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Comparative Analysis: Resource Consumption and Environmental Pollution by Subsoil Users in Northern Asia (Russia)

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Abstract: This article examines resource use issues and the anthropogenic impact on the environment of companies operating in the mineral resource sector of northern Asian regions. The research aims to comprehensively analyze resource consumption and environmental intensity indicators for leading companies in mineral extraction. A set of indicators reflecting the necessary parameters for mineral resource consumption and pollution intensity due to their production activities is constructed based on quantitative and cost indicators. A pollution intensity assessment is carried out based on environmental intensity indicators. The sectoral and corporate-level indicators are of the most interest in industrial production. The study identified seven critical northern Asian companies that play a decisive role in the mining industry, which were examples for analyzing material resource consumption and production greening pace. Reducing resource use and environmental impact is a crucial task for sustainable development. This study emphasizes the importance of evaluating resource consumption and environmental impact for companies in the mineral resource sector, providing valuable insights for companies, government bodies, and international organizations working towards the region's sustainable development and efficient resource management.

Keywords: mineral and raw materials sector; resource consumption assessment; environmental impact assessment

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1. Introduction

Over the past decades, the global share of mineral resources (metallic, non-metallic, and energy) has sharply increased, averaging about 50% of total material extraction [1]. Economic development is closely related to resource (energy) consumption; the more resources (energy) consumed, the higher the economic development [2] and economic growth [3]. The leading sector of the Russian economy is the mineral resource sector, contributing 12.8% in GDP structure in 2021 [4], creating jobs and ensuring economic stability in northern Asia [5]. Meanwhile, the mining industry affects various environmental aspects, including land subsidence, building damage, water pollution [6], ecological disruption, and pollution caused by coal gangue [7]. As mineral resource demand grows, the volumes of mineral extraction increase, resulting in severe environmental damage [8], such as groundwater and heavy metal pollution, that is challenging to eliminate once they occur. The pursuit of improving human prosperity and well-being has led to significant environmental degradation and the depletion of natural resources. Projected resource extraction will nearly double by 2050, posing severe risks to the Earth's capacity to sustain human life and development [9]. According to forecasts by the Organization for Economic Cooperation and Development

(OECD), by 2060, the material-intensive sectors of the economy will significantly increase: industry by 3.2 times, construction by 2.6, and agriculture by 1.8 [10]. By 2060, global material resource use will more than double. Particularly significant may be the increase in the consumption of metals and non-metallic minerals by 2.5 and 2.3 times, respectively. Consequently, resource deficits in the economy and the impact on the environment, pollution, and waste volumes may grow [11]. It is evident that the large-scale impact on natural complexes during deposit development significantly affects the state of the environment. This prompts the need for sustainable practices and mitigation measures to address these environmental challenges [12], such as the use of renewable energy [13], efficient water management practices [14], investment in research, and innovation [15]. As resource consumption and environmental pollution are closely interconnected and mutually reinforcing, reducing resource consumption and reaching resource efficiency is one of the critical tasks in the transition to sustainable development [16,17]. Indicators of mineral production and consumption characterize modern trends in material flow. Resource consumption indicators in extractive industries are evaluated as indicators of economic efficiency and serve as the basis for managerial decision-making [18]. Assessing the level of resource consumption, especially in the extractive industries, is a relevant problem, as the increasing resource demand trend is expected to persist with ongoing technological development. The efficient use of natural resources and minimization of environmental pollution have become major concerns for the subsoil use sector, particularly in the mining industry. A comprehensive assessment and analysis of material resource consumption and environmental impact are critical in reducing adverse environmental effects. An analysis of the existing studies on the subject [16–21] reveals the need for a more in-depth examination of the comprehensive assessment and analysis of resource consumption and environmental pollution in the subsoil use sector due to the lack of consideration of the complex mix of economics, investment, and innovation in the mining sector, mainly focusing on energy efficiency from an environmental point of view. Mining's impact on ecosystems varies based on factors such as the type of ore, production scale, and output duration [22]. Despite this, there needs to be more effective environmental regulations and monitoring due to technological gaps and a dearth of development in sustainable mining practices [23]. Russia's pursuit of environmentally friendly mining remains nascent [24,25] due to the absence of sustainability principles such as social equity, resource and energy efficiency, integrated decision-making, low carbon emissions, and maintaining economic growth [26]. Various conceptual and methodological approaches have been used to study mining's environmental impacts [27,28]. Multiple studies [16–21,29–31] offer indicators reflecting resource consumption in industrial production, emphasizing the necessity of a multifaceted approach for evaluation. The indicators of resource intensity have been mainly considered and analyzed in energy production, the fuel and energy complex, and the formation of a resource-efficient model for the mining industry company. The International Energy Agency (IEA) report has developed energy efficiency indicators. For example, energy intensity by industry based on value-added or physical production volumes measure the amount of energy required to produce one economic or physical output unit. Energy consumption per unit of production is a preferred indicator [32–36]. The overall resource intensity of a country's economy hinges on an industrial production scale, driving substance and energy extraction. Industrial resource intensity, indicating resources used per unit of final product, gauges production efficiency. Environmental intensity reflects eco-economic interactions, highlighting natural capital use. Environmental intensity reduction is critical to shifting towards sustainable development and lessening resource consumption and pollution [20]. A move to sustainable development entails upgrading production with resource-saving technologies, aiding in assessing economies, and making informed decisions. A number of studies [37–39] thoroughly characterize the mineral resource base of the Russian Far East, providing feasible proposals for improving the management system in subsoil use, examining the functioning and development of the mineral resource complex (MRC) in Siberian regions, and justifying the need for new approaches to resource–industrial and

innovative development processes, while at the same time demonstrating the necessity of considering regional specifics in shaping state policies in the mineral resource complex. Several studies address issues of resource conservation management in mining industry companies [40,41].

The issues of using modern innovative technologies to ensure the environmental safety of companies are addressed in works in [42–44]. Several studies analyzed and identified the functioning patterns of companies in the mineral resource sector, both overall and for specific types of extracted minerals. In recent years, economists have paid particular attention to sustainability issues at the industry level [32,33]. However, the existing studies, while informative, do not adequately address the urgent need for a unified, comprehensive, and comparative analysis of resource consumption and production greening. This need is particularly pressing in terms of their interconnectedness and interdependence in the context of sustainable development. The efficiency of mineral resource utilization and environmental effectiveness has not been sufficiently examined in a holistic manner. A review of the literature highlights the necessity for improvement in the assessment practices of resource consumption and environmental pollution. There is a pressing need for a more precise and comprehensive methodological approach to evaluate resource consumption and production greening at the corporate level. The reviewed approaches suggest that a thorough analysis of resource consumption and environmental pollution by mining enterprises should utilize indicators that assess their resource and eco-economic characteristics, allowing for comparison across key types of minerals.

We aimed to analyze mining companies' resource consumption parameters and environmental pollution intensity to identify reserves for increasing resource efficiency and environmental sustainability in production. We constructed an indicator system for resource consumption and production pollution intensity based on quantitative and cost indicators, conducted a comprehensive analysis and assessment of resource consumption and environmental impact using examples from mineral resource sector companies in northern Asian regions that are engaged in the extraction of various types of minerals, and identified directions for reducing resource intensity and environmental impact in the mining industry.

The novelty of this study lies in its proposal of a comprehensive indicator system to characterize resource consumption and environmental pollution by mining companies. This unified approach enables a comparative analysis of resource consumption and production greening for different types of minerals, based on statistical data from the annual reports of leading mining companies. The study emphasizes the interconnection and interdependence of resource consumption and environmental protection. The practical significance of this study is the usability of the proposed indicators to address resource consumption and environmental protection comprehensively. This methodology applies to mining enterprises extracting minerals, facilitating systematization, calculations, comparisons, and identifying untapped reserves for resource conservation and production greening. The results will help form an environmentally significant corporate information base, regulate economic policies to reduce resource consumption, and promote sustainable development. Additionally, they will aid in developing and implementing corporate environmental programs and incorporating the proposed indicators into companies' sustainable development reports. We obtained the initial data for this study from official annual reports, environmental reports, sustainable development reports of leading subsoil users in northern Asia (Russia), and official statistical reports for 2016–2021 [45–52].

