Auto-abstract
on the achievements of scientific and research activities as well as teaching and organizational work

List of contents

1. First and last name

Katarzyna Maria Kołecka

2. Awarded diplomas and academic degrees

2002 Obtaining the Master of Science degree in the field of environmental engineering at the Faculty of Hydraulic and Environmental Engineering of the Gdansk University of Technology (actually: the Faculty of Civil and Environmental Engineering), the title of the master thesis was "The assessment of groundwater quality of the Cretaceous floor on selected Gdańsk intake stations in the light of the new regulation", supervisor: Prof. PhD MSc Eng. Krystyna Olańczuk-Neyman

2007 Obtaining the PhD degree of technical sciences in environmental engineering at the Faculty of Civil and Environmental Engineering, the title of the PhD thesis was: "Long-term changes in the speciation of heavy metals in sewage sludge utilized in reed beds", supervisor: Prof. PhD MSc Eng. Hanna Obarska-Pempkowiak

3. Employment history in research institutes

2002-2006 PhD study "Geotechnics and Environmental Engineering", the Faculty of Hydraulic and Environmental Engineering in the course changed to the Faculty of Civil and Environmental Engineering

2008-2010 Assistant professor at the Department of Sanitary Engineering, the Faculty of Civil and Environmental Engineering and Architecture of the University of Science and Technology in Bydgoszcz

2009-2012 Assistant professor at the Department of Sanitary Engineering, the Faculty of Civil and Environmental Engineering of the Gdansk University of Technology (in the years 2009-2010 part-time, from 2010 full-time)

2012 - till now Assistant professor at the Department of Water and Wastewater Technology, the Faculty of Civil and Environmental Engineering of the Gdansk University of Technology

4. Identification of an achievement resulting from article 16, section 2 of the act on academic degrees and titles and about degrees and titles in the field of fine arts of march 14, 2003 (Journal of Laws January 19, 2018, item 261)

a) Title of the achievement

Pollutions removal and stabilization of sewage sludge in reed systems

b) Publications which are the part of scientific achievement

A monograph:
Kołecka K. (2019). Pollutions removal and stabilization of sewage sludge in reed systems, Monographs of the Committee of Environmental Engineering of the Polish Academy of Sciences, no. 149, Gdańsk 2019, 212 pages (196 pages without a list of monographs of the PAN Committee), ISBN: 978-83-63714-48-2

c) Discussion of the above mentioned research work aim and the results achieved with the presentation of their possible use

The law[1] defines municipal sewage sludge as waste from fermentation chambers and other installations for wastewater treatment from wastewater treatment plants. European Directive 2000/60/EC[2] specifies that municipal sewage sludge should be reused if its adverse impact on the natural environment is minimized.

Sewage sludge is a serious problem, especially for small and medium wastewater treatment plants with limited financial resources. This problem deepened in 2016, when a law has practically prevented sludge storage. The solution of the sewage sludge problem can be reed systems where integrated dewatering and stabilization processes take place. This method has been known and used since the late 1980s in many European countries, including France, Denmark, Germany, Greece, Spain, Belgium, Great Britain and Italy. In France, there are around 120 facilities of this type, and in Denmark about 140 ones[3,4,5].

In Poland on a technical scale, reed systems work in conventional wastewater treatment plant in Gniewino near Wejherowo and in Zambrów in the Podlasie province. For smaller wastewater treatment plants reed systems were used in Darżlubiu near Puck and

[1] Ustawa z dnia 14 grudnia 2012 r. o odpadach (Dz.U. 2013 poz. 21)
[2] Directive 2000/60/WE of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water
[3] Nielsen S., Peruzzi E., Macci C., Doni S., Masciandaro G, (2014). Stabilisation and mineralization of sludge in reed bed system after 10 – 20 years of operation. Water Science and Technology, vol. 69, no 3, 539-545
[4] Uggetti E., Ferrer I., Llorens E., García J., (2010). Sludge treatment wetlands: a review on the state of the art. Bioresource Technology, vol. 101, no 9, 2905–2912
[5] Troesch S., Liénard A., Molle P., Merlin G., Esser G., (2009). Sludge drying reed beds: a full and pilot-scales study for activated sludge treatment. Water Science and Technology, vol. 60, no 5, 1145–1154

Nadole near Wejherowo[6,7]. So far, the functioning of reed systems in Poland has not been comprehensively studied.

The aims of the work are following:

1. The evaluation of fertilizer values of sludge from reed systems and possibilities of it use for land reclamation or for agricultural purposes.
2. The evaluation of the reject water quality generated in reed systems and it impact on the operation of the wastewater treatment plant.
3. The determination of the possibility of new emerging pollutants removal on the example of selected pharmaceuticals and phthalates.
4. The determination of the processes of sludge stabilization on the basis on analysis of stable carbon isotopes.
5. The assessment of biocenosis biodiversity and processes in reed systems by using of metagenomic analysis.

The research was conducted in three reed systems for dewatering and stabilization of sewage sludge located in Gniewino, Nadole and Inwałd wastewater treatment plant. The system in Gniewino has been operated to the present time. However, due to changes in the municipalities wastewater management, the systems in Nadole and Inwałd have been closed.

ad.1.

To assess the fertilizer values of sludge from reed systems and the possibilities of it use for land reclamation or for agricultural purposes, the following determinations were carried out: dry matter, organic matter, nutrients compounds, heavy metals and phthalates, as well as the initial pot tests using stabilized sludge.

The dry matter concentration from Gniewino was similar to the values obtained by Nielsen[8] in reed systems where operational problems occurred. The values were on average 10%. In the other analyzed reed systems significantly higher dry matter concentration was obtained. It was 33.0% in Inwałd and 53.1% in Nadole. High dry matter concentration probably was a result of a long period without discharging of raw sludge (2 and 3 years, respectively). The conducted research confirmed that in well-operated reed systems, the dewatering process occurs very effectively. The effective dewatering is a very important process of sewage sludge treatment, as it contributes to a significant reduction in volume.

[6] Kołecka K., Obarska-Pempkowiak H., Gajewska M., (2018). Polish experience in operation of sludge treatment reed beds. Ecological Engineering, 120, 405-410

[7] Obarska-Pempkowiak H., Tuszynska A., Sobocinski Z., (2003). Polish experience with sewage sludge dewatering in reed systems. Water Science and Technology, vol. 48, no 5, 111–117

[8] Nielsen S., (2005). Sludge reed bed facilities: operation and problems. Water Science and Technology, vol. 51, no9, 99–107

Increasing the dry matter concentration to 9% reduces the initial volume to 14%. A dry matter concentration above 50% causes that sludge has only 2% of the initial volume.

