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AUTO PRESENTATION

1. **Name and surname:** Izabela Siebielska
2. **Diploma, university degree titles:**
    1. Master of chemistry – Faculty of Mathematics, Physics and Chemistry, University of Gdansk, 1991
    2. Doctor of technical sciences (with honours)– Faculty of Environmental Engineering, Institute of Engineering of Environmental Protection, Wroclaw University of Technology, 2002. The dissertation „The migration of aromatic hydrocarbons in groundwater". Promoter: prof. Kazimierz Szymański
3. **Information about the current employment in scientific units :**
    1. 1993-2002 junior lecturer in the Department of Civil and Environmental Engineering in Koszalin University of Technology
    2. From 09.2002 assistant professor in the Faculty of Civil Engineering, Environmental and Geodetic Sciences in Koszalin University of Technology
2. **Indication of the achievements resulting from the art. Paragraph 16. 2 of the Act of 14 March 2003 on Academic Degrees and Title and on Degrees and Title in the arts (Diary of Law No. 65, pos. 595):**

    A. Author, title , date of issue, publisher

    The achievements resulting from the art. Paragraph 16. 2 of the Act of 14 March 2003 on Academic Degrees and Title and on Degrees and Title in the arts is the monograph:

    – Siebielska Izabela *Degradation of PAHs and PCBs in biological processes of the utilization of chosen biodegradable waste*, 2013, Publisher of Koszalin University of Technology, Monograph no. 239, Faculty of Civil Engineering, Environmental and Geodetic Sciences, p. 211

    B. The description of research aim of scientific/artistic above-mentioned publication and results achieved with the conclusions.

My research is focused on a problem connected with polycyclic aromatic hydrocarbons and polychlorinated biphenyls degradation during the utilization of the biodegradable waste. The inspiration for my research was the adoption by the Polish Government European Union Council Directive no. 99/31/WE, on the landfill from the date 16.07.1999. A disposal of the biodegradable waste should be reduced to 35% by the 31st of

December 2020. Therefore there is an urgent need to introduce other methods of utilization of this waste, including biological. In Poland, the organic fraction is not extracted from municipal waste in the "source separation", but it is sieved on sieves of different mesh sizes. The consequence of that is the presence of many organic contaminants, including PAHs and PCBs in the said fraction.

The both biotic and abiotic degradation of the polycyclic aromatic hydrocarbons and the polychlorinated biphenyls during sewage sludge treatment is described widely in the literature. However, there is a little data on the study of concentration of these pollutants changes during the utilization of the organic fraction of municipal waste, extracted in the manner described above.

The aim of my research work was to evaluate the possibility of removal of PAHs, PCBs in the process of composting and anaerobic digestion of a mixture of the organic fraction of the municipal waste and the sewage sludge. The study compared the degree of elimination of polycyclic aromatic hydrocarbons and polychlorinated biphenyls in the mixture under aerobic and anaerobic conditions during composting and anaerobic digestion. It allowed me to assess the influence of the content of the organic fraction of the municipal waste on the change of the analytes concentration during composting or anaerobic digestion.

The mixtures, which were treatment, were prepared in a different proportions: 30% of the organic fraction of the municipal waste and 70% of the sewage sludge (30% I and 30% II), 50% of each component (50% I and 50% II) and 70% of the organic fraction of municipal waste and 30% of the sewage sludge (70% I and 70% II). The organic fraction of municipal waste was collected from the municipal factory of waste management, processing about 40 000 Mg of municipal waste per year. Mixed waste initially had been run through a sieve of mesh with a diameter of 8 cm, and then through a sieve with a diameter 2 cm. Fractions (8> d> 2), regarded as the organic fraction was essentially granulometric fraction with a high concentration of biodegradable pieces.

Six cycles of composting and anaerobic digestion six cycles were experimented in the batch reactors (one dose at the beginning of the process) in the laboratory. In the case of the composting, the ratio of the composted mass surface to reactor’s volume was 15,7:1 m^2/m^3., which ranged characteristic bioreactor working on a laboratory scale. Thus prepared, the system allowed to reduce the impact of external variables on the process. Every composting cycle lasted 182 days and every anaerobic digestion cycle lasted about 21 days. All cycles were carried out under identical process conditions. The concentrations of 16 PAHs: naphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, chrysene, dibenzo(a, h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and

pyrene and 7 PCB congeners: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 and PCB 180 were examined in the samples. The quantity and quality determination was made on a gas chromatograph (AT 7890A) equipped with a mass detector (AT 5975C VL MSD).

