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FEATURES OF SEASONAL DYNAMICS OF HAZARDOUS CONSTITUENTS IN WASTEWATER FROM COLLIERY SPOIL HEAPS OF NOVOVOLYNSK MINING AREA

Abstract. Surface run-off is water from rain and snowmelt flowing from the territory of industrial enterprises. The part of surface run-off in the total volume of discharged wastewater from the coal industry is 2%. Their volume depends on the amount of rain and melt water, as well as the size of the sites of industrial enterprises.

The objects of surface run-off contaminants in the Novovolynsk mining area are: outdoor coal and concentrate storages, colliery spoil heaps, sludge and tailings, crushing compartments, storages fuels and lubricants, points of railway cars loading and unloading, cable cars, boiler installations, etc.

On the territory of the Novovolynsk mining area besides the wastewater a huge amount of mining waste is formed. It is stored on flat heaps, adjacent to the area. Coal also accumulates on flat dumps. The surface run-off from the area of the flat heaps may contain chemical compounds. Surface water from the mine area is not purified, although in terms of quality, it is highly polluted. During investigation period the Novovolynsk mining area the storm run-off from their territory contained more than 15,000 mg / ml of suspended substances and up to 500 mg / ml of petroleum products [4].

Spoil heaps are the main sources of surface run-off contamination by suspended solids, mineral salts and heavy metal ions. Thus, the amount of suspended solids in rainwater reaches 12000 mg / l and in meltwater - up to 50,000 mg / l, the total salt content reaches 8000 mg / l. The maximum amount of iron is more than 7550 mg / l. It is found in the meltwater from the spoil heaps of almost all mines in the Novovolynsk mining area. The composition and concentration of pollutants in coal storage water runoff doesn't differ too much from the spoil heaps water run-off. An extremely important factor of man-made impact on the sanitary status of natural water bodies is the pollution of the water-intake areas around coal and mining enterprises by chemical elements, especially during polymetallic ores development [2].

Key words: wastewater, hazardous constituents, colliery spoil heaps, ponds, pollution, organic substance.

Introduction. The development and implementation of effective wastewater treatment methods is an urgent environmental task. There are various methods of wastewater treatment. The most common are: mechanical, physico-chemical, chemical and biological methods. Depending on the hazard level and type of the pollution, wastewater treatment can be carried out by one method or a set of methods (combined method). The purification process involves the treatment of sediment (or excess biomass) and the disinfection of wastewater before discharge. The theoretical basis and problematic features of seasonal dynamics of the content of hazardous components in wastewater from the waste heaps of the coal mines of the Novovolynsk mining area are the subject of research for many scientists [5].

Purpose, tasks and methods of research. In this paper the investigations of content of hazardous components in wastewater from coal mine dumps of the Novovolynsk mining area and the peculiarities of their seasonal dynamics are presented.

Results and their discussion. Rock dumps are the current storage of empty rock – a waste of coal mining technology. Although, when coal was mined manually, the content of empty rock was lower. Mechanized production could either optimize or increase its quantity. Speaking about ecological safety in the process of mine decommissioning, the author tried to build his methods of description, modeling and predicting the ecological status of coal mines [3]. The communication elements listed are directly dependent on the amount of empty rock produced. Thus, based on the annual production of empty rock, new possible remedies should be identified. Quantitative indicators are introduced into the model and the current amount of empty rock per tonne of coal produced is obtained. Improvements of operation could be measured by the reduction in the volume of empty rock per tonne of coal. The immediate positive effects of such an improvement could be the reduction of transport costs, frequency and intensity of dust pollution [10-12].

Maximum admissible concentration of harmful substances in the water is the maximum concentration, which does not have a direct or indirect impact on the health of the population and the next generations, that is determined by modern methods of research with its impact on the human body throughout life and does not impair the hygienic conditions of water. Features of harmful substances manifest in their adverse effect on the processes of natural self-purification of water reservoirs (general sanitary index), organoleptic properties of water (organoleptic index) and population health (sanitary toxicological index), characterized by limiting and threshold concentrations [6]. The admissible threshold harmful concentration by the organoleptic features is the maximum concentration in water at which changes of organoleptic properties of water are acceptable for the population. The admissible threshold harmful concentration of a substance by a general sanitary features is a maximum concentration that does not lead to disfunction of natural self-purification of reservoirs. The admissible limiting harmful concentration by a sanitary toxicological feature is maximum concentration that does not adversely affect the health of the population. The limiting harmful index is one of the indexes of harmfulness that determines the adverse effect of this substance and is characterized by the smallest amount of threshold or subthreshold concentration.

