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MICROBIAL CONTAMINATION OF THE AIR AT THE WASTEWATER TREATMENT PLANT

M. Vítězová, T. Vítěz, H. Mlejnková, T. Lošák

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Abstract

VÍTĚZOVÁ, M., VÍTĚZ, T, MLEJNKOVÁ, H., LOŠÁK, T.: *Microbial contamination of the air at the wastewater treatment plant.* Acta univ. agric. et silvic. Mendel. Brun., 2012, LX, No. 3, pp. 233–240

Wastewater treatment plants (WWTPs) primarily serve to protect the environment. Their task is to clean waste water from the agglomerations. On the other hand wastewater treatment plants can also negatively affect the environment in their neighbourhood. These include emissions of odour and microorganisms. This article discusses the microbial contamination of the air, called bioaerosols in selected wastewater treatment plant for 18 000 p.e. From results of the work is evident that the largest group of microorganisms in the monitored air were psychrophilic and mesophilic bacteria and microscopic fungi. The number of psychrophilic bacteria ranged from 14 to 12 000 CFU/m^3 (colony forming units in 1 m^3), the number of mesophilic bacteria varied in the range from 20 to 18 500 CFU/m^3 and the fungi from 25 to 32 000 CFU/m^3 in the air. The amount of actinomycetes ranged from 1 to 1 030 CFU/m^3 and faecal coliform bacteria from 0 to 2 500 CFU/m^3. Furthermore, it was confirmed that the highest air contamination was around the activation tank, area for dewatered sludge and around the building of mechanical cleaning, depending on the season. The density of studied microorganisms correlated with air temperature.

wastewater treatment plant, microbial air contamination, bioaerosol, bacteria

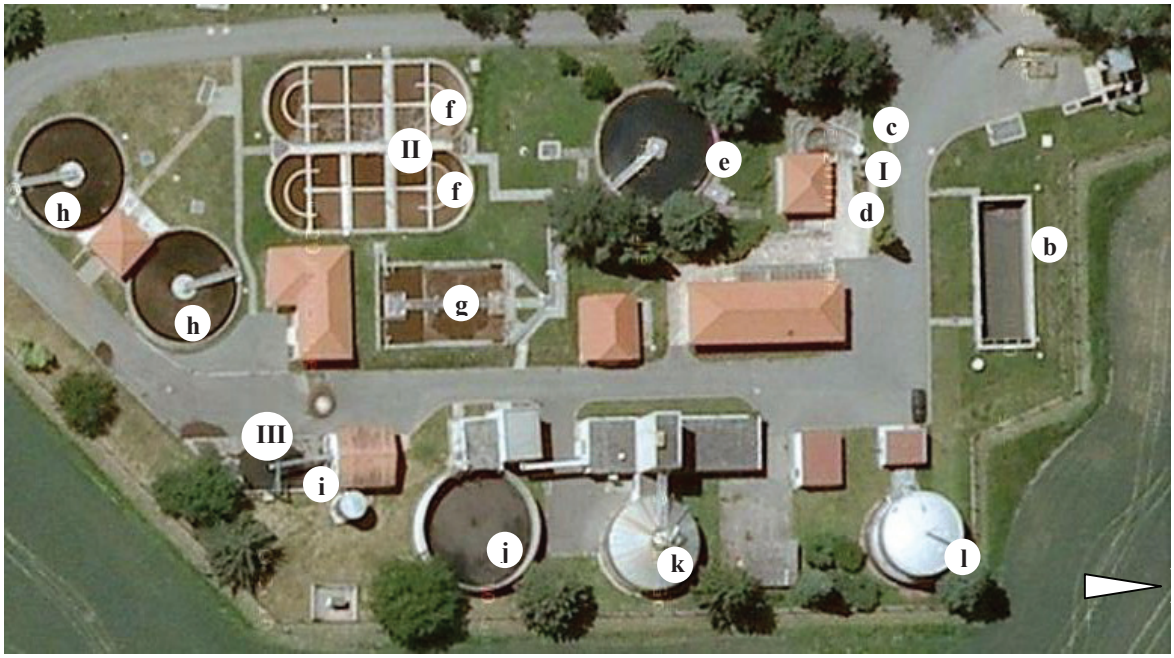
Wastewater treatment plant may affect the environment in many different ways, according to its basic parameters. These are mainly the size of wastewater treatment plant, technology used, machinery used and treating method used. One of the most important contaminants in the wastewater treatment are bioaerosols, which may contain different types of microorganisms (Brenner *et al*., 1988; Fracchia *et al*., 2006). Bioaerosols are generated from the bursting bubbles produced by the aeration systems, which provide oxygen for the biodegradation processes. These bioaerosols may contain bacterial, viral and fungal species (Gerardi and Zimmerman, 2004; Fannin *et al*., 1985), and may cause potential health hazard for workers of wastewater treatment plants. A significant risk is also posed by microbial allergens and endotoxins (Rylander, 1999; Thorn *et al*., 2002). The highest emission of bioaerosols are at the sites of pre-treatment and the primary clarifiers, as well as those sites containing moving mechanical equipments for water aeration (Pascual *et al*., 2003). Dose response relationships have not been established for most biological agents and knowledge about threshold values is sparse. In the Czech Republic there is only ČSN P CEN/TS 16115-1 Ambient air quality – Measurement of bioaerosols – Part 1: Determination of moulds using filter sampling systems and culture-based analyses. The goals of the present study were to determine the degree of bacterial contamination of bioaerosols generated by wastewater treatment plant, determine the presence of fungi and bacteria.

