Ecological assessment of wastewater on the environment by the example of Khanty-Mansiysk (KhMAO-Yugra)

E E Zhelonkina1, E G Pafnutova2, A A Andreev3, I D Pafnutova4 and K A Andreev5

1 Candidate of Geographical Sciences, Associate Professor, of the State University of Land Use Planning, Moscow, Russia
2 Head of the Department for Monitoring Educational Activity and Statistics, Master's, of the State University of Land Use Planning, Moscow, Russia
3 Deputy General Director for Operations, LLC "Naftan", Moscow Region, Russia
4 Student of Moscow State University, Faculty of Journalism, Moscow, Russia
5 Head of the department of formation and maintenance of the database Moscow City Property Department, Russia

E-mail: pafnut140576@mail.ru

Abstract. Due to the increase in the population, water consumption increases, and the volume of wastewater increases accordingly. In this regard, an environmental assessment of wastewater, relief, granulometric composition of the city of Khanty-Mansiysk was carried out. Sewerage facilities have been analyzed, technology gaps have been identified. Methods for improving the operation of sewage facilities that will comply with environmental standards in order to remove the negative load on the natural environment are recommended. Water quality is a determining factor in the level of civilization and the manufacturability of production facilities, as well as an indicator of the rational management of territories [1].

1. Introduction
The current problem is the ecological state of the natural environment and, in particular, the preservation of the quality of fresh water resources, as well as issues of its conservation [1-4]. At the initial stages of human development, nature coped with the waste of human life. However, the population of the planet is increasing, the rapid pace of technology is growing and these technologies are far from being environmentally friendly, respectively, the waste products of humankind are increasing and causing irreparable damage to nature. Since wastewater from cities, industrial facilities, oil production complex and other complex industries is discharged into the natural environment, it has long been necessary to thoroughly clean and disinfect wastewater before it is discharged into river networks. This problem is also because the ecology of the environment directly affects the stability of economic processes, the efficiency and durability of production and various economic activities, the prospects for the innovative attractiveness of the development of territories [5-7]. International experience in the use of water resources is strategic in nature. A historical example of resolving the issue of water resources exploitation is the Agreement on the quality of waters in the Great Lakes and joint actions to improve it (USA, Canada - 1972). This document resolved the issues of joint work on the exploitation of water resources and established the minimum standards for the possible discharge
of wastewater [6]. The problem of the spread of pollutants is relevant throughout the world and is especially acute in areas with a high population density and high industrial production, which cannot function without the production (discharges) of wastewater, which is an obligatory part of technological processes [8].

2. Materials and methods

The Khanty-Mansiysk District includes the main waterways Irtysh and Ob. The relief of the territory around the capital of Ugra is flat, clayey, sandy loam soils are poorly drained, which leads to excessive water logging and leads to strong swampiness. The climate is characterized by sharply continental, severe long winters, short summers, transitional seasons are almost invisible, late spring and early autumn frosts. The winter months are characterized by persistent low temperatures, winds, clear and frosty weather. March is a typical winter month with average temperatures below zero or around zero.

The negative ecological consequences of the development of the territory are mainly associated with insufficient knowledge of the landscapes, their features, resistance to various types of anthropogenic impact [9]. The source for making rational management decisions is the creation of a development model with various technologies for influencing natural objects, such a complex characteristic of landscape areas can serve. Landscaped areas should be based on the following principles:

- Be sufficiently homogeneous in natural and ecological terms, i.e., smaller areas (ecosystems) included in them should be characterized by similar indicators of the value of resistance to anthropogenic impacts
- Take into account the nature of the development of the territory; stand out within the boundaries, convenient for the adoption of environmental and economic relations.

The zoning scheme is based on three aspects:

- The first one presents a list of geological and biotic factors in the formation of landscape complexes;
- The second takes into account the structure of the landscape;
- The third one contains an analysis of the unique properties of the landscape used in the land management turnover of territories.

The site allocated for treatment facilities and sludge fields is located one kilometer from the development line of the northern part of the city of Khanty-Mansiysk. The area around this site is forested with dense cedar forest. The relief in this area is hilly with elevation fluctuations from 30 to 37 meters.