The organic matter concentration in sludge from Gniewino reed system was on average 64% d.m. This value was higher than from the other reed systems (average organic matter concentration was from 41 to 62% d.m.[9,10]). On the other hand, in Inwałd and Nadole reed systems organic matter concentration was 41.6 and 28.6% d.m., respectively. High efficiency of both stabilization and dewatering processes resulted mainly from a long rest period (without discharging of sludge).

The Kiejdahl nitrogen concentration in the Gniewino reed system was from 4.8 to 5.8% d.m. High nitrogen concentration was probably caused by a large proportion of wastewater from the food industry, which was characterized by a high load of this element. In the other analyzed reed systems the concentration of nitrogen was 1.3% d.m. in Nadole and 2.2% d.m. in Inwałd. The concentration was more than twice lower than in the Gniewino system. The lower concentrations of nutrients compounds in Nadole and Inwałd wastewater treatment plant was caused by inflow of only domestic wastewater which has the lower concentration of nutrients. However, the nitrogen concentration in sludge from reed systems was significantly higher than in natural fertilizers, which on average is 0.45 for manure and from 0.12 to 0.45% d.m. for slurry[11].

In the case of phosphorus in the Gniewino reed system, its concentration was from 2.7 to 4.1% d.m. The high concentration of phosphorus in sludge was caused by a high proportion of industrial wastewater. Additionally, sludge from chemical precipitation of phosphorus in the wastewater treatment process was discharged to reed system together with surplus sewage sludge. In the other analyzed systems, average phosphorus concentration was 2.1 for Nadole and 0.7% d.m. for Inwałd. Low concentration of phosphorus in Inwałd is caused by the type of sludge which was primary one. This type of sludge is characterized by a much lower concentration of phosphorus than secondary sludge[12] (which was discharged to the other systems). However, the phosphorus concentration of sludge from reed systems was much higher than its average concentration in natural fertilizers (0.087 for manure, and 0.017 ÷ 0.10% for slurry[11]).

The concentration of heavy metals (cadmium, nickel, chromium, lead, copper, zinc) in the analyzed sludge was significantly below the permissible values for agricultural use, described by the Regulation of the Minister of Environment of 6 February 2015 on municipal

[9]Nielsen S., Bruun EW., (2015). Sludge quality after 10–20 years of treatment in reed bed systems. Environmental Science and Pollution Research, vol. 22, no 17, 12885-12891

[10] Peruzzi E., Nielsen S., Macci C., Doni S., Iannelli R., Chiarugi M., Masciandaro G., (2013) Organic matter stabilization in reed bed systems: Danish and Italian examples. Water Science and Technology, vol. 68, no 8, 1888-1894

[11] Roman M., Bernacka J., (2002). Problem komunalnych osadów ściekowych - możliwe rozwiązania w świetle przepisów polskich i unijnych. Materiały Konferencji nt."Uregulowania prawne i kierunki dotyczące gospodarki osadami w Polsce oraz Unii Europejskiej", Lublin

[12] Bień J., (2007). Osady ściekowe. Teoria i praktyka, Wydawnictwo Politechniki Częstochowskiej, Częstochowa 2007, 150 s.

sewage sludge[13]. The lowest concentration in all analyzed systems was found in the case of cadmium. On the other hand, the highest concentration was found for zinc. Low concentration of metals in sludge from reed systems was caused by the lack of heavy industry in the catchment areas of the analyzed wastewater treatment plants. The food industry from Gniewino significantly influences the increase of nutrients and organic matter concentration, but it is not a source of metals. The concentration of metals was characterized by high variability, both due to the types of metals and the objects in which they were determined.

In the case of phthalates, the concentration of DPB in analyzed sludge from the Gniewino reed system was from 2.1 to 6.4 mg/kg d.m. According to Cifci et al.[14] DBP concentration in sewage sludge from conventional wastewater treatment plants is from 2.8 to 6.2 mg/kg d.m. While, the concentration of DEHP in analyzed sludge was from 8.9 to 22.6 mg/kg d.m. Literature data indicates that the average concentration of DEHP in sewage sludge from conventional wastewater treatment plants is from 18 up to 490 mg/kg d.m.[15] Therefore, the concentration of DEHP in sludge from reed systems was much lower.

On the basis of preliminary pot tests, it was found that the addition of a small amount of stabilized sewage sludge resulted in much better plant growth. Grass (*Lolium perenne*) thrived well on sludge mixed with sand as well as on sludge itself. However, in the case of beans (*Phaseolus vulgaris L*) it was found that for the development of this plant the optimal proportion of sand: sludge was 5: 1.

ad.2

To assess the quality of reject water generated in the Gniewino reed system and its impact on the operation of the wastewater treatment plant, the following determinations were carried out: COD_{Cr}, BOD_5, total nitrogen and its forms, concentration of total phosphorus and orthophosphate. Also the susceptibility to biochemical degradation of reject water was calculated.

The reject water is formed during sewage sludge dewatering process, when the solid phase is separated from the liquid one. In the Gniewino wastewater treatment, the reject water is returned to the beginning of the wastewater treatment process. Therefore its quality is very important.

The concentration of the total suspended solids in reject water from the Gniewino reed system was significantly lower than in the inflowing wastewater. The highest value was 60 mg/l. According to Wójtowicz et al.[16] the concentration of the total suspended solids in the

[13] Rozporządzenie Ministra Środowiska z dnia 06 lutego 2015 r. w sprawie komunalnych osadów ściekowych (Dz. U. 2015 poz. 257)
[14] Cifci D.I., Kinaci C., Arikan O.A., (2013). Occurrence of Phthalates in Sewage Sludge from Three Wastewater Treatment Plants in Istanbul, Turkey. CLEAN - Soil, Air, Water, vol. 41, iss.9, 851-855
[15] Fromme H., Küchler T., Otto T., Pilz K., Müller J., Wenzel A., (2002). Occurrence of phthalates and bisphenol A and F in the environment. Water Research, vol. 36, iss. 6, 1429-1438
[16] Wójtowicz W., Jędrzejewski C., Bieniowki M., Darul H., (2013). Modelowe rozwiązania w gospodarce osadowej, Izba Gospodarcza "Wodociągi Polskie" Bydgoszcz, 498 s.

reject water below 300 mg/l does not affect the work of a treatment plant. In the analyzed reed system higher concentration of the total suspended solids was found at the first phase of the reject water formation. The dynamics of reject water outflow in the first phase is the most intense, which has an effect on "leaching" of the suspension from the beds and inferior retention in the system.