MATERIAL AND METHODS

Sampling and weather condition characterisation

To determine the microbial contamination of bioaerosols mechanical-biological wastewater treatment plant for 18 000 p.e. in the effluent flowing from a single sewer system was selected.

Description of wastewater treatment plant and location of measurement points is shown in Fig. 1.



1: *Scheme of wastewater treatment plant: a –grit catcher, b – rainwater reservoir, c –sand catcher, d – screens, e – primary settling tank, f – activation tank, g – sludge regeneration, selector, h – secondary settling tank, i – area for dewatered sludge, j – sludge storage tank, k – anaerobic digester, l – gasholder;*
I – measurement point 1, II – measurement point 2, III – measurement point 3.

At the selected wastewater treatment plant three sampling points (I–III) marked in Fig. 1 were defined. Point I was placed at the sand catcher and screens object (c, d) and (d), point II was placed near to the activation tank (f), point III was placed at the area for dewatered sludge (i). Control point IV for the estimation of the contamination the neighbouring air (background) was placed 150 meters from wastewater treatment plant and its placement depended on the prevailing wind direction in the collection time. The air sampler MAS-100 (Merck, Germany) was situated at individual locations at a height of 1.5 m above the earth's surface. Strictly determined air volume was sucked directly onto Petri dish with agar medium placed in the sampler. Sampling rate was 1.6 dm^3/s. The volume of the air passed through the air sampler was elected to the expected contamination of the air and ranged from 100 dm^3–1 000 dm^3. Air sampling was conducted from January to December 2010, by measurement conditions listed in Tab. I. Data on weather conditions (particularly wind speed) are of great importance due to the spread of microorganisms both the WWTP site, but also in its surroundings. Sampling was performed in three replications.

I: *Sampling weather conditions*

Date	Average air temperature	Atmospheric pressure	Wind speed	Wind direction
[-]	[°C]	[hPa]	[m/s]	[-]
13. 1. 2010	0.1	1009.2	5	W
10. 2. 2010	0.5	1055.8	7	SW
17. 3. 2010	6.4	1012.6	5	W
14. 4. 2010	13.2	1016.0	7	W
12. 5. 2010	14.4	1009.6	7	NW
16. 6. 2010	20.3	1012.3	3	W
14. 7. 2010	23.8	1015.3	3	S
18. 8. 2010	21.0	1015.4	5	S
15. 9. 2010	12.4	1007.2	3	S
13. 10. 2010	7.5	1018.6	12	N
10. 11. 2010	5.3	1003.3	9	SW
15. 12. 2010	0.2	1015.5	3	W

Detection of studied microorganisms

The following groups of microorganisms were determined in this study.

