MIDDLE POMERANIAN SCIENTIFIC SOCIETY OF THE ENVIRONMENT PROTECTION
ŚRODKOWO-POMORSKIE TOWARZYSTWO NAUKOWE OCHRONY ŚRODOWISKA

Annual Set The Environment Protection
Rocznik Ochrona Środowiska

Volume/Tom 20. Year/Rok 2018 ISSN 1506-218X 887-904

Influence of Catchment Use on the Degree of River Water Pollution by Forms of Phosphorus

Małgorzata Wojtkowska, Damian Bojanowski
Warsaw University of Technology

1. Introduction

Contamination in surface waters is common, due to the tremendous human impact on the natural environment. Currently, it is very difficult to determine, what content of particular chemical compounds in water reservoirs can be considered as natural, therefore as contamination are considered substances in such quantities, in which they can potentially be a threat to ecosystems or humans. These are mostly soluble in water substances, organic or mineral origin, occurred in chemical compounds or less frequently in unbounded elements. Some of them undergo transformations in water and changes their chemical character or oxidation state (Ribeiro et al. 2014).

One of the most important element, which gets into the water, as a consequence of human activity is phosphorus (Palanisamy & Parthasarathy 2016). Phosphorus naturally occurs in mineral forms, mainly as apatites ($Ca_5(PO_4)_3OH$), but also as strengite ($Fe(PO_4)\cdot 2H_2O$) ($Ca_3(PO_4)_2$), vivianite ($Fe_3[PO4]_2\cdot 8H_2O$) and berlinite ($AlPO_4$) (Pagliari et al. 2017). Those minerals are used as a source of phosphorus in fertilizers. Natural source of phosphorus in waters, is decomposition of organic matter and also erosion from minerals and soils. It occurs in living organisms cells, as an important component of nucleotides (compounds of phosphoric acid, nitrogen bases and carbohydrates: ribose and deoxyribose), which are main component of nucleic acids compounds as DNA and RNA. Another important nucleotide is adenosine triphosphate (ATP), the universal unit of intracellular energy transfer in living cells. It

is also occurred in vertebrate cells as tricalcium phosphate in about 60% of bone mass. It is natural part of proteins and in consequence of transformations of organic compounds, it circulates between living organisms and non-living matter (Mackey 2009).

Rivers as a specific type of surface waters, among the typical characteristics for watercourses, also have features which belong only to them. Water flow speed have influence on mixing water in whole river profile, on increasing erosion of soils through which the river flows and lower threat of eutrophication in comparison to lake waters. Rivers are also able to transfer contamination on long distances, especially those which are not reduced in self-cleaning processes ex. heavy metals (Zieliński & Jekatierynczuk-Rudczyk 2015, Krasowska & Banaszuk 2011).

The most important parameter influencing the increase of phosphorus amount in rivers is density of population. Human activities cause the increase of concentration of all forms of phosphorus in surface waters (including rivers), where they get into with wastewater, in which important source of phosphorus are detergents and other surfactants (Nedwell et al. 2002).

Surfactants which are used in detergents and other cleaning products, are the following source of phosphates in water. In detergents surfactants are used as extender to increase efficiency in binding divalent cations and to maintain proper pH. Phosphates in detergents usually occurs in the forms of: sodium triphosphate, sodium pyrophosphate, sodium silicate, sodium sulfate. Amount of surfactants could reach 15-20% of the mass of detergent, in particular cases even 50%. Currently, the amount of phosphates in surfactants is being reduced (UC 2002, 2003).

Nowadays the main source of phosphorus in surface waters is discharge of communal and industrial wastewater and elution from fertilizers (agriculture runoff) (Czechowska-Kosacka 2016). In domestic wastewater amount of phosphorus may occur 2-8 g/l, wherein human within a day excrete about 1.5 g of phosphorus. In fertilizers amount of phosphorus may be miscellaneous and it is assumed that average loss in fertilizing are 0.1-5%. Amount of phosphorus which is eluded from soils and goes to watercourses is about 0.05-1 mg/l. This amount may be higher, depending on amount and type of used fertilizer. The considerable amount of phosphorus may be contained in waters which flows through forested areas which can occur even 0.25 mg/l of phosphates.

Phosphates may occurs in water in soluble or insoluble forms. Phosphorus occurs in water mainly as orthophosphates ($H_2PO_4^-$, HPO_4^{2-}, PO_4^{3-}). Surface waters occurs also condensed forms of phosphorus – polyphosphates and metaphosphates which creates through connection of orthophosphates (Haygarth et al. 1998). Intensity of transformations of phosphorus compounds in water environment depends on many factors. The concentration of phosphorus is variable over time. The highest concentrations shall be observed in lower temperature seasons and insolation: winter, spring and autumn; the lowest in the season of most intense vegetation, which is summer. In summer the highest concentration of phosphorus is observed in the bottom area and sediments. In clear surface waters concentration of phosphorus is very low (Gomez et al. 1999, Kentzer 2001).

