

Assessment of wastewater impact on a natural reservoir in Kyrgyzstan

Evaluación del impacto de las aguas residuales en un embalse natural en Kirguistán

Kanybek Raimbekov¹, Saparbek Moombekov², Joodarbek Iliyazov³, Imankul Myrzabaev⁴

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ABSTRACT

Introduction: Anthropogenic activities artificially increase the concentration of toxic substances in surface reservoirs by discharging polluted water back into the natural environment. Maximum risks for aquatic ecosystems are observed in regions with limited wastewater treatment, which includes Kyrgyzstan. The purpose of the work – research and analysis of factors of pollution of natural reservoirs of Kyrgyzstan by wastewater, consequences for regional aquatic ecosystems and public health, and search for optimal solutions to minimise destructive pollution. **Material and Methods:** The research was conducted using general scientific methods of cognition, in particular, system analysis, synthesis, generalisation, and concretisation. **Results and Discussion:** In the course of the research the ecological state of natural water resources of Kyrgyzstan, into which wastewater is discharged, the dynamics of pollution of the aquatic environment depending on various factors of influence is analysed, optimal and feasible to implement measures to reduce the adverse effects of wastewater on the state of natural reservoirs and public health, and improve the overall environmental situation in the region are developed. In addition, the possibilities of applying modern management and technological measures to minimise the content of pollutants in wastewater, based on the synergy of environmental safety and economic efficiency, with the introduction of modern innovative systems of control and monitoring of environmental pollution have been explored. **Conclusion:** It is established that there is no safe wastewater, therefore, optimisation of the water uses and water treatment system in Kyrgyzstan involves the application of an ecosystem approach and the introduction of integrated water resources management.

Keywords: Water Resources Management; Treatment Methods; Ecosystem; Eutrophication; Biocoenosis.

¹ Department of Biology, Chemistry and Nature Use, Osh State Pedagogical University named after A. Myrsabekov, 723500, 73 Isanov Str., Osh, Kyrgyz Republic, raimbekovkanybek60@gmail.com

² Department of Biology, Chemistry and Nature Use, Osh State Pedagogical University named after A. Myrsabekov, 723500, 73 Isanov Str., Osh, Kyrgyz Republic. Moombekov@outlook.com

³ Department of Biology, Chemistry and Nature Use, Osh State Pedagogical University named after A. Myrsabekov, 723500, 73 Isanov Str., Osh, Kyrgyz Republic, joodarbekiliyazov@hotmail.com

⁴ Department of General Clinical Biochemistry and Pathophysiology, Osh State University, 723500, 331 Lenin Str., Osh, Kyrgyz Republic, Myrzabaev.I@outlook.com

INTRODUCTION

A large volume of polluted wastewater containing many compounds and elements harmful to the aquatic environment and ecological situation in general – nitrates, chlorides, oil products, heavy metal salts – is discharged into natural open watercourses and reservoirs of Kyrgyzstan without proper treatment. To date, the basins of the main rivers in the republic are subject to significant pollution: Tyup, Djergalan, Kara-Darya, Chu, and Syr-Darya. Anthropogenic impact today actively develops a specific modified natural background, for which a significant pollution index is characteristic, and the upper limits often exceed the established maximum permissible concentrations of pollutants in natural water bodies. The content of harmful substances in wastewater exceeds normative values dozens of times, in connection with which chemical and microbiological pollution is observed in open water bodies. Therewith, the most significant impact is caused by polluted effluents from industrial and agricultural facilities, discharges from irrigated fields saturated with decomposition products of pesticides and mineral fertilisers, and municipal and economic activities of the population.

