The Ecological State of the Sosna River and Realization of the Regional Policy in the Area of Substantial Natural Resources Exploitation

I N Kondrashova¹, V I Tikhii¹, N N Kondykova¹ and N E Zakharov²

¹ Orel State University named after I. S. Turgenev, 95, Komsomolskaya Street, Orel, 302026, Russia
² Bryansk State Technological University of Engineering, 3, Stanko Dimitrov Avenue, Bryansk, 241037, Russia

E-mail: eco-kondrashova@yandex.ru

Abstract: This article focuses on the research and analysis of the ecological state of the Sosna River on the Orel region territory. The article provides a description of the Sosna which is a tributary of the Don River, as natural resources exploitation object, its ecological and hydrologic peculiarities are being described. The main anthropogenic sources, exerting an impact on the ecological state of the river are being studied. The ramifications of the Sosna water pollution by industrial and agricultural enterprises as well as by the local population are being analyzed. Measures for protection and enhancement of the Sosna waters ecological state are being proposed along with those suggested within a framework of the regional ecological policy implementation.

1. Introduction

There are few inviolate natural water systems left in the world. The problem of qualitative and quantitative water resources depletion due to the watercourse pollution and intensive consumption has become especially acute over recent decades [1].

Ecological rehabilitation of hydro objects appears to be one of the top priorities for rational natural resources exploitation, which is being implemented on the international scale, as well as on the federal and regional ones. One of the goals of the regional agenda in terms of sustainable development up to 2030, acclaimed in UNO back in 2015 is Clear Water and Sanitation (GSD6).

The federal project “Unique Hydro Objects Preservation” as part of the national project “Ecology” puts forward solutions to such problems as regeneration and rehabilitation of water objects, enhancement of the hydrographic network ecological state, a clean-up of the litter along the riverbanks and nearby rivers and lakes water areas, engaging the population into the cleansing of the water objects shoreline.

Regional programs also include goals in rational water resources exploitation with regard to their peculiarities, connected with their natural climatic and hydrological processes as well as with anthropogenic influence.
2. Materials and Methods
There are over 2100 rivers on the territory of the Orel region, which are referred to the basins of such rivers as the Volga, the Don and the Dnepr [2]. The river waters are used with multiple purposes: aquacultural, industrial, agricultural, commercial fishing, recreational and etc.

The growing anthropogenic strains against the background of climatic factors dynamics lead to the rivers ecological state and their ecosystems alteration. In view of this, carrying out the water objects ecological monitoring, especially for rivers with the aim of their further protection and rehabilitation measures development, acquires particular significance.

The research of the Sosna on the territory of the Orel region was carried out in 2016-2019. In the course of it, a visual inspection and the river bed description and water conservation zone were performed. The ecological state of the river was assessed according to the integrated score: water pollution index (WPI) and chemical pollution index ($\text{CPI}_{10}$). The calculations for indexes were carried out according to the universally accepted “Methodology of the Eco-Aquicultural Assessment of the Water Resources”. The WPI is widely used by various researchers as a means of a complex informative assessment, allowing to divide the qualitative surface water content into seven classes depending on their pollution level [3-4]. In accordance with the numbers for WPI the natural water is divided into seven classes: I - extremely clean (WPI less than 0.3), II - clean (0.3- 1.0), III - moderately polluted (1.0 - 2.5), IV - polluted (2.5 - 4.0); V - foul (4.0 - 6.0); VI - very foul (6.0 - 10.0); VII - extremely foul ( over 10.0). For background conditions for $\text{CPI}_{10}$ equals or approaches 1, the crisis situation is characterised by the range $1 < \text{CPI}_{10} < 10$, when there is a catastrophic situation (ecological disaster) $\text{CPI}_{10} > 10$.