3. Results

After the development of the general plan and the construction of structures, as well as their age of research, it became necessary to carry out additional engineering and geological works. Nine additional wells were drilled within the silt maps: 7 by 5 m, 2 by 15 m. The distance between them is about 200 m. The wells were drilled by the percussion-rope method with a diameter of 12 mm., For exploration and 168 mm., For technical ones. Samples of the disturbed structure were taken from exploration wells. The data showed that the filtration properties of soils are weak, the filtration coefficient of sandy loam was 0.72 м / day, and loam 0.3 m / day, loams contain interlayer’s of sand. Construction in such soils can be carried out under the protection of open drainage by pumping out water from the pits. In the area of well 157 there is a connection current route with an aluminum cable covering it crosses the Gryaznukha river channel, which has a canyon-like channel 1 m deep. The section along the routes is represented by alluvial deposits (sandy loam and loam) of the Irtysh. On the floodplain, they are covered with a layer of silty clay up to 3 m thick; in the soil there are frequent
inclusions of plant residues, interlayer’s of water-saturated sand, and silty particles. On the floodplain terrace, groundwater is at a depth of 1.8 to 2.5 m. The consistency of soils is from solid to fluid, depending on the availability of groundwater, when freezing, the soils have highly powdered properties (table 1). In relation to the aluminum sheath of the cable running on this territory, the soils have an average degree of corrosive activity, and sandy loam ones are high, which is explained by their different water permeability.

**Table 1.** Calculation of discharges of pollutants into the floodplain of the river. Irtysh through the emergency collector.

| Indicator                                      | 2016     | 2017     | 2018     | 2019     |
|------------------------------------------------|----------|----------|----------|----------|
| Wastewater volume per year, m³                 | 209000   | 155673   | 210539.5 | 335967.9 |
| Total mass of pollutants, tn                   | 263.714  | 149.647  | 104.182  | 345.974  |
| including:                                     |          |          |          |          |
| Suspended substances, tn                       | 130.312  | 48.365   | 22.289   | 13.819   |
| Dry residue, tn                                | 101.156  | 73.371   | 71.067   | 246.9    |
| BOD, tn                                        | 6.729    | 6.544    | 16.071   | 45.157   |
| Nitrate nitrogen, tn                           | -        | -        | 0.26     | 0.11     |
| Ammonium nitrogen, tn                          | 10.847   | 5.653    | 5.485    | 12.434   |
| Nitrite nitrogen, tn                           | -        | 0.0124   | -        | 0.012    |
| Phosphates, tn                                 | 3.574    | 0.859    | 0.3686   | 1.486    |
| Sulfates, tn                                   | -        | 1.570    | 0.946    | 5.677    |
| Chlorides, tn                                  | 10.366   | 12.894   | 6.5735   | 15.121   |
| Iron, tn                                       | 0.159    | 0.158    | 0.482    | 1.31     |
| SPAV, tn                                       | 0.117    | 0.185    | 0.344    | 0.547    |
| Oil products, tn                               | -        | 0.034    | 0.260    | 0.374    |

The city discharges more than 2 million cubic meters of untreated wastewater annually. Domestic waste water is disposed of at the city dump, which is located within the city. From the designated area for the discharge of sewage trucks, liquid household waste enters the swamp, which acts as a natural accumulator. It is fenced off by a low sandy dam, through a pipe in the dam, sewage from the swamp flows down a ravine into the channel of the river. Gornaya and r. Irtysh, practically washed, the city from the northern part to the southern. On the contaminated territory, cotton grass predominates from herbaceous plants; woody vegetation is marked by a depressed state with subsequent withering away (table 2).

