Auto-abstract

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

1. First and last name

Eliza Anna Kulbat

2. Awarded diplomas and academic degrees

1990 Obtaining the Master of Science degree in Environmental Engineering Department in the field of Environmental Engineering at the Faculty of Environmental Engineering at the Gdansk University of Technology (actually: the Faculty of Civil and Environmental Engineering). Master's degree in water management, the title of the master thesis: "Application of peat filter for sorption of heavy metals from industrial wastewater"

2000 Obtaining the Doctor degree of technical sciences in environmental engineering with a specialization in water and wastewater technology at the Faculty of Hydraulic and Environmental Engineering, Gdansk University of Technology (actually: the Faculty of Civil and Environmental Engineering), the title of the doctoral thesis: „ Studies on the occurrence of heavy metals in the Straszyn Lake as a source of drinking water for Gdańsk".

3. Employment history in research institutes

1996-2000 Ph.D. studies „Geotechnics and Environmental Engineering", Faculty of Environmental Engineering (actually: the Faculty of Civil and Environmental Engineering).

2000-2002 Lecturer in Gdansk University of Technology, Environmental Engineering Faculty (actually: the Faculty of Civil and Environmental Engineering), Department of Water and Wastewater Technology.

2002-till now Assistant Professor in Gdansk University of Technology, the Faculty of Civil and Environmental Engineering, Department of Water and Wastewater 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 (Dz.U. [Journal of Laws] No. 65, Item 595, as amended)

a) Title of the achievement

Heavy metals in landfill leachates and technological wastewater from municipal solid waste plants in the aspect of changes in their management

b) Publications which are the part of scientific achievement

A monograph:

Kulbat E., Heavy metals in landfill leachates and technological wastewater from municipal solid waste plants in the aspect of changes in their management, Polish Academy of Science, The Committee of Environmental Engineering, Monograph Series, 138, Gdańsk 2018, 149 s. ISBN: 978-83-63714-37-6

Independent publication, participation 100%

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

The legal framework for waste management in the European Union is laid down in Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008. According to its content, disposal of waste, and above all its landfilling, is a last resort. This process should only be subject to waste that can't be prevented, can't be reused, recycled or recycled. Poland strives to meet these requirements. Introduced, among others sorting waste at source, and mixed municipal waste are directed to the installation of mechanical and biological processing (MBP). Selectively collected green waste and bio waste are sent to the composting plant, while waste is destined for waste generated in the MBP process of mixed municipal waste and residues from waste sorting. The construction and operation of no longer typical landfills started, but technologically complex installations using waste sorting and composting facilities. The measures taken have allowed for a significant reduction in the amount of municipal waste being disposed of: in 2005, this method of management covered 95% of municipal waste, and in 2015 only less than 45%. The National Waste Management Plan 2022 specifies further specific targets for municipal waste management. Belong to them:

- reducing the amount of waste generated,

- achieving the level of recycling of paper, metals, plastics and glass from municipal waste in the amount of at least 50% of their mass by 2020 and 65% in 2030,
- reduction of municipal waste storage to a maximum of 10% by 2030,
- implementation in the municipalities of separate collection systems for green waste and other biowaste at source - by the end of 2021,
- reduction of the amount of biodegradable municipal waste sent to landfills, so that in 2020 more than 35% of this waste will not be stored in relation to the volume of waste generated in 1995,
- balancing the functioning of the municipal waste management system in the light of the current ban on the storage of certain municipal waste fractions and from the treatment of municipal waste, including waste with a total organic carbon content above 5% d.m. and with a heat of combustion exceeding 6 MJ/kg of dry matter, from January 1, 2016.

The coming years will be a period of further dynamic progress in the field of waste management. Changes in the methods of municipal waste management bring not only the expected positive effects in the form of reducing the amount of waste sent to storage, but also involve unexpected problems. These are therefore issues that deserve careful observation.

The problem inseparably connected with the existence of landfills for municipal waste, both in operation and closed, is the generation of landfill leachate. The leachates from the new type of landfill prisms, which collect waste undergoing MBP processes, with a limited content of organic matter, diverge from the typical young leachate from the existing, traditional landfills. In addition, wastewater generated during sorting and composting of waste is also generated in modern municipal waste treatment plants operating today. Very few works on the subject can be found in the literature[1-5]. They show that wastewater from sorting and composting can be a source of significant amounts of pollution. They are present in higher concentrations of ammonium nitrogen, phosphorus, BOD_5 and COD than in the leachate from the landfill prism. At the same time, as a result of faster maturation of the waste, the leachates from the modern prism differ significantly from the data given so far in the literature.