3. Results
The Sosna River, which starts on the territory of the Orel region, is the right-bank tributary of the Don. Its headstream is situated near the settlement called Fedorovka in the Pokrovsky district. The total length is 296 km, including 191 km in the Oryol region. The acreage of the catch basin is $17400 \text{ km}^2$.

The river lets in a number of stream tributaries such as Bolshaya Chernava, Vorgol, Yelchik, Kshen, Livenka, Luchok, Tim, Olym, Trudy, Yasenek and etc.

The Sosna is referred to the East European type of the water regime, which is characterized by spring high water, summer-autumn and winter ( during thaws) flooding. The maximum discharge rate for spring high water has dropped over the last few years due to the winters having a small amount of snow and not exceeding 1000 $\text{m}^3/\text{s}$. The river inflow is mostly snow and springs. The key role in forming the river flow and its genetic constituents performs, above all, the climate, which is primarily connected to the changes of specific and absolute river flow characteristics over the last decades [5]. On the whole, global warming has led to alteration of the conditions for the river flow and water resources in the basin of the Don, and also to a substantial transformation of the river water regime [6]. Given current mild winters and frequent cases of temperatures exceeding 0 °C an increase in rainfall can be observed [7].

The river runs in the eastern direction. It is characterized by a canyon-like valley. The width of the valley varies between 0.5 to 1.5 km. The flood-plain of the river is rather narrow. In low water season, the width of the Sosna is 40-50 m, the depth is no more than 5 m. The river flow velocity is 0.2 -0.8 m/s. In the lower part of the river sand and silty mud prevail in the channel deposits. The river bed is winding, there are reaches, rifts, small islets and deep places.

The headstream of the Sosna is located in the forest area among steep banks. Here its width does not exceed 2 meters. The riverbed is muddy. The stream is slow and smooth. The water conservation zone has a radius of 200 meters. Along the entire length of the Sosna the abrasion and landslide processes and crumbling of the banks can be observed, the banks are overgrown with either shrubs or bushes or with meadow vegetation.

The riverbed, especially in the upper stream, is overgrown with hydric or hydrophilous vegetation. Various kinds of fish typical for other rivers of the Don basin populate its waters: the pike, the burbot,
the bream, the tench, the perch, the nase, the pike-perch, the ide, the chub, the roach, the bleak and etc. Some banks bear the witness to beavers’ activity.

4. Discussion
The waters of the Sosna are mostly used for the following purposes: for the water supply of sectorial industrial and agricultural enterprises, for fish-farming, and for recreation. However, the utilization of the ground waters in the Orel region exceeds the usage of the surface waters.

Downstream, there are a few dams built and small water storage reservoirs created. For instance, there is a water storage reservoir 0.038 km in the vicinity of the village Dyukovskaya. In the settlement Verhososenye 1, another reservoir 2 km in length and up to 200 m in width is situated, which is called Lake Sosna by the locals. It has a vital role in amelioration and recreation.

The main sources of anthropogenic influence on the ecological state of the river Sosna within the Orel region are agricultural and industrial enterprises, especially LLC “Livny Sakhar” and ZAO “Sugar Plant “Kolpnyansky”.

As a result of sheet floods, fertilizers and pesticides from the farmlands are washed into the waters of the Sosna. Besides, in winter, the snow with chemicals after the roads cleanup is quite often dumped on the slopes of the river banks (such cases have been recorded on a number of occasions near the settlement Yamskoy, the Livny district), thus, when it starts melting in spring, the toxic components get into the river.

Apparently, the first major pollutant along the Sosna stream is the ZAO “Sugar Plant “Kolpnyansky” which is included in top-10 sugar plants in Russia in terms of the amount of sugarbeet processed during the season. The plant performs water intake from the river and dumps the wastes into it. The cases of mass fish kill (asphyxiation, occurring as a result of oxygen level decrease in the water) on the stretch of the river running through the Kolpna district, are, unfortunately, a recurring issue. The reason for that is the clean-contaminated waters, used for the cooling of the machinery and dumped into the river, as well as waters without proper cleansing (partially clean water) from TPP of the same enterprise. The suspended load of the water in the industrial waste dumping spots is increased; an unpleasant stench is also present.