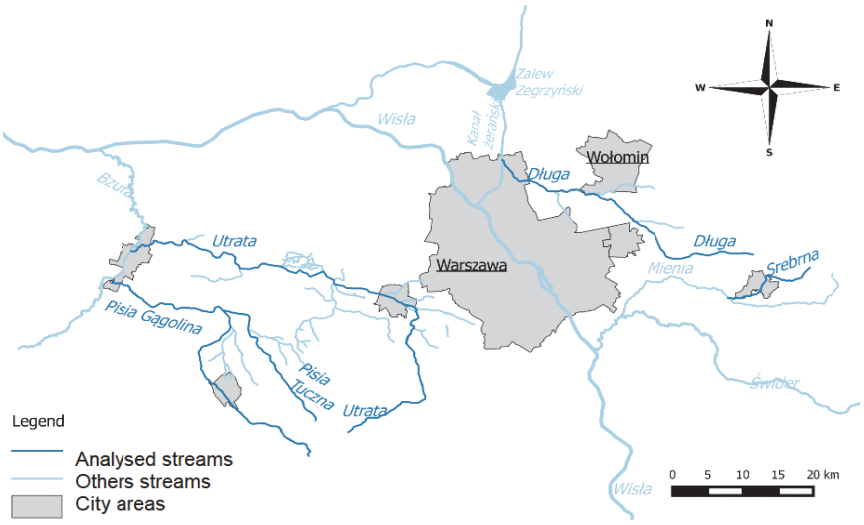
As a part of organic matter phosphates are important for development of living organisms, both terrestrial and aquatic. The deficiency of phosphorus shall be supplemented by correct fertilizing. It is observed to supplement phosphates to water to reduce its corrosivity and ability to precipitate iron and calcium salts. The excess of phosphorus carries a threat of eutrophication. In case, where relation of concentration of nitrogen and phosphorus is lower or equal to 14:1, the phosphorus is the factor which limits the growth of algae. That is why concentration of phosphorus is limited in surface waters. It is assumed that 1 mg of phosphorus which is introduced to environmental, leads to growth of 100 mg of algae dry weight (Dodds & Smith 2015, Dojlido 1995).

Polish legal standards do not establish the limits of phosphates concentration in drinking water, however in treated wastewater limit is 1 mg P/l. For watercourses the limit of concentration of phosphates depends on water class and type of watercourse, and it fits between 0.005-0.065 mg P/l for class I water, 0.026-0.101 mg P/l for class II water (ortophospahes) and 0.03-0.2 mg P/l for class I and 0.14-0.4 for class II (total phosphorus). For standing waters the limits are mainly 10-times lower, which is caused by lower ability to self-cleaning and threat of eutrophication (Journal of Laws of 2014, Item 1800).

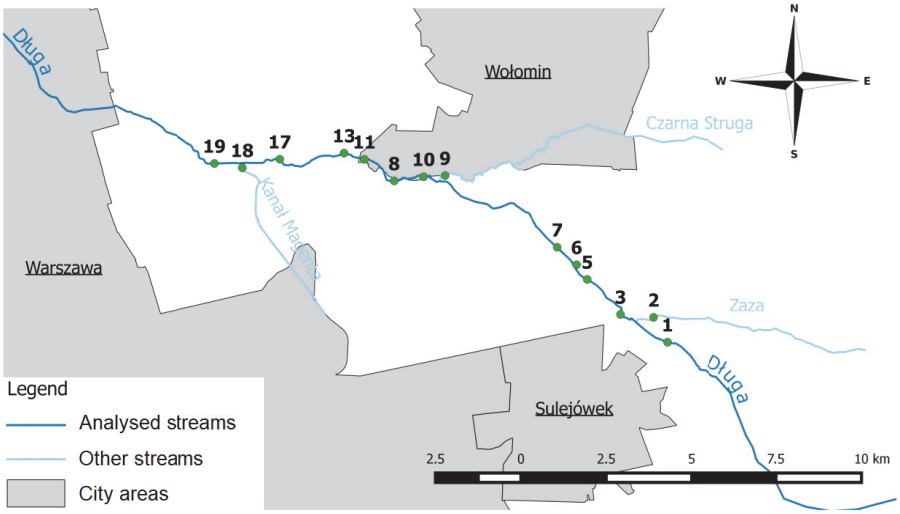
The aim of research was assessment of concentration of dissolved compounds of phosphorus and estimation of influence of municipal sewage treatment objects which are located in area of selected rivers on possibility of eutrophication process basing on concentrations of phosphorus forms.