The concentration of organic matter expressed as BOD_5 in none of the analyzed samples exceeded the value of 100 mgO_2/l. Research carried out by Gajewska[17] showed that BZT_5 values in reject water from fermentation chambers after centrifuges were from 310 to 500 mg/l. So in reject water from the reed system BOD was significantly lower.

The concentration of organic matter expressed as COD in reject water from the Gniewino reed system was higher than obtained in the other reed systems, where the values were from 59 to 98 mgO_2/l[18]. This may indicate the operational problems in the Gniewino reed system. However, despite of operational problems in the analyzed system, the obtained results were lower than in the case of reject water after presses (on average from 365 to 446 mgO_2/l) or from fermentation chambers after centrifuges (on average from 980 to 1400 mgO_2/l)[19].

In reject water from the Gniewino reed system the concentration of total nitrogen was lower than the its value from other dewatering processes. The nitrogen concentration in reject water after dewatering of primary and secondary sludge in presses was from 26 to 31 mg/l, while in reject water from the fermentation chambers after centrifuges was much higher and amounted to 710-1309 mg/l[19]. In the Gniewino reed system, the nitrate nitrogen concentration was very variable (from 10.4 to 129 mg/l), and its share in total nitrogen was from 5.39 to 46.24%. Also nitrite nitrogen was characterized by very high variability, and its share was from 0.01 to 20.22%. In the analyzed system in Gniewino (except for 2 samples), ammonium nitrogen was the predominant form of nitrogen. However, the ammonium nitrogen concentration in Gniewino was significantly lower than in reject water from fermentation chambers after centrifuges, which according to Gajewska[17] amounted to from 692 to 1330 mg/l. Relatively high concentrations of ammonium nitrogen in the Gniewino system may indicate the anaerobic conditions and confirm that the reed system in Gniewino was not working properly.

Research carried out by Uggetti et al.[20] indicated that the total phosphorus in reject water from reed systems was from 7 to 25 mg/l, while the concentration in the Gniewino system was significantly higher and amounted from 26.9 to 42.8 mg/l. It was probably caused

[17] Gajewska M., (2011). Oczyszczanie odcieków z mechanicznego odwadniania przefermentowanych osadów ściekowych w wielostopniowych złożach hydrofitowych, Inżynieria Ekologiczna, nr 25, 86-98
[18] Uggetti, E., Llorens, E., Pedescoll, A., Ferrer, I., Castellnou, R., Garcá, J., (2009a). Sludge dewatering and stabilization in drying reed beds: characterization of three fullscale systems in Catalonia, Spain. Bioresource Technology, 100, 3882–3890
[19] Gajewska M., Obarska-Pempkowiak H., (2008). Wpływ zawracania odcieków z odwadniania osadów ściekowych na pracę oczyszczalni ścieków. Przemysł Chemiczny, tom 87, nr 5, 448-452
[20] Uggetti E., Llorens E., Pedescoll A., Ferrer I., Castellnou R., Garcá J., (2009b). Sludge drying reed beds: a case study. Journal of Residuals Science and Technology, vol. 6, no 1, 57–59

by very high concentration of total phosphorus in the accumulated sludge and its outflow from the system. The organic form of phosphorus prevailed in the reject water, which confirms the above conclusion. In the reject water from fermentation chambers the phosphorus concentration was 336-477 mg/l for P_{og} and 235-387 mg/l for $P\text{-}PO_4^{3-}$ respectively. In Gniewino much lower values were found.

In Gniewino reject water is returned to the beginning of the wastewater treatment process. For this reason it susceptibility to biochemical degradation is very important factor. In 2017, the quotient COD:BOD_5 showed that reject water was moderately or easily biodegradable. A less favorable ratio was found in the first hour of outflow. In the next 10 hours, this ratio did not change or was reduced. In 2018, the value of COD: BZT_5 indicated a significantly worse susceptibility to biodegradation [21]. In April 2018, the quotient of COD: BZT_5 in samples of reject water exceeded 5, which according to Miksch and Sikora[22] showed the lack of susceptibility to biodegradation. Regular discharging of sludge to the reed system caused that reject water contained more easily decomposed matter, and thus the quotient of COD: BZT_5 was more favorable. BOD_5:N_{tot} values in all analyzed samples were definitely too low compared to the recommended values. However, the average BOD_5:N_{tot} ratio in wastewater flowing into the treatment plant was relatively high and amounted to 6.8. Therefore, the introduction of reject water from the reed system to inflowing wastewater resulted did not affect the proper work of the wastewater treatment plant.

Although the Gniewino reed system was not working properly, the quality of reject water was very good. In the case of the total suspended solids, BOD_5 and COD, their values in reject water were much lower than in inflowing wastewater. In the case of nitrogen and phosphorus, their concentrations in reject water were higher than in inflowing wastewater. However, due to little amount of reject water generated and returned to the beginning of the treatment process, there is no danger of deterioration of the treatment plant work.

ad. 3.

To determine the possibility of new emerging pollutants removal, the determinations of phthalate concentration in sludge from the reed system and selected pharmaceuticals in the liquid phase of sludge as well as in reject water were carried out. A balance of pharmaceuticals from the reed system was also made. It took into account the amount of inflowing and outflowing pharmaceuticals.

In the Gniewino system, the highest concentration of DPB (di-n-butyl phthalate) was found at a depth of 20 to 60 cm. It was 6.4 mg/kg d.m. (for sludge layer at a depth of 20-40 cm) and 5.5 mg / kg s.m. (for sludge layer at a depth of 40-60 cm), respectively. While, the lowest concentration amounted to 2.1 mg/kg d.m. was in the lowest layer. DPB is permanent

[21] Heidrich Z., Kalenik M., Podedworna J., Stańko G., (2008). Sanitacji wsi. Wydawnictwo Seidel-Przywecki, Warszawa
[22] Miksch K., Sikora J., (2010). Biotechnologia ścieków. Wydawnictwo Naukowe PWN, Warszawa

organic compound. Its degradation is possible, but it requires a large amount of oxygen[23]. The deepest sludge layer was stabilized the longest, additionally stabilization occurred before operation problems. Thus, oxygen was likely to be available, which contributed to a decrease in DPB concentration.

