

Water supply of the population as a problem of energy efficiency on the example of the Tyumen region of Russia

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Abstract. The purpose of this article is to draw public attention to the problems of water supply in the city of Tyumen, the capital of the oil region and one of the most important objects in Russia from the point of view of strategic water supply, located in the region with vast freshwater resources. The article outlines main water supply problems related to the quality of drinking water, its chemical composition, and risks of water contamination by industrial effluents, problems of water transport to the consumers, problems of energy efficiency. The issues raised are part of the energy efficiency not only of the Tyumen region, but also of the Sverdlovsk region, from which the waters of the drinking basin are transited, being a sewage channel for many industrial enterprises. The article touches the issues of water protection, conservation and quality of water coming from the Velizhansky water intake, as well as the possibilities of using alternative sources of drinking water. The article analyzes legal measures, and proposals for improving work with increasing the quality of drinking water, combating melt water and pollution with oil.

1. Introduction

The problem of water resources is the most important urgent problem of ecology. Water is the main value in a person's daily life, the source of health, longevity and well-being. Clean water is the most important condition for social stability in the society.

It seems that the problem of the world-class quality fresh water should bypass Russia - a country that has a high water potential, where one resident has more than 30 thousand cubic meters of fresh water. Nevertheless, more than 70% of rivers and lakes and 30% of groundwater have lost their importance as sources of quality water supply. Often the chemical composition of water is not suitable for use even for technical tasks. It is no coincidence that the availability of a safe source of water supply is the most important task of ecology in Russia nowadays. Its solution influences upon life of the population of the country.

The Tyumen region, located in the basins of such rivers as Irtysh, Tobol, Tura, Ishim, is one of the well-watered regions of the Russian Federation per capita. Water resources of rivers in the average water year are estimated at 80 m³, mainly formed due to transit flow. Nevertheless, water supply to the population of Tyumen is also an environmental problem. The growing population of Tyumen, the implementation of investment projects, including the construction of industrial enterprises, an impressive rate of housing construction - all this makes us think about the quantity and quality of drinking water.



The purpose of this article is to consider water supply problems in Tyumen as a part of environmental problem, to identify causes of water pollution, ways to improve water quality, and measures to regulate environmental issues in accordance with the principles of optimizing the national economy.

The main source of water supply in Tyumen is the river Tura. It accounts for about 164 thousand m³, with the daily consumption of the city about 240 thousand m³ i.e. 2/3 of all the water taken off. However, in recent years, the quality of water in the river Tura significantly deteriorated, and in 2012 reached a critical state. Many researchers attribute this to the low water level of the year and low water level in the river. Problems of water quality in the river Tura exist also in the years of high water. According to Rosprirodnadzor for the Tyumen region, "r. Tura has been in a poor condition for about 30 years." This situation deteriorated sharply by 2016, namely, according to data, the supply of benign drinking water in the Tyumen region is almost 87%. For the spring of 2017, water abstraction is carried out from surface (86%) and underground (24%) sources. The Tura River is constantly exposed to pollution by industrial, domestic and storm sewage. The enterprises of the Sverdlovsk region have a particularly negative impact on surface waters, since the main part of the catchment area of the river is located on its territory. In the basin of the Tura River are located 16 cities of the Sverdlovsk region and 45 enterprises of various focus. Their emergency discharges can suddenly worsen the quality of water in the river and, thereby, cause an emergency situation with water supply. The water quality of the Tura River is classified as grade 4 and is assessed as "dirty". Therefore, for the purpose of its use for drinking water supply of the population, it is necessary to use rather complicated expensive water treatment. Environmentalists of Tyumen have repeatedly stated that the city's new buildings in the near future can remain without water. [1, 2, 4, 5]

There are a lot of other problems, for example, contamination of surface water sources, which are used for drinking water supply. According to the environmental pollution index, the Tyumen rivers are classified to the 3rd to 4th grade - from contaminated to dirty. Among the main causes of pollution are inappropriate work of treatment facilities, discharge of storm sewage and sewage of enterprises. Over 76% of the total discharge of contaminated sewage in the south of the Tyumen region is aroused from the enterprises of the Housing and Communal Complex.

Water quality is also affected by the natural background of the rivers of the Tyumen region, which is characterized by a high content of iron, manganese, copper and phenols. In addition, the anthropogenic load on the Tura river annually increases due to the transit of pollutants from the Sverdlovsk region.

