Attachment 2b

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SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS

1. Full name

Tomasz Paweł Baczyński

2. Academic degrees

1989 M.Sc. in Environmental Engineering; Cracow University of Technology, Faculty of Sanitary and Water Engineering. Thesis title "*Optimalization of anaerobic-aerobic municipal wastewater treatment system using mathematical models*" („*Optymalizacja beztlenowo-tlenowego układu oczyszczania ścieków miejskich przy użyciu modeli matematycznych*"); supervisor: doc. dr inż. Jerzy Kurbiel).

1999 Ph.D. in Engineering, discipline of Environmental Engineering; Cracow University of Technology, Faculty of Environmental Engineering; Thesis title "*Application of anaerobic process for removal of organochlorine pesticides from wastewater*" („*Zastosowanie procesu beztlenowego do usuwania pestycydów chloroorganicznych ze ścieków*"); supervisor: prof. dr hab. inż. Jerzy Kurbiel; reviewers: dr hab. inż. Jadwiga Bernacka, prof. IOŚ; prof. dr hab. Renata Kocwa-Haluch, prof. dr hab. inż. Korneliusz Miksch.

3. Employment in scientific institutions until now

1989 laboratory technician in the Division of Water and Wastewater Treatment of the Institute of Water Supply and Environmental Protection, Cracow University of Technology (part time, 6 months)

1989-91 intern assistant in the Division of Water and Wastewater Treatment of the Institute of Water Supply and Environmental Protection, Cracow University of Technology

1991-2000 assistant in the Division of Water and Wastewater Treatment of the Institute of Water Supply and Environmental Protection, Cracow University of Technology

2000-present assistant professor in the Division of Water and Wastewater Treatment (present: Chair of Environmental Technologies) of the Institute of Water Supply and Environmental Protection, Cracow University of Technology; in 2000-01 on leave for internship abroad (Marie Curie Fellowship)

2000-01 postdoc in the Sub-Department of Environmental Technology, Wageningen University, the Netherlands.

2013-present deputy director for scientific affairs of the Institute of Water Supply and Environmental Protection, Cracow University of Technology

4. Scientific accomplishment according to article 16 section 2 of the Act from 14th of March 2003 on Academic Degrees, Academic Title and Degrees and Title in Arts (Dz. U. nr 65, p. 595, as amended)

4.1. Title of scientific accomplishment

Series of publications entitled: *Bioremediation of soils contaminated with DDT pesticide and its derivatives*, comprising of a monograph and 2 journal papers (att. 3, A.2.1-A.2.3)

4.2. Author, title of publication, year, publisher, reviewers

1) **Baczyński Tomasz**; *Bioremediation of soils contaminated with dichlorodiphenyltrichloroethane (DDT) and its derivatives (Bioremediacja gruntów skażonych dichlorodifenylotrichloroetanem (DDT) i jego pochodnymi)*; 2015; Cracow University of Technology Publishing Office, Monograph 512 Series Environmental Engineering; reviewers: prof. dr hab. inż. Ewa Klimiuk, prof. dr hab. Barbara Maliszewska-Kordybach.

2) **Baczyński Tomasz**; *Influence of process parameters on anaerobic biodegradation of DDT in contaminated soil: preliminary lab-scale study. Part I. Surfactant and initial contamination level*. Environment Protection Engineering (2012), 38 (4), pp. 113-125; (IF 0,423, MNiSW 15; citations acc. to Web of Science: 3, by other authors: 2)

3) **Baczyński Tomasz**; *Influence of process parameters on anaerobic biodegradation of DDT in contaminated soil: preliminary lab-scale study. Part II. Substrates and pH control*. Environment Protection Engineering (2013), 39 (1), pp. 5-16; (IF 0,439, MNiSW 15)

The core element of the series is the monograph (A.2.3, att. 3). Journal papers (A.2.1, A.2.2, att. 3) are complementary works, presenting of partial results of the first stage of investigation, published before completion of the full scope of the research. Their content (in abbreviated form) was also included in the monograph, which presents full results of the conducted studies.

4.3. Presentation of the scientific objectives of the above publications and results achieved with discussion of potential application

4.3.1. Objective of the study

The aim of the conducted investigations was expanding a body of knowledge about anaerobic bioremediation of soils contaminated with dichlorodiphenyltrichloroethane (DDT) and its derivatives, degradation process and its conditions. The main investigated aspects of this process were: removal (dissipation) of parent compounds – isomers p,p' and o,p' DDT – and formation of metabolites: DDD (both isomers), DDE (as above), p,p'-DBP and p,p'-DDCN. Attention was also paid to removal of DDT derivative – methoxychlor, also occurring in investigated soil samples (field-contaminated; taken in obsolete pesticide "tombs" vicinity). The conducted study encompassed influence of several factors: activity of autochthonous soil microflora and bioaugmentation with mixed cultures (e.g. methanogenic granular sludge), stimulation with easy degradable co-substrates and surfactants, pH, temperature, change of conditions to aerobic, initial concentration of pollutants and their bioavailability.

