Kraków 5th Dec 2015

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SELF-PRESENTATION

description of the outputs and scientific achievements, translated into English language,

in particular those set out in Article 16 section 2 of the Act of 14 March 2003. on Academic Degrees and Titles and on Degrees and Title in Art (Decree Announcement No. 65, item. 595, as amended) and in the Regulation Minister of Science and Higher Education of 30 October.2015 on the detailed procedure and conditions for activities undertaken in the doctoral, habilitation proceedings and proceedings for awarding the title of professor; ((Decree Announcement 2015 item1842).

Kraków, 2015

1. Personal data

Name and Surname: Stanisław Maria Rybicki
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Employed at: Politechnika Krakowska im. Tadeusza Kościuszki
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2. Diplomas and degrees

(year, name and place of obtaining)

1983 **Master of Science in Civil (water) Engineering, Thaddeus Kosciuszko Cracow University of Technology, Faculty of Sanitary Engineering and Water Management, 1983.** Thesis: Analysis of the system of reservoirs, taking into account some quality issues. Supervisor: MSc. Jerzy Szczęsny Thaddeus Kosciuszko Cracow University of Technology. Diploma thesis: excellent. Thesis highlighted the resolution of the Faculty Council, Awarded with the Prof. Roniewicz award for most-improved thesis on the direction;;

1996 **Doctor of Technical Sciences in the discipline of Environmental Engineering, Thaddeus Kosciuszko Cracow University of Technology, Department of Environmental Engineering, 1996 PhD thesis:** The influence of chemical pre-precipitation of phosphorus on the work of biological reactors. Supervisor: Professor. Jerzy Kurbiel, Cracow University of Technology. External Reviewers: Professor. Marek Roman, Warsaw University of Technology, Assoc. Prof. Jadwiga Bernacka, Institute of Environmental Protection, Warszawa. Internal Reviewer: Assoc.Prof. Renata Kocwa-Haluch, Cracow University of Technology. The work featured a resolution of the Faculty of Environmental Engineering Thaddeus Kosciuszko Cracow University of Technology, Job awarded the Prize of the Ministry of Education for outstanding scientific achievements.

1986 **Certificate of professional qualification, entitlement to self-perform management functions in the construction industry (ie. Building qualifications):**

i. specialization installation and engineering, without limitation, No. 174/86
ii. specialization in construction and engineering, without limitation, No. 226/86

1994 **Certificate of professional qualification, entitlement to self-perform designer's functions in the construction industry (ie. Designer's qualifications):** specialization in installation and engineering, without limitation, No. Upr.678/94/RP

3. Information on previous employment, including in scientific units:

3.1. Professional experience before scientific work:

1983-1986 Engineer in apprentice, Chief foreman, Construction manager; State Owned Enterprise "Przedsiębiorstwo Budownictwa Hydrotechnicznego Energopol - 2" w Krakowie" (currently non-existent);

1984 Military Academy (Res.) - according to the regulations in force university graduates;

3.2. Experience in a scientific institution

1986-1996 Assistant, Senior Assistant (scientific) in the Chair of Water and Wastewater Technology, Institute of Water Supply and Environmental Protection, Thaddeus Kosciuszko Cracow University of Technology, since Sept 1,1986 till Sept 1, 1996

1996- to the present Assistant Professor, Chair of Water and Wastewater Technology (now Chair of Environmental Technologies), Institute of Water Supply and Environmental Protection, Thaddeus Kosciuszko Cracow University of Technology, since Sept 1,1996

1998-1999 Deputy Dean, Faculty of Environmental Protection, Thaddeus Kosciuszko Cracow University of Technology

2008-2012 Deputy Dean, Faculty of Environmental Protection, Thaddeus Kosciuszko Cracow University of Technology

Other functions and organizational activities of academic and professional organizations is presented in Appendix "Other information"

4. Description of output and scientific achievements

(under Art. 16, paragraph. 2 of the Act of 14 March 2003. on Academic Degrees and Titles scientific-dimensions and degrees and title in art,. No. 65, item. 595, as amended. and Articles . 12 ust.2.Decree of Minister of Science and Higher Education dated October 30, on detailed way and conditions of conduction in PhD procedure and procedure of apllication for the Professor's title,. 2015, item 1842)

4.1. Title of scientific achievements

A series of publications related thematically around a theme

Selected interaction between processes in a highly efficient water purification and sewage treatment

This series consists of following scientific papers being published[1]:

I.1. **Rybicki S.M.**,2005, *Biological phosphorus removal in case of specific appearance of nitrates in raw wastewater*, IWA Spec. Conf.: Nutrient Management in Wastewater Treatment Processes and Recycle Streams, str. 997-1003, Kraków,
International scientific conference proceedings ***(Applicant's contribution 100%);***

I.2. Balcerzak W., **Rybicki S.M.**, Kaszowski J.,2007, *Odwadnianie osadów powstających w procesach oczyszczania wody powierzchniowej na przykładzie wodociągu Raba (In Polish) i.e. Dewatering of sludges from surface water treatment in case studey of Kraków-Rawa WTPfr*, Ochrona Środowiska, nr 3, str. 69-73.
JCR IF= 0,320, **Ministry of Science and Higher Education list "A": 15 points**
(Applicant's contribution 50%: *Idea of investigation, completion of investigation of sludge dewatering, conclusions , results of dewatering in natural conditions, figures, final article editorial)*

I.3. **Rybicki S.M.**,2009, *Interactions between advanced wastewater treatment and sludge handling process and their impact on reduction of water pollution*, Polish Journal of Environ. Stud., ISSN 1230-1485, vol. 18., pp. 396-403.
JCR IF=0,947(suplement) **MofSaHE list "A": 15 points** **WoS citations:1**
(Applicant's contribution 100%),

I.4. Balcerzak W., **Rybicki S.M.**,2011, *Pilot scale experiments on surface water treatment sequence including ozonation and adsorption processes*, Journal of Water Supply, Research and Technology-AQUA, vol 60, no 7, str. 459–467.
JCR IF=0,597, **MofSaHE list "A": 20 points**
(Applicant's contribution 50%; *Completion of pilot-scale experiments of ozonation, testing sorption efficiency, development of final version, text editing in English)***,**

I.5. **Rybicki S.M.**,Cimochowicz-Rybicka M., 2011, *Selected Interactions between Metha- ne Recovery from Wastewater Sludge and Phosphorus Removal*, Proc. 4th IWA-ASPIRE, Conference & Exhibition, electronic media, kod: Sr119H01141DIS, Tokyo, Japan. **International scientific conference proceedings**
(Applicant's contribution 50%, *Idea of investigation, adaptation of phosphorus uptake rate measurement, part of respirometric test, final development of results, editing)***,**

[1] Numbers of papers listed below are consent with numbering applied in Appendix "List of scientific papers being published by an applicant (...)" - Appendix in Polish language

I.6. **Rybicki S.M.,**2013, *Rola hydrolizy i fermentacji kwaśnej osadu wstępnego w eksploatacji oczyszczalni ścieków*, In Polish i.e. *Role of sludge hydrolysis and acidic fermentation in wastewater treatment plant operation* Konferencja międzynarodowa: Praktyczne działanie przedsiębiorstw wodociągowo-kanalizacyjnych w warunkach rosnących wymagań ekologicznych, ekonomicznych i społecznych, AQUA S.A. Bielsko-Biała, str.173-187, ISBN 83-60354-07-3.
MofSaHE: Chapter in monography: 4 points ***(Applicant's contribution 100%),***

