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Petrov D.S.[1] *, Yakusheva A.M.[2]

[1, 2] Saint Petersburg Mining University, Saint Petersburg, Russia

* Correspodning author (petrov_ds[at]pers.spmi.ru)

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ASSESSMENT OF THE INPUT OF PHOSPHORUS AND NITROGEN COMPOUNDS INTO THE GULF OF FINLAND THROUGH TRIBUTARIES OF THE NEVA RIVER WITHIN THE BORDERS OF ST. PETERSBURG

Research article

Abstract

The article is devoted to the actual problem of eutrophication of the eastern part of the Baltic Sea. The paper provides a general analysis of the intake of phosphorus and nitrogen compounds from the territory of the Russian Federation to the Gulf of Finland. Chemical analysis of water samples from the main tributaries and small watercourses of the Neva River delta within the borders of St. Petersburg was also carried out. Such watercourses as Okhta, Lubya, Okkervil, Slavyanka, Murzinka, Chernaya Rechka, Smolenka, Volkovka and Karpovka were studied. The concentrations of phosphates, ammonium and nitrate nitrogen were determined by spectrophotometry. Conclusions about the contribution of individual tributaries of the Neva River to the total inputs of biogenic elements into the Gulf of Finland were made. It is noted that the greatest contribution to the supply of biogenic elements is made by Okhta River and Slavyanka River.

Keywords: Baltic Sea, eutrophication, Neva River, phosphorus and nitrogen compounds.

Петров Д.С.[1] *, Якушева А.М.[2]

[1, 2] Санкт-Петербургский Горный Университет, Санкт-Петербург, Россия

* Корреспондирующий автора (petrov_ds[at]pers.spmi.ru)

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ОЦЕНКА ПОСТУПЛЕНИЯ СОЕДИНЕНИЙ ФОСФОРА И АЗОТА В ФИНСКИЙ ЗАЛИВ ЧЕРЕЗ ПРИТОКИ РЕКИ НЕВА В ГРАНИЦАХ САНКТ-ПЕТЕРБУРГА

Научная статья

Аннотация

Статья посвящена актуальной проблеме эвтрофикации восточной части Балтийского моря. В работе проведен общий анализ поступления соединений фосфора и азота с территории Российской Федерации в Финский залив. Также проведен химический анализ проб воды из основных притоков и малых водотоков дельты реки Невы в границах Санкт-Петербурга. Были исследованы такие водотоки как Охта, Лубья, Оккервиль, Славянка, Мурзанка, Черная речка, Смоленка, Волковка и Карповка. Концентрации фосфатов, аммонийного и нитратного азоты были определены методом спектрофотометрии. Сделаны выводы о вкладе отдельных притоков Невы в общий сброс биогенных элементов в Финский залив. Отмечено, что наибольший вклад в поступление биогенных элементов вносят Охта и Славянка.

Ключевые слова: Балтийское море, эвтрофикация, Нева, соединения фосфора и азота.

1. Introduction

The Baltic Sea is affected by climate change [1] and increased eutrophication [2], [3]. Eutrophication is driven by excessive inputs of nutrients from rivers and atmosphere which lead to increased sedimentation of organic material and oxygen depletion in the bottom layer and the internal loading of phosphorus [4]. Eutrophication is the main environmental problem of the Baltic Sea, which over the past 200 years has turned from an oligotrophic state to a eutrophic one, primarily due to the input of nitrogen and phosphorus. According to HELCOM [5], the main sources of biogens polluting the Baltic Sea are agricultural facilities, especially livestock farms located in the catchment basin, as well as the discharge of untreated wastewater. Approximately 75 % of nitrogen and at least 95 % of phosphorus enter the Baltic Sea through rivers or through direct discharges. The share of nitrogen and phosphorus input from different countries varies significantly depending on the size of the catchment area, the number of population, the intensity of agriculture, the quality of wastewater treatment, and other reasons. HELCOM faces a very high variability of the reported estimates between countries caused by various non-harmonized assessment methods and a remarkable difference in both temporal, geographical and sectoral data coverage. This requires clarification of information about the inputs of biogens from different countries, including Russia. The contribution of the Russian Federation to the total input of nitrogen and phosphorus to the Baltic Sea looks significant, currently estimated at 12 % nitrogen and 18 % phosphorus [5]. The recipient of biogens from Russia is mainly the Gulf of Finland. Based on the HELCOM data, it can be argued that the main sources of biogen inputs are the catchment basins of several large rivers and direct wastewater discharges, for example, from St. Petersburg. The "Baltic Sea Action Plan" adopted in 2014 provides that the amount of phosphorus entering the Gulf of Finland should be reduced by 2,000 tons, and the amount of nitrogen — by 6,000 tons.

The input of phosphorus and nitrogen to the Gulf of Finland from the territory of Russia mainly caused by the flow of four large rivers: Neva, Luga, Narva and Seleznyovka, Input has been decreasing for the last 15 years (Fig.1), but the current environmental situation requires further research in the field of determining the sources of biogen inputs with a view to their subsequent reduction.

