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SANITARY ANALYSES OF SURFACE WATER IN THE INFLUENCE AREA OF MUNICIPAL WASTE DUMP BARYCZ IN KRAKOW

BADANIA SANITARNE WÓD POWIERZCHNIOWYCH W STREFIE ODDZIAŁYWANIA SKŁADOWISKA ODPADÓW KOMUNALNYCH BARYCZ W KRAKOWIE

Abstract: Microbiological analyses of surface water and soaking water were carried out in the area of the municipal waste dump Barycz in Krakow. The surface water samples were taken from June 2004 to May 2005 in monthly intervals from 5 measuring points, located following the direction of Malinowka stream water flow, nearby the waste dump, and the sample of soaking water from the drainage trench. While comparing the results from the period in which the II section was exploited, and then the III section, it may be ascertained, that the waste and mostly soaking water are the main sources of different microorganisms' penetration into the surface water. Amount of the tested indicating bacteria in the samples was mainly dependent on the distance of the measuring points from the borders of waste dump sections. On the basis of the regulations from the Ordinance of Ministry of Environment (DzU Nr 32, poz. 284) it was ascertained that in four measuring points – from above the III section, which is the inflow to the waste dump, until the point about 2 000 m further – the water in Malinowka stream is in class IV. Only in further part of the stream, even 2 700 m further, the water was classified into class III.

Keywords: microbiological indexes, surface water, municipal waste dump, soaking water

Waste dumps may be the source of different contamination, not only for soil, but also for groundwater and surface water. Threat to the quality of water nearby the waste dumps depends mainly on amount and composition of waste, technology of deposition, and location of the object. The highest danger comes from the waste dumps with wrong ground impregnation, where the contamination may infiltrate even to the significant distances and depths [1, 2].

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Influence of municipal waste dumps on the groundwater and surface water may be various: from the local contamination – e. g. soaking water, surface flows which carry the contamination from the near waste dumps, drained by the watercourses and collectors of water-bearing beds as well as washing away of waste during surface waters overflow. These factors may occur individually or in complex [3, 4].

Until now, microbiological analyses of surface water in the areas of waste dumps have been minor. The reason for this is lack of legal norms (in the Ordinance of the Minister of Environment from January 2003 about the range, time, way and conditions of monitoring of waste dumps, the biological factor was totally disregarded) and universal, standardized methods of evaluation of waste dumps influence on the environment and human health. Appreciating the role of such analyses, the main scientific aim of this work was the research of sanitary state of surface water nearby the big municipal waste dump.

This paper aimed to determine the effect of an active municipal waste landfill on microorganisms participating in nitrogen transformation in the soil environment.

Material and methods

Microbiological analyses of surface water and soaking water were carried out in the area of the municipal waste dump Barycz in Krakow. It is the biggest and the longest exploited object of such type in the area of Malopolska province and one of the biggest in Poland (its total area is 37 ha). The area of waste dump was divided into three parts: one was exploited from the end of 1974 to 1992, second to 2005, and currently the III section is being exploited – 11 ha syncline. At present, the municipal waste dump Barycz in Krakow may be considered as one of the best organized in Poland.

Samples of water were taken from June 2004 to May 2005 in monthly intervals from 5 measuring points, located following the direction of water flow of Malinowka stream, nearby the waste dump, and one sample of soaking water was taken from the drainage trench.

The chosen measuring points were marked on the map (Fig. 1) and described as following:

A – "background" – Malinowka stream before the III section, by the fence closing the waste dump (570 m from the gateway to the waste dump in the South-West direction),

B – Malinowka stream near the middle part of the III section, 260 m from the gateway to the waste dump in the South-East direction,

C – Malinowka stream, by the approaching road – nearby the unused collector for the soaking water, 720 m from the gateway in the North-East direction,

D – Malinowka stream near the P-8 piezometer, 660 m to the North from the borders of the I section,

E – Malinowka stream near the G piezometer, 1230 m to the North from the borders of the II section,

O – soaking water from the drainage trench by the II section of the waste dump, 450 m from the gateway to the waste dump in the North-East direction.

