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Wioletta ADAMUS-BIAŁEK[1], Monika WAWSZCZAK[1] and Anna ŚWIERCZ[1]

IMPACT OF SEWAGE TREATMENT PLANT ON LOCAL ENVIRONMENT

WPŁYW OCZYSZCZALNI ŚCIEKÓW NA OKOLICZNE ŚRODOWISKO

Abstract: The aim of the study was the analysis of three wastewater treatment plants operations (Busko Zdroj, Kazimierza Wielka and Pinczow in Swietokrzyskie voivodship). The sanitary condition of sewage sludge and the management of sludge in wastewater treatment plant were investigated. These data were made available by these wastewater treatment plants. The analyses of the sewage sludge have included the sanitary basic analysis, especially the identification of *Salmonella* spp. and the present of intestinal parasites eggs. It stated, that the sanitary condition of the analyzed sewage sludge was acceptable. Microbiological purity of sewage sludge and mineral composition similar to soil organic matter (humus) allows to use them as natural fertilizers, but not for the cultivation of the plants intended for human consumption. These deposits have been widely used as a material for land reclamation in Pinczow. The further aim of the research was to investigate the microbiological purity of air near the two wastewater treatment plant (Stykow and Szczecno in Swietokrzyskie voivodship). The number of colony forming units of mannitol-positive *Staphylococcus* sp. and the total number of mesophilic and psychrophilic bacteria were analyzed in four different distance from wastewater treatment plants. Mannitolo-positive staphylococci belong to microbiological indicators of air pollution. The number of mesophilic and psychrophilic bacteria indicate the level organic matter contamination. The air pollution was observed at all measurement points. It is known, that pathogenic microorganisms can easily pass from the water to the air and next spread in the environment. This analysis shows that the use of sewage sludge to land reclamation is helpful to preserve and restore the ecological balance of mineral elements, which is an important aspect of economic and environmental protection. It is also likely, that wastewater treatment plants may have an impact on air pollution.

Keywords: sewage sludge, environment pollution, air pollution, fertilizers

Introduction

There are many sources of emissions, which include also wastewater treatment plants (WWTP). Sewage treatment plants are a serious source of toxic chemical compounds, gases and biological contaminations. That may have a direct impact on the surrounding environment. A separate threat are microorganisms present in wastewater. Microorganisms gets into the wastewater and sewage sludge with humans' and animals' excrements [1]. The most frequently identified species includes *Escherichia* sp., *Salmonella* sp., *Shigella* sp., *Pseudomonas aeruginosa*, *Clostridium perfringens*, *Bacillus anthracis*, *Listeria monocytogenes*, *Vibrio cholerae*, *Mycobacterium tuberculosis*, *Streptococcus faecalis*, *Proteus vulgaris* [2, 3]. Most of the pathogenic microorganisms are removed, but some of them can get in to a sewage sludge and survive even for a few months [4-6]. The highest number of pathogens are identified in the sewage sludge arising from purification of municipal and industrial wastewater [7, 8]. The number of microorganisms in the wastewater also depends on climate, wastewater quality and the method of wastewater purification [9]. Mineral and organic composition of sludge from municipal sewage treatment plants is similar to soil organic matter (humus). Therefore, sewage sludge can be

[1] Department of Environment Protection and Modelling, Jan Kochanowski University, ul. Świętokrzyska 15, 25-406 Kielce, Poland, phone +48 78 886 06 04, email: wioletta.adamus-bialek@ujk.edu.pl
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treated as a good organic fertilizer rich in nitrogen, phosphorus and easily degradable organic matter. This allows to use of sewage sludge to fertilize crops and soils [10-12]. Due to the economic growth in Poland, the production increase of sewage sludge is observed. The rules of the management of sewage sludge in Poland are based on European directives.