I.7. Cimochowicz-Rybicka M., **Rybicki S.M.,**2011, *Methods of digestion chambers dimension-ning in wastewater treatment plants with modern sludge disintegration*, Polish Journal of Environ. Stud., ISSN 1230-1485, vol. 20, no 4A, s.34-38, 2011.
JCR IF=0,508(suplement) **MofSaHE list "A": 15 points**
(Applicant's contribution 50%, *Idea of investigation, development of dimensioning method supervision of full-scale application, conclusions),*

I.8. **Rybicki S.M.,** Cimochowicz-Rybicka M., 2013, *Selected effects of anaerobic sludge composition on a biogas production*, Polish-Swedish-Ukrainian Seminar Cracow 2011: Future urban sanitation to meet new requirements for water quality in the Baltic Sea region, Joint Polish-Swedish Seminar, Report no 17, Ed.: E.Płaza, E.Levlin, str.213-218, TRITA-LWR.REPORT 3031, ISSN 1650-8610, ISRN KTH/LWR/REPORT 3026-SE.
Chapter in foreign monography **MofSaHE: 15 points**
(Applicant's contribution 50%, *Idea of paper, general concept, development of measurement methodology, part of respirometric tests, final conclusion, text editing),*

I.9. **Rybicki S.M.,**2013**,** *Specific impact of enhanced biological phosphorus removal from wastewater on fermentation gas generation*, Environmental Engineering IV: Proceedings of The Conference on Environmental Engineering IV, Lublin, Poland, 3-5 September 2012. – Leiden : CRC Press/Balkema, 2013. – str. 135-139. – doi: 10.1201/b14894-23. – ISBN 978-0-415-64338-2.
Web of Sci.Core Collection **MofSaHE: 10 points** ***(Applicant's contribution 100%),***

I.10. **Rybicki S.M.2013,** Chapter 11 'Costs of operation' w: Best practice guide on the control of Iron and Manganese in water supply; IWA Book Series: Best Practice Guides on Metals and Related Substances in Drinking Water .
Web of Sci. Core Collection **MofSaHE: 10 points** ***(Applicant's contribution 100%),***

I.11. **Rybicki S.M.,** Cimochowicz-Rybicka M.,2013, *Dimensioning of Digestion Chamber for Upgrading of Gas Recovery at Wastewater Treatment Plant*; Archives of Environmental protection, vol.39, no.4, str. 105-112, ISSN 2083-4772.
JCR IF=0,901, **MofSaHE list "A": 15 points** **WoS citations:3**
(Applicant's contribution 50%, *Idea of paper, general concept, development of measurement methodology, part of respirometric tests, final conclusion, text editing),*

I.12. Balcerzak W., **Rybicki S.M.,**2014**,** *Changes in sludge quality at the water treatment plants* Technical Transactions. Environment Engineering = Czasopismo Techniczne. Środowisko; Y. 111, iss. 1-Ś, s. 19-25. – Seria gł.: Technical Transactions = Czasopismo Techniczne, ISSN 0011-4561. – ISSN 1897-6336, 1-Ś (20).
MofSaHE, list "B": 6 pkt
(Applicant's contribution 50%, *Concept of the paper, completion of sludge quality texts and metals in sludge concentration measurements, figures, final conclusions, editing;),*

I.13. **Rybicki S.M**.,2014, *Role of primary sludge hydrolysis in energy recovery from municipal wastewater sludge*, Polish Journal of Environmental Studies, t.23(3), str.1033-1037, ISSN 1230-1485.

JCR IF=0,871, **MofSaHE, list "A": 15 points** ***(Applicant's contribution 100%),***

I.14. **Rybicki S.M.,** Górka J.,2015, *Studies on real opportunities for energy recovery in the wastewater treatment (Badania rzeczywistych możliwości odzysku energii w procesie oczyszczania ścieków)*, Przemysł Chemiczny, 94/9, str. 1551-1553, DOI: 10.15199/62.2015.9.XX, 2015.
JCR IF=0,399, **MNiSZW, lista A: 15 pkt,**
(Applicant's contribution 75%, *Idea of investigation, concept of the paper, calculations and results' processing, conclusions final editing in English).*

4.2. The scope of research work and its results including practical applications

4.2.1. Introduction

The search for technological and technical solutions involving high-efficiency water and wastewater treatment has long been associated with a rapid socio-economic changes, especially an urbanization and metropolisation development. Additionally, a global population growth and shifts between rural and urban inhabitants, in favor of the latter, have also stimulated an intensive search for new technological solutions.

These events as well as resulting rapid urbanization, observed over the last twenty years in our country, have become a technological challenge that looks for rational solutions combining the following aspects:

a) functional technological efficiency, as indicated by a maximum treatment effect at a given time;
b) low energy consumption, preferably combined with some energy recovery to use it as a renewable energy source;
c) minimization of sludge volumes generated in technological processes and their possible utilization/disposal - to minimize their negative impact on the environment ('ecological footprint');
d) need to adapt to climate changes; their consequences are already visible in both water supply and water management fields and will become more severe in the near future;
e) improvement the life quality by combining effective water and wastewater technologies with issues concerning health security and reliability of water and sewage infrastructures;

These challenges made that numerous research groups in this country are working on elements of the system (technology, engineering, materials, energy) in order to gradually achieve the desired results. The studies are innovative and very often require adaptation of technical activities to the existing conditions, that may differ both regionally and locally. However, this way a mosaic of activities is crated in which both my individual research works and our team's works have a broader importance for the scientific development and technological progress, while at the same time they also show a "practical" feature, unique for specific conditions and enterprises, that enhance the effectiveness of particular processes.

Idea of so-called 'Smart Cities', popular in Europe and worldwide in recent years, provides additional reasons for reorientation of technological research in water and wastewater treatment and combining it with metropolisation of our country. The studies should focus on such solutions in cities infrastructures, including a municipal infrastructure, that would not

add to a negative impact on the environment. Especially water and wastewater treatment facilities cannot be longer treated in a conservative manner, if they are to carry out tasks under the "Smart Cities". The current approach considers them as separate elements of the urban structure, carrying out separate tasks. It has to be changed so that the facilities are designed and operated as integrated elements of a single structure that is managed and operated to maintain or improve the quality of life of residents without overburdening the environment.

Therefore, while pursuing the idea of "Smart Cities" at water and wastewater treatment plants it should be considered to what extent integration of various processes and technological operations affects the entire agglomeration. Such modern approach to water and wastewater facilities used to have and still has an impact on both my individual work and our team's research work. It has also significantly contributed to the wide range of my expert jobs, which on one hand broaden my knowledge and competence in this field, but on the other hand directed the research to specific solutions, which then lead to the following achievements.