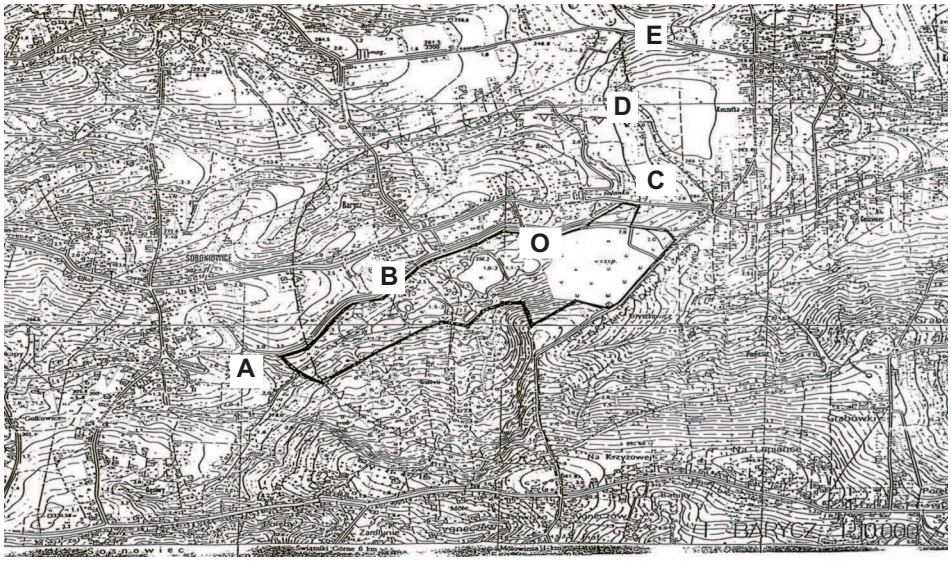

Fig. 1. Location of measuring points

It has to be mentioned, that the D and E measuring points were placed beyond the 500 m of protective zone measured from the borders of the waste dump.

Samples of water and soaking water were transported to the lab of Department of Microbiology at the University of Agriculture in Krakow, where the microbiological analyses were carried out, which consisted of:

1. evaluation of general number of mesophilic bacteria on nutritious agar,
2. evaluation of number of general coliforms and thermotolernat coliforms on Kessler–Swenarton agar, and in order to confirm the presence of coliform group bacteria – on Endo agar and on brilliant green bile agar,
3. evaluation of count of fecal *Streptococci* on APB medium and on AFE medium in order to confirm the presence of fecal *Streptococci*.

Number of microorganisms was defined using inoculation of diluted and non-diluted water and soaking water on the media as well as using membrane filters. The results were counted over 1 cm^3 or 100 cm^3 or were presented as a count.

Results and discussion

Waste dumps and inconveniences related to them become more and more visible issue in environment protection during last years. Waste cultivation, especially municipal and industrial waste, has to be included into very important but also very difficult tasks. In Poland, it was not possible to solve all of these problems for a large scale [5].

While searching for the solution of these problems, from June 2004 to May 2005 microbiological analyses were performed on surface water of Malinowka stream, which

flows through the area and surroundings of the municipal waste dump Barycz in Krakow. The gained results are presented in the Table 1 and in the Figures 2, 3 and 4.

On the basis of gained analytical data (Table 1, Fig. 2) a visible tendency of mesophilic bacteria increase was observed, as well as other microbiological indexes from March 2005, which is from the beginning of active usage of the II section of the waste dump. This fact evidences the influence of the waste dump on the microbiological state of the tested water. It is worth to mention, that the maximal amount of mesophilic bacteria was observed in March 2005 (point A) in the month in which the III section of the waste dump became active. The quatitative analyses also show that the highest number of mesophilic bacteria was after the water of Malinowka stream flew along all three sections of the waste dump and the old collector for the soaking water (from 2900 to 4895250 cfu/cm^3, mean value 800410 cfu/cm^3) – point C. The further the stream flew, the lower number of mesophilic bacteria was found, until the D measuring point (about 650 m from the C point) where the amount of mesophiles was from 6000 to 630000 cfu/cm^3. However mean number of mesophilic bacteria (77810 cfu/cm^3) was over ten times lower than in the C point. Very slow, gradual self-purification process was observed with the flow of water to the North. The first symptoms of this phenomenon occurred in the water taken 950 m, and 1230 m to the North from the borders of the waste dump.