Another issue related to the wastewater treatment is microbial air pollution. Air is not an optimal environment for microorganisms [13, 14]. They form different bioaerosols to transmission from different environments (soil, water, waste, surface plants, animals and others) by wind gusts, sneezing or coughing. The source of bioaerosols is also wastewater treatment during the purification of water [15-17]. There can be found mostly *E. coli*, *Salmonella* spp., *Shigella* sp., but also *Micrococcus* sp., *Staphylococcus* sp., *Streptococcus* sp., *Klebsiella pneumoniae*, *Neisseria meningitidis* [13]. The main place in the treatment plant, where the contamination is most likely is biological reactor chamber. Aerosols are formed during aeration of waste water. Another place, where aerosols may be formed, is the place where the vacuum trucks deliver wastewater to the treatment plant [18]. Bioaerosols spread for about 800 meters from the source of generation. Spread range is addicted to weather conditions, seasons, landform and size (range) of sewage treatment [9, 19, 20].

The aim of the study was the analysis of wastewater treatment plants operations, presence of *Salmonella* spp. and intestinal parasites eggs. The next step of the study was to investigate microbiological purity of the air near wastewater treatment plants.

Materials and methods

The five wastewater treatment plants (Szczecno, Stykow, Pinczow, Busko Zdroj, Kazimierza Wielka) in Swietokrzyskie voivodship were analyzed in differend field.

The documentation of the analysis provided by sewage treatment plants located in Pinczow, Busko-Zdroj and Kazimierza Wielka was used as a research material. Analysis of sewage sludge management was based on data from wastewater treatment plant in Pinczow.

The total number of aerobic plate count in the air was measured based on culture settling plate technique. Open Petri dishes with the agar were distributed at the processing areas and exposed for 10 minutes. The Petri dishes were closed and incubated at 37ºC for 24-48 hours. The colony forming units (CFU) of mesophilic bacteria were counted on plates with enriched agar. The colony forming units (CFU) of mannitol-positive *Staphylococcuc* sp. were counted on the Mannitol salt agar. The degree of contamination was determined based on the total number of CFU in 1 m^3 of air according to Polish standard PN-89-Z-04111/02 [20]. The microbiological air pollution was carried out on a four points between the sewage treatment plant and water reservoir in Szczecno. The second place of analysis was in the six points differently distanced from the centre of sewage treatment plant in Stykow. The analyses were performed in autumn and winter.

Results and discussion

The aim of this study was to analyze two important aspects related to the functioning of wastewater treatment plant (WWTP). The investigation of the management and the sanitary condition of sewage sludge in wastewater treatment plants was the first research. In the other hand we have analyzed the microbiological condition of the air around and near the WWTPs. The study covered the period 2008-2012. The capacity of the sewage

treatment plant in Pinczow in 2010 and 2011 was about 12000 m^3 per day. Wastewater came mainly from private households and blocks of flats, public facilities and also from the industrial sector. Examined sewage sludge in Pinczow took the earthy form. Dry matter content was various. In 2010, the obtained dry matter was 22.5% of sludge, in 2011 - it was 14.7%. The excess sludge was generated in sewage treatment plant in Pinczow in the bioreactors and Imhoff tank. Sludge after stabilization and dehydration should be removed from the area of wastewater treatment [8]. Received data shows that precipitate was used on private lands. In 2010, 1011 mg of sludge was used on the surface of the 4.22 hectares of the soil. The precipitate was used for the reclamation of soils intended for arable land in two villages Pasturka and Szczypiec. In 2011, weight of sewage sludge used for fertilization was lower - 760 mg of sludge was spread on the surface of 25.24 hectares. In 2011, the fertilizer was used in Kije, Brzescie and Pasturka. Within this two years, the proportion between the weight of sewage sludge and the treated area were considerably different. This was mainly due to the doses limitation of sewage sludge, which was distributed on the land. The amount of sludge used for the reclamation depends on the type of soil, method of use, the quality and composition of the used sludge [14]. In 2010, 0.23 mg of the sludge was spread on 1 m^2 of soil, but in 2011, quantity of sewage sludge was 0.02 mg/m^2.