2. Materials and Methods

2.1. Study Area

Northern Asia (Russia) consists of the Asian part of the country. In modern Russia, this includes almost the entire Ural, Siberian, and Far Eastern regions. These areas are home to vast deposits of mineral resources, including significant oil, gas, coal, strategic minerals,

and timber reserves. It is a unique and essential region that holds great significance for the economy and ecosystems of the country.

This study sampled the major mining enterprises located in northern Asia, which are leaders in various groups of mineral resources. The main factors influencing the selection of companies were the open publication of annual reports, the open publication of annual environmental reports, reports on the sustainable development of companies for the analyzed period, and companies with significant facilities located in the regions of northern Asia. As a result, we identified the leading subsoil users in northern Asia that are important for mining industry development: Public Joint Stock Company (PJSC) Alrosa—the largest diamond-mining company; PJSC Polymetal—the leading group of companies in precious metals mining; Open Joint Stock Company (OJSC) Severneftegazprom—one of the leading production facilities of the Gazprom Group; PJSC Norilsk Nickel—the leading company in the Russian mining and metallurgical industry and the largest global producer of palladium and high-grade nickel, as well as a significant producer of platinum and copper; Joint Stock Company (JSC) SUEK—a leading coal industry enterprise; PJSC Polyus—the largest gold producer in Russia and one of the top ten gold-mining companies in the world; PJSC Surgutneftegas—one of the largest private vertically integrated oil companies in Russia.

2.2. Research Methodology

Mineral resource mining (especially fossil fuels and metals) remains the cornerstone of economic growth. However, the efficiency of resource utilization (value-added) in this form of utilization significantly decreases, and exporting materials creates less value for the economy than processing them into more valuable end products. Therefore, one of the factors accelerating the development of the mineral resource sector is increasing productivity and decreasing resource intensity [53].

Mining enterprises significantly differ in development conditions, factors, locations, and operation characteristics. To assess the differentiation and ranking of resource consumption indicators during mineral extraction and evaluate anthropogenic impact in the northern Asian regions, a dynamic comparative analysis of companies in the mineral resource sector was conducted based on indicators.

The methodology for constructing indicators of resource consumption and environmental intensity of mineral resource sector companies includes the following sequence (Figure 1).

The proposed methodology for developing an indicator system, reflecting all the necessary parameters, is based on quantitative and cost indicators characterizing the consumption of mineral resources in their production activities and the level of impact on the surrounding natural environment. To assess the resource consumption of companies in the mineral resource sector of northern Asian regions, we determined a set of indicators characterizing the use of material resources in their production activities. The costs of natural resources are presented in both non-monetary and monetary terms. Non-monetary indicators of resource consumption are limited to the frameworks of individual types of resources consumed in the production of industrial products. Specific indicators of product resource consumption at the industry and corporate levels include consumption indicators in both non-monetary and monetary terms for main types such as energy intensity, fuel consumption, gas consumption, etc. Indicators of reduction (increase) in material intensity are defined based on expenditure derived from the cost of sales of products.

We determined indicators of environmental intensity based on the magnitude of negative effects on the surrounding environment. As pollutants, we considered harmful substances in emissions and discharges from enterprises, various gases, and production and consumption waste.

When selecting factor indicators, we took into account the following: the indicator should reflect the factor under consideration, be available in official statistics with numerical values in one of the information databases, be simple in terms of measuring characteristics and provide the possibility of comparison, ensure multidimensional measurement and

account for the structural features of the studied object, and provide the possibility of constructing and interpreting indicators that characterize the achievement of the goal.

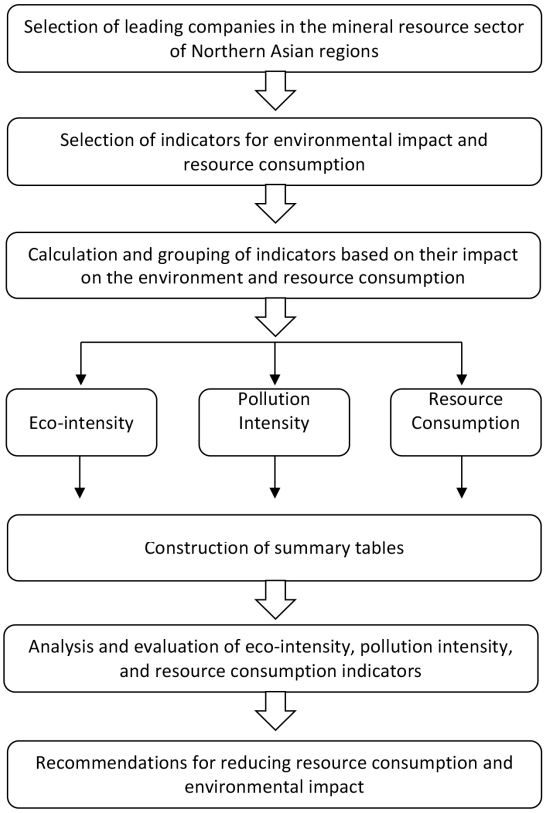


Figure 1. The main stages of the developed methodology.

We considered the environmental intensity of production as the integrated indicator of the environmental assessment of material production.

The indicators of environmental intensity (Env_{Int}) are determined by the costs of using a natural resource R per unit of final product Q produced based on this resource:

$$Env_{Int} = R/Q$$

Figure 2 shows the relationship between indicators characterizing the level of environmental impact.

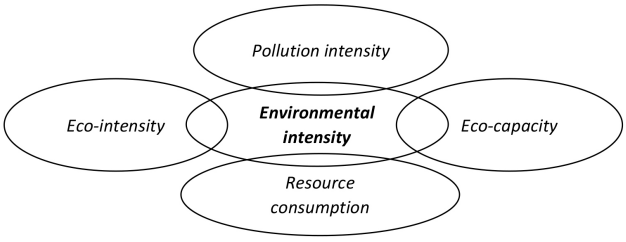


Figure 2. Relationship between environmental intensity and resource consumption indicators of production companies.

2.3. Environmental Intensity Indicator Calculation Methodology

Table 1 shows the research results on ton forming and determining the environmental intensity leading indicators of northern Asian mineral and raw materials sector companies.

Table 1. Environmental intensity indicators.

