Dorota Jolanta Papciak PhD, Eng.

Summary

of scientific, research, organisational and didactic work achievements

1. First name and surname:

DOROTA JOLANTA PAPCIAK

2. Titles and degrees held

1990 - a degree of MSc Eng. in Chemistry with the specialization of chemical technology awarded by the The Faculty of Chemistry of the Rzeszow University of Technology
Subject of the MSc thesis:
„Reactions of hydroxymethyl derivates of melamine with oxiranes"
MSc thesis advisor: Prof Jacek Lubczak DSc, PhD, Eng.

1998 – a degree of PhD in agricultural sciences in the scope of fisheries awarded by the resolution of the Faculty of Environmental Science and Fisheries of the Agricultural and Technical Academy in Olsztyn
(the University of Warmia and Mazury at present)
Subject of the doctoral thesis:
"Use of clinoptilolites to remove ammonium nitrogen from water solutions"
doctoral thesis advisor: Prof. Marian Granops DSc, PhD, Eng.
reviewers: Prof Konstanty Lossow DSc, PhD
Bogdan Sieliwanowicz, DSc, PhD, Associate Prof

3. Information on previous employment

1990-1991 – an assistant trainee in the Department of Water and Sewage Technology, the Faculty of Civil and Environmental Engineering of the Rzeszow University of Technology

1991-1995 – an assistant in the Department of Water and Sewage Technology, the Faculty of Civil and Environmental Engineering of the Rzeszow University of Technology

1995-1999 - an assistant in the Department of Water Purification and Protection, the Faculty of Civil and Environmental Engineering of the Rzeszow University of Technology

1999-till today - an assistant professor in the Department of Water Purification and Protection, the Faculty of Civil and Environmental Engineering of the Rzeszow University of Technology

4. **The indication of the achievement resulting** from art. 16 item 2 of the act dated on the 14th of March 2003 on degrees and academic titles and on degrees and titles in the scope of art (the Official Journal no. 65, item 595 with subsequent amendments):

a) a title of the scientific achievement:

"The influence of abiotic factors on the formation time of a nitrification biofilm and effectiveness of the biofiltration process of underground waters"

b) positions in the series

No.	Author/Title/Magazine
1.	**Papciak D**.(2007) Effect Of Nitrification-Filter Packing Material On The Time To Reach Its Operation Capacity. *Environmental Engineering*. Taylor & Francis Group, London, UK, pp.125-132. The score of MNiSW [the Ministry of Science and Higher Education] 5, IF=0
2	Zamorska J., **Papciak D**.(2008) Activity of nitrifying biofilm in the process of water treatment on diatomite bed. *Environment Protection Engineering*. Vol. 34, No.1, pp.37-52 . The score of MNiSW = 6, IF=0
3	**Papciak D**., Zamorska J., 2003, Bio-filter filling and effectiveness of the nitrification process. *Research Bulletin of the Rzeszow University of Technology*, Vol.35, pp.147-160, Publishing House of the Rzeszow University of Technology. The score of MNiSW = 4, IF=0
4	**Papciak D**., Zamorska J.(2008) Single and double layer nitrification beds as the biotechnological method of ammonium nitrogen removal from water. *Biotechnology* 1(80), pp.189-201, Publishing House of the Polish Academy of Sciences. The score of MNiSW = 5, IF=0
5	**Papciak D**, Zamorska J., Piech A., (2008)The influence of iron(III) ions on effectiveness of ammonium nitrogen removal in the nitrification process in the chalcedonite beds. *Water Supply and Water Quality*. Vol.1, pp.579-590. PZiTS, Published by PZITS Poznań-Gniezno. The score of MNiSW = 0, IF=0
6	**Papciak D**., Zamorska J., Kaleta J., Puszkarewicz A. (2009) Effect of Manganese(II) on the Time of Biofilm Formation and on the Effectiveness of Ammonium Nitrogen Removal from Water in Biofiltration Process. *Polish Journal of Environmental Studies*. Vol.2, pp. 43-50. The score of MNiSW = 15, IF=0,947
7	**Papciak D**. (2009) Oxygen paradox in the process of ammonium nitrogen removal from water with the biofiltration method. *Gas, Water and Sanitary Engineering*. Vol. LXXXIII, No. 11, pp. 21-25. The score of = 6, IF=0
8	**Papciak D**., Kaleta J., Puszkarewicz A.(2012) The comparison of removal effectiveness of manganese(II) and ammonium nitrogen in the biofiltration process on the chemically active beds. *Water Supply, Water Quality*. The series: Engineering for Environmental Protection. Vol. II pp.449-458, Published by PZITS Poznan. The score of MNiSW = 4, IF=0
9	**Papciak D.,** Kaleta J., Puszkarewicz A.(2013) Ammonium nitrogen removal from underground waters in the two-stage biofiltration process on the chalcedonite beds. *Annual Set The Environment Protection*; ISSN 1506-218X, vol.15. pp.1352-1366. The score of MNiSW = 15, IF=0,068
10	**Papciak D**.(2013) Biofiltration of ground waters in chalcedony beds. *Instal.* 10 (344) pp. 49-54. The score of MNiSW = 5, IF=0

My essential participation in the co-author's publications usually included defining a problem, establishing assumptions and methodology of doing physicochemical analyses and drawing conclusions. My percentage share in the co-written publications is presented in Table 1.

The scope characterising the co-authors' share has been attached to the application as Appendix 7.

Tab.1. List of publications together with the number of points (according to the regulation of the Ministry of Science and Higher Education concerning scientific magazines dated on the 13th of July 2012) and the participation of the habilitated doctor.

Item	Number of points in the publication year	Percentage of participation in the publication	Number of points after taking the habilitated doctor's participation into account	Impact factor in the publication year
Ad b) 1.	7	100	7	0
Ad b) 2.	6	80	4,8	0
Ad b) 3.	4	80	3,2	0
Ad b) 4.	5	80	4	0
Ad b) 5.	0	70	2,8	0
Ad b) 6.	10	70	7,3	0,947
Ad b) 7.	6	100	6	0
Ad b) 8.	4	80	3,2	0
Ad b) 9.	15	80	12	0,068
Ad b) 10.	5	100	5	0
Total	**62**	-	**55,3**	**1,015**

c) The discussion on the scientific aim of the above mentioned papers and the results obtained together with the discussion on their possible use

Objectives of research

The scientific objective of the presented one-point series of 10 publication entitled The influence of abiotic factors on the formation time of a nitrification biofilm and effectiveness of the biofiltration process of underground waters is:

1) evaluating the influence of properties of biofilter filling on: the formation time of a nitrification biofilm, effectiveness of the ammonium nitrogen removal and water quality after the biofiltration process,
2) defining the influence of iron and manganese on the formation time of a biofilm and effectiveness of the ammonium nitrogen removal from underground waters with the biofiltration method,
3) defining the actual usage of oxygen in the biofiltration process,
4) evaluating a possibility to use chemically active beds removing manganese for the process of the ammonium nitrogen removal from underground waters with the biofiltration method

I did the significant majority of research and measurements myself in the laboratory and I evaluate my share in the experimental part as 80%. The character of my research is both elementary and cognitive as well as the application one.

Assumptions and the topic of research

According to the recommendations of the Water Framework Directive of the European Union and the act on Water Law binding in Poland, underground waters should be the main source of drinking water supply for the population. Nowadays they make up about 66% of the total amount of water in Poland which is used in water pipes. With reference to the Regulation of the Minister of Health of the 29th of March 2007 together with the amendments in 2010 concerning water quality for the human consumption (the Official Journal No. 61, item 417), they are usually of a much better quality than surface waters and only some physicochemical indicators are exceeded which is characteristic of them. They are, among others, the compounds of iron, manganese, ammonium nitrogen and nitric nitrogen (V). It is estimated that about 70% of underground waters intake stations in Poland take waters requiring adequate treatment. A lot of water treatment plants face a necessity of intensification of the water purification process and modernization of exploited appliances, and numerous self-governments confront taking the decision with regard to exploiting underground water for drinking and household purposes.

Technology of underground water purification is not so complicated as that of surface waters, however, it may cause problems when apart from iron (which is usually easy to be removed in the traditional system of aeration and filtration) there are also other additions such as manganese(II) and ammonium nitrogen. The increasing contamination of underground waters with nitrogen compounds and especially with ammonium nitrogen enforces a necessity to search for unconventional, highly effective methods of their purification. Waters containing ammonium nitrogen from 1-3 g $N\text{-}NH^{+}_{4}/m^3$ are taken for household purposes more and more frequently. With regard to the expenses connected with the use of physicochemical methods and doubts connected with the use of biological methods, taking underground water was often abandoned where the presence of ammonium nitrogen was found. The long-time of nitrogen biofilm formation and time-consuming bacteriological analyses requiring specialist service additionally discouraged from the use of the biological processes.

Ammonium nitrogen belongs to the most burdensome compounds existing in water. Its presence makes the process of water chlorination difficult, it makes problems with the manganese removal, it accelerates corrosion of water conduits and influences the biological stability of water. Moreover, the increased amount of ammonium nitrogen in treated water uses oxygen in waterworks which may lead to development of harmful anaerobic bacteria and secondary water contamination. The removal of ammonium compounds from water destined for drinking is a serious problem in water technology. With regard to the cost, the biological methods are suggested more and more often. The biological nitrification realized with the biofiltration method can be used where there is a need for the removal of ammonium ion without the necessity of the complete removal of nitrogen compounds. The limitation of its use is a suitable content of oxygen necessary to go through the complete process of nitrification. With the theoretical need for oxygen amounting to 4.57 g O_2/m^3, in order to transform 1 g $N\text{-}NH_4^+/m^3$ into the form of $N\text{-}NO_3^-$, in the one-step filtration with the water surface over the filtration layer, it is possible to oxidize not more than about 2 g $N\text{-}NH_4^+/m^3$, in the conditions of the complete saturation of water with oxygen (10-16°C). This limitation refers to the biofiltration processes performed in the filters with the filling not participating or participating to a small degree in the removal process of ammonium ions. The use of the biosorptive beds in the removal processes of ammonium nitrogen from water, and especially the use of their oxidizing-reducing, ion-exchange, sorptive and buffering properties can solve two problems:

1) the significant reduction of the biofilm formation time by the creation of permanent connections between a carrier and microorganisms,
2) the creation of a possibility to remove bigger amounts of ammonium nitrogen than it results from the content of oxygen in water being treated.

