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## THE INFLUENCE OF THE QUALITY OF FLOWING WATERS ON FRESHWATER ECOSYSTEM SERVICES ON THE EXAMPLE OF THE LEŚNA PRAWA RIVER

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### WPŁYW JAKOŚCI WÓD PŁYNĄCYCH NA ŚWIADCZENIA EKOSYSTEMÓW WODNYCH NA PRZYKŁADZIE RZEKI LEŚNA PRAWA

**STRESZCZENIE:** Ekosystemy mogą spełniać swoje funkcje pod warunkiem utrzymania odpowiedniej jakości ich komponentów. Ekosystemy powiązane są ze sobą siecią silnych zależności i powiązań. Istotną rolę odgrywają zwłaszcza ekosystemy wodne. Zanieczyszczenie wód powoduje zmiany nie tylko w samym zbiorniku lub cieku, lecz także w otaczających go ekosystemach lądowych, w tym także leśnych.

W artykule zaprezentowano wpływ zmian jakości wód rzecznych na świadczenia ekosystemu wodnego na przykładzie rzeki Leśna Prawa przepływającej przez obszar Puszczy Białowieskiej. Walory przyrodnicze Puszczy Białowieskiej są niepowtarzalne. Bogactwo fauny i flory, unikatowe na skalę światową sprawia, że z jej walorów korzystają nie tylko okoliczni mieszkańcy ale także turyści z całego świata. Niewiele osób jednak zdaje sobie sprawę z wartości świadczeń ekosystemów i z tego jak maleją wraz z postępem procesów niszczenia ekosystemów. Świadomość ich utraty jest często niezauważana lub bagatelizowana przez lokalne władze.

W artykule przedstawiono wyniki badań jakości wód rzeki Leśna Prawa. Zła jakość wód wpływa nie tylko na utratę korzyści płynących z usług podstawowych rzeki, ale również z kulturowych.

**SŁOWA KLUCZOWE:** świadczenia ekosystemów, jakość wód powierzchniowych, rzeka Leśna Prawa

## Introduction

Ecosystem services refer to the benefits which the society or economy can obtain from the environment. The environment then becomes an important partner for the authorities on various levels regarding the decision-making process for planned investments<sup>1</sup>. The proper management of such services should therefore be in accordance with the rules of balanced development, achieving mutual benefits, for the environment as well as for the economy<sup>2</sup>.

Contemporary literature divides ecosystem services into four categories:

1. Provisioning – these are all the products obtained from the environment (food and fibres, fuel, genetic resource, biochemical substances, natural medicine and pharmaceuticals, food additives, decorative materials).
2. Regulating – encompassing all the benefits obtained from regulation the processes occurring in ecosystems (maintaining proper air quality, climate regulation, water regulation, erosion control, water and sewage treatment, biological control, pollination).
3. Cultural – focusing on the non-material benefits resulting from the contact of humans with nature such as: spiritual enrichment, reflection, recreation, aesthetic experiences.
4. Supporting – necessary for the functioning of all other elements of the ecosystem, ensuring living space for plants and animals, and also maintaining their diversity. It differs from services in the fact that its influence on people is indirect and occurs in a very long period of time, whereas changes in the other categories have a direct and short-term effect on people. An example of such a basic service can be the production of atmospheric oxygen, or the circulation of nutrients<sup>3</sup>.

The two last services are especially important in areas of unique natural values which at the same time are a source of income to the local community. Despite the fact that the idea of ecosystem services in the world had its beginnings in the 1960s, its use in Poland has begun quite recently. The low awareness of our governing bodies of the cooperation of the economy, environment and society, which is the basis for balanced development, causes not only significant financial losses, but also losses in the natural environment. One of the elements of the environment, especially sensitive to changes and pollution are aquatic ecosystems. The main source of water pollution is human activities. Among the anthropogenic sources, the most important are: unregulated water-waste economy (point sources), surface and groundwater runoff from agricultural areas (area sources–

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<sup>1</sup> J. Kronenberg, T. Bergier, K. Maliszewska, *Usługi ekosystemów jako warunek zrównoważonego rozwoju miast – przyroda w mieście w działaniach Fundacji Sendzimira*, in: M. Kosmala (ed.), *Miasta wracają nad wodę*, Toruń 2011, p. 279-285.