1. Number of heterotrophic bacteria were detected on the general purpose culture medium Nutrient Agar No. 2 (HiMedia, Czech Republic). Incubation temperature for mesophilic bacteria was 37 °C, incubation time was 24 hours. Incubation temperature for psychrophilic bacteria was 20 °C for 72 hours. All types of colonies were enumerated.
2. Number of fungi (including yeasts and filamentous species of moulds) was estimated on the general cultivation medium for fungi Czapek Dox Agar (Merck, Germany). Plates were incubated at 25 °C for 48–72 hours. All types of colonies were enumerated.
3. Actinomycetes counts were detected using Actinomycete Isolation agar (Sigma-Aldrich, Czech Republic). Incubation proceeded at 26 °C for 7 days.
4. Presence of faecal indicators were detected by faecal coliforms enumeration on m-FC agar (Merck, Germany). Plates were incubated at 44 °C for 24 hours. Blue colonies of faecal coliforms were enumerated.

Evaluation of data

Based on the determined numbers of microorganisms from 3 parallel samples the mean values of CFU were calculated and converted to CFU in cubic meter of the air. The results were worked into graphs and compared with weather condition data.

RESULTS AND DISCUSSION

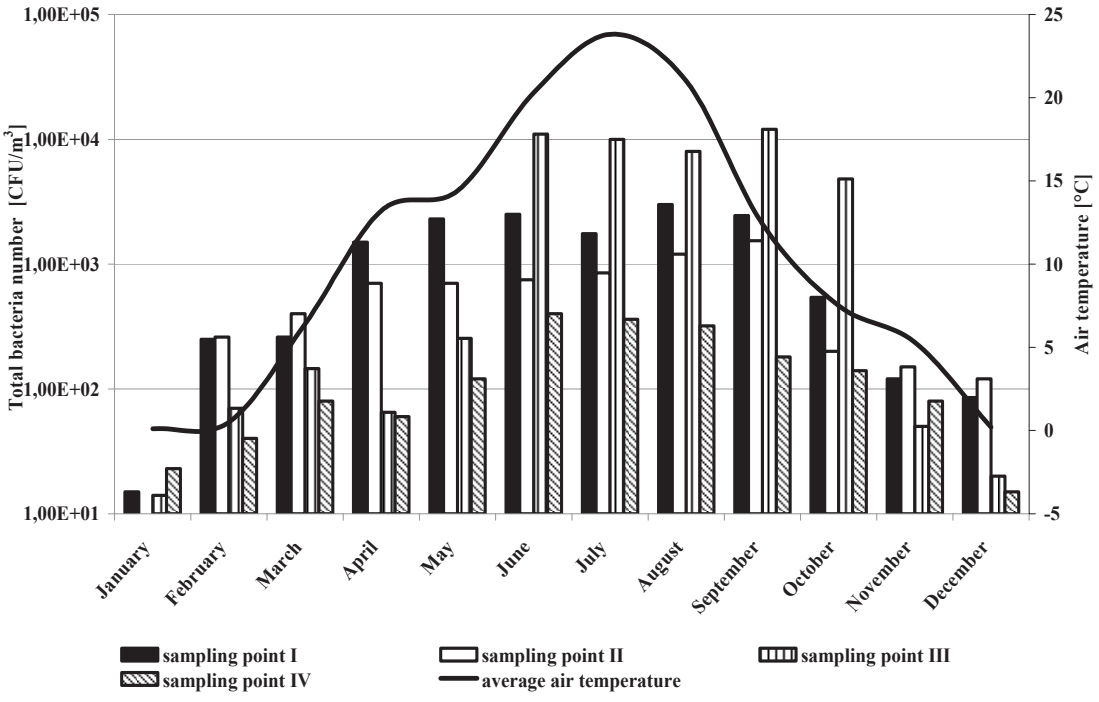
Results are shown in Fig. 2–6. The number of heterotrophic bacteria in the air at the wastewater treatment plant ranged from 10^1 to 10^4 CFU/m^3 (Fig. 2 and 3).

Psychrophilic group have been found around area for dewatered sludge in large numbers, i.e. about 10 000 CFU/m^3. This group of bacteria was dominant also around sand catcher. Average values more than 1 000 CFU/m^3 have been noticed in the period between April and September, in contrast with mesophilic group, which occur in this sampling point in so high concentrations only in July and August.

