The study of indicators for environmental protection in Russia during the extraction of natural resources

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Abstract. The article analyzes the statistical data of environmental pollution resulting from the activity of extracting natural resources in Russia in the period of 2009-2018. The present study of the dynamics in statistical data is resulting in conclusions concerning the effectiveness of measures implemented for the protection of atmospheric air, water sources and soil. Statistics for the period under study showed the decrease in the effectiveness of measures practiced in the industry to protect atmospheric air and to utilize (neutralize) production and consumption wastes. The same period revealed that the quality of wastewater treatment in the industry under study improved. The results of the present analysis can be used for developing the strategy for the planned management of measures to protect the environment during natural resources extraction.

1. Introduction
The problems of environmental protection and the rational use of natural resources are relevant for many countries of the modern world. It’s common knowledge that the environment is understood as a complex set of such important components as atmosphere, hydrosphere and lithosphere, which are fundamental for maintaining a comfortable and safe environment for the life and activity of every human being.

Facilitated by fast technological progress, economic activity of people often leads to significant changes in ecosystems. In accordance with that, there is a constant growing necessity to monitor the state of environmental components on the regular basis to provide the necessary level of environmental safety, to use natural resources in the most effective way, and to limit harmful pollution.

Several scientific studies [1-5 et al.] emphasize the importance of assessing and analyzing the data obtained by monitoring in the area of environmental safety, which gives an opportunity to identify the most complex and problematic branches of economy, as well as to reveal the level of their anthropogenic impact on certain components of the environment.

Russian and international practical experience shows that both resource-producing sector of the economy and the industry responsible for the extraction of natural resources are substantial contributors to environmental pollution [1, 5-7]. For example, in 2014, 28.2% of the total amount of in the EU waste resulted from extracting natural resources, while in 2016, it was 25.3%. Greenhouse gas emissions, which resulted from this type of economic activity in 2015, amounted to 79 518 thousand tons (CO₂ equivalent) [7].
In order to assess the dynamics of environmental pollution caused by extracting natural resources in Russia, the research presented in this article collected and analyzed the necessary statistical indicators for the period 2009-2018. In Russia, there is a complex system of statistical indicators, which are used for analyzing the state of environmental protection; the system provides assessment for several anthropogenic factors affecting the state of the environment as a whole and, in particular, each of its components: atmosphere, hydrosphere, and lithosphere. The most important indicators of this kind are emissions of pollutants into the air, discharge of polluted wastewater into surface water sources, as well as the level of wastes generated in production and consumption, besides, there are some other ones.

2. Analysis and research results
Table 1 provides the data on the main indicators for atmospheric air pollution caused by stationary sources resulting from the extraction of natural resources during the period 2009-2018; the table is based on the reports of the Federal State Statistic Service of the Russian Federation. Below, a stationary source is understood as the source of emission located by using the Russian State Geodetic Coordinate System.

Table 1. Dynamics of indicators for atmospheric air pollution caused by stationary sources in extracting natural resources over the period 2009-2018 (thousand tons)\(^a,b\).

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|------|------|------|------|------|------|------|------|------|------|------|
| Emissions of pollutants into the atmospheric air | 5238.6 | 5200.3 | 5616.0 | 6128.4 | 5265.9 | 4943.8 | 4754.0 | 4911.9 | 4918.9 | 4851.4 |
| The volume of captured and neutralized atmospheric air pollutants | 2825.1 | 3572.9 | 4199.0 | 3612.2 | 3002.2 | 3387.8 | 3203.7 | 3167.5 | 2640.8 | 1934.4 |
| The total amount of atmospheric air pollutants emitted by stationary sources | 8063.7 | 8773.2 | 9815.0 | 9740.6 | 8268.1 | 8331.6 | 7957.7 | 8079.4 | 7559.7 | 6785.8 |

\(^a\) Environmental protection in Russia: Statistical publications of the Federal State Statistic Service of the Russian Federation (https://gks.ru/folder/210/document/13209)

\(^b\) Key environmental indicators: Information and analytical materials of the Federal State Statistic Service of the Russian Federation (https://gks.ru/compendium/document/13294)

The analysis of the data presented in table 1 show that during the period under study, the highest indicators for emissions into atmosphere were in 2012, while the lowest ones were in 2015. Nevertheless, it is possible to state that since 2012, there is an evidence of the general trend towards the decrease in the volume of polluting emissions. Table 1 also proves that the largest amount of captured and neutralized air pollutants is registered in 2011, while the smallest amount is revealed in 2018. Along with that, due to the decrease in the total volume of generated pollution after 2011, the volume of captured and neutralized substances decreases correspondingly.

It is important to mention that at present in Russia, statistical records of emissions present the total amount of atmospheric air pollutants emitted by stationary sources as the sum of emissions and the amount of captured and neutralized pollutants. The data of table 1 is the basis for creating the
following diagram of annual change of the share of captured and neutralized pollutants and emissions in the total amount of atmospheric air pollutants (as a percentage) over the 10 years considered in the present analysis (figure 1).

![Diagram showing annual change of the share of captured and neutralized pollutants and emissions in the total amount of atmospheric air pollutants](image)

**Figure 1.** Annual dynamics of the share of captured and neutralized pollutants (a) and emissions (b) in the total amount of air pollutants emitted by stationary sources during the extraction of natural resources (as a percentage).

The results of the diagram analysis (figure 1) show that the situation in the area of atmospheric air protection in the industry is getting worse after 2014. This conclusion is based on the observation of the decrease in the total amount of pollutants emitted by stationary sources, which is accompanied by the increase in the portion of captured pollutants backed by the growth of emissions into the atmosphere.