**Table 2.** Content of pollutants in the channel, mg / l.

| Contaminants         | 2011     | 2012     | 2013     | 2014     | 2015     | 2016     | 2017     | 2018     | 2019     | MPC r/h |
|----------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|
| Suspended substances | 288.20   | 4.50     | 41.80    | 5.40     | 0.30     | 39.70    | 57.10    | 49.60    | 97.80    | -       |
| Dissolved oxygen     | 6.96     | 4.32     | 9.44     | 0.96     | 6.24     | 6.48     | 13.00    | 5.76     | 6.88     | 2-4     |
| BOD mg O₂ / l        | 2.96     | 4.56     | 1.76     | 3.09     | 2.40     | 2.81     | 1.76     | 28.24    | 4.56     | -       |
| Iron                 | 0.95     | 1.28     | 0.91     | 1.63     | 2.52     | 2.64     | 3.99     | 3.83     | 2.82     | 0.12    |
| Petroleum products   | 0.22     | 0.26     | 0.07     | 0.58     | 0.22     | -        | 0.13     | 0.22     | 0.58     | 0.05    |
| Phenols              | no       | 0.011    | 0.001    | 0.008    | 0.095    | 0.001    | 0.005    | 0.003    | 0.002    | 0.001   |
| Copper               | 0.262    | 0.141    | 0.374    | 0.083    | 0.171    | 0.045    | 0.119    | 0.182    | 0.036    | 0.001   |
| Lead                 | 0.033    | -        | 0.008    | 0.008    | 0.010    | no       | no       | no       | -        | -       |
| SPAV                 | 0.150    | 0.060    | 0.130    | 0.050    | 0.115    | 0.110    | 0.015    | 0.401    | 0.075    | -       |
Oil products, suspended solids, phenols, iron and copper salts with excess of the MPC for fishery rivers got into the Irtysh River with wastewater from the city's enterprises. Significant excess was recorded for copper - 350 units. MPC (2013). In the Gornaya channel, 95 units were recorded. MPC for phenol (2015) and 40 units. Iron MPC (2017). This amount of pollutants affected the quality of surface waters (table 3).

Table 3. Mass of discharge of pollutants into surface waters.

| Contaminants                  | 2013     | 2014     | 2015     | Change in 2015 compared to 2014 |
|-------------------------------|----------|----------|----------|-------------------------------|
| BOD full, tn                  | 4120     | 3330     | 2940     | -390                          |
| Oil products, tn              | 60       | 50       | 50       | 0                             |
| Weighted islands, tn          | 4470     | 3900     | 3720     | -180                          |
| Dry residue, tn               | 46700    | 42360    | 44870    | +2510                         |
| Sulfates, tn                  | 970      | 1250     | 1380     | +130                          |
| Chlorides, tn                 | 6860     | 7050     | 5120     | -1930                         |
| Phosphorus, tn                | 327.5    | 347.9    | 320.7    | -27.2                         |
| Total nitrogen, tn            | 1982.5   | 1663.0   | 1609.8   | -53.2                         |
| Ammonium nitrogen, tn         | 1189.7   | 856.9    | 739.2    | -117.7                        |
| Phenols, tn                   | 0.19     | 0.26     | 0.07     | -0.19                         |
| Nitrates, tn                  | 765.9    | 872.8    | 952.7    | +79.9                         |
| SPAV, tn                      | 41.9     | 32.5     | 27.4     | -5.1                          |
| Fats, oils, tons              | 4.31     | 0.06     | 7.83     | +7.77                         |
| Iron, tn                      | 52.2     | 59.7     | 55.5     | -4.2                          |
| Copper, tn                    | 22.2     | 0.85     | 0.52     | -0.33                         |
| Nickel, tn                    | -        | -        | 0.08     | +0.08                         |
| Aluminum, tn                  | 0.26     | 1.15     | 1.16     | +0.01                         |
| Nitrite, tn                   | 28.8     | 30.4     | 23.8     | -6.6                          |
| Total pollutants, tn          | 67595.46 | 61805.52 | 61818.76 | 13.08                         |
| Waste water volume, million cubic meters | 134.46 | 134.84 | 139.96 | +5.12 |

At present, the population in the city and the general urbanization of the territory are increasing manifold, respectively, the water consumption increases and the supply of waste water increases [2]. The city has a centralized sewerage system. Waste from residential buildings is collected in centralized collectors and transported to treatment facilities located in the northern part of the city by gravity and pressure pipelines. Nevertheless, most of the wastewater (3 thousand cubic meters / day) is collected in cesspools from where it is taken out by transport means. Waste water from the main pumping station and from the pump station 1 goes to the tanks for biological treatment. For this purpose, various methods of wastewater treatment are being developed, sewage facilities with complete biological treatment are being built. As a result of low concentrations of organic pollutants, the operation of the technological scheme of wastewater treatment in the city of Khanty-Mansiysk using free-floating microorganisms is difficult due to the small increase in activated sludge.