The temperature and humidity were measured in the composted mass during the composting process. At the same time, the loss of organic matter was checked by a determination of the chemical oxygen demand (COD_{Cr}), the content of total organic carbon (TOC) and total nitrogen (N_{tot}). However, the process of anaerobic digestion was controlled by physicochemical tests such as: the methane content measurement in the biogas during the process and the total alkalinity determination, volatile fatty acid concentrations and pH-testing in the fermented sludge.

Additionally, in my research work, the changes of the copper, cadmium, chromium, nickel and lead concentrations were analyzed. The choice of the heavy metals was dictated by the Regulation of the Minister of the Environment [Dz. U. No. 137, item. 924] and the Regulation of the Minister of Agriculture and Rural Development [Dz. U. No. 119, item. 765]. In both biological processes the change of analyzed metals concentration was small. Therefore their impact on the biodegradation of PCBs and PAHs was stable and similar at all times. The determination was made by FAAS (camera Philips 9100X).

Based on the research carried out and obtained results, the changes of polycyclic aromatic hydrocarbons and polychlorinated biphenyls concentration in a mixture of sewage sludge and organic fraction of municipal waste were compared. In both processes, the composition of the mixture was variable. However, I have showed (statistical analysis), the percentage composition of the feed did not have a significant effect on the reduction of analyzed compounds concentrations.

Trends in concentration changes of individual polycyclic aromatic hydrocarbons and polychlorinated biphenyls were best described by the logarithmic functions, in both processes: composting and anaerobic digestion, assuming $t > 0$.

Changes of the polycyclic aromatic hydrocarbons and polychlorinated biphenyls concentration ware different during the composting of mixtures containing 30% of the organic fraction. The composting mixtures with the 50% of each of the components were characterized by a similar changes of the polycyclic aromatic hydrocarbons and polychlorinated biphenyls concentration. In the last two experiments carried out with mixtures containing 70% of the organic fraction, a decrease of the polycyclic aromatic hydrocarbons and polychlorinated biphenyls concentrations was similar.

Anaerobic digestion cycles, in which the feedstock to the bioreactor contained 30% of the organic fraction of municipal waste, characterized by the similar effect of removal of the naphthalene, 4 - and 5-ring aromatic hydrocarbons, PCB 28 and 153. Changes of the concentration of other polycyclic aromatic hydrocarbons and polychlorinated biphenyls were variable in both cycles. The difference between the change of naphthalene, 4 - and 5-ring aromatic hydrocarbons, PCB 28 and 153 concentration was noted in the anaerobic digestion cycles of the mixture with the 50% of each component. Changes of the content of other organic analysts seemed to be the same in different experiments. During the anaerobic digestion of mixture with the 70% of the organic fraction, the difference of the change of the polycyclic aromatic hydrocarbons and polychlorinated biphenyls concentration were not significant.

The obtained results were subject to the principal components analysis (PCA). The statistic analyzes allowed me to select those cycles in which the course of degradation events of pollutants occurred in the same way.

In the case of composting, the change of PAHs, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 and PCB 180 concentrations was a statistically different in the cycle 30%I. Therefore, it was not included in any subsequent statistical tests. The degradation PCB 28 was similar in the cycles: 50%I, 50%II and 30%II and different in the cycles: 30%I, 70%I and 70%II. Choosing the first three cycles to follow the statistical tests was dictated by a similar course of changes the remaining PCBs concentration.

In the case of anaerobic digestion, only the cycles: 30%I, 50%II, 70%I and 70%II were taken into account in the further statistical tests. In this cycles, the degrees of all PAHs did not differ significantly. The degradation of PCBs did not differ significantly only in the cycles: 30%II, 50%I and 70%II and therefore they were chosen as a comparison method for the biodegradable waste utilization.

The average of polycyclic aromatic hydrocarbons and polychlorinated biphenyls loss in aerobic and anaerobic conditions were compared using the analysis variance (Fisher's test). The F value was determined at a given significance level ($\alpha = 0.05$). The null hypothesis of the equality of the mean values of PAHs and PCBs loss was rejected, because $F \geq F_{\alpha}$ ($F\alpha$ - limit value given in the tables with the F-Snedocora distribution).