LLC “Livny Sakhar” has been dumping its waste into the Sosna over the past years as well. Given that the enterprise is being currently modernized, and, therefore the production capacities are growing, the amount of waste is increasing as well. Recently, a pipeline from the plant to the river has been laid (it does not have a complete structure from all the way from the plant to the river so in some places the stream runs on the surface) which is used to dump unrefined sewage into the river. It is worthy of note that, the sewage water continues to run into the river in some places on the surface. The foul smell filling the air is not the limit. Occasionally, as a result of wastewaters contamination, a mass fish kill takes place.

The regional office of ecological monitoring and exploitation of natural resources carries out occasional tests of the river water, the results of which indicate that the highest concentration of the harmful substances exceeds the limits. Not once has there been recorded excess concentration of the ammonium nitrogen, nitric nitrogen, petrochemicals, phenols, phosphates, iron, cupric and etc. The ground of the river is quite often covered in slime. As a result, where the waste dumping from the plant takes place the degree of contamination of the water in the Sosna is qualified as “polluted”, and during the period of active sewage dumping - as “very polluted”. Sometimes the enterprise receives hefty fines. Namely, in summer 2018 the court sustained the claim of the nature protection prosecutor about the compensation of damage caused by LLC “Livny Sakhar” as a result of sewage waters dumping into the river Sosna (the lawsuit of damage compensation in the amount of 1.92 million of rubles).

In 2016-2017 we carried out a research of the qualitative content of the Sosna waters in two fixed checkpoints in the vicinity of Livny: the first - 7 km above, the second one 4.5 km below the town. The acidity, dissolved oxygen, suspended substances, BOD₅, COD, sulphates, nitrate nitrogen, nitric
and ammoniac nitrogen, phosphates, calcium and magnesium ions, total iron and other nutrients, as well as phenols, pesticides, heavy metals, petrochemicals and other contaminating substances.

The water samples collected at the test point above the town revealed the excess of LOC for cupric, \( \text{BOD}_5 \), COD and ammoniac nitrogen. The town of Livny appeared to be the main effluence source for nearly all substances tested. An increased concentration for ammoniac nitrogen (1.1 times), nitrate-nitrogen (1.15 times), phosphates (1.3-1.5 times), sulphates (1.16 times), petrochemicals (1.2 times), total iron (1.4 - 1.75 times), cupric (2.0-2.2 times), and also for COD (1.1 times) was discovered.

The accumulation of the enumerated chemical substances enables their further transition to the waters of the Don and then, transferring of those biogenic elements to the Azov Sea [9].

The values for WPI for the Sosna waters which were flowing into Livny in 2016 reached the point of 1.07 (moderately polluted waters) but in 2017 it was 0.94 (clear waters), while outside the town limits downstream the results appeared to be the following: 1.35 and 1.15 respectively, thus signifying moderately polluted waters.

In 2016 the values for CPI\(_{10}\) at the monitoring section above Livny reached 7.52, and below the town - 9.8, which indicated a crisis situation. In 2017 the results were slightly lower, the same could be said for WPI and amounted to 6.91 and 8.74 respectively, which still allowed evaluating the situation as a crisis. Thus, the contribution of Livny into the deterioration of the Sosna waters quality was proved.

Significant damage is also done by ploughing the soils in water conservation zones in the river valley. For instance, LLC “Rainland” (the Kolpna district) committed ploughing of the shoreland protective belt of the Sosna in the vicinity of the village Khutor-Lomovoe. Only the intervention of the interdistrict natural protection public prosecution office stopped this violation.