<sup>2</sup> J. Kostecka, *Edukacyjne znaczenie pojęcia świadczenie ekosystemów dla ochrony awifauny miast*, „Inżynieria ekologiczna” 2010 no. 22, p. 34-42.

<sup>3</sup> MEA, *Ecosystems and Human Well-being*, A Report of the Conceptual Framework Working Group of the Millennium Ecosystem Assessment, 2003, p. 49-70.

crop protection chemicals, animal excrement), atmospheric pollution (dry and wet deposition)<sup>4</sup>. While it can be hard to assess the losses in the environment and the spreading of pollutants from area and atmospheric sources, point sources are fairly easy to locate and remove, on condition that appropriate repair systems are planned and introduced.

## The quality of the Leśna Prawa river and the ecosystem services

The values of the Białowieża Forest are known all over the world. First of all it is the only complex of lowland forests in Europe, which has preserved its natural character. It is a refuge for many rare species of fungi, plants and animals<sup>5</sup>. The loss of any element of this ecosystem would infringe on the biotic and abiotic environment of the Forest. The area of the Białowieża Forest is covered by a thick network of watercourses. One of them includes the Leśna Prawa river, which is a right tributary of the Bug river. A large part of the Leśna Prawa river, along with its source, lie in the territory of Poland (approx. 33 km), the remaining part (approx. 30 km) lies on the Belarussian side. The river flows through the town of Hajnówka, and further down into the area of the Białowieża Forest. The river bed up to the border with Belarus is characterised by shallow depths (from 0.5 to 1.5 m) and widths (from 0.5 to 6 m). The municipal character of the river, the discharging of treated waste from the municipal waste treatment facility, the vicinity of agricultural areas and its lowland character, result in an almost complete lack of flow (0.5 m<sup>3</sup>/s) and mixing of waters causing the river waters to be of low quality.

In order to assess the influence of water quality of the Leśna Prawa river on the possibility of providing services by this ecosystem, studies were conducted in 2012 on water samples from 6 locations. The first location was set outside the town of Hajnówka to determine the influence of a rural habitat, including the water-waste economy. The remaining 5 locations were in the area of the Białowieża Forest. The water was analysed for concentration levels of ammonia nitrogen, nitrate nitrogen, total phosphorus and the content of dissolved oxygen. The studies were conducted in spring: May, June, July and autumn: October, November, December.

As the research shows, the low quality of waters is mostly caused by an increased concentration of biogenic compounds—phosphorus compounds, ammonia nitrogen, and a low amount of dissolved oxygen. According to the Water Framework Directive, the quality of surface waters in Member States of the European Union should reach a good level until 2015. The improvement needs to be both in the chemical and ecological state. The ecological state includes the quality

<sup>4</sup> A. Jarosiewicz, *Proces samooczyszczania w ekosystemach rzecznych*, „Słupskie Prace Biologiczne” 2007 no. 4, p. 27-41.

<sup>5</sup> G. Rąkowski, *Przyrodnicze i kulturowe walory Puszczy Białowieskiej*, „Ochrona Środowiska i Zasobów Naturalnych” 2010 no. 42, p. 276.

of structure and functioning of the surface water ecosystems, classified through analyses using biological, physiochemical and hydromorphological factors<sup>6</sup>. The decision whether a given watercourse falls into the good, average or bad category is based on the results of individual analyses mentioned above, the rule being that the awarded class corresponds to the lowest result value. The classification of physiochemical elements is based on assigning to each analysed indicator to a class through comparing their characteristic values with borderline values. There are two classes:

- class I refers to a very good condition,
- class II refers to a good condition,
- not fulfilling the requirements of class II refers to a physiochemical state below good<sup>7</sup>.