Aggregate Indicators	**Formula**
Eco-intensity E_i of production, considering environmental load (p), is defined as the environmental load per unit of final production output	$E_i = \frac{q_i^p}{v_i}$ v_i—final production output (i) q_i^p—environmental load (p) produced by the production (i)
Pollution intensity—the specific volume of pollutants (q_i) per unit of extracted raw material	$Int_i = \frac{q_i}{Q_m}$ q_i—volume of pollutants (i-th type) produced by the industry (organization) Q_m—amount of raw material extracted by the industry (organization)
Resource consumption R_c—the amount of resources consumed per unit of produced product	$R_c = \frac{r_i}{v_i}$ r_i—amount of resources consumed in the production process v_i—value added produced by the production
Specific Indicators	
Cost Indicators	**Formula**
Eco-intensity of air	$E_{emissions} = \frac{q_{emissions}}{Q_s}$ $q_{emissions}$—emissions, t Q_s—revenue in rubles
Eco-intensity of wastewater	$E_{wastewater} = \frac{q_{wastewater}}{Q_s}$ $q_{wastewater}$—wastewater, m^3; Q_s—revenue in rubles
Eco-intensity of polluted wastewater	$E_{polluted\ wastewater} = \frac{q_{polluted\ wastewater}}{Q_s}$ $q_{polluted\ wastewater}$—polluted wastewater, m^3; Q_s—revenue in rubles
Eco-intensity of waste	$E_{waste} = \frac{q_{waste}}{Q_s}$ q_{waste}—total amount of waste, t; Q_s—revenue in rubles
Non-Monetary Indicators	**Formula**
Emissions intensity	$Int_{emissions} = \frac{q_{emissions}}{Q_m}$ $Int_{emissions}$—emissions intensity $q_{emissions}$—emissions, t Q_m—amount of extracted raw materials, t
Water consumption intensity	$Int_{water\ consumption} = \frac{q_{water\ consumption}}{Q_m}$ $Int_{water\ consupmtion}$—water consumption intensity $q_{water\ consupmtion}$—water consumption volume, m^3 Q_m—amount of extracted raw materials, t
Waste utilization intensity	$Int_{utilized\ waste} = \frac{q_{utilized\ waste}}{Q_{m\ waste}}$ $Int_{utilized\ waste}$—waste utilization intensity $q_{utilized\ waste}$—amount of utilized waste, t $Q_{m\ waste}$—total amount of waste, t
Waste intensity	$Int_{waste} = \frac{q_{waste}}{Q_m}$ Int_{waste}—waste intensity, t q_{waste}—waste, t Q_m—amount of extracted raw materials, t
Greenhouse gas intensity	$Int_{greenhouse\ gas} = \frac{q_{greenhouse\ gas}}{Q_m}$ $Int_{greenhouse\ gas}$—greenhouse gas intensity $q_{greenhouse\ gas}$—amount of greenhouse gas, t CO_2-eq Q_m—amount of extracted raw materials, t

The pollution intensity and eco-intensity indicators represent the specific magnitude of negative environmental impact. Specific indicators of "eco-intensity" are calculated based on the contribution of each type of pollution—atmospheric air, production waste, and wastewater—to the production of final products. In international systems of eco-economic accounting, these indicators (pollution intensity or eco-intensity) for various types of environmental impact are calculated as specific pollution indicators per unit of final production output.

Overall, indicators of environmental intensity characterize the efficiency of functioning of any organization: the type, level, and quality of eco-economic development. Among economic criteria, reducing companies' environmental intensity is a practical criterion for transitioning to sustainable development.

2.4. Resource Consumption Indicator Calculation Methodology

Table 2 shows the research results on forming and determining the leading resource consumption indicators of northern Asian mineral and raw materials sector companies.

Table 2. Resource consumption indicators.

Indicators	Formula
Energy intensity, kWh/thousand rub.	$Enrg_{int} = \frac{V_{enrg}}{Q_s}$ V_{enrg}—volume of consumed electricity, kWh Q_s—revenue.
Gas intensity, m^3/thousand rub.	$G_{int} = \frac{V_g}{Q_s}$ V_g—volume of consumed gas, m^3 Q_s—revenue
Heat intensity, kWh/thousand rub.	$H_{int} = \frac{V_h}{Q_s}$ V_h—volume of consumed heat, kWh Q_s—revenue
Fuel intensity, GJ/thousand rub.	$F_{int} = \frac{V_f}{Q_s}$ V_f—volume of consumed fuel, GJ Q_s—revenue
Energy intensity from renewable sources (hydropower plants), GJ/thousand rub.	$Enrg_{int} = \frac{V_h}{Q_s}$ V_h—volume of consumed heat, GJ Q_s—revenue
The share of electricity from renewable energy sources in electricity consumption, %	$P = \frac{V_{er}}{V_o} * 100$ V_{er}—volume of electricity consumed from renewable sources V_o—total electricity consumption
Water intensity of production, m^3/rub.	$W_{int} = \frac{V_w}{Q_s}$ V_w—volume of consumed water resources, m^3 Q_s—revenue
Material intensity of production, rub./rub.	$M_{int} = \frac{M_c}{C_p}$ M_c—material cost C_p—production cost
Fuel intensity of production, rub./rub.	$F_{int} = \frac{M_f}{C_p}$ M_f—fuel cost C_p—production cost
Energy intensity of production, rub./rub.	$Enrg_{int} = \frac{M_e}{C_p}$ M_e—electricity cost C_p—production cost
Energy intensity per ton of resource, GJ/t	$Enrg_{int} = \frac{V_h}{q_s}$ V_h—volume of consumed heat, kWh q_s—production volume

The transition to a sustainable development model implies a qualitative improvement in production based on resource-saving technologies: technologies for waste recycling,

wastewater treatment systems, integrated plant protection, irrigation technologies, environmentally friendly materials for production, combined geo-technologies, energy-saving technologies, the transition to renewable energy sources, advanced drilling systems using hydraulic fracturing, the application of artificial intelligence for process optimization, the use of liquefied natural gas (LNG) as environmentally friendly fuel for industrial vehicles, and the drilling of extended-reach drilling (ERD) wells, among others [34,43,54]. Appropriate managerial decisions can be made by assessing the efficiency of the economy through the parameters of specific indicators of industrial resource consumption.

3. Results

3.1. Analysis of Eco-Intensity by Mineral Raw Materials Sector Companies of the Northern Asian Regions

Table A1 shows the study's results on calculating the indicators of the eco-intensity of companies in the mineral raw materials sector of the northern Asian regions. We took cost indicators for assessing the environmental intensity at the current prices, as published in the companies' annual reports.

Figure 3 shows examples of eco-intensity indicators by companies in northern Asia's mineral raw materials sector.