The biofilm formation time can be accelerated by the use of the properties of the biofilter filling which will enable to remove impurities without the delay resulting from depositing bacteria or an addition into treated water of a biopreparation which include nutrients with nitrogen bacteria of the 1st and 2nd phase. However, the necessity to keep an appropriate concentration of biomass in the bed is a problem. The research presents that the activity of bacteria can be kept as a result of the use of the immobilization techniques. The most often used and at the same time the simplest immobilization technique of cells is a limitation of their movement as a result of absorption or formation of covalent bindings between ion-active groups of cellular polymers and reactive groups of a carrier. It seems that the appropriate choice of the biofilter filling may be significant for the course and effectiveness of the nitrification process. The cultivation of microorganisms takes place both in intergranular spaces and in macropores, the sizes of which enable penetration of cells of microorganisms inside creating the so-called places protected against the unfavourable activity of shearing forces connected with the flow of water. The material which is used to fill the biofilter can perform a function of not only a ground for development of a biological membrane but also a function of an adsorbent, an ion exchanger, a nutrient and buffering substance of the environment of the biochemical reaction. The price should also be a factor taken into consideration together with effectiveness while choosing a biofilter filling. Therefore, fillings which are cheap, effective and stimulating the cultivation of nitrification microorganisms are sought.

The influence of the type of a filling on the nitrification biofilm formation time

In order to define the influence of the type of a filling on the biofilm formation time, the following were used in the research: the biofilters filled with natural materials such as diatomite, clinoptilolite, natural pumice of a commercial name Hydro-Filt and chalcedonite and the most often used so far such as quartz sand and active carbon. I did the research in the laboratory scale, on the model solutions made with water from waterworks, enriched with ammonium nitrogen (2-3 mg N/dm^3) and a biopreparation including nitrification bacteria. I evaluated the work of the beds on the basis of the physicochemical indicators, i.e. ammonium nitrogen, nitrate nitrogen (III), nitrate nitrogen (V), a pH value, a colour, turbidity, dissolved oxygen. I analysed the influence of the specific surface area, sorptive, ion-exchange, buffering properties and those stimulating the development of the biological membrane used in the fillings[1,2,3] for the biofilm formation period.

[1] **Papciak D**.(2007) Effect Of Nitrification-Filter Packing Material On The Time To Reach Its Operation Capacity. Environmental Engineering. Taylor & Francis Group, London, UK , pp.125-132.

I found out that properties of a material which is a filling of a biofilter decide on the nitrification biofilm formation time and effectiveness of the nitrification process.

I observed the presence of the biological membrane on the clinoptilolite bed the earliest, although effectiveness of the ammonium ions removal after the exhaustion of ion-exchange properties was the smallest with the used filtration materials. The effectiveness was the highest in the nitrification process on the diatomite filling, but the best water quality, considering all the indicators taken into consideration while evaluating the use for consumption, was received on the bed with active carbon. Taking the cost of purification and the biofilm formation time into account, I did more detailed research on diatomite. I evaluated its work on the basis of the technological effect and the quantitative evaluation of microorganisms settling the bed together with the evaluation of their activity[4].

I used the flow opposite to the gravitational one in the study, which occurred to be more beneficial for the nitrification process because:

- it created better conditions for the complete course of the nitrification process by using less oxygen than in the filters with the gravitational flow,
- it regulated the biological membrane thickness and kept the permanent microbiological activity of the biofilm and arranged the biofilm surface evenly in the whole section of the biofilter.

I estimated the biological activity of the bed in connection with effectiveness of the ammonium nitrogen removal in the nitrification process and the biofilm formation. I proved that diatomite has good properties stimulating the development of biomass and the ammonium nitrogen removal was very effective amounting to the value of 100%. The picture from the scanning microscope confirmed the colonization of microorganisms on the grain surface. The biofilm had a loose and porous structure characteristic of the aerobic biofilm and covered the whole grain surface. At the same time the number of psychrophilic and mesophilic bacteria was small after the biofiltration process. The designation of nitrification bacteria in the biofilm was very low, which proved the high number of these bacteria.

I also analysed the changes in colour and turbidity of water after the biofiltration process. The increase in turbidity of water can be caused by rinsing microorganisms from the bed. The literature on the subject informs that the increase in turbidity up to 2 NTU was observed in the aerobic film and up to 22 NTU for the anaerobic one. The maximum value of turbidity did not exceed 2 NTU in the research. It indicates that the biofilm structure is characterised by permanent bonds between grain material and a biofilm as well as by mutual interactions among organisms. The microscopic observations confirmed the spongy, uneven biofilm structure, closely covering the grains of the filling. The numerous canals and chambers in the biofilm structure enabled deep penetration of oxygen and nutrients which resulted in the high effect of the ammonium nitrogen removal.

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[2] **Papciak D**., Zamorska J.(2008) Single and double layer nitrification beds as the biotechnological method of ammonium nitrogen removal from water. *Biotechnology* 1(80), p.189-201, Publishing House of the Biotechnology Committee of the Polish Academy of Sciences and the Institute of Bioorganic Chemistry.

[3] **Papciak D**., Zamorska J., 2003, Bio-filter filling and effectiveness of the nitrification process. *Research Bulletin of the Rzeszow University of Technology,* vol. 35, p.147-160, Publishing House of the Rzeszow University of Technology.

[4] Zamorska J., **Papciak D**.(2008) Activity of nitrifying biofilm in the process of water treatment on diatomite bed. *Environment Protection Engineering*. Vol. 34,No1, p.37-52.

I proved in the study that:

1) diatomite has good properties stimulating the development of biomass and the nitrification process takes places with high effectiveness, reaching effectiveness of the ammonium nitrogen removal amounting to 100%,
2) the chemical composition of diatomite stimulates the growth of microorganisms and has a decisive influence on the biofilm formation,
3) diatomite plays a role of nutrients for microorganisms which accelerates their colonization significantly,
4) the activity of dehydrogenase can be an indicator of the presence of heterotrophic microorganisms in the biological membrane. Most probably, most of these heterotrophs are able to conduct the nitrification process,
5) the small numbers of psychrophilic and mesophilic bacteria in water after the treatment process can be an indicator of stabile work of the biosorptive bed.

A lot of tasks which biofiltration is to do were solved (in the way which is not fully satisfactory) by the use of one type of a filling – a single-layer biofiltration. In order to increase effectiveness of appliances, improve water quality, and at the same time gain investment and material savings, I considered a possibility to use multi-layered biofiltration. With the application of this type of filters apart from the effective removal of nitrogen compounds, I expected improvement of physical indicators of water quality such as colour and turbidity.

I did the research on diatomite-sand beds and diatomite-carbon ones[5]. I analysed the influence of the character of the grain outer structure on the formation time of the biological membrane and the duration of bonds between microorganisms and a carrier on the basis of the changes in physicochemical parameters of treated water and the scans of biofilm structures. I found out that on the double-layer diatomite-carbon bed and the single-layer diatomite one the nitrification was most effective, the biological membrane was the most stabile which resulted in the lowest turbidity of the treated water. I also found out that the second phase of the nitrification process started faster on the double-layer filters. Next, the connection of diatomite properties with good sorptive properties of active carbon allowed to limit secondary contamination of water and maintain a big concentration of biomass in the biofilter. Additionally, active carbon prevented from rinsing microorganisms from the filter. The use of active carbon as the filling of the one-layer biofilter significantly lengthened the maturation time of the nitrification bed in comparison with the double-layered beds. However, the diatomite-sand bed with the gravitational flow additionally allowed to eliminate the colour and the turbidity in the treated water maintaining the high effectiveness of the nitrification process simultaneously. Yet, the fact of collecting organic matter in the filter and the increasing intake of oxygen should be taken into consideration which is connected with the necessity to rinse filters.

In connection with the fact that iron and manganese compounds very often contaminate underground waters next to ammonium nitrogen, the next stage of the research was to evaluate the influence of the presence of iron and manganese on the formation time of the biological membrane and the effectiveness of the nitrification process. In literature there is no information on this topic apart from

[5] **Papciak D.**, Zamorska J.(2008) Single and double layer nitrification beds as the biotechnological method of ammonium nitrogen removal from water. *Biotechnology* 1(80), p.189-201, Publishing House of the Biotechnology Committee of the Polish Academy of Sciences and the Institute of Bioorganic Chemistry

the fact that the removal of ammonium nitrogen from underground waters takes place while removing iron and manganese.

The influence of iron on the nitrification biofilm formation time

I evaluated the effectiveness of the removal of ammonium nitrogen in the presence of iron ions with the use of chalcedonite[6] - the filling which characterizes of the iron removal, which is well documented and described. Chalcednite has a mesoporous structure with the relatively high homogeneity of pores, the total volume of which amounts to 0.03-0.04 cm^3/g. The merit of chalcedons is a shorter time of introducing beds in the process of the iron and manganese removal in comparison with traditional quartz beds.

I did the research with the biofiltration method, with the flow opposite to the gravitational one, at the speed of 1.5, 3.5 and 6 m/h. I used two models of biofilters the filling of which was chalcedonite thermally modified. The model solution containing 2 mg $N\text{-}NH_4^+/dm^3$ and 1 mg Fe(III)/dm^3 was directed at one of them, and the other one – the model solution containing only ammonium nitrogen of the same concentration. In order to accelerate the maturation time of the beds, the model solutions were additionally enriched with the biopreparation containing nitrification bacteria of the 1st and 2nd phase. On the basis of the physicochemical and bacteriological research I evaluated the influence of iron on the biofilm formation time and the intake of oxygen in the biofiltration process.