4.2.2. Description of research and the mains achievements

Municipal wastewater treatment plants use multi-phase reactors as a primary device for biological wastewater treatment. With some simplification it can be assumed that three basic types of biochemical processes take place in multiphase reactors:

I. Conversion of the organic matter present in the raw wastewater into activated sludge ("biomass') i.e. a mixture of different groups of microorganisms with ability to transform the substrate present in wastewater into new bacterial cells and respiration end products - carbon dioxide and water. The excess amount of biomass thus formed is removed from the process as the excess sludge;

II. Assimilation of phosphates from wastewater by specific types of bacteria present in activated sludge, providing that a suitable energy source and alternating aerobic and anaerobic conditions are ensured; the process is essential for an enhanced biological phosphorus removal (EBPR);

III. Conversion of organic nitrogen and ammonia, which constitute the basic form of nitrogen in raw wastewater, into nitrates and nitrites (nitrification) and then (in anoxic conditions) into gas, released to the atmosphere;

A supply of a suitable amount of easily biodegradable carbon, predominantly volatile fatty acids, remains the most important issue, that is strongly related to changes in the wastewater composition [I.3.;I.6.][2]. The compounds act as electron donors in biochemical reactions of phosphorus transformations. A demand for these donors for intracellular reaction is met by supplementation of the process with additional carbon sources upstream from the anaerobic zone; they are external sources (ethanol, methanol, acetic acid et al.), or - more often - internal sources. The concept of internal carbon sources relates to a mixture of short chain fatty acids that is produced during acid fermentation of primary sludge. In the processes of biological excess phosphorus removal (EBPR), bacteria that can store and release phosphates (i.e. bacteria Bio-P) use easily biodegradable carbon compounds as a source of energy necessary to release phosphates under anaerobic conditions.

[2] See the papers listed as my research achievement in the „ List of publications" enclosed to this "Summary of professional accomplishments" as an appendix;

My research studies, carried out as a part of this scientific achievement, originated from the need to provide a necessary scientific support to a typical real-life implementations, where a general knowledge did not offer sufficient explanations to particular technical and technological issues, specific for local conditions.

Investigating the issues of interactions between technological processes used in water treatment and wastewater treatment, I have identified two main groups of research problems, that should be further developed:

i. EBPR system operation and its impact on operation of anaerobic sludge digestion (stabilization)
ii. phenomenon that disrupt the final result, i.e. high-efficient removal of organic pollutants from water during the treatment process

In both these areas there is a specific situation where constituent processes ("scattered" in various places of technological systems) become important for the final outcome. In the years preceding the study, a state of the art did not allow for use of ready-made reproducible solutions, while the results of research (laboratory) works found practical application confirming the validity of the work.

The study on specific relations between biological removal of phosphorus from wastewater and sewage sludge processing issues was initiated at the Nowy Sacz WWTP in 2003. During the study a possibility of competition between these two processes was noticed. The wastewater treatment plant, as most of the contemporary treatment plants, was designed in mid-nineties of the last century and as such employed primarily biological processes rather than chemical. Later on, the plant operation, special attention was given to the highest possible energy recovery mainly by sludge anaerobic digestion, following the popular trends of that time. Research on the efficiency of fermentation gas ("biogas") production from mixed sludge demonstrated that despite of many attempts to optimize the process, the parameter [3] has values significantly lower than the ones assumed by the designer on the basis of the literature. The values are shown in Figure 1, that comes from my first publications on this topic at the IWA international conference on: *"Nutrient management in Wastewater Treatment Processes and Recycle Streams"* [I.1][4] . In this phase of the research, I assumed that the adverse effects were caused by a long retention time in fermenters, which was justified by the presence of relatively large concentrations of nitrates in raw wastewater, specific for this particular city sewer [I.1., I.3]. Therefore, it was necessary to ensure sufficient generation of short (volatile) fatty acids (VFA), based on the solutions proposed at that time by J.L.Barnard. In the mid-90s of last century, he carried out research on phosphorus removal of from wastewater, when VFA concentrations were insufficient to carry out the sequence: release/ uptake of phosphates [Barnard, 1994; Oleszkieiwicz and Barnard, 1997][5]. In particularly unfavorable conditions, there is a depletion of VFA before conditions change from anaerobic to aerobic. In this case, in the absence of both external nutrients and energy sources, the total energy demand of cells must be satisfied by a breakdown of intracellular polymers. This in turn leads to the undesirable release of phosphates to a solution without a simultaneous uptake of VFA and PHA formation. This phenomenon (secondary release of phosphorus), though stays beyond the scope of this paper, has undoubtedly a negative effect, since a phosphorus release rate stimulated by VFA consumption is by one order of magnitude higher than a secondary release rate

[3] Measured as a unit gas production per mass of dry volatile solids fermented in anaerobic digesters
[4] Numbers as in Sections 3.2. and 3.2. of this publication; other publications listed in Section 4. of this publication
[5] Publications other than mine were listed in Section "Other achievements" being an appendix to this document (In Polish)

(approx. 19 mgP / g VSS * h for VFA and only approx. 1.8 mg P / g VSS * h for a secondary release) [Seviour et al.,2003; Mino et al., 1998; Vermande et al., 2002].

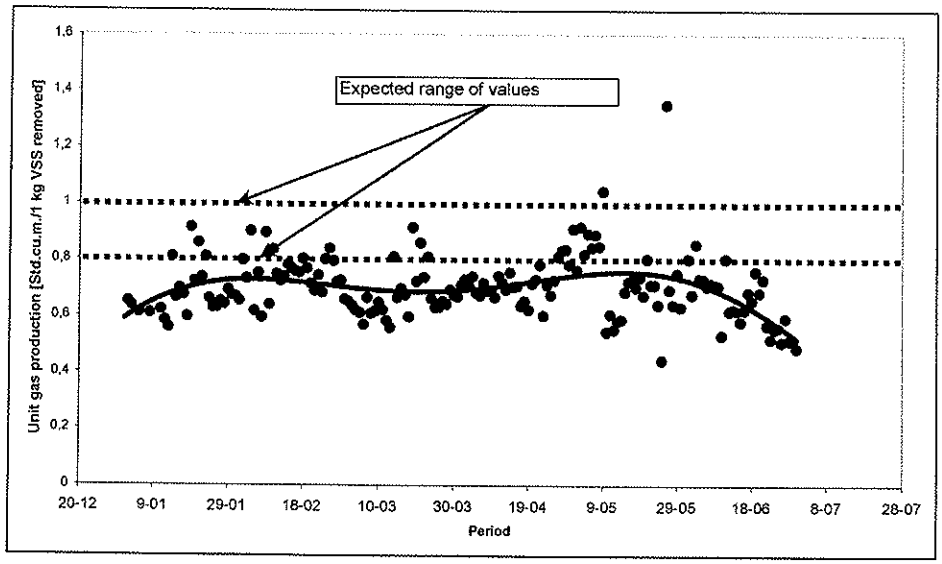

Fig. 1. Biogas production measured (solid line) vs. a literature data range [I.1.].

My further research studies, carried out in years 2003 - 2006, focused on determination of a phosphate release rate in anaerobic conditions using the supernatant from pre-fermenters as the carbon source to compensate for the deficit of the organic compounds consumed by the activated sludge bacteria. The results that have been published [I.3] confirmed that a higher available carbon to nitrogen ratio in the wastewater upstream from the multiphase reactor only slightly increased a release rate. The change was more pronounced for shorter activated sludge retention times (SRT = 10 d), as shown in Figure.2.

The tests confirmed that pre-fermentation of sludge improves biological excess phosphorus removal, but the process may quite significantly hinder fermentation gas production and thereby worsen the energy characteristic of the plant [I.5.].