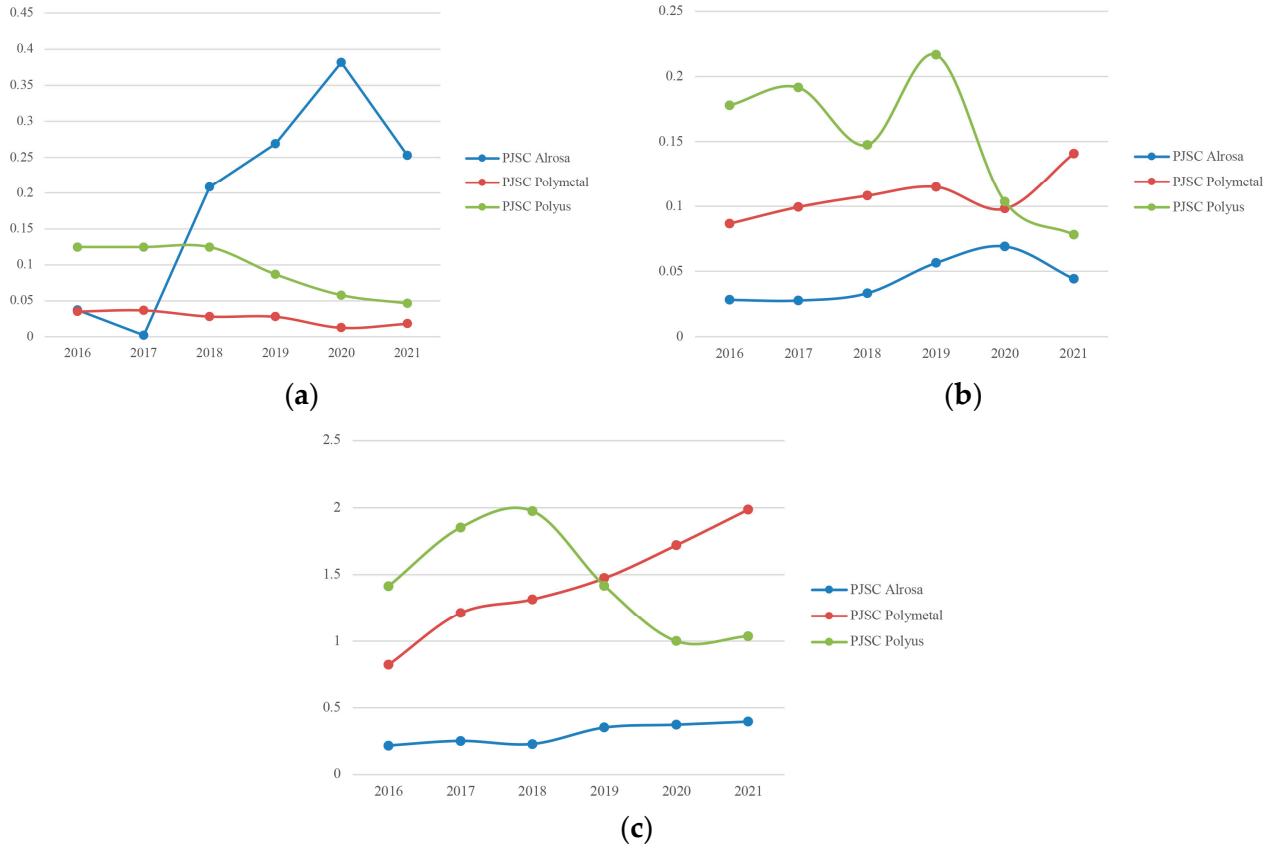


Figure 3. Eco-intensity indicators by companies in northern Asia's mineral raw materials sector: (**a**) Eco-intensity of wastewater, m^3/thousand rub.; (**b**) eco-intensity of air, t/million rub.; (**c**) eco-intensity of waste, t/thousand rub.

The results showed that the highest reduction rates in eco-intensity indicators were in the operational activities of companies such as PJSC Surgutneftegas and PJSC Polyus (Table A1). The average rate of reduction in eco-intensity indicators for PJSC Surgutneftegas over the analyzed period was 52.7%, with the main contributing factor being a revenue increase of 1.9 times; for PJSC Polyus—51.5%, with a revenue increase of 2.2 times. Therefore, a reduction in eco-intensity does not necessarily indicate positive developments

in improving the environmental situation and reducing anthropogenic pressures, as an essential factor here is the production aspect, which involves changes in the dynamics of production indicators.

Similarly, a positive trend indicating a reduction in companies' eco-intensity is evident in the operational activities of JSC SUEK and PJSC Norilsk Nickel. However, in the case of PJSC Polymetal, the rate of increase in the eco-intensity of air was 162.4%, and for waste, 2.4 times; meanwhile, the growth rate in sales revenue was 2.0 times over the analyzed period. Figure 3a shows the highest rate of increase in the eco-intensity of wastewater observed in the operational activities of PJSC Alrosa, which increased by 6.8 times. The increase in wastewater discharge is associated with measures to eliminate tailings of one of the beneficiation plants. Overall, eco-intensity indicators reflect the impact of all types of pollution or indicate a certain level of impact.

3.2. Analysis of Pollution Intensity by Mineral Raw Materials Sector Companies of the Northern Asian Regions

Table A2 shows the pollution intensity indicators of companies in the mineral raw materials sector of the northern Asian regions. It should be noted that calculations for all the indicators recommended in Table 1 were challenging due to incomplete official statistical information. Figure 4 shows the dynamics of pollution intensity indicators over the analyzed period.

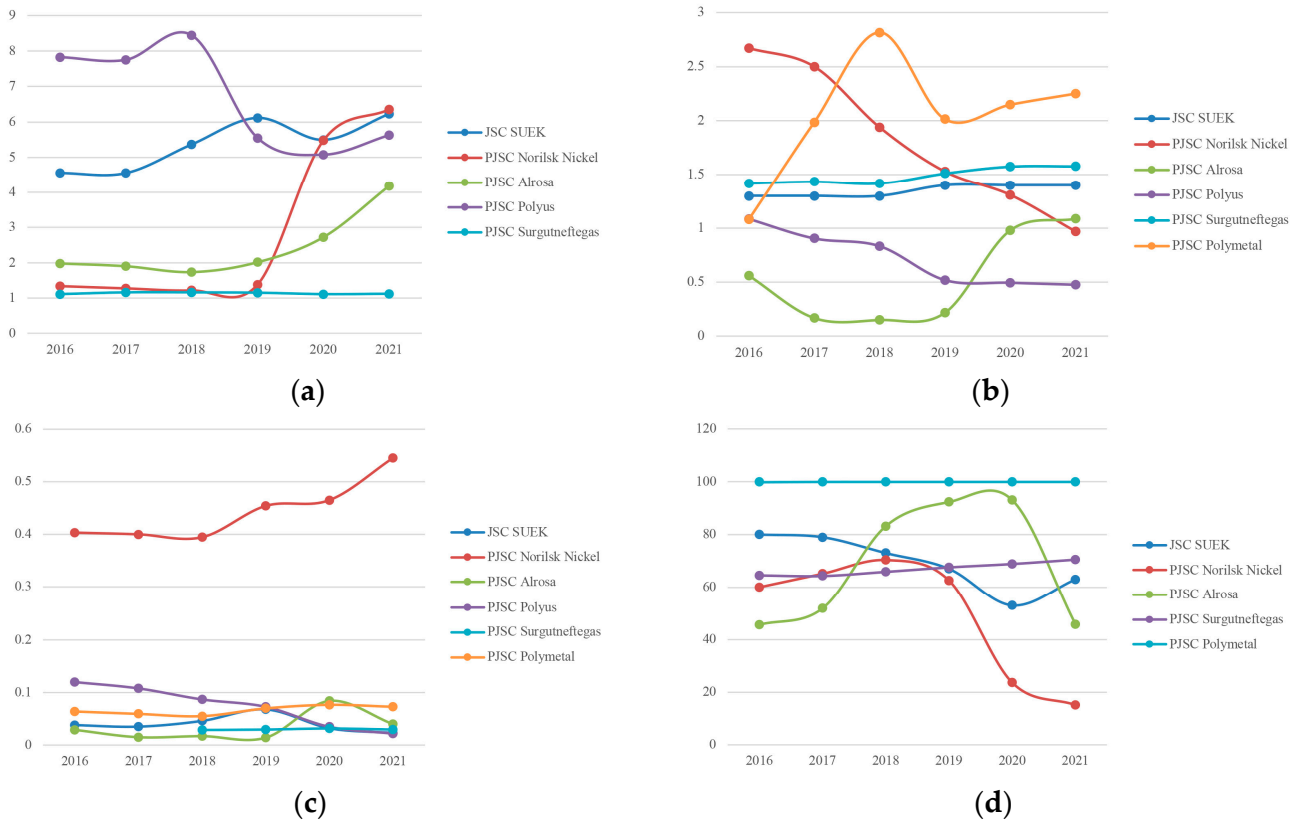


Figure 4. Pollution intensity indicators: (**a**) waste intensity, t/t; (**b**) water consumption intensity, m^3/t; (**c**) greenhouse gas intensity, t CO_2-eq/t (t CO_2-eq/carat for PJSC Alrosa); (**d**) production waste utilization intensity, %.

Mineral raw materials sector companies typically generate a large amount of waste during the extraction of ores and precious metal sands, rare metal ores, and coal mining. Figure 3 shows a positive trend in the intensity of waste production in PJSC Polyus, with a reduction rate of 71.8%. Despite a 2.3-fold increase in the overall volume of extracted ores, the rate of waste growth reached 163.0%. Regarding waste utilization intensity and

treatment in their production, PJSC Polymetal led with 99.9%. The lowest utilization level was observed in PJSC Norilsk Nickel at 15.1%, with a reduction rate of 25.1%. In 2021, the waste generation volume for PJSC Norilsk Nickel reached 156.5 million tons. The significant increase in waste generation, starting from 2020, can be attributed to the inclusion of the Bystrinsky Mining and Processing Plant in the reporting perimeter due to its reaching total capacity in 2020 and the overall increase in raw material processing volumes.