River waters can potentially provide all four types of ecosystem services. However, this is conditioned by the quality of the waters. As mentioned earlier, an ecosystem which is too polluted has limited possibilities for potential uses. The waters, which physiochemical parameters do not fall into any of the classes i.e. did not reach a good condition, lose the possibility to provide the majority of ecosystem services. The conducted analyses of the selected pollutants in the Leśna Prawa river show that the waters of this river are below a good physiochemical condition. It is especially visible in the first measurement location outside the town of Hajnówka, in village Sacharewo. All of the studied parameters exceeded the values attributed to the very good and good conditions of waters (Figure 1, 2, 3). In the remaining research locations the concentration of the analysed compounds did not exceed class II of water purity, which is an indicator of the ability of the river waters to self-purify, provided the pollution from the rural area is eliminated. Therefore the possibilities of utilizing the waters of the Leśna Prawa river are very limited.

One of the most important aquatic ecosystem services are the resource services. Potentially, every water course could provide such services. However, currently many surface waters cannot provide such service due to their bad quality. The Leśna Prawa river has no drinking water intake stations. This article however assesses the potential possibility of the analysed river to fulfil the drinking water provision function.

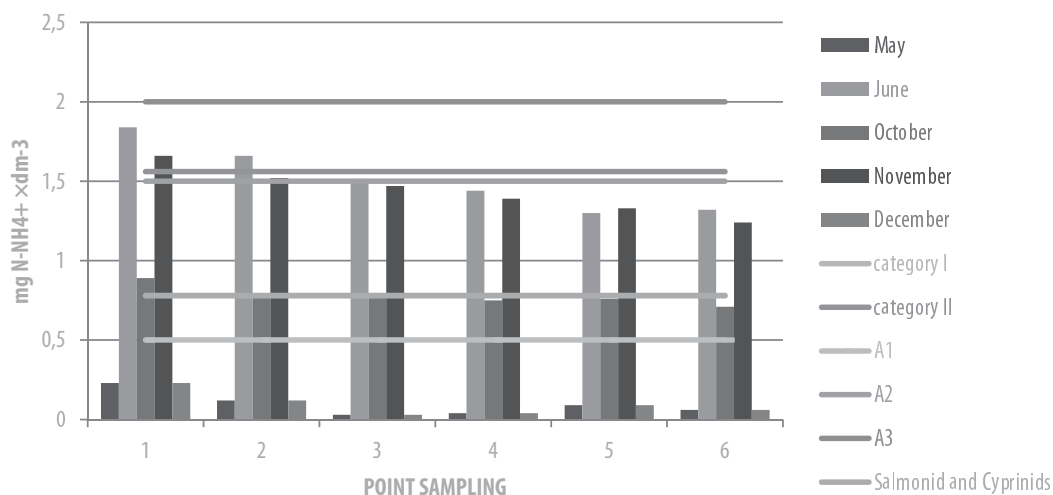
For these ecosystems its mainly the function of providing drinking water. In the case of surface waters used to provide people with water for consumption there are 3 categories of usefulness, which are:

- category A1 – waters requiring only basic physical treatment through filtration and disinfection,

<sup>6</sup> Dyrektywa 2000/60/WE Parlamentu Europejskiego I Rady z dnia 23 października 2000 r. ustanawiająca ramy wspólnotowego działania w dziedzinie polityki wodnej.