The most important or complicated problem is the protection of surface water from pollution. The following environmental measures are envisaged, namely:

- development of non-waste and anhydrous technologies. Implementation of circulating water supply systems;
- sewage treatment (by bio-plateau method, etc.);
- sewage pumping into deep aquifers;
- treatment and disinfection of surface water used for water supply and other purposes.

The main pollutant of surface water is untreated wastewater. Mechanical purification of industrial wastewater by screening, precipitation and filtration removes more than 90% of insoluble mechanical impurities of different dispersion rate (sand, clay particles, etc.) from industrial waste, more than 60% from domestic waste. Water screens, sand extractor, sand filters, sediment ponds of various types are used for these purposes. Substances floating on the surface of wastewater (oil, resins, fats, polymers) are entraped by oil separator or burned [13-15].

Chemical and physico-chemical treatment methods are most effective for the treatment of industrial wastewater. The main chemical methods include neutralization and oxidation. For neutralization of acids and alkalis special reagents (lime, soda ash, ammonia) are added into the wastewater. Different oxidants (O_3, $KMnO_4$) are used for oxidation. These methods give an opportunity to remove toxic and other components from wastewater. Physical and chemical purification includes:

1. Coagulation - the addition of coagulants (salts of ammonium, iron, copper, sludge waste, etc.) into the wastewater

2. Sorption - the ability of some substances (bentonites, activated carbon, silica gel, peat, etc.) to absorb pollutants. valuable soluble substances can be extracted from the wastewater by sorption and subsequently disposed.

3. Flotation - the blowing of gas through the wastewater. Gas bubbles capture surfactants (oil or other contaminants) when moving upwards [7,8].

The biological (biochemical) method is widely used for the purification of sewage from pulp and paper, oil refining and food processing enterprises. The method is based on the ability of microorganisms to use organic and some inorganic compounds contained in wastewater (hydrogen sulfide, ammonia, nitrites, sulfides) for their development. Purification is carried out by natural (irrigation fields, filtration fields, biological ponds, bioplato method) and artificial methods (aerotanks, biofilters, circulating oxidation channels).

After screening of the wastewater, a residual matter is formed, which is fermented in concrete tanks and then removed on a sludge site for drying. Dried sludge is usually used as a fertilizer, but in recent years, many harmful substances (namely heavy metals) have been detected in wastewater, which eliminates this method of disposal [17].

The clarified wastewater is purified in aerotanks by special closed tanks, where the oxygen-rich effluents mixed with activated sludge are slowly discharched into the treated water. Active sludge is a mixture of heterotrophic microorganisms and small invertebrates (mold, yeast, aquatic fungi), as well as a solid substrate. It is important to choose the right temperature, pH, additives, mixing conditions, oxidizer (oxygen) to maximize the intensification of hydrobiocenosis [9].

In wastewater treatment systems, the biological method is final stage after which the wastewater can be used in circulating water or discharged into surface water.

In recent years, new effective methods have been actively developed, contributing to the greening of the wastewater treatment process, namely:

– Electrochemical methods are based on the processes of anodic oxidation and cathodic reduction: electrocoagulation and electro-flotation.

– Membrane processes. Ultra filters, electrodialysis.

– Magnetic processing. Improves the flotation of suspended solids.

– Radiation purification of water, gives an opportunity to expose pollutants to oxidation, coagulation and decomposition as soon as possible.

– Ozonation: no hazard substances are formed in wastewater.

– Introduction of new selective types of sorbents for selective recovery of useful components from wastewater for reuse [20-22].

Methane, CO_2, H_2S release during decomposition of organic substances. The energy of this biogas is used for heat and energy production. One promising way to reduce surface water pollution is to pump wastewater into deep aquifers through a system of absorbing wells (underground disposal). Among the water protection issues, one of the most important is the development and implementation of effective methods of disinfecting and purifying surface water used for drinking purposes. Insufficiently treated drinking water is dangerous both from an ecological and social points of view. Beginning from 1896 to the present day, chlorine water disinfection is the most common method. However, the chlorination of water carries a serious risk to human health. Reducing the content of carcinogens in drinking water is possible by replacing primary chlorination by ozonation and UV treatment, as well as by using a non-reagent pre-purification method in biological reactors [23].

