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Changes in surface water microflora caused by discharge of purified sewage into rivers

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ABSTRACT

Progressive environmental degradation results in an increase in the number of waters that do not meet the standards in force. Surface waters are particularly vulnerable to pollution because they are receivers of purified water and agricultural or industrial wastewater flow. In addition, the local increase in temperature and the increase amount and availability of nutrients associated with wastewater discharged improves the microbial growth and thus increase their quantity. The treated sewage must meet certain requirements regarding their physicochemical and biological parameters. However, the regulations do not require to check microbiological quality by treatment plants, so the purpose of the study was to determine the impact of discharge of purified wastewater by the "Warta" sewage treatment plant down to Warta river. The study was conducted in 2008-2016 at three collection points near the place of discharge of purified sewage from Warta SA sewage treatment plant. It has been demonstrated that the process of sewage treatment is not enough in terms of microbiological pollution because the water samples collected at the points behind the discharge site of the effluent into the river were characterized by increased abundance and microbiological diversity.

***Keywords*:** Sewage, water microflora, sewage treatment plant, river, sewers

1. INTRODUCTION

The quantity of surface waters in Poland considered as non-class that means not matching with current standards is constantly increasing. This is due to an increased number of people concentrated in large urban agglomerations, industrial development and increased use of plant protection products in agriculture [1]. Poland's integration with European Union has led to the necessity of adjustment the provisions of national law to requirements of the EU regulations [2]. According to the recommendations of the Water Framework Directive binding all EU Member states, five levels of water quality have been introduced in Poland [3]. Member states are required to prevent the deterioration of surface waters condition and should seek to achieve and maintain good status, ecological potential and chemical status of surface and groundwater [4]. According to the Ordinance of the Minister of Environment from 21 July 2016 on the classification the states of surface water bodies and environmental quality standards for priority substances (DzU z 2016r., poz. 1187), about attachment to water class and suitability are determined by: physical indicators (temperature, general slime), acidification indicators (pH), salinity (chlorides, sulfates) also biogenic conditions (ammonium nitrogen, nitric nitrogen, total nitrogen, total phosphorus), oxygen (dissolved oxygen, biochemical oxygen demand (BOD5), chemical oxygen demand (COD)) and biological and hydromorphological indicators.

In order to meet new legal requirements in Poland, we have carried out activities to improve of the quality of surface and underground water for many years of, inter alia construction and modernization of the wastewater system and sewage treatment plant or changes in waste management, including sewage sludge. For discharge and wastewater treatment systems, these activities are concentrated mainly in rural areas [2]. The construction of sewer systems and sewage treatment plants is a basic activity aimed at reducing the amount of anthropogenic contaminants entering water. One of the main tasks of the sewage treatment plant is to remove all substances considered as pollutants and to stabilize their composition so that they do not disturb its balance after introduced into receiver [5]. However, studies conducted by Kannik and Królak showed that most of the examined sewage treatment plants have changed the chemical composition and taxonomic composition of macrozoobenthos in water of the receiver to which the purified water was discharged, although these changes did not affect the water receiver class [5,6].

In years 2005-2015 the length of the sewers system increased by 69.5 thousand km (i.e. by 86.8%), reaching in 2015 year 149.7 thousand km. In rural areas the increase was bigger of sewers system, i.e. by 51 thousand km (138%) than in cities, i.e. an increase of 18,700 km (43.2%). Because of discharges of sewage the most vulnerable to pollution is the Warta River in Częstochowa, which has been the receiver of purified wastewater from "WARTA SA" sewage treatment plant for years. Within the framework of the National Program for Municipal Sewage Treatment with the financial contribution of the European Union Cohesion Fund, the central Sewage Treatment Plant has been modernized and more than 71 km of sanitary sewers have been built [7]. According to data provided on the website "WARTA SA" Sewage Treatment Plant, the treatment plant receives 43616 m^3 of sewage daily and purifies more than 16 million m^3 of sewage per year.

