensitivity of organisms to environmental conditions that exist in the biological facilities of wastewater treatment plant. However, the abundance of green algae and diatoms are also influenced by the availability of light associated with the clarity of wastewater.

**Conclusions:**

1. The most stable populations in analyzed objects are swimming ciliates, flagellates and amoebas.
2. The greatest variation in the abundance of organisms within m-f groups occurs in the case of green algae.
3. Swimming ciliates are the most stable group in the meaning of abundance which suggests that group is least sensitive to changes in parameters of bioreactor.
4. Both measurement days have a certain similarity of coefficient of variation.

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# STORM WASTEWATER QUALITY OF CHOSEN CONDUIT IN LUBLIN CITY ON THE BACKGROUND OF RECEIVER WATERS QUALITY – BYSTRZYCA RIVER

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**Introduction:**

According to literature – the storm wastewaters contain the significant concentrations of pollutants such as: COD, $BOD_5$, total suspended solid (TSS), nitrogen compounds etc. and it's usually dependent on the type and usage of the dewatered surface of urbanised area [1]. Moreover, the quality of water in rivers is unsatisfactory in Poland. Consequently , the aim of this paper is to present the analysis of storm wastewater discharged to the Bystrzyca River from the drainage system of Muzyczna St. basin, on the background of waters quality of the Bystrzyca river, Lublin, Poland for selected period between 2009 and 2010.

**Method and methodology:**

Samples were taken in two locations: first, at 42.4 km of river (outflow of storm wastewater) and the second one at 42.9 km of river (point with the full mixing of river water and storm sewage). The content of pollutants expressed as the pollution indicators was determined in the laboratory of Lublin University of Technology, Poland.

Qualitative measurements of storm wastewater discharged from the drainage system conducted in research covered the chemical oxygen demand (COD) and the biochemical oxygen demand ($BOD_5$) according the Polish Standards [2, 3]. The Authors selected two of pollutants indicators because they are most popular. Moreover, the $BOD_5$/COD coefficient gives information about Bystrzyca River biodegradation ability, and as COD/$BOD_5$: informs about type of sewage.

**Results and discussion:**

Exemplary results are presented in figure 1 and 2. The conducted research shows changes of Bystrzyca River quality at the background of storm wastewater quality. There is an occurence of mixing storm wastewater and river water which was expressed by decrease of contaminations indications value.

The flow of rainwater into the Bystrzyca River causes minor changes in the physical-chemical parameters. The maximum value of COD at 23.09.2009 and 18.03.2010 in Bystrzyca river may be the result of a high COD in the storm wastewater, on the same day. During the results on other days ( both in 2009 and as well as in 2010 ) it has not been noticed an impact of storm wastewater from the storm water trunk on receiver water – the Bystrzyca river.

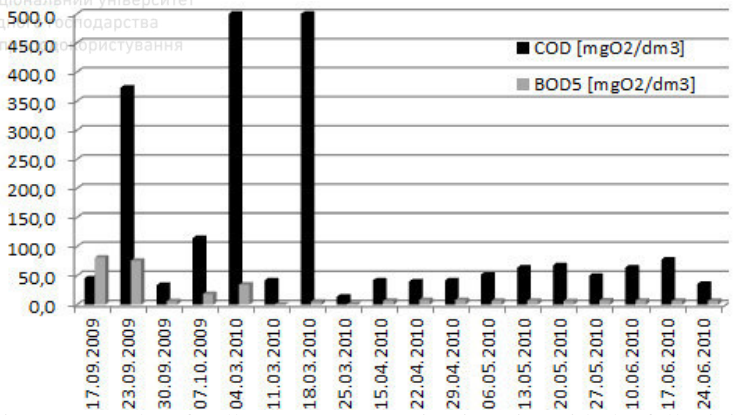


Figure 1 Results of pollutants concentration in point with the full mixing of Bystrzyca River water and storm sewage, Lublin, Poland




Figure 2. Results of pollutants concentration
in the Bystrzyca River, Lublin, Poland

Table 1 presents the $BOD_5/COD$ coefficient and $COD/BOD_5$ in the storm wastewater and the Bystrzyca river. According to the data contained in the literature, storm wastewater, the same as water in the Bystrzyca river, can be characterized by properties similar to industrial sewage ($COD/BOD_5$ >2.0), only 17.09.2009 presents another situation which classifies the storm water and the Bystrzyca river water as polluted water containing significant share of organic compounds [4]. This is disturbing information meaning that waters in Bystrzyca River were in unsatisfactory condition. Next, based on data about biodegradation ability coefficient, we noted that 9 of results are placed in the group called as: not biodegradable ($BOD_5/COD$: < 0.2), 8 of results: slowly biodegradable ($BOD_5/COD$: 0.2-0.4), and one as easily biodegradable ($BOD_5/COD$: >0.5) [5].

Table 1

Coefficient in storm wastewater and Bystrzyca River, Lublin, Poland

| Date | Storm wastewater | | Bystrzyca River | |
|---|---|---|---|---|
| | $COD/BOD_5$ | $BOD_5/COD$ | $COD/BOD_5$ | $BOD_5/COD$ |
| 17.09.2009 | 0.6 | 1.8 | 1.0 | 1.0 |
| 23.09.2009 | 4.9 | 0.2 | 27.0 | 0.04 |
| 30.09.2009 | 5.4 | 0.2 | 14.1 | 0.1 |
| 07.10.2009 | 6.1 | 0.2 | 4.9 | 0.2 |
| 04.03.2010 | 14.4 | 0.1 | 8.3 | 0.1 |
| 11.03.2010 | 70.0 | 0.01 | 71.1 | 0.01 |
| 18.03.2010 | 86.2 | 0.01 | 5.2 | 0.2 |
| 25.03.2010 | 12.7 | 0.1 | 2.8 | 0.4 |
| 15.04.2010 | 6.0 | 0.2 | 7.0 | 0.1 |
| 22.04.2010 | 4.8 | 0.2 | 4.9 | 0.2 |
| 29.04.2010 | 5.1 | 0.2 | 8.0 | 0.1 |
| 06.05.2010 | 7.6 | 0.1 | 8.3 | 0.1 |
| 13.05.2010 | 8.9 | 0.1 | 6.0 | 0.2 |
| 20.05.2010 | 10.6 | 0.1 | 4.6 | 0.2 |
| 27.05.2010 | 6.5 | 0.2 | 7.5 | 0.1 |
| 10.06.2010 | 8.9 | 0.1 | 6.4 | 0.2 |
| 17.06.2010 | 11.5 | 0.1 | 7.4 | 0.1 |
| 24.06.2010 | 5.2 | 0.2 | 7.9 | 0.1 |



**Conclusions:**

1. The level of pollutants concentration in water of the river was more stabile in time than the wastewater from the sewerage rainwater.

2. The highest value of the $COD/BOD_5$ coefficient occurs in storm wastewater. This may be caused by the fact that in the storm wastewaters occur substances which inhibits process of biodegradation.

3. Storm wastewater discharged to the Bystrzyca river from the drainage system of Muzyczna St. basin, influences the quality of the the river.

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# RESEARCH OF WATER SUPPLY AND DISTRIBUTION SYSTEMS STATE IN MAKEYEVKA

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As a part of the research work "Measures to Optimize Water Supply in the Cities and Towns of Donetsk Region",at the chair of "Water Supply, Sewerage and Protection of Water Resources(WSaPWR)" of Donbas National Academy of Civil Engineering and Architecture the research of the condition of water supply and distribution systems in Donetsk Region has been carried out. We have studied the problem of water supply in Makeyevka.

The chair of WSaPWR has developed and proposed a complex of engineering and technological measures to optimize water supply lines to reduce and liquidate leakage of drinking water from town's water supply lines.

To develop proposals for the optimization of water supply and distribution system (WSaDS), as a pilot project, the research of water supply system in the district of Makeyevka has been carried out. We have chosen the following strategy for the execution of long-term optimization: from target and local directions to complex optimization schemes [1]. Firstly, it is necessary to develop and implement a short-term optimization schemes aimed at removing main deficiencies in water supply systems.The execution of planned activities with a minimum of investing will reduce the leakage of water and increase the energy efficiency of the system on small local parts of the water supply lines. At the expense of profit from cost savings in several districts we should develop and execute a complex scheme of optimization of the larger districts or the entire town.

We have performed the following activities:

- collecting data on the investigated water supply line;
- finding the actual volume of water consumed by the population;
- determination of emergency and dangerous areas of water supply lines;
- hydraulic calculation of the current water distribution system in terms of water consumption and fire prevention;
- comparison of free pressures in dictating and nodal points and the probability of their possible redeployment;
- analysis of current condition of WSaDS;
- a survey, optimization and issuance of the design parameters of the booster pump stations in WSaDS.

The evaluation of actual volume of water supplied to the population allows finding the following shortcomings in SWSaD:

1. Water supply system does not provide population with the necessary quantity of water. Thus, according to standard documents, the norm per person for buildings with bath and local water heaters is 160-230 l / day per person. At the same time, the actual water consumption is 70-125 l / day per person, it is almost two times less of norm. According to [2] BNaR 2.04.02-84 * for the first reliability category system, it is possible to decrease water supply for drinking needs by no more than 30% of design water flow; reducing duration of the supply should not exceed 3 days.

2. WSaDS works with a gross violation of standard documents. Water on schedule is supplied only 8 hours a day. According to [2] BNaR 2.04.02-84 for the first reliability category system, it is allowed to interrupt water supply for a time when damaged elements turn off and reserve elements of the system (hardware, fittings, facility, pipelines, etc.) turn on but no more than for 10 minutes.

On the basis of the results we have the current steel water pipe and possible replacement of it for a plastic one. The calculations have shown that the replacement of steel pipe by the plastic one will reduce pressure loss by 75% and therefore will reduce the cost of electricity to the water supply pumps. At the same time taking into account unstable work of SWSaD and destruction of metal pipes, replacement of the existing water supply line by plastic pipes for water supply will significantly reduce leakage of water.

Based on the above the following activities have been proposed:

- to stop water leakage;
- to remove the emergency areas;
- to improve the reliability of the water supply line in terms of fire safety requirements.

Thus, we have developed an optimization scheme of Makeyevka district. The analysis of residential, social domestic and industrial buildings equipped with water meters have showed significant reduction in water consumption compared with current standards, so the current norms should be revised.

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# FORECASTING OF WATER CONSUMPTION IN HOUSING ESTATE WITH USING THEORY OF ARTIFICIAL NEURAL NETWORKS

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The prediction of water consumption (load on pumping station) is necessary for solving almost full range of tasks of the current planning and operational management by regimes of functioning of the pumping station, according to [1]. The prediction of the load take place in the following time ranges of the hierarchy control:

– operational (within the current day);
– short (day-week-month);
– long (month-quarter-year).

There were developed a large number of methods and models of forecasting load. The traditional statistical models can be conditionally divided into the regression model and model based on time series [2]. Statistical forecasting methods are based on the using of quantitative information on the status and the behavior of the investigated object. In case of anticipated changes in the conditions of functioning of the object in the future should be applied forecasting methods for expert assessment of exposure to conditions that have changed, the behavior of the object in the forecast period.

With the development of the theory of artificial intelligence in the last decade was proposed the solution of the problem of forecasting using models based on expert system and artificial neural networks [3]. The advantage of such approaches over traditional ones is primarily the lack of a model object, the ability to work efficiently even in terms of the incompleteness of the incoming information, as well as resistance to noise and high performance. According to [1], the characteristic features of the feasibility of the application of neural networks to solve the problem is:

- the algorithm is missing or not known principles of solving problems, but are accumulated a sufficient number of examples;
- the problem is characterized by large amounts of incoming information;
- the data are incomplete or redundant, deformed, partially contradictory.

In the many publications for the prediction of load using artificial neural network of direct spread signal with learning by backward error propagation.

The application of neural networks leads to the necessity of solving an

optimization problem of forming a network, selecting the type of neurons and appropriate values of weights.

The issue of constructing NN has two stages: the choice and selection of neural network architecture and weights (learning) of neural network. The first step is to choose which neurons we want to use (the number of inputs, feature activation) and which way you should connect them among themselves. At the second stage we need to "teach" the selected neural network network.

In addition, when we solving the task of forecasting it is relevant to search combinations of input variables that make a decisive impact on the formation of the predicted variable value. This task is logically divided into three stages: 1) the formation of the initial list of input variables; 2) determination of delay between forerunner and prediction moment [2]; 3) selection list of input significant variables that form the input array.

In addition to reducing the dimensionality of the input array, definition of the essential variables can allow to establish logical relationships between the elements of the input array and predictable variable.

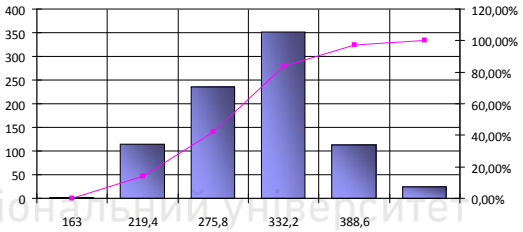


Figure .1. Histogram and curve integral distribution of water after hours

It is well known that water consumption isn't determined, is changed in time, and nature of changes is casual. Therefore, for the identification of influence of each input variable we will use means of a mathematical statistics.

To assess the impact of each variable and determine the depth of the backstory to forecast water consumption, we use elements of correlative analysis, certainly, having in mind that correlative analysis can only point to the possibility of the existence of a linear functional relationship between the values of the type. To do this, first of all, we check the assumption of normal distribution of the population from which are obtained experimental data. Is constructed histogram (Fig. 1) reminiscent of a normal curve ( Gauss curve) and indicating the normality of the data.

To calculate the correlation coefficient we will accept the assumption of linearity of the relationship between random values, and calculate the correlation coefficient as a measure of the linear connection.

Data were obtained during the analysis of correlating matrix for water consumption in different months, days of the week and hours.

The analysis of the matrix showed the existence of medium and low degree of correlation between water consumption months, days of week and time of day. Thus, data values must be elements of input vector of NN.

As a result of statistical analysis of data from the pumping station it was found that the nature of water studied in the neighborhood was influenced by time of day, day and month of the year. In addition to these variables to the input of neural network it is necessary to provide the current value and importance of water consumption in previous times. Preferred structure of the neural network will be sought in the form of dynamic neural network with 7 inputs (Fig. 2).

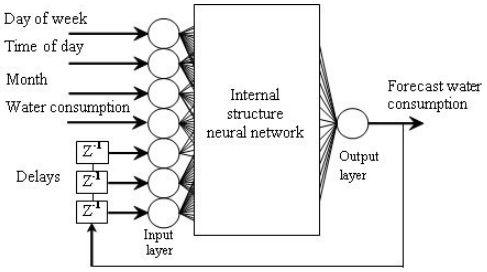


Figure. 2. Structure of the neural network for prediction of water consumption

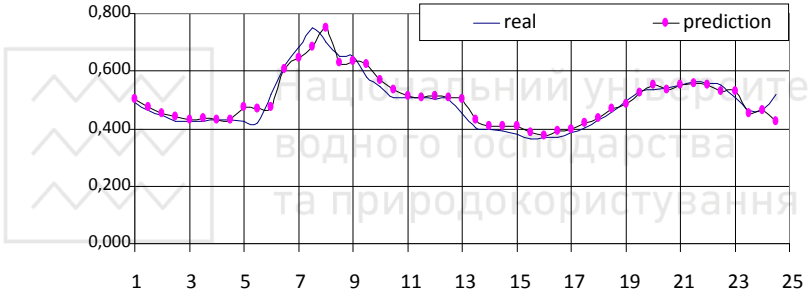


Figure 3. Results of prediction of direct distribution network signal

**Conclusions**

Based on the input vector obtained by statistical analysis of existing data sets have been researched different structures of neural networks. Error prediction is less than 1.5% which is satisfactory for prediction of water (Fig. 3).