The research is based on the data of scientists who carried out an assessment of the ecological status of operating sources in the city of Tyumen: Borzunova E.A., Kuzmin S.V., Akramov R.L., Kiyamova E.L., Grigoryev Yu.I., Lyapina N.V., Lutai T.F., Novikov Yu.V., Isarov S.I., Plitman S.I., Onishchenko G.G., Secunda A.A., Tafeeva E.A., Ivanov A.V., Vavashkin K.V., Tulakin A.V., Sayfutdinov M.M., Gorshkova E.F., Roslovskiy A.P. [1, 3, 6, 7, 8, 9, 10, 11]

In the course of the study, the methods of hydrological and hydrogeological analysis and the comparative-descriptive method were used.

2. Methods

We have revealed that the Rosprirodnadzor Department for the Tyumen Region implements a set of methods for preventing, detecting violations and suppressing violations of environmental legislation in order to improve the environmental situation in the south of the Tyumen region within the framework of federal supervision in the field of protection and use of water bodies.

First, typical violations of the legislation on the use and protection of water bodies were analyzed. For example, violation of the requirements for the protection of water bodies that can lead to their contamination, blockage or depletion (Part 4, Article 8.13 of the Code of Administrative Offenses) - (9 violations in 2015, 9 in 2014); Violation of the rules for the operation of water management or water protection facilities and devices (Article 8.15 of the Code of Administrative Offenses) - (2 violations in 2015, 3 in 2014); Use of the coastal protection zone of the water body, the water protection zone of the water body with violation of economic or other restrictions (Part 1, Article 8.42 of the Code of Administrative Offenses (5 violations in 2015, 3 in 2014).

Second, measures were proposed to identify and prevent the unauthorized use of water bodies and facts of violation of water use regulations. Unauthorized water use is the illegal use of surface water resources for various purposes. In case of unauthorized water use, norms are not established, fees for negative impact on water bodies are not paid, water quantity and quality is not monitored.

The discharge of storm sewage can be made only on the basis of decisions on the provision of water bodies for use, as follows from Art. 11 of the Water code of the Russian Federation. In 2013, there was issued a Demand to the head of the Administration of the city of Tyumen to determine the owners of storm collectors in the city of Tyumen and obtain permits for water outlets in the Tura river balance-holders. This issue was submitted to the standing interdepartmental working group on environmental protection and nature management, established in June 2014 under the Prosecutor's Office of Tyumen.

Third, methods have been established to ensure the legal regime of water protection zones of water bodies. For the years 2015 - 2016, the Department identified and suppressed 24 cases of violation of the use of the coastal protective strip, the water protection zone of the water body with violation of economic and other restrictions. The perpetrators are brought to administrative responsibility.

Fourth, plans for reducing discharges of pollutants, methods for modernizing treatment facilities have been developed. For example, in "Steklotech" Ltd repeated commissioning works were performed, and oil traps were installed, which led to decrease in concentrations of all pollutants.

Fifth, methods are established for monitoring the elimination of emergency situations associated with oil spills. A big role in the solution of this issue plays the activity and consciousness of citizens who address signals about violations of the water legislation of the Russian Federation. For example, the management of JSC "Ob-Irtysh River Shipping Company" issued a demand for immediate measures to localize oil products in the water area. All necessary measures have been taken on the demand.

Sixth, measures have been developed to assist economic agents aimed at rational use of natural resources, achieving high environmental standards, introducing new technologies and devices that reduce harmful impact on the environment.

Seventh, the analysis of the chemical composition of the waters of the Tura River basin was carried out. Scientists have found that according to the chemical composition, the water of the Tura River is hydrocarbonate-calcium water. It is stably polluted all over and belongs to the class "very dirty" [2]. The Tura River receives the main pollution from the territory of the Sverdlovsk region. The water of the river comes in the Tyumen region already with an increased content of petroleum products, phenols, ammonium and nitric nitrogen, iron, copper, etc. As the qualitative analysis shows, the content of oil products in the waters of the Tura River increased until 1992 and amounted to 30 MPC, then began to reduce their concentration, which is observed until 2015. The main source of oil products entering the river is industrial wastewater, as well as thawed snow and rainwater from the territories of settlements located along the river banks.