4.3.2. Justification for tackling specific problems

The following prerequisites justified undertaking the study:

a) DDT was applied after the Second World War on a large scale as an active ingredient of insecticides. The estimated global production exceeded 2 million tons. Serious concern regarding its harmful effects on human health and the environment have resulted in progressing bans of DDT use, starting from 1970s. At present, DDT use is minimal, mainly for fighting tropical diseases vectors. However, decades of mass production and application left considerable amounts of wastes and contaminated areas of soils and sediments. This refers, among others, to areas adjacent to former manufacturing plants, areas of intensive use and obsolete pesticide landfill sites. This problem occurs in many countries of the world, both highly developed, such as USA, Germany, and developing as well: China, several states in Africa, Latin America, former socialist block etc. In Poland such pollution could be found at so-called "tombs" and also at still existing industrial waste landfill in Jaworzno. Besides, for agricultural soils, river and lake sediments there are several sites where permissible concentration of DDT and its metabolites is still exceeded, even many times.
b) Remediation of such contaminated soils requires not only removal of DDT alone, but also removal of its primary degradation products: DDD and DDE, considered to be hazardous compounds as well. Because of that, soil pollution assessment is most often based on the sum of DDT, DDD and DDE concentrations (DDX index). Physico-chemical remediation methods, such as thermal desorption, are effective against such contamination, but their application entails high costs and destroys organic and biological soil components. Bioremediation technologies have been investigated since long as an alternative solution, not having such disadvantages. Especially interesting is bioremediation in anaerobic conditions, because of relatively easy attainable anaerobic biotransformation of DDT, even with use of not specialized or unadapted microorganisms. However, in spite of several performed studies, many aspects of such method are recognized only superficially. This refers, among others, to stimulation with use of surfactants, influence of environmental conditions or significance of bioavailability of DDT

sequestered in soil. It turned out as well, that for apparently well studied DDT anaerobic degradation pathway some issues still need to be clarified.

4.3.3. Experimental methods

The study was executed in three stages. First stage comprised series of lab scale experiments aimed at better recognition of DDT anaerobic degradation pathway and relevance of a wide range of factors for the process course. In the next stage experiments were still conducted at the laboratory scale, and focused on the influence of selected factors with analysis of anaerobic degradation kinetics (mathematical simulation). Third stage was performed as a pilot scale experiment with large 30 kg soil samples. Effectiveness of the bioremediation was verified in quasi-field conditions and dependence of its results on temperature, change of conditions to aerobic and presence of selected co-substrates were ascertained more precisely.

4.3.4. Discussion of results

Conducted tests and their results enabled a deeper recognition of several aspects of anaerobic bioremediation of soils contaminated with DDT, with bioaugmentation using anaerobic sludge. In my opinion, my most important findings and achievements were:

a) Demonstration that main products of primary p,p'-DDT anaerobic degradation were not only p,p'-DDD, but also p,p'-DDCN and p,p'-DBP.

Degradation of DDT is usually described in the literature as proceeding along only one pathway, starting with dechlorination to DDD, then followed by several consecutive transformations into intermediate products (metabolites). However, during my investigation I found that degradation of p,p'-DDT occurred, apart from the above described pathway, also on parallel pathways leading to formation of p,p'-DDCN and p,p'-DBP, without p,p'-DDD as intermediate. DDCN is rarely mentioned in current publications concerning DDT and its metabolites; in such cases it is regarded as one of metabolites within DDD further degradation pathway or its formation pathway is described as unexplained. Admittedly, there are single papers[1,2] published in 1970s, suggesting direct formation of DDCN from DDT. It seems however that they have disappeared from awareness of scientists dealing with degradation of this pesticide. Results of my studies point out to an important role of DDCN, formed in large quantities during anaerobic degradation of DDT. As for DDT direct transformation into DBP in anaerobic conditions, without DDD as intermediate, it was not mentioned in the literature so far. In the context of DDT anaerobic degradation, DBP is regarded only as terminal product of transformations occurring

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[1] Jensen S, Göthe R, Kindstedt M-O. Bis-(p-chlorophenyl)-acetonitrile (DDN), a new DDT derivative formed in anaerobic digested sewage sludge and lake sediment. Nature. 1972;240(5381):421–422

[2] Quirke JME, Marei ASM, Eglinton G. The degradation of DDT and its degradative products by reduced iron (III) porphyrins and ammonia. Chemosphere. 1979;8(3):151–155

on the „DDD" pathway. In contrast to that, results of my research have demonstrated that direct transformation of DDT into DBP is mainly responsible for formation of large amount of this metabolite.

b) Mathematical model description of DDT and methoxychlor removal and DDT metabolites formation during soil anaerobic bioremediation.

The model assumed that each pesticide – DDT isomers and methoxychlor – is present in soil as two fractions, rapidly and slowly removed in parallel according to the first order kinetics, respectively. In this way the model accommodated the effect of sequestration („aging") of hydrophobic organic contaminants (HOCs), that is, partial limitation of their bioavailability resulted from sorption and diffusion processes taking place during long contact with soil components. This sequestration was decisive for the practically achievable effectiveness of pesticide removal. Results of simulation were well fitted to experimental data obtained for soils from the different sites. Similar two-phase models were so far used for modelling of degradation of "aged" HOCs others than pesticides, e.g. PAHs. Formation and later dissipation of metabolites: DDD, p,p'-DDCN and p,p'-DBP were included in the model assuming their simultaneous formation during decomposition of DDT, followed by degradation according to the first order reaction. Also in this respect, simulation results met experimental data, which additionally confirmed suggested above p,p'-DDT transformation pathway with simultaneous formation of p,p'-DDD, -DDCN and -DBP.

c) New findings concerning stimulation of bioremediation of DDT contaminated soils using surfactant.