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## RESEARCH OF WASTEWATER TREATMENT TECHNOLOGY OF CONCENTRATED APPLE JUICE PRODUCTION ENTERPRISES

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The production of fruit and vegetable juices and nectars in Ukraine is concentrated mainly in Mykolayiv, Odesa, Dnipropetrovsk, Vinnytsia and Transcarpathia regions. In 2007 it reached 1.1 million tons a year, but in recent years has decreased slightly, mainly due to unfavorable weather conditions. The largest quantity (up to 39%)is while apple juice much of which is produced in concentrated form and further used as a component of most blending beverages and nectars. Processing of apple concentrated juice is accompanied by the formation of highly concentrated wastewaters that threatens water sources.

Our own researches of wastewater enterprises re the production of concentrated apple juice composition and properties allowed to establish that they contain significant amounts of organic pollutants, suspended solids, peels, seeds, peduncles, small leaves and other wastes of apples, with a low content of nutrients, usually weak acidic reaction, which becomes strongly alkaline during washing equipment at the enterprise [1].

Based on these features and characteristics of wastewater, we developed the technology of deep treatment of highly concentrated wastewater at enterprises producing concentrated apple juice, which provides for neutralizing and correcting the content of biogenic elements, the removal of major contaminants in arc sieves, removal of suspended solids in the settler-flotator, full biological treatment in the two-step-air tanks with jet aeration and tertiary reagent treatment of wastewater [2]. The efficacy of treatment facilities, built just for such technology at the enterprise for the production of concentrated apple juice "Bukofrut" in Chernivtsi region (see Fig.), was carried out during the season of 2010-2011.

The start up of air tanks at treatment facilities in the early season of apple processing was carried out using as a “seed” activated sludge from municipal wastewater treatment plants. This dose of sludge in the air tanks increased the average – 3.2 g / l during three weeks, when the launch was carried out in the work of the company, indicating the acceptability as a substrate of neutralized fortified with nutrients and previously clarified wastewater. Further sludge dose increased to 5.8 g / l, and excess active sludge periodically looked like before the settler-flotator for biological coagulation of pollution.

General view of the treatment facilities of the enterprise for the production of concentrated apple juice

To neutralize the wastewater to the receiving reservoir of the pumping station supplying wastewater to treatment facilities caustic soda was dosed and for correcting nutrient composition - ammophos and ammonium nitrate. This allowed for the maintenance of air tanks pH within 6.48-7.55 with an average value 7.08, to increase value in waste water BOD : N : P, accordingly, with 100:0.36:0.07 to 100:4.3:2.1.

Two arc sieves brand SD-F-50 provide the effective removal of peels, seeds, peduncles, leaves and other wastes of apples and a large hang from wastewater. The effectiveness of their work determined by the concentration of suspended solids, was 24.8-35.7 % and humidity of detained solid fraction – 84.1-86.8 %. Further reducing the concentrations of suspended solids and other contaminants was provided in the settler-flotator diameter 7.2 m, which is initially short-term settling of wastewater, after which they are treated by dissolved air flotation scheme with recycle stream. Average residual concentration of suspended solids in wastewater after settler-flotator thus amounted to 288 mg/dm$^3$, and the average efficiency of treatment – 56.6 % for COD and 46.0 % for BOD.

The results of treatment at wastewater treatment plant are listed in Table.

Table

The results of wastewater treatment of concentrated apple juice production enterprises (average value)

| Rates | Concentrations of wastewater pollutants mg/dm3 | | | Purification effect, % |
|---|---|---|---|---|
| | untreated | after settler-flotator | after air tanks-settlers | |
| pH | 4.9-11.4 | 6.22 | 7.08 | - |
| Suspended solids | 2176 | 288 | 15.4 | 99.3 |
| COD | 9094 | 3947 | 62.5 | 99.3 |
| BOD | 5941 | 3207 | 17.7 | 99.7 |
| Ammonium nitrogen | 21.6 | 139.2 | 2.9 | 86.6 |
| Phosphates | 3.9 | 67.4 | 1.4 | 64.1 |

Experimental coagulation (coagulant Pro-AQUA-18) and subsequent settling of biologically treated wastewater ensures the achievement of indicators of quality standards for discharge into open waters.

This year at treatment plants will be mounted and put into operation node of mechanical sludge dewatering and reagent tertiary wastewater treatment.

Conclusions:

1. Wastewater from the production of concentrated apple juice containing significant amounts of organic pollution has low content of nutrients, usually with weak acid reaction.

2. The technology of tertiary wastewater treatment enterprises for the production of concentrated apple juice provides neutralizing and correcting the content of biogenic elements in arc cleaning sieves and a settler-flotator, full biological treatment in air tanks and tertiary reagent wastewater treatment.

3. Production technology research confirmed the possibility of achieving quality of wastewater treatment at enterprises for the production of concentrated apple juice, which comply with the discharge of treated wastewater into open waters.

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## WASTEWATER TREATMENT FROM PHOSPHORUS

# COMPOUNDS IN ACTIVATED SLUDGE SYSTEMS

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This paper presents the scientific research of phosphorus removal process from wastewater and its implementation in effective technologies which decrease phosphorus to level accepted by Ukrainian normative documents.

The protection of water resources is one of the main environmental problems at the present stage of human development. Of special interest is the problem of municipal wastewater treatment from nitrogen- and phosphorus-containing compounds that cause eutrophication of aquatic ecosystems.

Increasing nitrogen and phosphorus concentrations in the ecosystems causes rapid algae growth and secondary pollution, color and water temperature changes, dissolved oxygen concentration reducing and organoleptic characteristics deterioration. These processes complicate water usage for industrial enterprises, households, as well as violate natural processes occurring in aquatic ecosystem.

The main sources of nutrients in water are domestic and industrial wastewaters, recreation areas and fertilizers outwash from fields.

Of particular relevance problem has become in recent decades due to a significant increase in the concentration of dissolved phosphates in household effluents as a result of intensive development of new technologies in industry and daily use of phosphorus detergents. The problem has become particularly actual during the last decades due to significant increase of dissolved phosphates concentration in household effluents because of intensive development of new technologies in industry and daily phosphorus detergents application.

Phosphorus has a significant influence on the process of eutrophication because it is the main limiting element for algae growth in aquatic ecosystems. Therefore, phosphorus has to be removed at the first setout to hinder the eutrophication process.

The problem of phosphorus removal from wastewater hasn't an optimal solution at present and requires further research. Different methods (physical, physico-chemical and biological) can be used for phosphorus removal from wastewater. The biological method of wastewater treatment has relatively low cost and relatively high efficiency. Unfortunately, the vast majority of treatment facilities in Ukraine can not remove phosphorus compounds to required level and do not provide additionally treatment for phosphorus removing. The physico-chemical methods allow obtaining good results but have several disadvantages:

contamination of treated water by reagents, the complexity of precipitation processing, high cost of electricity and reagents.

It has been found that different oxygen conditions of environment are necessary for phosphorus extraction from wastewater. Bacteria of the genera *Acinetobacter*, *Acetobacter*, *Nocardia*, *Cereus* [1] are able to accumulate a significant amount of phosphates under aerobic conditions and release it in anaerobic conditions. Phosphorus removal occurs under aerobic conditions in which bacteria cells consume orthophosphate and accumulate it as polyphosphate within the cell. For the process cells use the energy released from carbohydrates accumulated in anaerobic fermentation. For effective phosphorus removal it is necessary to maintain a neutral pH, control the presence of volatile fatty acids and carbohydrates with a short carbon chain, avoid high nitrate concentration [2, 3].

After analyzing the existing anaerobic-aerobic configuration of systems for biological wastewater treatment from phosphorus compounds we decided that system Phoredox / A / O is the most expedient for the further development. The system contains an anaerobic-aerobic stages and a secondary clarifier for separation of treated water from sludge which accumulated phosphorus inside. Further the sludge is removed from the system.

This technology will provide an effective wastewater treatment from phosphorus compounds, cost reduction associated with using reagents and electricity, environment protection from the excessive contact with phosphorus compounds

Conclusions:

1. Biological wastewater treatment method can be used to remove phosphorus from municipal wastewater. Preliminary results have shown that this method allows cleaning the wastewater to a concentration accepted by normative documents.

2. Activated sludge may be a cause of increasing the concentration of phosphorus because cells of microorganisms could release phosphorus from inside, the residence time of contact of treated water with the sludge has to be minimized for efficient phosphorus concentration reducing.

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# USING WATER TREATMENT SLUDGE IN WASTEWATER TREATMENT TECHNOLOGIES

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A large volume of concentrated waste is generated in wastewater treatment processes. These wastes constitute 1-2% of the total amount of wastewater which inflow to the wastewater treatment plant [1]. In a case of Ukraine the amount of sludge was about 21mln. $m^3$ in 2009 (Fig.1).

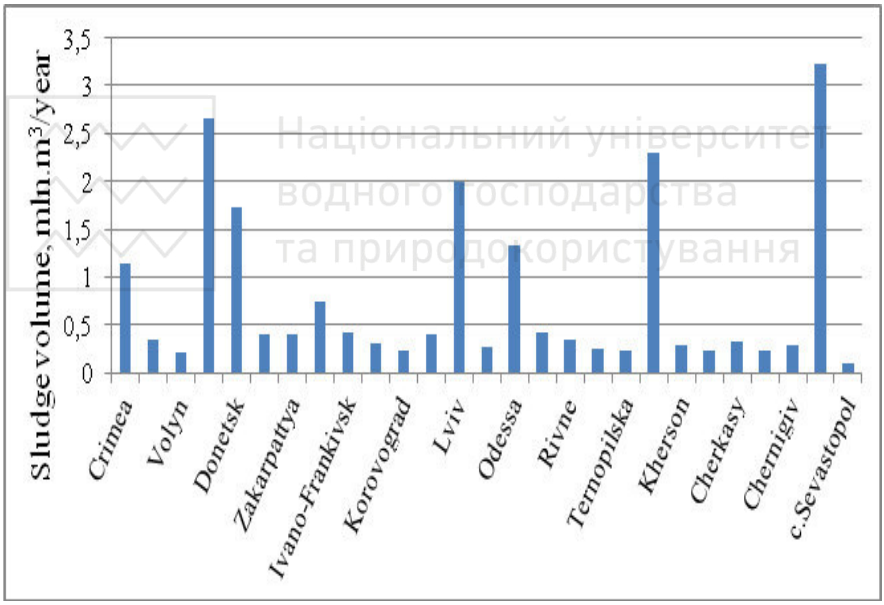


Figure 1. Annual volume of sludge produced at wastewater treatment plants in Ukraine

Wastewater treatment sludge is sanitary dangerous and have to be processed. Sludge processing means the reduction of its fermentation ability and total volume [2].

Thickening and dewatering decrease the humidity, volume and mass of sludge and it is a necessary part of all sludge treatment processes. But for improving sludge dewatering characteristic pre-conditioning is necessary. The most

widespread methods is conditioning by chemical reagents using the following mineral coagulants: $FeCl_3$, $Fe_2(S0_4)_3$, $FeS0_4$, $A1_2(S0_4)_3$, not slaked CaO and slaked lime $Ca(OH)_2$. Ferric chloride is most effective one among these coagulants [3].

Despite the widespread conditioning with mineral coagulants they also have disadvantages, among which the main is a high cost of coagulants. So, using of new reagents, re-use of regenerated coagulants and using reagents from recycled materials is a promising direction to reducing wastewater sludge dewatering cost.

Within drinking water preparation process a large amount of concentrated technological waste water is generated (Fig.2). The amount of this water depends on the quality of water source, type of coagulants, chemicals, building design features and can reach 5% of the total amount of water being treated [4].

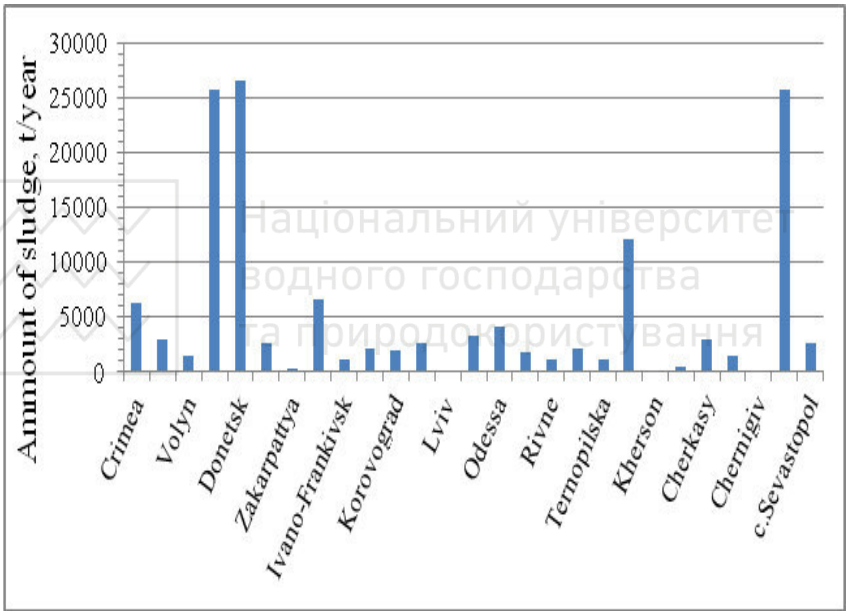


Figure 2. Annual amount of sludge produced
at water treatment plants in Ukraine

Drinking water supply in Ukraine is carried out from underground sources for 30%. The main pollutant of such water is iron, which have to be removed according to existing regulations for water quality.

National and international experience of underground water treatment plants waste management shows that the most widespread are methods for waste disposal, e.g. discharge of sludge into lagoons, wetlands, old well. These methods provide for storage of waste in the environment and lead to excessive pollution of the environment, groundwater and soil. The method of sludge disposal by transporting

it into natural emptiness of geomorphological stable layers, which helps to protect ground water and soil from pollution, is spreading in USA. But totally ecologically-clean result is not always achieved in practice. These methods of sludge disposal do not provide adequate environment protection from repeated pollution, require large areas for sludge storage, do not meet current requirements and thus may be only temporary actions for sludge disposal.

Coagulant production from sludge with high concentration of iron dioxide is a perspective way of sludge utilization at ground water treatment plants.

Table 1

Chemical composition of dry sludge from water treatment plant at Tomsk intake

| Sludge from plant | Oxide content,% | | | | | |
|---|---|---|---|---|---|---|
| | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | CaO | MgO | l.d.c.* |
| | 5.48 | 42.45 | 1.02 | 4.20 | 2.00 | 30.34 |

* - loss during calcination

Our laboratory research of activated sludge thickening intensification showed positive effect on thickening rate by received reagent addition.

Further use of obtained reagent for the intensification of wastewater treatment plants sludge thickening allows achieving not only a positive ecological effect by reducing the discharge of sludge in the environment, but also gives prerequisites for positive economic effect of using the received reagent instead of industrial.

**Conclusions:**

Analysis of data shows that water and wastewater sludge are problem for communal services. This sludge requires special facilities for processing and utilization which are additional capital and operating costs. Existing methods can achieve a positive ecological effect. But they often depend on other sector of national industry, requires additional costs and increasing total cost of water treatment. Methods which can decrease cost of sludge utilization and provide positive ecological effect are perspective in this case.

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# THE MECHANISM OF "PNEUMOEXPLOSION" IN WATER WELL CONDITIONS

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Process of the expiration of air through exhaust openings is rather rapid and consequently without a significant error can be considered as adiabatic. With exhaust compressed air passes through exhaust openings of a pneumocartridge (pneumopatron) practically an instant expiration of air in to water occurs.