Water and environmental problems are reflected in the degradation of water and land resources, deterioration of public health indicators, destructive processes in ecosystems, and reduction of biodiversity. Many scientific works and studies are devoted to the problem of wastewater impact on natural water bodies, and to the search for solutions that would reduce the anthropogenic load of wastewater on the environment. Adverse effects of pollutant discharges into the natural aquatic environment are explored in the works of modern researchers E.R. Jones et al. ⁽¹⁾, L. Hou et al. ⁽²⁾, and S.D.W. Comber et al. ⁽³⁾. Scientists of Kyrgyzstan pay special attention to the toxic and carcinogenic properties of some components of wastewater from industry and municipal services ⁽⁴⁻⁶⁾. Modern scientists S. Bonetta et al. ^(7,8) and H. Hamdhani et al. ⁽⁹⁾ come to the conviction that many destructive changes in aquatic ecosystems, difficult to regenerate, are provoked by large-scale releases of toxic substances from industrial processes. The conclusions of scientists are complemented by a group of researchers led by S. Lu et al. ⁽¹⁰⁾ and M. Preisner ⁽¹¹⁾ are convinced of the special urgency of the impact on natural reservoirs of new understudied pollutants, which actually cannot be treated even with satisfactory condition of complete wastewater treatment systems. M.T.H. van Vliet et al. ⁽¹²⁾, in the search for ways to optimise the situation and levelling of adverse consequences, concluded that modernisation of existing treatment facilities, with the priority of environmental friendliness, combined with effective monitoring of environmental pollution parameters by wastewater, is the optimal method of an ecosystem approach to water use and prevention of adverse consequences for the environment and public health.

Despite the relevance of the issue considered, there are still many aspects that require detailing, analytical processing and search for optimal solutions. The purpose of the research is to explore the real impact of wastewater on natural water bodies of Kyrgyzstan, and to find optimal innovative opportunities to minimise the destructive load on the environment from wastewater, and to develop effective preventive measures.

MATERIALS AND METHODS

During the review of literary sources and publications in specialised editions devoted to the examined problem, the main purpose was to select relevant and progressive works on the issues of the selected subject to evaluate the current state of research in this area. The materials of this research are a set of works and research results of modern Kyrgyz ⁽⁴⁻⁶⁾ and foreign scientists ^(1-3; 7), analytical materials ⁽⁹⁾, and publications in scientific and metric databases ⁽¹⁰⁻¹⁵⁾. The activities in the course of the research, which had the purpose of identifying typical features and regularities of the examined problems, opportunities for optimising the situation and finding the most beneficial

solutions, were conducted using the method of generalisation. The attention was focused on the latest studies of the issue being examined in recent years.

In the process of the research was used general scientific methods of cognition. The general scientific method of deduction was used to determine the essence of the process of the impact of pollutants in the composition of wastewater on water-landscape ecosystems of surface natural reservoirs of Kyrgyzstan and public health as a multifactorial process. In addition, the method of ascent from the abstract to the particular was used in the research process, in the form of a sequential transition from general abstract data on the vectors of the adverse impact of wastewater on water resources to specific data on the consequences of wastewater discharges of different degrees of treatment for the environment, and to practical innovative opportunities for preventive measures.

To determine the effectiveness, features and advantages of specific solutions in the process of research, the system approach was used. Using this approach, the work is focused on disclosing the integrity of the object of research and a comprehensive search for solutions to optimise the management of risks of pollution of surface natural reservoirs of Kyrgyzstan by hazardous and toxic substances in the composition of wastewater. Particular attention is paid to the variability of approaches and the need to provide for possible difficulties in practical implementation in the economic reality of developing countries. The method of synthesis was applied to determine the feasibility of modern management decisions in the water treatment industry at the regional and national levels. The method of abstraction was used to form a representation of the process of monitoring, management and control in the field of influence of quantitative and qualitative indicators of effluents on the state of aquatic ecosystems of surface reservoirs in Kyrgyzstan.