I found application of Tween 80 successful; it was the most effective among investigated polysorbate surfactants: Tween 60, 65, 80 and 85.

It was stated, using simulations, that Tween 80 enhanced DDT removal in two ways: it increased disappearance rate and also increased rapidly removable fraction share in a total pool of a given pesticide, thus increasing its bioavailability. Supposedly, the latter effect resulted from interaction of surfactant with a fraction of pesticide strongly bound in soil due to the sequestration process, characteristic for HOCs. In works of other authors studying application of surfactants in DDT bioremediation only the former effect was considered so far.

Application of Tween 80 lowered accumulation of DDD metabolite, which was also noted by the other authors using other surfactants. However, they ascribed this effect to intensification of further conversion of this metabolite. On the contrary, my studies have shown, basing on simulations of metabolites formation and degradation, that this resulted mainly from decreased share of DDT transformation into DDD in the overall conversions of the parent pesticide (i.e. less DDD was formed). I demonstrated as well that Tween 80 increased production of p,p'-DBP metabolite and stimulated its further disappearance in anaerobic conditions.

Contrary to the other authors, studying surfactants application only at specific dose, I investigated results of Tween 80 stimulation over a range of doses. This allowed me to conclude that increasing Tween 80 dose led to the decrease of DDD metabolite accumulation, but only up to a certain level [6 g (kg soil)$^{-1}$ in case of investigated sample NDZ(4)]. Higher doses caused renewed increase in concentration of produced metabolite. I also found that some stimulation of anaerobic bioremediation by Tween 80 (both in terms of DDT removal and DDD accumulation decrease) took place even at a low dose, not high enough to achieve critical micelle concentration (CMC) of this surfactant in a water phase of investigated samples. This questions the opinion given by the other authors, asserting that enhancement of bioremediation effectiveness of DDT contaminated soils results only from increase of apparent solubility of this compound and due to that, surfactants have to be applied in doses which ensure that CMC is exceeded. My findings point out to possible existence of other mechanisms of surfactant operation which intensify DDT degradation in soil even while CMC is not reached.

d) Conclusion that accumulation of produced metabolites DDD and p,p'-DBP depends on soil initial contamination level, which was not mentioned in the literature so far.

Higher level of soil pollution (higher concentrations) resulted in higher amount of DDD formed, whereas simultaneous p,p'-DBP production was lower. However, DDT anaerobic degradation was not inhibited even at the highest investigated concentration of 102 mg kg^{-1} (p,p' isomer).

Besides, during investigations on bioremediation performed with different setups of the process valuable results of practical relevance were obtained, concerning optimal selection of the process parameters. These are the following findings, referring to:

e) Stimulation of the process with an easy degradable co-substrate

Within the scope of conducted experiments I studied stimulation of the bioremediation process with a wide range of easy degradable co-substrates: starch, molasses, sucrose, whey, sodium or calcium lactate and sodium salts of simple organic acids: pyruvic, acetic, propionic and butyric. I found that the most effective was sodium or calcium lactate, which, even at a small dose, considerably increased removal rates of DDT and methoxychlor. A new finding was its simultaneous influence on formation of metabolites: lactate increased production of DDD and p,p'-DBP, at the same time stimulating their later disappearance. Similar results were obtained with use of sodium salts of other organic acids, especially pyruvic.

f) Control and influence of pH on anaerobic bioremediation process

A phenomenon connected with application of sodium salts as co-substrates, so far not described in the literature despite frequent use of e.g. sodium lactate as co-substrate for anaerobic bioremediation of different contaminants, was a gradual rise of pH up to about 9. This alkalization did not hinder DDT removal, nor was its detrimental for formation and later disappearance of its metabolites. However, it negatively affected bioremediation results in terms of restoration of useful properties of soil. Soil structure was changed to very tight (impermeable) with simultaneous increase of salinity, which together seriously impaired soil habitat function. I attributed this pH rise to accumulation of soluble carbonates as products of anaerobic degradation. This was confirmed by successful application of calcium ions (replacement of sodium lactate with calcium lactate or dosage of calcium chloride) as a mean preventing the above described soil alkalization. This resulted in precipitation of carbonates as hardly soluble calcium carbonate.

My investigations also delivered findings concerning influence of environmental conditions on anaerobic bioremediation of DDT contaminated soil. Low pH inhibited DDT and methoxychlor removal. It was completely stopped at pH 4; a negative influence was noticeable at pH 5.5 already. I used calcium carbonate as a countermeasure against the pH decrease during anaerobic bioremediation, arising from e.g. application of easy fermentable carbohydrate co-substrates, such as whey. This enabled, at least partially, to offset negative effects produced by acidification.

g) Temperature influence

Temperature is a significant factor, which increase resulted in higher effectiveness of DDT and methoxychlor removal. Also, higher temperature increased disappearance rates of DDD and p,p'-DBP in anaerobic conditions, which made their concentrations to decline faster.

h) Inoculation (bioaugmentation) with anaerobic sludge

Applied bioaugmentation with mixed cultures of microorganisms, coming from anaerobic sludge: granular or fermented sewage, enabled effective anaerobic bioremediation even when relevant degradation activity of polluted soil endogenous microflora was insignificant or absent.

i) Influence of changing bioremediation conditions to aerobic ones

It is often held in the literature that application of alternate anaerobic–aerobic conditions is necessary for successful bioremediation of DDT contaminated soils. However, my research led to a conclusion that sole change of process conditions to aerobic ones is not sufficient for intensification of results of preceding anaerobic phase. Generally, sample aeration inhibited removal of DDT and methoxychlor, and slowed DDD disappearance as well. In such case, continuation of anaerobic bioremediation phase for a longer time could be more effective.