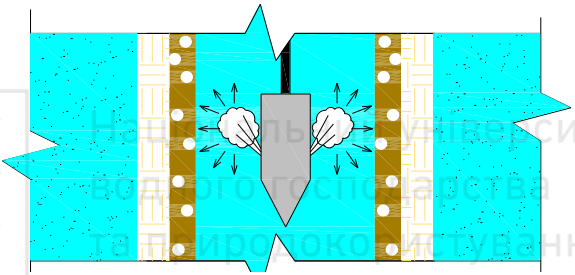

**Fig. 1.** Process of air from a pneumocartridge expiration

As a result of the resistance of an environment a bubble is formed. It is possible to consider as the cartridge (patron) a point source of perturbation, the bubble takes the form of a spheroid. Kinetic energy of air flows at forming air bubble will be transformed in to potential energy of pressure and in this connection the initial pressure in a bubble is much higher than the pressure of the environment.

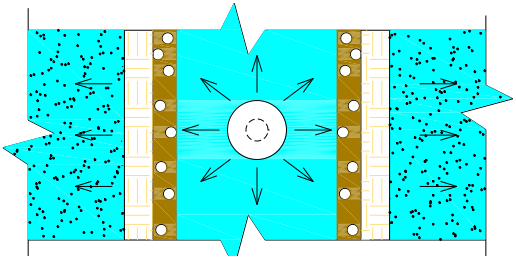

**Fig. 2.** Process of a bubble expansion

The initial high pressure in a gas bubble causes fast expansion of a bubble. Water carried away by an extending bubble, possesses significant speed of spreading movement. Expansion proceeds during rather a long period time, and the pressure in a bubble falls at development of this process, but expansion of a bubble continues owing to inertia of an expansion stream. When the pressure in a bubble becomes below hydrostatic pressure of the environment, expansion and divergence move of water stop. Borders of a bubble start to reduce with a continuously growing speed. Converging movement of a gas bubble continues until the increase of the air pressure in a bubble will not stop this reduction. After that the bubble again starts extending, and the pressure falls in it.

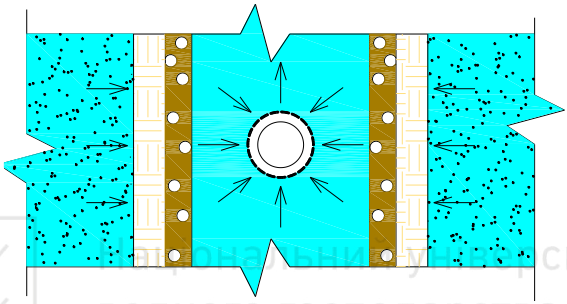

**Fig. 3.** Process of a bubble compression

Thus, inertia and elasticity of water, together with elasticity of gas create the necessary conditions for the origin of the fluctuation system; the bubble makes consecutive cycles of expansion and compression with continuous attenuation.

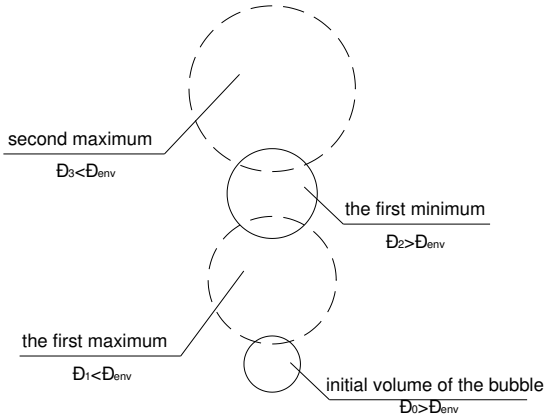


**Fig. 4.** Process of expansion and compression of a bubble

These pulsations of the air bubble, supported by new explosions of compressed air, resulting in intensive moving significant liquid masses, cause the powerful

wave process influencing colmating formations of a filter and around–filter zones of a water well.

Rising to the well, the air is mixed with water, forming a mixture, the density of which is less than the density of water. As a result, under certain conditions airlift-effect arise. This makes destroyed colmating sediments submitted.

We calculations of working parameters of the airlift-effect caused by work of a deep pneumocartridge had been executed.

Calculation of density of a water and air mix and height of its lifting depending on diameter (150, 200, 250, 300 mm) of a water well, depth of work (50, 100, … 500 meters) of a pneumocartridge and strength of colmating formations ($2 \cdot 10^6$ Pa) has been made.

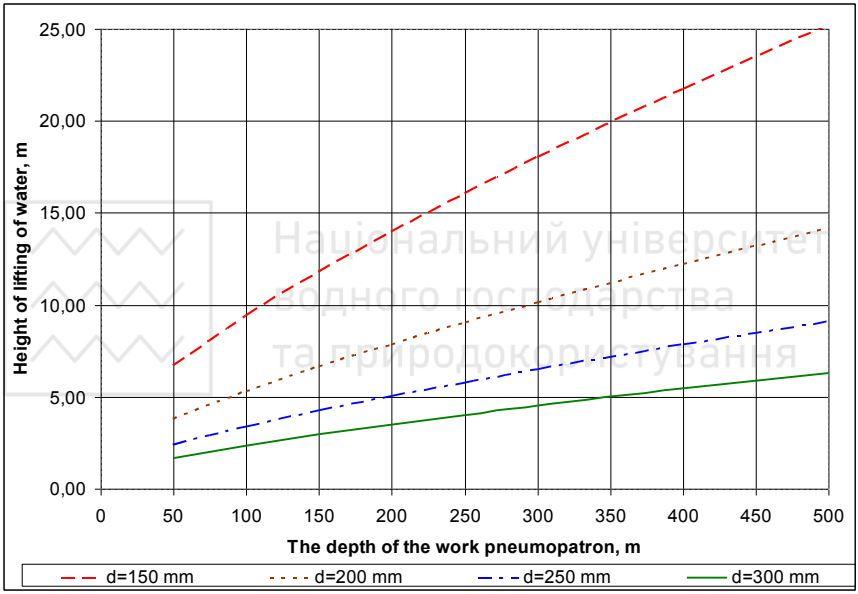


**Fig. 5.** The dependence of the height of lifting of a water and air mixture of depth of work of a pneumocartridge

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# VACUUM SEWER SYSTEMS

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Modern engineering and architectural decisions of public and production buildings, high-rise construction along with development of underground space, cause need of adoption of new non-standard design decisions of internal engineering systems.

Gravity sewer systems can cause problems for city administration, the construction and assembly organizations and owners of real estate. It is connected with high cost of these systems, the long periods of carrying out construction works and restrictions on traffic during construction. Also, designers and construction companies often should solve the questions connected with the difficult geological soil structure, circumvention of existing pipelines, overcoming of natural obstacles and other problems.

Vacuum sewer systems are innovative and cost-effective solution of such problems, while possessing many advantages. Vacuum sewer technology appeared a few decades ago and is a high-tech and perfect alternative to gravity systems. For the last 40 years more than 500 vacuum systems are installed worldwide.

In comparison to conventional gravity or pumping systems vacuum system offers the following important advantages to residents and operators:

- much shorter period of construction;
- considerable savings in construction costs;
- pipelines are laid in shallow and narrow trench;
- small diameter of pipelines (80 - 250 mm) and their flexible design;
- pipelines of lines of the vacuum sewer systems and water supply can be laid in one trench;
- sealed system with no leakages or smells;
- one central vacuum station can replace several pumping stations;
- the possibility of joining up to 90 units of sanitary facilities to a single line of vacuum sewerage systems.

Since the vacuum sewer systems have the ability to self-cleaning and do not require the creation of water supplies for washing lines, they are more profitable not only from an economic point of view, but also exceed environmental indicators. These systems provide a number of advantages in the construction of sewage systems in complex terrain or geological structure of the soil.

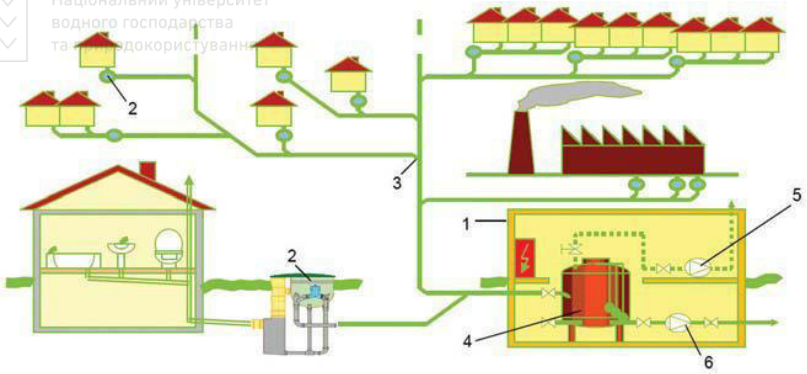


Figure 1. Functional scheme of the vacuum sewer system

Depending on the terrain, the wastewater collect within a few kilometers from the central vacuum station (1). Wastewater from each buildings fall by gravity into the collecting chamber (2), installed outside the building. When in the collection chamber accumulates a certain amount of waste water, hydrostatic pressure activates a pneumatic controller, which opens the pneumatic vacuum valve, and the entire volume of wastewater arrives into the pipeline (3). Connection of the collecting camera to the electrical network is not required, because all the equipment is controlled pneumatically. Atmospheric air is let in through vacuum valves system in the points located on removal from vacuum station, and the stream of sewage with high speed passes through pipeline lines to the central vacuum station. All lines of pipelines of system of the vacuum sewerage incorporate to the vacuum accumulative reservoir (4) established at the central vacuum station where by means of vacuum pumps (5) required negative pressure (about-0.6 bar) is created. Further pressure pumps (submerged or external) transfer wastewater from the reservoir at the treatment plant or in the pipeline of an existing gravity sewer.

The leader in the European, Asian and African markets is the Roediger Vacuum company. International experience of this company includes prestige projects like the Formula-1 racetrack in Shanghai, the waste water disposal system for the historic Old Town of Flavigny sur Ozerain in France, Durrat Al Bahrain, Palm Island Jumeirah in Dubai, the Olympic Sailing Centre in Athens and the Olympic National Sports Complex in Kyiv.

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# ASSESSMENT OF ENVIRONMENTAL RISKS IN THE AREA OF BASIN RIVER HORYN

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The environmental security is a crucial factor for sustainable development of any country. Providing of sustainable social-ecological-economic development is accompanied by the creation of a safe environment for the life of society and every individual in particular, present and future generations.

Based on the content of the concept of sustainable development of the interpretation of ecological security should combineting of the three main areas:

- anthropocentric, which provides of quality human environment;
- biosphere-environmental, which provides of the preservation properties of ecosystems and the biosphere as a whole;
- resource, which provides the necessary natural resources for capacity of normal economic and social development of society and state, and therefore rational use taking into account the possibility of recovery.

The aim of our study is determineting of the level of environmental safety of area Horyn River Basin. The subject of research are quantitative and qualitative indicators which characterizes the environmental state of the Basin River.

According to the investigations by Gerasymchuk Z. and Vahovych I. we can describe the environmental security of the region with three blocks of indicators [1].

In the resource block take place analysis of indicators that shows the level of engagement and exhaustion, rationality and efficiency of natural resources - namely, plowed area, the area of hayfields and pastures, the land area of cities and town, the area of land affected by water, wind erosion and their joint action, the area of wetlands and wetland soils, the area of acid soils, the area of saline soils, the proportion of eroded land, consumption of fresh water, saving water intake at the expense of working and consistent water supply, share of forest resources in the general area of the region, restoration of forests.

Biosphere-environmental block includes indicators that reflect the level of contamination of the environment of the region and opportunities for conservation properties of the biosphere in the future ¬ m. In particular, such indicators - total emissions, the density of pollutant emissions per capita, emissions of pollutants into the air, the proportion of contaminated wastewaters in the total discharge,

specific indicators of the formation of industrial toxic waste hazard 1-3 class, the presence of a waste 1-3 hazard class in designated places or objects in the enterprise and others.

Anthropocentric block proposed to form of the indicators which reflect health demographics of the region - population, fertility rate, mortality rate, natural increase of population, the incidence of some infectious and parasitic diseases, active tuberculosis, malignant neoplasms, diseases of blood forming organs.

Within each block we getting the partial integral indicator by methods [2], which describes the development of the environmental safety of each region.

Table 1

Grouping of regions by level of ecological safety

| Zone | Level of ecological safety | | | |
|---|---|---|---|---|
| | Safety | Risk | Disaster | Threat |
| Polissia Zone | 2 | 5 | 12 | 0 |
| Forest-step Zone | 3 | 4 | 10 | 1 |

Its will give the opportunity to conduct comparative description of areas and give a qualitative evaluation of the ecological state of a particular region that provides its complexity and increases the practical value.

The general integral indicator of ecological security reflects generalized description of the environment in the basin. Its value can determined in which of the state gets a certain study area - environmental safety, environmental risk, environmental disaster, environmental threat. According to our researches 1 districts belongs to the zone of ecological disaster, most districts in the basin of the river Horyn characterized by low-ecological threatening the values of ecological security (22 districts), 9 districts came to the area of risk, 5 districts in the area of environmental safety.

Thus, the very definition of the integral indicator of ecological security allows for the comparative description of the regions (in our case - districts) in terms of its environmental safety, which will generateding objective conclusions about the state of environmental safety and take the appropriate action.

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# NUMERICAL SIMULATION OF THE SECONDARY SETTLER WORKING

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In the present paper the developed numerical model to simulate the secondary settler working is presented. To simulate the flow in the settler the model of potential flow is used. In this case the governing equation is

$$\frac{\partial^2 P}{\partial x^2} + \frac{\partial^2 P}{\partial y^2} = 0, \qquad (1)$$

where $P$ – the potential of the velocity.

The components of the flow field are calculated as follows $u = \frac{\partial P}{\partial x}$, $v = \frac{\partial P}{\partial y}$.

To simulate the pollutant dispersion in the secondary settler the transport model is used

$$\frac{\partial C}{\partial t} + \frac{\partial uC}{\partial x} + \frac{\partial (v - \omega)C}{\partial y} + kC = \frac{\partial}{\partial x}\left(\mu_x \frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(\mu_y \frac{\partial C}{\partial y}\right), \qquad (2)$$

where $C$ – the concentration of the pollutant; $u$, $v$ – the velocity components; $\omega$ is the speed of gravity fallout; $k$ – the parameter taking into account the process of pollutant transformation (agglomeration etc.); $\mu = (\mu_x, \mu_y)$ – the diffusion coefficients.

To calculate '$k$', '$\omega$' parameters the empirical models are used. The meaning of the diffusion coefficients is calculated using recommendations by Prof. A. Ya. Oleynic et al.

Numerical simulation is carried out using rectangular grid. To form the comprehensive geometrical form of the vertical secondary settler the porosity technique is used (*markers* method). This technique allows to create any geometrical form of the settler.

Before the integration of the equation of the potential flow this equation is written in the following form

$$\frac{\partial P}{\partial \eta} = \frac{\partial^2 P}{\partial x^2} + \frac{\partial^2 P}{\partial y^2}, \tag{3}$$

where $\eta$ – the fictive time.