For water disinfection, sodium hypochlorite is used, which is obtained by electrolysis from table salt. Excess sludge is removed at two sludge sites, after which wastewater is discharged into the Khodovaya channel of the Ilevaya river, and then into the Irtysh. In case of violation of the technological regime, during the discharge of highly toxic waters, pollution of the reservoir may occur. Pollution entering the reservoir, depending on the volume and their composition, can have various effects:

- Changes in the physical properties of water, turbidity, specific smell, color;
Floating substances appear on the surface of water bodies (oil products);
Changes in chemical composition, organic matter content, etc.;
The number of biological species changes, the food base of the inhabitants of the ecological system is disrupted;
Polluted water bodies become unsuitable for the use of a drinking regime, and sometimes for technical water supply.

4. Discussion
The regularity of the process of self-cleaning from bacterial contamination has not yet been fully established. Often, in the river below the wastewater outlet, bacterial pollution increases, and then the bacteria begin to die off in the process of self-purification of natural water. In this case, the maximum bacterial contamination can occur significantly below the place of almost complete mixing. In the northern regions, the river needs 1.5-2 km for self-cleaning. During long-term movement of water in a reservoir, bacterial contamination remains significant and the self-cleaning process in winter slows down greatly, therefore, disinfection of wastewater is necessary [10].

The reasons for ineffective wastewater treatment at wastewater treatment plants are varied and the main ones can be distinguished:

- Outdated designs and cleaning technology;
- Poorly executed projects of treatment facilities (inconsistency of the designed facilities with the quality and volume of treated wastewater; errors made in technological calculations;
- Underloaded or overloaded in terms of the content of pollutants in the wastewater treatment plant;
- Destruction of structures and technological equipment
- A significant excess of the volume of industrial pollution in relation to the volume of domestic wastewater
- Unsatisfactory operation of treatment facilities.

5. Conclusion
A combination of the listed reasons for the ineffective operation of treatment facilities is possible, which makes their diagnosis a rather difficult task. The usual practical operation of biological structures requires not only accurate calculations and the performance of numerous hydrochemical analyzes, but also the combined efforts of technologists, hydrobiologists, and hydrochemists to obtain prompt and sufficient information that allows timely action to be taken to ensure a stable and satisfactory quality of treatment, under conditions of a continuously changing composition. Wastewater. This task is of a global nature, since in the long term, this can lead to catastrophic consequences of the accumulation of causal relationships in the environment [3].

References
[1] Bruce J P and Wood K 2012 Canada - Water Quality in the USA One Step Forward, Two Steps Back (Toronto) 16
[2] He Y and Fullerton T M Jr 2020 An economic analysis of estimating instrumental variables in dynamic best-case models for water consumption. Agric Economy 66 413-423
[3] Gessess A T and Heh G 2020 An Analysis of Carbon Dioxide Emissions, Energy Consumption and Economic Growth in China. Agric Economy 66 183-192
[4] Gleik P 2003 Global fresh water resources: soft solutions for the 21st century. Science 302 1524-1528
[5] Kareevo N A 2006 Environmental assessment of the impact of wastewater on the processes of natural biological treatment (Bryansk region Engineering and Technological Academician) 179
[6] Great Lakes 1972 Water Quality Agreement, USA and Canada 04 15
[7] Probirskiy M D, Rublevskaya O N, Lysova T I and Malysheva V V 2012 Experience of development and modernization of the Northern aeration station. *Water supply and sanitary engineering* 3 132

[8] Shozy J, Gabriel I, Woon Chin et al 2015 Sustainable management of biological wastewater sludge: a review of the best technologies for stabilization and reduction of precipitation. *Water supply and sanitary engineering* 6 321

[9] Zhelonkina E E, Boytsenyuk L I, Gruzdev V S, Valiev D S and Pafnutova E G 2019 Territorial monitoring and proposals for establishing a filling station in accordance with environmental standards. IOP Conference Series: Earth and Environmental Science 211 012049

[10] GOST R 58556-2019 Assessment of water quality in water bodies from an environmental point of view Retrieved from: http://docscntdru/document/1200168048