The most significant indicators of greenhouse gas intensity were in the production of PJSC Norilsk Nickel. The main factor contributing to the increase was the expansion of iron ore concentrate sales, the processing of which into steel involves a highly carbon-intensive process. At PJSC Polymetal, the increase in greenhouse gas emissions was associated with production growth (+6%), mining (+6%), overburden volumes (+25%), and underground mining activities (+26%) at newly introduced enterprises, as these are fuel-intensive processes. The total greenhouse gas emissions for PJSC Alrosa in 2021 amounted to 2173 thousand tons of CO_2-eq. The increase in greenhouse gas emissions was linked to the resumption of production processes at specific sites, the relaxation of measures related to COVID-19, and the expansion of the PJSC Alrosa coverage area.

3.3. Analysis of Resource Consumption by Mineral Raw Materials Sector Companies of the Northern Asian Regions

Table A3 shows resource consumption indicators. We adopted cost indicators for assessing resource consumption at current prices published in the annual reports of companies in northern Asia's mineral raw materials sector. It should be noted that calculations for all the indicators recommended in Table 1 were challenging due to incomplete official statistical information. We used cost indicators to assess resource consumption at the current prices published in the annual reports of mineral resource sector companies in northern Asia. Calculating the volume of resource consumption for individual companies for subsequent comparison was not always possible due to the incomparability of non-monetary indicators resulting from the disproportionate extraction of different types of minerals.

Figure 5 shows the dynamics of the leading resource consumption indicators.

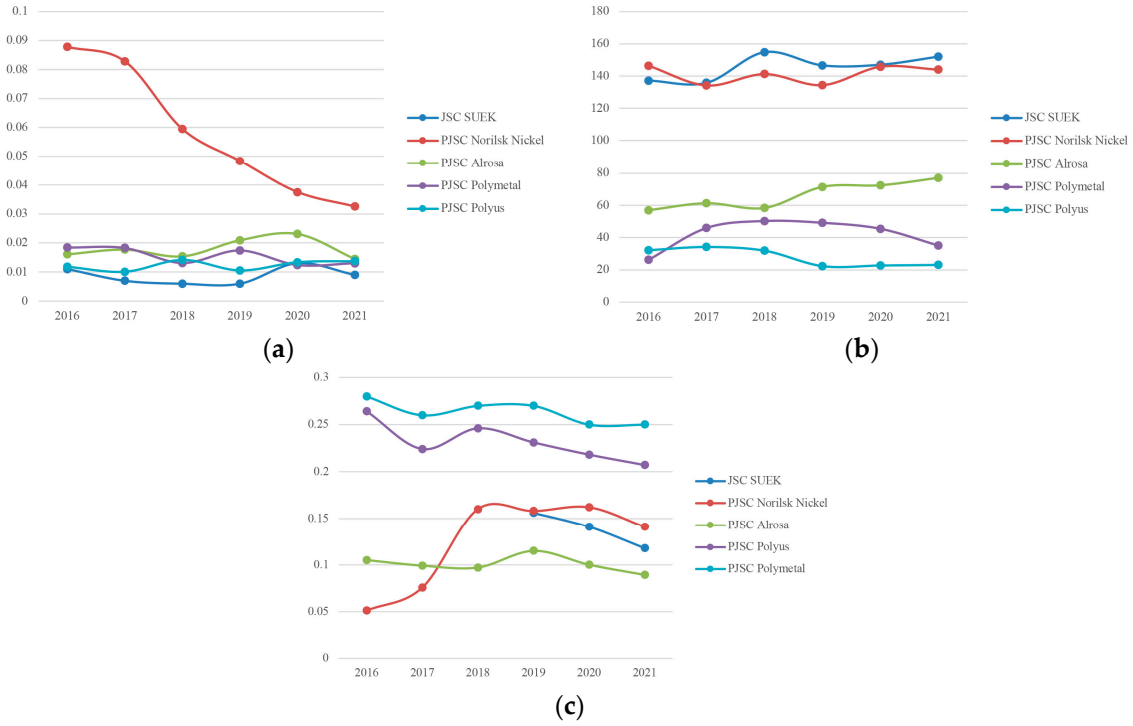


Figure 5. Resource consumption indicators: (**a**) energy intensity, kWh/thousand rub.; (**b**) water intensity, m^3/rub.; (**c**) material intensity, rub./rub.

Resource consumption indicators are the most informative indicators for determining the anthropogenic load on all types of natural resources. Resource consumption indicators help establish the overall consumption of each resource type per unit of produced output. The analysis of resource consumption indicators of companies in the mineral raw materials sector revealed the following. PJSC Polyus showed high growth rates in energy consumption indicators over the analyzed period, with electricity, gas, and heat consumption increasing by 16.4%. The increase in energy intensity of PJSC Alrosa in 2020 occurred due to a decrease in the rational use of energy resources directly in the primary production process. PJSC Norilsk Nickel showed the most positive dynamics of energy consumption indicators.

4. Discussion

A comprehensive analysis of resource consumption dynamics and production eco-modernization in mineral resource sector companies in northern Asian regions showed the following. Over the analyzed period, eco-intensity indicators tended to decrease in the activities of PJSC Surgutneftegas, PJSC Polyus, JSC SUEK, and PJSC Norilsk Nickel. In PJSC Polymetal, a large increase in the eco-intensity of air and waste occurred due to a 1.6-fold increase in pollutant emissions and a 2.4-fold increase in waste. At OJSC Severneftegazprom, pollutant emissions increased by 2.0 times, and waste increased by 1.9 times, resulting in increased eco-intensity indicators. Also, positive dynamics of eco-intensity indicators do not necessarily indicate significant shifts in improving the environmental situation and reducing anthropogenic loads, as a significant factor here is production, which involves changes in the dynamics of production output and volumes. Therefore, the outpacing growth of revenue from sales compared to the rates of environmental pollution is one of the factors influencing the reduction of eco-intensity indicators.

The production specifics explain the high waste generation rate in the extractive industry. Activities such as stripping operations, waste rock disposal, ore processing, and energy use result in emissions containing carbon dioxide, nitrogen and sulfur oxides, inorganic dust, and a large amount of waste. Enterprises use dust suppression systems, dust collection equipment, and dust screens to reduce dust emissions. For instance, PJSC Polymetal only uses modern transport and mining equipment meeting European quality standards that was produced using the latest technologies. PJSC Polymetal adheres to sustainable development principles, focusing on resource efficiency, energy management, and emissions reduction.

In 2021, the volume of waste generated by PJSC Norilsk Nickel amounted to 156.5 million tons. The increase in raw material processing volumes of the Bystrinsky mining and processing plant explains a significant increase in waste generation. PJSC Norilsk Nickel plans to eliminate sources of border emissions and intends to construct a new copper-refining line based on modern eco-friendly technologies [55].

PJSC Alrosa has undertaken initiatives to reduce emissions despite an overall increase in its environmental intensity indicators. Energy-saving efforts saved 519 TJ or 1.21 billion rubles while transitioning transport to natural gas, and using renewables cut greenhouse gas emissions by 1016.494 tons of CO_2-e compared to 2020. PJSC Alrosa's transparent environmental reporting earned it top-tier rankings for the fourth time, aligning with sustainable development principles and international business standards. The company ranks highly in Financial Times Stock Exchange (FTSE4Good), Morgan Stanley Capital International Environmental, Social, and Governance (MSCI ESG), Sustainalytics, and World Wildlife Fund (WWF) Russia ESG ratings.

PJSC Polyus stands out for its significant reduction in greenhouse gas emissions and product carbon footprint over six years, with a decrease in intensity of 81.7%. Amid growing attention to low-carbon trends, PJSC Polyus sees transitioning to a low-carbon economy as an opportunity, expecting gold to play a crucial role in new industrial technologies. The company focuses on improving energy efficiency and reducing emissions, aligning with International Council on Mining and Metals (ICMM) principles and joining Climate

Governance Initiative (CGI) Russia as part of its climate mitigation efforts. Specific emissions from its mining units decreased from 28 kg CO_2-e per ton of processed ore in 2020 to 19 kg in the reporting period, reflecting a continued correlation between emissions and production. Increased hydropower use and acquiring "green" International Renewable Energy Certificate (I-REC) certificates facilitated the reduction in overall emissions from 2018 to 2021.