I found out that the biofilm formation time (the bed maturation) depends on the chemical composition of water directed to the biofilters. The presence of iron(III) in treated water in the nitrification process influences the increase in the effectiveness of the ammonium nitrogen removal and the reduction of the biofilm formation time. Chalcedonite removed iron in almost 100%, and the concentration of ammonium nitrogen reached the level below the standard value during the experiment. The presence of iron also influenced the starting time of the 2nd phase of the nitrification process positively, but the intake of oxygen was higher than on the bed where treated water contained only ammonium nitrogen. The microscopic studies of the biological membrane and the results of the bacteriological research confirmed the higher activity of the biofilm on the bed to which water with the addition of iron was directed. It was discovered that not only the filtration speed but also the area of the active biofilm decides on the final effect of the treatment process.

Both the increase in the filtration speed up to 6 m/h and the decrease in the filtration speed twice to the value of 1.5 m/h did not cause significant changes in the chemical parameters of water being purified. The big influence on the final effect of the nitrification process has the area of the active biofilm, which is influenced to a significant degree by the features of the base and the structure of pores. The applied parameters of the biofilters occurred to be insufficient to reach the complete nitrification process. The 2nd phase of nitrification leading to oxidizing nitrates(III) to nitrates(V) happened to the unsatisfactory degree as the required concentration of nitrates(III) was not reached. The actual intake of oxygen was about twice lower than the theoretical one which may indicate the removal of ammonium nitrogen in a different way than nitrification. Comparing the microscopic picture of the raw (dry) chalcedonite grains with the grains taken from

[6] **Papciak D**, Zamorska J., Piech A., (2008) The influence of iron ions (III) on effectiveness of ammonium nitrogen removal in the nitrification process in the chalcedonite beds. *Water Supply and Water Quality*. Vol.1. pp. 579-590. PZiTS O/Wielkopolski, Published by PZITS Poznań-Gniezno.

the filtration beds, I noticed the very well- developed slimy biological membrane surrounding the bed grains, which was made by the cell activity of microorganisms. It was also noticed that the cell membrane taken from the F_{NH4-Fe} bed showed the bigger differentiation of the surface (folding) than the membrane from the F_{NH4} bed. Moreover, I found out that the membrane is thicker on the material taken from the lower layers of the bed, which may prove a higher number of heterotrophic bacteria, additionally confirmed by the higher values of the enzymatic activity of the biological membrane. Analyzing the results of the research, I noticed that not only do the filtration speed and the retention time connected with it decide on the final effect of nitrification, but also the area of the active biofilm is of great importance. Most likely, in order to obtain the standard values of nitrate nitrogen(III), the amount of the bed should be increased with the use of the second degree of filtration or with the use of the filter with the bigger diameter. The activity of the respiratory enzymes of the organisms of the biological membrane on the grains of the filters up to the 10^{th} day of work of both beds was similar. During the next days the activity of dehydrogenases was always higher on the bed to which water with the content of iron was directed.

The influence of manganese on the nitrification biofilm formation time

Literature provides information that ammonium nitrogen may disturb the process of the manganese removal. However, the question is posed if the presence of manganese influences the maturation time of the bed and the course of the nitrification process. In the research I proved that the presence of manganese in water in the biofiltration process influenced the course of the nitrification process and the effectiveness of the removal of ammonium nitrogen[7]. The increase in the effectiveness of the ammonium nitrogen removal in the biofiltration process happened when the effectiveness of the manganese removal decreased. At the same time, the increase in the concentration of the nitrate(III) ions was observed, which indicated the beginning of the nitrification process. The literary sources quote that nitrates(III) which came into being in the first stage of the nitrification process cause the reduction of manganese dioxide, but they themselves are chemically oxidized to nitrates(V). The layer of the manganese oxides which are included in the material which fills the biofilter has the sorptive and autocatalytic properties in comparison with the manganese(II) ions. The reduction of the oxidized forms of manganese MnO_2 created in the filtration process could bring about the appearance of manganese in the runoff. Since the variety of chalcedonite used for the research did not have the developed layers of manganese oxides, and the formation of the active catalytic layer is obtained during the water filtration including manganese (lasting even several months), the negative influence of the nitrification process on the decrease of the effectiveness of the manganese removal should be excluded. It was discovered on the basis of the analysis of the results that the process of the manganese removal can take place in the process of sorption (the ion exchange or chemisorption), there is a little likelihood of the autocatalytic oxidation of manganese. The small changes in the concentration of nitrates(V) and the lack of the increased content of manganese in water after biofiltration do not indicate the delay of the nitrification process due to the reaction of nitrates(III) with manganese dioxide, and the decrease in the effectiveness of the removal of

[7] **Papciak D**., Zamorska J., Kaleta J., Puszkarewicz A.(2009) Effect of Manganese(II) on the Time of Biofilm Formation and on the Effectiveness of Ammonium Nitrogen Removal from Water In Biofiltration Process. *Polish Journal of Environmental Studies.* Vol.2, pp. 43-50.

Mn(II) ions should be explained by the exhaustion of the sorptive abilities of the mineral.

I evaluated the development of the biological activity in the biosorptive beds as well as the observations concerning the mutual relations between the processes of sorption and biodegradation on the basis of the decrease in oxygen dissolved in water on the ground of Eberhardt, Madsen and Sontheimer's test (EMS). The EMS test is based on the designation of the value of **S** indicator defined by the proportion of the changes in the chemical demand for aerobic ΔChZT to the exhaustion of dissolved oxygen ΔO_2:

$$\mathbf{S} = \Delta ChZT / \Delta O_2$$

If:

- **S** = 1 – sorption and biodegradation take place with the same intensity,
- **S** < 1 – biodegradation dominates over sorption,
- **S** > 1 – sorption dominates over biodegradation,
- **S** = 0 – sorption and biodegradation do not happen,
- **S** – unmarked: ΔChZT > 0 and $\Delta O_2 = 0$ – only sorption takes place,
  ΔChZT = 0 and $\Delta O_2 = 0$ – no sorption and biodegradation.

I noticed the cases on the chalcedonite bed to which water with manganese was directed in which sorption dominated (**S** > 1) or happened with the same intensity (**S** = 1) as the biodegradation process. However, the biodegradation process dominated over the physicochemical processes in the bed to which water containing only NH_4 was directed during the whole experiment. I observed the decrease in the value of the indicator **S** together with the decrease in the effectiveness of the manganese removal and the decrease in the effectiveness of the ammonium nitrogen removal (after 30 days), which proved the increasing share of the biological processes.

Comparing the microscopic pictures of the chalcedonite grains before the biofiltration process with the grains taken from filtration beds, the well-developed slimy biological membrane surrounding the bed grains was observed which was the result of the cell activity of the microorganisms. I also noticed that the biological membrane taken from the F_{NH4} bed indicates a bigger differentiation of the surface (folding) than the membrane from the $F_{NH4\text{-}Mn}$ bed, it is thicker and covers all the grains. This picture is proved by the higher values of the enzymatic activity of dehydrogenases of the microorganisms settling the F_{NH4} grains, which proves the bigger number of heterotrophic bacteria. Additionally, I found the presence of black blooms of manganese oxides. Summing up: manganese did not influence the activity of the nitrification bacteria positively, it lengthened the biofilm formation time and delayed the beginning of the second phase of the nitrification process. The bigger effectiveness of the ammonium nitrogen removal could be observed in the bed to which water contaminated only with ammonium nitrogen was directed.

The removal of ammonium nitrogen on the chemically active beds

Technology based on the double filtration is the most often used technology of water purification with the excessive content of iron and manganese. Having removed iron in the first stage of filtration, it is sometimes necessary to use the filtration beds which have an ability to oxidize manganese catalytically such as Braunsztyn, Metallex, Piroluzyt, Defeman, Greensand (MZ-10), Birm, MTM.

The process of the manganese removal is inhibited if there is a significant disproportion between the concentration of Mn(II) and NH_4^+ ions.

With regard to the insufficient effectiveness of the manganese removal on the chalcedonite bed, I also studied the biofiltration process on the catalytic beds mainly intended for the manganese removal from water[8]. I did the research in the laboratory with the use of the biofilters filled with:

1) thermally modified chalcedonite, the initially activated 0.3% solution of potassium manganate(VII),
2) a Braunsztyn bed with the commercial name of Pyrolox,
3) manganese ore MZ-10, also known as green sand initially activated 0.3% solution of potassium manganate(VII).

The obtained results of the research indicated the bigger effectiveness and stability of the process of the manganese removal on the MZ-10 bed. As early as the 5th day of the experiment, the bed effectively decreased the content of manganese to the standard value (0.05 mg Mn/dm^3) and maintained this effectiveness to the end of the experiment. In case of the Pyrolox bed the removal of manganese was sufficient only up to the 17th day. From the 18th to the 53rd day the content of manganese fluctuated in the range from 0.07 – 0.24 mg Mn/dm^3 and then again the concentration fluctuating around the standard value of 0.05 mg Mn/dm^3 was noticed.

Comparing the changes in the manganese concentrations with the changes in the content of ammonium nitrogen in water after the biofiltration process, I found out that the effectiveness of the ammonium nitrogen removal was very high on the first days of work of the beds, which was caused by the catalytic and sorptive properties of the studied beds. As these abilities were being exhausted in water after biofiltration, there was an increase in the ammonium nitrogen concentration and then after the nitrification biofilm formation the decrease in the ammonium nitrogen concentration in purified water was observed.

I found out that the increase in the effectiveness of the ammonium nitrogen removal in the biofiltration process happened when the effectiveness of the manganese removal decreased. The standard values of 0.39 mg $N\text{-}NH_4/dm^3$ were obtained the fastest in case of chalcedonite (the 22nd day), and then Pyrolox (the 53rd day). In case of the MZ-10 bed the concentration of nitrogen in water after treatment was the lowest after 55 days of work of the bed, but exceeded the standard values for water intended for consumption and fluctuated in the range of 0.5-0.7 mg N/dm^3. The bigger amount of nitrates (III), the lower effectiveness of the manganese removal, which can indicate that the nitrification process can disturb the effectiveness of the manganese removal in the period of the nitrification biofilm formation.

