Analyzing Water Conservation Indicators in Russia

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Abstract. The authors collected and analyzed statistical indicators of the use and pollution of water resources in Russia for the time period 2009-2019. The authors studied the dynamics of statistical data on water withdrawal from natural water reservoirs for practical use, as well as on discharge of polluted sewage, and also differentiated the data obtained by the main types of economic activity (industries). Some conclusions are made on the effectiveness of the implementation of measures for the protection of water resources for each type of activity. The article highlights the industries using water resources most efficiently over the past 10 years and systematically implementing measures to reduce the discharge of polluted wastewater into surface water bodies. The study shows in which industries the efficiency of water purification and water use activities has decreased for the same period. The results of the analysis can be used to optimize and manage measures for the use and conservation of water resources for certain types of economic activities.

1. Introduction
Conservation of water resources is one of the most pressing environmental problems in the modern world. Russia is the largest country in the world, which is also one of the richest in water. Nevertheless, the protection of the aquatic environment belongs to a number of priority state issues in the development of the water management complex [1]. In general, the area of the country occupied by water is over 72 million hectares, which is approximately 88.9 thousand km³ of fresh water [2]. Despite such significant reserves, in accordance with the state program, Russia seeks to preserve and restore water bodies to a state that provides environmentally friendly living conditions for the population, as well as halve the discharge of polluted sewage for the period from 2012 to 2020 [1]. To achieve these goals, the Federal Agency for Water Resources of Russia regularly monitors the state of the water environment. Such monitoring is one of the important tools for planning and implementing environmental protection measures.

2. Materials and Methods
The importance of statistical assessment and analysis of monitoring results in the field of environmental safety is justified by a fairly large number of scientific studies [3-6, etc.]. Currently, in Russia, the main environmental indicators for assessing the state of the aquatic environment are the following:

- water withdrawal from natural water reservoirs for practical use, mln.cu. m;
- discharge of polluted sewage, mln.cu. m

The indicator of water withdrawal from natural water reservoirs shows the characteristics of the withdrawal of water resources from natural sources for further use.
Discharge of polluted sewage (industrial and municipal) is one of the important components of the total volume of wastewater discharged into surface water bodies, which also includes normatively clean and normatively treated wastewater.

These indicators, differentiated in the context of individual types of economic activity, allow us to assess the effectiveness of environmental protection measures for the main sectors of the Russian economy.

The authors collected and analyzed the required statistical indicators for the period 2009-2019 based on data from the Federal Agency for Water Resources, in order to assess the dynamics of water pollution by enterprises and organizations of various types of economic activity [2, 7, 8]. It should be noted that due to the transition of the statistical observation system to a new version of the All-Russian Classifier for Economic Activities (OKVED-2), there are differences between 2017-2019 and previous years in terms of the names and characteristics of the studied industries. In this regard, the dynamics of the studied indicators of water resources cannot be absolutely comparable with the previous data, but, nevertheless, it can show the directions of the main trend in water withdrawal and discharge of polluted sewage.

### Table 1. Volume of water withdrawal from natural water reservoirs by type of economic activity (mln. cu. m) [2, 7, 8].

|          | 2009      | 2010      | 2011      | 2012      | 2013      | 2014      | 2015      | 2016      | 2017      | 2018      | 2019      |
|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Agriculture, hunting and forestry (since 2017 - agriculture, forestry, hunting, fishing and fish farming) | 18184.2    | 17262.7   | 16995.1   | 16920.7   | 16898.6   | 16833.78  | 15811.58  | 16289.9   | 19798.93  | 18632.44  | 19482.3   |
| Mining   | 2596.29   | 2810.87   | 2927.6    | 3034.5    | 3056.26   | 4000.13   | 4422.8    | 5084.42   | 6663.34   | 5207.96   | 5214.7    |
| Manufacturing industries | 5333.77   | 5648.72   | 5245.5    | 5068.8    | 4576.4    | 4392.12   | 4181.11   | 4240.55   | 3880.89   | 4 053.93  | 4054.5    |
| Production and distribution of electricity, gas and water (since 2017 - provision of electricity, gas and steam, air conditioning) | 41252.68  | 46336.93  | 43244.7   | 40994.7   | 39482.36  | 39383.28  | 38552.37  | 37734.92  | 22162.88  | 24090.54  | 23442.4   |
| Transport and communications (since 2017 - transportation and storage) | 1483.97   | 1483.97   | 3509.75   | 3718.5    | 3408.3    | 3156.67   | 2862.86   | 2914.18   | 3594.3    | 3089.2    | -         |

The presented data show that the largest volumes of water withdrawal are typical for the activity "Production and distribution of electricity, gas and water", and the smallest ones for “Transport and communications”.