JSC SUEK achieved a 60.5% reduction in direct greenhouse gas emissions in the coal segment in 2021 by capturing and utilizing mine methane and developing new seams with lower methane content.

The analysis of resource consumption indicators in the mineral resource sector, including energy consumption and material intensity, revealed the efficiency of resource utilization. The energy intensity indicator is crucial for ensuring environmental sustainability. Several factors contribute to this:

- Leading role of the energy sector in the Russian economy, GDP formation, tax revenues, employment, and export earnings;
- Significant contribution of the energy sector to environmental pollution, depletion of natural resources, and degradation of vast pristine territories;
- Notable adverse impact of the energy industry on public health;
- Continued role of the energy sector in the economy despite plans to increase energy resource extraction;
- Necessity of significantly reducing energy intensity, improving energy efficiency, and implementing energy-saving programs.

For instance, PJSC Polymetal has adopted a new methodology since 2021 to provide more accurate information on energy consumption. Positive trends in energy resource consumption indicators were observed in PJSC Norilsk Nickel, influenced by the annual increase in electricity production from renewable sources and a 37.0% overall reduction in energy intensity. The industrial structure significantly influences production energy intensity, especially in the mineral resource sector, which has five-times-higher energy costs per employee than the country's average. The material intensity indicator allows for evaluating companies' economic growth, the efficient use of primary resources, and identifying corporate strengths and weaknesses through comparative analysis. Positive trends in reducing material intensity were evident in all companies except PJSC Norilsk Nickel, where material intensity increased by 2.8 times. The overall increase in this indicator over the analyzed period was influenced by a nearly 2.4-fold increase in revenue despite a 0.7% decrease in ore production.

This study identified the main criteria for increasing resource consumption in the mineral resource sector of northern Asia: Increased production costs lead to reduced competitiveness in domestic and international markets; the rise in raw material costs due to increased expenditures on exploration, extraction, transportation, and enrichment; the structural deformation of industrial production towards the decline of knowledge-intensive production types and the increase in the share of extractive industries; the deterioration of the economic situation due to environmental pollution growth; the increase in inflation levels, primarily driven by price hikes on mineral resources; the sustained and growing demand for additional raw materials and energy resources due to their inefficient utilization, which leads to reduced reserves and corresponding price dynamics globally, resulting in the limited production of certain types of raw materials at higher prices.

It is essential to highlight that the dominant features of the development of the mineral resource sector in northern Asia include the predominant role of vertically integrated companies, service market formation processes, and the underdevelopment of small and medium-sized, including innovation-oriented, extractive, and specialized geological exploration companies.

In this context, managing resource consumption and conservation processes should involve administrative and economic measures affecting all natural resource users. The

primary means of reducing resource consumption entail decreasing the use of natural resources and, consequently, the scale of environmental pollution.

Reducing environmental impact is a crucial task in transitioning to sustainable development [56–58]. The primary approach involves reducing the consumption of natural resources and pollution levels. We identified several pathways for reducing environmental impact: economic growth should be achieved by enhancing production efficiency, resource, and labor productivity, thereby rationalizing production processes; the comprehensive processing of extracted natural resources to extract all possible functional properties from each resource unit; natural resource trade restriction; the development of innovative production technologies to reduce the specific product types' environmental impacts; the administrative regulation of environmental protection activities, including developing and enforcing legislation regarding environmental protection; providing economic incentives for rational natural resource use and environmental protection activities.

To reduce resource intensity and environmental impact, a shift in the mechanism of resource consumption is necessary. In Russian practice, there are three mechanisms of natural resource management: the compensatory mechanism; the stimulatory mechanism, which utilizes market instruments, particularly taxation; the suppressive mechanism of natural resource management, which rigidly restricts the use of natural capital, even to the extent of "freezing" the development of specific industries.

In Russia, the traditional economic model relies on the compensatory mechanism of natural resource management. However, the worsening global environmental situation necessitates shifting from compensatory to stimulatory mechanisms. Otherwise, the widespread adoption of the suppressing mechanism of natural resource management may become the only viable option in the future, inevitably leading to global economic crises and increased social tensions.

Modern mechanisms of resource consumption have different directions, but the primary objective is to reduce the consumption of natural resources and pollution and rationalize natural resource management. In Russia, the established regulatory framework for subsurface management needs improvement in implementing resource-saving policies and ensuring sustainable growth. The rationalization of resource consumption can become one of the main drivers of economic growth and the improvement of technical policy by introducing scientific and technological innovations, creating a resource-saving model of the economy. Overall, establishing a mechanism for the state regulation of resource-saving activities in the economic system will positively impact reducing environmental pollution. Among the measures of state influence, the tax regime plays a significant stimulating role in the successful development of the extractive sector of the economy, which needs to coordinate with the rates and procedures for mineral extraction taxes.

Additionally, the economic stimulation of effective subsurface management measures should include the differentiation of the tax on mineral extraction aimed at increasing the investment attractiveness of subsurface areas located in remote and inaccessible areas and the completeness of the extraction of minerals containing their main and valuable by-products. Due to the increasing anthropogenic pressure on the environment, it is necessary to develop schemes of eco-economic zoning.

It is necessary to create a database on waste and processing methods, implement a monitoring system, and take measures to stimulate the economical use of waste to address the waste disposal problem, including a detailed inventory of all mining objects previously operated in the territory, both from the perspective of justifying the possibilities of landscape reclamation of physical disturbances and studying the environmental hazard of accumulated overburden dumps and hosting rocks, as well as their utilization.

The following principles of resource conservation will help to reduce the resource intensity of production:

- Improving the consumed resources structure by reducing the share of raw material exports and increasing the proportion of environmentally friendly and efficient resource types;

- Increasing the mineral extraction rate;
- Increasing the share of resource-saving technologies;
- Analyzing resource utilization throughout the life cycle of objects;
- Developing methods for analyzing, forecasting, optimizing, and incentivizing improved resource utilization;
- Applying scientific management approaches in addressing resource conservation issues.

Since January 2022, Russia has implemented significant changes in subsoil use regulations, including introducing electronic auctions for subsoil use and mechanisms to enhance industry investment attractiveness [59], establishing regulatory mechanisms based on international agreements to facilitate the development of transboundary deposits, and developing new procedures for granting subsoil plots for greenhouse gas injection. A notable legal improvement requires former subsoil users to clean up environmental damage and restore affected areas. In China, mineral resource management is governed by specific legal frameworks [60], with licensing agreements playing a pivotal role in granting exploration and utilization rights. Bilateral initiatives in international cooperation for decarbonization are noteworthy. Russia–China collaboration aims to transition to a low-carbon trajectory by 2030, increasing the gas trade share while decreasing coal and oil [61]. China's decarbonization focuses on reducing coal use to peak emissions by 2030 [62] and fully transition by 2060 [63]. This "green transition" benefits Russia's gas industry by stabilizing the carbon balance. Joint gas pipeline projects and Chinese investments in Russian LNG ensure a market niche [64]. Environmental policies targeting a carbon emissions peak and carbon neutrality, along with stricter regulations on ecology and environmental protection, drive the need for energy conservation, clean energy, and low-carbon initiatives. European countries, exemplified by Austria, Denmark, Norway, Ireland, and Luxembourg, have achieved high levels of rationality, productivity, and frugality in resource usage through recycling, R&D, innovation, digitization, and clear state policies promoting resource efficiency in the economy [65]. Germany's "green economy" prioritizes rationalizing the processing of secondary raw materials and waste [66], enabling the industry to meet 15% of its energy and resource consumption needs. The recent implementation of technological innovations has led to a general decrease in eco-intensity indicators. In sustainable development, many companies worldwide are implementing measures to improve energy efficiency, reduce emissions, and invest in clean technologies and renewable energy sources, focusing on environmental protection, ecosystem restoration, and community development. Mining companies must align economic growth with environmental responsibility to achieve sustainable development goals.