2. Methodology and area of research

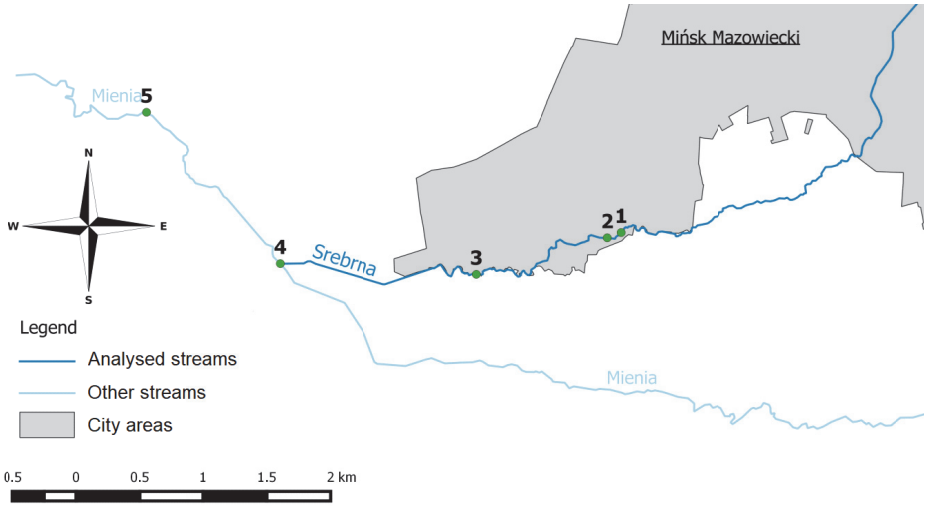
Research was conducted from May to July of 2016. As a part of research phosphorus forms were analyzed: total phosphorus without filtration after mineralization in acidic environment with the use of ammonium persulfate. All samples were taken from the depth of 20 cm. Total hydrolyzable phosphorus (P, hydro) – phosphorus in the sample as measured by the sulfuric acid hydrolysis procedure, and minus pre-determined orthophosphates. This hydrolyzable phosphorus includes polyphosphorus. [$(P_2O_7)^{-4}$, $(P_3O_{10})^{-5}$, etc.]. Dissolved Phosphorus (P-D)-all of the phosphorus present in the filtrate of a sample filtered through a phosphorus-free filter of 0.45 micron pore size. Total Orthophosphate (P, ortho) – inorganic phosphorus [PO_4^{-3}] in the sample as measured by the direct colorimetric analysis procedure. Total Organic Phosphorus (P, org) – phosphorus (inorganic plus oxidizable organic) in the sample measured by the persulfate digestion procedure, and minus hydrolyzable phosphorus and orthophosphate. All forms after transformation into orthophosphates ($P\text{-}PO_4^{3-}$) were analyzed with the use of a spectrophotometric method (reaction involving with ammonium molybdate and tin(II) chloride) using Hach 4000 spectrophotometer.



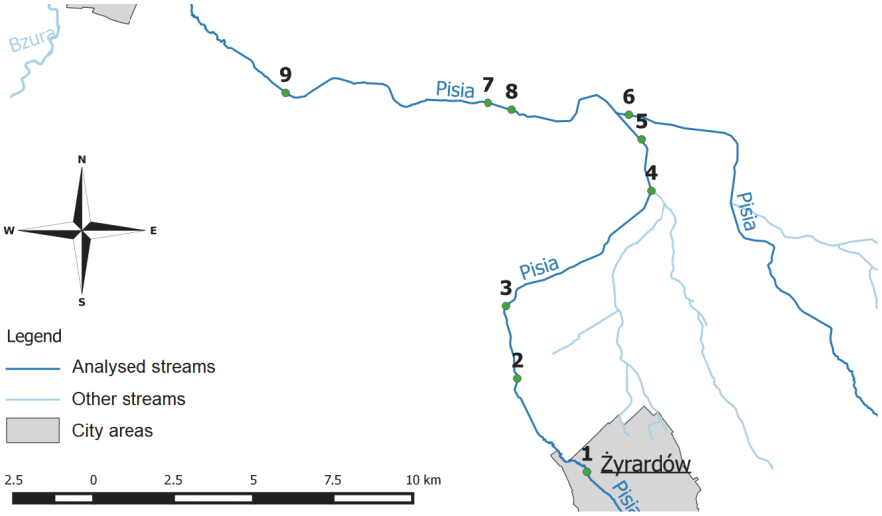
Rys. 1. Mapa sytuacyjna badanych obiektów
Fig. 1. Map of researched objects



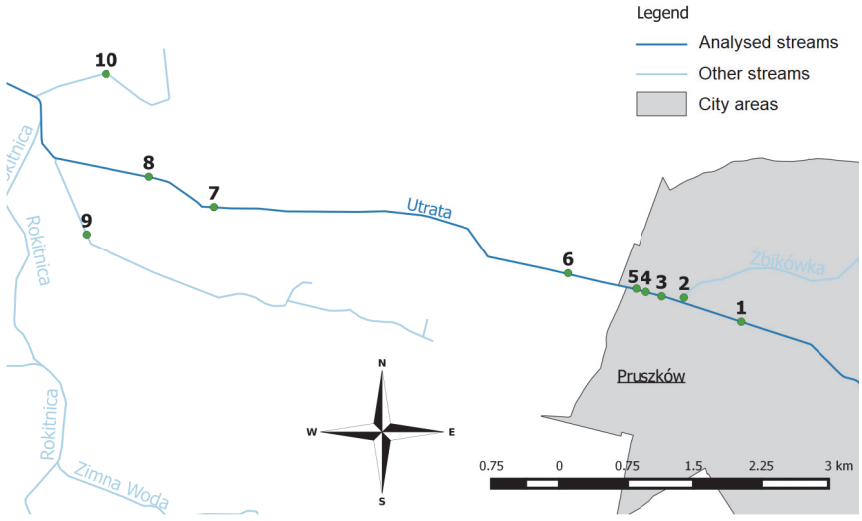
Rys. 2. Punkty pomiarowe na rzece Długiej
Fig. 2. Points of research in the Długa river