In the case of DEHP (di-2-ethylhexyl phthalate) in sludge from the Gniewino system, it was found an increase of the concentration with a depth (from 8.9 to 22.6 mg/kg d.m.). However, despite the increase of DEHP concentration, it was much lower than in sewage sludge stabilized by using of conventional methods. The low concentration of DEHP may indicate that it was significantly biodegradable during stabilization process. The remaining part of phthalate is probably no longer susceptible to degradation or requires a longer time. It can be assumed that the increase of concentration along the depth is caused by the decomposition of organic matter, while at the same time DEHP is kept in the system.

So far, the research on concentration of pharmaceuticals in the liquid phase of sludge and in reject water from dewatering processes was not conducted. The ibuprofen values obtained in the analyzed samples in Gniewino were much lower than the values given for wastewater in the literature, which ranged from 3.73 to 353 μg/l[24]. According to Zhang et al.[25] concentration of paracetamol in wastewater was above 6 μg/l. While, in the analyzed samples from Gniewino, paracetamol was not found in any samples in 2017. Its highest concentration was in the liquid phase of sludge in September 2018 and it was 1.076 μg/l. In the case of naproxen in wastewater, it was found that its average concentration was from 2.02 to 8.50 μg/l[25]. During the research in Gniewino, naproxen appeared in a few samples, and its concentration was significantly lower than in wastewater. Average concentration of diclofenac and its metabolites in wastewater was 2.2 μg/l for diclofenac, 0.42 μg/l for 4OH diclofenac and 0.26 μg/l for 5OH diclofenac[26].

In several samples, the presence of pharmaceuticals in reject water was found, although it was not present in the liquid phase of sludge. In the case of ibuprofen only in September 2017, its presence in reject water was not found. In the other samples, it was present in reject water, although it did not appear in the liquid phase of sludge or its concentration in sludge was lower than in reject water. Differences in the presence and concentration of the analyzed pharmaceuticals in the reed system are currently difficult to explain. They can be affected by the transformation of pharmaceuticals in the human body, during the treatment of wastewater in treatment plants, as well as in the reed system itself. During these transformations, pharmaceutical metabolites may be formed. For example, in the

[23] Aparicio I., Santos J. L., Alonso E., (2009) Limitation of the concentration of organic pollutants in sewage sludge for agricultural purposes: a case study in South Spain. Waste Management, 29, 1747–1753
[24] Santos J.L., Aparicio I., Callejón M., Alonso E., (2009). Occurrence of pharmaceutically active compounds during 1-year period in wastewaters from four wastewater treatment plants in Seville (Spain). Journal of Hazardous Materials, vol. 164, 1509–1516
[25] Zhang L., Hu J., Zhu R., Zhou Q., Chen J., (2013). Degradation of paracetamol by pure bacterial cultures and their microbial consortium. Applied Microbiology and Biotechnology, vol. 97, no 8, 3687-3698
[26] Stülten, D., Zühlke, S., Lamshöft, M., Spiteller, M., (2008). Occurrence of diclofenac and selected metabolites in sewage effluents. Science of the Total Environent, vol. 405, 310–316

case of diclofenac, 7 metabolites have been identified in natural waters. In addition, new compounds may appear as a result of transformations under aerobic and anaerobic conditions[27].

In most of the analyzed samples, there were no ibuprofen, paracetamol, flubiprofen and naproxen. The exceptions were samples from September 2018, where in most cases these pharmaceuticals were present, both in the liquid phase of sewage sludge and in reject water. A presence of the above-mentioned pharmaceuticals (apart from naproxen) in the liquid phase of sludge was a result their high concentrations in influent to the wastewater treatment plant. However, in the samples, where the efficiency of pharmaceuticals removal could be calculated, it was very high from 93.2 to 99.8%.

ad.4

The carbon isotopes were determined to confirm the stabilization process.

Stable carbon isotopes are indicators of the origin of organic matter and processes. The organic matter of terrestrial origin (allochthonous) is depleted from the 13C isotope (usually δ13C <-28 ‰) compared to the organic matter of indigenous origin (δ13C ~ -22 ‰). The value of δ13C index is also changed during sedimentation, degradation and transformation of organic matter[28]. Lower δ13C-TOC values suggest that the mineralization process is less effective. This is caused by the release of CO_2, which occurs during the mineralization process. It provides to the increase of the δ13C value in the accumulated material[29].

The values of δ^{13}C-TOC indicator in the Gniewino reed system were from - 26.38 to - 24.40 ‰. The values obtained in Gniewino confirm that part of the organic matter, which was discharged to the system, was transformed there, while part of the organic matter was also produced in the system. The lowest value was obtained in the deepest layer in bed no. 3, where the reed poorly covered the bed due to operational problems. It can be assumed that the mineralization process in this bed occurred least efficiently. Also, a low value was obtained in the bed no. 1, which has been operated for only one year. While, the highest value of δ^{13}C-TOC was in the deepest layer in bed no. 6 very well covered with reeds. This confirms that the presence of reeds, as well as a correspondingly long operation time, affect the intensity of the mineralization process. The better covering the bed with reed and longer the time of deposit, the more effectively the process of organic matter decomposition occurs.

[27] Lonappan L., Brar S.K., Das R.K., Verma M., Surampalli R.Y., (2016). Diclofenac and its transformation products: environmental occurrence and toxicity - a review. Environment International, vol. 96, 127–138

[28] Torres I. C., Inglett P.W., Brenner M., Kenney W. F., Reddy K. R., (2012). Stable isotope (δ^{13}C and δ^{15}N) values of sediment organic matter in subtropical lakes of different trophic status. Journal of Paleolimnology, vol. 4, 693-706

[29] Hellings L., Dehairs F., Tackx M., Keppens E. and Baeyens W., (1999). Origin and fate of organic carbon in the freshwater part of the Scheldt Estuary as traced by stable carbon isotope composition. Biogeochemistry, vol. 47, 167-186

Higher values of δ13C-TOC index were obtained in reed beds, in which mineralization process was more effective[30].

ad.5.

The metagenomic analysis make possible to estimate the biodiversity and composition of bacterial biocenosis in the reed system in order to determine the direction of changes in sludge during stabilization process.

The species biodiversity was determined on the basis of the α index, which is estimated on the basis of the effective number of species and the average species diversity attributable to the operational taxonomic unit (OTU). The bed no. 6, which was the longest operated and well covered with reed, showed statistically higher biodiversity than the other analyzed beds due to higher values of the α index as well as the number of unique DNA sequences per 1000 readings. The lowest biodiversity was found in bed no. 1, which was operated only for a year. In the vertical profile of the sludge, the highest biodiversity of microorganisms was found in the surface layers (depth 0-25 cm). This was probably due to the way of sludge discharging (from surface) and better oxygen availability.