Subsequently, the provided data of microbiological analysis of sewage sludge of three sewage treatment plants (Pinczow, Busko Zdroj, Kazimierza Wielka) were compared. The aim of the study was to identify the microbial pathogens *Salmonella* spp. and the eggs of intestinal parasites *Ascaris* sp., *Trichuris* sp., *Toxocara* sp. The presence of *Salmonella* spp. was identified only in the one sample, in sewage treatment plant in Pinczow. It should be mentioned that in this WWTP the study was conducted only in 2011. These microorganisms were not detected within five years (2008-2011) in the other treatment plants. The presence of eggs of intestinal parasites was found in Busko Zdroj (two positive samples) and Kaziemierza Wielka (one positive sample). Parasites were not detected in the sewage treatment plant in Pinczow. It can be concluded that examined sewage sludge were no danger and could be used in agriculture and for land reclamation for agricultural purposes, as it was performed in the case of sewage sludge from Pinczow. Used sludge from the treatment plant did not contain elevated levels of heavy metals and microbiological contamination. Therefore, there was no risk to contamination of the environment. Data analysis leads to the conclusion, that the use of sewage sludge to soil remediation in the municipality was relevant. According to the publication, there is no universal solution to the issue of sludge management, but the solution must be appropriate to local conditions. Pinczow is a small town in which the amount of sludge formed in wastewater treatment is not big. There is also the possibility of using sludge for energy recovery by combustion, co-firing and others. Use of components of sewage sludge for soil fertilization is cost-effective. It is also beneficial to soil provided that the levels of contaminants in sludge will be acceptable. Therefore, the use of sludge as fertilizer in this case is appropriate [4, 21]. As previously mentioned, a lot of different bacterial species can be present in the savage sludge. Some of them could can be pathogenic. The use of savage sludge as an organic-mineral fertilizers and organic soil conditioners should be careful. They can be source of bacterial, viral and parasitic diseases in humans and animals [22, 23]. This fact is evidenced by descriptions of epidemics caused by infection of soils in Poland

and Europe. In Darmstadt (Germany), 89% of the population became sick for salmonellosis after eating vegetables from field irrigated with sewage sludge [3]. Also epidemic of typhoid fever was recorded in Stuttgart. During this epidemic, 600 people get sick and 10 people died. The cause of epidemic was lettuce grown on field fertilized with fresh sludge. Similar epidemics have also been reported in France after ingestion of lettuce and watercress from cultivation of contaminated sediments. In Poland, epidemics of salmonellosis and viral hepatitis A in Pisz, Braniewo, Chelm, Ustrzyki Dolne was recorded as a result of water polluted by sewage and sewage sludge. Nevertheless, the use of sewage sludge can be useful as a natural fertilizer for soil, but after a careful examination [3, 24, 25].

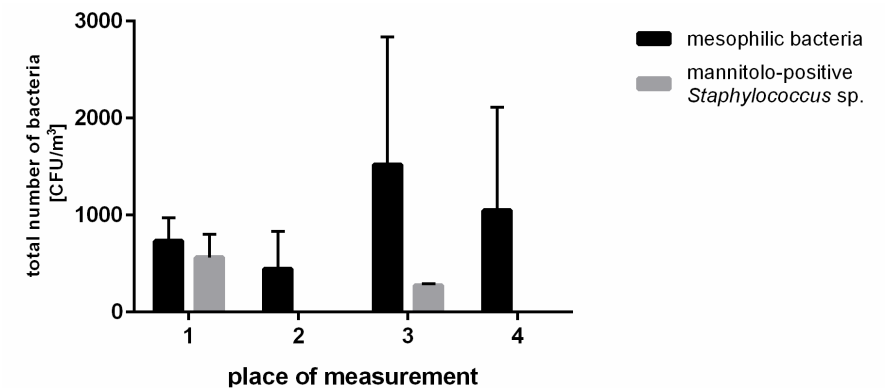

Fig. 1. Total number of bacteria in 1 m^3 of air in wastewater treatment plant in Szczecno. Place of measurement: 1 - area of sewage treatment plant, 2 - basin, 3 - flood area and 4 - pond