The method of specification is applied to determine the factors of effectiveness and economic feasibility of preventive measures, forecasting and modelling of extreme adverse consequences of irrational water treatment and discharge of untreated wastewater into the natural aquatic environment. Therewith, the determining factors for selecting optimal management and production-technological solutions to reduce the adverse impact of wastewater are highlighted. The possibility of an effective combination of innovative technological solutions with the development of a monitoring system of environmental pollution parameters in the process of water treatment and wastewater discharge into natural reservoirs is considered. In addition, the formalisation method was used in the course of the research.

RESULTS

Evaluation of water abstraction and water treatment system in Kyrgyzstan

Kyrgyzstan is rich in natural water resources. Therewith, the components of river runoff for the republic are equal in their economic significance – both surface and underground. Surface runoff needs to be regulated for more efficient and rational use. Its particularly valuable function is to provide water for irrigated agriculture. More than half of the river flow resources in Kyrgyzstan (34.7 km³) belong to the high-mountain and glacial-naval natural belts. Thus, the areas located near mountain ranges are maximally provided with water resources ⁽⁴⁾. Wastewater collection in the Kyrgyz Republic accounts for about 70% of the total water supply ⁽⁶⁾. Therefore, many of the wastewater treatment facilities are not functioning or are operating inefficiently. In addition, the lack of proper control over the treatment process and parameters of its efficiency is characteristic.

According to the data of the Department of Water Management, about 1 billion m³ of wastewater is discharged annually in the country, of which 19.5% enters surface water bodies. The volume of normative-treated water is 150-160 million m³, polluted water – 3.8 million m³. Therewith, the content of harmful and toxic substances in discharges exceeds permissible standards dozens of

times, which provokes large-scale chemical and microbiological pollution of the country’s reservoirs.

About 90% of water pipelines use water from reliable underground sources. But, therewith, in recent years, there has been a progressive deterioration of the sanitary and technical condition of water pipelines, and there is virtually no construction of new ones. As a result, 236 sanitary protection zones and water intake facilities do not meet sanitary standards, and 242 disinfection plants are not functioning. 160 out of 290 wells of the Bishkek city water supply system cannot be operated today, and the situation is critical in Naryn and Osh regions ^(6;13). The economic recession in the republic has adversely affected the state of sewage and wastewater treatment facilities in Kyrgyzstan. The decrease in the quality of wastewater treatment and deterioration of water indicators of natural open reservoirs is primarily due to the deterioration of financing of the industry. Only 30% of wastewater treatment facilities in the country meet sanitary standards, and 40% of the total number do not perform their functions at all, which indicates the criticality of the situation ⁽⁴⁾. The situation with wastewater treatment is catastrophic in the cities of Naryn, Osh, Tokmok, Karakol, Jalal-Abad, Balykchy, and Chol-pon-Ata ⁽⁶⁾. Considering that the quantitative majority of wastewater flows to treatment facilities of municipalities, special attention should be paid to compliance of their operation parameters with the design regime. Such measures will contribute to reducing the amount of untreated and insufficiently treated wastewater in surface water bodies. The largest amount of wastewater discharged without treatment is in the Chui region (Table 1).

Table 1. Indicators of untreated and insufficiently treated wastewater discharge in Kyrgyzstan

Region	Measurement unit	Quantitative indicator
Kyrgyz Republic	million m ³	2.1
Jalal-Abad region	million m ³	0.6
Issyk-Kul region	million m ³	0.1
Batken region	million m ³	0.1
Talas region	million m ³	0.1
Chui region	million m ³	1.1
Bishkek	million m ³	0.1

Most small towns and settlements do not have centralised sewerage systems at all. Industrial and domestic wastewater accumulates in cesspools with further disposal in water catchment areas or, in the worst case, directly on water bodies, polluting the environment, worsening the ecological situation and endangering public health.

