THE OCCURRENCE OF POTENTIALLY PATHOGENIC BACTERIA IN ATMOSPHERIC AIR IN THE VICINITY OF A SEWAGE TREATMENT PLANT

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SUMMARY

The aim of the study was to evaluate the microbiological contamination of atmospheric air on the premises and in the vicinity of the Municipal Sewage Treatment Plant in the town of Słupsk. The concentration of selected bacteria in atmospheric air was determined at the fermentation pools, at the composting facility as well as 350, 600, and 800 m outside the sewage treatment plant. The largest bioaerosol emission source in the sewage treatment plant was the storage area of maturing compost. The total number of bacteria reached the maximum of 10^4 CFU m^{-3}. The number of the indicator bacteria *Pseudomonas fluorescens* ranged from 0 to 14.3 CFU m^{-3}. *Escherichia coli* was detected only in one time in May.

On the basis of the results obtained one may come to the conclusion that the tested facility does not pose a hazard of the emission of tested bacteria over the areas beyond the sewage treatment plant.

Keywords: bioaerosol, *Pseudomonas fluorescens*, *Escherichia coli*, sewage treatment plant

INTRODUCTION

Municipal objects have an effect on surrounding soils, surface and ground waters, the air, and through the atmosphere, on distant agriculture, town and recreation areas. Main factors contaminating the air are chemical and microbiological (bioaerosols) pollutants and odours [1, 6]. Bioaerosols are mainly created by opportunistic pathogens commonly occurring in soil and water. They are mainly bacteria of the genera: *Pseudomonas*, *Enterobacter* and *Bacillus* [9]. A large number of microorganisms occurring in the air is a frequent indicator of a bad sanitary state of the environment surrounding big urban agglomerations. Air may be a way of transmission of microbiological pollutants from contaminated areas to not contaminated ones. Particular attention should be given to ways of the air flow and the elimination of pollution sources [1].

Sewage is a potential carrier of pathogenic microorganisms and it may pose a health hazard when it penetrates into the atmosphere during aeration [2]. Sewage aeration using an aerator, diffuser, sprinkles and water-drawing wheels increases the probability of transmission of microorganisms present in sewage into the air [5].

Monitoring studies are frequently conducted recently, concerning the measurements of the air composition. The knowledge obtained makes it possible to design new sewage treatment plants properly and improve their exploitation so as to minimize the noxious effect on the environment.

The aim of the study was to estimate the impact of the Municipal Sewage Treatment Plant in Słupsk on the level of air microbiological contamination and to determine the range of spreading the emitted bacterial aerosol.

MATERIAL AND METHODS

Monitoring studies of atmospheric air were conducted at the Municipal Sewage Treatment Plant in Słupsk and at points located at different distances from the object: point 1 – composting facility, point 2 – open fermentation pools, point 3– a farm about 350 m away to the east and about 600m to the south from the sewage treatment plant, point 4– agricultural and orchard area about 800 m away to the east from the sewage treatment plant.

The air samples were taken with the crash method using Microbiological Air Sampler MAS-100 Eco™ by Merck. Through the head of the apparatus a strictly determined air volume was sucked on a Petri dish with agar medium, according to a season of the year and atmospheric conditions. The research was conducted monthly in the period from October to December 2005 and from March to June 2006.

The following groups of microorganisms were determined at suitable selective media:

- total bacteria number on standard nutrient agar (incubation at 28ºC – 72 h)
- *Pseudomonas fluorescenc* on the King B medium (incubation at 28ºC – 48h)
- *Escherichia coli* on agar ENDO with fuchsine and lactose (incubation at 37ºC – 24 h)

All air measurements for the tested groups of microorganisms were made in four replications. Meteorological conditions during the sample collection were presented in Table 1.