Due to participation of unidentified types of bacteria, the biocenosis of the analyzed reed beds formed an intermediate structure between the soil ecosystem and biocenosis of activated sludge [31]. In wastewater treatment systems biocenosis of activated sludge is well recognized. In all analyzed samples it was found the dominant role of three bacterial species: *Bacteroidetes*, *Firmicutes* and *Proteobacteria*. The percent of these three groups representatives in each sample was above 10% of the general population. The first two types are known as organisms with dominating heterotrophic metabolism, which may indicate a high biocenosis potential to the biodegradation of organic matter, even with a very complex structure[32].

In the sludge samples from beds no. 6 and 1, representatives of *Nitrospirae* type were a significant group. The percent of bacteria of this type in sludge from above mentioned beds was from 2 to 6%. For bed no 3 the percent of these bacteria was less than 1%. *Nitrospirae* bacteria include aerobic bacteria of the genus *Nitrospira*, which are responsible for the second phase of nitrification.

In contrast to the 6 and 1 beds, a unique component of the biocenosis of the bed no. 3 was bacteria: *Spirochaetes* and *Acidobacteria*. Representatives of *Spirochaetes* have the ability to settle different ecological niches. They are mainly free-living microorganisms that prefer anaerobic conditions. In the case of the *Acidobacteria* type, its representatives are

[30] Kołecka K., Gajewska M., Obarska-Pempkowiak H., Rohde D., (2017a). Integrated dewatering and stabilization system as an environmentally friendly technology in sewage sludge management in Poland.
[31] Bach E.M., Williams R.J., Hargreaves S.K., Yang F., Hofmockel K.S., (2018). Greatest soil microbial diversity found in micro-habitats. Soil Biology and Biochemistry, vol. 118, 217-226
[32]Gibiino G., Lopetuso L.R., Scaldaferri F., Rizzatti G., Binda C., Gasbarrini A., (2018). Exploring Bacteroidetes: Metabolic key points and immunological tricks of our gut commensals. Digestive and Liver Disease, vol.50, iss. 7, 635-639

commonly found in soils, but they prefer a low pH environment[33]. The presence of *Spirochaetes* and *Acidobacteria* bacteria, and the limited presence of *Nitrospira* type, additionally confirms the insufficient oxygenation of the bed no 3 and probably acidification of stabilized sludge[34].

The most important achievements resulting from the conducted research:

- For the first time, comprehensive research of reed systems located in Poland was carried out. The research included the quality of sludge dewatered and stabilized in the reed system and generated reject water as well as biocenosis of the reed system.
- It was shown that sludge stabilized in the reed systems was characterized by high concentration of nutrients as well as low concentration of metals and phthalates, and can be used as a fertilizers or a soil-forming component.
- It was also shown that reject water was good quality and it could be returned to the beginning of a wastewater treatment plant without any negative impact on its operation.
- For the first time, the determinations of pharmaceuticals were carried out in reed systems used for dewatering and stabilization of sewage sludge. Based on the results and calculations, it was found that the analyzed pharmaceuticals were efficiency kept in the reed beds.
- Research of stable carbon isotopes carried out in the Gniewino reed system confirmed that the mineralization process was taking place. The efficiency of this process depends both on the time of operation as well as the covering of beds with reeds.
- The metagenic analysis allowed to determine the biodiversity and composition of biocenosis of the reed system. Based on this analysis, it was found that the biodiversity of microorganisms from reed systems depends on the time of operation as well as the density of covering of beds with reeds. The highest species biodiversity occurred in the surface layers of the analyzed beds. Whereas the lowest biodiversity was in case of bed the shortest operated. It was shown that decomposition of organic matter in the reed system occurred both in aerobic and anaerobic conditions.

The possibility of using the results:

- The results has demonstrated that reed systems can be used for treatment of sewage sludge. It was confirmed that in properly operated facilities, dewatering and stabilization processes are very effective, and the obtained material can be used as a fertilizer or for soil reclamation. This was confirmed by preliminary pot tests, which showed that the addition of stabilized sludge from reed systems contributed to better plant growth.

[33] http://ssu.ac.ir/cms/
[34] Kielak A.M., Barreto C.C., Kowalchuk G.A., van Veen J.A., Kuramae E.E., (2016). The Ecology of *Acidobacteria*: Moving beyond Genes and Genomes. Front Microbiology, vol. 7, 744

- It has been shown that due to good quality of reject water and its little quantity, it can be safely returned to the beginning of the wastewater treatment process without adversely affecting the treatment plant's operation.
- It has been shown that the analysis of stable carbon isotopes can be an indicator of the mineralization processes in reed systems.
- It has been confirmed that metagenomic analysis can be used to assess the course of processes and their control to obtain a product of the expected quality.

5. Description of other scientific and research achievements

a) Before receiving of PhD degree

I started my master's studies in 1997 at the Faculty of Environmental Engineering at the Gdańsk University of Technology (currently the Faculty of Civil and Environmental Engineering). In 2002, under the supervision of Prof. PhD MSc Eng. Krystyna Olańczuk-Neyman, I prepared a master's thesis entitled " The assessment of groundwater quality of the Cretaceous floor on selected Gdańsk intake stations in the light of the new regulation " and I graduated with a very good result, obtaining the title of Master of Science in environmental engineering specialization in sanitary engineering.

From October 2002, I continued my study as a student of the PhD program "Geotechnics and Environmental Engineering" at the Faculty of Hydraulic and Environmental Engineering at the Gdańsk University of Technology (currently the Faculty of Civil and Environmental Engineering). Initially, my interests concerned the possibility of water treatment using magnetizers (Att. 4, II E 29 and 30). Due to the change of the supervisor, I changed my interests to hydrophyte systems. Initially, I was interested in the cultivation of energetic willow irrigated with wastewater and sewage sludge (Att. 4, II E 26 and 28). Finally, I decided to start the research on the use of reed systems to utilize sewage sludge. Consequently, I wrote a PhD work on this topic under the supervision of Prof. PhD MSc Eng. Hanna Obarska-Pempkowiak. The realization of the PhD thesis was possible thanks to receiving the grant no N-207,064 31/3100 entitled "The long-term changes in the speciation of heavy metals in sewage sludge utilized in reed beds". I defended my PhD thesis under the same title as the grant on September 25, 2007.