According to Smylla [6] the amount of bacterio-plankton in 1 cm^3 of the surface water ranges from 102 to 109 in water non-contaminated with the sewage. The results of analyses performed in 1992 in the border of the protective zone (500 m) showed that the water in this part has not been self-purified [7]. Such phenomenon was also presently observed, but the fact of decreasing of the microbiological contamination in the further part of the stream is encouraging.

The current sanitary evaluation of water is based on the indirect conclusions about the presence of pathogens and indicators which normally live as saprophytes in the gastrointestinal tract of humans and higher animals. The sanitary indicators play the warning role from the infections, because there is a direct dependence between the amount of indicating bacteria in water and the amount of pathogens [6, 8, 9]. Water is not the natural environment for the pathogens, it is only their transport, and it is just in the period in which these microorganisms may stay alive [10, 11].

The basic indicator of bad sanitary state are coliforms, which amount decides, according to the Ordinance of the Ministry of Environment (DzU Nr 32, poz. 284) [12], of the division of surface water into five classes. Taking these criteria into account, it should be concluded that water of Malinowka stream in the part from the A to D measuring points include in the IV class, which means it is of bad quality. However, water from E point (located 2740 m from A point and 800 m from D point) was classified into class III (water of satisfactory quality regarding the microbiological state) But it should be pointed out that in August 2004, the amount of fecal coliforms reached the top border of this class. It is also worth to mention that these bacteria were not found in 8 among 12 analyses in 100 cm^3 of water taken from E point. Water quality evaluation is based on the border amounts of indicators, which for the IV class count: coliforms – from 5000 to 50000, fecal coliforms from 2000 to 20000 in 100 cm^3 of water.

Table 1

Amount of microorganisms in surface water in Malinowka stream in the area of municipal waste dump Barycz in Krakow

Measuring point	Dates of sampling											
	30 VI 2004	29 VII 2004	31 VIII 2004	26 IX 2004	27 X 2004	25 XI 2004	28 XII 2004	27 I 2005	25 II 2005	29 III 2005	28 IV 2005	25 V 2005
	Mesophilic bacteria [cfu in 1 cm^3 of water]											
A	553330	930250	549330	17910	250	200	190	680	347890	950000	721890	400000
B	319000	580670	1206350	1659750	200	150	850	6300	18470	78000	138950	152000
C	4895250	1138000	70500	3396700	17000	10000	13560	27900	14780	2900	8300	10000
D	41000	6000	61000	630000	54500	21100	35800	14540	19800	7300	18650	24000
E	35300	46180	58100	46180	21300	16210	8100	7800	6900	12340	21520	23100
O	3000330	920670	4267500	20890000	17000	16000	43320	893500	654200	1090000	3870000	28000000
	Fecal streptococci [count]											
A	>1	>1	0.0001	0.1	0.1	>1	>1	>1	0.01	0.0001	0.001	0.0001
B	0.1	0.01	0.01	0.1	0.01	>1	>1	>1	0.1	0.0001	0.001	0.0001
C	0.001	0.01	0.001	>1	0.1	>1	>1	>1	0.1	0.0001	0.01	0.01
D	0.1	0.001	0.001	>1	>1	>1	0.1	>1	0.1	0.001	0.001	0.0001
E	>1	0.1	0.1	0.1	>1	>1	>1	>1	>1	0.1	0.01	>1
O	0.00001	0.001	0.001	0.001	0.01	0.01	0.01	0.001	0.0001	0.00001	0.001	0.00001