Main sources of wastewater generation, their impact on natural water bodies

Entering natural water bodies, pollutants contained in wastewater introduce significant changes in the regime of the aquatic environment and disturb the equilibrium of local ecosystems. In the process of natural self-cleaning of the reservoir, secondary decay products of pollutants may be developed, which have an adverse effect on water quality ^(9;11). According to the information of the State Enterprise on Hydrometeorology, the rivers Karakol, Alamedin, Tyup, Chu, Ak-Buura, Zhazy, Mailuu-Suu. The greatest impact on the chemical composition of water in the above rivers is caused by polluted wastewater from industrial and agricultural enterprises, products of economic activity of the population, and discharge water from irrigated fields, which contain a large amount of decay products of mineral fertilisers ⁽¹⁵⁾.

A specific danger is posed by numerous mining waste dumps, where cyanide-containing and radioactive substances, and salts of heavy metals are stored for utilisation. The dumps themselves

are located in intermountain hollows and depressions, floodplains of rivers. The threat of large-scale toxic pollution of water bodies is increasing in proportion to the existing threats of man-made and natural catastrophic events, requiring special attention from society. Municipal and partly industrial wastewater from cities and towns is treated at sewage treatment plants (STPs). According to the State Inspectorate for Environmental and Technical Safety under the Government of the Kyrgyz Republic, there are 145 operating facilities for mechanical and biological treatment of wastewater, of which 14 discharge treated wastewater directly into surface reservoirs, 5 – into dry ditches of streams and rivers, 114 – for irrigation, 2 – on the terrain, and only 10 – into filtration and evaporation fields. The largest number of wastewater treatment facilities are located in Chui and Issyk-Kul regions ⁽⁶⁾.

A significant factor affecting the ecological situation in the republic is the ameliorative condition of lands that are subjected to irrigation. About 13% of irrigated lands are subject to a high degree of salinity and salinization ⁽⁵⁾. The situation requires urgent measures to improve these territories. The majority of small rivers in the valley part of the republic are intensively polluted and saline, recently becoming practically unsuitable for drinking water. The ecological condition of large rivers of Kyrgyzstan – Chu, Naryn, Talas, Tyup, Ak-Buura – is unsatisfactory, in particular in the sections located downstream at the outlet of adjacent cities ⁽⁶⁾. One of the sources of pollution of the natural aquatic environment in Kyrgyzstan is also collector-drainage water (CDW), which significantly affects the chemical composition of surface water. CDWs contain a large amount of sulphates, chlorides, and sodium ions. In addition, they contain pesticides, phosphorus and nitrogen compounds ⁽¹⁶⁾.

Consequences of wastewater pollution of natural reservoirs

Pollutants in wastewater in the soluble state contain a large number of organic and mineral compounds, which have a destructive effect on organisms living in the natural aquatic environment, and lead to the unsuitability of water for use in economic and industrial activities. Mineral toxic compounds include salts of lead, fluorine, arsenic, copper, chromium, acids and bases. The latter, in addition, causes changes in the acidity of the aquatic environment, leading to the death of organisms participating in the process of self-purification of natural reservoirs. Heavy metals are absorbed by phytoplankton and then passed along the food chain, continuing the toxic effect in the ecosystem ^(2; 17).

Organic compounds, entering surface water bodies with wastewater, reduce the amount of dissolved oxygen and delay biological processes in the aquatic environment. Therewith, they are extremely difficult to decompose, establishing a prolonged effect. Organic contaminants of municipal and industrial wastewater, when dissolved in water, undergo biological oxidation and decomposition, provoking the spread of pathogenic microorganisms. Notably, pollutants do not necessarily have to have toxic properties to lead to a decrease in water quality and the death of living organisms. A prime example is nitrates and phosphates, which cause eutrophication of reservoirs. Under natural conditions, with gradual temperature fluctuations, aquatic organisms adapt to changes in ambient temperature. But in the case of discharge of hot wastewater into the reservoir, primarily from industrial enterprises, the new temperature regime is established in short time intervals, living organisms do not have time to acclimatise and die of heat shock. In addition, as a result of discharging heated effluents into water bodies, there are changes in the metabolism of living organisms, and their oxygen demand increases ⁽¹⁸⁾. But, therewith, due to the increase in water temperature, the oxygen content in water drops significantly, which destructively affects the fauna of the aquatic environment ⁽¹⁵⁾. Artificial water heating can significantly affect the behaviour of fish, disrupting migration processes and provoking untimely spawning ⁽¹⁹⁾.