The process of oil oxidation under aerobic conditions takes 3-5 months, and in case of a lack of oxygen, which is observed in the Tura river, it stretches for 1-3 years. The presence of oil in water even in concentrations slightly exceeding the MPC (0.3 mg / l) for drinking water sources is accompanied by the appearance of a specific odor that does not disappear after filtration and chlorination. The intake of phenols in the waters of the Tura (within the limits of 2-9 MPC) is associated with the enterprises of the wood chemical industry in Turinsk and, Verkhoturys of the Sverdlovsk Region [3]. At the same time, phenols can have a natural origin, being a product of rotting of many kinds of organic substances. Phenols impart a sharp, unpleasant smell and taste to the water. They spend on their oxidation part of oxygen dissolved in water, which affects the sanitary-hygienic state of water. With sewage of metallurgical enterprises of the Sverdlovsk region the Tura river receives lead, tin, cadmium, chromium, nickel, copper, arsenic, zinc. In the upper reaches of the Tura River the excess of zinc is 37 MPC, copper - 26 MPC, nickel - 22 MPC in certain years. Inorganic lead compounds disrupt the metabolism and act as inhibitors of enzymes, which leads to the emergence of acute and chronic diseases. Throughout the study period in the waters of the Tura river there is a constant presence of nitrites, which provoke a person acute gastrointestinal disorders and such a dangerous disease as metagemo-globinemia even with

a slight excess of their permissible dose in drinking water, which disrupts the transport of oxygen in the body.

Eighth, measures have been developed to minimize the consumption of water from unprotected sources, namely, the transition to underground sources of water supply. Within the framework of state programs aimed at providing the population with protected sources of drinking water supply, as well as protecting groundwater from pollution and depletion, additional underground freshwater sources are being searched for and explored, as well as construction of water intakes, repair and reconstruction of treatment facilities, and the removal of disabled wells.

3. Results

The joint activities of scientists, management bodies in the Tyumen region to address the problem of quality water supply led to positive results for some indicators. The statistical data testify to the actual reduction of the negative impact on the environment. An anthropogenic pressure on water bodies is reduced. In terms of river basins, the anthropogenic load was million m³ / year (in brackets there is shown change to the level of 2015): Tura (including the Pyshma river basin) - 323.37 (+ 30.14); - Irtysh (without the basin of the rivers Tobol and Ishim) - 12.59 (- 4.60); Ishim-4.42 (-0.47); Tobol (without Tura River basin) - 4.22 (+ 0.41).

As part of sewage, 20.9 thousand tons of pollutants reached into water bodies, which is 16.4% lower than the level of the previous year. The mass of pollutants entering the water bodies of the Tyumen Region is decreasing. In 2014, 66.3 thousand tons were delivered to water bodies, in 2013 there were 80.9 thousand tons of pollutants.

However, the ecological state of the waters of the Tura river are critical as evidenced by the data of the chemical analysis. The water of the river is not suitable for use even for production and technical needs without preliminary cleaning. The problem is that the purification of river water requires the use of scarce and expensive chemical reagents. Currently, Tyumen Vodokanal Ltd uses aluminum sulfate and aluminum oxychloride (OXA) as main reagents for deep water purification by chemical and biological parameters; Polyacrylamide for clarification, acceleration of flocculation and sedimentation of suspended particles; potassium permanganate for accelerating the processes of oxidation of organic matter; calcined soda to alkalize water; liquid chlorine for disinfection; quartz sand and activated carbon as filter materials.

An important problem of drinking water quality is its secondary pollution (iron enrichment, deterioration of organoleptic properties, etc.) in the worn-out water supply system of Tyumen.