On the basis of the microorganism number obtained the means were calculated from the colony-making units. In order to work out the results, a conversion table of the positive holes number for the air monitoring system MAS-100 was applied, and the colony number obtained was counted over 1 m^3 of the atmospheric air. The evaluation of the atmospheric air pollution level was performed according to the recommendation given in the Polish Standards: PN-89/Z-04111/02 [8]

RESULTS AND DISCUSSION

The number of the tested microorganisms in atmospheric air turned out to vary depending on a place and time of sampling. The results, showing the bacteria number and the level of air pollution were presented in Fig. 1 and 2 and in Table 2.

The total number of bacteria in the air on premises of the tested sewage treatment plant ranged from 10^1 to 10^4 $CFUm^{-3}$ (Fig. 1.). The highest bacteria emission took place at the composting facility. At this site a strong air pollution occurred in May, and the total number of the bacteria reached up to 17220 CFU m^{-3}. At the fermentation pools and at all the points beyond the sewage treatment plant air pollution did not occur. The total bacteria concentration determined at these points indicates that the air is not polluted according to the Polish Standards recommendations.

Table 1. Meteorological conditions during air sampling (data coming from IMiGW in Słupsk)

Sampling date	Pressure (hPa)	Mean temperature (ºC)	Humidity (%)	Wind direction	Wind velocity (m/s)
18.10.2005	1025.8	7.1	87	N	2
14.11.2005	1017.0	7.1	87	W	1
05.12.2005	999.7	2.8	90	SE	2
02.03.2006	996.7	–1.6	83	SW	2
04.04.2006	1008.3	4.6	79	SSE	2
08.05.2006	1019.3	13.9	66	N	3
02.06.2006	1024.2	10.5	77	NW	2

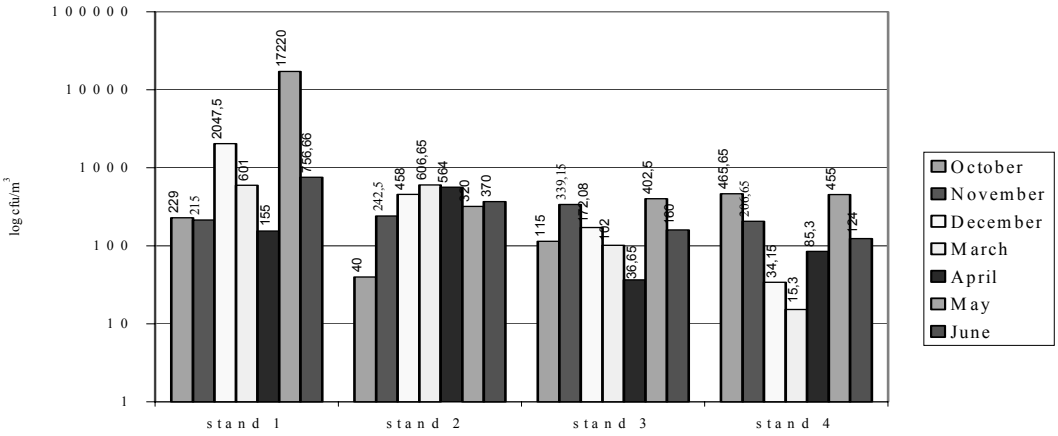

Figure 1. Total number of bacteria at particular sites in autumn 2005 and spring 2006

In the case of the indicator bacteria *Pseudomonas fluorescens* the higher concentration coming to 14.25 $CFUm^{-3}$ was also reported in the air at the composting facility (Fig. 2). The bacteria were the cause of moderate air pollution at the open fermentation pools during the whole research period. At sites 3 and 4 outside the sewage treatment plant their number decreased from 4.5 to 0 $CFUm^{-3}$ along with a distance from the object. At the point at a distance of 800 m from the sewage treatment plant *P. fluorescens* was not recorded in two times: in December and April.