The properties of the biofilter fillings and the way of their preparation influenced the water quality after the biofiltration process:

- water treated on the Pyrolox bed characterised with the excessive content of manganese and nitrates (III);
- water treated on the MZ-10 bed characterised with the excessive content of ammonium nitrogen and nitrates (III);
- water treated on the chalcedonite bed did not meet the requirements with regard to the manganese content.

[8] **Papciak D.**, Kaleta J., Puszkarewicz A.(2012) The comparison of removal effectiveness of manganese (II) and ammonium nitrogen in the biofiltration process on the chemically active beds. Water supply, water quality. The series: Engineering for environmental protection. Vol. II p.449-458, Published by PZITS Poznan.

The presence of nitrates(III) can indicate that the area of the active biofilm is too small and the height of the 2nd zone of nitrification in the biofilter is insufficient. The bacteria of the 2nd phase of the nitrification process did not have a possibility to deposit on the filtration bed which was too low and they were rinsed from the biofilters filled with Pyrolox and MZ-10. Chalcedonite, which is characterised with the high porosity, enabled to reach the complete nitrification process with the identical size of the biofilter.

The removal of ammonium nitrogen with the simultaneous iron and manganese removal

I used the models of the filters working in the serial design. The filtration columns were filled with chalcedonite sand with the granulation of 1.0-2.0 mm. The filling of I° biofilter was activated once with the 0.3% solution of $KMnO_4$. In order to supply the design, I used the model solution made on the basis of water taken from waterworks enriched with compounds of iron, manganese and ammonium nitrogen[9].

Analysing the changes in the concentrations of ammonium ions in water after the biofiltration process, I found out that the process of the ammonium nitrogen removal started after 20 days of work of the beds. In case of the first degree biofiltration the standard values could be reached after 53 days of the experiment, however, the use of the second degree biofiltration enabled it as early as after 25 days. In both analysed cases, the increase in the concentration of nitrate(III) ions was recorded in the filtrate, which proved the beginning of the nitrification process. The distinct increase in the content of nitrate nitrogen(III) happened after 20 days which correlated with the amount of the removed ammonium nitrogen. In both cases discussed only after 65 days of work of the beds the concentration of nitrate nitrogen(III) decreased to the standard value 0.5 mg NO_2^-/dm^3 (0.15 mg $N\text{-}NO_2^-/dm^3$). The increase in nitrates(V) was recorded together with the decrease in the content of nitrates(III). The changes in the content of nitrate nitrogen(V) in the filtrate were comparable for both beds. Nitrates(V) showed the highest increase tendency in I° biofiltration on the 33rd day. In case of II° biofiltration the increase in this form of nitrogen was visible a little later which is on the 39th day.

The results of the research proved the high efficiency of chalcedonite in removing iron compounds. Water received already after the first degree of filtration met the standard requirements with regard to the content of this contamination in water intended for consumption 0.2 mg Fe/dm^3.

The effectiveness of the manganese removal varied for both degrees of biofiltration. In case of the one-degree biofiltration the concentrations of manganese in treated water met the standard requirements, but the effectiveness of its removal decreased since the 10th day and till the end of the performance of the experiment its concentration did not differ much from the concentration in water flowing into the biofilter. Manganese was removed more effectively in II° biofiltration. After the process of the two-degree biofiltration the effectiveness of the manganese removal amounted to almost 100% till the 23rd day, and next the increase in its concentration in the purified water up to the value of 0.7 mg Mn/dm^3 was recorded, and after the 45th day the gradual increase in the

[9] **Papciak D.,** Kaleta J., Puszkarewicz A.(2013) Ammonium nitrogen removal from underground waters in the two-stage biofiltration process on the chalcedonite beds. *Annual Set The Environment Protection*; Vol.15. pp. 1352-1366.

effectiveness of the manganese removal was recorded again. After the 64th day of the duration of the experiment the purified water met the requirements for water intended for consumption with regard to the content of manganese.

The results of the studies proved that the increase in the effectiveness of the ammonium nitrogen removal resulted in the decrease in the effectiveness of the manganese removal. In spite of the differentiation of the removal mechanisms of both of these kinds of contamination, I confirmed that the removal of ammonium nitrogen and manganese from waters were the competitive processes. The initial chemical activation of the I° biofilter influenced the effectiveness of the removal of ammonium and manganese ions. The analysis of the changes in the content of these kinds of contamination allows to state that the processes of the chemical oxidation dominated up to the 10th day of work of the bed. The fact of the removal of manganese with the high effectiveness in the II° biofiltration (in spite of the lack of the chemical activation) can only be explained by depositing the oxidized forms of manganese formed in the process of the I° biofiltration on the filling of the second biofilter. The studies on the manganese removal on chalcedonite inform about the sufficient efficiency of the manganese removal only up to the 10th day of work of the bed.

The results of the research obtained by me proved the biological processes of water purification with the use of the two-degree biofiltration through the initially activated chalcedonite bed are the effective processes with regard to the removal of ammonium nitrogen from underground waters of the excessive content of iron and manganese. The one-degree biofiltration at the filtration speed of 2 m/h and the contact time 21 minutes used in the research was not sufficient to carry out the nitrification process and to obtain water for human consumption. Water after the I° biofiltration did not meet the requirements with regard to the content of nitrates(III) and manganese. Lengthening the contact time up to 42 minutes by the application of the II° biofiltration allowed to obtain water meeting all the requirements included in the regulation of the Minister of Health of the 29th of March 2007 concerning the controlled parameters. The observed intake of oxygen varied significantly from the theoretical demand for oxygen resulting from the stoichiometric calculations and fluctuated at about 2 mg O_2/dm^3 per each mg of removed nitrogen.

The reasons for the non-stoichiometric intake of oxygen

In each case of the ammonium nitrogen removal in the nitrification process studied by me, I found out the discrepancies between the theoretical demand for oxygen and its actual demand. Therefore, I tried to explain the reasons for the non-stoichiometric intake of oxygen and to determine the actual demand for oxygen for the process of the ammonium nitrogen removal from water with the biofiltration method[10].

In each of the studied cases the actual intake of oxygen was about twice lower than the theoretical one and sporadically exceeded 2 mg O_2 per each mg of nitrogen removed in the biofiltration process. The reason for the lower intake of oxygen than it results from the stoichiometric calculations may be the fact of the ammonium nitrogen removal in another way than nitrification. Although it was proved that oxygen can originate from a water molecule and not only from dissolved oxygen in the first stage of ammonium nitrogen oxidizing to

[10] **Papciak D**. (2009) Oxygen paradox in the process of ammonium nitrogen removal from water with the biofiltration method. Gas, Water and *Sanitary Engineering*. Vol. LXXXIII, no. 11, pp. 21-25.

hydroxylamine[11], the presence of oxidoreductase was also found which may influence the lower intake of oxygen and be the reason for the excessive accumulation of nitrates (III)[12], but the above facts decrease the theoretical demand for oxygen only to the value of 4.16 mgO_2/mgN, so other processes which can take place in the biofiltration process cannot be omitted.

Considering the changes in ammonium nitrogen in the biofiltration process, I took a possibility to remove ammonium nitrogen as a result of the following reactions into account:

complete nitrification *AOB →NOB*: (**A**mmonia **O**xidizing **B**acteria **AOB**, **N**itrite **O**xidizing **B**acteria **NOB**)	$NH_4^+ + 2O_2 \rightarrow NO_3^- + H_2O + 2H^+$	(1)
shortened nitrification *AOB*:	$NH_4^+ + 1{,}5O_2 \rightarrow NO_2^- + H_2O + 2H^+$	(2)
oxidizing *NOB*:	$NO_2^- + 0{,}5\ O_2 \rightarrow NO_3^-$	(3)
Anammox (**An**aerobic **amm**onia **ox**idation)	$NH_4^+ + NO_2^- \rightarrow 0{,}5N_2 + 2H_2O$	(4)
aerobic deammonification *:*	$NH_4^+ + 0{,}7O_2 \rightarrow 0{,}5N_2 + 1{,}5H_2O$	(5)

If the sum of inorganic forms of nitrogen after the biofiltration process does not balance an amount of nitrogen compounds before the process, there is a phenomenon of a loss of nitrogen.

Considering the results of the research, I found out that the process of Anammox can be a non-nitrification way of removing ammonium nitrogen next to the assimilation process. In favour of such an advanced thesis there is the fact that the losses of nitrogen connected with the formation of N_2 exist only in the equation (4) and (5). The lack of correlation between the intake of oxygen and the losses of nitrogen (the low ratio of determination R^2= 0.003) excluded the reaction (5) as the non-nitrification way of changes of ammonium nitrogen. Analysing the actual intake of oxygen, it can be concluded that ammonium nitrogen could not be completely nitrified to NO_2 which took part in the reaction Anammox (4) as an acceptor of electrons. The remaining ammonium nitrogen was oxidized anaerobically to nitrogen acting as a donor of electrons for NO_2^-. It is confirmed by the high correlation between the losses of nitrogen and the removed ammonium nitrogen in the first degree of biofiltration (R^2=0.856). The reaction (3) plays a crucial role in the nitrogen removal in the second degree biofiltration, hence there is no correlation between the losses of nitrogen and the amount of the removed ammonium nitrogen (R^2=0.204). The similar phenomenon of the losses of nitrogen takes place in the bioreactors to purify sewages (in the bioreactors in order to remove nitrogen biologically at the low ratio C:N). In this mechanism which involves the connection of the shortened nitrification and Anammox, in the outer layer of the biofilm oxidize ammonium nitrogen to nitrate(III) and next these two reagents enter the inside layer of the biofilm through diffusion. *Brocardia Anammoxidans* and *Kuenenia stuttgartiensis* are simultaneously removed by *AOB* in the inside layer of the biofilm, in the so-called niches with the limited access of

[11] Graaf van de A.A., Mulder A. & Bruijn de P.& Jetten M.S.M.& Kuenen J.G., 1995, Anaerobic oxidation of ammonium is a biologically mediated process, *Appl. Environ. Microbiol*. 53:754-760

[12] Bock E.& Wilderer P.A.& Freitag A., 1988, Growth of Nitrobacter in the absence of dissolved oxygen, *Wat. Res.* 22: 245-250.

oxygen. X. Yu states[13] that this path is independent of the changes in ChZT, PO_4 and the oxygen intake:

- if losses of nitrogen ΔN in the biofiltration process remain in correlation with an amount of removed $ChZT_{Mn}$ i.e. $\Delta N = f(\Delta ChZT_{Mn})$, denitrification is a non-nitrification way of removing ammonium nitrogen,
- if losses of nitrogen ΔN in the biofiltration process remain in correlation with an amount of removed ΔP, i.e. ΔN = f(ΔP), assimilation is a non-nitrification way of removing ammonium nitrogen,
- if losses of nitrogen ΔN in the biofiltration process remain in correlation with an amount of removed ammonium nitrogen $\Delta N\text{-}NH_4^+$, i.e. $\Delta N = f(\Delta N\text{-}NH_4^+)$, aerobic deammonification is a non-nitrification way of removing ammonium nitrogen, but only when the filling of the biofilter does not have ion-exchange and sorptive properties, otherwise the physiochemical processes also influence losses of nitrogen.