For $\eta \to \infty$ the solution of the equation (3) tends to the solution of the equation (1). The implicit scheme of the *conditional approximation* is used to integrate the equation (3). At the first step the of approximation the modeling equation is as follows:

$$\frac{P_{i,j}^{n+\frac{1}{2}} - P_{i,j}^{n}}{\Delta t} = \left[\frac{-P_{i,j}^{n+\frac{1}{2}} + P_{i-1,j}^{n+\frac{1}{2}}}{\Delta x^2}\right] + \left[\frac{-P_{i,j}^{n+\frac{1}{2}} + P_{i,j-1}^{n+\frac{1}{2}}}{\Delta y^2}\right]. \tag{4}$$

At the second step the approximation is as follows:

$$\frac{P_{i,j}^{n+1} - P_{i,j}^{n+\frac{1}{2}}}{\Delta t} = \left[\frac{P_{i+1,j}^{n+1} - P_{i,j}^{n+1}}{\Delta x^2}\right] + \left[\frac{P_{i,j+1}^{n+1} - P_{i,j}^{n+1}}{\Delta y^2}\right]. \tag{5}$$

The unknown meaning of $P$ is calculated using the explicit formula of the 'running calculation'. In allows creating the effective algorithm of calculation at each step of splitting in the computational region having comprehensive geometrical form. To solve the equation of the pollutant transport the implicit change–triangle difference scheme is used. In this scheme the unknown meaning *C* is also calculated using the explicit formular. On the basis of the numerical model of the settler the code "Settler-2" was developed. The *FORTRAN* language was used to create the code.

The results of the numerical experiments are presented. These results include the mathematical modeling of the vertical settlers having different geometrical forms, different position of the in- and out openings, settlers with guiders.

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# MODELING OF OXYGEN REGIME IN THE USTIA RIVER IN CONDITIONS OF HUMAN INFLUENCE

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The main issue of the research is the methods of modelling oxygen regime in rivers with the help of mathematical models. In this case the issue is solved by numerical methods (method of Runge - Cutt). The research work analyses the model sensibility to the change of coefficients. As a result of the undertaken work simple in use the model of oxygen regime in conditions of human influence has been elaborated.

The study of processes of the transformation of organic substances of natural or anthropogenic load becomes particularly important in Ukraine because of overloading of treatment plant by the drainage of poisoned substances from farmlands. Because of this in rivers arises a zone of high deficit of dissolved oxygen that causes ice formation during freezing period. Therefore, very important moment in systems of ecological monitoring is the development of very simple and reliable models, based on which one could predict the consequences of human activities during exploitation of water objects of Ukraine.

This work presents the results of calculation using the model describing the dynamics of organic pollutants and dissolved oxygen in waters of the Ustia river of Rivne region, considering the spatial variability of hydraulic properties. It is changed models Stritera - Phelps, represented in the form of two ordinary differential equations. The values of coefficients and parameters of the model represent the main hydrochemical characteristics of the river

$$\frac{V(x)dl}{dt} = -\left[K_1(x) + K_2(x)\right]L + R_a \quad (1)$$

$$\frac{V(x)dD}{dt} = K_1(x)L - K_2(x)D + R_b \quad (2)$$

where: x – the distance from sewage disposal into the river, km; V(x) – water flow velocity in river, km/day; L(x) – concentration of pollutants expressed as BOD, mg $O_2$/l; D(x)=$C_s$- C(x) – lack of dissolved oxygen, mg $O_2$/l; $C_s$, C(x) – real concentration and concentration of oxygen during saturation, mg/l; $R_a$ – additional accumulation of pollutants in the downstream flow, mg·l/day; $R_b$ – rate of oxygen depletion by bottom sediment, mg·l/day; $K_1(x)$ – coefficient of biochemical

oxidation of organic matter, mg·l/day; $K_2(x)$ – coefficient of re-aeration of water environment, $day^{-1}$; $K_3(x)$ – coefficient of sedimentation of organic contaminants, $day^{-1}$.

Calculations were carried out considering the following conditions: water stream is stationary; longitudinal dispersion of pollutants is very small (correlation $V^2/(2K_1E) > 100$) and running on any section of the river, where E – longitudinal dispersion coefficient of substance; biochemical oxidation of organic pollutants by the equation of reaction 1-th order; main mechanism of mass transfer of oxygen, associated with re-aeration (photosynthesis unavailable); re-aeration rate is proportional to the oxygen deficiency; oxygen concentration during saturation depends on water temperature, which is assumed to be constant at certain periods of time, relevant calculation: summer(July) and winter (February).

The value of the coefficients $K_1$ and $K_2$ were chosen based on sound literature data (confidence interval 90 %). So, the value of coefficients of biochemical oxidation $K_1$ changed in the rages: $0.11<K_1<0.59$ $day^{-1}$, and value of $K_2$ changed in ranges $0.31<K_2<1.19$ $day^{-1}$.

As a result of the analysis of our models, it was found that the water quality of the river mouth undergoes significant polluting effect by such towns as Zdolbuniv, Kvasyliv and Rivne city (surface flow).

Calculations were perfumed by Runge-Kutta`s method. Initial concentrations of BOD and dissolved oxygen appeared on the basis of field research. As a result of model calculations we obtained distribution deficit of dissolved oxygen in the river mouth of the respective ranges, where measurements were carried out. The calculated curves match well with observation data.

Using the model we estimated carrying capacity of the Ustia River. In the absence of re-aeration in winter ($K_2=0$) deficit rises sharply in the initial section of the river, and then its changes are not so considerable.

An important aspect in realization of the model is rating an impact on changing a value of coefficients $K_1$ and $K_2$.Taking typical for summer condition marking $L^0$ = 15 mg · $O_2$/l;$D^0$ = 3mg/l; $R_a=R_b=0,03$mg/l·day, with $K_2$ = const, we get initial data series of characteristic curves change D, depending on x. So, when $K_1=0.1$,$day^{-1}$ maximum D (3.2) occurs later and is less distinct, and with increasing $K_1$ by 3 times in value at the point of extremum increases 2.5 times.

Regarding the sensitivity of the model to the change of a value of $K_2$, the following results were obtained: with decreasing speed of re-aeration from 1.19 to 0.31 $day^{-1}$ (that is 4 times) D in extremum point increases by 2.5 times. Thus, with a decrease in $K_2$ extremum point D shifts for large value of x.

So, for the prediction of oxygen regime of rivers that are effected by human pressure we can use a very simple model, which takes into account changes in hydraulic characteristics of the river. The analysis showed high sensitivity of model solutions to the values of coefficients.

# THE SENSITIVITY OF OXYGEN REGIME IN THE WATERCOURSE TO THE VARIATION OF THE COEFFICIENTS OF BIODESTRUCTION POLLUTANCES AND RE-AREATION OF THE STREAM

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The oxygen regime of natural waters is one of the most important factors determining the structure and functioning of ecosystems of the river and largely determines the intensity of self-cleaning processes.

Pollution of watercourses and self-cleaning processes are linked. Type of contamination largely determines the degree of existing natural balance in the aquatic facility and impact on the physical-chemical and biochemical stability of aquatic ecosystems. At the same time into the water "mobilized forces" that oppose the natural environment and try to turn multi-system in steady state.

The content of dissolved oxygen is among the basic parameters that determine the quality of water in watercourses.

Analysis of our and foreign literature indicates that oxygen regime is a sensitive indicator of pollution level of natural waters, which depends on the physico-chemical, biochemical and hydrodynamic factors.

This work presents the research of the sensitivity of oxygen regime of water currents to the change of the numerical values of biodestruction of organic pollutants entering the waterways from sewage and numeric values of atmospheric re aeration of water flows. The following mathematical model was used for these researches:

$$V(x)\frac{dL}{dx} = -K_1(x)L - K_3(x)L + Ra \quad (1)$$

$$V(x)\frac{dD}{dx} = -K_1(x)L - K_2(x)D + Rb \quad (2)$$

where:

$x$ – the distance from the source of the river, km;

V ($x$) – water flow velocity, km / day;

L ($x$) – the concentration of organic matters (in terms of BOD), mg / l;

O ($x$) = CS – C ($x$) – deficiency of dissolved oxygen, mg / l;

C ($x$) – the concentration of oxygen in water, mg / l;

Cs – concentration of the saturation, mg / l;

Ra – additional revenue of organic matter in the downstream flow, mg / L·day;

Rb – oxygen uptake rate by bottom sediment, mg / L·day;

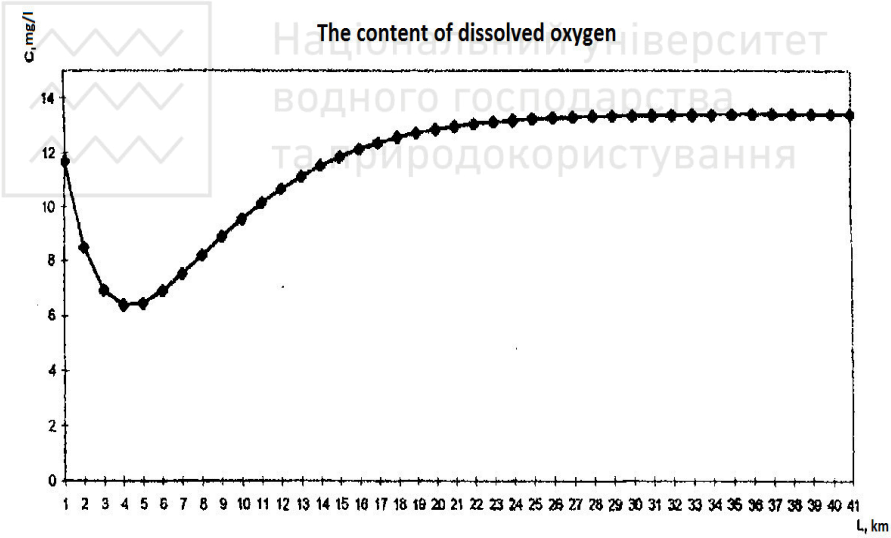
$K_1$ (*x*) – coefficient of biochemical oxidation of organic matter, $day^{-1}$;

$K_2$ (*x*) – coefficient of re-aeration of water, $day^{-1}$;

$K_3$ (*x*) – coefficient of sedimentation, $day^{-1}$.

Basing on the proposed model with the help of the numerical method of Runge-Kuga we investigated the sensitivity of the oxygen regime of the river to change numeric values of biochemical oxidation of organic matter. For research we used 13 chemicals for which the numerical values of biochemical oxidation coefficients were established.

First we investigated the sensitivity of variation coefficient of $K_1$ at constant value $K_2$. Taking a typical summer conditions, for the Ustya river (Rivne region), the initial values L = 10 mg$O_2$ / l, D = 2 mg $O_2$/ l, V = 0.25 m / s, Ra = 0.3, Rb = 0.3 mg / (l·day) and fixed $K_2$ = 0.3 $day^{-1}$ we obtain a series of curves, one of which is shown in the picture.




Analysis of the curves showed that they all have typical minimum (minimum content of $O_2$), which depends on the type of chemicals. Besides reducing $K_1$ three times gives 1.5 times feedback in $O_2$ concentration at the point of extremum. With increasing $K_1$ distance from release of sewage decreases to the point of extremum.

## DETERMINATION OF PER CAPITAL WATER

# DEMAND RATES OF A COMMUNITY

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The main category of water using in the cities of Ukraine is population. The realization of water to residential districts reaches 70% (even more in some cases). It is very important to know the structure of total water consumption for determination of per capital water demand in a community. The total water consumption in residential districts consists of not only useful water using that reflects a real need in water but also of a process and water losses (as a part of a process of water distribution to the community) [1, 3-4].

Useful water consumption, which includes slaking the thirst, cooking, washing food, cloth and the dishes, cleaning, hygiene procedures, ranges from 30 to 95 L/d per person. This currently accounts for about 20 ... 50% of total water consumption. The rest of the total water amount (50 ... 80%) are water losses in residential districts and process losses of water distribution system as the difference between the amount of water taking from the water networks and the amount of a rational need in it [1, 3-4]. Water losses include unauthorized water using, inaccurate water meter readings, and water losses during water transmission to the consumers. According to researches, water losses in residential districts account for about 20 ... 40% of total water amount [1, 3]. This indicates that the residential sector that accounts for the largest share of water using has bigger amount of water losses. Process losses are formed during the water transmission to the consumer (pipeline emptying, flushing, and disinfection). Therefore, we should take into account the needs of useful water use and increase it by a certain percentage during determination of per capital water demand for the community.

For example, the determination of per capital water demand rates for Zdolbuniv town were carried out as follows:

1) *Collecting of initial data.* The basic data for determination of potable water consumption rates are: total water input and output of the city during the last three years, the planned water amount for the next year; types of sanitary accommodation in dwelling sector and its corresponding characteristics: the value of present per capital water demand rates, number of consumers and people served with water meters and without it, the value of monthly water flow rates by the community with water meters and without it during the last three years, selected data of real water consumption (determined during the researchers), approved individual technological water requirements (process losses) of potable water, measures of water losses reducing and prevention [2].

2) *Analysis of initial data.* At this stage, we analyze the initial data: determine the tendency of the total water input and output changing during the last years,

separately by the community with water meters and without it; the percentage of water losses in the system and water using by the community of the total water input; the percentage of water consumers, equipped with water meters and without it, of the total population; the prevailing types of sanitary accommodations in the city and etc.

3) *Estimation of per capital water demand rates of the community.* We need to know the monthly value of water consumption based on a flat rate (without individual water meter) for each type of sanitary accommodations during the last three years and selected data of real consumption to estimate the values of per capital water demand of a community. Using methods of mathematical statistics (screening the anomalous values, check the obtained values of per capital water demand for normalcy of distribution), we can estimate the average value of per capital water demand by the community for each type of sanitary accommodation.

4) *Determination of estimated per capital water demand rates.* For determination of estimated per capital water demand rates it is should be considered the estimated values of per capital water demand, the planned water amount for the next year, technological water requirements (process losses) of potable water (process water flow rates, water losses from water transmission and distribution system, unmetered water flow rates), the planned measures of water losses reducing and water use rationalization.

For example, the planned water amount by the community based on a flat rate (without individual water metering) for Zdolbuniv town (Rivne region) do not differ from the average value during the last three years (2009-2011). The average percentage of water losses is 29.6%, which include process water flow rates, water losses from water transmission and distribution system, unmetered water flow rates. Table 1 presents the average values of per capital water demand rates of a community including water losses and without it. The planned measures of water leakage reducing and rational water using will reduce the value of the total water consumption by 10-20%. Determined per capital water demand rates in case of implementing measures of water rational use and energy saving are shown in Table 1 for each type of sanitary accommodation. These values are within the rates of the average values of per capital water demand with and without water losses for Zdolbuniv town.

If to compare present and determined per capital water demand rates for different types of sanitary accommodation (Table 1) we can see that the values are the same for five types of sanitary accommodation, for three types the values of present per capital water demand are more than the determined ones (especially for sanitary accommodation of yard water column) and for two types – are less.

Table 1

Comparison the values of per capital water demand rates for each type of sanitary accommodation

| Number | Sanitary accommodation | Per capital water demand, *L/d per person* | | | |
|---|---|---|---|---|---|
| | | Average | Average including water losses | **Present** | **Determined** |
| 1 | Central water supply, urban sewage systems (only cold water) | 185.1 | 234.3 | **225** | **200** |
| 2 | Water supply and sewerage systems, without bathroom | 100.2 | 126.8 | **95** | **110** |
| 3 | Water supply and sewerage systems, without bathroom, with gas supply | 109.9 | 139.1 | **120** | **120** |
| 4 | Water supply and sewerage systems, bathroom, water heating system based on solid fuel | 138.9 | 175.8 | **150** | **150** |
| 5 | Water supply and sewerage systems, bathroom, gas water heating system | 186.1 | 235.6 | **190** | **200** |
| 6 | Water supply and sewerage systems, bathroom, water heating system based on multipoint water distribution | 198.0 | 250.7 | **210** | **210** |
| 7 | Water supply system without sewerage system | 91.4 | 115.7 | **100** | **100** |
| 8 | Street water column | 37.6 | 47.6 | **50** | **40** |
| 9 | Yard water column | 77.9 | 98.7 | **150** | **85** |
| 10 | Water supply system, septic, bathroom, gas water heating system | 156.6 | 198.2 | **150** | **170** |

Thus, it is necessary to analyze water using by a community for each type of sanitary accommodation during the last three years, take into account the process losses, water losses in water transmission and distribution system, planned water amount for the next year and measures of water losses reducing in order to determine per capital water demand rates of a community.