The switch to water supply exclusively from underground sources is seen by many environmentalists as controversial. The problem is that there was observed until recently, technogenic pollution of the underground waters of the Oligocene-Neogene complex (1977-2006) in the operation of the Velizhanskaya group of deposits. At present, anthropogenic pollution of operational waters is practically excluded with the improvement of sanitary and ecological conditions in the water intake area, with the intensification of the zones of sanitary protection. Groundwater, unlike surface water, does not require complex purification. De-ironing of groundwater is carried out by means of aeration and subsequent filtration through quartz sand. Simultaneously with the purification of water from iron, the content of manganese in it is slightly reduced and physical properties such as turbidity; color and oxidability are improved without additional costs for these purposes. Despite the 40-year operation of the water intake, the observed lowering of the levels does not exceed the estimated permissible values, i.e. Depletion of groundwater resources does not occur. This is due to the presence of favorable sources of groundwater supply from overlying aquifers, which determined the steady-state filtration regime. In the last decade, there has been a general increase in the levels of the productive aquifer complex, which indicates an active replenishment of natural reserves. Analysis of the water quality of artesian wells at the Velizhansky water intake showed that this field of underground water has a high degree of sanitary reliability, maintains a stable mineral composition and is not subject to anthropogenic influence. The water of the Metelyevsky and Velizhansky water intakes as sources of water supply was assigned to the 3rd class according to the complex of organoleptic and chemical indicators, in accordance with GOST

2761-84 "Sources of centralized household and drinking water supply. Hygienic, technical requirements and selection rules ".

4. Discussion

Many questions on the solution of the water supply problem in the Tyumen region are controversial and attract constant attention of the public and the management bodies of the national economy.

So, on March 12, 2016, there was held meeting of the commission for environmental safety of the Public Chamber of the Tyumen region. The issue of the quality of urban water supply was discussed. In the discussion on the future of the rivers of the Tyumen and Sverdlovsk regions, more than a dozen specialists (scientists, public figures, representatives of "profile" departments from Tyumen and Yekaterinburg) participated. The round table participants decided that the proposals formulated at the end of the event will be sent to the authorities of the Tyumen and Sverdlovsk regions, as well as to the federal environmental authorities.

The issue of the quality of drinking water remains acute. The deputy head of the department of the Rospotrebnadzor administration in the Tyumen region, Nadezhda Tokareva, presented the actual data according to which the deviation in water by microbiological indicators was found in only 0.7 percent of the samples. And the company "Tyumen Vodokanal" made a statement that the water reserves within the boundaries of the Metelevsk and Velyagersky water intakes, as well as the effective use of this resource, will even reduce water consumption in the regional capital.

A document was developed and adopted on the implementation of methods that reduce water consumption. The document considers the development prospects of the city until 2020. So, it is assumed that the population will grow from 653 to 725 thousand people, while within the existing dynamics, including in connection with the installation of individual meters, it is expected to reduce the rate of water consumption from 207 to 180 liters per day per person. The Commission for Environmental Safety recommended conducting a scientific assessment of the current ecological state of the Tura, as well as the sanitation of its basin. This means inspecting and cleaning the river and its tributaries, identifying industries that allow the discharge of untreated sewage and forcing them to build new or upgrade obsolete inefficient wastewater treatment plants.

At the regional level, the program for the water management complex of the Tyumen Region was approved by the Department of Subsoil Use and Ecology of the Tyumen Region. A special project for the environmental rehabilitation of the Tura within the city boundaries will be developed as a part of the implementation of this document, on behalf of the governor.

The researcher Alla Zagorskaya reported on the negative consequences of storm and snowmelt sewage at a scientific seminar on environmental problems. According to her, thawed and rainwater gathering on the territory of settlements and industrial enterprises is one of the most intensive sources of pollution by various impurities of natural and technogenic origin.

In the year in the territory of Tyumen there are formed from 11,233 to 44,932 million cubic meters of surface sewage. Contamination of surface runoff depends on the degree of landscaping, relief and amount of precipitation. According to the data received, the pollution concentrations in the surface runoff for the Tura River are exceeded by chemical consumption of oxygen (by 42.96 times), by biological oxygen consumption (by 30.05 times), by petroleum products (by 95.4 times), by phenols (by 5720 times), by compounds of nitrogen (by 2.86 times).

Anthropogenic pressure on the water bodies of the city of Tyumen increases annually due to the transit of sewage from other regions. Background concentrations of contamination differ from hygiene standards. Even taking into account mixing of surface sewage and river water, the background concentrations of pollution increase tens of times during the period of intensive precipitation.

This problem is also very controversial, since the Russian Federation's water legislation prohibits the discharge of untreated rain and melted water into water bodies, in practice, the surface runoff causes considerable damage to the Tura River and, as a result, affects the water supply systems of the city of Tyumen.