Due to the lack of reed systems operated during long time in Poland, the samples was collected from four Danish reed systems. The aim of the PhD thesis was to assess the concentrations of labile and stable heavy metals in sewage sludge from reed beds. Changes in the quality of sewage sludge during long-term stabilization in reed facilities were also determined. Based on the obtained results, it was found that due to their concentrations, the analyzed metals could be divided into 4 groups. The first group was cadmium, which was characterized by the lowest concentrations about 1 mg/kg d.m. The second group created three metals: lead, chromium and nickel. Their concentrations were at the level of several dozen mg/kg d.m. The third group were Cu and Zn, whose concentrations were at the level of several hundred mg/kg d.m. However, the highest concentrations was found in case of aluminum and iron, they amounted to several thousand mg/kg d.m. The concentration of heavy metals in the analyzed sludge was below the permissible values for their agricultural use. In most of analyzed sludge samples, the metals were primarily associated with the most stable fraction. However, the most mobile metal was zinc. The specialization of sludge utilized in reed beds showed that after long-term stabilization sludge can be considered as a safe product.

b) After receiving of PhD degree

My research interests after obtaining a PhD degree can be qualified in the following areas:

1. Research on fertilizing properties of various sewage sludge and sediments
2. The use of natural methods in wastewater management
3. The analysis of the impact of wetlands on the environment
4. The specific pollutants in wastewater treatment plants

ad.1

The research interests concerning: "Research on fertilizing properties of various sewage sludge and sediments" are presented in the following publications: Att. 4 II A 4, 8, 9, 12, II 19, 20, 22.

The aim of the research was to determine the quality of sewage sludge stabilized in reed systems located in conventional wastewater treatment plants as well as in wastewater treatment plants with a high share of industrial wastewater and sediments from ecological systems used in the third degree of wastewater treatment. The obtained results allowed to determine their fertilizing properties.

Initially, the above-mentioned topic was a continuation of the issues from PhD thesis.

Research conducted in reed systems used for utilization of sewage sludge from conventional wastewater treatment plants showed that it was stabilized due to a decrease of organic matter concentration average from 51.4 to 36.6% d.m. In all analyzed facilities the lowest concentration of organic matter was in sludge from deepest layers which was the longest utilized. Sewage sludge utilized in reed beds in the long term was characterized by a decrease of Kiejdahl nitrogen concentration with a depth (average from 2.8% to 1.5% d.m.). The decrease of nitrogen concentration was probably caused by the physical and chemical processes occurs near the reed rhizomes and roots and relatively high nitrogen uptake by the plants. However, despite the decrease of nitrogen concentration, it was still very high (much higher than in the manure and slurry). Concentration of total phosphorus in sludge from reed beds increased average from 3.5 to 5.2% d.m. with depth. And concentration of heavy metals in sludge was significantly below the permissible values for agricultural use.

In 2009, as the main contractor, I received the research grant "Transformation of phosphorus compounds in ecological treatment systems" (Att. 4 II J 7) and in 2010 the target subsidy of the Voivodship Fund for Environmental Protection and Water Management in Gdańsk (Att. 4 II J 8). Thanks to the co-financing, the research was extended about the fertilizing properties of bottom sediments from ecological systems used as third stages of wastewater treatment.

Based on the results it was found high nitrogen concentration average from 3.0 to 4.2% d.m. In addition, these sediments were a very rich source of bioavailable phosphorus. The proportion of biologically available forms in bottom sediments, determined on the basis of phosphorus speciation, was about 80% of total phosphorus. It was also shown that concentration of selected heavy metals in the analyzed sediments did not exceed the

permissible values for agricultural use. The barrier to agricultural use of sediments was high content of water as well as the presence of pathogens (pathogenic bacteria, protozoa, fungi and parasites).

In 2015, I started cooperation with the Gniewińskie Municipal Company and obtained a subsidy for research from it (Att. 4 III F 1). This allowed to conduct the research on the Polish reed system located at the treatment plant. It is significant that in this wastewater treatment plant, the share of industrial sewage was about 35%.

In the analyzed reed system, which was operated a shorter time than the Danish facilities, an increase of dry matter concentration (average from 1.1% to 15.5%) and at the same time a decrease of the organic matter concentration (average from 71.2% to 52.4% d.m.) was observed. Sludge was characterized by a very high Kiejdahl nitrogen concentration, which was on average 3.6% s.m. Such high nitrogen concentration was caused by a high proportion of wastewater from the food industry (dairy and fish industry) in inflowing wastewater. The average phosphorus concentration was 3.5% d.m. and was similar to those obtained in sludge from Danish systems. Also in the case of the Polish facility, concentration of heavy metals was below the permissible values to agricultural use.

In summary, both sewage sludge stabilized in reed systems (conventional and with a high proportion of industrial wastewater), as well as bottom sediments from the ecological treatment system was characterized by high concentrations of nutrients compounds. These values were much higher than in the case of natural fertilizers, such as slurry or manure. In all the analyzed sludge and sediments, low concentration of heavy metals was found. The problem in the case of bottom sediments was the presence of pathogenic microorganisms and their high content of water. These problems did not occur in sludge stabilized in reed systems.

ad.2

The issues related to the topic "The use of natural methods in wastewater management" are presented in the following publications: Att. 4 II A 2, 6, 7, II E 3, 6, 15, 16.

The aim of this scientific activity was to present the possibilities of new applications of the hydrophyte method in the management of wastewater and sewage sludge.

In 2010, I started working with members of the research group under the direction of Prof. PhD MSc. Eng. Hanna Obarska-Pempkowiak. In 2015, the research group received the project "Strategies for sustainable communal wastewater management in the Baltic Sea Region (SUWMAB)" (Att. 4 II J 4).

The following issues were taken into account in the conducted research: (i) local wetlands treatment plants intended for biological treatment of wastewater (from 15 to 750 inhabitants) after initial mechanical treatment in septic tanks; (ii) single-family treatment plants using the hydrophyte method, (iii) pilot plants operating in a technical scale for the treatment of reject water from mechanical dewatering after digester of sewage sludge, (iv) reed systems for dewatering and stabilization of sewage sludge from conventional wastewater treatment plants.