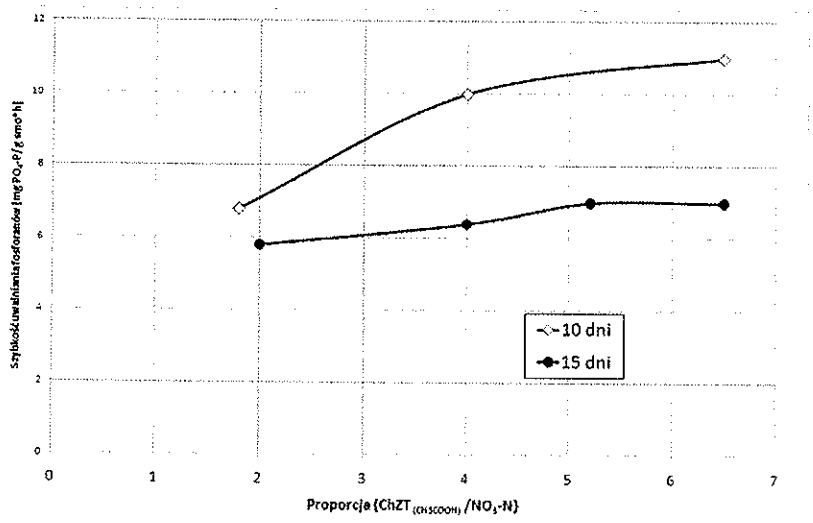

Fig. 2. Phosphates release rate vs. an easily biodegradable COD/nitrates ratio in wastewater upstream from the biological reactor [I.5].

At the time of this research, wastewater treatment plant operators looked at the plant as at a potential source of renewable energy. The operating contradiction, observed between the need to produce easily degradable carbon compounds (mainly volatile fatty acids - VFA) and fermentation gas, reassured that the adopted direction of research was right.

Further research on selection of the methods for generation of short (volatile) fatty acids to "resolve" the conflict between a pre-fermenter line and a sludge processing / energy recovery line (anaerobic digesters), serve as a base for my research grant.

The KBN (Committee for Scientific Research) research project: No. N N523 3775 33 *Systems of biological excess phosphorus removal from wastewater and their impact on gas production in mesophilic sludge fermentation,* Iwas granted in 2007, was carried out in years 2007-2011. It started with studies on hydrolysis and pre-fermentation to determine to what extend a retention time of these technological operations influences the final production of fermentation gas. So far these processes were considered as performing well when very high concentrations of VFA were achieved, without checking how such operation affects gas production [Carlsson et al., 1996; Jardin & Popel, 1996; Mulkerrins et al, 2004]. Operation of wastewater treatment plants that use systems for VFA generation (in a sewage line) and also try to increase a fermentation gas production (within a sludge line) present some operational problems but even the recognized authors did not attempt to provide a quantitative description of this phenomenon. [Canzani et al., 1995; Jonsson et al.,1996; Ekama et al.,1999;Vollertsen et al.,2006;Yang et al., 2010].

Observations gathered during the first period of my research showed a significant drop in gas production in systems with hydrolysis and fermentation (acidic) of primary sludge. Generally, the main provision for a conversion of organic matter in sludge and wastewater is a balance between the amount of substrate and the number of bacteria, mostly methanogenic. There are four main phases of organic compound breakdown :

- I phase - hydrolysis of macromolecular substances,
- II phase – acidogenesis,
- III phase - acetogenesis,
- IV phase - methanogenesis.

The amount and type of the products, produced in the particular phases, is determined by a chemical composition of organic compounds undergoing decomposition in anaerobic conditions with the help of micro-organisms, as well as by time and temperature of the phase. Different bacterial species specialize in methane production from various substrates; some of them employ a substrate for growth and reproduction - both as a source of energy and as a sole carbon source, whereas the majority of methanogenic bacteria uses H2 for the cell growth and CO_2 as the sole carbon source. As different acids: acetic, propionic and butyric (other acids to much less extend) are the end products of anaerobic decomposition of organic material and at the same time serve as the main raw organic material for methane production therefore I focused my research on a conversion path of these compounds. It should be noted that there are clear differences in reaction rates prevailing in various stages paper [I.6].

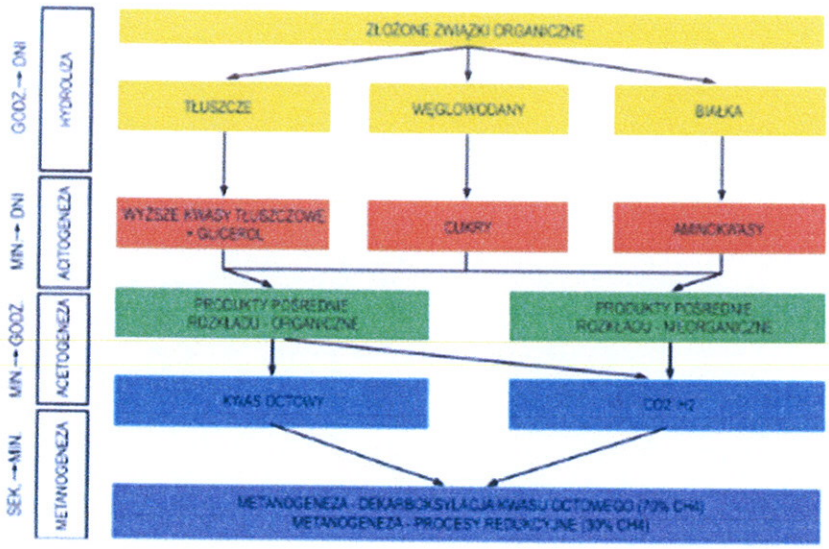

Fig. 3. Conversion of organic compounds during hydrolysis and fermentation[I.6]

The research work focused on checking whether pre-fermention hinders (or not) the biogas production. This issue was important since the recovery of an energy carrier (fermentation gas or biogas) is an important factor in plant operation. Utilization of the fermentation product as an energy source in a wastewater treatment line (and thus lower biogas production) can be compensated to some extent by longer retention times in the anaerobic digesters. Therefore, a precise determination of the retention time in the digesters is of fundamental importance in the design and operation of these facilities. The research conducted by the author at the wastewater treatment plant at Malopolska (MUCT, 120000 p.e.) showed that phosphorus removal was satisfactory when a single-stage fermenter was used. The final concentration of phosphorus in the effluent remained below 1 mg/Liter at all times, while a lower gas production was observed, which confirmed the previous assumptions.

In this part of the study I confirmed that the generation of short-chain fatty acids from primary sludge provided sufficient number of electron donors to ensure highly efficient removal of phosphorus without chemical precipitation. Also, a "competition" for substrates converted to fatty acids may take place between a VFA generation process and production of fermentation gas rich in methane; such process configuration requires careful operation and occasionally may force decision optimization. Energy from hydrolysis (tearing up polyphosphate bonds) is consumed during an accumulation phase, when the matter is cumulated within the cells. Under aerobic conditions, cumulated phosphates are used to produce new cells; the energy for this process is obtained from respiration. Eventually, phosphates are gathered in the activated sludge cells in amounts lower than it would happen if cells were not subjected to the alternating conditions. Research on these process interactions was described in my next articles, which comprise my research achievement. In particular they were:

- Proceedings of the 4th IWA ASPIRE Conference [I.5.], where I presented a follow up of my previous research, carried out within the framework of the grant project. The research showed a two stage process with hydrolysis/pre-fermentation followed by mesophilic fermentation. The study was conducted according to author's own

methodology, using two 8 – cell respirometers. The results were presented in Fig 4. And 5. It was shown that though longer times of hydrolysis/pre-fermentation enhance COD solubilisation (conversion to an easily biodegradable soluble form, Fig..4) they also result in much lower fermentation gas production. I have not noticed any impact of acidic pre- fermentation on a methane content in fermentation gas [I.5.;I.9].