4.3.5. Practical application of the results

a) Results of my work are a stage in research on anaerobic degradation of DDT and its derivatives. Perceived as such, they contribute to expending a body of knowledge and could be a starting point for further studies on that subject. It refers both to studies on remediation of contaminated soil and to studies on environmental fate of these compounds. As for the latter, the possibility of formation of considerable quantities of metabolites other than DDD: DDCN and DBP, during anaerobic DDT degradation is of great importance. These metabolites are not routinely analyzed, and their toxicity and further fate are poorly recognized. Hence, they pose a „hidden" risk related to DDT pollution.

b) From the practical point of view, an important conclusion is confirmation of efficacy of the proposed bioremediation method and conditions of its use established during the study: inoculation with anaerobic sludge, use of supportive agents: Tween 80 surfactant and calcium lactate, with soil warming using a greenhouse. This verification was done in the last stage of the research. Field test of 15-week bioremediation method of selected contaminated soil resulted in 62% or 66% reduction of the sum of p,p'-DDT, -DDD and –DDE (p,p'-DDX), respectively for anaerobic-aerobic or solely anaerobic conditions. Results of the experiments suggest that longer duration or more favorable conditions (low initial concentration of contaminants, especially DDD and DDE, their high bioavailability) may produce even higher reduction of p,p'-DDX sum index, above 70%. The process is promising in the context of practical application. Further, currently conducted studies should result in better recognition of this method efficiency in terms of soil detoxification (experiments with biotests) and definitive confirmation of its applicability.

5. Presentation of other academic accomplishments

5.1. Before receiving Ph.D.

My academic education at the Faculty of Water and Sanitary Engineering of the Cracow University of Technology was accomplished according to individual program, with some courses at the Institute of Environmental Biology of the Jagiellonian University (i.a. biochemistry, hydrobiology, toxicology, ecology), which enabled me to place my further works in a broader scientific context. I completed my education in September 1989, defending a master thesis in which I proposed a mathematical model of wastewater treatment system comprising of anaerobic UASB reactor and activated sludge tank. Basing of conducted simulations I demonstrated that such optimized system could be advantageous in terms of investment and operational costs to treatment in activated sludge tank alone. What is more, my part-time employment as a laboratory technician during the last semester of my studies allowed me to gain first experience in conducting research.

During the first period of my scientific activity, before receiving Ph. D. degree, the main area of my interest was anaerobic treatment of wastewater. Initially it referred to more general applications, then I focused on its use for pesticide removal from wastewater. A secondary area of my interest was application of tests measuring activity of functional groups of activated sludge microorganisms for performance assessment of biological wastewater treatment plants.

Most important achievement of that time, in my opinion, was my participation in 3 research project concerning referring to application of anaerobic wastewater treatment:

a) After starting an employment as an intern assistant in the Division of Water and Wastewater Treatment in 1989, I took part in the project "*Application of upflow anaerobic reactors for treatment of low-strength wastewater*" (att. 3, B.10.1), under the leadership of doc. dr inż. Jerzy Kurbiel. I was involved in experimental studies on effectiveness of municipal wastewater treatment using laboratory model of a system consisting of anaerobic UASB reactors and low-loaded activated sludge tank, operating at ambient temperatures. The findings of this research were presented by me at a conference (B.12.1, att.3). These results confirmed that anaerobic UASB reactors could be used for primary treatment of municipal wastewater as a part of anaerobic-aerobic system.

b) The next research project concerning anaerobic wastewater treatment, with my involvement, was executed in 1991-94 in co-operation with US EPA (B.10.2, att. 3). Within this project I was responsible for long-term experiments on effectiveness of selected pesticides removal in continuous-flow models of UASB reactors. The chosen compounds were: organochlorine methoxychlor, organophosphorus chlorfenvinphos and 2,4-D herbicide. For each of these pesticides, I determined relationships of effectiveness to HRT in UASB reactors and contribution of sorption and degradation to overall removal. I also tried to identify products of their degradation, which resulted in establishing putative transformation paths of chlorfenvinphos and 2,4-D. The findings were published as journal paper (B.5.1, att. 3) and presented at conferences, including one international (B.12.2, B.12.4-B.12.7, att.3).

c) The issue of anaerobic pesticide removal from wastewater was again addressed by me in expanded range during preparation of my Ph. D. thesis "*Application of anaerobic process for removal of organochlorine pesticides from wastewater*" (supervisor prof. dr hab. inż. Jerzy Kurbiel). I conducted, as a primary and sole investigator of the project (B.10.3, att. 3), a wide range of studies on removal of organochlorine pesticides: lindane (γ-hexachlorocyclohexane, γ-HCH) and methoxychlor from wastewater, using laboratory model of anaerobic UASB reactor. I established a dependency of removal effectiveness on initial concentration of pesticide, wastewater COD, HRT and temperature, making use of statistical methods: design of experiments and response surface analysis. I also identified, using GC and GC-MS analysis, products of anaerobic degradation of lindane and methoxychlor. An approximate mass balance of these pesticides and their metabolites was accomplished, in order to determine roles of sorption and degradation processes in pesticide removal. An additional experiments on aerobic post-treatment using model of aerated filter were performed, establishing its effectiveness in removal of pesticides residues and their metabolites. Results of this research were presented by me as a platform presentation at an international conference(B.12.9, att. 3), already after my Ph.D. defense (which took place on 27.10.1999).