Modern technology for the purification of drinking water from petroleum products from surfactants, pesticides, organic and other compounds is based on the use of sorption processes on activated carbon. Agroforestry and hydrotechnical measures are of great importance in protecting surface water from pollutants. Resulting data of Mine #9 of Novovolynsk mining area are presented in table 1.

Table 1 – Resulting data of Mine #9 of Novovolynsk mining area

		Spring		Winter		Autumn		Summer	
Index	*units*		MAC		MAC		MAC		MAC
1	*2*	3	4	5	6	7	8	9	10
Smell at +20 °C	*scores*	0	< 2	0.5	< 2	0	< 2	0	< 2
Transparency	*cm*	5	> 20	28	> 20	40	> 20	30	> 20
pH	*pH units*	7.9	6.5-8.5	5.9	6.5-8.5	6.4	6.5-8.5	6.6	6.5-8.5
Suspended solids	*mg/l*	169	N/A	93	N/A	18.2	N/A		N/A
Dry residues	*mg/l*	2463	<1000	29,2	< 1000	1633	< 1000	770	< 1000
Total hardness	*mg/l*	31.2	< 7.0	0.31	< 7.0	22.5	< 7.0	9.3	< 7.0

Continuation of table 1

1	2	3	4	5	6	7	8	9	10
Carbonate hardness	*mg/l*	2.5	< 6.5	0.25	< 6.5	3.6	< 6.5	2.9	< 6.5
Hydrocarbonates (HCO3-)	*mg/l*	153	< 300	153	< 300	220	< 300	177	< 300
Chlorides (Cl-)	*mg/l*	43.2	< 250	4.2	< 250	15.8	< 250	54.8	< 250
Sulfates (SO42-)	*mg/l*	1004	< 500	580	< 500	552	< 500	243	< 500
Nitrites (NO2-)	*mg/l*	12.3	< 3.3	0	< 3.3	21.8	< 3.3	18.6	< 3.3
Nitrates (NO3-)	*mg/l*	123.6	< 45	90	< 45	158.3	< 45	88.2	< 45
Phosphates (PO43-)	*mg/l*	1.9	N/A	0	N/A	185.4	N/A	0.3	N/A
Calcium (Ca2+)	*mg/l*	373	N/A	520	N/A	201	N/A	122	N/A
Magnesium (Mg2+)	*mg/l*	153	< 80	0.6	< 80	150	< 80	38.9	< 80
Total Ferrum (Fetot)	*mg/l*	2.5	< 0.3	0.18	< 0.3	0.51	< 0.3	0.1	< 0.3
Ammonium (NH4+)	*mg/l*	1.24	< 2.0	0.15	< 2.0	18.3	< 2.0	2.4	< 2.0
Sodium (Na+) + Potassium (K+)	*mg/l*	199	< 300	5.5	< 300	105.8	< 300	51.1	< 300
Total Dissolved Solids	*mg/l*	2453	N/A	37.8	N/A	1721	N/A	1924	N/A
Chemical oxygen demand	*mgO/l*	15.1	< 5	5.3	< 5	12.6	< 5	21.3	< 5

If we compare the data of mines # 2, # 4, # 9 of Novovolynsk mining area, the results of the researches are almost identical and there is no significant difference between the content of harmful substances in the mines depending on the time of year. For example, we take producing mine # 9 (mines # 2, # 4 are not operating, (figure 1)).