As the correlation between the removal of $N\text{-}NH_4^+$ and the losses of nitrogen happened, this allowed to draw the conclusion that the Anammox process can be one of the transformation processes of ammonium nitrogen in the biofiltration process. Additionally, the fact of the accumulation of nitrites the creation of which is a criterion of Anammox confirmed this thesis. However, it requires the performance of additional research confirming the presence of Anammox bacteria and gas nitrogen.

These correlations were found only in the 1st degree biofiltration in the example discussed by me, but in the 2nd degree of biofiltration the losses of nitrogen occurred sporadically. The amount of nitrogen compounds after the biofiltration process was mostly higher than the amount flowing into the biofilter. It can be assumed that the oxidizing process of nitrates(III) to nitrates(V) (the reaction 3) was a dominant process in the 2nd degree of biofiltration. However, it is striking that the changes in the concentration of nitrates(III) show the low ratio of determination in comparison with the amount of consumed oxygen ($R^2 = 0.03$). Therefore, it should be considered if there was a reaction of nitrates (III) with the ammonium ions kept in the diatomite bed in the process of the ion exchange next to the oxidizing process of nitrates(III) (the reaction 3).

[13] Yu X., Qi Z., Zhang X., Yu P, Liu B., Zhang L., Fu L.: *Nitrogen loss and oxygen paradox in full-scale biofiltration for drinking water treatment.* Wat. Res. 41(2007), pp.1455-1464

The most important achievements resulting from the carried out research

My most crucial research achievements include the information gap filling connected with the application of the nitrification process in underground water treatment and the completion of information on the actual demand for oxygen, the influence of the filling parameters on the nitrification biofilm formation time and the influence of the presence of typical contamination of underground waters on the activity of nitrification bacteria.

In my research I proved that:

1) The area of the active biofilm, on which the features of the ground and the structure of pores decide, has a big influence on the final effect of the nitrification process.
2) Diatomite is the most effective filling of the biofilters intended for the removal of ammonium nitrogen with regard to the biofilm formation time and the effectiveness of the nitrification process.
3) Natural resources used in the research can be arranged proportionally with the increasing biofilm formation time:
   Diatomite < active carbon WG-15 < chalcedonite < clinoptilolite < hydrofilt < < quartz sand < anthracite
4) To remove 1 mg of ammonium nitrogen in the biofiltration process, 2 mgO_2 per each mg of nitrogen is needed regardless of the type of the biofilter filling.
5) The presence of iron ions in treated water with the biofiltration method:
   - influences the increase in the effectiveness of the ammonium nitrogen removal and the decrease in the biofilm formation time,
   - influences the beginning of the 2^{nd} phase of the nitrification process positively,
   - causes the increase in the oxygen intake in comparison with the bed where water was treated without the presence of iron.
6) Manganese does not influence the activity of the nitrification bacteria positively, it lengthens the biofilm formation time and delays the beginning of the second phase of the nitrification process.
7) While designing appliances to remove ammonium nitrogen with the biofiltration method from water with the excessive content of iron and manganese, the following should be taken into consideration:
   - the appropriate height of the biofilters on which the process of the removal of iron and ammonium nitrogen takes place. It should be chosen in such a way so that the complete nitrification process (for the concentration of $N\text{-}NH_4^+$ to 3.5 mg/dm^3 the contact time 40 minutes, the filtration speed up to 6m/h) could happen before the removal of manganese,
   - the lack of the formation of the zone of the 2^{nd} phase of the nitrification process will disturb the removal of manganese in the second degree of filtration. Nitrates (III) reacting with MnO_2 will bring about the appearance of manganese in the outflow from the biofilters,
   - the application of the opposite flow to the gravitational one in the first degree of biofiltration will allow better conditions for the complete course of the nitrification process, because of the smaller oxygen intake than in the filters with the gravitational flow, the regulation of thickness of the biological membrane and the maintenance of the constant microbiological

activity of the biofilm and the even distribution of the biofilm surface in the whole section of the biofilter.

The possibilities to use the results

The application in technology of underground waters purification intended for human consumption.

5. The review of the other research achievements

5.1. Before being granted the degree of a PhD

I started my research activity during my studies taking an active part in work of the Student Scientific Organisation of the Chemical Department of the Rzeszow University of Technology. My tutor then was Jacek Lubczak, PhD Eng (a professor currently), and the research referred to the determination of the reactions mechanism of hydroxymethyl of melamine derivate with oxiranes. The results of the research were presented during the Youth Forum of the Scientific Conference of the Polish Chemical Society as well as the Association of the Engineers and Technicians of the Chemical Industry in Gliwice in 1989[14] and in Szczecin in 1990[15]. This period was extremely important as it allowed me to learn about research work, improve analytical techniques and taught me to plan an experiment. Having graduated from the Chemical Department of the Rzeszow University of Technology, I started a job in the Department of Civil and Environmental Engineering in the Institute of Water and Sewage Technology. Within 1990-1991 I participated in the organization of research laboratories and classes in the Specialization of Environmental Engineering re-established after the long-term break under the direction of Prof. Janusz Tomaszek. Since the beginning of work in the Specialization of Environmental Engineering my scientific interests were closely connected with the acquired education, which I was expanding with the issues connected with water and sewage technology participating in classes and research in Prof Marian Granops' group. The effect of this cooperation is co-authorship of 11 scientific publications and 10 papers for industry and economy [App. 5]. After the reorganization of this specialization in 1995 I was employed on the position of an assistant in the Institute of Water Purification and Protection, led by Prof Marian Granops. Then, I got interested in the problem of the ammonium nitrogen removal from water solutions with the use of natural zeolites. Therefore, I started the literature and laboratory research, which allowed me to be admitted into the PhD. program in the Department of Environmental Protection and Fishing of the Agricultural and Technical Academy in Olsztyn (the University of Warmia and Mazury at present). Prof Marian Granops was appointed my doctoral thesis advisor and the topic of my doctoral thesis was "Use of clinoptilolites to remove ammonium nitrogen from water solutions." In that period my research was concentrated, first of all, on defining possibilities to use clinoptilolites in the

[14] Tkacz (Papciak) D., Papciak B., Kinetic analysis of reactions occurring in the system (hydroxymethylo) melamine-oxirane. Materials of the Scientific Conference of the Polish Chemical Society and the Association of the Engineers and Technicians of the Chemical Industry, the Youth Forum , Gliwice 1989 .

[15] Papciak B., Tkacz (Papciak) D., Kinetic models of reactions occurring in the system (hydroxymethylo) melamine-oxirane. Materials of the Scientific Conference of the Polish Chemical Society and the Association of the Engineers and Technicians of the Chemical Industry, the Youth Forum , Szczecin 1990 .

processes of the ammonium nitrogen removal from water especially taking possibilities of purifying of circulating water in fishery into account. The conducted research let me establish the mechanism of the removal of ammonium ions on clinoptilolite, determine decisive factors concerning effectiveness of the process and indicate the ion-exchange capacity of the clinoptilolite beds. I found out that the process of the ion exchange may be an effective and useful method of the ammonium nitrogen removal from water solutions, however, the following fact should be taken into consideration that the length of work of the filtration column is determined by water hardness, and especially calcium ions which may block even up to 80% of the ion-exchange capacity of mineral. I also proved that the chemical processing of clinoptilolite with different solutions is not justified economically with reference to benefits which result from it, but I noticed a possibility to lengthen work time of clinoptilolite filters by connecting ion-exchange capacities with biosorptive ones. I demonstrated the lack of influence of clinoptilolite on the environment of clean water and the condition of carp alevin and I determined advantages and disadvantages of the use of clinoptilolite in the system of water regeneration in fishery.

I defended my doctoral thesis in September **1998** being conferred a degree of Philosophy Doctor Engineer of agricultural sciences in the scope of fishery, awarded on the basis of the resolution of the Council of the Department of Environmental Protection and Fishing of the Agricultural and Technical Academy in Olsztyn (the University of Warmia and Mazury at present)[16].

5.2. After being granted the degree of a PhD

The main issues taken in my research and professional work refer to:

1. use of natural and modified minerals in water purification
2. treatment technology of underground waters with the excessive amount of compounds of nitrogen, iron and manganese,
3. use of biotechnological methods to remove contamination from the water-ground environment.

Ad.1.

Within the first area of my research interests concerning the use of use of natural and modified minerals in water purification, three trends can be distinguished:

- the removal of ammonium nitrogen,
- the removal of petroleum-derived substances,
- the removal of chromium compounds from water solutions.