Additionally, during the project b) (B.10.2, att. 3) I completed a training (Q.1, att. 4) and gathered experience in gas chromatographic (GC) analyses. Owing to that, in next projects I was able to perform majority or even all such tests in person, which allowed me for more thorough observation and analysis of obtained results.

Anaerobic wastewater treatment was also included in the next research project I participated in, commissioned by BPBK (Bureau of Designs in Communal Engineering) in Krakow and conducted in 1992 (M.1, att. 4). This project aimed at development of treatment technology for leachate from municipal waste landfill in Barycz. As for my involvement, I performed experiments with use of laboratory models of treatment systems. It was demonstrated that anaerobic UASB reactor was ineffective; the alternative investigated system included lime precipitation, ammonia stripping and biological treatment in aerated SBR. Despite complete removal of ammonia, effectiveness in terms of COD was still not satisfactory due to recalcitrant character of organic contaminants. I conducted series of laboratory experiments on physic-chemical post-treatment with application of coagulation with iron salts, advanced oxidation and adsorption on activated sludge, finally obtaining the required quality of the effluent. The results of this project were presented as conference presentation B.12.3 (att. 3).

Experience acquired in the area of anaerobic wastewater treatment was used by me later during preparation of several commissioned expert opinions and reports (M.9, M.10, M.12, M.19, M.28, M.29, M.31, M.32; att. 4), and also in my teaching activity (development of original program for "Anaerobic wastewater treatment" course; I.7, att.4).

During my internship held in 1996 at the Royal Institute of Technology (KTH) in Stockholm (L.2, att. 4) I became familiar with methodology of tests evaluating activity of functional groups of activated sludge micro-organisms: OUR, AUR, NUR, PRR. I participated in research carried out there on denitrification enhancement by dosing of external substrates. After my return I made use of these methods, conducting studies on inhibition of municipal wastewater biological treatment processes by discharges of some industrial effluents. Results of these investigation were presented as a conference paper B.12.8 (att.3). The tests were also used by me during preparation of expert opinions (M.4, M.6; att. 4).

5.2. After receiving Ph.D.

Since receiving Ph.D. degree my main research activity has been still related to problem of pesticide contamination and degradation, but pertaining to another branch of environmental technologies – soil remediation. A related issue is assessment of bioavailability of such contaminants in soil and its influence on toxicity and bioremediation efficiency. A minor area of my scientific activity has remained a problem of wastewater components biodegradation, i.a. wastewater COD fractionation and determination of degradation processes kinetics parameters, using respirometric techniques.

In my opinion, my most important achievements of this period are: execution of the research project concerning degradation and bioavailability of cyclodiene pesticides during my fellowship abroad and conducting studies on bioremediation of chlorinated pesticide polluted soils under two research grants with me as a projects' leader, complemented with own studies:

a) In years 2000-2001, under a Marie Curie fellowship awarded by European Commission and employment as a postdoc at the Wageningen University, I executed an individual research project „*Bioavailability and biodegradability of organochlorine pesticides in contaminated soil/groundwater*" (B.10.4, att. 3). The topic of the project were: feasibility assessment of cyclodiene pesticides biodegradation, well known for their persistence in the environment, and determination of their bioavailability in contaminated soil/sediments. During my stay, on request of my fellowship supervisor dr. ir. Tim Grotenhuis, I supervised a research internship of a graduate student, Ms. Petronella Knipscheer, (J.2, att. 4), who under my guidance participated in a part of laboratory work, planned by me. Results of the project were published, with me as a senior author, as papers B.1.1, B.12.12 and B.12.14 (att. 3). I demonstrated possibility of anaerobic biodegradation (dechlorination) of aldrin, dieldrin, isodrin and endrin, by methanogenic granular sludge originating from anaerobic reactors. This was confirmed by GC, GCMS analyses and chloride balance (determined by IC) (B.1.1, att. 3). My studies provided new insights into anaerobic degradation pathways of these compounds. In contrast to previously described in the literature transformation into two monodechlorinated products, degradation of dieldrin and endrin exhibited more complex pathways. In case of dieldrin I found reduction to aldrin and formation of two monodechlorinated derivatives of dieldrin together with two monodechlorinated derivatives of aldrin. Endrin was rapidly degraded into at least three mono- and three didechlorinated analogues. Increase of chloride concentration indicated possibility of even more advanced dechlorination of endrin (average number of released chlorine atoms ~ 3 per one particle of the compound). I performed also analyses of aldrin and isodrin (bio)availability in samples of contaminated soils (B.12.12, att.3), adapting a sequential solid phase extraction (SPE) method, with use of Tenax TA. This method was previously applied for other HOCs, mainly PAHs. The method was effective, demonstrating clear two-phase course of pesticide desorption from soils. Slowly desorbing fraction share varied for samples from different sampling sites, which indicated different impact of contaminant sequestration (aging) in spite of similar contact time (~40 years). In case of Rozenburg polder almost 90% of pesticides remained as rapidly desorbing fraction, thus were easy bioavailable. An important conclusion of this part of investigation was that even after long contact time it cannot be taken for granted that contamination becomes bound in soil and thus presents negligible risk.