A (above the III section) and B (on the height of the middle part of the III section) points had in 100 cm^3 of water as following: from 500 to 18200 cfu of coliforms and from 300 to 7600 cfu of fecal coliforms (thermotolerant), from 3200 to 18900 cfu of coliforms and from 500 to 10600 cfu of fecal coliform. However the mean amount was similar to the first group – 7708 and 7467 cfu, 4200 and 4125 cfu for the second group of the tested bacteria. During 12 months of the research, samples of water from A point

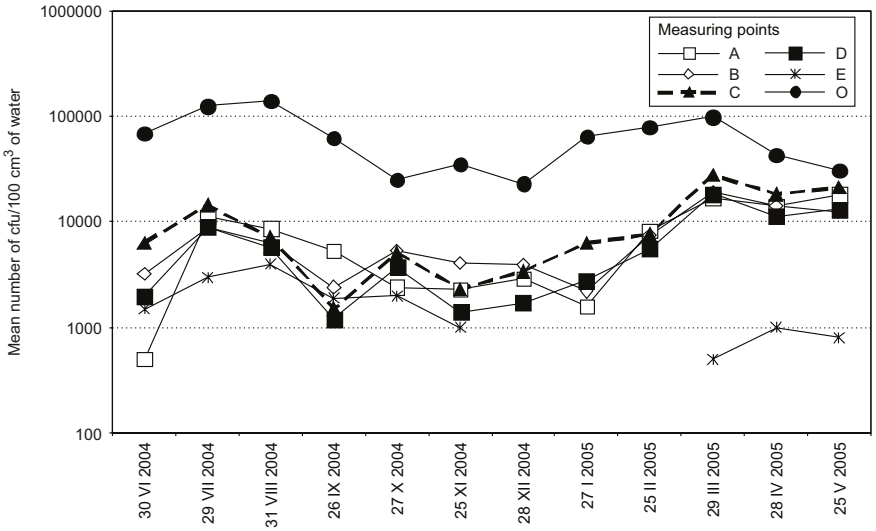

Fig. 2. Amount of coliforms (log scale) in surface water and in soaking water depending on the date of sampling in the area of the municipal waste dump Barycz in Krakow

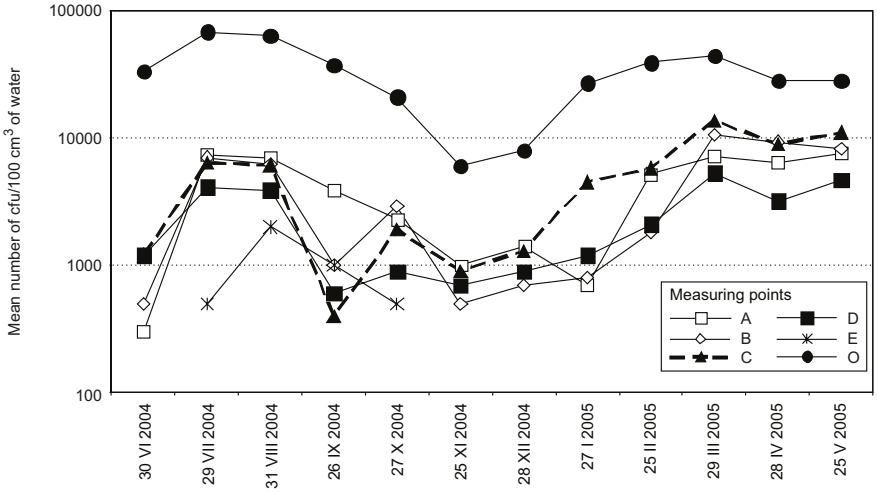

Fig. 3. Amount of thermotolerant coliforms (log scale) in surface water and in soaking water depending on the date of sampling in the area of the municipal waste dump Barycz in Krakow