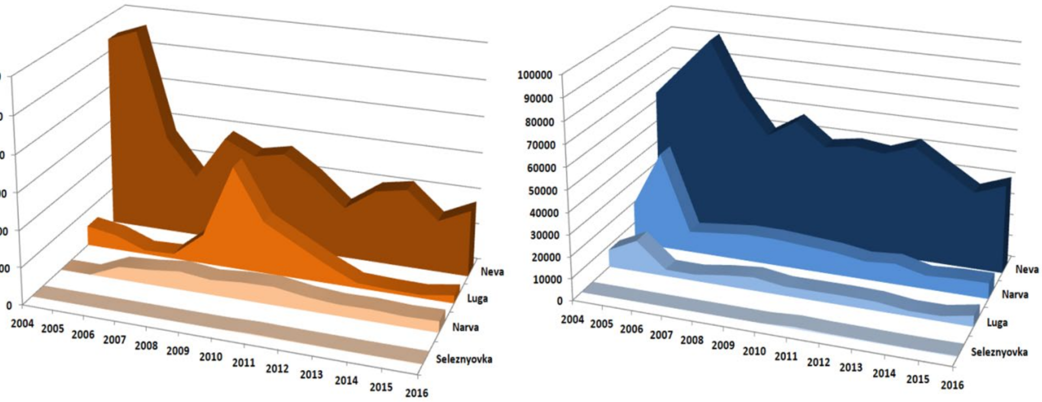

Figure 1 – Dynamics of phosphorus (left) and nitrogen (right) inputs into the Gulf of Finland with river flow from Russia (tons / year)

The Neva River has the largest drainage basin of all Baltic rivers: 281 600 km^2. The biggest part of the catchment belongs to Russia, but also a large area is in Finnish territory. According to the data of the Nature Management Committee of St. Petersburg [6], the input of nitrogen and phosphorus to the Gulf of Finland through the large arms of the Neva River in 2019 was evaluated as 41447 tons (N_{tot}) and 1665 tons (P_{tot}). At the same time, the intake of nitrogen and phosphorus from Lake Ladoga was 36000 and 1080 tons. The difference between these numbers shows us the contribution that is given: surface runoff, wastewater discharged directly into the watercourse, and, especially, the tributaries of the Neva River. Research work on the study of the state of small watercourses flowing on the territory of St. Petersburg is carried out extremely rarely. A number of works devoted to the eutrophication of the eastern part of the Gulf of Finland and the Neva River estuary can be noted [7], [8], [9]. Official information in the form of reports on the environmental situation issued by the Nature Management Committee of St. Petersburg [6] contains information on the hydrochemical regime of watercourses in 15 observation points, of which 8 are installed on small watercourses.The total catchment area of the tributaries is more than 85 % of the total catchment area of the Neva River.

Thus, the main aim of this study is to analyze the inputs of biogens into the Neva River with the waters of its tributaries.

2. Methods and Materials

Hydrochemical studies were conducted in July-August 2020 on several rivers within St. Petersburg: Okhta, Lubya, Okkervil, Slavyanka, Murzinka, Chernaya Rechka, Smolenka, Volkovka and Karpovka. The general environmental condition of all the studied watercourses can be estimated from «polluted» to «very polluted», however, a systematic study of the phosphorus and nitrogen concentrations is not carried out in these small rivers. Water samples were taken by a bathometer in each sample point according to [10] in small cans made of polymer material, while the transfusion of samples from the bathometer minimized the contact of water with air. The combined sample was formed from three point samples taken from a depth of 0.3-0.5 m in the middle of the riverbed and at an equal distance from both banks. The concentrations of phosphates, ammonium and nitrate nitrogen were determined by spectrophotometry in accordance with [11] and [12]. The mass flow rate was calculated using the formula:

$$Q = 0.0315 * C * F_{AA} \quad (1)$$

where: Q – mass flow rate (tons/year),
C – average concentration (ppb),
F_{AA} – average annual flow of river (m^3/sec).

4. Results and Conclusion

The results of the measurements and calculations are summarized in Table 1.

Table 1 – Results of chemical analysis of water and calculations of phosphorus and mass flow rates

River (point)	FAA, m3/sec	CP, ppb	QP, tons/year	CN, ppb	QN, tons/year
Okhta River (Chelyabinskiy bridge)	5.0	101.06	15.92	3441.29	542.00
Lubya River (mouth)	1.6	92.91	4.68	2620.86	132.09
Okkervil River (mouth)	0.5	237.98	3.75	10353.98	163.08
Okhta River (mouth)	7.2	111.17	25.21	9800.50	2222.75
Slavyanka River (mouth)	4.0	305.14	38.45	4957.96	624.70
Murzinka River (mouth)	0.2	101.06	0.64	792.58	4.99
Chernaya River (mouth)	0.1	10.43	0.03	2272.11	7.16
Smolenka River (mouth)	3.0	8.15	0.77	1943.94	183.70
Volkovka River (mouth)	0.5	41.40	0.65	4180.43	65.84
Karpovka River (mouth)	2.0	3.26	0.20	1573.62	99.14

It should be noted that only a part of the biogens, namely, orthophosphates, and some forms of inorganic nitrogen were determined. It does not give us a complete picture of the total content of biogens in the watercourses. In many rivers, the detected concentrations exceeded the maximum permissible concentrations for fishery water bodies, even if compared with the standards for eutrophic conditions.

Based on the results of the study it should be noted that the largest input of nitrogen into the Neva River is provided by the Okhta. However, the supply of orthophosphates is determined not only by the Okhta, but also by the Slavyanka. Other tributaries show a small contribution to the inputs of biogens due to low water flow, or due to low concentrations. The data obtained from the delta watercourses (Smolenka and Karpovka) allow us to draw conclusions about the distribution of nitrogen and phosphorus before its discharge into the Gulf of Finland. It should be noted that despite regular monitoring of the hydrochemical state of the Neva River by government agencies, the assessment of hydrochemical indicators of tributaries of the Neva River and small delta watercourses is not carried out effectively enough. Taking into account the instability of the hydrochemical regime under conditions of anthropogenic pressure from urbanized territories, this may lead to insufficient knowledge of the pollution of the estuary of the Neva River and the eastern part of the Gulf of Finland.

Conflict of Interest

None declared.

Конфликт интересов

Не указан.

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