An equation describing the temporary rate, the Michaelis-Menten constant and maximum rate of PAHs and PCBs degradation under aerobic and anaerobic conditions were set based on the results of the change of the analytes concentration in the mixtures. During the composting, the temporary rate of the degradation depended on the amount of the condensed

rings in a hydrocarbon. The minimum temporary value of the rate had hydrocarbons containing at least five condensed rings. The values of the Michaelis constant and maximum rate confirmed a slower biodegradation of these compounds. This was probably due to the high lyophobic property of these compounds and therefore an increased tendency to sorption on the solid material. These phenomena have limited PAH bioavailability and inhibit biodegradation processes. In contrast to the composting, statistical analysis showed that the rate of PAHs decrease did not depend on the number of condensed rings in the molecule during anaerobic digestion. The highest temporary rate was observed for a degradation of the PCB 28 in both biological processes of the biodegradable waste treatment. The PCB decomposition under anaerobic conditions was related to the number of chlorine atoms in the molecule. Polychlorinated biphenyls, containing six or seven chlorine atoms, were neglected with the lowest maximum rate, and PCB 28 with three chlorine atoms - with the most. The greater the number of chlorine atoms in the molecule, the smaller the decrease rate of PCB during anaerobic digestion. This relationship was not confirmed in the results of the tests from composting.

The degree of polycyclic aromatic hydrocarbons degradation was higher under aerobic conditions. The duration of the process was the biggest impact, among other things, on the results of the research. Composting took 182 days whereas anaerobic digestion only 21. Probably, the chemical reactions without the participation of microorganisms took place in the composting time in addition to the biodegradation of hydrocarbons. PAH degradation efficiency depend on the type of compound, including the number of rings in the molecule. The phenomena was confirmed by the results of the research. The macromolecular compounds difficult were degraded and the decomposition rate was lower. Characteristic properties of the PAH indicates that the more rings in the molecule which are more hydrophobic, the lower the solubility and a value of logarithm of octanol/water partition - greater. The compounds tend to sorption on particulates. The adsorbed PAHs are readily available for microorganisms and therefore their distribution is limited.

During anaerobic digestion, a decrease of hydrocarbons concentration did not exceed 30%, regardless of the number of fused rings. PAHs degradation was slower under anaerobic conditions. Designated in the literature degradation paths indicate, that the introduction an oxygen atom to the ring is necessary in the first stage of biodegradation.

In contrast to polycyclic aromatic hydrocarbons, polychlorinated biphenyls were more easily biodegradable under anaerobic conditions. Evidence of this was greater rate of degradation and decreasing concentrations of substrates. Described in the literature path

decomposition of these compounds indicate that chlorine atoms are disconnected mainly through anaerobic microorganisms in the first stage. Under aerobic conditions, the rate of dechlorination is smaller. Next stages of the PCB decomposition may occur also under aerobic conditions. Due to the high rate of compounds dechlorinated under anaerobic conditions, the number of chlorine atoms in the molecule did not have a significant effect on the degree of polychlorinated biphenyls degradation in contrast to the changes in aerobic conditions. During composting, the greater the number of chlorine atoms per biphenyl molecule, the removal efficiency of the compound and the maximum rate of decomposition were smaller.

The analysis of the research leads to the following conclusions:

1. The influence of the mixture's content on the reduction of the PCBs' and PAHs' concentration was not observed neither during the anaerobic digestion nor during the composting process.
2. During composting, the effectiveness of PAHs' biodegradation (44.6% - 70.6%) depend on the number of condensed aromatic rings, and decreased along with their increase. During anaerobic digestion, the loss of the individual hydrocarbons contents remained at the level of 24.6% to 29.9%.
3. During composting, a decrease of the PCBs' concentration depend on the degree of chlorination (the more chlorine atoms in the molecule, the smaller the degree of loss of these compounds during the process) and ranged from 6.9% to 15.7%.
4. PCBs' removal efficiency during anaerobic digestion did not depend on the degree of chlorination of PCBs and ranged from 18.1% to 23.9%.

Based on the conclusions, The effective technology of polycyclic aromatic hydrocarbons removal was composting of an organic fraction of municipal waste. It is advised to direct the digested sludge with the high levels of PAH to the treatment under aerobic conditions. However, an anaerobic digestion of organic fraction of municipal waste was a more efficient process of removing polychlorinated biphenyls. For this reason, the decomposition of PCBs is preferred to conduct the first step in anaerobic conditions.

3. Discussion of other scientific achievements of the research

The scope of my research before obtaining a PhD included the pollution of ground water by the petroleum compounds, especially aromatic hydrocarbons (BTX) and polycyclic aromatic hydrocarbons (PAHs) and also polychlorinated biphenyls (PCBs). The choice was dictated by the high toxicity of the compounds to living organisms (e.g., benzene, benzo(a)pyrene, PCB). The first research on the organic compounds contamination of the

river Parsęta and its tributaries was conducted in the framework of a research project No. 118-01 " Optimization systems of the ecological development of Koszalin Region", funded by the KBN. The next step was to analyze the groundwater near landfills near Koszalin. The result of these studies was a dissertation "Migration aromatic hydrocarbons in groundwater", which was supervised by Professor Kazimierz Szymański.