As a water pollution is determined by changes in their biological, chemical and physical characteristics which are attributable to discharges excessive quantities of organic and inorganic substances as well as heat or radiation of UV that prevents from drinking or using

for economical purposes. Wastewater also contains numerous opportunistic and saprophytic microorganisms, and in some cases pathogenic or relatively pathogenic microorganisms. Domestic wastes are characterized by the most abundant microflora in composition of which bacterium belonging to the families *Enterobacteriaceae* and *Pseudomonadaceae*, *Staphylococcus, Clostridium* and *Enterococcus* bacterium, *Actinomycetales* and numerous filamentous fungi and yeast are present [7]. Surface water is mainly affected by contaminants, especially rivers because of receiving of purified domestic wastewater and exposure to flow from agricultural and industrial areas. Typical water borne bacteria includes *Shigella, Salmonella* and *Yersinia* [1,8].

Pollutants entering rivers, lakes or streams can have different sources: area, point and linear [4]. Particularly dangerous are point contaminants from one and specified source, for example the discharge pipe of treated sewage into river, which can cause local increase of water temperature and nutrient content that allows microorganisms to multiply. Consequently contributing to increased in the abundance and diversity of the bacterial population in water. Additionally, a purified wastewater can be a source of bacteria, because even modern technological processes that allows for highly efficient treatment of sewage inluding phosphorus and nitrogen removal do not ensure complete removal of bacteria. Furthermore, Polish Sewage Treatment Plants does not apply additional disinfection of cleaned sewage before discharging into the river [9,10].

2. MATERIAL AND METHODS

The purpose of the study was to determine the effect of discharges purified sewage by the "WARTA SA" Sewage Treatment Plant on the Warta River local microflora.

The study was conducted in 2008-2016 during the summer season. Samples of water were collected at two points located in the city of Czestochowa close to the Sewage Treatment Plant "WARTA SA":

1. Before the place of discharge into the river of purified sewage - 50°49'35.9"N 19°09'36.5"E
2. Behind the place of discharge into the river of purified sewage - 50°49'38.8"N 19°09'41.9"E

In addition, in 2016, due to results of the tests obtained in previous seasons, in addition samples were collected at third point located in the outlet of the sewage pipeline to the Warta River.

Samples of water were sown on the ½ agar medium by spread plate method from appropriate dilutions to determine the overall abundance of bacteria. Water samples of 1 ml volume were filtered through membrane filters and transferred to Endo medium to detect the presence of Escherichia coli bacteria.

Grown colonies were counted, morphology was determined, and later on analyzed through tests:

- Gram staining,
- The test for production of cytochrome oxidase,
- Mobility,

- Inoculation on diagnostic media (Chapman, Slanetza-Bartley, McConkey, Pseudomonas Agar F, Kinga B, EMB Agar).

3. RESULT

In all study seasons, there was a significant impact of discharge of purified sewage to overall abundance of bacteria (Figure 1 and Figure 2).