In addition, the structure of fauna is disturbed due to thermal pollution of the aquatic environment by sewage water. The phenomenon of eutrophication is becoming widespread. Under the influence of even a minimal amount of surface-active substances (surfactants) in reservoirs, a persistent foam is developed, which accumulates in places of current delay and can spread over considerable distances and accumulate in the coastal zone. The ability to foam development is manifested in most surfactants already at a concentration of 1 mg/l, and wastewater treatment is ineffective in this case ^(10; 17). The presence of these substances changes the chemical composition of natural waters, depresses the biocoenosis of the aquatic environment, and reduces oxygen saturation. In addition, surfactants have a synergistic effect with other toxic substances, increasing their destructive effect (e.g., pesticides) ⁽²⁾.

All consequences of wastewater pollution of reservoirs cause enormous damage to natural ecosystems, adversely affecting their various components. In general, it can be stated about economic (e.g., loss of productivity of water bodies, regeneration costs), social (in particular, degradation of landscapes) and environmental (e.g., destruction of unique ecosystems, disappearance of species diversity) vectors of adverse effects of wastewater effluents on natural reservoirs of Kyrgyzstan. In the coming years, it is not expected that the amount of pollutants flowing into the natural reservoirs of Kyrgyzstan will decrease. This situation actualises the need for effective monitoring, modelling and forecasting of the state of natural surface waters under the conditions of increasing influence of anthropogenic activities. To optimise the situation in the water-ecological area in Kyrgyzstan, the following measures are optimal and feasible for implementation:

1. Rationalisation of water use in economic sectors with a focus on resource conservation.
2. Wastewater reuse in industrial recycling systems.
3. Prioritise the upgrading and improvement of wastewater treatment systems in the planning and implementation of regional development programmes.
4. Development and implementation of modern wastewater treatment systems to limit and, in the future, ban direct discharge of wastewater into natural reservoirs.
5. Improvement of the system of water resources management, distribution and rational use.
6. Implementation and optimisation of the water resources condition monitoring system.
7. Toughening of liability measures for pollution of natural reservoirs with wastewater.
8. Optimisation of the legislation framework in the water use sector.

For the “green” economic development of Kyrgyzstan and the ecologization of production processes, it is necessary to introduce energy-efficient, environmentally oriented innovative technologies, through which it becomes possible to maximally control the processes of establishment of harmful substances and reduce their quantitative indicators in wastewater.

DISCUSSION

A large number of scientific studies confirm the fact of extremely adverse effects of sewage pollution on natural water objects. Modern scientists E.R. Jones et al. ⁽¹⁾ and H.F. Abd-Elhamid et al. ⁽¹⁴⁾ in their studies convince that the environmental quality standards for surface water do not always correspond to the discharge standard for treatment plants. Thus, wastewater, even though it meets the discharge standards, always carries a load of varying degrees on the water quality of the receiving water object. Scientists have determined the amount of water required to sufficiently dilute wastewater to complete neutralisation: 30.2 km³ or 58% of Kyrgyzstan’s river flow resources ⁽⁶⁾.