Rys. 3. Punkty pomiarowe na rzece Srebrnej
Fig. 3. Measurement points on Srebrna river



Rys. 4. Punkty pomiarowe na rzece Pisia Gągolina
Fig. 4. Measurement points on the Pisia Gągolina river



Rys. 5. Punkty pomiarowe na rzece Utracie
Fig. 5. Measurement points on the Utrata river

The results obtained were referred to the ordinance of the Minister of the Environment (Journal of Laws of 2016 position 1187) for the Single Parts of Surface Water (JCWP).

3. Characteristic of analyzed objects

To complete the subject of dissertation, four watercourses were selected. All of them are placed in the Masovian Voivodeship: Długa, Pisia Gągolina, Utrata rivers and Srebrna stream (Fig. 1). All of them have several common features. Those are lowland rivers, located near to Warsaw agglomeration. Długa and Srebrna have sources near to Mińsk Mazowiecki (city placed to the east from Warsaw). Pisia Gągolina and Utrata flow through districts on west from Warsaw and flows into Bzura near Sochaczew city. Sources of contamination in all river were mainly: disposal of wastewater from water treatment plants, leaks from septic tanks (damaged or intentionally leaked), surface runoff from agricultural areas and roads, landfill leachate. The ecological state of all watercourses, according to WIOŚ (Regional Inspectorate for Environmental Protection) monitoring was bad.

Długa – is lowland river about 50 km long. Source of river is located near to Mińsk Mazowiecki. Długa flows into Kanał Żerański. It is divided on two sections, classified to Single Parts of Surface Water: from source to Kanał Magenta and from Kanał Magenta to mouth. Upper section of the river is classified as natural, downer section as strongly changed. Upper section is classified by Regional Inspectorate for Environmental Protection as III class of biological elements, II class of hydromorphologycal elements, II class of physicochemical elements. Ecological state was classified as moderate, chemical state is below good. The general water condition is bad. Downer section meets the water requirements of IV class of biological elements, II class of physicochemical elements and II class of hydromorphologycal elements. The ecological potential of watercourse was low. Overall rating is bad state of water. Długa is the recipient of wastewater from the following objects: Przedsiębiorstwo Wodociągów i Kanalizacji Sp. z o.o. in Wołomin ("Krym" treatment plant), Miejski Zakład Wodociągów i Kanalizacji in Sulejówek, Zakład Komunalny in Halinów, Wojskowa Agencja Mieszkaniowa Oddział Terenowy Nr 1 in Warsaw.

Srebrna – is a stream, which have a source near to Mińsk Mazowiecki and flows into Mienia river – located near this city. Total length of Srebrna is about 16 km. It is recipient of wastewater from treatment plant for Mińsk Mazowiecki. It is not classified as Single Part of Surface

Water, according to the Water Act (Journal of Laws of 2001 OJ L 115, Item 1229 with subsequent amendments). It means, that Srebrna is not classified by PMŚ (State Monitoring of Enviroment). Srebrna is recipient of wastewater from treatment plants in Minsk Mazowiecki, Barcząca and Janów.

Pisia Gągolina – source of Pisia is placed near to Mszczonów, the mouth is located in Sochaczew. The recipient is Bzura. Total length is about 58 km. The greatest tributary of Pisia Gągolina is Pisia Tuczna river, which flows into Pisia Gągolina about 13 km from mouth. Both rivers are classified as three natural parts of Single Parts of Surface Water: Pisia Gagolina from source to Okrzesza, Pisia Gagolina from Okrzesza to mouth and Pisia Tuczna. Regional Inspectorate for Environmental Protection classified Pisia Gągolina as IV class of biological elements, I class of hydromorphologycal elements, and physicochemical were evaluated as below good. The ecological state was bad, overall rating was bad. Pisia Tuczna meets the requirements which allows it, to be classified as III class of biological elements, I class of hydromorphologycal elements and II class of physicochemical elements. Ecological state was moderate. Overall rating was bad. The most important objects which discharge wastewater to Pisia are: Bakoma Sp. z o.o., Zakład Gospodarki Komunalnej in Żyrardów, Zakład Gospodarki Komunalnej i Mieszkaniowej Gminy Mszczonów in Mszczonów, Gminny Zakład Gospodarki Komunalnej in Teresin, City of Mszczonów (treatment plant in Grabce Józefpolskie), Zakład Wodociągów i Kanalizacji – Sochaczew Sp. z o.o.; Mars Polska.