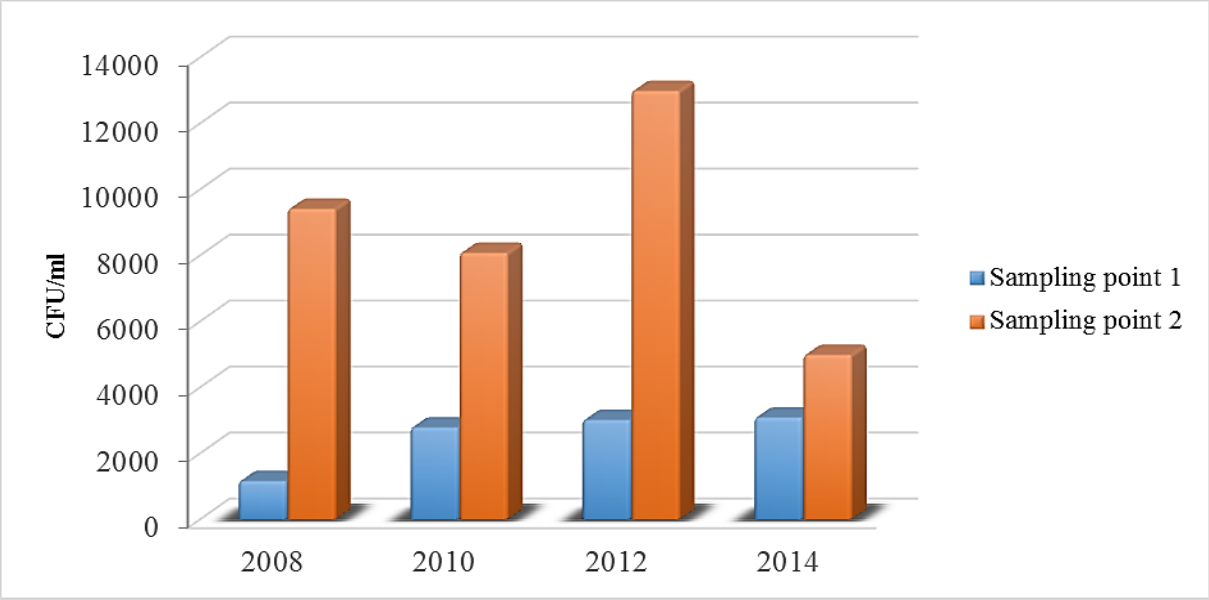

Figure 1. The overall quantity of bacteria in 1 ml Warta River from both points of water collection in 2008-2014.

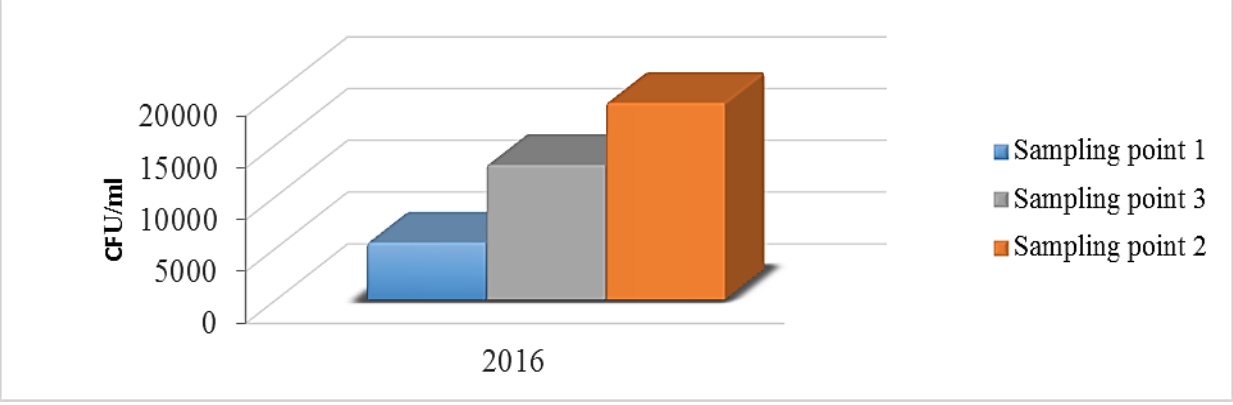

Figure 2. The overall quantity of bacteria in 1 ml Warta River water at three water intake points in 2016.

Increasing the number of water intake points by the third one, i.e. outlet of the sewage discharge pipeline to river has shown that the wastewater treatment process does not eliminate enough microorganisms so as not to affect the surface water microflora (Figure 2).