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## WATER DECARBONIZATION

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Water softening is the process of removing cations of hardness - calcium and magnesium. Due to STST 2874-82 "Potable water" hardness of water can't be more than 7 mmol/dm$^3$. Some types of productions pull out the requirements of deep softening to technological water – till 0.05…0.01 mmol/dm$^3$. Water sources, which are usually used, have hardness that meets the standards of economic-potable water and don't need softening. Water softening is conducted mainly during its preparation for technical aims.

Water softening is conducted by such methods: thermal, that is based on heating water, its distillation or freezing; using reagents - ions of $Ca^{2+}$ and $Mg^{2+}$, that are in the water, bound by different reagents in practically insoluble connections; ionic exchange, that is based on water filtration through special materials that truck the ions of $Na^+$ or $H^+$, which are included in their composition, for the ions of $Ca^{2+}$ or $Mg^{2+}$, which are contained in the water; dialysis; combined, which shows various combinations of the enumerated methods [1, 3].

The choice of the method of water softening is determined by its quality, necessary depth of softening and from the technical and economic point of view.

Water quality data are shown in Table 1. It needs purification for the further use in chemical industry.

Table 1

Water quality data

| Parameters | Units | River water | |
|---|---|---|---|
| | | Winter period | Summer period |
| pH | | 8.05 – 8.2 | 8.0 – 8.1 |
| Carbonate hardness | mmol/dm$^3$ | 5.6 – 6.0 | 4.5 – 4.7 |
| General hardness | mmol/dm$^3$ | 6.7 – 7.0 | 5.6 – 5.7 |
| Calcium hardness | mmol/dm$^3$ | 5.2 – 5.6 | 4.2 – 4.6 |
| Ferrum | mg/dm$^3$ | 0.16 – 0.7 | 0.16 – 0.7 |
| Suspended substances | mg/dm$^3$ | 10 - 13 | 15 - 25 |
| $SiO_2$ | mg/dm$^3$ | 12 – 16 | 12 – 16 |

| | | | |
|---|---|---|---|
| Langelier Index | norm J=0 | 0.9 – 1.07 (carbonate sedimentations) | 0.69 – 0.85 (carbonate sedimentations) |

Due to Table 1, the decarbonization of water by precipitating sedimentations is usually used for such water quality (softening and clearing up with lime solution and coagulation with sulphuric acid iron and filtration through a pin filter) (Figure 1). Softening and clearing up passes in clearers VTI-1000-I.

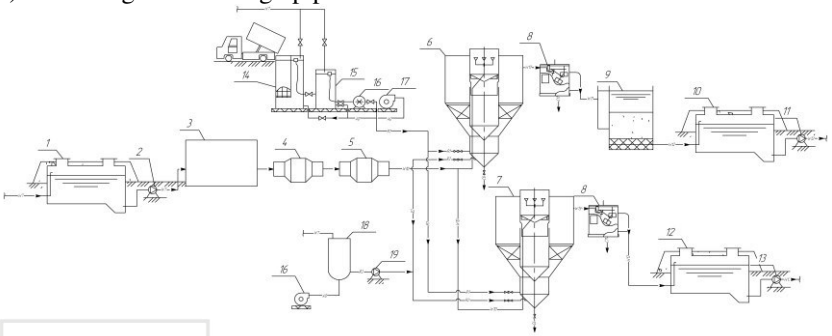

Figure 1. Technological scheme of water decarbonization using lime solution and coagulation:
1, 10, 12 – reservoirs; 2, 11, 13, 19 – pump; 3 - caldron workshop; 4, 5 –steam and runback heat-exchangers; 6, 7 – clearers; 8 – tank of break of stream; 9 – pin filter; 14 – soluble tank of coagulant; 15 – feed-tank of coagulant; 16 – metering pump-device; 17 – compressor; 18 – tank of lime

Using liming free and constrained carbonic acid is removed from water, general and carbonate hardness, dry remains of initial water decrease. We can remove organic and colloid substances, decrease colouring of water and content of compounds of silicon when we combine liming with coagulation.

Reactions of liming process in molecular form [2]:

- free carbonic acid removing:

$$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 \downarrow + H_2O \ ; \quad (1)$$

- calcium hardness removing:

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + 2H_2O \ . \quad (2)$$

Ferrum hydroxide is a reagent for the formation of colloid system in future. During liming of water with coagulation next reaction takes place

$$4FeSO_4 + 4Ca(OH)_2 + H_2O + O_2 \rightarrow 4Fe(OH)_3\downarrow + 4CaSO_4\downarrow. \quad (3)$$

However, there is a need of initial river water heating to the temperature 20-30˚C for the effective passing of higher resulting processes. It leads to using quite enough amount of electric power which is quite expensive.

There were conducted researches for finding an alternative for its quality with the coagulant. It is possible to use flocculants for the reduction of energy consumption during the production of decarbonized water. Flocculants are substances that increase clinging aggregate unsteady particles and in the same time intensify the process of flocculation and enlarge their sizes. In this way the process of decarbonization will pass at temperature 10-15 °C without the additional heating. Results of researches are shown in Table 2.

Table 2

Results of conducted researches using flocculant Purofloc-890

| Test name | River water | Decarbonized water | | Effect, % | Norm |
|---|---|---|---|---|---|
| t, °C | - | 10 | 15 | - | - |
| $D_f$, mg/dm$^3$ | - | 0.5 | 0.5 | - | - |
| pH | 8.03 | 9.48 | 9.55 | - | 9.0-10.5 |
| Suspended substances, mg/dm$^3$ | 7 | 9 | 6 | - | n/m 15 |
| General hardness, mmol/dm$^3$ | 7 | 1.9 | 1.9 | 73 | n/m 2.0 |
| Calcium hardness, mmol/dm$^3$ | 6 | 0.8 | 0.8 | 87 | - |
| Carbonate hardness, mmol/dm$^3$ | 6.2 | 0.2/1.0 | 0.2/1.0 | 84 | n/m 0.4/1.0 |

The usage of this flocculant for the decarbonization of initial river water in clearers VTI-1000-I allows:

1. Working during reduced temperatures.
2. Refusing the use of the coagulant that promotes content of sulphates and iron in the decarbonized water.
3. Decreasing the amount of liming to coagulant dose
4. Decreasing loading on ionic exchange equipment, to prolong the term of suitability of filter ionic exchange materials.

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# IDENTIFY AREAS OF THE JET-JET FILTER WITH THE GRID, WHICH MESH SIZE IS 2 MM

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Mesh jet-jet filters (MJJF) is one of the surface water sources intake devices, which can be used effectively for the detention of debris and fish protection at water intake of narrow waterways in the light nature sources.

To ensure reliable and cost-effective treating pollutants on the filter mesh, their parameters are calculated using energy-saving technique. The calculation is performed for determining the geometric dimensions of the cylindrical filter housing, the size of washing device and its holes, pressure and water consumption of flushing system. The set of design parameters ensures removal of contaminants from the grid in the transit water flow at the lowest cost of electricity.

Earlier researches gave three scopes of the MJJF applying: the domain of rational-complex (RC), conditionally permitted (CP) and inappropriate (I) applying. The area RC is characterized by:

- the opportunity to supply flushing system of filters by the low-pressure main pump at the pumping station of water intake;
- the mandatory provision of the economic aspects of fish protection (safety of fry);
- determination of consumption in the wash filter system within 3% of their operation.

The criteria for this area are expressed by the following formulas:

$$H_{min} \le H \le H_{max\ RC} \quad (1)$$

$$H \le H_{fp}, \quad (2)$$

$$Q \le 0.03 \cdot Q, \quad (3)$$

where H, $H_{min}$, $H_{max\ RC}$, $H_{fp}$ – the pressures in the flushing system of filters:

H – adopted calculated pressure;

$H_{min}$ – is the minimum allowable accepted pressure that in these conditions is ensured by removing dirt and fry in the transit flow zone;

$H_{max}$ – maximum potential pressure that can be created by low-pressure pump in JJF flushing device;

$H_{fp}$ – maximum potential pressure while the economic aspect of fish protection is provided;

q – in the cost of flushing the filter system;
Q – system output.

The area CP is characterized by the ability to service the filter flushing system by high pressure pump in the main pump station of intake and identify consumption in the flushing system within 5% of MJJF operation. The criteria for this area are expressed by the formulas:

$$H_{max\ RC} < H \leq H_{max\ CP}, \quad (4)$$

$$0.03 \cdot Q < q \leq 0.05 \cdot Q, \quad (5)$$

where $H_{max\ CP}$ – the highest possible pressure, which can be obtained by high-pressure pump in the JJF washing device.

In area I must be installed a special flush pump for servicing the filter flushing system. The criteria for this area are described by the following formulas:

$$H > H_{max\ CP}, \quad (6)$$

$$q > 0.05 \cdot Q. \quad (7)$$



For energy-saving methods filter parameters were calculated, for Q = 0.1 $m^3/s$ for various fixed operating conditions of water intake on the streams $\overline{Q}$ and $\overline{\ell}$ ($\overline{Q}$ – relative flow rate of water intake $\overline{Q}$ = Q / (Qpmin-Q), where Qpmin – the estimated minimum river discharge; $\overline{\ell}$ – the relative width of the watercourse $\overline{\ell}$ = $l/D_c$, where l – the width of the watercourse at the middle of filter tip forming, $D_c$ – filter diameter) at different concentrations of contaminants in the water. Mesh grid size of 2 mm was adopted in the calculations because of its the relatively low resistance, and to ensure a sufficient degree of fish protection.

For two-section intake with the flow rate of 0.1 $m^3/s$, flushing MJJF system can be serviced by low-pressure pump D500-65 or high-pressure pump D630-90. Criterion value of the pressures of scope areas of the filter accordingly can be determined as follows:

$H_{min}$ = 6m; $H_{max\ RC}$ = 25m pk; $H_{fp}$ = 35m; $H_{max\ CP}$ = 60m.

The results of calculations with determining the areas of MJJF using for the different conditions are shown in Table.

Table

Applications of JJF, Q = 0.1 $m^3$ / s with a mesh grid size of a = 2 mm

| $\frac{\bar{\ell}}{\bar{Q}}$ | $\xi$ | 5 | 10 | 20 | 40 |
|---|---|---|---|---|---|
| 0.025 | 0.0001 | RC | RC | RC | CP |
| | 0.0003 | RC | RC | RC | CP |
| | 0.0005 | RC | RC | RC | CP |
| 0.05 | 0.0001 | RC | RC | CP | I |
| | 0.0003 | RC | RC | CP | I |
| | 0.0005 | RC | RC | CP | I |
| 0.1 | 0.0001 | RC | RC | I | I |
| | 0.0003 | RC | CP | I | I |
| | 0.0005 | RC | CP | I | I |
| 0.2 | 0.0001 | RC | CP | I | I |
| | 0.0003 | RC | CP | I | I |
| | 0.0005 | RC | CP | I | I |



The calculation results confirm the effectiveness of the MJJF in narrow waterways. This allows:

1. Make an informed decision about the possibility of using MJJF of set performance with established grids;
2. Ensure the power-saving mode of operation;
3. Decide reasonably the problem of source supply for the flush system;
4. Provide additional measures to ensure the economic aspect of fish protection.

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## TECHNOLOGY OF WASTEWATER TREATMENT FOR HEAVY METALS IONS

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For the purpose of intensification of the work of units [1, 2] for reagent-free wastewater treatment for industrial enterprises' ions of heavy metals and the research of the possibility of maximum removal of heavy metals electrolysis baths are used. These multichamber baths are installed chain-like and given optimal parameters (including economic factor) will secure removal of all metals to the necessary values (threshold limit value (TLV) for wastewater). Through the system of electrolysis baths multicomponent wastewater is being electrolysed and the removal of a metal (or group of metals) occurs in a separate electrolyzer (cell) according to their capacity of being electrochemically removed from wastewater under optimal technological parameters for given metal (or group of metals).

Processes which take place in the wastewater treatment unit of the electrochemical reactor depend on the configuration of the active area of the electrode (cathode), current density in the interelectrode space. Due to the perforation of electrodes specific value of the current density is bigger than that of the solid-core electrodes. Apart from the current density in the interelectrode space, semitransparent membrane porosity considerably influences the efficiency of wastewater treatment. The greater the porosity of the membrane, the greater the intensity of the processes of wastewater treatment for heavy metals ions. However, because of the intermixing of the elementary cathode and anode volumes (volume) of the wastewater, pH water gradient is being reduced, which leads to efficiency decrease of metal ions removal.

Gradual flow of the effluent in the cells with equal current density distribution and porosity of the semitransparent membrane enables logical sequence of the wastewater treatment in the unit, which can be expressed by formula:

$$\frac{dC_{unit}}{dt} = n\left(\frac{Q_i \cdot C_i}{1000} - i \cdot \omega_{activ} \cdot \varepsilon_{me} \cdot P\right) \cdot \frac{1}{V_{unit}}, \qquad (1)$$

where n – coefficient of sequence of the electrochemical wastewater treatment in the unit, Q – amount of inlet water, L/s; C – concentration of heavy metals, mg/dm$^3$; P – porosity of the semitransparent membrane; $\omega_{activ}$ – active area of the electrode, m$^2$; V – unit volume, m$^3$; $i$ – current density, A/m$^2$; $\varepsilon_{me}$ – electrochemical equivalent of heavy metal.

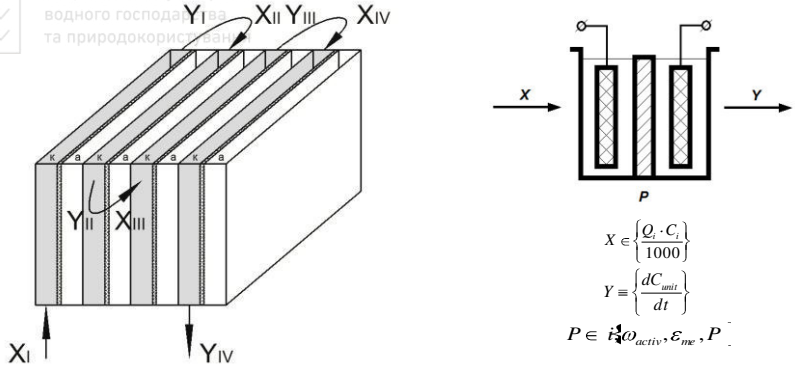


Figure 1. Model of the sequence of the unit performance in the process of wastewater treatment for heavy metals ions

The unit is divided into four types of cells with different current density, and the water on different stages is being affected by different current densities. Therefore, taking into account this fact, equation (1) is described by equation (2)

$$\frac{dC_{unit}}{dt} = \sum_{f=1}^{k}\left(\frac{n\left(\frac{Q_i \cdot C_i}{1000} - i \cdot \omega_{activ,k} \cdot \varepsilon_{me} \cdot P_k\right)}{V_k}\right), \quad (2)$$

where k – quantity of multitype cells, where the process of electrochemical wastewater treatment for heavy metals ions takes place.

Thus we received generalized equation, which will allow us to estimate the efficiency of the wastewater treatment in the given unit structure taking into account the porosity of the semitransparent membrane, current density, water discharge, initial concentration of the heavy metals ions, their electrochemical equivalent, staging of the water treatment in single-type and multitype cells of the unit of electrochemical wastewater treatment.

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# CHARACTERISTICS OF LEAKAGE CURRENT IN ELECTROCHEMICAL REACTORS WITH BIPOLAR ELECTRODES FOR MINE WATER TREATMENT

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The electrochemical treatment of mine water is the most effective method to remove most pollutants from mine water: heavy metals, suspended solids, bacteria, etc [1]. Electrochemical cells consist of pairs of orthogonal polymer plate with metal electrodes separated by a few millimetres with a low voltage applied at high current densities [2]. The achievement of high current density is possible due to reduction of active electrodes area.