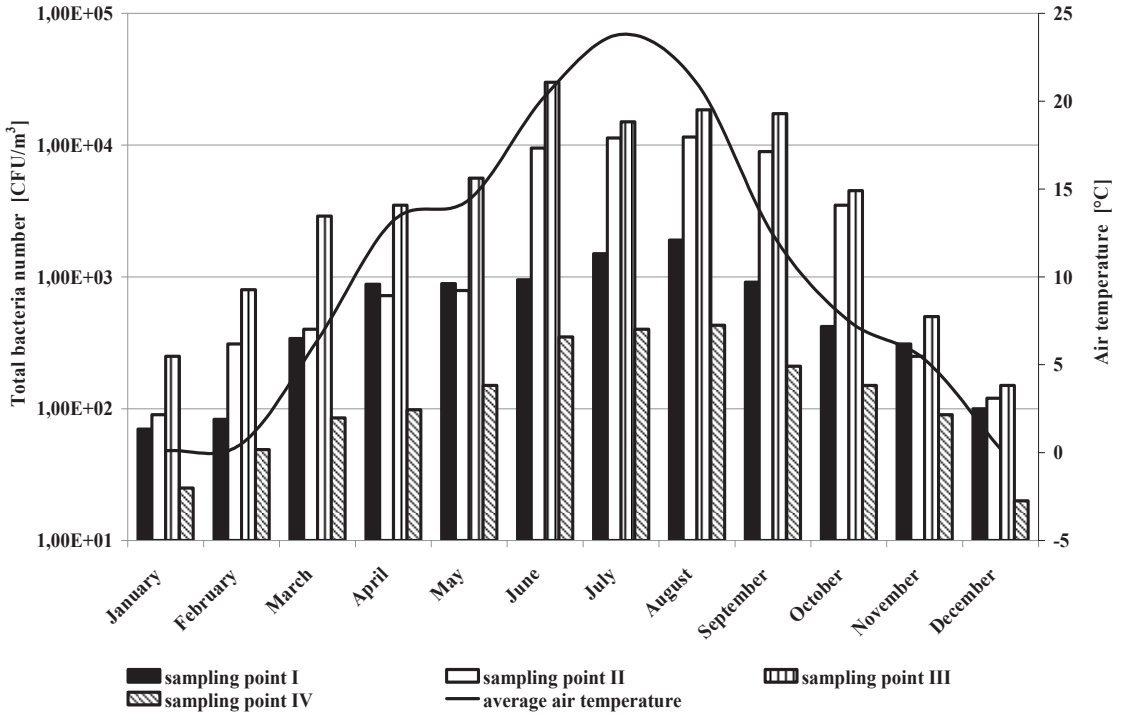
Around activation tanks high numbers of mesophilic bacteria (11 500 CFU/m^3), but only 1 540 CFU/m^3 psychrophilic bacteria have been detected in summer months. Overall highest average number of heterotrophic bacteria have been detected in June around area for dewatered sludge (measurement point III), namely the 30 000 CFU/m^3. The amounts of both groups of heterotrophic bacteria were in correlation with air temperature, i.e. the maxima were in summer months in samples situated on WWTP and in control sample respectively (Tab. II).

According to Fernando and Fedorak (2005) the number of bacteria in the air emitted from activation tanks and the other sites decreases along with a distance from the source of emission. Only the microorganisms which are the most resistant and the best adapted to unfavourable living conditions maintain the longest vitality (Taha *et al.*, 2005).

Fungi in the air at the wastewater treatment plant ranged also from 10 to 10 000 CFU/m^3 (Fig. 4).



2: *Psychrophilic group of total bacteria in the air at the wastewater treatment plant*



3: *Mesophilic group of total bacteria in the air at the wastewater treatment plant*

II: *Correlation between the amounts of microorganisms and the air temperature during the year*

Group of microorganisms	Correlation coefficient for sampling point I	Correlation coefficient for sampling point II	Correlation coefficient for sampling point III	Correlation coefficient for sampling point IV	Mean correlation coefficient
Mesophilic bacteria	0.94	0.83	0.81	0.93	0.9
Psychrophilic bacteria	0.87	0.74	0.73	0.90	0.8
Fungi	0.79	0.79	0.35	0.81	0.7
Actinomycetes	0.42	0.31	0.74	0.36	0.5
Faecal coliforms	0.61	0.63	0.63	-	0.6