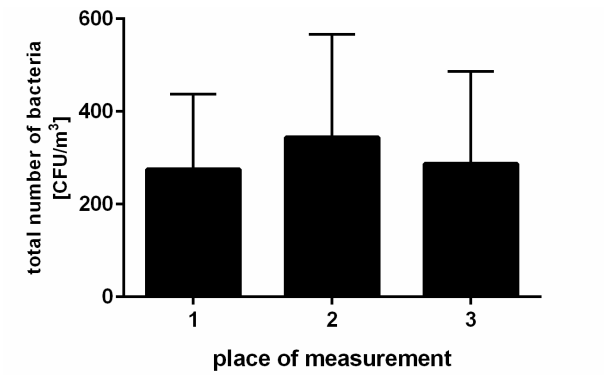

Fig. 2. Total number of bacteria in 1 m^3 of air in wastewater treatment plant in Stykow. Place of measurement: 1 - 3 meters from the aeration chambers, 2 - 5 meters from the border of sewage treatment, 3 - 20 meters from the compost flitch and 12 meters from the aeration chambers. All places (8) were symmetrically arranged on East and West side of WWTP

The further research included the microbiological analysis of the air near to wastewater treatment plants in Szczecno and Stykow. Studies have been conducted to determine the

total number of bacteria. In the sewage treatment plant in Szczecno also identified the total number of mannitol-positive *Staphylococcus* spp. The WWTP in Szczecno was analyzed in four places: area of sewage treatment plant, basin, flood area and pond. The WWTP in Stykow was analyzed in three places, each from East and West sides first located 3 meters from the aeration chambers, second - 5 meters from the border of sewage treatment and third - 20 meters from the compost flitch and 12 meters from the aeration chambers. It was observed, that the number of bacteria was generally high and varied (Figs. 1 and 2).

The number of bacteria was not dependent on the date of sampling. The highest number of bacteria was detected in the further distance from WWTPs, but the differences wasn't significant. According to standard PN-89-Z-04111/02, in case of WWTPs in Szczecno (Fig. 1) the total number of mesophilic bacteria in the air near to sewage treatment plant and basin was not too high, but high number of *Staphylococcus* spp. in all cases classified air as contaminated. The results of microbiological analysis of the air in WWTP in Stykow were similar to the WWTP in Szczecno (Fig. 2).

It has been shown that the total number of bacteria isolated from the air from each places was acceptable. There was no relationship between the number of microorganisms in the air and the distance from the individual elements of the sewage treatment. However, it was observed the slight increase of the number of bacteria in further distance from the sewage treatment plant. It is known, the number of bacteria in the air may depend on the wind direction, temperature and intensity of operation in sewage treatment plants [15, 25]. Our results indicate high number of bacteria even in long distance from WWTPs. The low temperature of the air also didn't influence on the bacterial transport. The results confirm that the presence of sewage treatment plants can affect the air pollution in the area.