A notable damage to the ecological state of the Sosna is inflicted by the illegal sand and crushed rock extraction in the shoreline area and from the river ground (a similar case occurred close to the village Vasilievka in the Livny district and was exposed by a local newspaper “Uyezdnuy Gorod” in their article “The Golden Sand of the Sosna”). As a result, the relief of the ground is changing because in the extraction area deep pits, filled with water, appear and consequently, the overall water line drops and the river becomes shallow. Apart from that, living and spawning conditions for fish seriously deteriorate; the death of juvenile fishes is a frequent matter, which might ultimately lead to extinction of some fish species. Besides, there is a livestock farm situated in the shorelland protection belt near the village Viktorovka. The aforementioned facts lead to worsening of the ecological situation along the river banks.

On the outskirts of Livny on the right bank of the Sosna next to the Gornostaevka settlement on the barrow Uderev there is a stone quarry, the part of which belongs to the water conservation zone. The quarry is currently disused, it is an object of historical significance as it represents a classical outcrop of limestone dating back to Upper Devonian formation, rich in fossilized remnants of the ancient Devonian flora and fauna.

The population of the area have their own contribution to the Sosna water pollution. There are vegetable patches and allotment gardens along the river banks, including the water protection zones, cattle and poultry grazing takes place as well. Near the settlement Retchitsa downstream in the water conservation zone there is a functioning cemetery.

Due to human activity the littering of the Sosna banks and slopes with various wastes (including animal carcasses) occurs. There are domestic waste landfills near the settlements Verhosenye 1, Gubkino, Andreevka, Kartashovka, Timiryazevka and etc. An annually organized campaign in refuse collection called “Clean Riverbank” has a local scale and has not contributed greatly to ecological education of the inhabitants.

It is quite comforting that the present adverse situation forced people to implement certain measures. In particular, in 2021 preparatory works for ecological rehabilitation (clearing) of the Sosna stretch within Kolpna are due to begin. The clearing presupposes elimination of the bottom deposits and aquatic vegetation from the river bed. The works have been scheduled for 2021-2024.
This project is just a part of the work in terms of the national project “Ecology” in the course of realization of its federal scheme “Unique Water Objects Conservation”. Its lion share focuses on the neighboring Lipetsk region where it is planned to clean the 8.5 km sweep of the Sosna starting from the headstream of the river Olym. The project realization will create necessary prerequisites for rural territories recreational development.

In the course of the project preparation, which is financed from the federal budget, a design estimate documentation has already been prepared and archeological research has been carried out. It is vital to complete engineering-geological, engineering-hydrometeorological, engineering-geodesic and engineering-ecologic site investigations. Such a complex approach to natural environmental conditions research will allow us to find the utmost effective project solutions. Then, a state expertise will be carried out, the project has to be approved by the Federal Water Resources Agency, which will issue the decision, permitting it to assign federal money.

5. Conclusion
The research has revealed that the upper stream of the river is more polluted. It is common for other rivers, the headstreams of which are located in the Orel region, the Oka for instance. Besides, they share common pollutants like cupric, nitrite nitrogen, organic substances (based on the BOD$_5$ and COD) [1-2; 5; 7].

The discovered facts prove that complex measures for the river banks protection from flooding and wash-out are required. More over, it is important to recover minor streams in the river valley, sustain the depths on certain stretches of the riverbed, and do work aimed at clearing and recovering the drainability of the river.

In view of providing ecological safety and conservation the biodiversity of the Sosna it is required to continue the modernization of the already existing and construction of new objects like storm water runoff like and purification plants in major settlements (the town of Livny, urban-type settlement Kolpna and etc).

It must be noted that it is necessary to review the existing Russian sanitation and hygiene standards, as they do not guarantee ecological well-being of the water resources, which degrade and lose their resource value [8-10].

It is obvious that without solving the aforementioned problems there will be further deterioration of the river ecological state and significant decrease in its recreational potential, which, in the long run, will have a detrimental effect on the quality of life of the population living in the designated part of the region.

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