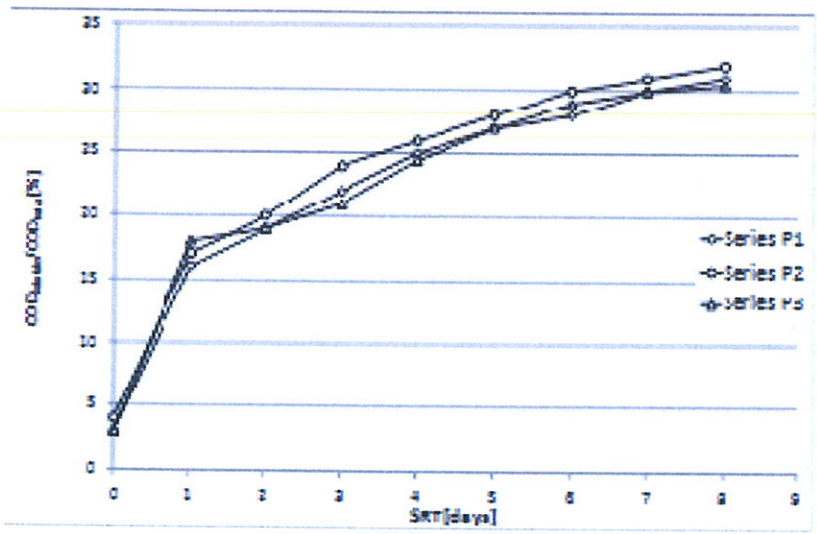

Fig.4. *Acid fermentation time vs. efficiency of hydrolysis of organic carbon compounds (COD) [I.9]*

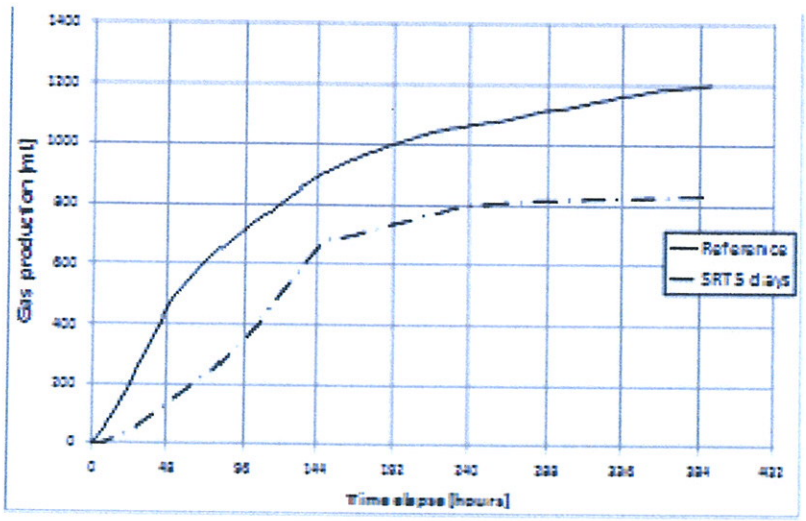

Fig. 5. Production of fermentation gas in mesophilic conditions after acidic fermentation (t = 5 days) [I.5]

This work [I.5.]was a first comprehensive evidence that confirmed the thesis of my research and showed that there can be a contradiction between using only biological excess phosphorus removal, which is the primary task of the wastewater treatment plant, and the production of fermentation gas, which is a modern idea carried out in pursuit of so-called sustainable development cities. The idea of 'smart cities' in this case will be based on operational optimization. My research methodology may facilitate such optimization. Paper [I.9] was a follow-up of previous paper [I.5.].

- Another papers, presenting the results of similar studies, provide further evidence for the principal thesis; they summarize the results of studies on sludge hydrolysis and have been published in the prestigious Polish journals [I.8;I.13]. Moreover, I have published, as the author or co-author, other papers on a mutual influence of a wastewater treatment process and sludge processing in different conference proceedings as well as domestic and foreign monographs of a lower rank (apart from Web of Science), listed in the „ List of publications" enclosed to this "Summary of professional accomplishments" as an appendix.

The evolution of my interests in research and implementation issues made that apart from studying multiphase reactors and their impact on the fermentation gas production I have worked on the development of a method that would help to size anaerobic digesters (WKF) and adjust retention times to the actual process. Typically, the digesters were designed using the "intuitive" method and sludge retention times were adopted based on the designer's own experience in the range of 15-25 days. I met repeatedly application, where too short retention times led to unsatisfactory sludge stabilization and poor utilization of a biogas production potential; on the other hand, too long retention times led to unnecessary energy loss for heating and mixing of sludge that has already been producing relatively low volumes of fermentation gas I developed a method of sizing of anaerobic digesters that uses respiration tests. This way one can precisely determine the required retention time. Figure 6. (from paper [I.7.].) illustrates how this parameter can be determined. This work went through full scale implementation.

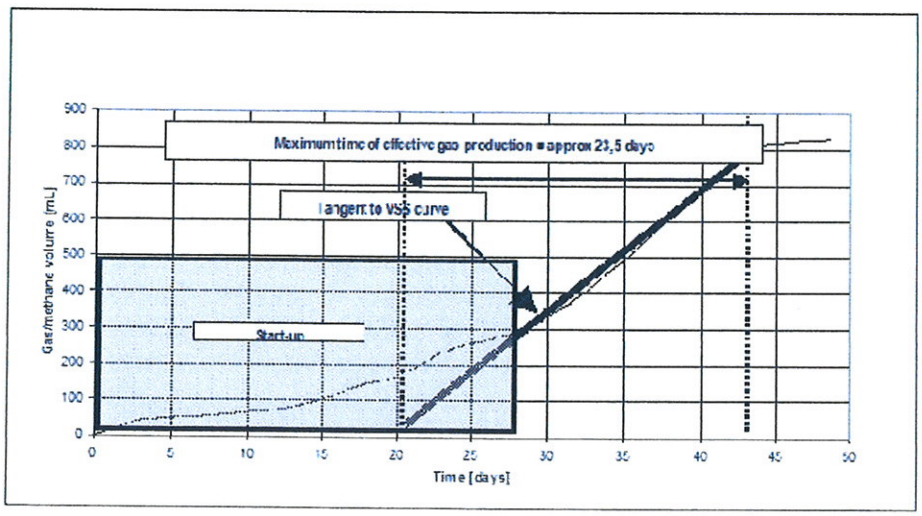

Fig.6. Retention time in anaerobic digesters determined based on respirometric methods [I.7.]

The main advantage of the method is the possibility to check the design parameter for various scenarios of digester feeding with sludge (e.g. different ratios of primary to secondary sludge). It is also possible, to check during preliminary studies whether co-digestion of sewage sludge and other municipal and / or industrial wastes is feasible. Because the method has been successfully used in practical applications during both design and consulting phases (including a full-scale installation for 120 000 p.e.), the results of its implementation have been published both in journals of high rank [I.7;I.11.] as well as in other scientific publications (listed in a "Summary of professional accomplishments").

Following my work on technological features that reduce fermentation gas production I took part in the study, that tried to increase a methane production efficiency and this way "compensate" for a loss of VFA during hydrolysis using, e.g. sludge disintegration. While participating as contractor in the state grant No. 1 T09D02830 I supervised the research team, which in the years of 2010-2013 was financed by RWE AG, Germany Research and Development Programme: Schlammdesintegration Standardtechnik als für die für Abwasserklärung the Reduction und der Betriebskosten Erhöhung der Erzeugung der Energie erneuerbaren. In these studies, we have demonstrated that excess sludge disintegration, that has been willingly used at the treatment plants at the end of the last decade, should be designed with a great care, since full sludge disintegration (with ultrasounds) may require more energy than later can be recovered from the extra biogas volume. This work marked the beginning of my current field of interest, which focuses on issues how sludge processing can affect energy efficiency at wastewater treatment plants [I.8.;I.9.;I.14]. Like previous research, this one also tries to understand the actual interactions between different processes and technological operations.