Removal of ammonium nitrogen

Just after the defence of my doctoral thesis I participated in work of Prof Granops' group within the research project "Strategy of development of the systems of water supply and sewage treatment for the area of the Wislok River

[16] **Papciak D.**, Application of clinoptilolites to remove ammonium nitrogen from water solutions. The Ph.D. Thesis. Department of Environment Protection and Fishery, the Agricultural and Technical University in Olsztyn, 1998

basin"[17]. The carried out research proved that the problem of the removal of ammonium ions from underground waters is still up-to-date and it is not solved satisfactorily[18]. The increasing contamination of underground waters with nitrogen compounds, and especially with ammonium nitrogen forced a necessity of looking for unconventional, highly effective methods of purification. With regard to the costs connected with the use of physicochemical methods and fear connected with the use of biological methods, intake stations of underground waters where the presence of ammonium nitrogen was found were often abandoned. Knowledge of the possibilities of using the nitrification process in water technology occurred to be incomplete and vague as it is in treatment technology of sewage and caused a lot of fear. When the presence of the nitrification process in the ammonium nitrogen removal was found, it happened in the intake stations where the concentration of ammonium nitrogen did not exceed the previously admissible value of 1.5 mgNH_4^+/dm^3. In such cases the decrease in the content of ammonium nitrogen was observed and spontaneous "work-in" of the nitrification beds on the filters intended for the removal of iron and manganese (most often in the sand filters) was discovered. The belief that the amount of oxygen in the condition of the full saturation of water with oxygen at the temperature of 10-16°C would be enough to remove 2 mg N/dm^3 (in the filled pressure filters) also limited the use of biofiltration for water where the concentration of ammonium nitrogen did not exceed this value. This fact confirmed me that I should undertake the research on effectiveness of the nitrification process of water and accelerate the formation of the active biofilm containing nitrification bacteria. The part of this research was presented as a series of 10 publications in the application process in order to be granted a title of a habilitated doctor.

My studies on effectiveness of the ammonium nitrogen removal in the connected processes of ion exchange and nitrification[19] contributed to cooperation with Prof Dorota Antos' group in the Faculty of Chemistry of the Rzeszow University of Technology. The cooperation referred to the ion exchange of ammonium nitrogen on the synthetic zeolite in the presence of the nitrification bacteria biofilm[20]. The biofilm was formed on the zeolite carrier as a result of the use of various hydrodynamic conditions: in the reactor with the fluidized bed and in the reactor with the piston flow. The influence of the biofilm on inside, outside and total porosity of zeolite was studied. In order to do it, the values of retention time of dextrane and sodium chloride to determine the outside and total porosity respectively. In the presence of the biofilm the inside porosity increased twice, but the outside one by about 20%. The values of porosity were independent of the concentration of salt and the type of the used bioreactor. The research results showed that the presence of the biofilm significantly influences the values of the intergranular space, both for the inside porosity and the outside one increasing it considerably.

In order to analyse the transfer mechanism of mass and kinetic quantitative coefficients, the LDF (linear driving force) model and the generalized model were

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[17] Strategy of development of the systems of water supply and sewage treatment for the area of the Wislok River basin. The research project KBN no. PBZ 007-12, 1999-2000

[18] **Papciak D**., Puszkarewicz A., Granops M., Underground waters in the Wislok River basin. Hydropresentations II the Vistula River, 1999

[19] **Papciak D**., Zamorska J., Clinoptilolite as a filling of the nitrification filters. VI International Conference "Current problems of the construction industry and environmental engineering, Lviv, 2001

[20] Górka A**., Papciak D**., Zamorska J., Antos D., 2008, The influence of biofilm on the effectiveness of ion exchange process. *Ind. Eng. Chem. Res.*, 47, p. 7456-7664

used. The comparison of the characteristics of the ion exchange and the mass transport on the carrier covered with the biofilm to characterise clean zeolite was made. It was found out that the presence of the biofilm influences the mass transport kinetics and the zeolite ion-exchange capabilities by the increase in expansion. The ion-exchange capability compared with the bed volume increased significantly in the presence of the biofilm while the effective ion-exchange capability compared with the column volume depended on the biofilm to a lesser degree. The significant influence of the biofilm on the mass transport kinetics was not found. The procedure suggested in the article is relatively a simple tool allowing the analysis of the mass transport kinetics in the biofilm.

Removal of petroleum-derived substances

With regard to the universality of oil use, the petroleum-derived substances pose a big threat to the natural environment. The removal of dispersible petroleum-derived contamination from water is difficult and it very often becomes real only after connecting several individual processes. Therefore the research was undertaken in order to define if the technological system consisting of the connected processes of sorption and coagulation will provide the sufficient degree of their removal[21]. Moreover, the attempt was made to define the degree of use of dusty active carbons: charcoal and hard coal as an agent supporting coagulation with the use of the traditional reagents: iron chloride (III) and aluminium sulphate (VI). The volume coagulation supported with the adsorption process occurred to be the effective purification method of oil emulsion. Both coagulants used independently occurred to be effective but the removal of oil emulsion was not satisfactory. Only the dusty active carbons introduced into the research caused the decrease in 97% of the oil concentration in post-coagulative water. The importance of active carbon is emphasized by the fact that it is a non-toxic substance, relatively cheap in the production (mainly charcoal), and at the same time it is easy to utilize (for instance, by burning).

Other research results included in the publication[22] indicate wide possibilities of the use of clinoptilolites and diatomites in purification of the water environment from petroleum-derived substances. It was proved that the studied minerals can be a cover material for the protection of microporous active carbons against oil and fat contamination. The crucial aspect deciding on the practical use of a given adsorbent is the influence of the already used material on the environment and a possibility of its disposal. Both diatomites and clinoptilolites can be regenerated and disposed thermally and with regard to the low percentage of desorption they can be stored on properly secured dumps. Contrary to clinoptilolites, the higher brittleness of diatomites after being calcined can influence the decrease in their adsorptive capabilities after the multiple regenerations and limit their reuse.

My interests in the methods of the removal of petroleum-derived substances resulted in the cooperation with the Subcarpathian Production and Implementation Centre "EKO-KARPATY" (the Production Plant TECHNITEX in Glogow Malopolski) in the scope of technologies of production of highly effective non-woven composites for adsorption of petroleum-derived compounds. Within this cooperation, I was appointed a manager of the grant "Technology of protection

[21] Puszkarewicz A., Kaleta J., **Papciak D.**, 2009, Use of active carbons to purify oily water solutions. *Environmental Engineering and Protection,* vol.12, no. 2, pp. 153-161.
[22] Kaleta J., **Papciak D.**, Puszkarewicz A., 2007, Clinoptilolites and diatomites with reference to usefulness in water treatment and sewage purification. Publishing House of IGSMiE PAN Krakow, *Mineral Resources Management*, Vol. 23, Z.3. pp. 21-34.

of highly effective non-woven composites for adsorption of petroleum-derived compounds”[23]. Non-woven composites for adsorption of petroleum-derived substances form the paving belong to modern, pro-ecological and highly effective sorptive materials. Those which were studied were produced from waste, synthetic (on the basis of polyester), natural (on the basis of cotton) materials and improved with additives increasing rigidity, weight (making blowing away by wind impossible) and non-inflammability. The above properties are determined by:

- a type of fibres (a length, a diameter, a shape of a section, a type of polymer, rigidity) used for production of nonwoven fabric,
- a structure of nonwoven fabric (a distribution of fleece, density, porosity),
- an addition of modifying substances.

The products studied within the project occurred to be a sorptive material with the sorptive efficiency several times higher in comparison with loose materials and imported nonwoven fabric available on the Polish market. They are competitive with regard to mechanical strength, a lack of flammability and also the price. Polish components including waste materials were used to produce them. The used nonwoven composites can be utilized thermally and they do not emit any toxic substances while burning them. The additional advantage is a possibility to use them many times as there is a possibility to recycle absorbed substance which can undergo the process of purification or burning.

Removal of chromium

The evaluation of usefulness of different sorptive materials such as diatomites[24], active carbons[25] and synthetic ion exchangers[26] was also performed with reference to the removal of chromium(VI) compounds. It is proved that chromium compounds(VI) are the most dangerous substances for human beings and biocenose. Adsorption on active carbon is the most popular sorptive method to remove heavy metals (including chromium(VI)) from water. The additional benefit of this method is a possibility to burn sorbent (with the addition of alkalis) and the further processing of adsorbed chromium but the drawback is a relatively high cost of production.

Nowadays, valued sorbents are natural minerals, environmentally friendly, much cheaper and easily available. Carpathian diatomite can be distinguished among them, the structure and the physicochemical properties of which enabled to assume that it will prove to be adsorptive to chromium. The influence of diatomite modification with iron compounds on the adsorption effectiveness of chromium(VI) was defined in the research on usefulness of diatomites as adsorbents to remove chromium ions from water. The process of sorption carried out on Carpathian diatomites showed that the modification of the surface with iron compounds brought about the increase in adsorptive properties of the mineral to

[23]Technology of production of the highly effective woven composites for adsorption of petroleum-derived compounds ROW 568-2004, the agreement number U 393/P-439/2005.

[24] Puszkarewicz A., **Papciak D**., 2009, Removal of Chromium(VI) from Water in Sorption Process Using Carpatian Diatomite. *Polish Journal of Environmental Studies* vol.2, p. 56-61.

[25] Puszkarewicz A., Kaleta J., **Papciak D**., 2012, Analysis of adsorption of chromium ions (VI) on active carbons. Water supply, water quality. *The series: Engineering for environment protection.* Vol. II pp.471-484, Publishing House PZITS Poznan.

[26] Puszkarewicz A., Kaleta J., **Papciak D**., 2013, Efectiveness of chromium(VI) removal from water solutions in the process of ion exchange. *Chemical Industry,* 92,6, pp.1000-1003

absorb dichromate(VI) ions from water in the significant way. Owing to covering the surface of diatomite with iron oxide, the adsorptive area increased by 35%. The adsorptive balance was analysed on the basis of the Freundlich model, the adjustment of which to the experimental conditions with reference to diatomite-Fe was very good, and the received constants K and n were comparable with a lot of other adsorbents.

The unquestionable advantage of Carpathian diatomites as adsorbents, in spite of the low adsorptive capacity with reference to chromium(VI), is their common occurrence and low cost.