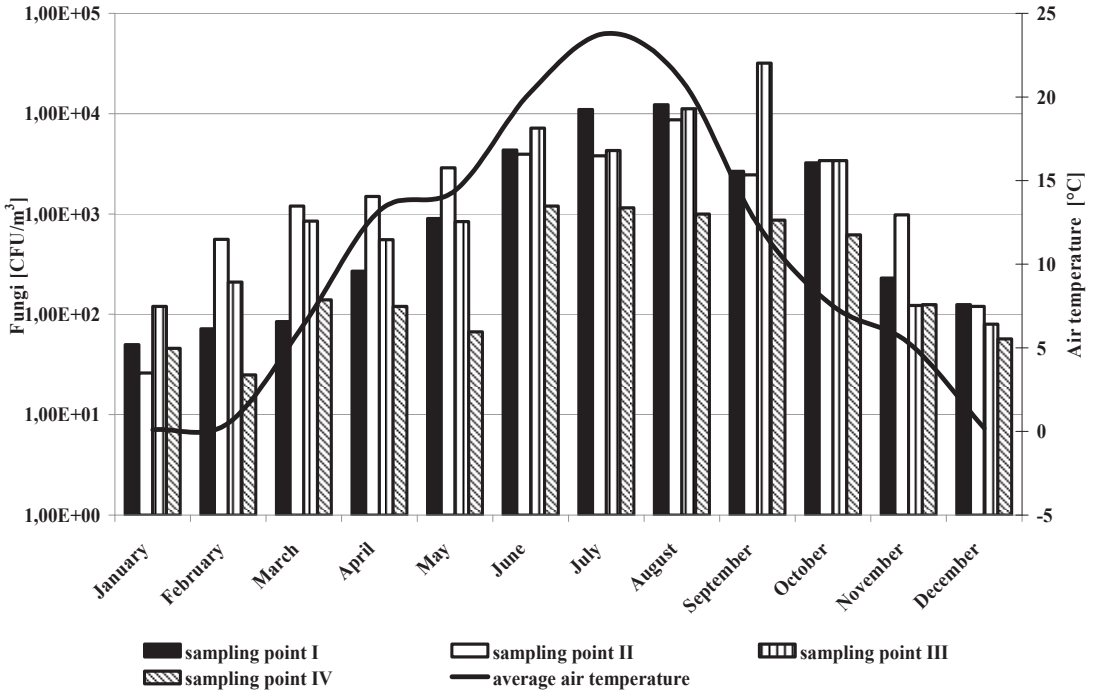
Fungi like bacteria pollute air strongly in summer months. Around the sand catcher highest values of spore concentration have been occurred from July to August (12 000 CFU/m^3), around the area for dewatered sludge in September (32 000 CFU/m^3). All values of the air contamination with fungi spores were balanced on the same amounts level in all measurement points on WWTP in October. Also the counts of fungi correlated with the air temperature during the year.

Actinomycetes in the air at the waste water treatment plant ranged from 10 to 1 000 CFU/m^3 (Fig. 5).