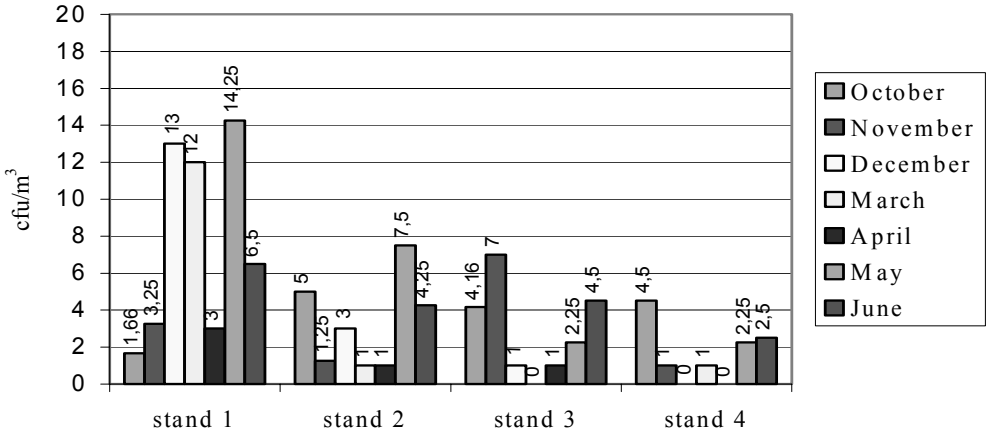

Figure 2. Number of *Pseudomonas fluorescens* at particular sites in autumn 2005 and spring 2006

During the whole research period from October to December 2005 and from March to June 2006, *E. coli* was detected only in May in the air at two sites: at the composting facility and 350 m outside the sewage treatment plant (Table 2). No *E. coli* was reported in the air at the open fermentation pools as well as at a distance of 600 and 800 m outside of sewage treatment plant.

Table 2. Number of *Escherichia coli* in autumn 2005 and spring 2006 at the tested sites

Stand	Concentration [CFU m $^{-3}$]						
	October 2005	November 2005	December 2005	March 2006	April 2006	May 2006	June 2006
I	0	0	0	0	0	2	0
II	0	0	0	0	0	0	0
III	0	0	0	0	0	2	0
IV	0	0	0	0	0	0	0

The level of bacterial bioaerosol concentration was diverse at particular measurement points. It depended mainly on a distance from the sewage treatment plant, but also on atmospheric conditions (wind direction), and a season of the year. Bioaerosol is spread mainly with the wind in eastern direction. The highest level of microorganisms was observed in May. In the studies by Petrycka [6] and Pillai [7] it was observed that a high temperature may contribute to the increase in emission of potentially pathogenic microorganisms.

The results obtained proved that the number of microorganisms penetrating into air decreases substantially along with a distance from the source of emission. This is supported by the research conducted by other authors [2, 4].

For the bacteria of the family *Enterobacteriaceae* there are no standards indicating the admissible content of this groups of bacteria in the air. Analyses conducted at German composting plants indicated a considerably higher level of *E. coli* than in the present study. Böhm [3] reports that a number of the bacteria of the genera *Escherichia coli* on the premises of the composting plant amounted even to 2400 CFUm^{-3} air.

Only the microorganisms which are the most resistant and best adapted to unfavourable living condition maintain longest their viability in the air [10]. One should bear in mind that bacteria

contaminating atmospheric air may also come from other sources than the sewage treatment plant. A lot of factors have an effect on the number of microorganisms in the air, such as the lie of the land, or tree-covered areas [1].

CONCLUSIONS

1. The composting facility was the biggest emitter of bioaerosol at the sewage treatment plant. Most tested bacteria were isolated here.
2. No significant generation of bacterial bioaerosol was detected from the open fermentation pools, which is confirmed by a low concentration of the tested bacteria in the air.
3. The bacteria *Pseudomonas fluorescenes* occurred at all the research sites for most time of the study. Their absence was reported at site 3 in March and at site 4 in December and April. Their number shows that the air was moderately contaminated with this species of bacteria.
4. Potentially pathogenic bacteria *Escherichia coli* were detected only in one time at sites 1 and 3. The results obtained at the points located in different distances and direction from the sewage treatment plant indicate that the tested facility does not influence negatively on the microbiological quality of the air around the area and does not pose a threat to local people, and the applied technology of sewage treatment does not contribute to spreading the tested microorganisms.

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