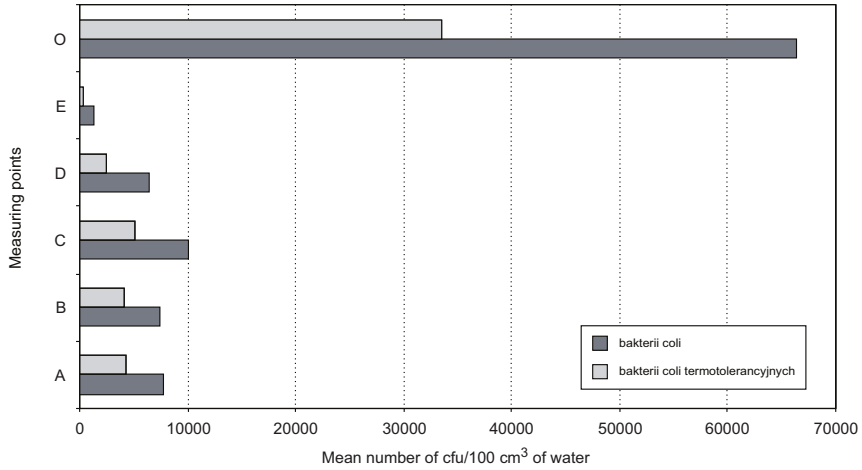

Fig. 4. Average amount of coliforms and thermotolerant coliforms (linear scale) in surface water and soaking water in the area on the municipal watse dump Barycz in Krakow

8 times, and from B point 6 times did not transgress the border values of fecal coliforms for the IV class. According to the general coliform index, 7 out of 12 analyses classified the water from A and B point into the IV class.

Many more bacteria were isolated from water from C point, taken from Malinowka stream nearby the old collector for the soaking water. In 100 cm^3 of this water, coliforms occurred in the amount from 400 to 13600 cfu. The border value of coliform index for the II class was transgressed 9 times, whereas for fecal coliforms – 7 out of 12 analyses, which caused classification of this water into the IV class. In the further parts of Malinowka stream the amount of both groups of bacteria decreased, but as far as 1 450 m from the C point it could be classified into the III class.

In 1 cm^3 of water taken from A, B, C and D points – periodically no fecal *Streptococci* were found, or they were found even in 10–4 dilution. The gained results of bacteriological analyses were given as a count, and its range was defined from > 1 to 0.0001. Only in water from E point, the range of fecal *Streptococci* was from > 1 to 0.01, and the minimal value was found only once – 28th April 2005. In other 7 months these bacteria were not found, and in 4 dates of sample taking their presence was found only in water ten times diluted, taken from the point located the furthest from the waste dump (Table 1).

Soaking water has the greatest influence on the contamination of the surface water. Decrease of their occurrence is synonymous with the decrease of the degrading influence of the municipal waste dump on the environment. However, it should be mentioned that municipal waste collecting leads to the occurrence of soaking water. The amount of soaking water depends on the type of waste, way of its collection, period of the waste dump exploitation and on the amount of precipitation. The composition of the soaking water depends on the stage of decay and the waste substance [13].

Basing on the chemical analysis in 2004, it was found that the soaking water in the area of the municipal waste dump Barycz in Krakow is mainly contaminated with

organic compounds and is highly salted. The border pH values were 6.9 and 9.5 but most often pH was on the level of about 7–8 [14].

The analyses of the soaking water taken from the drainage trench nearby the II section of the waste dump Barycz in Krakow showed very profuse occurrence of different microorganisms groups during the whole year of tests. On the basis of the analyses, occurrence in 1 cm^3 of the soaking water from 16000 to 28000000 cfu of mesophilic bacteria was found from 30th June 2004 to 25th May 2005. The sanitary indexes were on the high level, because the count of fecal streptococci in the soaking water was from 0.01 to even 0.00001, and coliforms were from 23000 to 141000 cfu/100 cm^3 whereas fecal coliforms were from 6000 to 68000 cfu/100 cm^3. Comparing these results with surface water classification, a high transgression of the bottom border values for the last V class of water may be found. These values are: coliforms > 50000 and fecal coliforms > 20000 in 100 cm^3. Mean monthly amount of these bacteria in the tested soaking water was as follows: 33583 and 66417 cfu in 100 cm^3. In summer (July and August) maximal value of coliforms index was found: over 100000 for the general group and over 60000 for the fecal – thermotolerant group. It should be mentioned that the soaking water temperature was on the level 2.9–20.7 ^oC during the research year. The high temerature in summer was promoting the growth of most microorganisms.