Table 2 presents data on the main indicators of polluted wastewater discharges by certain types of economic activities for the period 2009-2018. We didn’t evaluate this indicator for 2019 due to the lack of data in open sources at the time of writing. Therefore, further comparative analysis of data will also be carried out for the period 2009-2018. The values presented in Table 2 show that "Production and distribution of electricity, gas and water" is also in first place in terms of the volume of polluted effluents, and in the last one - "Transport and communications".
Table 2. Volume of discharge of polluted sewage into surface water bodies by type of economic activity (mln. cu. m) [2, 7].

| Year | Agriculture, hunting and forestry (since 2017 - agriculture, forestry, hunting, fishing and fish farming) | Mining | Manufacturing industries | Production and distribution of electricity, gas and water (since 2017 - provision of electricity, gas and steam, air conditioning) | Transport and communications (since 2017 - transportation and storage) |
|------|------------------------------------------------------------------------------------------------------|--------|--------------------------|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| 2009 | 875.91                                                                                               | 1016.59| 2732.8                   | 8817.23                                                                                                           | 41.18                                                        |
| 2010 | 842.10                                                                                               | 911.4  | 3055.88                  | 9204.8                                                                                                             | 45                                                           |
| 2011 | 891.6                                                                                                 | 928.9  | 3077.7                   | 8730.9                                                                                                             | 35.6                                                         |
| 2012 | 853.2                                                                                                 | 933.8  | 2818.1                   | 8407.5                                                                                                             | 32.9                                                         |
| 2013 | 819.4                                                                                                 | 847.8  | 2710.45                  | 8306.45                                                                                                            | 30.8                                                         |
| 2014 | 7829.8                                                                                               | 813.23 | 2522.9                   | 8030.09                                                                                                            | 30.46                                                        |
| 2015 | 771.89                                                                                               | 839.11 | 2540.91                  | 8253.75                                                                                                            | 30.76                                                        |
| 2016 | 816.84                                                                                               | 801.31 | 2634.75                  | 970.06                                                                                                             | 34.12                                                        |
| 2017 | 984.9                                                                                                 | 831.72 | 2308.44                  | 883.1                                                                                                              | 85.12                                                        |
| 2018 | 748.79                                                                                               | 784.05 | 7257.5                   |                                                                                                                    | 34.72                                                        |

We have compiled diagrams for each industry for a visual assessment and comparison of the dynamics of indicators of water withdrawal and discharge for the period 2009-2018. (figure 1-5).

Figure 1. Annual dynamics of water withdrawal from natural water reservoirs (a) and discharge of polluted sewage to surface water bodies (b) by the type of activity "Agriculture, hunting and forestry", mln. cu. m.

Analysis of the data on "Agriculture, hunting and forestry" (figure 1) shows that during the period under study in this industry there is a general tendency to maintain almost constant volumes of water withdrawal and discharge. Their average value is 17362.79 m³ and 838.76 m³, respectively. Increase in water withdrawal values in 2017-2018 is most likely connected with additional accounting in these years of the volume of water withdrawal for fisheries. However, it should be noted that there was no increase in the discharge of polluted sewage. This indicates that in recent years there has been a relative improvement in the efficiency of water protection measures in this industry.
Figure 2. Annual dynamics of water withdrawal from natural water reservoirs (a) and discharge of polluted sewage to surface water bodies (b) by the type of activity “Mining”, mln. cu. m.