The criterion of the reduction of active bipolar electrodes area can be found by formula:

$$p_{bip} = \frac{\omega_{el}}{1.57 \cdot N_{\max}\left(\left(\frac{d^2{}_i - d^2{}_{hol}}{2}\right) + d_{hol} \cdot B_{bip}\right)} > 1 \qquad (1)$$

where $\omega_{el}$ – area of bipolar electrode module, $m^2$; $N_{max}$ – maximum numbers of bipolar electrodes in nonconductive polymer plate (0.01 $m^2$); $d_i$ – diameter of bipolar electrodes, m; $d_{hol}$ – diameter of hole in bipolar electrodes, m; $B_{bip}$ – electrode width, m.

Maximum numbers of bipolar electrodes ($N_{\max}$) in nonconductive polymer plate can be calculated, using the equation (2).

$$N_{\max} \rightarrow \begin{cases} N = \frac{\eta^2_{paired}}{2} \\ N = \frac{\eta^2_{unpaired}}{2} + 0.5 \end{cases}, \qquad (2) \qquad \eta = \frac{L_{\text{mod}}}{d_i}, \qquad (3)$$

where η – number of bipolar electrodes in nonconductive polymer plate, rounded down; $L_{mod.}$ – width of polymer electrode module, m.

The higher is the level of mine water salinity, the higher is mine water conductivity or the lower electrical resistance of mine water. Leakage current is possible in electrochemical reactor on account of the hole in electrodes. The numerical experiment of leakage current determinate in electrochemical reactor with bipolar electrodes was performed (Fig.1 and Fig. 2).

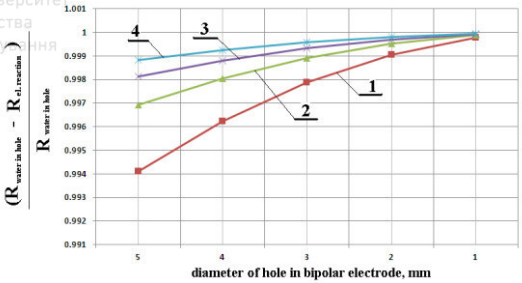


Figure 1. Relative value of mine water resistance in hole of bipolar electrode (electrode width 5 mm, salinity of mine water 1 g/dm$^3$)

1 – diameter of bipolar electrode 15 mm; 2 – diameter of bipolar electrode 20 mm; 3 – diameter of bipolar electrode 25 мм; 4 – diameter of bipolar electrode 30 mm; voltage drop 1.5 V; electrical current 2.5 A

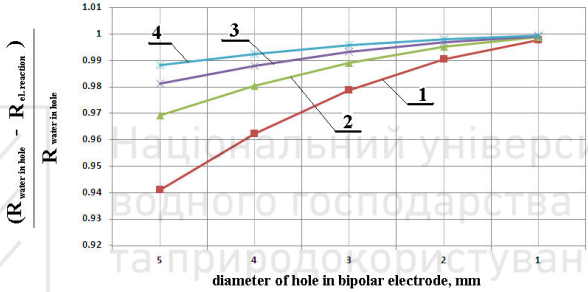




Figure 2. Relative value of mine water resistance in hole of bipolar electrode (electrode width 5 mm, salinity of mine water 5 g/dm$^3$)

1 – diameter of bipolar electrode 15 mm; 2 – diameter of bipolar electrode 20 mm; 3 – diameter of bipolar electrode 25 мм; 4 – diameter of bipolar electrode 30 mm; voltage drop 1.5 V; electrical current 2.5 A

The value of leakage current is no more than 6% from total electrical current when the mine water salinity 1 g/dm$^3$ and 5 g/dm$^3$ (Fig.1 and Fig. 2). Thus, the value electric current is greater than 94 % pass through metal of electrodes in electrochemical reactor for mine water treatment and 6 % current can lost as a leakage current.

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# IDENTIFICATION OF UNKNOWN MASS-TRANSFER COEFFICIENT IN TASKS OF THE TYPE CONVECTION-DIFFUSION-MASS-TRANSFER

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The well-known analytical equations which describes the process of sewage filtering [1-8] and wastewater treatment process [5, 6] don't allow to describe the process of cleaning with a broad range of parameters, in addition, do not include the reverse influence of process characteristics on the environment characteristics. Similarly, insufficient attention is paid to studying mass-transfer coefficients and the experimental dependences [6] do not give a complete picture. Therefore, the current task is to build a nonlinear mathematical model of the wastewater treatment process by sorption filter, which includes the definition of mass-transfer factor. The solution of the inverse task gives the ability to bring the numerical calculations to real experimental data and more accurately predict and calculate the effectiveness of the filtering process of various water-dispersed systems.

**1. Setting a task.** Let us look at the one-dimensional space (in order to facilitate lectures) the process of cleaning fluid by filtering in the filter-layer thickness $L$ identical segment $0, L$ axis $0x$. Assuming [6] that particle pollution contaminants can moves from one state to another (the processes of capture, separation, sorption-desorption) and, thus, have the inverse effect of concentration on the characteristics of the considered layer. The corresponding process of inverse filtering of the process (the concentration of contamination of fluid and sediment) on the medium characteristics (coefficient of porosity, filtration, diffusion, mass transfer, etc., by analogy with [9, 10]) we are describing the following model problem:

$$\begin{cases} \dfrac{\partial\ \sigma\ \rho\ c\ \ x,t}{\partial t} + \dfrac{\partial \rho\ \ x,t}{\partial t} + v\dfrac{\partial c\ \ x,t}{\partial x} = D_c \dfrac{\partial^2 c}{\partial x^2}, \\ \dfrac{\partial \rho\ \ x,t}{\partial t} = \beta c\ \ x,t\ - \varepsilon\alpha\ \ t\ \ \rho\ \ x,t\ + D_\rho \dfrac{\partial^2 \rho}{\partial x^2}, \end{cases} \tag{1}$$

$$c\big|_{x=0} = c_*^*(t),\ c\big|_{t=0} = 0,\ \rho\big|_{x=0} = 0,\ \rho\big|_{t=0} = 0,\ \frac{\partial c}{\partial x}\bigg|_{x=L} = 0,\ \frac{\partial \rho}{\partial x}\bigg|_{x=L} = 0, \tag{2}$$

$$\alpha(t)\int_0^L \rho(\tilde{x},t)d\tilde{x} = \mu(t)\,, \qquad (3)$$

where $c(x,t)$ – concentrations of admixtures in the liquid medium at point x in the moment of time $t$, $\rho(x,t)$ – the concentration of impurities trapped by the filter, $\beta$ – coefficient, which characterizes the mass volumes of admixture particles sedimentation for time unit; $\alpha\ t$ – the required coefficient, which characterizes the massive amounts of grain filling separated particles, $\mu\ t$ – function characterizing the mass distribution of sediment over time (there is an experimental method [14]), condition redefinition (3) – is for finding $\alpha\ t$ ([11, 12]), $c^*(t), c_*^*\ t\ , \rho^*(t), \rho_*^*\ t$ - the concentration of impurities and particles deposited on the filter input and the initial time, respectively, $\sigma\ \rho$ – porosity filtering filling ($\sigma_0$ – initial porosity filling), $v = \kappa\ \rho\ \cdot grad\ p$ – speed filtering, $\kappa\ \rho$ – filtering coefficient $\kappa\ \rho\ = \kappa_0 - \varepsilon\gamma\rho\ x,t$ (see [10]), $\sigma_*, \kappa_0, \gamma, \varepsilon$ – solid parameters (its characterizes those coefficient $\sigma\ \rho\ , \kappa\ \rho$ – soft options which experimental method), $D_c\ , D_\rho$ - diffusion coefficient, where $D_c = b_c\varepsilon$ , $D_\rho = b_\rho\varepsilon$ , $0 < b_c \le 1$ , $0 < b_\rho \le 1$, $\varepsilon$ – a small parameter which characterizes the corresponding disturbance, $p$ - pressure. It should be noted that in more general case pressure $p = p\ x,t$ should be determined by solving equation $\frac{\partial}{\partial x}\left(\kappa\ \rho\ \frac{\partial p}{\partial x}\right) = \frac{\partial\sigma\ \rho\ p}{\partial t}$ (which comes out on the basis of above recorded equations of motion and equation of state: $div\ v = \frac{\partial\sigma\ \rho\ p}{\partial t}$) at the boundary $p\ 0,t\ = p_*\ t$ , $p\ L,t\ = p^*\ t$ ($0 < t < \infty$) and the initial $p\ x,0\ = p_*^*\ x$ ($0 < x < L$) terms ($p_*\ t$ , $p^*\ t$ , $p_*^*\ x$ – raised quite smooth and coordinated at the corner points of the field $G = \ x,t\ : 0 < x < L, 0 < t < \infty$ function). In order to simplify the forms in this paper consider the case when $v = const$. Thus, in the process of solving the problem, we can determinate an appropriate value $grad\ p$, in particular - the difference pressures $p^*\ t\ - p_*\ t$ input and output of the filter.

**Algorithm (asymptotic) solution**. The solutions of system (1) in terms (2) and (3) we find in the form of asymptotic series (see [3-5]).

$$c\ x,t\ = c_0\ x,t\ + \sum_{i=1}^{n}\varepsilon^i c_i\ x,t\ + \sum_{i=0}^{n+1}\varepsilon^i U_i\ \xi,t\ + \sum_{i=0}^{n+1}\varepsilon^i \tilde{U}_i\ \xi,t\ + R_c\ x,t,\varepsilon\ ,$$

$$\rho\ x,t = \rho_0\ x,t + \sum_{i=1}^{n} \varepsilon^i \rho_i\ x,t + \sum_{i=0}^{n+1} \varepsilon^{i/2} \underset{\sim}{P}_i\ \mu,t + \sum_{i=0}^{n+1} \varepsilon^{i/2} \tilde{P}_i\ \mu,t + R_\rho\ x,t,\varepsilon\ , \quad (4)$$

$$\alpha\ t = \alpha_0\ t + \sum_{i=1}^{n} \varepsilon^i \alpha_i\ t + R_\alpha(t,\varepsilon)\ ,$$

where $R_c, R_\rho, R_\alpha$ – the remaining members, $c_i\ x,t$ , $\rho_i\ x,t$ , $\alpha_i(t)$ $(i = \overline{0,n}\ )$ – searched asymptote members, $\underset{\sim}{U}_i\ \xi,t$ , $\underset{\sim}{P}_i\ \mu,t$ , $\tilde{U}_i\ \xi,t$ , $\tilde{P}_i\ \mu,t$ $(i = \overline{0,n+1}\ )$ – function type boundary layer, (as amended at the input and output flow filtration), $\xi = (L-x)\cdot\varepsilon^{-1}$, $\mu = (L-x)\cdot\varepsilon^{-1/2}$ – appropriate regulation transformation.

Based on the obtained solution was created software system and a computer experiment was done.

**Conclusion**. A mathematical model which describes the patterns of accumulation and filtering particles in porous back filling with inverse process (sediment concentration) on the medium characteristics (diffusion coefficients, mass-transfer) and includes the ability to determineting the unknown mass-transfer coefficients.

The algorithm of solution of the perturbed task, in particular, enables the timing of the protective filter.

The results of calculations of the specific distribution of mass concentration and volume of solids (length filtering porous backfill) for various time moments.



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# WASTEWATER TREATMENT USING MICROBIA FUEL CELL TECHNOLOGY

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Conventional biological wastewater treatment processes, such as activated sludge, are energy demanding processes. Energy use for wastewater aeration can account for up to 50% of operating costs, with typical requirements of 500Wh/$m^3$, or 1 kWh for oxidation of 1 kg organic compounds removed during treatment. Aerobic treatment processes also produce large amounts of residual solids which are costly to treat and dispose. The high energy requirements of these processes make it important to investigate methods to reduce operational costs through process optimization or the use of more energy efficient anaerobic processes [1].

Bioelectrical systems are novel devices enabling to convert energy of chemical bonds of different compounds into electricity or energy carriers (e.g. hydrogen) using living organisms and their enzymatic systems. Mediatorless microbial fuel cell (MFC) is the type of bioelectrical system in which chemical energy converts into electricity with the help of living microorganisms without adding a mediator of electron transfer. Nowadays, using MFC in wastewater treatment systems is the most promising and intensive developing mode of application. Therefore, the aim of the study is the comparative analysis of scientific data and rationale for the possibility of using MFC in wastewater treatment system.

The efficiency and economic viability of converting organic wastes to bioenergy depends on the characteristics and components of the waste material. Especially the chemical composition and the concentrations of the components that can be converted into products or fuels, is of major interest while considering the potential substrates in MFC [2]. The substrates influence on the integral composition of the bacterial community in the anode biofilm and the performance of MFC including the power density and Coulombic efficiency [1]. Thus, starch processing wastewater is one of the most attractive substrate for electricity generation. It was obtained a maximum voltage output and power density of 490.8 mV and 239.4 mW/$m^2$. However, the Coulombic efficiency was only 7%. These low values of Coulombic efficiency are due to the biological processes of anaerobic conversion of the substrate that are not associated to the exoelectrogenesis (methanogenesis, biological synthesis of hydrogen, etc.).

Table

Comparative characteristics of electrical yield from wastewaters in MFC

| Wastewaters | COD, $mgO_2/l$ | Source inoculum | Current density ($mA/cm^2$) at maximum power | Authors, year |
|---|---|---|---|---|
| Swine wastewater | 8320 | Full-strength swine wastewater | 0.015 | Min et al., 2005 |
| Food processing wastewater | 1670 | Anaerobic sludge | 0.05 | Oh et al., 2005 |
| Meat processing wastewater | 1420 | Domestic wastewater | 0.115 | Heilmann et al., 2006 |
| Real urban wastewater | 330 | Domestic wastewater | 0.018 | Rodrigo et al., 2007 |
| Brewery wastewater | 2240 | Full strength brewery wastewater | 0.2 | Feng et al., 2008 |
| Wastewater amended with acetate | 1600 | Domestic wastewater | 0.08 | Min et al., 2008 |
| Paper recycling wastewater | 2450 | Diluted paper recycling wastewater | 0.25 | Huang et al., 2008 |
| Beer brewery wastewater | 600 | Anaerobic mixed consortia | 0.18 | Wen et al., 2009 |
| Chocolate industry wastewater | 1460 | Activated sludge | 0.302 | Patil et al., 2009 |
| Domestic wastewater | 600 | Anaerobic sludge | 0.06 | Wang et al., 2009 |
| Protein-rich wastewater | 1750 | Mesophilic anaerobic sludge | 0.008 | Liu et al., 2009 |
| Starch processing wastewater | 4850 | Starch processing wastewater | 0.09 | Lu et al., 2009 |

It is necessary to indicate that the type of construction of MFC also plays a leading role in electricity generation process (data are not shown). One-chamber air-cathode MFC construction shows the highest values of voltage output and power density (0.2 mA/cm$^2$ for the brewery wastewater with 2240 mg$O_2$/l COD, 0.18 mA/cm$^2$ for the beer brewery wastewater with 600 mg$O_2$/l COD, 0.25 mA/cm$^2$ for the paper recycling wastewater with 2450 mg$O_2$/l COD and other).

The cathode processes also determine the overall energy outputs of electricity generation. Using air oxygen as the oxidant in cathodic redox reaction is the most expedient because of water as the only byproduct of the process. But the highest value of current density of 0.302 mA/cm$^2$ at maximum power was produced in two-chambered MFC with graphite rods as electrodes (16.485 cm$^2$) and ferricyanide as catholyte [4]. It was also investigated that the cathodic reaction is the limiting stage and the effective area of the cathode surface should be eight times higher than the anode surface.