The conducted research confirmed that there are many different processes in the hydrophite facilities which contribute to the removal of pollutants. This is the result of specific conditions connected to the development of microorganisms and hydrophytes. Their cooperation contributes to the intensification of the oxidation and reduction reactions responsible for the removal of pollutants. These processes are supported by sorption, sedimentation and assimilation processes. In local and single-family wastewater treatment plants the obtained results confirmed high efficiency of organic matter removal expressed in BOD_5 and COD (64.0-92.0% and 65.7-89.6%, respectively). For nitrogen the removal efficiency was 44.0-77.0%, and for phosphorus 24.0-66.0%. In the case of hydrophyte facilities for reject water treatment, it was found that, despite the very bad quality of reject water, high pollution removal efficiency took place. Average efficiency removal for COD was 77.7% and for $N\text{-}NH_4^+$ - 83.3%. In case of the reed systems for dewatering and stabilization of sludge, it was confirmed that the obtained material can be used as a fertilizer.

The increase of popularity of the hydrophyte method results from the progress related to applications and elimination of possible defects of this technology. For example, in the past it was assumed that constructed wetlands could be used for wastewater treatment up to 2000 PE (Person Equivalent) due to the high demand for a unit area. Recently unit area has significantly decrease and hydrophyte facilities are used even for 3500 PE. The selection of right technologies using of multi-stage beds with horizontal and vertical wastewater flow has allowed to reduce the unit area to 1.75 m^2/PE (compared to the previously recommended values of 4-6 m^2/PE).

ad.3

The issues related to the "Analysis of the impact of hydrophyte facilities on the environment" are presented in the following publications: Att. 4 II A 2, 4, E 1, 2, 3, 14.

The aim of scientific activities in the third area of interest was the assessment of the impact of hydrophyte systems on the natural environment. This assessment was made on the basis of the conducted research in the area of issues 1 and 2 and knowledge gained during their implementation.

The analysis showed that reed systems meet the requirements of the circular economy. The circular economy assumes the minimizing of environmental impact during the creation of products. This is achieved through the selection of substrates and technology that make possible to reuse of components and energy emitted into the environment (pollutants). Hydrophyte systems meet the requirements of circular economy in the following areas: (i) re-use of water (gray wastewater treatment for reuse or recreation, treatment and storage of rainwater, removal of persistent organic pollutants at low concentrations, 3rd stage of wastewater treatment for the re-use of treated wastewater), (ii) recovery of nutrient compounds (the production of fertilizers from sewage sludge, preliminary fertigation treatment (iii) recovery of phosphorus compounds from wastewater by use of new filters for effective adsorption, (iv) energy production (biogas plants - hydrophyte systems for treatment

of post-digestion water, wetland systems as places for biomass production), (v) ecosystems (multifunctional hydrophyte systems for rainwater collection, recreation and artificial wetlands, creation of artificial ecosystems - green roofs, green walls, green areas inside buildings, parks). In addition, the hydrophyte systems remove CO_2 from the atmosphere and they create the environment for a habitat of many organisms, contributing to the increase of biodiversity. They also increase transpiration, contribute to the accumulation of water improving retention processes.

In addition, in 2015, scientific activities in the above-mentioned area were extended to research of reject water from the reed system, financed by the Gniewińskie Municipal Company (Att. 4 III F 1). The conducted research showed that the use of a reed systems for dewatering and stabilization of sewage sludge generates reject water which do not adversely affect the processes of wastewater treatment.

The implementation of the reed method for utilization of sludge in Poland could solve the problems of small and medium-sized wastewater treatment plants with the management of sewage sludge, without generating of reject water with high concentration of pollutants. The presented theoretical knowledge and obtained results are the basis for further work and expanding knowledge about the use and operation of reed systems for dewatering and stabilization of sewage sludge.

ad.4

The topic: "Specific pollutants in wastewater treatment plants" is presented in the publications: Att. 4 II A 1, 4, E 9

The aim of the research was to determine the specific pollutants including heavy metal speciation and selected pharmaceuticals in wastewater treatment plants with different technologies of wastewater and sewage sludge treatment.

Initially, as in the case of the first research area, the studies was a continuation of the issues from PhD thesis and included heavy metal speciation. Speciation determination was conducted using the sequential extraction method modified according to the BSR procedure. On the basis of extraction, fraction (I) - ion exchange and carbonate (most mobile) fraction, fraction (II) - hydroxide (associated with iron and magnesium oxides and hydroxides), fraction (III) - organic and fractions (IV) - residual (the most stable) were determined. It was found that the speciation of the analyzed metals was affected by the rest time, i.e. the time when raw sludge was not discharged. The percentage of mobile fractions (I), (II) and (III) in sludge from reed beds, where raw sludge was not discharged for more than 2 months, did not exceed 10.0%. While, in reed bed, where the sludge was discharged only 2 weeks before sampling, the share of mobile fraction was clearly higher and in several samples exceeded even 30.0%. The fraction (IV) predominated in all analyzed sludge, although a relatively high iron concentration was also observed in fraction (II).

In 2017, I received a MINIATURA project No. 2017/01/X/ST8/00844 entitled "Impact of municipal wastewater treatment processes on the distribution of selected new

emerging pollutants". Thanks to the funding, I expanded the research on selected pharmaceuticals in wastewater treatment plants. As part of the research, I collected average 24-hour samples of inflowing and outflowing wastewater, an average sample of surplus sludge and reject water after sludge treatment processes. The obtained results indicated that in the case of ibuprofen, naproxen and paracetamol, there was a significant increase in concentration of these pharmaceuticals in inflowing wastewater in the autumn. The above-mentioned drugs have analgesic and antipyretic effects (ibuprofen, naproxen additionally have anti-inflammatory effect). Their higher concentration was associated with the period of flu and colds and their greater intake by people. The efficiency of ibuprofen removal from wastewater was very high and in most samples it was over 95%. The efficiency of paracetamol removal was even higher, ranging from 99% to 100%. This drug was present in most samples of the liquid phase of sludge, but its concentration was relatively low (0.026 - 2.867 μg/l).

In comparison to the other analyzed pharmaceuticals, the lowest removal efficiency was found in the case of diclofenac. In many samples, its concentration in outflowing wastewater was higher than in inflowing one. The efficiency of metabolites: 4OH diclofenac and 5OH diclofenac removal was characterized by high variability. In some of the samples, the metabolites were completely removed. However, an increase in their concentration in treated wastewater was also found. Diclofenac and its metabolites were found in the majority of samples of liquid phase of sludge.

Due to the fact that the project ended in October 2018, only a part of the results were published (Annex 4 II A 1). Currently, two more publications are being prepared, which will be published in the near future.

Further scientific activities

At the end of 2018 and at the beginning of 2019, I started the implementation of 3 international projects (Annex 4 II J 2, 3, 4).