The popularity and hopes connected with the exploitation of zeolite beds in the area of South-Eastern Poland resulted in the beginning of research on possibilities of the application of clinoptilolite-montmorillonite zeolite claycy shale for the needs of protection and environmental engineering as well as zootechnics and agriculture[27]. As a subcontractor of the special-purpose project, I conducted the research concerning the definition of an ion-exchange capacities of the studied minerals and the influence of the chemical processing on its value[28], the influence of contamination rinsed out of claycy shales on the environment of clean water[29], possibilities of their application to remove petroleum-derived substances[30] and metals [31] from water solutions.

Ad.2.

The second area of the research dedicated to treatment technologies of underground waters was mainly connected with cooperation with business entities. My cooperation benefited both in the immeasurable way by the increase in my professional experience and its transfer to didactics, but also in the measurable way by writing several publications, the inspiration of which were the expert opinions or technological research done by me[32,33,34,35,36,37,38,39,40,41,42,43,44,45,46].

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[27] Exploatation and processing of clinoptilolite-montmorillonite zeolite claycy shale for the needs of environmental protection and engineering and zootechnics and agriculture (the agreement number 03811/C.ZR6-6/2006), 2007.

[28] Kaleta J., **Papciak D**., 2011, Influence of chemical processing on the ion-exchange capability of clinoptilolite-montmorillonite zeolite claycy shale. *Research Bulletin of the Rzeszow University of Technology 276*, vol.58 no. 2, pp. 97-104.

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[31] Kaleta J., **Papciak D**., Puszkarewicz A., 2011, Removal of metals from water solutions with the use of clinoptilolite-montmorillonite zeolite claycy shale. *Research Bulletin of the Rzeszow University of Technology* 276, vol. 58 no. 4, pp. 77-88.

[32] Kaleta J., **Papciak D,** Puszkarewicz A., 2009, Natural and modified minerals in underground waters treatment. Publishing House of IGSMiE PAN Krakow, *Mineral Resources Management*, vol. 1 vol. 25, pp. 51-63,

[33] Kaleta J., Puszkarewicz A., **Papciak D**., 2007, Removal of Iron, Manganese and Nitrogen Compounds from Underground Waters with Diverse Physical and Chemical Characteristics. *Environment Protection Engineering* Vol. 33, No. 3, pp. 5-13.

[34] Kaleta J., **Papciak D**., Puszkarewicz A., 2011, Application of chemically active beds to remove iron and manganese from water. *Research Bulletin of the Rzeszow University of Technology* 276, vol. 58 no. 2, pp. 113-126.

[35] Puszkarewicz A., **Papciak D**., Kaleta J., 2008, Treatment of underground water on the catalytic and biosorptive beds. vol. XVI, notebook 4, pp. 135-140, Bydgoszcz Scientific Society, Ecology and Technics

The experience acquired within this cooperation was also presented in the national conferences[47],[48].

Ad 3.

The third area of the research was connected with the organisation of the laboratory of environmental biotechnology and biochemistry, which was entrusted to me, together with the programme elaboration of a series of lectures and laboratory practice for 2 subjects: Environmental Biotechnology and Biochemistry. At that time I started cooperation with PhD Justyna Zamorska, a microbiologist, which allowed me to widen my knowledge of the issues connected with the use of microorganisms to remove contamination from the water-ground environment and resulted in 10 mutual publications. The publications include the results of the research connected with the application of technology with the participation of biological processes[49],[50]. These technologies origin from the processes occurring in nature where microbes exist providing the natural cyclical circulation of elements due to mineralization of organic matter. These processes can be intensified by

36 Kaleta J., **Papciak D**., 2005, Treatment technologies of chosen underground waters with the excessive content of nitrates, *Gas, Water and Sanitary Technics,*, No. 5, pp. 23-26

37 **Papciak D**., Kaleta J., 2004, Rules to choose anion exchangers for the nitrate removal from underground waters. *Research Bulletin of the Rzeszow University of Technology,* vol. 2, Vol 37, pp. 285-290, Publishing house of the Rzeszow University of Technology.

38 Granops M., **Papciak D**., Wójcik B., 2003, Possibilities to remove nitrates from consumption waters on the example of the water treatment plant in Wola Wielka near Debica. *Research Bulletin of the Rzeszow University of Technology*, Vol 35, pp. 75-82, Publishing house of the Rzeszow University of Technology.

39 Kaleta J., Puszkarewicz A., **Papciak D**., Removal of iron, manganese and nitrogen compounds from underground waters, The Congress of Environmental Engineering, Lublin 2005

40 Kaleta J., **Papciak D,** Puszkarewicz A., 2009, Natural and modified minerals in treatment of underground waters. Publishing House of IGSMiE PAN Krakow, *Economy of mineral resources*, Vol 1 vol. 25, pp. 51-63,

41 Kaleta J., Puszkarewicz A., **Papciak D**., 2007, Removal of Iron, Manganese and Nitrogen Compounds from Underground Waters with Diverse Physical and Chemical Characteristics. *Environment Protection Engineering* Vol. 33, No. 3, pp. 5-13.

42 Kaleta J., **Papciak D**., Puszkarewicz A., 2011, Application of chemically active waters to remove iron and manganese from water. *Research Bulletin of the Rzeszow University of Technology.* 276, Vol. 58, No 2, pp. 113-126.

43 Puszkarewicz A., **Papciak D**., Kaleta J., 2008, Treatment of underground water on the catalytic and biosorptive beds.Vol. XVI, Vol 4, pp.135-140, Bydgoszcz Scientific Society, Ecology and Technics

44 Kaleta J., **Papciak D**., 2005, Treatment technologies of chosen underground waters with the excessive content of nitrates, *Gas, Water and Sanitary Technics,* No. 5, pp. 23-26

45 **Papciak D**., Kaleta J., 2004, Rules to choose anion exchangers for the nitrate removal from underground waters. *Research Bulletin of the Rzeszow University of Technology,* vol. 2, Vol 37, pp. 285-290, Publishing house of the Rzeszow University of Technology.

46 Granops M., **Papciak D**., Wójcik B., 2003, Possibilities to remove nitrates from consumption waters on the example of the water treatment plant in Wola Wielka near Debica, *Research Bulletin of the Rzeszow University of Technology,* Vol 35, pp. 75-82, Publishing house of the Rzeszow University of Technology.

47 Kaleta J., Puszkarewicz A., **Papciak D**., Removal of iron, manganese and nitrogen compounds from underground waters, the Congress of Environmental Engineering, Lublin 2005

48 **Papciak D**., Kaleta J., Elimination of nitrogen compounds from underground waters. VIII Lviv-Kosice-Rzeszow International Conference on “Current problems in construction industry and environmental engineering”, Lviv, 2003

49 Zamorska J., **Papciak D**., Biosorption of metals, Research Bulletin of the Rzeszow University of Technology, Construction and Environmental Engineering, Vol 57 [271] no. 1, pp. 179-193

50 **Papciak D.,** Zamorska J.,2010, Biosorption of cobalt from water solutions with the use of yeast *Saccharomyces cerevisiae,* Research Bulletin of the Rzeszow University of Technology, Construction and Environmental Engineering, Vol 57 [271] no. 1, pp. 95-104

creating appropriate technical conditions, but for several years the increase in the interest in the use of defined species of microbes with well-discovered technological properties has been observed, the selection of strains with special degradation capabilities have been made. The introduction of the biotechnological methods requires the use of appropriate preparations and the conditions of their safe and effective use. The biopreparations are compositions of microbes with the defined population composition and the quantitative proportions. Introduced into the environment as biological strains, they enable the effective development of the active microflora, supporting the processes of contamination liquidation significantly[51],[52],[53]. A lot of ready biopreparations have appeared on the Polish market, which repeatedly do not include essential information concerning their composition, way of dosage, storage and use. The influence of abiotic factors on the speed of the biodegradation process of petroleum-derived compounds in the ground was defined in the study[54]. The process was stimulated with the biopreparation DBC plus – type R5. The influence of temperature, pH and dosages of the biopreparation on the effectiveness of biodegradation of diesel oil in soil was studied.

The main achievement of this cooperation is a publication of two textbooks[55],[56] and 1 manual[57] together with PhD Justyna Zamorska.

I am also an author and co-author of numerous expert's opinions and elaborations, the aim of which was to evaluate water corrosiveness and to determine the causes of corrosion of waterworks installations. With regard to the importance of the issue, the problem of corrosion caused by water and microbiological corrosion was discussed in the publications[58],[59],[60],[61],[62] and presented in conferences[63].

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[51] Zamorska J., **Papciak D**., Puszkarewicz A., 2002, Application of biopreparates in sewage purification technology. *Ecological Engineering*, notebook 7, pp. 49-54, Polish Society of Ecological Engineering.

[52] Zamorska J., **Papciak D**., 2003, Application of biopreparates in ground purification from petroleum-derived compounds. *Research Bulletin of the Rzeszow University of Technology,* notebook 35, pp. 243-249, Publishing house of the Rzeszow University of Technology,

[53] Zamorska J., **Papciak D**., 2004, Removal of petroleum-derived compounds from the ground – microorganisms and the conditions of performing the process, *Research Bulletin of the Rzeszow University of Technology*, notebook 38 pp. 159-170, Publishing house of the Rzeszow University of Technology.

[54] **Papciak D**., Zamorska J., 2004, Possibilities to use the DBC-plus biopreparation to support the biodegradation processes of petroleum-derived substances, *Research Bulletin of the Rzeszow University of Technology*, notebook 38, pp. 95-108, Publishing house of the Rzeszow University of Technology.

[55] Zamorska J., **Papciak D**., Chosen issues of environmental biotechnology. Publishing house of the Rzeszow University of Technology, Rzeszow 2001

[56] **Papciak D**., Zamorska J., Basics of biology and environmental biotechnology. Publishing house of the Rzeszow University of Technology, Rzeszow 2005

[57] **Papciak D**., Zamorska J., Kiedryńska L., Microbiology and biotechnology in the water purification processes, Publishing House of the Rzeszow University of Technology 2011.

