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Analysis of the coliform in the Wilga River (southern Poland)

Introduction

The progressive development of industry, as well as the cities suburbanisation cause inevitable damages to the environment. These damages are related to water and soil pollution. Only 2% of surface waters in Poland belong to the first class purity. The rest of water bodies is named as waters of poor quality. The water pollution is caused usually by industrial wastewater and municipal sewage, which are directly discharged into rivers. Furthermore, pre-treated wastewater in industrial facilities is also the factor leading to the environmental pollution (*Rozporządzenie Ministra Środowiska…*, 2004).

The pollutions of drinking water are caused by the occurrence of leaky septic tanks or by direct sewage discharging into watercourses and the surface areas. The sewages seep through the ground and after that they are present in groundwater. The groundwater should be pure, however, results of the monitoring carried out in the nineties of the twentieth century revealed, that water bodies are not included in the first class purity. The microbiological contamination of the surface waters can cause food poisoning of water consumers. Moreover, it is responsible for fish diseases, which in result are not suitable for consumption. Thus, the monitoring of drinking water intakes, as well as smaller watercourses is indispensable (George et al., 2002; Pant, Mittal, 2007; Hendricks, Pool, 2012; Budzińska et al., 2014).

The Wilga River is the right tributary of the Vistula River flowing through Kraków with the length of 11.5 km. The total length of the river is 21.4 km and its spring is located in the north-eastern part of the Wieliczka Foothills in Pawlikowice (*List of names…*). The middle course of the river is a part which strongly meanders and the final stretch has been dug up and straightened. In the part from Swoszowice to Kraków, Wilga flows within the built-up area. The catchment of the river is located in the rural area. The banks in the upper and middle courses are covered with alluvial forests. These forests give way to grassy flora in Kraków. The Wilga River is relatively short comparing to other rivers of Wieliczka Foothills, but it is characterised by trough characteristic to mountain rivers with swift stream and rocky riverbed and by deep trough which occurs in lowland rivers with slow stream.

Wilga belongs to the most polluted rivers in Kraków (*Ocena jakości wód…*, 2004). The contaminations were mainly due to the occurrence of former industrial facilities in the IX district – Łagiewniki (Soda Solvay Factory). The microbiological tests of water coliforms (the smallest volume of water with detected *Escherichia coli* T. Escherich) in different locations along Wilga. This test is a basic method to indicate the presence of sewage in watercourses based on the appearance of a bubble in Durham tube. The bubble is the effect of the fermentation of lactose by *E. coli.*

The samples were collected from 16 locations along the Wilga River from the spring in Raciborsko up to Podgórze in Kraków (Fig. 1). In places of sampling we measured water parameters like temperature and pH.

The samples were initially diluted tenfold with physiological saline and after that the 1 cm^3 of water was transferred to the test tube (with Durham tubes inside) with broth enriched with 1% lactose. Experiments were conducted for samples with different water dilutions (1:10, 1:100, 1:1000, 1:10 000, 1:100 000). After 24 hours of incuba-

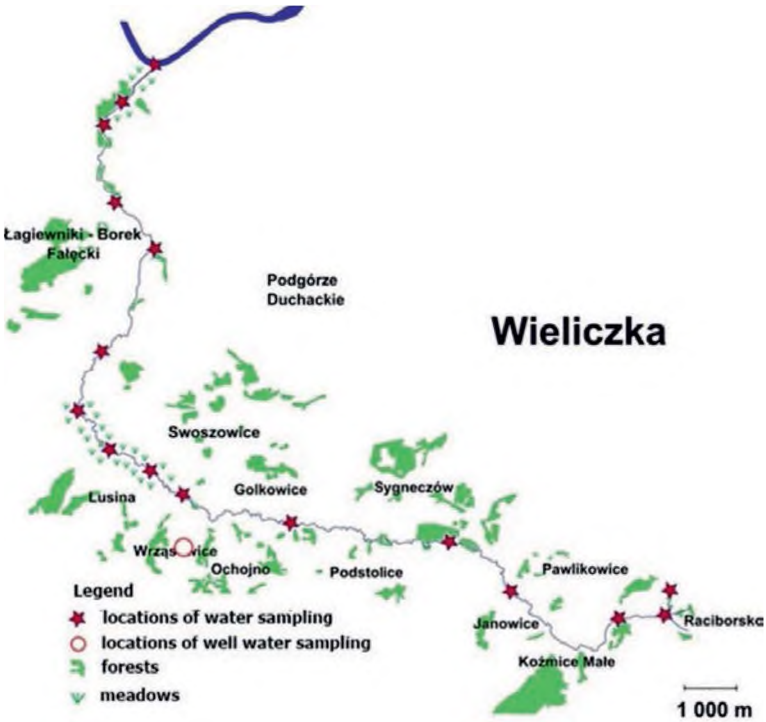

Fig. 1. Map of sampling locations along the Wilga River

tion at the temperature of 37°C the occurrence of broth turbidity and the presence of bubble in Durham tubes were observed.