Utrata – the river has its source near to Tarczyn and mouth near to Sochaczew (recipient is Bzura). Total length is about 76.5 km. It is divided on three segments classified as Single Part of Surface Water: from source to Żbikówka, from Żbikówka to Rokitnica and from Rokitnica to mouth. All three parts are classified as natural. According to Regional Inspectorate for Environmental Protection those segments were classified as IV class of biological elements, II class of hydromorphologycal elements and the physicochemical elements are below good. The most important objects which discharge wastewater into Utrata are: Miejskie Przedsiębiorstwo Wodociągów i Kanalizacji w m. st. Warszawy S.A. in Warsaw, Zakład Wodociągów i Kanalizacji sp. z o.o., Grodzisk Mazowiecki, Zakład Wodociągów i Kanalizacji – Sochaczew Sp. z o.o., Miej-

skie Przedsiębiorstwo Wodociągów i Kanalizacji w Błoniu Sp. z o.o., Przedsiębiorstwo Gospodarki Wodno-Ściekowej GEA-NOVA Sp. z o. o., Przedsiębiorstwo Komunalne Nadarzyn sp. z o.o., Lesznowolskie Przedsiębiorstwo Komunalne Sp. z o.o., Gminne Przedsiębiorstwo Komunalne "Eko-Raszyn" sp. z o.o., Mars Polska.

4. Results and discussion

4.1. Długa River

On the Długa river 19 points of collection of the water samples were selected (Fig. 2). Obtained results proved, that in all points of research on Długa river, the limits of total phosphorus for class I and II waters were exceeded. High range of results of total phosphorus (between 0.93 mg P/l and 8.11 mg P/l) may indicate a local contaminations which occur at single points. Average concentration of total phosphorus was 0.23 mg P/l.

In Długa waters, concentration of organic phosphorus and polyphosphates was dominant, especially in points 9 and 10, which were located near to mouth of Czarna Struga, the recipient of wastewater from treatment plants in Wołomin, and near to fish ponds in Ossowo. High concentration of organic phosphorus also may be caused by high influence of agriculture runoff. North segment of Długa, flows through farmlands area. Runoff from this area may be the reason of high concentration of organic phosphorus in the river.

According to Regional Inspectorate for Environmental Protection river monitoring data in 2013, on the river Długa average concentration of total phosphorus was 0.3 mg P/l in the segment from source to Kanał Magenta and 0.244 in the segment from Kanał Magenta to mouth. Concentration of orthophosphates occurred 0.074 in the segment from source to Kanał Magenta and 0.071 in the segment from Kanał Magenta to mouth. Analysis of researched segment of the river indicates, that from Kanał Magenta to mouth, are not any objects which may influence on increase of concentration of phosphates. The course of concentration of polyphosphates through the river on analyzed segment is also important: increases of polyphosphates concentration occur at single points and are reduced with the river course. Concentrations of orthophosphates are the lowest in points, which represent disposal of contamination and highest

in point which are located far from them. Average amount of orthophosphates occurred 50% of polyphosphates and 10% of total phosphorus (Fig. 6).

According to conducted research it may be concluded that Długa in the segment between Sulejówek and Rembertów does not meet the requirements of the Regulation of the Minister of Environment (Journal of Laws of 2016, Item 1187) for Single Part of Surface Water like lowland stream sandy (code 17). The level of eutrophication is very high. The reason of that state may be inflow of organic contamination from agricultural runoff and fish ponds and in lesser extent inflow of municipal wastewater.

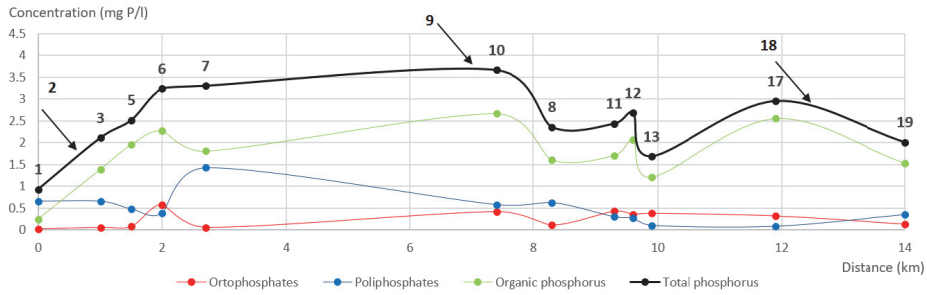


Fig. 6. Concentration of phosphorus forms in the Długa river
Rys. 6. Stężenie form fosforu w rzece Długa

4.2. Srebrna stream

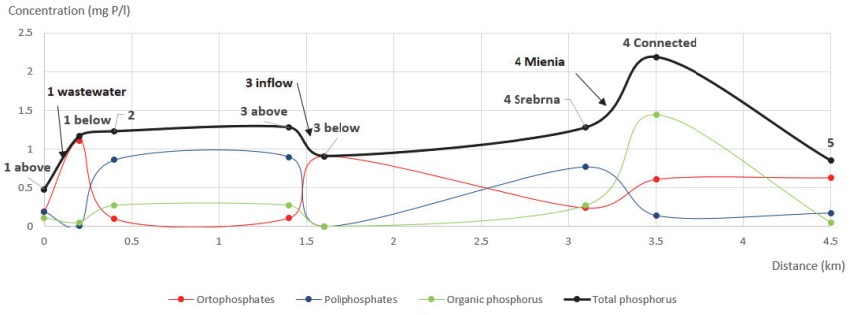
For Srebrna 5 points of research were selected. All of them were located on the down segment of the river (Fig. 3).