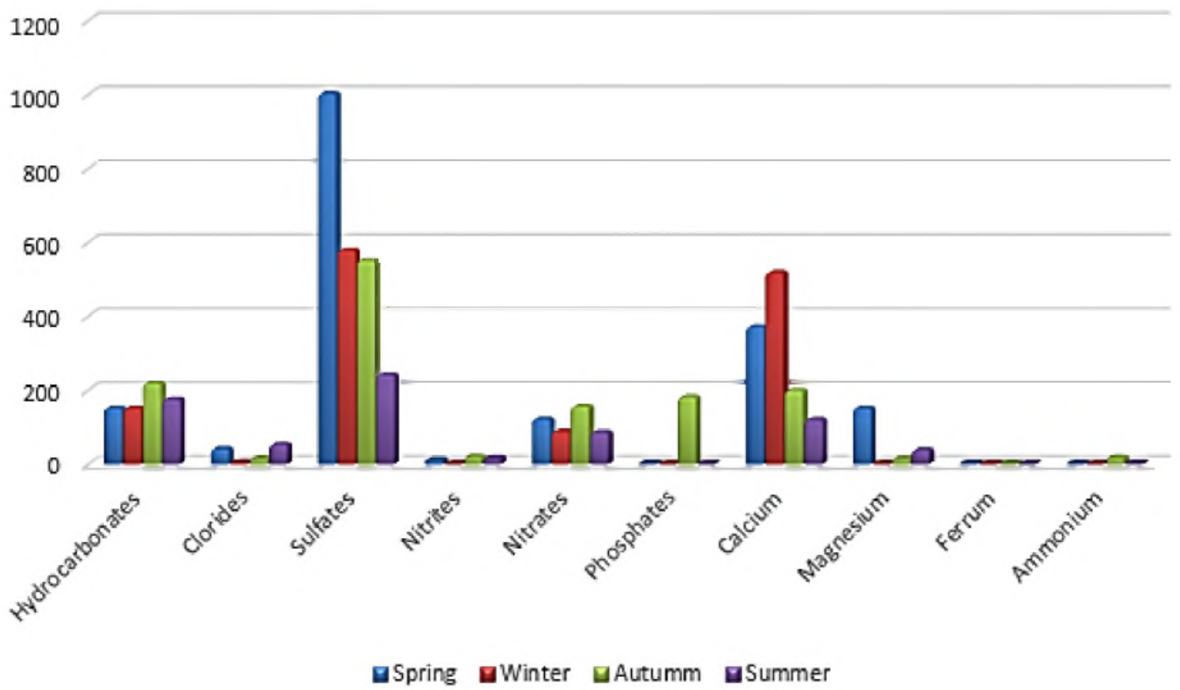

Figure 1 – The seasonal dynamics of the content of hazardous components in the wastewater from the waste heaps of mine № 9 of the Novovolynsk mining area

The aquifer of quaternary sediments is developed in quaternary formations, namely: in loam on watersheds and sandy loam in alluvial deposits in river valleys. Alluvial deposits are of the greatest importance for flooding processes. Are presented in table 2.

Table 2 – The impact of waste heaps

Environmental aspect and sources	Types	Potential impact
Wastewater and discharge of contaminated water, filtrate, drainage and pumped out groundwater Sources: Surface runoff from dumps, the filtrate, surface runoff from devastated lands and objects, discharge of pumped water	Water erosion Chemical contaminants Drainage of acid mine water Drainage of neutral mine water Heavy metals Salinity Soluble or captured resinous coal derivatives	Negative health impacts for people living downstream. Negative impacts on aquatic ecosystems: water turbidity, low dissolved oxygen content as a result of increased biological and chemical oxygen demand, increased toxicity, lower pH, salinity. Reduced municipal water supply. Increased costs for water treatment.

The composition of sediments is mainly represented by a layer of sand or sandy loam with a capacity of 0.5-6.0 m (with a maximum capacity of 16 m). Often there is a stratification. Sometimes at the foot a low-strength layer of gravel or pebble is present.

The coefficient of filtration of loam according to the literature data is more than 0.003-0.17 m/day, sand and sandy loam - 2-5 m/day. According to the pumping on the alluvial horizon, the filtration coefficients vary from 0.35 to 8.68 m/day with an average value of about 3 m/day.

The average value of the horizon's power is 15 m. The horizon is pressureless, not protected by the upper waterproof layer and is fed by precipitation and melt water. The infiltration rate is 607 mm/year on average. Therefore, the amount of infiltration supply to the groundwater, taking into account evaporation (570 mm/year), will be approximately 0.00013 m/day [1,16,24]. Based on the analysis of hydrogeological data in the area, the dynamics of the performance of the coal mines of the Novovolynsk mining area was determined (figure 2).