   Results of my work were highly appreciated at the Wageningen University, which resulted in inviting me in 2002, for training a doctoral student continuing this line of research (L.4, att. 4).

b) After return to Poland, in years 2005-2008 I was a leader of a research project financed by Committee of Scientific Research (KBN) *„Assessment of toxicity and possibility of bioremediation of soils contaminated with pesticide waste"*(B.10.5, att. 3). A part of this project was dedicated to an assessment of toxicity of polluted soils in the vicinity of selected pesticide „tombs", using biotests. It was executed in co-operation with the Environmental Biotechnology Department from Silesian University of Technology and the Institute of Plant Protection in Sośnicowice. Second part of the project consisted of laboratory research on bioremediation of such soils and bioavailability of their pesticide contaminants. This part was performed primarily by me. During the project I supervised a research internship of an graduate student from Internationales Hochschulinstitut in Zittau (Germany), Mr. Daniel Pleissner, held at Cracow University of Technology under DAAD scholarship. (J.3, att. 4). Mr. Pleissner, under my guidance, participated in performing a part of laboratory experiments planned by me.

Results of investigations on toxicity were presented in papers B.1.2, B.5.3 and B.12.15 (att. 3). These works compared results of selected biotests, Phytotoxkit (root growth inhibition) and tests with earthworms: acute toxicity, chronic toxicity (reproduction) and avoidance response, to results of analytical measurements of a wide range of pesticide contaminants. It was demonstrated that habitat function of investigated soils was greatly reduced. It was shown as well, that pollution assessment based only on analytical measurements of pesticides listed in current soil quality standards, such as DDT and HCH, is not sufficient. The most sensitive indicators were sublethal tests with earthworms: chronic (reproduction) and avoidance response. With regard to phytotoxicity tests, more sensitive were dicotyledonous plants: cress and mustard, in comparison to sorghum, representative of monocotyledonous plants. That could be attributed to presence of herbicide residues: phenoxy acids and dinitrophenols, in studied samples.

During the investigation on anaerobic bioremediation I found that stimulation of indigenous microflora of sampled soils with easy degradable co-substrate (sodium lactate) produces little effect, even with simultaneous use of redox potential reducing agents (papers B.1.5, B.1.6, B.5.5, B.5.6; att. 3). Good results were obtained by use of powdered metallic iron: high removal of dominant pesticide contaminants: γ-HCH (lindan), DDT (o,p' and p,p' isomers) and methoxychlor (II.E.6). Accumulation of DDD metabolite in this case was far less than stoichiometric, which resulted in considerable decrease of sum of DDT, DDD and DDE concentration, widely used as pollution index for soil contamination assessment. Similar effects, without occurrence of noticeable delay (lag phase), were achieved when samples were inoculated (bioaugmented) with mixed cultures of anaerobic microorganisms coming from granular or fermented sludge (B.1.5, B.1.6, B.5.5, B.5.6; att. 3). I found that during such process, after an initial period of fast partial removal of pesticides, slowly declining residues of these contaminants persisted for a long time (B.1.5, B.1.6, B.5.5, att. 3). This phenomenon was not caused by a depletion of co-substrate (B.5.5), it could rather resulted from a lack of bioavailability of a fraction (part) of contaminants. That was indicated by the fact that, after an initial period of fast partial removal of pesticides, their residues were hardly desorbable, which was demonstrated by a consecutive SPE using Tenax TA (B.1.5). I stated that an effective stimulating agent for anaerobic bioremediation with sludge inoculation was Tween 80 (B.1.6, B.5.6), which increased effectiveness of γ-HCH, DDT and methoxychlor, lowered DDD accumulation and enhanced production of p,p'-DBP metabolite. An improvement of removal resulted, among others, from reduction of quantity of slowly declining residues of some contaminants. However, high dose of Tween 80 caused DDD accumulation to rise again, which raised a question if Tween 80 influence on formation of this metabolite depends on exceeding critical micelle concentration of the surfactant in water phase (B.1.6).

Complementary experiments conducted under internal faculty project Ś3/BW/626/2007 (B.13.5, att. 3) allowed for establishing a relationship between results of anaerobic bioremediation with granular sludge bioaugmentation and temperature. At that time, the significance of this parameter to anaerobic degradation of organochlorine pesticides was poorly recognized in the literature. I stated that, apart from expected decrease of γ-HCH, DDT and methoxychlor removal rates, lowered temperature results in increase concentration of long-term persisting residues of these pesticides (B.1.5, att. 3). I interpreted that as caused by decrease of desorption rate of already slowly desorbing fractions of the pesticides, thus further decline of their bioavailability. A next observed effect of temperature lowering was higher accumulation of DDD metabolite, which in turn decreased effectiveness of DDX index reduction.