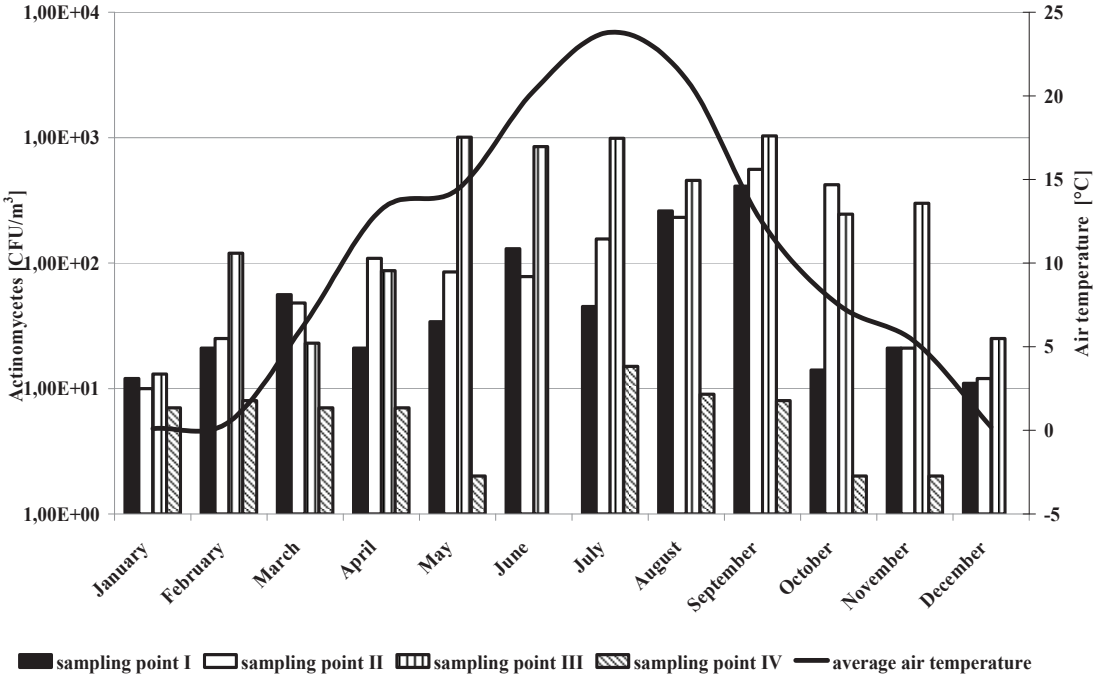
Quite balanced values showed the air around area for dewatered sludge in the period from May to September. Around sand catcher was growth dynamics of actinomycetes population fluctuating during the year with only one peak in September (1 000 CFU/m^3). In October we noticed great difference in occurrence of actinomycetes in the air around the sand catcher and measurement points II and III (activation tank and area for dewatered sludge). Organic compounds in compost stimulate the growth of actinomycetes. This material can use as many as 50 various sources of carbon (Grinshpun *et al.*, 1997; Lacey, 1997). There was not found the correlation with air temperature for the actinomycetes as by the other studied microbial groups (Tab. II).

Fig. 6 shows amounts of faecal coliform bacteria in the tested air.

In winter period (January and February) their presence was not detected in any of the measurement points. Around the sand catcher and activation tanks we observed low values of coliforms in March, April and December. The value 1 000 CFU/m^3 of faecal coliforms exceeded samples collected in the period between May and September only around activation tanks. There was the maximum of 230 CFU/m^3 in July at the area of the sand catcher. During the whole year was not recorded incidence of faecal coliforms in measurement point IV, i.e. control location,