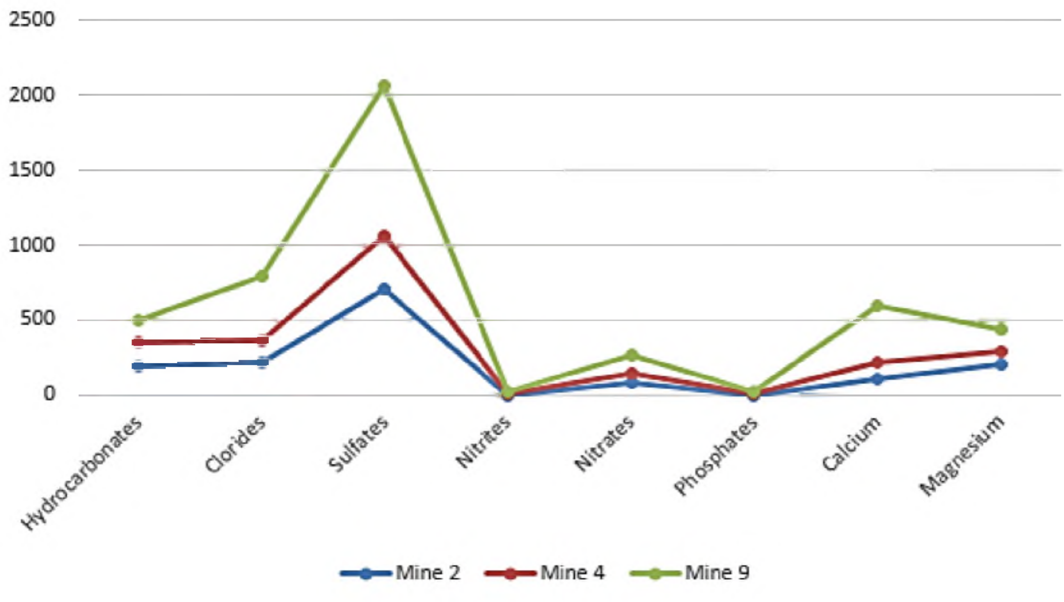

Figure 2 – Resulting data dynamics of mines of Novovolynsk minig area

Conclusions. Chemical and physico-chemical treatment methods are most effective for the treatment of industrial wastewater. The main chemical methods include neutralization and oxidation. To neutralize acids and alkalis, special reagents (lime, soda ash, ammonia) are added into the wastewater. Different oxidants (O_3, $KMnO_4$) are used for oxidation. These methods give an opportunity to remove toxic and other components from wastewater. Basing on the research, there is no significant difference between the content of harmful substances in mines. Collection, removal, detoxification, recycling and disposal are the main tasks of environmental engineering [25].

In order to investigate the system of environmental safety around the coal mines of the Novovolynsk mining area, a model of the interconnection of environmental and human components is taken. The mentioned system of ecological safety should protect the person from environmental threats caused by anthropogenic factors, in our case - it is coal production. The environment, in the context of environmental safety, means the development of a system of protection of man against man-made factors through environmental management [18,19]. The impact of man-made factors on the environment should be standardized by separate substantiated documents, that is, an integrated indicator should be developed for the total environmental status around the coal mines can be calculated. Considering that long-term production in the country has led to uncompensated, uncontrolled environmental degradation, we consider this environment to be critical. In order to remedy this situation, it is proposed to rehabilitate the coal territories by improving the management system in environmental protection and ecological safety, alongwith timely demineralization, recultivation, vegetative reclamation of disturbed lands and bio-plateaus.

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НОВОВОЛЫН КӨМІР ӨНЕРКӘСІБІ АУДАНЫНЫҢ КӨМІР ШАХТАЛАРЫ ҮЙІНДІЛЕРІНЕН САРҚЫНДЫ СУДАҒЫ ҚАУІПТІ КОМПОНЕНТТЕР ҚҰРАМЫНЫҢ МАУСЫМДЫҚ ДИНАМИКАСЫНЫҢ ЕРЕКШЕЛІГІ

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ОСОБЕННОСТЬ СЕЗОННОЙ ДИНАМИКИ СОДЕРЖАНИЯ ОПАСНЫХ КОМПОНЕНТОВ В СТОЧНЫХ ВОДАХ С ОТВАЛОВ УГОЛЬНЫХ ШАХТ НОВОВОЛЫНСКОГО УГЛЕПРОМЫШЛЕННОГО РАЙОНА

Аннотация. Проблема охраны водных ресурсов от загрязнения неочищенными сточными водами шахт приобрело особую важность, так как предприятия угольной промышленности характеризуются как поставщики большого объема стоков. Шахтные воды, загрязнённые механическими и органическими примесями, отличаются повышенным солесодержанием, что представляет реальную опасность загрязнения поверхностных и подземных вод.