First point was located in the near to tributary of wastewater from local treatment plant, fifth point was located on the river Mienia, a few kilometers behind the mouth of Srebrna. Among the analyzed samples only one had concentration of total phosphorus below the limit and it was 0.16 mg P/l. The highest concentration of total phosphorus was noticed in point located at mouth of Srebrna – 2.19 mg P/l. Highest concentration was only in sample which was wastewater from treatment plant. The amount of ortophosphates was between 0.09 mg P/l and 1.11 mg P/l (Fig. 7).

The average results for all points indicate on high level of phosphate contamination of waters of Srebrna. The main identified source of phosphorus compounds was water treatment plant located on the south of

Mińsk Mazowiecki. Concentration of phosphate in wastewater is high and its influence on Srebrna is noticeable. Polyphosphates concentrations are highest in points which represent tributaries, organic phosphorus occur in single points – in wastewater from treatment plant and next points behind tributary. Beyond these point concentration of organic phosphorus is low, which may indicate on its fast mineralization to ortophosphates, especially in waters of Srebrna and Mienia.

Total phosphorus concentration near to its mouth is similar to contamination in near point of research at the Mienia. Two kilometers behind the Srebrna's mouth, concentration of phosphates reduces significantly. According to Regional's Inspectorate for Environmental Protection data in place of Mienia's mouth to Świder, concentration of orthophosphates occurred 0.084 mg P/l and total phosphorus occurred 0.259 mg/l.



Rys. 7. Stężenie form fosforu w rzece Srebrna
Fig. 7. Concentration of phosphorus forms in the stream Srebrna

The average share of three phosphorus forms (polyphosphates, organic phosphorus and orthophosphates) indicates the greatest share of orthophosphates and polyphosphates in most of research points, which allows to conclusion, that the main source of phosphates in Srebrna was wastewater from treatment plant.

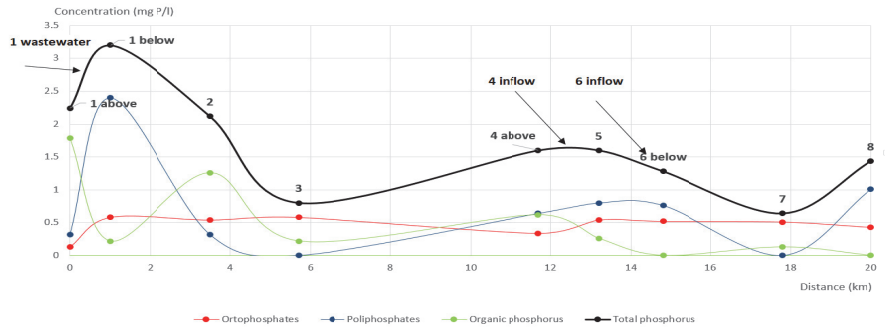
4.3. Pisia Gągolina River

Concentration of total phosphorus in samples from Pisia Gągolina was between 0.64 mg P/l to 3.2 mg P/l (Fig. 8) and that was over the limit established in the Regulation of the Minister of Environment (Journal of Laws of 2016, Item 1187). Average concentration was 1.6 mg P/l and the highest concentration was noticed in upper segment of river, near to

wastewater inflow from Żyrardów treatment plant (Fig. 4). Orthophosphate concentration on analyzed segment was between 0.13-0.58 mg P/l (average 0.45 mg P/l). The lowest concentrations was noticed in tributary from Żyrardów treatment plant. Average concentration of polyphosphates was 0.58 mg P/l. Concentration of polyphosphates was between 0.01 and 2.4 mg P/l. Concentration of organic phosphorus increased in single points, especially near to sources of contamination and reached to maximum concentration 2.02 mg P/l near to Żyrardów treatment plant.

Acorrding to Regional's Inspectorate for Environmental Protection data which were based on research point localized in Radziejowice (upper segment of Pisia Gągolina) average concentration of total phosphorus was 0.12 mg P/l and ortophosphates concentration was 0.06 mg P/l. That concentration do not exceed limits for class I waters. That point was localized beyond the segment analyzed in dissertation.

Provided data indicates, that on the analyzed segment of Pisia Gągolina, river was highly contaminated by phosphorus compounds and it results eutrophication of this river. Reason of that state may be influence of pollution from treatment plant in Żyrardów and Mszczonów and also agriculture runoff. Important source of contamination may also be industrial wastewater (in the area of Pisia there are 6 points of industrial wastewater tributaries).