Along with research on wastewater treatment and sludge processing, I have been involved in research and implementation activities concerning water treatment / purification. Research on the specifics of these deposits have been introduced much later than it did in the case of sewage sludge [Sozański, 1999; Leszczyńska and Sozański, 2009].In the middle of the previous decade I participated in a work team that dealt with a problem . Employing my expertise on sludge treatment, I studied various scenarios for final disposal of this particular type of waste. I pointed out that accession of Poland to the EU would result in stricter formal requirements regarding the drinking water quality, which would have impact on the characteristic of sludge from WTP. In particular, I worked on a problem of a periodic increase of organic fractions in the sludge dry mass in summer (due to crop production). The works have been published by our research group [I.2;I.12]. High efficiency removal of organic matter along with its "division" between oxidation and adsorption has been the subject of research commissioned by the Krakow MPWiK SA. The results have been summarized in the publication [I.4], where the author showed a methodology for the most efficient removal of the organic matter from water to minimize the negative effects for consumers. At the same time, I joined the team carrying out a research project COST 637: Metals and Related Substances in Drinking Water. The team worked on the interactions observed during water treatment. Together with the Malopolska water supply companies I worked on possible negative effects that water treatment processes may have on water quality (during technological operations intended to improve its quality). The results of the work were presented in the book [B.1.2.;B.1.13.]. Also together with the other members of the COST program team I complied a book published by the International Water Association [I.10], on removal of iron and manganese from drinking water.

4.2.3. The basic bibliography of world literature which the research was based,

not being prepared by the Author - bibliographical references to scientific achievements were made in accordance with the "List of published scientific or creative and most important professional work", annexed to this Self-presentation

Barnard J.,1994, Alternative Prefermentation Systems. Proc.Sem "Use of fermentation to enhance biological nutrient removal, Chicago;

Oleszkiewicz JA., Barnard JL., 1997, Fermetacja kwaśna osadu wstępnego dla intensyfikacji biologicznego usuwania fosforu i azotu. „Usuwanie związków biogennych ze ścieków" Konferencja Naukowo-Techniczna Kraków 06.1997 In Polish

Seviour R.J., Mino T., Onuki M.,2003,*The microbiology of biological phosphorus removal in activated sludge systems.* FEMS Microbiology Reviews,27,2003,99-127.

Mino, T., Van Loosdrecht, M.C.M., Heijnen, J.J.,*1998,* Microbiology and biochemistry of the enhanced biological phosphate removal process. *Water Research v 32 n 11 Nov. p 3193-3207*

Vermande S.M., Sötemann S., Aguilera Soriano G., Wentzel M, Audic J.M. , Ekama G., 2002,*Comparison of aerobic and anoxic phosphorus uptake in NDBEPR systems (UCT and ENBRAS),* Wat.Sci.Tech. 46,2002,201-207..

Canzani R., Pollice A., Ragazzi M.,,1995,Feasibility of using primary sludge mesophilic hydrolysis for biological removal of nitrogen and phosphorus from wastewater . Bioresources Technology,54, 1995,255-260.

Carlsson H., Aspegren H., Himler A.1996,,Interactions between wastewater quality and phosphorus release in the anaerobic reactor of the EBPR process. Wat.Res.,30,1996,1517-1527.

Ekama G.E., Wentzel M.C.,,1999,Difficulties and developments in biological nutrient removal technology and modelling. Wat.Sci.Tech.,39 nr 6, 1-11.

Jardin H., Pöpel H.J.,1996, Influence of the enhanced biological phosphorus removal on the waste activated sludge production. Wat.Sci.Tech.,34 nr 1-2,17-23.

Jönsson K., Johansson P., Christiensson M., Lee N., Lie E., Welander T.,1996,,Operational factors affecting enhanced biological phosphorus removal at the wastewater treatment plant in Helsingborg, Sweden. Wat.Sci.Tech.,34 nr 1-2, 67-74.

Jönsson K., Pottier A., Dimitrova I., Nyberg U. ,2008, Utlising laboratory experiments as a first step to introduce primary sludge hydrolysis in full-scale, Wat.Sci.Tech.,57,1397-1403.

Leszczyńska M,; Sozański M.M., 2009, Szkodliwość I toksyczność osadów i popłuczyn z procesu uzdatniania wody, Ochrona Środowiska I Zasobów Naturalnych nr 40, str.575585. In Polish.

Moser-Engeler R., Udert K.M., Wild D., Siegrist H.,1998, Products from primary sludge fermentation and their suitability for nutrient removal; Wat.Sci.Tech. Vol. 38 ,.265-273.

Mulkerrins D., Dobson A,D,W., Colleram E.,2004, Parameters affecting biological phosphate removal from wastewaters. Environmental International,30.,249-259.

Moser-Engeler R., Udert K.M., Wild D., Siegrist H.,1998, Products from primary sludge fermentation and their suitability for nutrient removal; Wat.Sci.Tech. Vol. 38 ,.265-273.

Sozański M.M., 1999; Technologia usuwania i unieszkodliwiania osadów z uzdatniania wody, Wydaw. Politechniki Poznańskiej, 1999.In nPolish

Vollertsen J., Petersen G., Borregaard V.R.,2006, Hydrolysis and fermentation of activated sludge to enhance biological phosphorus removal, Wat.Sci.Tech. Vol. 53 nr 12, .55-64.

Yang Q. et al.,2010, Enhanced efficiency of biological excess sludge hydrolysis under anaerobic digestion by additional enzymes, Bioresource Technology 101, pp. 2924-2930

4.2.4. Summary of results

As a result of my research, under this scientific achievement in the field of research on wastewater treatment and sludge got given below following important results in terms of interaction between the processes of water purification and wastewater treatment:

I. By conducting my own research project I examined the interaction processes of biological wastewater treatment and sludge, and I showed that the prolongation of operating hydrolysis solids retention time (SRT) from the primary sludge digestion (used for improving the effectiveness of biological removal of biogenic compounds) induces a significant decrease in a fermentation gas production during its final anaerobic stabilization; I presented the methodology for determining the actual reduction of biogas production based on respirometric tests;

II. I have shown that the prolongation of sludge acid fermentation above approx. 1-1.5 days causes lowering unit production 'biogas', which in turn significantly reduces the possibility of recovering heat and electricity in the final stage of sludge process;

III. I developed a precise method of determining a SRT for sludge digesters to maximize the potential production of 'biogas', the correctness of this method confirmed the full-scale technical support;

IV. Leading an international team over the use of sludge disintegration to increase the recovery of easily decomposable carbon sources in the processes of sludge, I pointed out that to achieve the technological effects while maintaining economic efficiency of this method in full scale there was no need a full break down of bacterial cells, these research findings also I confirmed in practice at full scale;

The use of these results in practice increases the efficiency of wastewater treatment processes and contributes to a more efficient treatment of sludge in the process of final processing (mainly for energy recovery).