Более 80% общего потребления воды шахтой составляет питьевая вода, используемая для орошения горных выработок, в административно-бытовых комбинатах, котельных, компрессорных, а незначительная часть шахтной воды, что выдается на поверхность, используется для технологических целей в горных выработках. Целесообразным решением данной проблемы является эффективная очистка шахтных вод (методом биоплато), цель которой – пополнение запасов пресной воды, используемой на технологические нужды предприятия, улучшения качества воды перед сбросом в водный объект, а также возможности использования в технологических процессах других отраслей промышленности и сельского хозяйства.

Шахтная вода каждого водоотливного комплекса имеет определенный химический состав. Контролируются основные показатели, регламентируемые для сточных вод угольной промышленности, которые сбрасываются в природные объекты. Это взвешенные вещества, солесодержание, сульфаты, хлориды, нефтепродукты, фенолы, тяжелые металлы и прочее. По своему составу шахтная вода водоотливных комплексов вполне пригодна для технического водоснабжения предприятий, например, металлургических, без дорогостоящей водоподготовки. Использование же шахтной воды для питьевого водоснабжения возможно только в сочетании с предварительной глубокой очисткой, особенно если это вода, откачиваемая водоотливными комплексами с погружными насосами. В такой воде, как правило, превышены предельно

допустимые концентрации железа, марганца. Это связано с геохимическими процессами, происходящими в подземных водных горизонтах после закрытия шахт.

Поверхностные стоки образуются из дождевых и талых вод, стекающих с территории промышленных предприятий. Доля поверхностного стока в общем объеме сбрасываемых сточных вод угольной промышленности составляет 2%. Их количество зависит от объема дождевых и талых вод, а также от величины площадок промышленных предприятий.

Объектами-загрязнителями поверхностного стока на территории Нововолынского углепромышленного района являются: открытые склады угля и концентратов, шахтные породные отвалы, шлам, дробильные отделения, склады горюче-смазочных материалов и фотореагентов, пункты погрузки и разгрузки железнодорожных вагонов, канатные дороги, котельные установки и т.п.

На территории Нововолынского углепромышленного района в качестве отходов производства, кроме сточных вод, образуется большая масса пустой породы. Она складируется на плоских отвалах на примыкающих территориях. На плоских отвалах накапливается также уголь. Порода и уголь в цикле обогащения контактируют с фотореагентами, поэтому ливневые стоки с территории плоских отвалов могут быть загрязнены химическими соединениями. Очистка поверхностных вод с территории шахт не проводится, хотя по качественному составу они относятся к сильнозагрязненным. При обследовании Нововолынского углепромышленного района ливневый сток с территории содержал свыше 15000 мг/дм^3 взвешенных веществ, концентрация фотореагента достигала более 450 мг/дм^3, а нефтепродуктов – 500 мг/дм^3.

Породные отвалы являются основными источниками загрязнения поверхностного стока взвешенными веществами, минеральными солями и ионами тяжелых металлов. Так, количество взвешенных веществ в дождевых водах доходит до 12000 мг/л и в талых – до 50000 мг/л, общее солесодержание достигает 8000 мг/л. Максимальное количество железа составляет более 7550 мг/л. Оно проявляется в талых водах отвалов почти всех шахт Нововолынского углепромышленного района. Стоки угольных складов по составу и концентрации загрязняющих веществ мало отличаются от стоков породных отвалов. Чрезвычайно важным фактором техногенного влияния на санитарное состояние природных водных объектов является загрязнение водосборных территорий химическими элементами вокруг угольных и горнорудных предприятий, особенно при разработке полиметаллических руд.

На основе исследований и анализа сточной воды из технологических отвалов пород шахт мы предложили оптимизационные мероприятия, направленные на улучшение состояния как отдельных компонентов окружающей природной среды, так и целостных природно-хозяйственных систем Нововолынского горнопромышленного района.

Ключевые слова: сточные воды, опасные компоненты, отвалы угольных шахт, водоемы, загрязнения, органические вещества.

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