5. Further Research

Building on the findings of this study, future research should explore the long-term impacts of resource consumption and pollution in the mining industry. Investigating the effectiveness of various mitigation strategies across different regions could provide valuable insights. Further research should focus on integrating the proposed set of resource consumption and environmental impact indicators into the system of regional and sectoral management within the framework of sustainable development. This includes developing programs for implementing resource conservation and greening the mining industry, which would serve as a unified information basis for regulating and timely adjusting the production activities of mining companies to achieve sustainable development. By contributing to the development of sustainable practices in the mining industry, this research has the potential to make a significant impact on our planet's future.

Additionally, we recommend applying the same methodological approach to similar companies in different regions. This comparative analysis could help to identify uniform trends across varying geographic contexts. Specifically, examining whether there is a consistent pattern in resource consumption and pollution intensity across different regions would provide deeper insights into the generalizability of the results. Such research would enhance our understanding of regional differences and similarities in the environmental

impacts of mining activities, contributing to more effective global strategies for sustainable resource management. Further studies should also consider the socio-economic impacts of mining activities on local communities.

6. Conclusions

The research has shown that the proposed approach to forming a set of indicators for assessing resource consumption and environmental intensity in the mineral resource sector is an essential factor in activating companies' efforts to transition to a path of resource-efficient sustainable development. In order to increase resource efficiency, the economic policies pursued by organizations in the extractive industries should focus on improving the environmental state, with critical measures including investment in the development and implementation of technologies to enhance production efficiency and environmental safety, maximizing the generation of heat and electricity through cogeneration to reduce emissions per unit of energy, and fostering inter-sectoral cooperation to achieve goals for reducing environmental pollution.

Assessing resource consumption and environmental intensity in the mineral resource sector provides valuable insights for organizations, governmental bodies, and international organizations working on regional sustainable development and efficient resource management. Actions such as increasing the role of indicators and parameters of resource consumption, greening production processes, and achieving the comparability of non-monetary indicators can enhance the proposed methodological approach. The proposed methodological approach has the potential for broader application and can help promote sustainable development practices beyond the scope of this study. It can, for example, be used in expert assessments to determine the sustainable development of companies and regions.

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Appendix A

Table A1. Eco-intensity indicators of mineral resource sector companies in northern Asian regions (cost indicators in current prices).

Indicators	Units	2016	2017	2018	2019	2020	2021	2021 to 2016, %
I. OJSC Severneftegazprom								
Eco-intensity of air	t/million rub.	0.0460	0.0460	0.0538	0.0581	0.0745	0.0903	196.4
Eco-intensity of wastewater	m^3/thousand rub.	0.0014	0.0015	0.0016	0.0016	0.0017	0.0018	130.2
Eco-intensity of waste	t/million rub.	0.0074	0.0104	0.0158	0.0174	0.0151	0.0157	2.1 times
II. JSC Siberian Coal Energy Company (SUEK)								
Eco-intensity of air	t/thousand rub.	0.0014	0.0010	0.0007	0.0008	0.0010	0.0009	62.4
Eco-intensity of wastewater	m^3/rub.	0.0004	0.0003	0.0003	0.0003	0.0003	0.0002	48.5
Eco-intensity of polluted wastewater	t/million rub.	0.0870	0.0575	0.0393	0.0434	0.0432	0.0294	33.8
Eco-intensity of waste	t/rub.	0.0018	0.0012	0.0011	0.0013	0.0011	0.0009	50.9
III. PJSC Norilsk Nickel								
Eco-intensity of air	t/thousand rub.	0.0035	0.0035	0.0026	0.0022	0.0018	0.0013	36.1
Eco-intensity of wastewater	m^3/rub.	0.0003	0.0003	0.0002	0.0002	0.0002	0.0001	52.0
Eco-intensity of polluted wastewater	m^3/thousand rub.	0.0492	0.0642	0.0462	0.0410	0.0294	0.0262	53.3
Eco-intensity of waste	t/thousand rub.	0.0606	0.0582	0.0560	0.0664	0.2647	0.2853	4.7 times
IV. PJSC Alrosa								
Eco-intensity of air	t/million rub.	0.0283	0.0278	0.0333	0.0565	0.0692	0.0443	156.5
Eco-intensity of wastewater	m^3/thousand rub.	0.0374	0.0023	0.2086	0.2688	0.3818	0.2526	6.8 times
Eco-intensity of polluted wastewater	t/million rub.	0.0245	0.0176	0.0493	0.0696	0.0640	0.0853	3.5 times
Eco-intensity of waste	t/thousand rub.	0.2166	0.2510	0.2280	0.3513	0.3726	0.3954	182.5
V. PJSC Polymetal								
Eco-intensity of air	t/million rub.	0.0867	0.0995	0.1082	0.1150	0.0982	0.1408	162.4
Eco-intensity of wastewater	m^3/thousand rub.	0.0353	0.0369	0.0283	0.0280	0.0127	0.0183	51.9
Eco-intensity of waste	t/thousand rub.	0.8225	1.2130	1.3160	1.4745	1.7207	1.9868	2.4 times
VI. PJSC Polyus								
Eco-intensity of air	t/million rub.	0.1779	0.1916	0.1475	0.2167	0.1036	0.0782	43.9
Eco-intensity of wastewater	m^3/thousand rub.	0.1245	0.1245	0.1245	0.0867	0.0579	0.0466	37.4
Eco-intensity of waste	t/thousand rub.	1.4152	1.8508	1.9732	1.4173	0.9993	1.0363	73.2
VII. PJSC Surgutneftegas								
Eco-intensity of air	t/million rub.	0.1864	0.1545	0.0915	0.0815	0.1156	0.0726	38.9
Eco-intensity of wastewater	m^3/million rub.	0.0321	0.0190	0.0148	0.0139	0.0203	0.0111	34.6
Eco-intensity of waste	t/million rub.	0.7190	0.6969	0.5237	0.6072	1.0828	0.6074	84.5

Table A2. Pollution intensity indicators of mineral resource sector companies in northern Asian regions.

Indicators	Units	2016	2017	2018	2019	2020	2021	2021 to 2016, %
I. OJSC Severneftegazprom								
Emissions intensity	t/million m^3	0.092	0.096	0.102	0.119	0.136	0.165	179.3
Water consumption intensity	m^3/million m^3	2.392	2.599	2.9412	3.223	4.400	4.012	167.7
Waste intensity	t/million m^3	0.0148	0.0206	0.0300	0.0359	0.0277	0.0288	195.0
Waste utilization intensity	t/t	3.6	15.6	4.4	11.5	10.1	7.4	2.1 times
Production waste utilization intensity	%	72.8	93.7	77.5	91.4	80.1	88.6	121.7
Greenhouse gas intensity	thousand t CO_2-eq/million t	0.013	0.012	0.015	0.019	0.022	0.026	2 times