Conclusions:

1. It is substantiated that the using wastewater as the substrate for the biological electricity generation in microbial fuel cells is one of the most promising issue of practical implementation of device.

2. The wastewater chemical composition and component concentration influence development of microbial association (substrate dependent selection) and as the result electricity outputs.

3. Microbial fuel cell construction is the determinative factor in electricity generation process, especially the cathode chamber performance.

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# ANALYSIS OF EXTRA EXPENDITURES OF TRANSPORTING WATER BY WATER PIPE "DNIESTER-CHERNIVTSI"

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Water supply in Chernivtsi is provided from two sources. One is surface water intake on river Dniester (74 %) – the main water pipeline "Dniester-Chernivtsi" and the other one is system of underground water intakes, located in the flood-lands of river Prut (26 %) – water intake "Rogizna" in the complex with water intakes "Lenkivzi-1", "Ocheret", "Bila" and "Magala". On the enterprise balance there are nine waterworks and one water-purifying plant, which are located in the complex with high-lift pump station of water main "Dniester-Chernivtsi". The length of the water supply system is 401.2 km, 133.8 km of it 33% is in emergency condition. The operation productivity of water supply system is 130 thousand $m^3$ per day. The operation productivity of water-purifying plant is 96 thousand $m^3$/per day [1]. The increase of water losses and the decrease of water volume realization is observed during of late. It is connected, on the one hand, with practically the absence of industrial water consumers and the cost increasing, particularly because of the cost for the consumed electro energy. On the other hand – with outdated facilities equipment and especially pipelines and increased unaccountable water usage. The tendency of the electro energy cost increase of water supply is stable, the costs of which is one of the highest for the cities of Ukraine and makes up to 2.0 kWt·h/$m^3$. The unaccountable water losses are up to 50% and accident rate of water pipelines and water leakage from the water network is 2.5 accidents per year/km [2].

The pipeline "Dniester-Chernivtsi" is one of the sections of "Chernivtsi water canal" the productivities of which are the biggest Saving the existing technological operation process of the pipeline equipment for keeping drinking water in the state of readiness and for the day and night reliable water supply in Chernivtsi needs constant operation with outdated present time equipment. It had been installed with the view of the reliability of the city's industrial needs with sufficient quantity of water, that is, with the perspective of water supply to the city up to 200 thousand $m^3$ per day and night.

On the technological regime of pump equipment–seasonal operation of SCE "Chernivtsiteplocommuneenergo", institutions of high and preschool learning.

Since April 2009, for example, after the finish of the heating season and on account of conducted works on the decrease of water tension in the city boundaries, SCE "Chernivtsi" water canal works in the following regime: the

difference between the volume of water supply from WPS "Mitkiv" and WPS "Wikno" makes up 12.3. thousand $m^3$ per day and night, from which 6.1 th. is water used for washing the filters, settling tank and household needs 6.2 th. $m^3$ per day – water used for "overflow" (return to Dniester) and which DKP "Chernivtsi "Watercanal has to use for additional washing of settling tank and the block of reagent economy.

The difference between the volume of water supplies from WPS "Wikno" and WPS "Shubranets" makes up 7.9 $m^3$ per day which is used for "overflow".

In this way, even by the usage of above mentioned regime of pump equipment operation which takes into account the work of the pumps in the limits of electric power costs in tariff zones, the increase of pump equipment operation at night time causes the overflow of drinking water in big quantity in the volume of 14.1 th. of $m^3$ per day (435<0 th. Ghr.per month). Besides, taking into account the above mentioned passport data of installed electromotors the accounted quantity of their electro usage must be equal to 89.2 th. kW hour and the factual average usage of electro power through water pipeline "Dniester- Chernivtsi" for April 2009 was 100.1 th. kW hours which, even including the work of additional equipment, allows to make a conclusion about the extra usage of electric power conducted by the present equipment, the selection of which was made in the 80th and doesn't meet the hydraulic account (the working pressure in the water network after the pump equipment is 132-134 m in st. And the established equipment is meant for 180-197 m in st) [3].

Besides, the regulation of pump equipment work (for the volume of water supply and the volume of electro energy usage by means of the method of constant daily launch and stoppage of pump aggregates results in their wreck.

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## BIOELECTROCHEMICAL HYDROGEN PRODUCTION WITH

# SIMULTANEOUS WASTEWATER TREATMENT

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Aggravation of environmental problems with growing demand for fuel motivates the international community to finding new technologies that will combine the energy production processes with environmental protection. An example of such approach is a hydrogen production biotechnology with simultaneous wastewater treatment. Therefore, the aim of the study is the review of biotechnological hydrogen production methods, which use different wastewaters as a feedstock. Wastewaters that contain large amounts of organic biodegradable compounds are good source for hydrogen production. In this process microbial association is able to consume compounds from wastewater.

Among existing biotechnologies of hydrogen production only dark fermentation and bioelectrochemical method can be used for wastewater treatment.

Even though many organic compounds enable the hydrogen production during dark fermentation, estimations of potential yields are mostly based on hexose conversions. The theoretical yield per mole of glucose is described in the following reaction:

$$C_6H_{12}O_6 + 4H_2O \rightarrow 2CH_3COO^- + 2HCO_3^- + 4H^+ + 4H_2 \quad (1)$$

A maximum of 4 moles of $H_2$ per mole of glucose can be produced concurrently with the production of energy which is sufficient to support microbial growth. The remainder of the hydrogen in the hexose is conserved in the byproduct acetate, and under non-ideal circumstances, more reduced product like ethanol, lactate or alanine. The complete oxidation of glucose to $H_2$ and $CO_2$ yields a stoichiometry of 12 mole $H_2$ per mole of glucose but in this case no metabolic energy is obtained [1].

For more effective wastewater treatment we need to apply the process in which microbiological association will use products of incomplete decomposition of organic compounds (such as acetate, ethanol, lactate). For solving this problem bioelectrochemical method of hydrogen production can be used. Bioelectrochemical method of hydrogen production is realized in bioelectrochemical system (BES) that is similar to the microbial fuel cell. This BES consists of anode and cathode chambers separated by a membrane. Both chambers are anaerobic. The separation between these chambers is established by means of a cation-exchange membrane. Biofilm of electrochemically active microorganisms at the anode provides oxidation of organic compounds contained

in wastewater. These microorganisms convert dissolved organic material to bicarbonate, protons and electrons. Externally, the anode and the cathode are connected to the power supply using an electrical circuit. While the power supply drives the released electrons from the anode to the cathode, an equal number of protons permeate through the membrane. At the cathode, protons and electrons combine to form pure hydrogen gas.

Production of hydrogen by this bioelectrochemical process is not limited to carbohydrates, as in the dark fermentation process, as any biodegradable dissolved organic matter can be used in this process to generate hydrogen from the complete oxidation of organic matter [2].

BESs have been used to generate hydrogen from a variety of wastewaters including brewery, chocolate, food processing, meat packing and paper recycling wastewaters [3].

Wastewater from breweries has been a favorite among researchers as a substrate in BESs, primarily because of its low strength. Besides, it is suitable for hydrogen production in BESs due to the food-derived nature of the organic matter and the lack of high concentrations of inhibitory substances (for example, ammonia in animal wastewaters).

Potato wastewater was a suitable substrate for bioelectrocemical process. This could be due in part to the relatively high concentrations of volatile fatty acids, and a relatively high solution conductivity of the potato wastewater [4].

Hydrogen can be produced from swine wastewater by electrohydrogenesis in BESs. It was shown BESs are an effective method for hydrogen recovery from swine wastewater treatment, although the process needs to be further evaluated for reducing methane production, increasing the efficiency of converting the organic matter into current, and increasing recovery of hydrogen gas produced at the cathode [5].

Landfill leachates are heavily polluted landfill effluents with a complex composition containing four major groups of pollutants: dissolved organic matter, inorganic macro-components, heavy metals, and xenobiotic organic compounds [6]. The feasibility of using BESs in landfill leachate treatment and electricity production was assessed under high levels of nitrogen concentration and conductivity. It shows the possibility of using of these wastewaters for bioelectrochemical hydrogen production.

The example of bioelectrochemical systems implementation is scalable purification plant for winery wastewater treatment. The demonstration plant is a continuous flow system that will process about 1,000 liters of wastewater per day. Added voltage is near 0.114V (the natural voltage for water electrolysis is 1.2 V). The plant is now producing about 0.2 ampere of electricity to fuel the hydrogen generation, and expects that to rise 200-fold. It is also producing some methane and sulfur products. The ideal level of BOD (bacterial oxygen demand) is 1,000 to 1,500, but the winery water varies between 500 and 4,000. This example shows perspective BESs in wastewater treatment [7].

Conclusions:

1. Hydrogen can be produced during wastewater treatment in two cases: in the dark fermentation and using electrochemical method. Combining these both technologies will help to receive valuable fuel and fully treat wastewaters.

2. Wastewaters are good feedstock for hydrogen production, if only they contain dissolved biodegradable organic compounds, nutrients and microelements.

3. BESs allow to produce hydrogen with simultaneous wastewater treatment.

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# RECENT DEVELOPMENTS IN BIOLOGICAL WASTEWATER TREATMENT METHODS

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Environmental protection, rational use of natural resources and providing ecological safety of human activities are essential conditions for sustainable economic and social development of Ukraine according to the Law of Ukraine "About protection of natural environment". Important place among environmental issues is taken by issues related to protection of natural water bodies from anthropogenic pollution. One of the main factors of the anthropogenic environmental impact is the discharge of contaminated wastewater into natural surface water bodies.

According to experts, today the quarter of the sewage treatment plants and networks in Ukraine is out of amortization period in terms of value. Most of them are currently out of order. Respectively, wastewater is discharged into environment completely untreated, and what is disturbing – it becomes the potential threat for health and life of people.

When dealing with issue of wastewater treatment, special attention should be paid to biotechnological treatment, which can provide a needed level of purification and can be applied in large scale, requiring considerable economic expenses. In addition, the use of some biotechnological treatment methods allows obtaining useful by-products (e.g. biogas, fertilizers). The work carried out at our department is dedicated to the investigation and design of new alternative methods of ammonium reduction in wastewater; analysis of bioindication methods; and study of possibilities to obtain useful by-products.

From our point of view one of the most important developments in the area of biological wastewater treatment in the last 10 years is the implementation of recently discovered anaerobic ammonium oxidation (anammox) process in wastewater treatment plants (WWTP). Anammox provides the low-cost removal of ammonia from high-strength waste streams. In this process, ammonia is oxidized with nitrite as primary electron acceptor under strictly anoxic conditions. The reaction is catalysed by a specialized group of bacteria which belong to the order *Planctomycetes*. Economic benefit of anammox-process application comparing with conventional technology of ammonia treatment consists in 60 % of a prime cost reduction.

Besides anammox (equation 1) there are other newly discovered reactions, which can be applied for reactive nitrogen species removal in wastewater treatment. One of such is the Oxygen-limited autotrophic nitrification-denitrification (OLAND) which is not a strictly anaerobic process like anammox. The OLAND-reaction (equation 2) is closely related to nitrite reduction.

$$NH_4^+ + NO_2^- \rightarrow N_2 + 2H_2O \quad (1)$$

$$2NH_4^+ + 1.5O_2 \rightarrow N_2 + 3H_2O + 2H^+ \quad (2)$$

Also the anammox process can be combined with partial nitrification in one reactor – the CANON (completely autotrophic nitrogen-removal over nitrite) process. In this process, growth of nitrite oxidizers has to be prevented. This requires that nitrogen load and aeration have to be well balanced in the operation of CANON reactors.

Other innovative alternative for nitrogen removal is SHARON (Single reactor system for High activity Ammonium Removal Over Nitrite) process. In the SHARON process the partial nitrification takes place, working at high temperature (around 35°C) and without retention sludge. In these conditions, nitrite oxidisers are selectively washed out.

Important investigations concerned with nitrogen removal also consist in using methane as external carbon source for biological denitrification of wastewater. Recently discovered microorganisms affiliated to the bacterial phylum NC10, named "*Candidatus* Methylomirabilis oxyfera", are capable for nitrite-dependent anaerobic methane oxidation. These microorganisms could be important players in a novel way of anaerobic wastewater treatment where ammonium and residual dissolved methane might be removed at the expense of nitrate or nitrite.

Not less interesting is using waste materials as new products for wastewater treatment. As an example carbonised red mud can be considered. It is a novel material, which is produced when red mud is used as a catalyst for methane cracking. And red mud itself is the waste produced by the extraction of alumina from bauxite ore in the Bayer process. Carbonised red mud has potential as a material for treatment of heavy metal-contaminated water. What is important carbonised red mud is magnetic, what allows easy separation of metal-loaded material.

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# THE ROLE OF RESPIROMETRY IN OPTIMALIZATION THE ACTIVATED SLUDGE PROCESS

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## Introduction

Characterization of wastewater and activated sludge is the one of the most significant factor in a monitoring of wastewater treatment plant. Respirometry can provide much useful information concerning biodegradable wastewater (COD fractions) and conditions of microorganism which is connected with bioactivity (OUR, NUR, AUR, PPR tests). This method could also define kinetic parameters, essential for mathematical models and computer modeling.

Respirometry is the measurement and interpretation of the biological oxygen consumption rate under defined conditions.

This paper presents the result of the respirometic analysis of activated sludge and wastewaters from WWTP Guadalhorce in Malaga, Spain.

## Materials and methods

Experimental tests were carried out in a respirometer BM - T. The equipment recorded directly the Oxygen Uptake Rate (OUR), total biodegradable chemical oxygen demand (COD) and readily biodegradable COD of wastewater ($S_S$). The sample of activated sludge was taken from a bioreactor D. The wastewater for determining COD fractions was taken form the effluence of the primary settling tank. The activated sludge sample for COD test was also collected from bioreactor D and was aerated over 24 hours.

For OUR COD measurements was used nitrification inhibitor, in order to eliminate oxygen consumption due to nitrification. Before an analysis (about 10 min) 10 ml solution of Allylthiourea (ATU) was added.

For all measurements a temperature was maintained at 20$^{o}$C.

The specific oxygen uptake rate (SOUR) was calculated in mg/g gram biomass per hour as follows:

$$SOUR = \frac{OUR}{MLVSS} \left[ mgO_2 / gMLVSS \cdot h^{-} \right] \quad (1)$$

where MLVSS – the mixed liquor volatile suspended solids in reactor.

The reactor was constantly aerated and mixed to maintain a dissolved oxygen concentration of 6 to 8 $mgO_2$/l. After reaching this level of concentration oxygen in reactor, the aeration was stopped.

Other fractions were defined by following calculations:

$$X_S = C_S - S_S [mg/l] \quad (2)$$

$$S_I = S_T - S_S [mg/l] \quad (3)$$

$$X_I = C_I - S_I [mg/l] \quad (4)$$

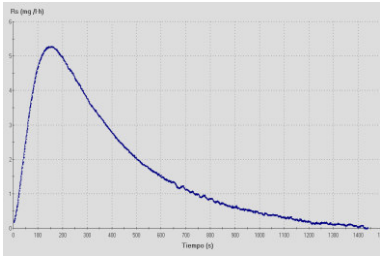
where $C_T$ – total COD of wastewater (mg/l);
$C_S$ – total biodegradable COD of wastewater (mg/l);
$C_I$ – total inert COD of wastewater (mg/l);
$S_I$ – soluble inert COD of wastewater (mg/l);
$S_S$ – readily biodegradable COD of wastewater (mg/l);
$S_T$ – total soluble COD of wastewater (mg/l);
$X_I$ – particulate inert COD of wastewater (mg/l);
$X_S$ – slowly biodegradable COD of wastewater (mg/l).