Experiments were conducted during the hot summer of 2014. Air temperatures were above 30°C and water temperatures ranged from 15 to 21°C. The temperature of upper river course reached 19°C. The low temperature of water is usually due to the swift stream in upper course. In the middle course, with slower stream, the temperatures reached 20°C. The highest temperature of water we measured in the mouth of the Wilga River was 21°C which was correlated to slow stream high exposure to solar radiation as well as Vistula backwaters.

We detected the purest water in the middle course of the Wilga River (in Janowice and Sygneczów) (Fig. 2). There are no farm buildings near the river trough and river flows fast. The coliform was 1 which indicates that the water is not suitable to drink according to Whipple scale.

Even at the spring of the Wilga River there was no microbiologically pure water. The value of coliform reached 0.1 and the contamination is caused by the presence of public toilet for inhabitants of the neighbouring plot near the river. The coliform of 0.1 was measured in 6 samples collected from: Pawlikowice, Raciborsko (ponds), Wrząsowice (near the bar "Wilga"), Swoszowice (near the boundaries of Kraków), Opatkowice and Łagiewniki (near the Sanctuary of Divine Mercy). There are courses of swift stream in each of mentioned locations. Therefore, these courses should be well

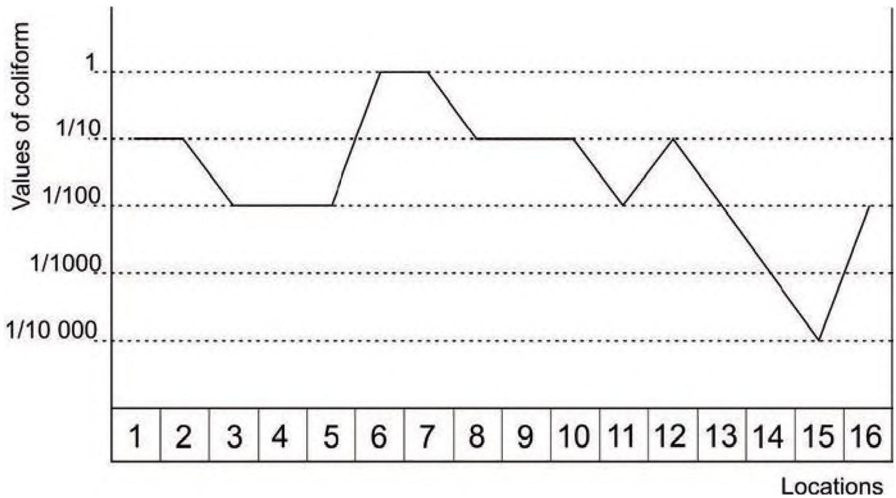

Fig. 2. The values of coliform of water collected from different locations: 1 – river spring, 2 – Raciborsko pounds, 3 – Raciborsko 2, 4 – Pawlikowice, 5 – Janowice, 6 – Sygneczów, 7 – Gołkowice, 8 – Wilga bar, 9 – Swoszowice G.M., 10 – Opatkowice, 11 – Swoszowice, 12 – Sanctuary of Divine Mercy, 13 – Zakopiańska street, 14 – Kopty forest, 15 – Mateczny roundabout, 16 – river mouth

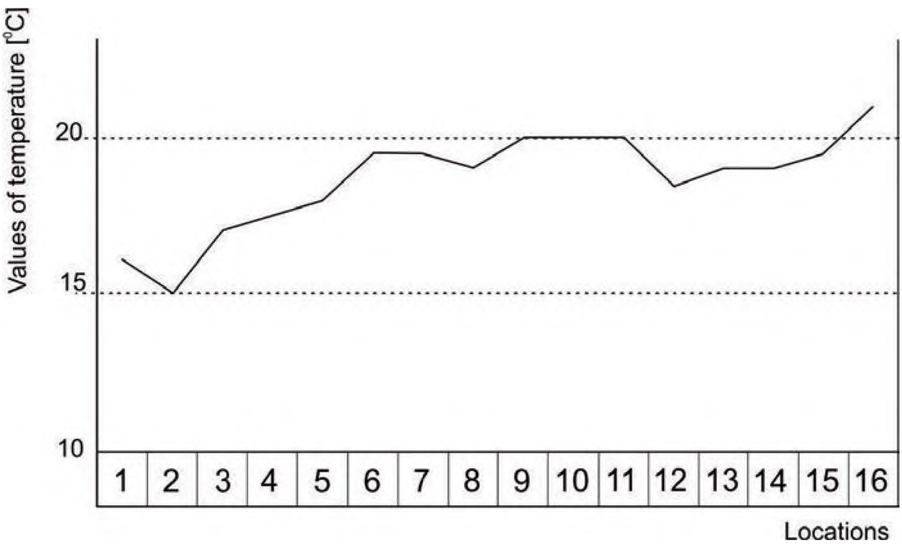

Fig. 3. The temperature of water [°C] measured in 16 locations of sampling along the Wilga River: 1 – river spring, 2 – Raciborsko pounds, 3 – Raciborsko 2, 4 – Pawlikowice, 5 – Janowice, 6 – Sygneczów, 7 – Gołkowice, 8 – Wilga bar, 9 – Swoszowice G.M., 10 – Opatkowice, 11 – Swoszowice, 12 – Sanctuary of Divine Mercy, 13 – Zakopiańska street, 14 – Kopty forest, 15 – Mateczny roundabout, 16 – river mouth