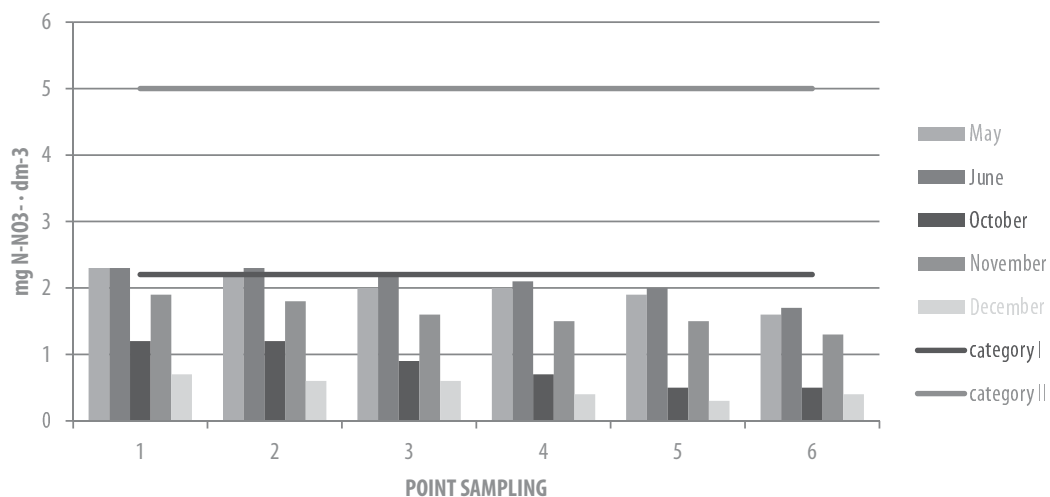
<sup>7</sup> Rozporządzenie Ministra Środowiska z dnia 9 listopada 2011 r. w sprawie sposobu klasyfikacji stanu jednolitych części wód powierzchniowych oraz środowiskowych norm jakości dla substancji priorytetowych.

Figure 1  
Concentration of ammonia nitrogen in the waters of the Leśna Prawa river



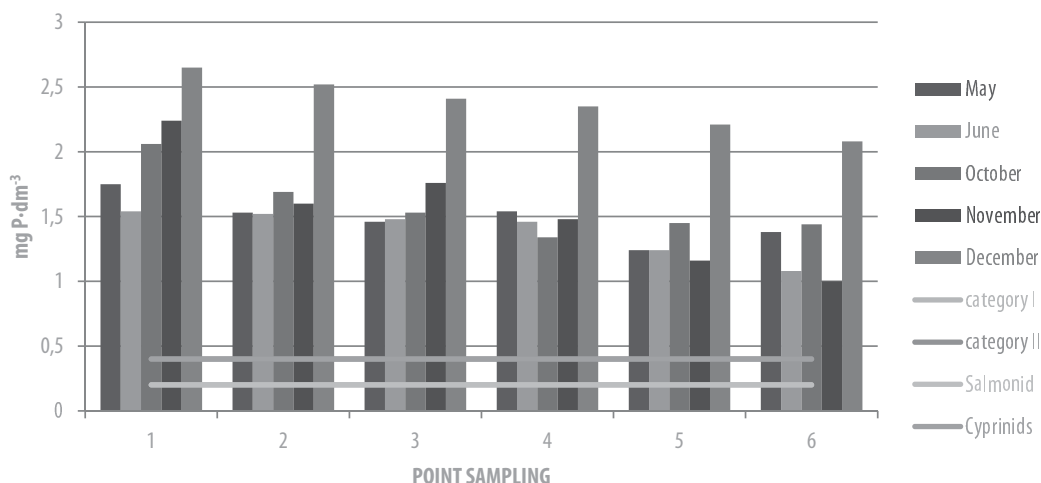
Source: own interpretation based on B. Mikucki, „Analiza chemiczno-hydrologiczna rzeki leśnej na przykładzie Leśnej Prawej”, Praca dyplomowa inżynierska, Hajnówka 2013.

Figure 2  
The concentration of nitrate nitrogen in the waters of the Leśna Prawa river



Source: own interpretation based on B. Mikucki, „Analiza chemiczno-hydrologiczna rzeki leśnej na przykładzie Leśnej Prawej”, Praca dyplomowa inżynierska, Hajnówka 2013.