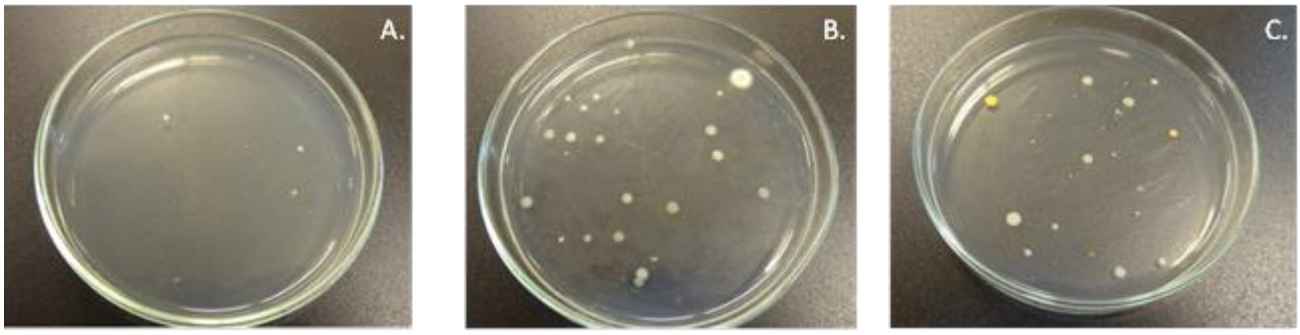

Figure 3. The overall quantity of bacteria on ½ agar medium from first point (A), second point (B) and third point (C) of water collection.

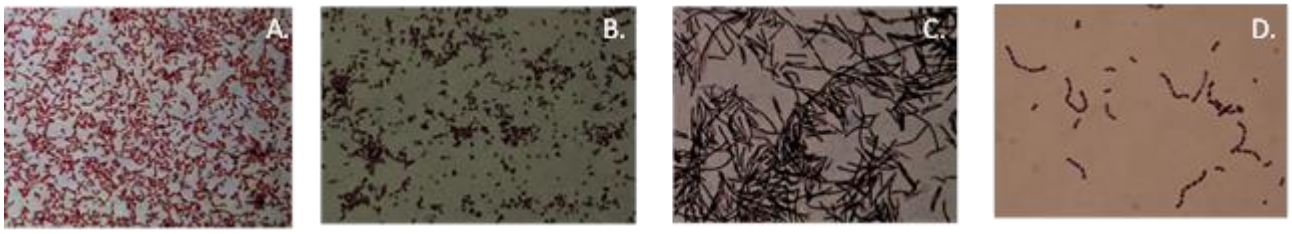

Figure 4. Bacteria collected from the second point water after Gram stain: gram-negative, rod-shape bacteria (A), gram-positive, rod-shape bacteria (B), gram-positive, bacilli-shape (C), and gram-positive, cocci-shape (D).

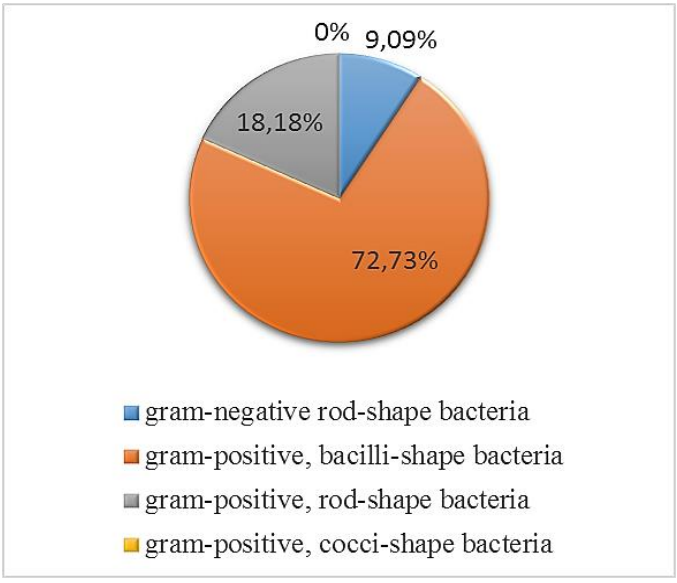

Figure 5. Percentage content for each morphological form of bacteria at first point.

Content of particular morphological forms has been changed, since at the first point the dominant form was bacilli-shaped gram-positive bacteria while in the second point was rod-shaped, gram-negative bacteria (Figure 5, 6).