oxygenated and relatively cool (even a few degrees colder) (Fig. 3). These locations are characterised by scattered buildings, the blanks are covered with meadows or even trees. There are neither farms near the river nor sewage discharge into the river. Thus, the river reveals better microbiological parameters.

The Wilga River tends to self-clean. It can be observed at the stretch: Janowice – Sygneczów – Gołkowice as well as at the stretch: Swoszowice – Łagiewniki. We can suppose that if there were neither direct nor indirect discharges of the sewage into water, the river would reveal a significant tendency to self-clean. The rivers self-cleaning process is long-term, therefore, if there is a large amount of sewage discharge, the process is inhibited and hard to observe.

The Wilga River is artificially regulated to avoid flood of the river at the stretch from Kraków up to the river mouth. The most polluted part of the Wilga River is located near to the Mateczny roundabout – coliform of 1:10 000. The second most polluted area was located at the mouth of the river: 1:100. These two stretches are characterised by slow stream and high temperature of water reaching 21°C. There is a sewer pipe near to the Health Resort with residue of the sewage sludge deposited on the grid protecting the river banks against lateral erosion. We also observed a lot of water birds – mainly ducks looking for food.

The pH of water samples collected from the Wilga River is alkaline and it oscillates within 8.0–8.2, which is correlated with the type of substrate that river flows through.

The Wilga River valley is cut in Miocene schists and covered with quaternary sands (Łojan, 2008). Up to the mouth of the Krzywica stream in Swoszowice, the Wilga River catchment is covered with loess soil and the Tertiary flysch layers beneath them consisting of shale, marl, sandstone and chalk layer.

The pH of water has an influence on water microorganism variety. These organisms require the water of neutral pH, but they also have an ability to adapt to the new environmental conditions, when water changes pH into weakly acid or alkaline (Pawlaczyk-Szpilowa, 1978). Rapid pH changes of surface waters are mainly due to discharge of some industrial sewage without their pre-neutralisation. The main cause of high values of coliform is discharge of large amount of sewage into the river, as well as the fertilisation of farmlands with manure which get into the soil and are washed down by rain into the river.

The surface waters contaminations by pathogenic bacteria, originating from both the sewage discharge and the sewage infiltration into the ground waters are serious problems. The purity of surface waters should be considered as poor. There is only 2% of rivers and lakes waters that fulfil the requirements for the first class purity (Libudzisz, Kowal, 2000). Microbiological quality of waters affects the quality of raw materials and the food products with aquatic originating. Waters that are polluted by bacteria belonging to the *coli* group are neither suitable to drink nor even to recreational purposes use. Even minor contaminations of water by *coli* bacteria poses a risk of causing illnesses or even epidemics among people (Langergraber, Muellegger, 2005).

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Analiza form coli w rzece Wildze (południowa Polska)

Streszczenie

Rzeka Wilga należy do najbardziej zanieczyszczonych rzek w Krakowie. Zanieczyszczenie tej rzeki wynika głównie z obecności obiektów przemysłowych w jej pobliżu. Analizy miana coli w próbkach wody pobranych w 16 miejscach (począwszy od źródła rzeki w Raciborsku, aż do Podgórza w Krakowie) wzdłuż rzeki przeprowadzone zostały w 2014 roku. Analiza ta jest podstawową metodą służącą do wykazania obecności ścieków w ciekach wodnych i jest oparta na pojawieniu się pęcherzyka powietrza w rurce Durhama, co z kolei jest efektem fermentacji laktozy prowadzonej przez bakterie *Escherichia coli*. Wodę o największej czystości wykazano w środkowym biegu rzeki, gdzie zaobserwowano szybki nurt oraz brak zabudowań gospodarczych w pobliżu rzeki. Wodę złej jakości stwierdzono nawet przy źródle rzeki, gdzie miano coli wynosiło 0,1. Wilga wykazuje tendencję do samooczyszczania się, co można było zaobserwować na odcinkach: Janowice – Sygneczów – Gołkowice oraz Swoszowice – Łagiewniki. Rzeka ta wykazałaby sporą tendencję do samooczyszczania się w przypadku braku ścieków odprowadzanych w sposób pośredni i bezpośredni. Samooczyszczanie się rzek jest procesem długotrwałym, dlatego przy znacznym dopływie ścieków proces ten jest hamowany i przez to trudny do zaobserwowania.

Key words: coliform, *Escherichia coli*, water contaminations, Wilga River

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