The results of the analysis of the “Mining” data (figure 2) show that over the past 10 years in this industry there has been an annual relatively uniform increase in the volume of water intake, and in general, from 2009 to 2017, the water withdrawal increased by 2.57 times. At the same time, we can talk about a systematic improvement in the quality of water treatment in the industry for an almost unchanged amount of polluted sewage - on average about 870.79 m³

Figure 3. Annual dynamics of water withdrawal from natural water reservoirs (a) and discharge of polluted sewage to surface water bodies (b) by the type of activity “Manufacturing industries”, mln. cu. m.

A relatively regular decrease in the volume of water withdrawal from 5333.77 to 4054.5 m³ is typical for the “Manufacturing industries” sector (figure 3) for 2009-2018. At the same time, the volume of wastewater decreased from 2732.8 to 2257.5 m³. This fact most likely speaks of a slight decrease in production in the industry than any changes in environmental protection measures.
The annual dynamics of the amount of water and wastewater intake in “Production and distribution of electricity, gas and water” (figure 4) shows that for the period 2010-2016 in this industry there is a general tendency towards some decrease in the volume of water withdrawal. This is most likely due to a decrease in the production capacity of the industry. The amount of discharge of polluted sewage remains virtually unchanged in the period 2009-2016 and averages 8566.23 m$^3$. For the period 2017-2018 the dynamics of the assessed indicators has changed significantly due to the change in the type of economic activity.

In the “Transport and communications” industry (figure 5), there is an uneven change in the volume of water withdrawal over a ten-year period, both upward and downward. At the same time, the level of the discharge of polluted sewage practically does not change. These values do not allow us to
unambiguously assess changes in the quality of water treatment in this sector of the economy over the period under study.

Next, we additionally analyzed the data in tables 1, 2 and built a diagram of the annual change in the share of polluted wastewater discharge from the amount of water withdrawal for practical use (figure 6). The results of this analysis show that the smallest share of discharges is typical for the “Transport and Communications” industry, and the maximum - for the “Manufacturing” industry. The nature of the annual change in the share of discharges for the "Manufacturing" industry as a whole is uneven, which does not allow an unambiguous assessment of the efficiency of water treatment in this industry. Most likely such fluctuations are associated with the annual change in production volumes. An almost constant share of discharge is typical for the following types of economic activities: "Production and distribution of electricity, gas and water", "Agriculture, hunting and forestry", "Transport and communications". This proves that there has not been any significant improvement in the quality of water treatment in these industries. The exception here is a significant decrease in the estimated share of discharge in the "Electricity, gas and steam supply, air conditioning" industry in 2017-2018 due to a change in the type of activity. Then we analyzed the diagram for the “Mining” activity and came to the following conclusion: in this industry in 2009-2018 there was a significant improvement in the efficiency of water treatment activities; and this fact led to a significant decrease in the share of polluted wastewater discharge from 39.16% to 15.05%.

**Figure 6.** Annual share of discharge of polluted sewage from the volume of water withdrawal by type of economic activity (%): a - agriculture, hunting and forestry; b - mining; c - manufacturing industries; d - production and distribution of electricity, gas and water; e - transport and communications.
4. Conclusions

Based on the results of the study, we can draw the following generalizing conclusions on the effectiveness of water treatment measures in 2009-2018 for certain types of economic activity:

1. “Production and distribution of electricity, gas and water” takes the first place in terms of the volume of polluted wastewater discharge.
2. The minimum discharge of polluted sewage into surface water bodies is carried out in the “Transport and communications” industry.
3. The analysis of statistical data did not show any significant improvement in the quality of water treatment in the following sectors of the economy: “Production and distribution of electricity, gas and water”, “Agriculture, hunting and forestry”, “Transport and communications”.
4. The analysis results on the “Mining” industries allow us to conclude that there has been a significant improvement in the efficiency of water treatment activities.
5. It is essential to continue monitoring the indicators of the state of water resources for a more accurate assessment of environmental protection activities in the analyzed sectors of the economy.

Thus, the carried-out analysis makes it possible to assess the impact of separate sectors of the Russian economy on the aquatic environment. The results of the study indicate the most problematic sectors for further analysis of the water protection measures carried out in them. In addition, the results of the analysis can be used to optimize and manage measures for the use and protection of water resources for certain types of economic activities.

References
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