Wastewater discharge, according to studies by H. Hamdhani et al. ⁽⁹⁾, deteriorates water quality in the natural watercourse in the area of the discharge site, mainly due to the increase in temperature

parameters of the aquatic environment, increase in the amount of organic matter, and decrease in the dissolved oxygen level. N. Wanders et al. ⁽¹⁷⁾ argue that the long-term consequences of such processes are the local loss of biodiversity and the replacement of sensitive species of the biotic environment by tolerant ones. Among the abiotic effects of runoffs L. Yang et al. ⁽¹⁸⁾ highlight changes in the hydrological regime of a water object and even channel morphology, as warmer and nutrient-rich runoffs affect the infiltration rate. In addition, this fact is emphasised by the modern scientists H.F. Ehlert Madeco ⁽¹⁴⁾ and S. Lu et al. ⁽¹⁹⁾.

The results of the studies of M.T.H. van Vliet et al. ⁽¹²⁾ and Y. Wen et al. ⁽¹⁶⁾ indicate significant changes in water quality indicators in natural reservoirs into which wastewater is discharged. Water temperature, alkalinity and conductivity increase, and the content of nitrates, ammonia, phosphates, and heavy metals increases. Therewith, the increase in water temperature provokes multiple ecological consequences, including an increase in the rate of biomass growth and the development of the eutrophication of water objects. A group of scientists led by S. Lu et al. ⁽²⁰⁾ in the development of this issue, pay attention to the fact that many aquatic species (e.g., fish) are adapted to specific temperature ranges, and the increase in the latter can exclude sensitive taxa from the areas affected by wastewater. Scientists testify that dissolved oxygen levels in water objects influenced by wastewater often fall below the critical levels required by many living organisms. Toxic phytoplankton blooms occur. Elevated ammonia concentrations lead to a decrease in the growth rate and reproductive capacity of aquatic species, and cause mortality of many fish species ⁽¹¹⁾.

In addition, the impact of wastewater on natural reservoirs can manifest itself in changes in the flow regime, including the establishment of ephemeral flows permanently and causing significant diurnal variations in flow where there is a small base flow. It is convinced in their research by scientists Z. Lian et al. ⁽¹⁰⁾ and M. Preisner ⁽¹¹⁾. In addition, they insist that many studies do not consider information on the relative percentage of wastewater flow to the receiving water object and the dynamics of seasonal fluctuations. According to the authors, a larger-scale mapping of the network of watercourses into which wastewater flows would allow consideration of non-point sources of pollution, which may hinder the natural restoration of the state of the aquatic environment of the objects.

Further research is required on the consequences of the introduction of new pollutants into water objects with wastewater, for example, such as microplastics ^(10; 21). In addition, it is necessary to use modern environmental monitoring capabilities for objective assessment, development of preventive measures and regeneration actions to minimise the impact of wastewater on the state of surface water ecosystems. It is necessary to conduct comprehensive measures to reduce the amount of toxic substances in wastewater, primarily from pharmaceutical enterprises, and to tighten the requirements for the degree of treatment of wastewater discharged directly into water objects ⁽²²⁾. Implementation of such a purpose presupposes the modernisation of treatment facilities and optimisation of their operation. I. Kauser et al. ⁽²³⁾ and S.D.W. Comber et al. ⁽²⁴⁾ draw attention to the insufficient functionality of the current system for monitoring the quality parameters of wastewater. In addition, many complex chemical and ecological processes occur directly in the aquatic environment of a natural object, including the synergistic effect of toxicity ⁽²⁵⁻²⁷⁾.

Many scientists of the present day, for example, D.K. Tilenova ⁽⁵⁾ and T.H. Karimov ⁽⁶⁾ are convinced that in the future the predominant role should be given to the biological method of purification, based on using the regularities of physiological and biochemical processes of self-purification of natural surface water objects. This type of treatment is based on using the vital activity of microorganisms, which can oxidise or regenerate organic compounds that are in wastewater in the form of suspensions, and colloidal solutions and are a source of nutrition for microorganisms ^(5; 28). Thus, the process of biological wastewater treatment utilises the natural

features and capabilities of living organisms ^(21; 29). Currently, this type of treatment does not have proper popularity. The advantage is given to conventional mechanical and physico-chemical treatment. As a result of the research of L. Hou et al. ⁽²⁾, and the current work, it was established that in the future it is considered appropriate to focus on a gradual increase in using closed-loop water recycling systems in industry. The priority should be the gradual cessation of the discharge of treated and, particularly, untreated wastewater into open natural water reservoirs, i.e. isolation of the economic link of the water cycle from the natural one. Treatment facilities of enterprises should function not for the preparation of wastewater for release into natural water objects but for its multiple uses in the course of production activities. In addition, researchers consider the introduction of membrane methods of wastewater treatment to be promising ^(19; 30).