Rys. 8. Stężenie form fosforu w rzece Pisia Gągolina
Fig. 8. Concentration of phosphorus forms in the Pisia Gągolina river

4.4. Utrata River

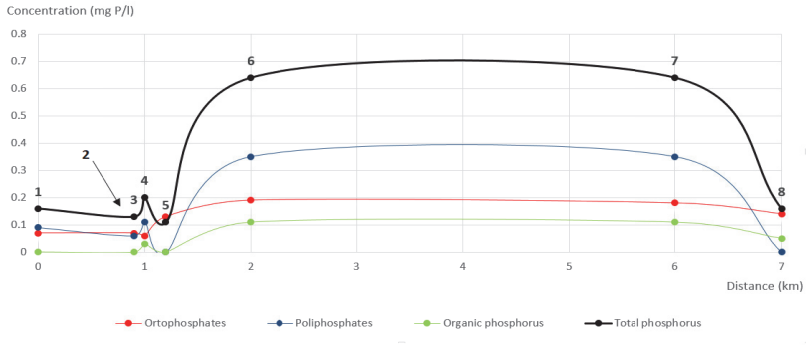
Analyzed segment of Utrata included points of research between south-east border of Pruszków and Rokitnica tributary (Fig. 5). In representative point of research according to Regional's Inspectorate for Environmental Protection data, which was located next to mentioned tributary, concentration of total phosphorus was 0.39 mg/l and concentration of orthophosphates was 0.127 mg P/l.

Conducted research proved that concentration of total phosphorus was between 0.16 and 0.8 mg P/l and orthophosphates was between 0.05 to 0.32 mg P/l. Highest concentrations of total phosphorus occurred in upper part of analyzed segment and the lowest near to the border of Pruszków (nearby to treatment plant).

Among the phosphates forms, in most points share of orthophosphates and polyphosphates was the highest in share of total phosphorus and their concentrations were similar. Organic phosphorus reached increased concentration in water from sample nr 10 and in the other points was small share of total phosphorus. Average share of total phosphorus in analyzed points was 0.38, which was amount very similar to Regional's Inspectorate for Environmental Protection data.

Reason of high concentration of phosphorus in Utrata may be agricultural runoff. The fact that concentration of orthophosphates through the analyzed segment is stable and concentration of polyphosphates and organic phosphorus is changing, is important.

Except the agriculture runoff, source of phosphorus may be industrial wastewater. Utrata was recipient of at least 9 industrial plants located in the area of river. Influence of municipal treatment plant in Pruszków was probably insignificant – concentration of phosphates near to the plant was the lowest.



Rys. 9. Stężenie form fosforu w rzece Utrata
Fig. 9. Concentration of phosphorus forms in the Utrata river

4.5. Discussion

Conducted research and data from Regional Inspectorate for Environmental Protection indicates on water states, which need improvement of concentration of phosphates forms:

- Share of particular forms of phosphorus depends on many factors, the most important of which is source of contamination.
- Source of organic phosphorus may be substances from decomposition of organic matter, mainly proteins.
- Condensed phosphates occurs as the result of wastewater inflow with surfactants containing phosphorus.
- Orthophosphates may occur as the result of leaching from soils or as the result of transformations of other phosphorus forms in water (mineralization, hydrolysis).
- The concentration of phosphates on small sections of rivers occurs in a wide range of values.
- In dissertation did not considered bottom sediments, which may be internal source of phosphates in water and may influence on concentration of phosphates among the river (Bartoszek & Koszelnik 2016).
- Municipal treatment objects have significant influence on water quality and contaminations from them may be transferred on long distances from source.
- Obtained results indicates high level of eutrophication in all analyzed rivers.

5. Conclusion

Among all the analyzed objects, the lowest concentrations of total phosphorus were noticed in the waters of Utrata – average 0.38 mg P/l, the highest in Długa – average 2.8 mg P/l. Average amount of orthophosphates was between 0.23 (Długa) and 0.45 mg P/l (Pisia Gągolina). According to conducted research, it may be concluded that all four watercourses are highly contaminated by phosphates. Identified sources of phosphates in analyzed objects were:

- Contamination from municipal wastewater treatment plants,
- Industrial wastewater from nearest industrial plants,
- Agricultural runoff,
- Organic contamination from fish ponds.

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Wpływ użytkowania zlewni na stopień zanieczyszczenia wód rzecznych formami fosforem

Streszczenie

Celem pracy było dokonanie analiza wpływu obiektów gospodarki wodno-ściekowej na jakość wody w wybranych rzekach poprzez ocenę stopnia eutrofizacji tych rzek. Zakres pracy obejmował analizę form fosforu: fosforu