The results of total COD and total soluble COD of wastewater were obtained by spectrophotometric analysis (HACH LANGE DR 5000).

**Results and discussion**

The specific respiration rate for standard activated sludge estimate between 20 and 40 $mgO_2/(g\ MLVSS \cdot h)$. The low result of the test (6.95 $mgO_2/(g\ MLVSS \cdot h)$) may indicate that the sludge is poisoned or there is no presence of easily degradable organic matter. To obtain more information about the activated sludge condition it is recommended to repeat the test (different times of day) and determine COD fractions after the primary wastewater treatment.

In the second part of this paper are presented the results of COD fractions ofwastewater from the settling tank. The total COD concentration was 347 and 505 mg/l, with a total soluble fraction of 152 and 162 mg/l. The total biodegradable COD fraction was containing between 40.11 and 47.98% of total COD. The most significant fraction was particulate inert COD ($X_I$), which may cause problems with the activated sludge.



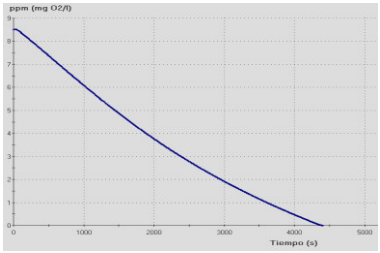




Figure 1. Respirograms of $C_S$ - total biodegradable COD (left) and OUR (right)

Table 1. Results of OUR and SOUR test

| bioreactor | OUR | SOUR | MLVSS |
|---|---|---|---|
| | $mgO_2/l \cdot h$ | $mgO_2/gMLVSS \cdot h$ | g/l |
| D | 13,34 | 6,95 | 1,92 |

Table 2. Contribution of particular fractions COD

| day | $C_T$ | $S_T$ | $C_S$ | $S_s$ | $X_s$ | $C_I$ | $S_I$ | $X_I$ |
|---|---|---|---|---|---|---|---|---|
| | $mgO_2/l$ | | | | | | | |
| 12.08.11 | 505,00 | 162,00 | 202,54 | 149,99 | 52,55 | 302,47 | 12,02 | 290,45 |
| 07.09.11 | 347,00 | 152,00 | 166,48 | 125,06 | 41,42 | 180,52 | 26,95 | 153,58 |

Table 3. Percentage contribution of particular fractions in total COD

| day | $C_S$ | $S_s$ | $X_s$ | $C_I$ | $S_I$ | $X_I$ |
|---|---|---|---|---|---|---|
| | % | | | | | |
| 12.08.11 | 40,11 | 29,70 | 10,41 | 59,89 | 2,38 | 57,51 |
| 07.09.11 | 47,98 | 36,04 | 11,94 | 52,02 | 7,77 | 44,26 |



## Conclusions

Respirometry is a useful tool for assessing the condition of activated sludge. The respirometric analysis provides the data to oversee the process on daily basis but also helps to avoid future problems. Compared to traditional methods described one is relatively easy and quick to apply.

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# DEVELOPMENT OF STANDARDS OF DRINKING WATER SUPPLY FOR DEBALTSEVO TOWN

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Saving and rational using water resources are the problems of prime importance. It's possible to reach it by decreasing the specific consumption of natural and drinking water by various groups of consumers.

One of the most important problems in the process of production, supply, and distribution of drinking water is the correct evaluation of the quantity of consumed water for any consumer. This problem is connected with the problem of the liquidation of water wastes [4].

The norms of water consumption are affected by following factors:

- technological water needs;
- social water demand;
- leakage of water;
- irrational water wastes;
- water discharge.

The methods of working out the norms of drinking water consumption for the population are represented in the paper. The main aim of the paper is the evaluation of real water use rate for various comfort dwellings in Debaltsevo town.

While calculating the specifications of drinking water supply according to the methodical demands we should take into account the following aspects:

- region and the living conditions of subscribers;
- current water supply in the given locality;
- the time-table of hot and cold water supply approved by local public authorities;
- the volume of water actually consumed by the population during three previous years;
- permanent population.

Real water consumption for all houses with different levels of facilities has been defined by means of the accurate water-meter in accordance with the established procedure. Processing the received data for each type of housing has been carried out by mathematical statistics methods.

Current norms for houses with various types of facilities are illustrated in Table 1.

Table 1

Current norms for houses with various types of facilities

| Facilities | Standard norm, l/day per person |
|---|---|
| Residential buildings with central water supply and local sewerages, with baths and water heaters on solid fuel | 150 |
| Residential buildings with central water supply and local sewerages, with baths and gas water heaters | 190 |
| Residential buildings with central water supply, sewerage, equipped with washbasins, sinks and showers in the absence of hot water supply | 250 |
| Hostels | 35 |
| The same, without hot water supply | 85 |

The analysis of water consumption in residential buildings with different levels of facilities in Debaltsevo [2] shows that the real water consumption exceeds the standard norms. It demonstrates the irrational consumption and significant losses of water in water supply systems.

The installation of water-meter in flats provides decreasing real water consumption in comparison with the standard norms (Fig. 1).

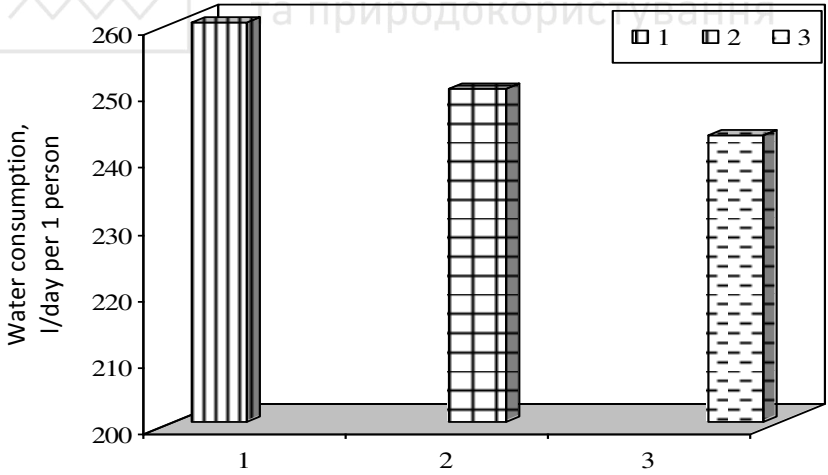


Figure 1. The excess of current standards of the real water consumption:
1 – lack of water meters; 2 –existing norm of water consumption; 3 – availability of water meters

Standard indicators have been compared with real water consumption by individual consumer depending on number of the residents. The comparison has shown that water consumption is reduced with increasing the number of residents in the flat. Discrepancy between indicators of the building water-meter and total values of the indicators of flat water-meter shows an unsatisfactory condition of an intra building water supply system.

Conclusions:

1. Total water consumption depends on many factors: the number and the type of consumers, the requirements for continuity of water supply, the amount and the type of sanitary facilities, mode and norms of water consumption, the pressure in the system.

2. The analysis of water consumption in Debaltsevo town has shown that the actual consumption of water exceeds the norms, water consumption is reduced with increasing the number of residents in the flat. Installation of flat water-meters reduces real water consumption compared with normal one.

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# EXERGY ANALYSIS OF WASTEWATER TREATMENT PLANTS

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By analogy with the chemical-technological processes [1] efficiency and excellence processes that occur in wastewater treatment plants (WWTP), to date, estimated by analyzing material and energy balances [2, 3]. However, material and energy balances of all kinds of matter and energy are considered without regard to their quality, that is of practical life, which makes it impossible to properly assess and optimize the processes that occur in WWTP. Due to increasing energy loads characteristic of large buildings and complexes, a significant appreciation of traditional forms of energy were entirely new structural and technological solutions that promote the full utilization of energy resources sewage WWTP, and therefore increase their effectiveness. Modern high performance WWTP include items such as digesters, boiler, gas generator and microturbines, heat pump units (HPU) and more. The need for energy efficiency WWTP leads to more complex structures of production, which - the maximum energy of the process flows within the WWTP without a supply of energy from outside. However, this task is concerned with the correct rating as energy flows and, consequently, the choice of the optimal level of energy that circulates in the circuit of WWTP, and the feasibility of using certain types of energy in general. For example, in the energy balance of large WWTP heat the heating steam from boiler is considered along with the warmth that give the wall units and structures in the environment. However, the practical possibility of using these types of heat is different, and the smaller the closer the temperature of the heat source to the ambient temperature.

In terms of technical applicability value of any energy is determined not only quantity but also the extent to which it can be used in these conditions, that is converted into other energy forms. The extent of reversible energy resources system was named exergy systems [4]. Exergy systems in this state is measured by the number of mechanical or other fully reversible energy which can be obtained from this system as a result of working on the transition state in equilibrium with the environment. Exergy WWTP remains unchanged only when the conduct of all reversible processes that occur inside buildings and in their interaction with the environment that has constant parameters. This feature allows using of exergy as a measure of reversibility of a process. The total amount of exergy difference that is introduced into the system and derived from it determines the total amount of losses from irreversibility in the system.

$$\sum E_{\partial} = \sum E_{\text{inp}} - \sum E_{\text{out}} \geq 0 \quad (1)$$

Only in working process performed equal sign in the formula (1).

The ratio of exergy, which is given out, to elevated exergy represents the efficiency – exergetic efficiency on, which characterizes the degree of approximation to perfect this process.

$$\eta = \frac{\sum E_{\text{out}}}{\sum E_{\text{inp}}} = \frac{\sum E_{\text{inp}} - \sum E_{\partial}}{\sum E_{\text{inp}}} = 1 - \frac{\sum E_{\partial}}{\sum E_{\text{inp}}} \quad (2)$$

Ideally, the process $\eta = 1$, always in real $\eta < 1$.

Exergetic efficiency can be used to evaluate the effectiveness of components WWTP (individual buildings and installations) [5].

For the determination of the exergy loss or exergetic efficiency days must pass exerghetic balance, which is necessary to determine the exergy of each type of energy. In general, the expression for determining the exergy is written as follows:

$$E = E_p + E_k + \Delta_0 E + E_{ch}\,, \quad (3)$$

where Ep, Ek, Δ0E, Ech – accordingly potential, kinetic, physical and chemical exergy.

Potential and kinetic exergy apparently identical in meaning with the relevant types of energy. Physical exergy, exergy is the part that is the result of differences in temperature and pressure of the considered materials with temperature To and pressure then Po environment. Exergy that occurs because of differences in compositions of substances called chemical exergy Ech. In analyzing the WWTP is the most important two components exergy: physical and chemical, the amount of which the so-called thermal exergy (Et). In general, the exergy of material flows (Eп) and flux (Et) is calculated by the following expression:

$$E_t = Q(1 - \frac{T_0}{T})\,, \quad (4)$$

where I, S – enthalpy and entropy process flow for WWTP;

To – ambient temperature, K;

μi, Ni – chemical potential and molar content of the i-th chemical component flow, index 0 refers to the thermodynamic functions defined by the parameters of the environment.

$$E_t = Q(1 - \frac{T_0}{T})\,, \quad (5)$$

where Q – flow of heat of waste waters (WW);

T – temperature of heat source, K.

One of the tools to use thermal potential WW on WWTP is HPU [3, 6, 7]. The feasibility of their use for heating is justified in terms of exergetic efficiency in [8]. Application of HPU on WWTP for the purpose of heating leads to an increase in its efficiency and simultaneously decreases the thermal pollution.

Conclusions:

In analyzing the WWTP based assembly exergetic balances and exergy loss study can be obtained only qualitative assessment of effectiveness, due to the fact that the main application exergetic balance is the comparative analysis of similar WWTP (or various alternatives designed system).

For quantitative performance indicators and the degree of perfection WWTP is being increasingly used thermoeconomical principle. Thermoeconomy is approach to the analysis of the WWTP, which is a combination of thermodynamic analysis and economic optimization.

Economic optimization of the links between a thermodynamically preferred alternatives and capital expenditures in order to achieve minimum cost per unit (cost of cleaning and processing of WW products cleaning).

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# CLEANING COPPER ENCLOSING WASTEWATER BY FERRITISATION

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Modern requirements for industrial wastewater treatment necessitate the development of technologies that would allow on-site to recycle and reuse both treated water and the heavy metals extracted. Instrument-making, chemical, engineering and other industrial facilities generate copper-containing wastewater and sludge. Copper is an important resource, as its natural deposits are rather limited. Wastewater neutralisation and sludge processing technologies, that are usually applied by industrial facilities, do not allow utilising valuable components: not more than 25% of primary copper are used efficiently in electroplating processes.

The current research study is dedicated to the development of the new resource-saving technology for wastewater treatment of copper electroplating facilities with re-use of compounds of heavy metals and purified water. Rinsing wastewater of copper electroplating facilities contains the following pollutants: up to 50 g/m$^3$, heavy metals ions ($Fe^{2+}$ and $Cu^{2+}$) - suspended solids - up to 4 g-eq/m$^3$, COD - up to 50 g/m$^3$ at pH of 3 to 4. All analyses were done by using photometric, potentiometric, Scanning Electron Microscopy, Curie Temperature Measurement, X-ray Diffraction, High Resolution Scanning Electron Microscopy

We proposed local wastewater treatment of rinsing wastewater flows instead of traditional reagent-based one. Our technology is based on ion-exchange method, which allows concentrating pollutants and thus effectively utilising copper compounds. The ion-exchange method could be applied only in case of rational utilisation of the eluate (solutions after regeneration of cationite filter). The eluate contains $Cu^{2+}$ and $Fe^{2+}$ ions (in almost equal concentrations) and their overall level may reach up to 20 g/l. The traditional method of eluate neutralisation and sedimentation by alkaline reagents generates large amounts of highly wet sludge. The sludge is not environmentally acceptable and results in irreversible loss of valuable components. We propose to apply the ferritisation method for formation of dispersed particles with magnetic properties in water contaminated by copper and other heavy metals. The method allows easy separation of almost insoluble and chemically inert sediments.

We developed low-temperature synthesis of copper ferrite and determine optimal parameters of it obtaining: pH value of ≈ 9.0; air bubbling for oxidation of Fe (II) at rate of about 1 cm$^3$/s; duration of the ferritisation process depends on

temperature; it lasts approximately 30 min at temperatures over 60°C. The process of ferrite formation may be accelerated (almost twice) by addition of crystalline ferrite particles. The necessary amount of the crystallisation initiator reaches about 0.05 g/dm$^3$. Using X-ray diffraction and electron microscopy we have studied structures of materials produced. They are insoluble in water, contain magnetite and copper ferrite with ferromagnetic properties, and therefore might be easily separated from solutions with usage of special magnetic filters. Kinetic of ferrite removing process has been investigated for designing and selecting optimal regime for work of sorption filters.

In the course of formation of the crystalline ferrite structure it incorporates traces of other heavy metals and organic substances present in the reaction solution. In terms of quality, the treated water of the proposed technological process meets all requirements for its secondary industrial use: suspended solids – up to 3 g/m$^3$, concentration of heavy metals ($Cu^{2+}$ and $Fe^{2+}$) ~ 0.02 g-eq/m$^3$, COD up to 3 g/m$^3$, and pH ~ 7.

Conclusions:

Thus, the research results are used for development of the new environmentally sound technology for integrated wastewater treatment. The technology allows the utilisation of toxic industrial waste with production of a marketable product - magnetostriction material. Depending on amounts, quality and properties of the product, we may propose other appropriate utilisation option:

- production of pigments for ceramic tile,
- landfilling of stabile ferrite compounds, substantially enhancing environmental safety of industrial waste.

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CONTENT

**HYDROAMELIORATION, HYDROTECHNICAL INGINEERING AND RATIONAL NATURE RESOURCES USE**

**WATER SUPPLY, WASTE MANAGEMENT AND WATER TREATMENT**