During the next project financed under internal faculty grant Ś3/463/BW/2008 (B.13.6, att. 3) I studied efficiency of anaerobic bioremediation pursued as „solid phase", i.e. with soil moistened to 100% of its water holding capacity. I found that results are similar to those obtained in tests with 10% soil slurry, applied by me up to then. This suggested possible practical application of the bioremediation process (B.1.3, B.5.9, att. 3). I also confirmed the efficiency of Tween 80 surfactant application as bioremediation enhancing agent. I tested use of methanol as an easy degradable co-substrate, which should additionally reduce the scatter of bioremediation results due to expected dissolution of pesticides microaggregates occurring in investigated soil, but this proved not really successful.

Experiences gained during execution of above described project were used by me for preparation of a review paper B.1.7 (att. 3), discussing practical (full-scale) applications of different bioremediation technologies of chlorinated pesticide contaminated soil.

c) Encouraging results of previous studies on anaerobic bioremediation of pesticide polluted soil enabled me to receive a next grant for a project *„Investigations and assessment of remediation process of pesticide waste contaminated soil"*. I managed this project in years 2009-2012 (B.10.6, att. 3), performing all experiments related to bioremediation in person. Its objective was to study a wide range of relationships and to improve a bioremediation process conducted in „solid-phase", together with verification of its effectiveness in conditions close to real ones. Within preparatory phase of the project I carried out complementary tests, which together with data from the project B.10.5 were used for preparation of a journal paper B.1.9 (att. 3). In this work I discussed results of a study on relation between γ-HCH, DDT and methoxychlor removal in anaerobic bioremediation tests and susceptibility of these contaminants for desorption, made with a number of soil samples of diverse level of pollution. In general, amounts of pesticides removed were larger that their sole rapidly desorbing fractions, measured by Tenax TA SPE method. However, I found that there is a statistically significant dependence between bioremediation effects and SPE extraction, which confirmed existence of a relationship between biodegradability and desorbability of pesticides. In consequence, I was able to propose a 72-h SPE extraction as an indicator for expected effectiveness of such contaminants removal.

The rest of the results, together with additional experiments conducted by me in 2013 after completion of the main project, were used for preparation of the works presented as my main scientific accomplishment (A.2.1-A.2.3, att. 3), already discussed in section 4.

My present research activity still involves the problem of chlorinated pesticide contamination. In year 2015 I published a journal paper B.5.11 (att. 3), discussing the current state of DDT pollution in Poland. I found that despite disposal of the "tombs" there are still several sites where soil quality standards are exceeded, even many times. In Poland the problem of occurrence of DDT metabolites, other that routinely measured DDD and DDE, e.g. DDA, DDCN and DBP, is not recognized completely. Also, I am preparing a publication elaborating results of toxicity studies (using a battery of biotests) of soil bioremediated in different variants, comparing then to the results of analytical determination of pesticide contents (research performed in co-operation with the Environmental Biotechnology Department of Silesian University of Technology). I am also planning to prepare a paper summarizing investigations using biotests for pollution assessment of soil sampled near „tombs". I applied for funding for continuation of studies on DDT anaerobic degradation with respect to newly found pathways. I would like to complement these experiments with testing of other enhancing agents, such as cyclodextrins.

A second line of my research activity, related to biodegradability of organic contaminants in wastewater, has been pursued under statutory activity projects (B.13.1, B.13.3, B.13.4; att. 3) and expert opinions commissioned by external entities (e.g. M.14, M.20, M.22, M.25, M.27, M.34; att. 4). These studies focused on different types of industrial wastewater, attempting to adapt methods of COD fractions and biodegradation kinetics parameters determination, previously developed for municipal wastewater. In a conference paper B.12.13 (att. 3) I presented results of respirometric tests and their modelling made for paper industry wastewater. I found that for a part of wastewater streams a characteristic of contaminants – COD fractions – and their biodegradation process are better reflected by ASM3 model, which includes substrate storage, due to clear smooth transition between rapidly degradable substrate utilization and slowly biodegradable (hydrolysable) substrate utilization phases. However, in case of wastewater form paper pulp bleaching ASM models were completely inadequate, because of quite different course of biodegradation process. It was necessary to develop the original model, distinguishing three different easy biodegradable fractions and one hydrolysable fraction. A conference paper B.12.11 (att. 3) presented results of modelling for volatile fatty acids generation during pre-fermentation of primary sludge, obtained at two Polish WWTPs.

My experiences from conducted studies were used for preparation of journal papers B.5.4 and B.5.8 (att. 3), discussing different methods for wastewater COD fractions determination. The latter received a great deal of attention, confirmed by citations in Polish journals (including one indexed by WoS). In a publication B.5.10 (att. 3) I referred to a scope of investigation needed for assessment of suitability of so-called external organic carbon sources used for enhancement of nutrients removal from wastewater. I also discussed a range of substances used for that purpose. At now I am planning a publication concerning specificity of COD fraction determination and respirometric studies carried out with industrial wastewater.