Studies on the effect of water purification processes on each other I completed as a participant of larger teams, they did not have the character so clearly innovative as research into processes for wastewater and sludge, the most important of them are:

V. The demonstration of the degree of secondary metal contamination of drinking water during the water treatment processes;

VI. To develop and validate methods for applying the absorbance of the right to determine changes in the concentration of natural organic matter in the individual unit processes of water purification;

In his works dealt with the issues of "scattered" in various areas of technology, water and wastewater treatment, usually, however, I dealt with the inter-linkages between these phenomena. Concluding the various stages of research, I tried to implement the results of the full-scale scientific facilities.

The result in publication reference of the presented scientific achievement was the publication of 14 thematically related articles in peer-reviewed journals and conference materials of which:

- 5 articles were published in journals indexed on Web of Science from the list of the JCR (these were the articles alone or with my share of copyright is not lower than 50%)
- 2 of my own items have been published in publications contained in the Web of Science Core Collection (1 item + 1 chapter in a book in English);
- 2 articles have been published in supplements to the list of JCR publications;
- 1 publication was published in the journal Polish indexed on the so-called B list of the Ministry of Higher Education and Science;
- 1 publication is a chapter in a book published abroad;
- 1 publication is a chapter in a book published in the country;
- 2 articles have been published in the materials of international conferences.

Total number of my publications has been compiled in Table 1. The list summarizing the scientific work in the 'List of published scientific papers (...) ".

4.3. Description of research and published scientific papers presented before and complementary scientific achievement

4.3.1. The course of scientific work to the degree of doctor of technical sciences[6]

I became seriously interested in the problem of mutual influence of processes in the various subsystems of water and sewage infrastructure while being a student of the civil (water) engineering at the Environmental Engineering Department of Cracow University of Technology. First attempts I made being engaged in the work of the Scientific Society of hydrologists. Later on, as technical assistance (while still a student) I participated in research on the impact of the type of pollution in the raw (grasped) water on the choice of treatment technology. These investigation were a part of activities conducted at the Institute of Water Supply and Environmental Protection of my University. During this period, I found interesting the relationship between the processes taking place in treatment and delivery of water also during the collection and treatment of urban waste water. This interest led me to expand, within an individual program, the range of teaching modules to be completed by me on all items related to water supply and wastewater treatment. I published my first articles on the problems of dimensioning and operation of equipment [B.3.0.1, B.3.0.2., B.3.0.3] in the materials of conferences and national seminars (of course as co-author).

Master's degree in civil (water) engineering I received after defending thesis: "Analysis of the system of reservoirs with special emphasis to selected issues of quality". It was the first time I was interested in interconnectivity and technical solutions in water management. In this particular case it was a way of linking scenario of building system of dams in the catchment of mountainous river with changes in water quality grasped in terms of below the lowermost dam. I worked out an original computer program that allows for forecasting changes in the concentration of phosphorus compounds in water. A few years later, on this basis I wrote my first independent publication, which is already published as an employee of the Cracow University [B.3.0.6.]. Since then, my interest more and more crystallized around the issues of the impact of the presence of phosphorus compounds on processes occurring in the aquatic environment: sources of its origin, the impact of the deterioration of water quality grasped and processes to rectify these adverse effects. With time, I broadened my interests with other biogenic compounds present in the water, but interest phosphorus remains my primary area of research. When I received the degree of Master of Science (15th Feb, 1983) our University had not conducted doctoral studies and research job opportunities were very limited in entire Poland, so I decided to start working in the Enterprise of hydraulic engineering and energy pipelines "Energopol-2" – state owned company, for many years non-existent. I worked in various positions in construction supervision ranging from trainee engineer to act as facility manager. The specificity of the company allowed me to acquire professional skills both in the construction of civil (water) engineering as well as construction of intakes and water treatment plants and in the final period as the sewage treatment plant. After completing my internship and passing the required qualifications, according to the prevailing regulations, in 1986 I got powers to manage construction works without limitation in the specialty installation and engineering and also in specialty construction-engineering. During this period, my contact with the University was limited to act as a proxy of my that-time- employer, responsible for the implementation of apprenticeship to be completed by the students of Cracow University of Technology. In the meantime, I took a year of military service in the manner provided for graduates, serving at

[6] Numbers of order of the literature of Author's own are consent with the numbering style applied in the Appendix "List of published scientific achievements"

the graduation from the Military Academy (Res.) in units of army engineers. Being an active member of the Polish Association of Sanitary Engineers and Technicians (PZITS) I participated in professional conferences organized by the Association, publishing materials national seminars which follow two papers of my students' interests [B.3.0.4, B.3.0.5]. My efforts to be employed by the Cracow University of Technology resulted in the transfer of me, on a consensus of employers, to the position of assistant in apprentice at the Chair of Water and Wastewater Treatment which was the part of the Institute of Water Supply and Environmental Protection at the Faculty of Sanitary Engineering and Water Management[7] Cracow University of Technology with effect from 1.9.1986. Scientific work begun under the direction of the creator of the Department late Assoc.Prof. Jerzy Kurbiel (later Full Professor, died in year 2002) had already focused on the interaction of various processes in water purification and sewage treatment. As a member of the team I was doing research, the effect of which was to be applicable reuse of urban wastewater for industrial purposes. This was the area most convergent with my contemporary scientific interests. I conducted a study on the wastewater reclamation pilot located at the sewage treatment plant in Krakow-Plaszow, I was leading the work on the station - created under the direction of late Professor Jerzy Kurbiel - from participation in the assembly until the end of the program. My research included various strategies to remove phosphorus from municipal wastewater in order to get reclaimed water not susceptible to eutrophication during the use in cooling circuits and devices using water for technological purposes in the manufacture of metal equipment.

In Poland in this period there was even a single treatment plant working on the basis of a multiphase reactor for simultaneous removal of organic carbon and nutrients. It can be stated that the then our investigation was one of the first strong foundations for the introduction of (a decade later), this technology as the dominant method of removal of nutrients from wastewater in Poland. An internal research reports of my research activities. The measurable result of my research were following: so-called "Own Investigation"[8] (BW) and internal research reports "Statutory Activities"(DS) and articles in national papers and/or proceedings being published in various Polish scientific papers [B.0.1, B.3.0.7; B.3.0.8], in the next period, however, more and more time I devoted to issues of phosphorus removal and recovery solutions, technological water systems [B.2.0.1, B.2.0.2, B.3.0.9, B.3.0.10; B.3.0.11, B.3.0.12];

Then I published my first article in the journal indexed in the JCR [A.0.1] (eight times cited in Web of Science), in the same year I published my second article in the journal indexed in the JCR [A.0.2].with my future promoter of the PhD thesis, Professor J.Kurbiel. Then, around 1991, I crystallized my plans for the direction of my dissertation. According to my research interest it was intended to focus on an impact of chemical removal of phosphorus on operation of the multiphase biological reactors for integrated nutrient removal. I have launched a research (on the aforementioned pilot station), whose purpose was to verify whether and to what extent - pre-precipitation of phosphorus may adversely affect the operation of multiphase reactors. In that time an initial precipitation was common in Poland, and almost the only, technology being applied for phosphorus removal from wastewater). I developed the research method in 1992 during the stay of the scholarship at the Royal University of Technology (KTH) in Stockholm[9], where a team of Professor Bengt Hultman worked on tests on the innovative procedure for the determination of the different fractions of

[7] At present the Faculty is named a Faculty of Environmental Engineering

[8] Complete list of reports from this type of activities has been published in the Appendix"Additional information".