The number of detected bacteria seems to be lower in comparison to studies conducted in other WWTPs [8, 16, 18, 19, 25]. The similar studies were performed in municipal sewage treatment plants located in Kujawsko-Pomorskie. The number of microorganisms isolated from the air was two times higher than in Szczecno and nearly six times higher than in Stykow. These differences may result from the various size of the object and the amount of sewage wastewater flowing into the treatment plant. In Kujawsko-Pomorskie voivodship is about 13 000 m^3 of sewage wastewater. On the contrary, in Szczecno and Stykow is about 300 m^3 of sewage wastewater [16]. In the sewage treatment plant in Kujawsko-Pomorskie also identified a significant amount of *Pseudomonas fluorescens*, which belongs to the bacteria naturally living in the heavily polluted surface waters and wastewater [2, 16]. In our study, we analyzed only the presence of total number of bacteria and mannitol-positive *Staphylococcus* sp. This group of bacteria is epidemiologically important and it can be a more dangerous source of pathogenic bacteria for human. It is worth noting, that wastewater treatment plants may also affect the sanitary condition of the local rivers. This aspect has not been presented in the work. To fully understanding the influence of sewage treatment plants on the environment, there should be carried out the examination of the waters from local rivers. There is also another aspect of monitoring bacteria in WWTPs. On the basis of reports in the literature, along with the spread of bacteria from sewage treatment the risk of occurrence in environment of strains resistance to antibiotics is higher. To the treatment plant with sewage may get microorganisms which are multidrug-resistant [26, 27]. Tests of air and sewage sludge should be carried out more

frequently. Carrying out such monitoring allows for constant control of risks of environmental pollution by treatment plants.

Conclusions

Analysis of sanitary condition of sewage sludge and the management of sludge in wastewater treatment plant shown, that the use of sewage sludge as fertilizer is a valid option. Properly neutralized and examined sludge may become an important element in the process of land reclamation [21]. Also, based on the obtained results, there is a risk of air pollution in the vicinity of sewage treatment plants.

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WPŁYW OCZYSZCZALNI ŚCIEKÓW NA OKOLICZNE ŚRODOWISKO

Katedra Ochrony i Kształtowania Środowiska, Uniwersytet Jana Kochanowskiego, Kielce

Abstrakt: Celem pracy była analiza działalności trzech oczyszczalni ścieków (Busko Zdrój, Pińczów i Kazimierza Wielka) w województwie świętokrzyskim. Materiały źródłowe zostały udostępnione dzięki uprzejmości oczyszczalni ścieków. Analizowano sposób zagospodarowania i stan sanitarny osadów ściekowych. Badania mikrobiologiczne osadu dotyczyły podstawowej analizy sanitarnej, zwłaszcza identyfikacji bakterii *Salmonella* spp. i jaj pasożytów jelitowych. Stwierdzono, że stan sanitarny analizowanych osadów ściekowych nie zagrażał środowisku. Mikrobiologiczna czystość osadów ściekowych i skład mineralny były zbliżone do materii organicznej gleby (humus) i pozwalały na wykorzystanie ich jako nawozów naturalnych, ale nie do uprawy roślin przeznaczonych do spożycia przez ludzi. Materiał ten był szeroko stosowany do rekultywacji gruntów w Pińczowie. Kolejnym celem pracy było określenie czystości mikrobiologicznej powietrza w pobliżu dwóch oczyszczalni ścieków (Szczecno i Styków w województwie świętokrzyskim). Określano ogólną liczbę gronkowców mannitolo-dodatnich oraz bakterii mezofilnych i psychrofilnych w czterech różnych odległościach od oczyszczalni ścieków. Mannitolo-dodatnie gronkowce należą do wskaźników mikrobiologicznego zanieczyszczenia powietrza. Liczba bakterii mezofilnych i psychrofilnych wskazuje na poziom zanieczyszczenia materią organiczną. We wszystkich punktach pomiarowych zaobserwowano zanieczyszczenie powietrza. Wiadomo, że patogenne mikroorganizmy mogą łatwo przedostawać się z cieczy do powietrza za pomocą bioareozoli. Analiza ta pokazuje, że wykorzystanie osadów ściekowych do melioracji jest pomocne do zachowania i przywrócenia równowagi ekologicznej, co jest ważnym aspektem ochrony ekonomicznej i środowiskowej. Jest również prawdopodobne, że oczyszczalnie ścieków mogą mieć niekorzystny wpływ na czystość powietrza.

Słowa kluczowe: osad ściekowy, zanieczyszczenie środowiska, zanieczyszczenie powietrza, nawozy