The aim of this study was to assess the impact of landfill leachate on the content of volatile aromatic hydrocarbons (BTX) and polycyclic aromatic hydrocarbons (PAHs) in groundwater near municipal landfill in Sianów. The ground, on which it is located landfill, was mainly fine and silty sands, with possible medium sands, but also dust. It is a characteristic ground of the Embankment Slowinski. The sum of 6 and 16 PAHs and the sum of BTX allow to assess the level of environmental pollution by aromatic hydrocarbons.

In 1997-2000, I examined the contents of 16 PAHs and 5 BTX in landfill leachate coming from the landfill in Sianów. I also examined the pollution concentration in groundwater collected from piezometers. The wells were located near the landfill in the groundwater flow direction. I analyzed also the BTX and PAH concentration in the groundwater, which had no contact with landfill leachate.

The model of a pollution dispersion in an aqueous-ground with landfill leachate near a landfill in Sianowo was developed by use the software package MT3D. The movement of groundwater was described by use the package of MODFLOW.

The result of my research was the model of the dispersion of benzene and benzo(a)pyrene in an aqueous-ground niear the municipal factory of waste management, processing about 40 000 Mg of municipal waste per year. This model allowed to predict the influence of landfill leachate, contaminated with analyzed hydrocarbons on groundwater.

A similar research was also carried out for the other landfills near Koszalin. I presented the results of polish and international conferences, including the Second Congress of Environmental Engineering, Lublin and at the symposium "CHEMICAL FORUM 2000" in Warsaw.

Another study of water-soil environment was implemented within the expertise and research projects. The research have confirmed the problem of hydrocarbon contamination areas with poor intensity traffic and low industrialization. The direction of my further research was therefore connected with the analysis of possible degradation of hydrocarbons and their derivatives at the time of waste disposal. The waste are one of the main sources of environmental contamination with compounds interest me. The research started from a validation of method of polycyclic aromatic hydrocarbons and polychlorinated biphenyls

analysis in solid samples. The results of these studies were presented in the papers published in the journals: "Environmental Pollution Control" and "Przemysł chemiczny".

Then, the degradation of polychlorinated biphenyls and polycyclic aromatic hydrocarbons during composting of sewage sludge was examined in the research and development project " Sewage sludge treatment – research of the influence of technological parameters and retention time of composting mass in the bioreactor on the stability and hygienisation of the final product " The results were presented in the papers published in the journals: "Polish Journal of Environmental Studies, Series of Monographs", "Bioresource Technology" and "Annual Set The Environmental Protection".

The next stage of my research was to analyze the degree of decrease organic pollutants concentration during biological treatment of biodegradable waste not only under aerobic conditions, but anaerobic conditions. The study was curried out research project "Changes of the PAHs', PCBs' and heavy metals concentration during composting and anaerobic digestion of the organic fraction of municipal waste." The result was a monograph set out in paragraph 4 B. Other results of study are expected to be published in the journal the "Water Science and Technology" (after the first review). The experience gained from realized research, I used practically working with Sewage Treatment Plant in Szczecinek.

Currently I curry out research on the paraffin's degradation during composting of sewage sludge, with high mercury content. The results will be presented in journals included in the JCR database.

I am also a tutor of dissertation "The use of biodegradable waste to immobilize arsenic pesticides" of MA Olimpia Burzyńska

To sum up my legacy publishing after obtaining a PhD, I was the author or co-author of nine articles in journals included in the Journal Citation Reports, and 14 chapters in books, scientific papers in national journals other than those contained in the database JCR and papers included in the conference proceedings. The total impact factor of the Journal Citation Reports list, according to the year of publication - 6,552 (5 year - 7,268).

While previously realized my research, there were new scientific problems that I would like to examine at a later stage of my work. I am currently a dissertation tutor for a PhD student. The aim of her research is the sorption benzo(a)pyrene as a representative of polycyclic aromatic hydrocarbons on particulates at different stages of the composting. My conducted research shows that the degradation of these hydrocarbons is preferred just under aerobic conditions. The dissertation opening for MA Natalia Kołacz is scheduled for the 2014.

Another direction of my research is the polychlorinated biphenyls degradation during the anaerobic digestion of the organic fraction of municipal waste without the addition of sewage sludge. One of the variables will be the initial concentration of PCBs in a ferrmentate. The research could be carried out within the research project, submitted by ScD Eng. R. Sidełko to NCBiR.