Figure 3  
The concentration of total phosphorus in the waters of the Leśna Prawa river



Source: own interpretation based on B. Mikucki *Analiza chemiczno-hydrologiczna rzeki leśnej na przykładzie Leśnej Prawej*, Praca dyplomowa inżynierska, Hajnówka 2013.

- category A2 – waters requiring typical physical and chemical treatment, especially initial oxidation, coagulation, flocculation, decantation, filtration and disinfection (chlorination),
- category A3 – waters requiring highly effective physical and chemical treatment, especially oxidation, coagulation, flocculation, decantation, filtration, adsorption on active carbon, disinfection (ozonisation, chlorination)<sup>8</sup>.

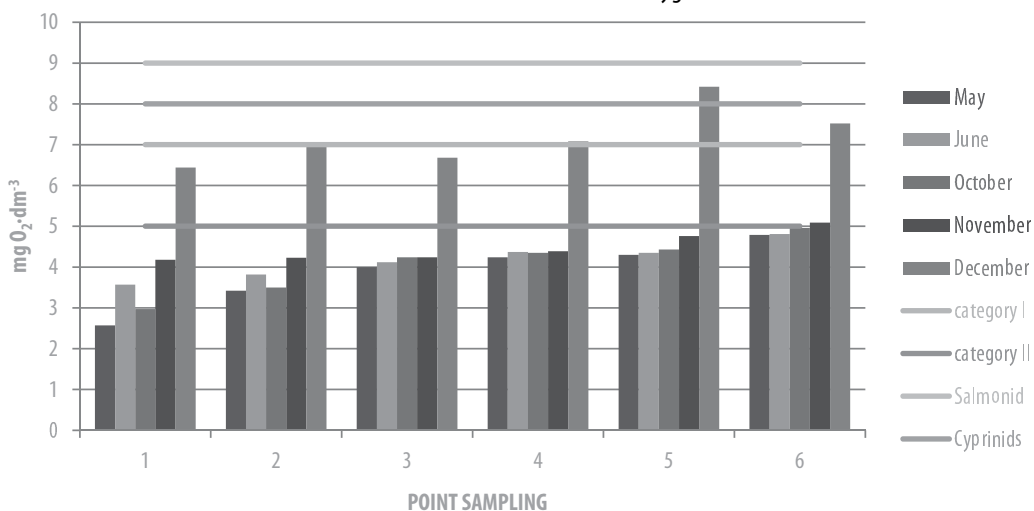
The studies of the Leśna Prawa river show that the amount of nitrate nitrogen in all analysed locations was within the A1 range (recommended 25 mg·dm<sup>-3</sup>), while the amount of ammonia nitrogen in most analysed locations was within the A2 category. Meanwhile, the amount of dissolved oxygen was within the A3 category. It can be stated, that the waters of the analysed river potentially do not meet the requirements of directly fulfilling the provisioning service.

The river also does not provide appropriate environment for fish. None of the analysed parameters of water pollution did not fulfil the requirements necessary for neither salmonidae nor cyprinidae to live in. The ecosystem of the Leśna Prawa river cannot, therefore, provide yet another provisioning service, namely the possibility of obtaining fish resource.

Due to the nature values of the area through which the river flows, cultural services are an extremely important element of the ecosystem services.