Tyumen scientists suggest the introduction of an integrated approach that provides effective

measures for water treatment, sanitary cleaning of territories, development of road infrastructure, landscaping of Tyumen regions. Among the activities there are named the use of modern technologies for snow removal, which will reduce the accumulation of pollutants in the winter and reduce the pressure on water reservoirs during intensive melting.

Participants in the discussion, members of the Institute of Geoinformation Systems Alexei Babushkin and Viktor Gennadinik proposed issuing environmental passports as a new tool for comprehensive environmental analysis of water bodies. Ecopassport is a geoportal that provides up-to-date environmental information with a set of web applications. This is a unique model of the territory, designed to assess the state of the environment, the impacts on it from hazardous sources, to identify priority tasks and develop territorial environmental policies. Ecopassport allows you to analyze the causes of pollution using search mechanisms or visually identify waste disposal sites potentially hazardous to water bodies, contaminated sites and other dangerous sources. Depending on the type of dangerous source, its characteristics are displayed. The analysis can be detailed by data on various social and natural objects associated with watercourses: populated areas, specially protected areas, fishing areas, habitats of rare species of animals and plants.

Another controversial issue is the catastrophic deterioration of water in the river, related to the man-caused factor: almost 90% of sewage is discharged to the Tura without any treatment.

The problem of reducing the level of drinking water, water supply in general, according to the participants in the discussion, can also be solved by the method of transfer to underground water supply.

5. Conclusions

1. Thus, the results of the assessment of drinking water quality have confirmed the relevance of providing the population of Tyumen with qualified water, since a significant number of residents use water that does not meet the drinking water quality in many aspects.
2. The main problem associated with the use of river water for household and drinking water supply is a high degree of contamination. Centralized drinking water supply is accompanied by a change in the qualitative composition of water due to a violation of the regime and operating conditions of water pipes, resulting in secondary water pollution in breeding networks [9]. It is necessary to note the low efficiency of water treatment, which determines the preservation in the drinking water of specific components characteristic of surface and underground water sources, and transport through the distribution network causes significant secondary pollution.
3. It is shown that the use of underground waters of the Velizhansky water intake as the main source of water supply in Tyumen is most expedient, since they are characterized by a consistency of chemical composition and high sanitary reliability, and elevated concentrations of iron and manganese are not an obstacle to their use. The main advantage of groundwater is its high natural protection against pollution due to the fact that it is blocked by waterproof rocks. In order to conserve the groundwater resources of the Velizhansky water intake for a long period of operation, it is necessary to continue the implementation of a complex of nature conservation measures, both general and special.
4. It should be noted that the results obtained in this paper can serve as a basis for developing more effective water treatment schemes at the city's water intakes. Solving the problem of water supply in the territory of Tyumen, namely, increasing the quality of drinking water supplied to the population, reducing the magnitude of the risk and raising the level of public health will further improve the set of preventive measures and priority management decisions aimed at optimizing the environmental situation in the Tyumen region.

References

- [1] Borzunova Ye A, Kuzmin S V, Akramov R L and Kiyamova Ye.L 2007 *Gigiena i sanitaria* **3** pp 32-34
- [2] Grigoriev Yu.I and Lyapina N V 2013 *Gigiena i sanitaria* **3** pp 36-38

- [3] Kopytova A V 2017 *Matec Web of Conferences* **106** 08056
- [4] Lutay T F 1992 *Gigiena i sanitaria* **1** pp 13-15
- [5] Novikov Yu V, Isarov S I and Plitman S I 1980 *Gigiena i sanitaria* **8** pp 69-70
- [6] Onishchenko G G 2009 *Gigiena i sanitaria* **2** pp 4-13
- [7] Onishchenko G G 2010 *Gigiena i sanitaria* **3** pp 4-7
- [8] Tafeeva E A, Ivanov A V and Vavashkin K V 2013 *Gigiena i sanitaria* **3** pp 30-32
- [9] Tulakin A V, Saifutdinov M M, Gorshkova Ye F and Roslovsky A P 2007 *Gigiena i sanitaria* **1** pp 27-30
- [10] Zotkina N, Bardasov S, Gusarova M and Kopytova A 2017 *Matec Web of Conferences* **106** 08050
- [11] Zotkina N, Kopytova A, Zenkina M and Zhigunjva O 2017 *Matec Web of Conferences* **106** 08058