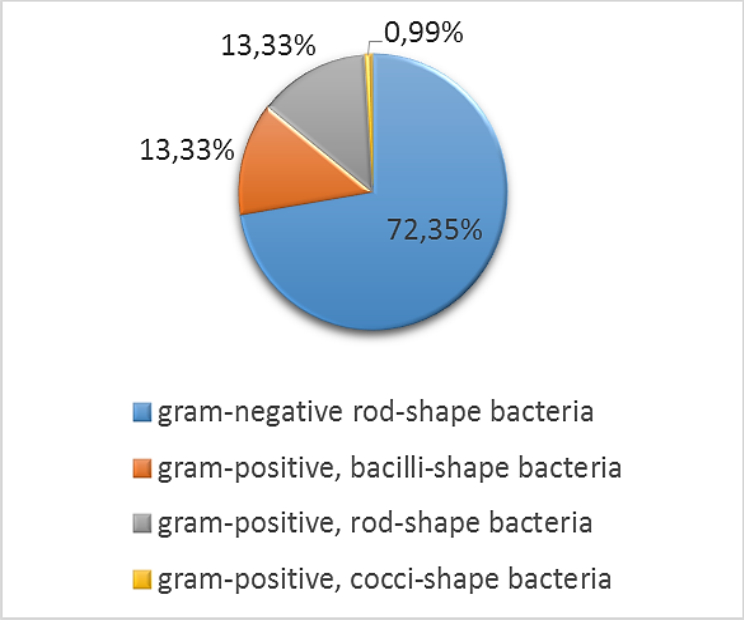

Figure 6. Percentage content for each morphological form of bacteria at second point

E. coli was not found at the first point of water collection, however at the second and the third points their presence was detected.

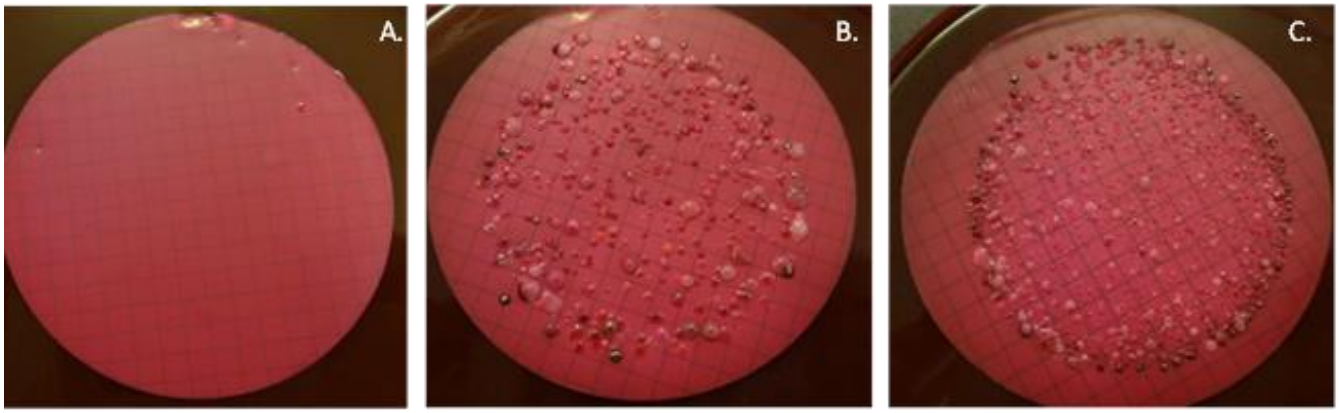

Figure 7. Membrane filters on the Endo medium: first point (A), second points (B), third point (C) of water samples collection.

4. CONCLUSIONS

The results obtained indicates significant effect of discharge of purified sewage from the "WARTA S.A." Sewage Treatment Plant on microflora of surface water which is caused not only by local elevation of water temperature and nutrient supply, but also by not effective technological process capable to reduction of bacterial abundance in discharged wastewater into Warta River.

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