Table A2. *Cont.*

Indicators	Units	2016	2017	2018	2019	2020	2021	2021 to 2016, %
				II. JSC Siberian Coal Energy Company (SUEK)				
Emissions intensity	t/thousand t	3.6404	3.6799	3.4701	3.5593	4.6669	6.0887	167.3
Water consumption intensity	m^3/t	1.3	1.3	1.3	1.4	1.4	1.4	107.7
Waste intensity	t/t	4.5588	4.5565	5.3650	6.1129	5.4940	6.2243	136.5
Waste utilization intensity	t/t	0.81	0.78	0.72	0.67	0.7	0.41	50.6
Production waste utilization intensity	%	80	79	73	67	53	63	78.8
Greenhouse gas intensity	million t CO_2-eq/million t	0.038	0.035	0.046	0.068	0.032	0.023	60.5
				III. PJSC Norilsk Nickel				
Emissions intensity	t/t	0.0780	0.0738	0.0764	0.0742	0.0742	0.0670	85.8
Water consumption intensity	m^3/t	2.67	2.5	1.94	1.53	1.31	0.97	36.3
Waste intensity	t/t	1.3414	1.2770	1.2192	1.3840	5.4792	6.3566	4.7 times
Waste utilization intensity	t/t	0.8145	0.832	0.8571	0.8669	1.2943	0.9626	118.2
Production waste utilization intensity	%	60.1	65.2	70.4	62.6	23.6	15.1	25.1
Greenhouse gas intensity	thousand t CO_2-eq/t	0.592	0.581	0.579	0.536	0.515	0.533	90.0
				IV. PJSC Alrosa				
Emissions intensity	t/thousand t	0.2587	0.2106	0.2538	0.3242	0.5055	0.4690	181.3
Water consumption intensity	m^3/t	0.5610	0.1685	0.1502	0.2167	0.9797	1.0873	193.8
Waste intensity	t/t	1.9796	1.9016	1.7357	2.0147	2.7239	4.1844	2.1 times
Waste utilization intensity	t/t	…	11.8	7	7.2	7.1	14.8	125.4
Production waste utilization intensity	%	…	51.9	83.2	92.3	93	45.8	88.2
Greenhouse gas intensity	t CO_2-eq/carat	0.029	0.015	0.017	0.014	0.084	0.04	137.9
				V. PJSC Polymetal				
Emissions intensity	t/thousand t	0.6856	0.7864	0.8553	0.9087	0.7761	1.1131	162.4
Water consumption intensity	m^3/t	1.0837	1.9860	2.8156	2.0155	2.1487	2.2510	2.1 times
Waste intensity	t/t	6.5	10.1082	9.9400	9.0653	11.8155	13.4672	2.1 times
Waste utilization intensity	t/t	0.3	1.2	6.1	7.1	5.7	4.3	1433.3
Production waste utilization intensity	%	99.97	99.98	99.98	99.98	99.98	99.98	100.0
Greenhouse gas intensity	t CO_2-eq/t	63.8	59.2	75.6	75.1	73	67.7	106.1
				VI. PJSC Polyus				
Emissions intensity	t/thousand t	0.9842	0.8025	0.6311	0.8483	0.5261	0.4243	43.1
Water consumption intensity	m^3/t	1.0870	0.9063	0.8350	0.5203	0.4957	0.4771	43.9
Waste intensity	t/t	7.8285	7.7517	8.4452	5.5481	5.0748	5.6265	71.9
Waste utilization intensity	t/t	0.011	0.010	0.007	0.01	0.011	0.01	90.67
Greenhouse gas intensity	t CO_2-eq/t	0.12	0.108	0.087	0.073	0.035	0.022	18.3
				VII. PJSC Surgutneftegas				
Emissions intensity	t/t	0.0026	0.0025	0.0020	0.0019	0.0020	0.0022	84.6
Water consumption intensity	m^3/t	1.4188	1.4347	1.4181	1.5116	1.5760	1.5790	111.3
Waste intensity	kg/t	9.9754	11.313	11.329	13.807	18.548	18.307	183.5
Waste utilization intensity	t/t	1.11	1.16	1.16	1.15	1.11	1.12	100.9
Production waste utilization intensity	%	64.566	64.317	65.89	67.57	68.841	70.48	109.2
Greenhouse gas intensity	kg CO_2-eq/t	…	…	28.67	29.44	31.34	29.44	102.7

Table A3. Resource consumption indicators of mineral resource sector companies in northern Asian regions (cost indicators in current prices).

Indicators	Units	2016	2017	2018	2019	2020	2021	2021 to 2016, %
I. OJSC Severneftegazprom								
Energy intensity	kWh/thousand rub.	0.714	0.728	0.753	0.694	0.814	0.810	113.5
Gas intensity	m^3/thousand rub.	2.742	3.304	4.361	4.039	5.635	6.828	2.5 times
Heat intensity	kWh/thousand rub.	0.001	0.001	0.001	0.001	0.001	0.002	130.0
Water intensity	m^3/rub.	81.54	87.04	90.13	99.74	123.3	102.6	125.8
Material intensity	rub./rub.	0.081	0.071	0.0655	0.0667	0.0676	0.0672	82.8
II. JSC Siberian Coal Energy Company (SUEK)								
Energy intensity	kWh/rub.	0.011	0.007	0.006	0.006	0.013	0.009	81.8
Water intensity	m^3/rub.	137.2	135.8	154.8	146.6	147	152	110.8
Energy intensity per ton of coal	GJ/t	…	…	…	0.234	0.255	0.256	109.4
Material intensity	rub./rub.	…	…	…	0.156	0.141	0.118	76.0
Fuel intensity	rub./rub.	…	…	…	0.127	0.139	0.316	2.5 times
Energy intensity	rub./rub.	…	…	…	0.036	0.041	0.034	95.2
III. PJSC Norilsk Nickel								
Water intensity	m^3/rub.	146.4	134.1	141.2	134.3	145.8	144.0	98.4
Energy intensity, total including	kWh/rub.	0.0878	0.0828	0.0594	0.0483	0.0375	0.0325	37.0
Fuel intensity	kWh/rub.	0.0873	0.0821	0.0562	0.0458	0.0350	0.0324	37.1
Energy intensity from renewable sources (hydropower plants)	kWh/rub.	0.0060	0.0065	0.0056	0.0048	0.0038	0.0031	52.1
Material intensity	rub./rub.	0.051	0.756	0.160	0.158	0.162	0.141	2.8 times
Electricity, heat intensity	rub./rub.	0.028	0.148	0.032	0.034	0.034	0.023	82.1
Fuel intensity	rub./rub.	0.017	0.084	0.019	0.022	0.024	0.024	141.2
The share of electricity from renewable sources	%	36	38	44	45	46	47	130.6
IV. PJSC Alrosa								
Electricity intensity	kWh/rub.	0.016	0.018	0.015	0.021	0.023	0.015	93.8
Water intensity	m^3/rub.	56.9	61.2	58.3	71.4	72.4	77	135.3
Material intensity	rub./rub.	0.105	0.099	0.097	0.115	0.100	0.089	84.8
Fuel, energy intensity	rub./rub.	0.112	0.095	0.107	0.148	0.117	0.093	83.0
V. PJSC Polymetal								
Energy intensity	kWh/rub.	0.0184	0.0182	0.0131	0.0174	0.0123	0.0129	70.5
Energy intensity	GJ/thousand ounces of gold equivalent	5500	4900	4300	5627	5702	5934	107.9
Energy intensity	GJ/thousand rub.	66.39	66.36	47.00	62.75	44.46	46.79	70.5
Material intensity	rub./rub.	0.28	0.26	0.27	0.27	0.25	0.25	89.3
Water intensity	m^3/rub.	26.3	45.9	50.2	49.1	45.4	35.1	133.5
VI. PJSC Polyus								
Energy intensity	kWh/rub.	0.0118	0.0100	0.0142	0.0105	0.0133	0.0137	116.4
Electricity intensity	TJ/rub.	0.037	0.045	0.051	0.027	0.024	0.025	66.8
Fuel intensity	rub./rub.	0.079	0.074	0.095	0.092	0.085	0.079	100.0
Fuel intensity	TJ/rub.	8.831	11.80	9.261	5.740	5.388	5.850	66.2
Water intensity	m^3/rub.	32.2	34.2	31.9	22.32	22.71	23.06	71.6
Material intensity	rub./rub.	0.264	0.224	0.246	0.231	0.218	0.207	78.4
VII. PJSC Surgutneftegas								
Energy intensity	kWh/rub.	0.012	0.010	0.008	0.007	0.010	0.011	91.7
Material intensity	rub./rub.	0.2045	0.195	0.273	0.2075	0.247	0.1602	78.3
Water intensity	m^3/rub.	0.102	0.088	0.066	0.066	0.092	0.091	89.7

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