Comparing the results gained in the period of II section exploitation, and then the III section of the municipal waste dump, in the samples of surface water, the soaking water may be considered to have the influence on spreading of microorganisms in the area and in the surroundings of this waste dump.

According to PIOS [15] the soaking water is many times overloaded than the city sewage, because it shows large quantitative differentiation of bacteria. Improvement of the soaking water quality was usually found after protection of the waste heap, by eg reinforcing the slopes, tightening the soil and surrounding it by the screen as deep as the impermeable level [2].

Conclusions

1. Microbiological analyses of the surface water and the soaking water performed from June 2004 to May 2005 nearby the municipal waste dump Barycz in Krakow showed the differentiation of indicating bacteria occurrence.

2. The collected waste and the soaking water are the basic source of different microorganisms' penetration into the surface water. Amount of the tested indicating bacteria in the samples depended on the distance of the measuring points from the borders of the waste dump sections.

3. Analyzing the results, it may be concluded that on the whole part of the Malinowka stream – 2740 m, occurrence of the fecal bacteria was found. According to this, there is a danger of the presence of other microorganisms, which may negatively influence people and animals health.

4. On the basis of the microbiological research and on the Ordinance of the Minister of Environment (DzU Nr 32, poz. 284) in four measuring points – above the III section (the place of inflow to the waste dump) to the point about 2 000 m further – water in

Malinowka stream may be of the IV class. Only in the further part of the stream distant over 2 700 m the water was classified into the III class.

5. The exact knowledge of the influence of the municipal waste dumps on the environment and human health is very important issue, which needs the complex, interdisciplinary, long-term research. This is why it is necessary to perform microbiological analyses of surface water in the area of waste dump influence, not only the physicochemical ones, and it should be legally defined.

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Abstrakt: Badania mikrobiologiczne wód powierzchniowych oraz odcieku prowadzone były w rejonie składowiska odpadów komunalnych Barycz w Krakowie. Próbki wód powierzchniowych pobierano w okresie

od czerwca 2004 r. do maja 2005 r. w odstępach miesięcznych z 5 stanowisk pomiarowych ułożonych kolejno w kierunku spływu wody potoku Malinówka w sąsiedztwie składowiska oraz próbkę odcieku z rowu opaskowego. Porównując uzyskane wyniki w okresie, kiedy był eksploatowany sektor II, a następnie sektor III składowiska odpadów komunalnych Barycz w Krakowie można stwierdzić, że składowane odpady, a przede wszystkim odcieki są zasadniczym źródłem przenikania różnych grup mikroorganizmów do wód powierzchniowych. Liczebność badanych bakterii wskaźnikowych w pobranych próbkach wody uzależniona była przede wszystkim od odległości wyznaczonych stanowisk pomiarowych od obrzeży sektorów składowiska. Na podstawie zaleceń zawartych w Rozporządzeniu Ministra Środowiska (DzU Nr 32, poz. 284) stwierdzono, że w czterech punktach pomiarowych – od powyżej III sektora składowiska, czyli miejsca wpływu na teren składowiska aż do punktu oddalonego około 2000 m – woda w potoku Malinówka odpowiada klasie IV. Dopiero w dalszym biegu potoku oddalonym ponad 2700 m zaliczono badaną wodę do III klasy.

Słowa klucze: wskaźniki mikrobiologiczne, wody powierzchniowe, składowisko odpadów komunalnych, odciek