ogólnego, ortofosforanów, polifosforanów oraz fosforu organicznego w wodach rzecznych. W celu realizacji zaplanowanych zadań, do badań wytypowano cztery cieki wodne, znajdujące się na terenie województwa mazowieckiego – rzeki: Długa, Pisia Gągolina i Utrata oraz struga Srebrna. Wszystkie cztery rzeki wykazują pewne cechy wspólne. Są to rzeki nizinne, przepływające w pobliżu aglomeracji warszawskiej. Długa i Srebrna mają swe źródło w pobliżu Mińska Mazowieckiego (miasto na wschód od Warszawy). Rzeki Pisia Gągolina i Utrata przepływają przez powiaty na wschód od Warszawy i obie uchodzą do Bzury w okolicach Sochaczewa. Źródła występujących zanieczyszczeń to przede wszystkim zrzuty ścieków z oczyszczalni, przecieki z nieszczelnych (uszkodzonych, bądź świadomie rozszczelnionych) zbiorników bezodpływowych, spływ powierzchniowy z terenów rolniczych oraz z dróg, odcieki ze składowisk odpadów. Stan ekologiczny wód, według monitoringu prowadzonego przez WIOŚ, dla wszystkich omawianych cieków jest zły. Przeprowadzone badania wykazały, że najmniejsze stężenia fosforu ogólnego odnotowano w wodach Utraty – średnio 0,38 mg P/l, natomiast największe w Długiej: średnio 2,8 mg P/l. Średnia zawartość ortofosforanów wynosiła od 0,23 mg P/l (rzeka Długa) do 0,45 mg P/l (rzeka Pisia-Gągolina). Na podstawie przeprowadzonej analizy można stwierdzić wysokie zanieczyszczenie fosforanami wody wszystkich czterech rzek. W trzech badanych ciekach, największy udział w odniesieniu do fosforu ogólnego stwierdzono dla ortofosforanów. W przypadku rzeki Długiej, przeważa zawartość fosforu organicznego (71%). Źródłem fosforu organicznego mogą być substancje pochodzące z rozkładu materii organicznej, głównie białek. Fosforany skondensowane występują na skutek dopływu do rzek ścieków komunalnych zawierających substancje powierzchniowo czynne, których składnikiem jest fosfor. Ortofosforany mogą pojawiać się na skutek wymywania fosforu z gleby lub na skutek zachodzących w wodach przemian związków fosforu, jak mineralizacja czy hydroliza. Stężenie fosforanów na niewielkich odcinkach rzek występuje w szerokim zakresie wartości. Ma to związek z dużym wpływem terenów rolniczych, stawów hodowlanych oraz odprowadzanych ścieków z oczyszczalni ścieków komunalnych. Obiekty gospodarki komunalnej mają znaczny wpływ na jakość wód, a zanieczyszczenia z nich pochodzące mogą być przenoszone na duże odległości od miejsca zrzutu ścieków. Ogólny stan jakości wód we wszystkich badanych rzek jest zły.

Abstract

The subject of dissertation was analysis of wastewater and sewage management on water quality in particular rivers by assessment of eutrophication level of those rivers. Scope of work concerned analysis of phosphorus forms: total phosphorus, orthophosphates, polyphosphates and organic phosphorus. To

complete the subject of dissertation, four watercourses were selected. All of them are placed in the Masovian Voivodeship: Długa, Pisia Gągolina, Utrata rivers and Srebrna stream. All of them have several common features. Those are lowland rivers, located near to Warsaw agglomeration. Długa and Srebrna have sources near to Mińsk Mazowiecki (city placed to the east from Warsaw). Pisia Gągolina and Utrata flow through districts on west from Warsaw and flows into Bzura near Sochaczew city. Sources of contamination in all river are mainly: disposal of wastewater from water treatment plants, leaks from septic tanks (damaged or intentionally leaked), surface runoff from agricultural areas and roads, landfill leachate. The ecological state of all watercourses, according to WIOŚ (Regional Inspectorate for Environmental Protection) monitoring is bad. Research showed that, the lowest concentration of total phosphorus was in the waters of Utrata (average 0.38 mg P/l), while the highest in Długa – average 2.8 mg P/l. Average concentration of orthophosphates was between 0.23 mg P/l (Długa) and 0.45 mg P/l (Pisia Gągolina). Basing on conducted analysis, it can be stated that phosphate contamination in all four watercourses is high, which leads to conclusion that eutrophication level is high. Reasons of that state can be caused by sewage disposals and agriculture. In three perennial streams (Długa, Pisia Gągolina and Srebrna), the highest share in total phosphorus concerned orthophosphates. It means, that phosphorus compounds in rivers are in some part subject to self-cleaning processes. In the case of Długa river, organic phosphorus is a main part of total phosphorus (71%). Source of organic phosphorus may be substances from decomposition of organic matter, mainly proteins. Condensed phosphates occurs as the result of wastewater inflow with surfactants containing phosphorus. Orthophosphates may occur as the result of leaching from soils or as the result of transformations of other phosphorus forms in water (mineralization, hydrolysis). Range of phosphates concentration occurs even on short segments of rivers. It is caused by strong influence of agriculture, breeding ponds and wastewater from treatment plants. Municipal treatment objects have strong influence on water quality and the contamination caused by them can be carried over long distances from place of sewage discharge. General state of water quality of all analyzed rivers, is bad.

Słowa kluczowe:
wody rzeczne, formy fosforu, eutryzacja, źródła zanieczyszczenia

Keywords:
river waters, forms of phosphorus, eutrycosis, sources of pollution