4: *Fungi in the air at the waste water treatment plant*

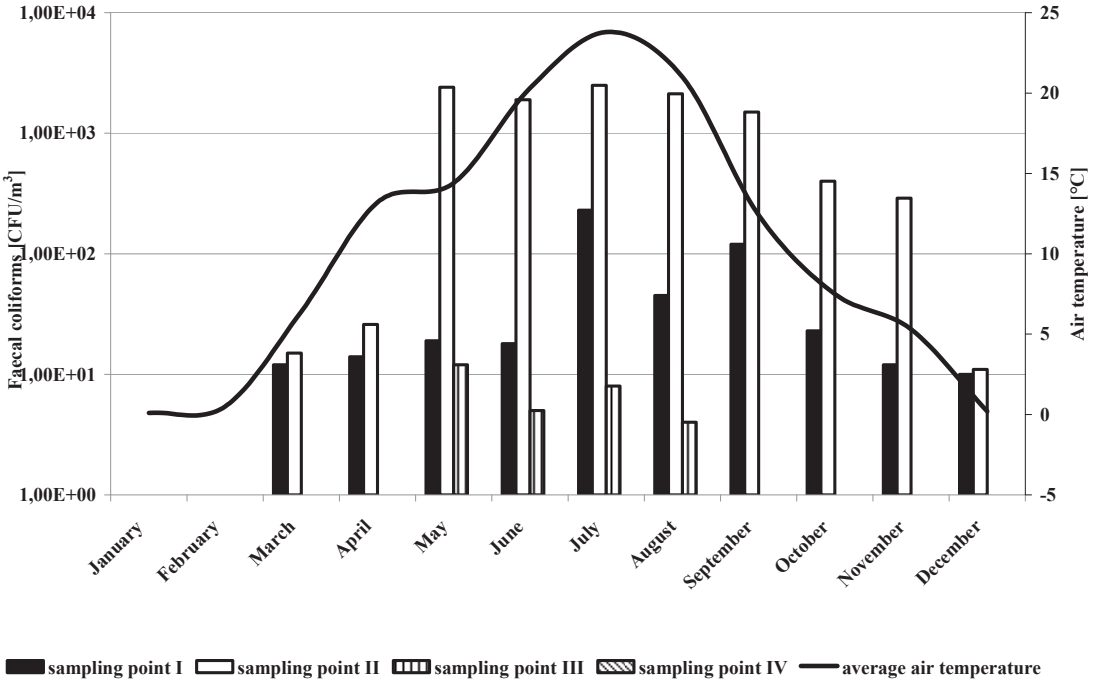


5: *Actinomycetes in the air at the waste water treatment plant*

situated at the distance 150 m from the WWTP. The correlation with air temperature was proved also for this group of bacteria (Tab. II).

On the basis of previous studies, the conclusions show that the area adjacent to activation tanks are the most exposed to the action of biological aerosols (Fernando and Fedorak, 2005; Bauer *et al.*, 2002). In our study such tendency was not observed, since the highest emission of the tested microorganisms was not observed at activation tanks. The most serious source of air pollution proved to be the sand catchers and the area for dewatered sludge storage.

Generally, the increased concentration of microorganisms in the air at the wastewater treatment plant can be observed in the warmer months (May–September), while the decrease in



6: *Faecal coliform bacteria in the air at the waste water treatment plant*

the concentration of microorganisms in the air can be observed in the colder months (October–February). In the study by Petrycka *et al.* (1995) the highest air contamination was also reported in the summer period. The high temperature can contribute to the rise in the emission of potentially pathogenic microorganisms (Pillai and Ricke, 2002). Effective monitoring methods are required to evaluate bioaerosol exposure and health risks for waste water treatment plant workers (Carducci *et al.*, 2000; Pollard *et al.*, 2006). There are no close references to the number of microorganisms in the air in connection with the epidemiological results of air pollution in the literature. In the Czech Republic is currently no law except the draft standard for moulds in bioaerosols (mentioned above). For this reason it was not possible to compare our results with the law given limits.

SUMMARY

Wastewater treatment plants represent a relatively significant source of air pollution. The technologies emit into the air microorganisms in aerosol form. Aerosol can contain pathogenic bacteria, spores of filamentous fungi or viruses. This article deals with the monitoring of microbial contamination of the air at the waste water treatment plant for 18 000 p.e. We investigated the occurrence of heterotrophic bacteria, fungi, actinomycetes and faecal coliform bacteria in the air around the sand catcher, activation tanks and area for dewatered sludge. Checkpoint was located at a distance of 150 m from the wastewater treatment plant area. The incidence of all investigated groups of microorganisms peaked in summer, while in winter the air was only slightly polluted. The biggest source of pollution appears to area for dewatered sludge, where gets into the air during the manipulation a large amount of fungi. In the vicinity of sand catcher and activation tanks, we detected an increased number of mesophilic bacteria, including faecal coliform bacteria, which have their optimum growth also around 37 °C. This group comprises the majority of microorganisms pathogenic for vertebrates. Mostly in the vicinity of these facilities is a risk of infection wastewater treatment workers high.

Acknowledgement

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Address

Mgr. Monika Vítězová, Ph.D., doc. Ing. Tomáš Lošák, Ph.D., Ústav agrochemie, půdoznalství, mikrobiologie a výživy rostlin, Ing. Tomáš Vítěz, Ph.D., Ústav zemědělské, potravinářské a environmentální techniky, Mendelova univerzita v Brně, Zemědělská 1, 613 00 Brno, Česká republika, RNDr. Hana Mlejnková, Ph.D., Oddělení hydrobiologie, Výzkumný ústav vodohospodářský T. G. Masaryka, v. v. i., Mojmírovo náměstí 16, 612 00 Brno, Česká republika, e-mail: monika.vitezova@mendelu.cz, losak@mendelu.cz, tomas.vitez@mendelu.cz, hana_mlejnkova@vuv.cz