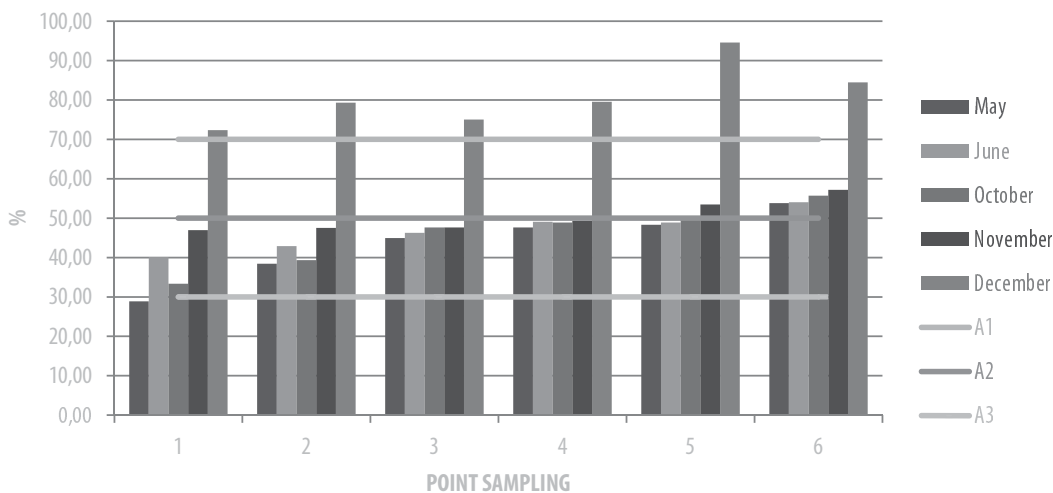
<sup>8</sup> Rozporządzeniem Ministra Środowiska z dnia 27 listopada 2002 r. w sprawie wymagań, jakim powinny odpowiadać wody powierzchniowe wykorzystywane do zaopatrzenia ludności w wodę przeznaczoną do spożycia (Dz.U. 2002 nr 204 poz. 1728).

Figure 4  
The concentration of dissolved oxygen in the waters of the Leśna Prawa river



Source: own interpretation based on B. Mikucki „Analiza chemiczno-hydrologiczna rzeki leśnej na przykładzie Leśnej Prawej”, Praca dyplomowa inżynierska, Hajnówka 2013.

Figure 5  
Level of oxygen saturation of the waters of the Leśna Prawa river



Source: own interpretation based on B. Mikucki „Analiza chemiczno-hydrologiczna rzeki leśnej na przykładzie Leśnej Prawej”, Praca dyplomowa inżynierska, Hajnówka 2013.

The Leśna Prawa River provides cultural services to the local community based on intangible benefits like recreation, aesthetic experiences and communing with nature. A bike path Hajnówka – Orzeszkowo – Hajnówka (blue 42 km), Nordic walking path around Sacharewo (red 11 km) and a narrow gauge railway line run through the river valley. The loss of such service would directly affect the village of Sacharewo especially, through which the river flows. In the time of research on water quality, the bad state of the waters could be stated even organoleptically. The water had a smell of raw sewage and lacked clarity. A survey conducted by direct interview the people of Sacharewo, clearly showed that the water quality of the Leśna Prawa river adversely affects providing cultural services. All persons of the respondents agreed that the quality of the waters of the Leśna Prawa River influences on their esthetic feelings (13 persons), 10 people do not use the waters of the river for recreational purposes (3 persons had no opinion).

Such conditions did not allow the people of Hajnówka and Sacharewo to use the area in the vicinity of the river for recreational purposes or family leisure time. The above mentioned tourist paths also run through the town. The bad condition of the river waters diminished the attractiveness of the area and was partly responsible for the limited ability of providing cultural services by the river. The potential of the analysed river in the direction of such ecosystem services cannot be fully utilised as well. The bad water quality causes the decline in the attractiveness of the area to people wanting to admire natural landscapes, or to fishermen. Kayak tourism or bathing are not possible either. The transboundary nature of the river makes that loss of cultural services affect not only the people of the Polish side, but also Belarusian. Poor water quality in terms of chemical indicators was confirmed by Regional Inspectorate of Environmental Protection in Białystok in profile Topiło near the border with Belarus. It can make the cultural benefits consisting in the use of the river for tourism purposes (kayak trail Kamieniuki-Brześć) will be also limited.

The conducted analysis of the river's waters show that, also in areas of high natural values, they do not fulfil the conditions which would allow to take full benefit of the ecosystem services.