[58] **Papciak D**., 2004, Evaluation of quality and corrosiveness of water in the Commune of Chmielnik Rzeszowski. *Research Bulletin of the Rzeszow University of Technology,* vol. 2, notebook 37, pp. 277-284, Publishing house of the Rzeszow University of Technology

[59] Granops M., **Papciak D**., Sito L., 2000, Influence of water quality on corrosion of copper appliances, *Research Bulletin of the Rzeszow University of Technology,* vol. 2, notebook 32, pp. 93-100, Publishing house of the Rzeszow University of Technology.

[60] **Papciak D**., Kaleta J., Puszkarewicz A., 2007, Corrosion processes in copper installations and water quality. *Research Bulletin of the Rzeszow University of Technology* , No. 244, notebook 46, pp. 71-84, Publishing house of the Rzeszow University of Technology.

SUMMARY OF ACADEMIC ACHIEVEMENTS

Before being granted a degree of a PhD, I was a co-author of 6 publications in magazines scored by the Ministry of Science and Higher Education and 5 publications in conference materials. I was a co-writer of 9 research papers for business entities.

After being granted a degree of a PhD, my achievements comprise of 78 publications, including 10 in magazines distinguished in the JCR database, 1 chapter in the English monograph and 35 publications in magazines not distinguished in the JCR database but which are in the list of the Ministry of Science and Higher Education and 6 publications in national monographs and magazines, as well as 26 published in conference materials. I participated in 5 international conferences and 9 national ones. I managed one grant, and in two others I was a member of the research team. I was a co-contractor of 12 research papers for business entities.

The total of IF for articles in the year of publishing is **4,372**.

The total points according to MNiSW [the Ministry of Science and Higher Education] for papers in the year of publishing is: **329** (including handbooks: **361**).

Tab. 2. List of types of academic achievements

No	Type of a publication	Before being granted a Ph.D.	After being granted a Ph.D.	Total
1	Publications in magazines distinguished in the JCR database	-	10	10
2	Publications in magazines scored not distinguished in the JCR database	6	35	41
3	Chapters in monographs	-	7	7
4	Publications published in conference materials	5	26	31
TOTAL		**11**	**78**	**89**
5	Develop for businesses	9	12	21

[61] **Papciak D**., Zamorska J., 2007, Microbiological corrosion in building caused by fungi. *Research Bulletin of the Rzeszow University of Technology*, No. 244, notebook 46, pp. 85-97, Publishing hHouse of the Rzeszow University of Technology.

[62] Zamorska J., **Papciak D**., 2007, Microbiological research on resistance of silicone materials used in construction. *Research Bulletin of the Rzeszow University of Technology*, No. 244. notebook 46, pp. 160-172, Publishing house of the Rzeszow University of Technology

[63] **Papciak D**., Water corrosiveness, VIII Lviv-Kosice-Rzeszow International Conference on "Current problems in construction industry and environmental engineering", Lviv, 2003

Tab. 3. List of magazines and publishing houses where original scientific papers were published

No.	Type of a magazine or a publishing house	Number of published papers	Language of publication
Journals from the list of the Journal Citation Reports (JCR)			
1	Industrial Engineering Chemistry Research	1	English
2	Polish Journal of Environmental Studies	2	English
3	Environment Protection Engineering	2	English
4	Annual Set the Environment Protection	2	Polish
5	Chemical industry	1	Polish
6	Mineral Resources Management	2	Polish
Journals scored according to the list of the Ministry of Science and Higher Education			
7	Gas, Water and Sanitary Engineering	3	Polish
8	Biotechnology	1	Polish
9	Engineering and Environmental Protection	1	Polish
10	Technology of Water	1	Polish
11	Ecological Engineering	2	Polish
12	Research Bulletins of the Rzeszow University of Technology	26	Polish
13	Research Bulletins of the Polish Association of Ecological Engineering	4	Polish
14	Ecology and Technics	1	Polish
15	Instal	1	Polish
Chapters in monographs			
16	Environmental Engineering, Taylor&Francis Group	1	English
17	Engineering for Environment Protection. Water Supply, Water Quality. The Publishing House PZiTS Poznan	3	Polish
18	Mineral Sorbents The Publishing House of the University of Science and Technology in Krakow	3	Polish
Others			
19	Rinok Instalacyjnyj	1	Ukrainian
20	Conference materials	31	Polish

Tab. 4. Numerical order of publication according to the place among the co-authors

Type of publication	Independent papers	Co-authorship of a publication				Total
		First author	Second author	Third author	Fourth author	
Publications in journals distinguished in the JCR database	-	3	5	2	-	10
Publications in journals scored not distinguished in the JCR database	5	13	18	2	3	41
Chapters in monographs	1	3	1	2	-	7
Publications published in conference materials	9	8	7	7	-	31
Total	15	27	31	13	3	**89**

Tab. 5. Participation in conferences

	International conferences	National conferences
Participation	5	18
Presented papers	4	14
Published papers	9	18

Tab. 6. Number of quotes

	According to Web of Science	According to Baz-Tech
Total of quotes	16	32
Number of quoted articles	8	31
Hirsch Index	2	-

I have been awarded for research activity five times with group prizes by the Rector of the Rzeszow University of Technology:

Awards for academic achievements:

1998 Award of the Rector of the Rzeszow University of Technology – collective the 2nd degree for the series of scientific publications concerning the application of new filtration materials in water technology.

1999 Award of the Rector of the Rzeszow University of Technology – collective the 2nd degree for the series of scientific publications concerning technology in water economy in the area of south-eastern Poland.

2008 Award of the Rector of the Rzeszow University of Technology – collective the 3rd degree for the series of scientific publications concerning advanced technology of water purification and regeneration.

2009 Award of the Rector of the Rzeszow University of Technology – collective the 2nd degree for the series of scientific publications concerning natural and modified minerals in water purification.

2010 Award of the Rector of the Rzeszow University of Technology – collective the 3rd degree for the series of scientific publications concerning protection of water resources.

Didactic activity

I started my didactic activity in the Institute of Water and Sewage Technology, the Department of Civil and Environmental Engineering of the Rzeszow University of Technology. Working on the position of an assistant, I conducted the following classes in the specialization of Environmental Engineering:

- laboratory classes of sanitary chemistry,
- laboratory classes of water technology,
- laboratory classes of industrial sewages,
- laboratory classes of waste disposal,
- counting classes of general and sanitary chemistry.

As a result of the reorganization in the Faculty, I became an employee of the Department of Water Purification and Protection. Then, I started to conduct the auditorium classes of environment protection and the laboratory ones of water technology, techniques of environment protection and biochemistry. I actively participated in the elaboration of education programmes of the subjects such as environmental biotechnology and biochemistry in the courses of *environmental engineering* and *environment protection* and the organization of the laboratory of biochemistry and environmental biotechnology. Having been granted a degree of PhD, I started to give lectures of the above mentioned subjects.

Currently, I conduct the following classes:

1. environmental biotechnology (a lecture, a laboratory) – full-time studies and part-time programmes, the courses of *environmental engineering* and full-time studies, the courses of *environment protection*;
2. biochemistry (a lecture, a laboratory) full-time studies and part-time programmes, the courses of *environmental engineering* and full-time studies, the courses of *environment protection*.

I am a co-author of 2 academic manuals and 2 textbooks and auxiliary materials:

Manuals:

- Kiedryńska L., **Papciak D.**, Granops M., Sanitary Chemistry. The publishing house of the Warsaw University of Life Sciences 2006.
- **Papciak D.**, Zamorska J., Kiedryńska L., Microbiology and biotechnology in the processes of water purification, The publishing house of the Rzeszow University of Technology 2011.

Textbooks:

- Zamorska J., **Papciak D.**, Chosen issues of environmental biotechnology. The publishing house of the Rzeszow University of Technology, Rzeszow 2001
- **Papciak D.**, Zamorska J., Basics of biology and environmental biotechnology, The publishing house of the Rzeszow University of Technology, Rzeszow 2005

Auxiliary materials:

Papciak D., Biochemistry - laboratory. The publishing house of the Rzeszow University of Technology, Rzeszow 2010

Within the didactic activity I was a thesis advisor of 52 MSc theses and 14 BSc theses and a year tutor in 2000-2004, 2005-2009, 2011-2013. Since 2013 I have been a manager of postgraduate studies *Environment protection in industrial plants and a municipality* in the course of *environment protection.*

I have been awarded for didactic activity three times with the collective prizes of the Rector of the Rzeszow University of Technology:

Awards for didactic activity:

2002 Award of the Rector of the Rzeszow University of Technology – collective the 2nd degree for the textbook entitled The chosen issues of environmental biotechnology, the elaboration of the education programme of the subject of Biotechnology in the specialization of Environmental Engineering.

2006 Award of the Rector of the Rzeszow University of Technology – collective the 3rd degree for the textbook entitled The basics of biology and environmental biotechnology.

2011 Award of the Rector of the Rzeszow University of Technology – collective the 2nd degree for the academic manual entitled "Microbiology and biotechnology in the processes of water purification"

Organizational activity

For three terms of office I have been representing a group of assistant professors and assistants in work of the Council of the Faculty of Civil and Environmental Engineering. It is an honour for me with regard to the fact that this function is by election.

Moreover, I am a member of the group for BSc and MSc theses appointed by the dean of the department. I actively participate in organizational work of the Department of Water Purification and Protection within the preparation and calculation of agreements concerning the didactic and statutory activity and the service of the entry exam in the architectural predisposition in the course of *architecture and urbanization*. In 2008 I participated in work of the Group of External Experts for the Delphi Analyses of the National Foresight Programme Poland 2020. Between 1990-1996 I was a member of the Polish Chemical Society and from 1996 to 2007 I was a member of the Polish Association of Sanitary Engineers and Technicians.

I took an active part in the event named "Girls on the university" (2009), and information campaigns for prospective students as the "Salon high school graduates".

I prepared and implemented laboratory exercises of biochemistry for high school students as part of a project co-funded by the European Union under European Social Fund, Project of the Operational Programme Human Capital, National Cohesion Strategy.