[9] In year 1991 I won Swedish Institute's competition for on-semester research fellowship at the Royal University of Technology

COD. This method in later years, I presented in Poland, and the result were used in other scientific centers [B.3.8, B.3.17]. In the dissertation I have shown adverse effects for precipitation of phosphorus which - especially at higher doses of precipitant agent could cause a shortage of easy biodegradable carbon in the multiphase reactor. My research confirmed the thesis that the most likely cause of this adverse phenomenon is very efficient removal of carbon in the form of particles in the pre-sedimentation (precipitation audited assisted) whereby the hydrolysis and the production of volatile fatty acids, necessary for a proper course of a sequence of processes dissolution / absorption of phosphates under anaerobic conditions and aerobic may not be sufficient for proper operation of the reactor It gave an argument for abandoning the initial precipitation of a large dose for purely biological phosphorus removal, possibly supplemented biological process simultaneous precipitation. In 1994 on the basis of my professional achievements, carried out in parallel with the work of scientific research, I got the power to design a specialization in installation and engineering. During this period I had a two-week internships in the United States: in 1990 at the Environmental Protection Agency (US EPA) and in 1995 at the Water Environment Federation.

Doctoral thesis (Supervisor Professor Jerzy Kurbiel) in the final entitled "Analysis of the interaction of chemical and biological phosphorus removal in the process of renewal of municipal sewage" I defended at 26th April 1996 at the Faculty of Environmental Engineering, Thaddeus Kościuszko Cracow University of Technology, receiving a doctorate in technical sciences. I was awarded by the Faculty Council and in 1997 I received her Award of the Minister of National Education for outstanding scientific achievements.

4.3.2. The course of scientific work after obtaining the degree of doctor of technical sciences

In the period after receiving the PhD (1996-2002), I published a series of articles presenting the results of research into different methods of phosphorus removal (eg. [B.3.1., B.3.2., B.3.4, B.3.6., B.3.7. , B.3.10.]). Due to the fact that in this period I shared interest between wastewater treatment and water purification, I published - mainly in the national conference materials - some results of my work implementation in the field of water purification (eg. [B.3.5., B3.9.]). In my case, simultaneous interest in the process of water purification and wastewater treatment was justified by the fact that dealing with the restoration of water had significantly expand the knowledge of the processes of coagulation, filtration and disinfection. One should remember that during this time in Poland, membrane processes in wastewater reclamation remained in the area of theoretical studies and pre-production experiments. After defending my dissertation, I published two more articles indexed in the JCR, which were : [A.1.1, A.1.2.] Both of these papers were later cited in journals indexed by Web of Science. During my post-doctoral scholarship at the Royal Technical University of Stockholm, which took place in 1996, I started working on a monograph summarizing the state of art and prospects for advanced phosphorus removal from wastewater. This monograph entitled "Advanced Wastewater Treatment - Phosphorus removal from wastewater - A Literature Review," was published in 1997 at the Royal Technical University in Stockholm as the first of series of monographs "Joint Polish Swedish Reports' (this series is issued today). A book about the volume of 106 pages is a study of that time state of knowledge, however, is still quoted and is my most precious legacy from the point of view of bibliometrics (15 citations at the Web of Science, 45 citations at Harzing's Publish or Perish, also approximately 40 non-indexed citations in other scientific papers, diplomas , published doctoral work, etc.). In 1998, the Faculty Council entrusted me with

deputy dean position of the Faculty of Environmental Engineering Cracow University of Technology, they made me responsible for the implementation of the two-stage system of study at the Faculty (I was elected in the second year of the term, which is why I served as only two years). Behind this activity in 2001 I received a team award of the Minister of Education. At the end of the twentieth century I began to realize the first study on the mutual influence of the biological process of excess phosphorus removal and sludge treatment. At that time I first took up the issue of gas production during sludge fermentation so. "Biogas"). The result reports (unpublished) for research and implementation as well as articles presented initially at national conferences (eg. [B.3.13., B.3.14.] then at seminars international and Polish scientific journals and industry. This was the prelude to the study, which resulted in articles as a basis to apply for a doctoral degree described in Part I of this self-presentation.

My interest has focused on several areas:

i. In the field of wastewater treatment sludge it was an interaction between processes in particular an impact primary sludge pretreatment on phosphorus removal and simultaneous effect of the intensification of the processes related to biological phosphorus removal on a fermentation gas production; secondary areas of interest are to maximize the yield of easy biodegradable COD eg. towards disintegration. Publications on these issues constitute a major part of my scientific achievement, presented in section 4.2. of this self-presentation. Simultaneously with the formation of major publications listed in Annex "A list of published scientific works" in Part I, I wrote and published a number of publications presenting the results of my research in papers of lower academic prestige, but these publications approximate the subject of research to a wider audience including future users of these processes. These articles were related to following subjects:
    a. Problems of phosphorus removal (eg. [B.1.2., B.1.7., B.2.1., B.3.1 .; B.3.4 .; B.3.6 .; B.3.7., B.3.8., B .3.10., B.3.12.]);
    b. The sludge processing in connection with the removal of phosphorus from wastewater (eg. [A.1.3., A.1.5., B.1.10., B.1.11., B.1.19., B.2.10., B.3.2 .; B.3.1.15 .; .; B.3.24 B.3.30., B.3.40., B.3.43., B.3.44]);
    c. Issues of energy recovery processes sludge processing (eg. [B.1.3., B.1.4., B.1.5., B.1.6., B.1.9., B.1.13., B.1.15, B.1.18 .; B.3.1.14., B.3.46.]);
    d. The yield intensification of fermentation gas. Such as disintegration (eg. [A.1.6., B.1.8., B.1.16., B.2.10., B.3.21 .; .; B.3.33 B.3.33. ; B.3.34., B.3.35., B.3.41., B.3.48]);
ii. In the area of water purification, acting under the inspiration of the different water companies I carried out work on the area between research and applications in the impact of highly effective removal of organic carbon on disinfection and water; secondary area of interest - interests resulting from sewage sludge has become a research on the formation and opportunities sludge from water production. As a result of work carried out jointly with City of Krakow waterworks, I produced several publications presenting this theme (eg. [B.1.12., B.2.2., B.2.3., B.2.4., B.2.5., B.2.6., B .2.7.B.3.25., B.3.48]);
iii. Continuation of the interest in the mutual interactions of unit processes used in water treatment is the use of the knowledge about the mechanisms of coagulation wastewater aluminum salts and iron I have learned in the course of the doctoral thesis, this knowledge has proven to be very useful in the study and implementation

of the removal of natural organic matter (NOM) from the water surface and entry of metals from water treatment processes to potable water. A measurable effect publication reference (except the items discussed in chapter 4.2. of this self-presentation) were articles ([A.1.7., B.1.14., B.1.17., B.2.12., B.3.5., B.3.9., B. 3.20., B.3.22 .;

More than twenty years of research and implementation work, presented above, became the basis of the work focused on the interaction of technological processes in a highly efficient water purification and treatment, which are the most important part of my accomplishments, outlined in sections 3.1. and 3.2. Self-presentation

Additional research activity, outside the mainstream of my interests. Attempts to apply vector calculus to work out the right decision in choosing appropriate solutions to water treatment plants (eg. [B.2.8., B.2.9 .; B.3.29., B.3.32 .; B.3.35.

I conducted this work on my own initiative (ie., Despite the lack of research programs) and I intend to continue in the future, because I believe that they represent an opportunity to create more than hitherto effective risk management tools in water supply. These works are in their infancy, they cannot therefore be even included in my scientific achievement within the meaning of the Act.