S. Bonetta et al. ⁽⁷⁾ emphasise the fact that even in the case of a perfect wastewater treatment system, including biological treatment, all dissolved inorganic substances and about 10% of organic pollutants remain in the treated wastewater. According to the authors, this indicates the need for a radical reorientation of the water use strategy, with the isolation of the anthropogenic water cycle from the natural one, transition to closed water supply, and introduction of low-waste technologies. It is difficult to disagree with these conclusions. In addition, notably, optimisation of the water use and treatment system in Kyrgyzstan envisages the application of the ecosystem approach and the introduction of integrated water resources management. Such conclusions are in line with the results of studies by many scientists ^(6; 9; 31). The ecosystem approach implies the inseparability of water resources with other components of the river basin (soil, flora and fauna, atmospheric air parameters), and proposes conceptual systemic management of the ecological environment in all interrelationships of its components ^(32; 33).

Integrated water resources management allows effectively solving such strategic tasks as optimisation of water use, improvement of sustainability of aquatic ecological systems, quality monitoring and effective response to situations carrying environmental risks. It is unambiguous that to optimise natural water objects, it is necessary to limit such activities that lead to chemical, radioactive and other dangerous types of pollution of natural water objects and to control the condition of domestic and industrial waste dumps and agricultural enterprises located in adjacent territories.

CONCLUSIONS

Critical environmental situations caused by salinization, pollution and depletion of water resources and soils are typical for most of the territory of the Republic. Their main causes are the increase of quantitative indicators of untreated wastewater discharges into the environment, insufficient level of industrial and domestic waste utilisation, deterioration of agricultural production culture, unsatisfactory conditions of storage and processing of residual pollutants and toxic materials, low environmental and resource-saving culture of the population, lack of effective management mechanisms to regulate environmental safety. In addition, the uneven distribution of natural water resources over the territory of the republic, and the very poor self-purification capacity of water reservoirs contribute to the development of typical water and environmental problems in the river basins of Kyrgyzstan. However, the main reason for the unsatisfactory ecological condition of natural water reservoirs is anthropogenic factors of influence. Crises caused by irrational wastewater discharge are often observed. They are reflected in indicators of public health and sanitary-epidemiological situation.

The research managed to analyse the main aspects of the adverse impact of wastewater on water quality parameters of natural water objects in Kyrgyzstan. Possible consequences for biocoenosis, and landscape system in case of long-term cumulative effect of pollutants impact are considered.

The research allowed confirming that effluents from industry and municipal economy reproduce the maximum load on the environment, first of all, due to the unsatisfactory condition of water treatment systems and low ecological culture in the republic. It was determined that only the joint application of technological, management measures and the introduction of innovative control methods can have a significant impact on minimising the consequences of wastewater discharge into natural water objects of Kyrgyzstan. The information obtained from the research can be used effectively for practical applications.

Unquestioning compliance with the requirements in terms of maximum permissible concentrations of harmful substances in wastewater, bringing the existing regulations to the standards of developed countries, and application of modern innovative technological solutions using the example of a closed cycle of water use will contribute to the optimisation of the state of natural water bodies, along with effective management measures and the introduction of environmental monitoring systems. The possibilities of modelling and forecasting the impact of understudied toxic substances in the composition of wastewater and the determination of optimal preventive solutions require further research.

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