My experience in the area of respirometric tests and mathematical simulation were the basis for trusting me with a supervision over a non-faculty doctoral student Mr. Karol Trojanowicz (in years 2004-2009) (K.1, att. 4), who was preparing a Ph.D. thesis concerning biological post-treatment of petrochemical wastewater using submerged aerated filter and development of a mathematical model of such process. Because of a lack of legal basis at that time, I was not formally recognized as e.g. auxiliary doctoral supervisor. The effect of my involvement was, among others, my co-authorship in journal papers B.1.4, B.1.8 and B.5.7 (att.3). As for the first of them, about determination of kinetics parameters for a model of petrochemical wastewater post-treatment using a biological filter, I advised on experimental methods, interpretation of results and helped in preparation of the final text. In the remaining papers, discussing results of pilot tests and control of biomass amount in the filter, I provided support in interpretation of results and text writing.

6. Summary of activities

6.1. Research activity

Most important achievements and their records, including items mentioned in section 4.			
	before receiving Ph.D	after receiving Ph.D	total
Monograph		1	1
Paper in journals indexed by JCR *(as a sole or main author)*		11 *(8)*	11 *(8)*
Paper in journals from B list of MSaHE *(as a sole or main author)*	1	8 *(4)*	9 *(4)*
Chapter in monograph *(as a sole or main author)*		2 *(2)*	2 *(2)*
Paper in international conference proceedings *(as a sole or main author)*	2 *(1)*	6 *(5)*	8 *(6)*
Paper in local conference proceedings *(as a sole or main author)*	6 *(3)*	2 *(1)*	8 *(4)*
Sum of journals IF (WoS, as per year of issue)		13,702	13,702
Citations in WoS, as of 16.05.2016 *(excluding self-citations)*		76 *(67)*	76 *(67)*
Hirsch index in WoS		4	4
Citations in Scopus, as of 16.05.2016 *(excluding self-citations)*		76 *(66)*	76 *(66)*
Citations in Google Scholar, as of 16.05.2016		114	114
Sum of MSaHE points (as per year of issue)		271	271
Platform presentation at conference *(at international conference)*	3 *(1)*	6 *(3)*	9 *(4)*
Poster presentation, communicate *(at international conferences)*	3 *(1)*	4 *(3)*	7 *(4)*
Internship in academic units abroad (at least 1 month)	1	1	2
Management of research projects, national call		2	2
Principal (sole) investigator in research project *(international call)*	1	1 *(1)*	2 *(1)*
Investigator in research project *(international call)*	2 *(1)*		2 *(1)*
Participation in research projects under statutory activity		4	4
Project performed under internal faculty grants		2	2
Supervision of doctoral student		1	1
Supervision of research internship of an graduate student from abroad		2	2
Review for scientific journal		35	35

(for journal indexed by JCR)		*(32)*	*(32)*
Preparation of expert opinions and reports commissioned by state, self-government and private entities	11	23	34

6.2. Teaching and popularization of science activity

As for my teaching activity, since starting my work at the Cracow University of Technology (CUT) I had been giving classes within the following courses: *Wastewater treatment* (laboratory and design classes), *Water Treatment* (design), *Water Reclamation* (design), *Industrial Water Treatment* (design), *Industrial Wastewater Treatment* (design), *Environmental Biotechnology* (selected lectures and lab classes) for full- and part-time students. Currently, since several years I have been a leader of the modules (courses): *Wastewater Sludge Processing, Technological Analysis in Water and Wastewater Treatment, Remediation of Soil/Groundwater Environment, Anaerobic Wastewater Treatment,* giving lectures, design and laboratory classes for undergraduate and graduate students. The last 3 courses are run according to my own original curricula, prepared with use of my experience from conducted research projects. I am also involved in running selected lectures for the courses: *Advanced Wastewater Treatment* and *State of the Art in Water and Wastewater Analysis* (in English).

Two times I was a visiting lecturer at the University of Geneva (I.11., att.4). I also give lectures in English for internship students staying at CUT under agreements with universities from abroad (I.10., att.4). I am also a co-author of a chapter in academic textbook (I.12., att. 4), awarded a group prize for the teaching achievement by the Rector of CUT. I supervised 14 engineering theses, 12 master theses and 1 diploma thesis on postgraduate studies

Concerning popularization of science, I hold selected lectures for postgraduate studies. I was a lecturer during 6 editions (I.1., I.2., I.4.; att. 4) of trainings for employees of water supply and sewerage companies (4 times after receiving Ph.D.), running lectures and practical laboratory classes.

6.3. Organizational activity

One of my most important accomplishment in the area of organizational activity is my participation, in years 1994-97, in the project TEMPUS-PHARE 07683-94 (A.1., att. 4). The project objective was to upgrade a quality of teaching on the Faculty of Environmental Engineering of CUT, including transition to modular course system. Within the project I was involved in preparation of seminars and was responsible for purchasing and installation of equipment for students' and staff laboratory of the Water and Wastewater Treatment Division. Also in the later time I was equipping of this laboratory, taking part in purchases of new apparatus and other accessories (searching for offers, preparation of specifications, tender commissions, installation of equipment).

Since September 2013 I act as a deputy director for research affairs of the Institute of Water Supply and Environmental Protection. As such, I am responsible for a general surveillance of research activity of the Institute, especially statutory activity and activity of young researchers (i.a. preparation of applications and reports, financial issues, verification of documentation and scientific reports), also overseeing a part of ongoing organizational activity. Since the same time I am a member of 3 faculty commissions: for statutory activity, for statutory activity of young researchers and for awards. Since December 2014 I am an elected member of the Council of the Faculty of Environmental Engineering as a representative of auxiliary research staff.