As part of these projects, the following scientific activities will be undertaken:

1. The participation in the creation of an internet platform as a place of contact between scientists, designers, contractors and local and national authorities associated with broadly understood environmental engineering. These activities will help in the implementation and the making of decisions, which aims to improve the quality of the Baltic Sea waters.
2. Research on the impact of excess flow from the combined sewerage system to the sea in urbanized areas. Creating a mathematical model of flow as well as actions to prevent it.
3. Research on the use of reed beds to manage algae thrown to the seashore to obtain fertilizer from waste. It is planned to perform an analysis of the impact of these activities on the quality of Baltic Sea waters.

6. Information on didactic, organizational and scientific activities and cooperation and popularization of science

As a student of the PhD study "Geotechnics and Environmental Engineering" I taught classes at the Faculty of Hydraulic and Environmental Engineering (currently the Faculty of Civil and Environmental Engineering). I taught classes for both daytime and evening studies, including a project on waterworks, sewage systems, heating installations, drainage systems and auditorium exercises of mechanical devices as well as installations and sanitary networks for students of the Faculty of Architecture at the Gdańsk University of Technology. Then from 2008-2010 I taught classes at the Faculty of Civil, Environmental Engineering and Architecture of the University of Sciences and Technology in Bydgoszcz in 1st and 2nd degree. I taught a project on waterworks, a laboratory and lecture on chemistry. From 2009 to 2012, I conducted classes at the Department of Sanitary Engineering, such as: projects on a heating installations, a waterworks, a sanitary techniques, a project and auditorium exercises of ventilation. In 2012, I changed the department. In the Department of Water and Wastewater Technology I have been teaching the following classes: a laboratory on chemistry (for environmental and civil engineering students), a water and wastewater technology, auditorium exercises on air protection, water bodies protection, a project on natural methods of wastewater treatment.

Together with a group of lecturers in 2018, we worked out a new program for the subject of Water and Wastewater Technology.

Since 2018 I have been the coordinator of the POWER 3.5 program in my department. This program is designed to better adapt the programs of 2nd degree studies to the needs of the labor market.

Since 2009, I have been the supervisor of 61 and the reviewer of 44 Master's thesis and the supervisor of 56 and the reviewer of 47 engineering diploma thesis. I was also an assistant supervisor of the PhD thesis of MSc. Marzena Stosik entitled "The variability of characteristic pollutants in the process of rainwater treatment in the hydrophyte system". The student obtained the PhD degree in 2018.

In 2017 and 2018, I took part in the sessions and assessment of presentations and posters on the Interdisciplinary Academic Conference on Environmental Protection "IAKOŚ". This is the conference organized by students and PhD students from the scientific clubs of the Gdańsk University of Technology. At the above-mentioned conferences, I was a member of the scientific committee.

I take active part in the organizational work of the Department of Water and Wastewater Technology. From 2014 until now I am a member of the Faculty Committee on the Quality of Education. In 2016, I was a member of the Commission for Verifying of Education Effects in the field of environmental engineering. My task was to collect data and check the realization of outcomes from the teaching programs. In addition, from 2017 I was a

deputy member of the Program Committee, and at the beginning of 2019, I became a full member of this committee.

In 2016, I was the secretary of the 15th International Conference on "Wetland Systems for Water Pollution Control" organized under the aegis of IWA (International Water Association). Over 200 people from many countries participated in the conference. For the organization of this conference, in 2017 I was awarded by the Rector of the Gdańsk University of Technology with the 1st degree Team Award for the organizational activities.

Currently, I am the secretary of the National Conference on "Innovation in Environmental Engineering", which will take place on 24-15 June, 2019 in Gdańsk.

I cooperate with many universities and scientific institutions (Attachment 4 III E 1, 2, 3, 4). The most important are: HELCOM and the SYKLI Institute from Finland, the International Center for Biogas and Bioenergy (IBBK) (Germany), the University of Aarhus (Denmark).

I also cooperate with many wastewater treatment plants, including WWTP in Gniewino, Swarzewo or Gdańsk ("Wschód" WWTP). The experience from scientific activities was used to prepare three expert opinions on the possibility of using the reed method for dewatering and stabilization of sewage sludge in wastewater treatment plants in Kamień Pomorski, Bytów and Warta. The cooperation with the Gniewino WWTP resulted in the implementation of the application on the modernization of existing reed beds. Currently, 3 beds (from 6 ones) have been modernized. In the following years, it is planned to modernize the remaining beds and build two new ones.

At the editorial offices request, I reviewed 14 articles in following journals: Bioresource Technology, Environmental Science and Pollution Research, Ecological Engineering, Journal of Water and Land Development, Polish Journal of Environmental Studies.

The series of publications from the journal "Rynek Instalacyjny" can be treated as the dissemination activities of science. These publications present the advantages and disadvantages of reed systems, principles of their design and operation, as well as research results on the quality of stabilized sewage sludge and the possibilities of it use.

At the "WATER WASTEWATER and SLUDGE" conference, which took place in Warsaw on 12-13.12.2017, I presented the lecture on "Polish and European experience with the reed systems method for dewatering and stabilization of sewage sludge". The lecture was addressed to the operators of the wastewater treatment plants.

7. Summary of the achievements

No	Type of the achievements	Number	
		Before receiving of the PhD degree	**After receiving of the PhD degree**
1	**Science publications, including:**	**7**	**35**
	journals from JCR list	0	11
	monographs	0	2
	chapters in international books	0	2
	chapters in a national books	0	7
	peer-reviewed journal	7	13
2	**Projects, including:**	**1**	**8**
	international	0	5
	national	1	3
3	**Participation in organizational/ scientific committees of conferences**	**1**	**4**
4	**Conferences**	**3**	**7**
	presentations	3	4
	active participation	0	3
5	**The creative professional work, including:**	**0**	**4**
	Implementations	0	1
	opinions and expertises	0	3
6	**Auxiliary supervisor the PhD**	**0**	**1**
7	**Supervisor of thesis, including:**	**0**	**117**
	engineering works	0	56
	master's thesis	0	61
8	**Reviewer of thesis, including:**	**0**	**91**
	engineering works	0	47
	master's thesis	0	44
9	**Citations (without self-citations)**	**0**	**53 (41)**
10	**H- index**	**0**	**5**
11	**Impact Factor**	**0**	**18,978[35]**
12	**Points according to the Ministry of Science and Higher Education**	**35,0**	**400,0[36]**
	including own contribution	26,6	203,35

[35] In the publications from 2018 and 2019, IF from 2017 was taken
[36] According to the year of publishing