Table 2 presents statistical data of indicators for the state of water resources, which are used for extracting natural resources; the data provides the basis for comparing the annual volumes of the processed water from natural sources and the discharge of contaminated wastewater to surface water sources.

**Table 2.** The dynamics of indicators for polluting water resources during mineral extraction over the period 2009-2018 (million m$^3$)

| Year   | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Water abstraction from natural sources used in the industry | 1336.6 | 1581.7 | 1753.4 | 1836.5 | 1823.0 | 2767.3 | 3176.1 | 3766.2 | 3794.7 | 5208.0 |
| Discharge of contaminated wastewater to surface water sources | 1016.6 | 911.4 | 928.9 | 933.8 | 847.8 | 813.2 | 839.1 | 801.3 | 832.2 | 784.1 |

*a* Environmental protection in Russia: Statistical publications of the Federal State Statistic Service of the Russian Federation (https://gks.ru/folder/210/document/13209)

*b* Key environmental indicators: Information and analytical materials of the Federal State Statistic Service of the Russian Federation (https://gks.ru/compendium/document/13294)
The analysis of the data from table 2 data shows that the level of water abstraction from natural sources used in the resource extraction industry in 2018 is 3.9 times higher than the same indicator for 2009, which is most probably connected with constant increase in production volumes. On the other hand, the significant increase in the volume of water abstraction during the period under analysis is accompanied by the planned decrease in the volume of contaminated wastewater discharged into water sources, which may evidence an improvement in the quality of water treatment in the industry.

In the Russian Federation, wastes are disposed and neutralized to reduce their negative impact on human health and the environment. In the process of recycling, wastes are used for producing goods, performing work, and providing services; to be more exact, it can include the following:

- the reuse of the wastes according to their function (recycling);
- the return of the wastes back to the production cycle after appropriate treatment (regeneration);
- extraction of valuable components for reuse (recovery);
- the reuse of wastes as a renewable energy source (energy utilization).

Neutralization of wastes presupposes the reduction of their mass, the transformation of their composition, physical or chemical properties, and (or) decontamination with the use of specialized facilities.

Table 3 shows the comparison of the amounts of generated and utilized (neutralized) industrial and consumer wastes formed during the extraction of natural resources over the period 2009-2018.

**Table 3. Dynamics in formation, reuse, and utilization (neutralization) of production and consumption wastes formed as a result of the extracting natural resources over the period 2009-2018 (million tons)**\(^a\,b^.

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|------|------|------|------|------|------|------|------|------|------|------|
| Waste formation | 3066.5 | 3334.6 | 3818.7 | 4629.3 | 4701.2 | 4807.3 | 4653.0 | 4723.8 | 5786.2 | 6850.5 |
| Reuse (recycling) and neutralization of wastes | 1469.4 | 1562.2 | 1800.1 | 2125.9 | 1753.1 | 2165.7 | 2473.3 | 2885.6 | 3021.8 | 3585.2 |

\(^a\) Environmental protection in Russia: Statistical publications of the Federal State Statistic Service of the Russian Federation (https://gks.ru/folder/210/document/13209)

\(^b\) Key environmental indicators: Information and analytical materials of the Federal State Statistic Service of the Russian Federation (https://gks.ru/compendium/document/13294)

The analysis of table 3 is the basis for creating the diagram of the annual change in the share of the treated wastes in the total amount (as a percentage) for the period under study (figure 2).

The assessment of the data obtained (table 3, figure 2) shows that the volume of waste generated during the extraction of natural resources in 2018 is 2.23 times bigger than the same indicator for 2009 by, which can be connected with constant increase in production volumes, a similar trend was observed in the increased level of water abstraction. On the other hand, with the significant increase in the volume of waste generation during the period under the present study, there is a decrease in the share of its utilization (neutralization) after 2014, which evidences the decrease in the efficiency of processing these wastes.
3. Conclusion

The results of the present study lead to the following conclusions on the state of measures for environmental protection implemented for extraction natural resources over the period 2009-2018:

1. The situation in the area of atmospheric air protection in the industry is getting worse after 2014, since with a decrease in the total amount of pollutants emitted by stationary sources, the share of captured pollutants decreases along with the increase in the share of emissions into the atmosphere.
2. There is a planned decrease in the volume of polluted wastewater discharge to surface water sources accompanied by the significant increase in the volume of water abstraction from natural sources. These facts evidence the improvement of the quality of water treatment in the industry during the period studied for the present analysis.
3. With a significant increase in the volume of waste generation, the share of their utilization (neutralization) decreases after 2014; this, accordingly, shows the decrease in the efficiency of measures for waste procession.

The presented conclusions show the insufficient effectiveness of measures in the field of air protection and waste processing in Russia in comparison with international data. For example, in Poland about 98% of all mining waste generated annually is utilized [8]. Overall, comparative data shows that over 90% of the waste generated in the EU is neutralized and utilized [7, 8]. Also in recent years, European countries have been regularly reducing their emissions into the atmosphere. The 2020 goal is to reduce emissions by 20 per cent from 1990 level [7, 9].

Thus, the present analysis results in assessing the impact of natural resource extraction in recent years on the indicators for pollution of such environmental components as atmosphere, hydrosphere, and lithosphere. The findings can serve as a basis for developing the industry strategy to improve the effectiveness of measures implemented for environmental protection. Besides, the results indicate the most problematic aspects of environmental protection in terms of further supplementary analysis of the economic efficiency of their implementation.

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