So far, there are no publications in the literature on the problem of heavy metals in sewage disposal plants operating under the changed principles. There are also no data from long-term observations of concentrations of heavy metals in leachate, the works available in the literature generally show the results of leachate tests from traditional landfills from short research series.

[1] d'Antonio L., Fabbricino M., Pontoni L.(2015): Optimization of the treatment cycle of pressed-off leachate produced in a facility processing the organic fraction of municipal solid waste, Environmental Technology, 36, 1367-1372

[2] Fudala-Książek S., Łuczkiewicz A., Kulbat E., Remiszewska-Skwarek A. (2016a). Charakterystyka odcieków powstających w aspekcie wyboru metody ich oczyszczania, Rocznik Ochrona Środowiska, 18, 952-963.

[3] Fudala-Książek S., Pierpaoli M., Kulbat E., Łuczkiewicz A. (2016b). A modern solid waste management strategy – the generation of new by-products, Waste Management 49, 516–529.

[4] Fudala-Ksiazek S., Pierpaoli M., Łuczkiewicz A. (2017). Fate and significance of phthalates and bisphenol A in liquid by-products generated during municipal solid waste mechanical-biological pre-treatment and disposal, Waste Management, 64, 28-38.

[5] Nayono S.E., Winter J., Gallert C. (2010). Anaerobic digestion of pressed-off leachate from the organic fraction of municipal solid waste, Waste Management, 30, 1828-1833

Therefore, it was considered useful to carry out tests of heavy metal concentrations in the leachate from modern landfill prism and technological wastewater from sorting and composting units of municipal waste. There are probably first analyzes on these dissertation. The main aim of the research was to assess whether and how modern processing and storage of municipal waste affects the concentrations of heavy metals in the leachates from landfill prism, and to what extent contaminated with heavy metals are technological wastewater generated in sorting plants and composting plants.

The scope of the tests carried out includes:

1. Determination of concentrations of heavy metals (zinc, copper, lead, cadmium, nickel, chromium) in the leachates generated on selected landfills of municipal waste in various operating conditions, both in modern and previous landfill prism.

2. Tracking changes in concentrations of heavy metals over time in the leachate generated on four newly constructed prisms, where only waste is collected after the mechanical and biological processing (MBP) process.

3. Determination of heavy metal concentrations in technological wastewater generated in MBP installations: municipal composting and sorting units.

4. Determination of the effect of recirculation of concentrate from leachates treated by reverse osmosis to heavy metal concentrations in the leachates of landfill prisms.

Ad. 1

The tests of concentrations of heavy metals (zinc, copper, lead, cadmium, nickel, chromium) in the leachates of modern and previous landfill prism were performed in four municipal waste utilization plants located in the Pomeranian Voivodship. The selected objects differed above all in the size and character of the area served:
1) Eko Dolina in Łężyce near Gdynia (metropolitan agglomeration, about 460,000 inhabitants)
2) Municipal Waste Utilization Plant Nowy Dwór near Chojnice (small and rural agglomeration, about 150,000 inhabitants)
3) Municipal Waste Utilization Plant Stary Las near Starogard Gdański (agglomeration of small towns and villages, 164,000 inhabitants)
4) Municipal Waste Utilization Plant in Elbląg (metropolitan agglomeration, 218,000 inhabitants)

All objects selected for research have been modernized in connection with the adaptation to changed legal requirements (obligation to reduce the amount of biodegradable municipal waste sent to landfills, so that there are no more than 75% of the mass of this waste stored in

2010 in relation to the mass waste generated in 1995 and accordingly 50% in 2013). Since July 2013, as a result of the entry into force of the Act on maintaining order and cleanliness in municipalities, municipal waste segregated at source is placed in rendering plants. In three of them, there were both old and new type landfill prisms, one (Stary Las) was a completely new facility.

The tests of metal concentrations in the leachate from modern landfill prism were carried out for all facilities, whereas in the leachate from previous prisms - for three. The age of the analyzed previous landfill prisms was at the commencement of the research: 8 years in Eko Dolina Łężyce (studies were conducted for a period of 56 months), 19 years in Nowy Dwór (studies were carried out for 30 months) and 20 years in Elbląg (two-month research series). Leachate research on modern landfill prisms was conducted in Łężyce from the first to the 56th month of operation of the quarters, in Nowy Dwór from 6 to 36 months, in the Stary Las from 9 to 25 months, and in Elbląg from 25 to 27. month. According to literature data, leachate from prisms above the age, reaching a maximum of 56 months, is classified as young leachate, characterized by higher concentrations of organic matter and heavy metals and lower pH values than those from previous prisms. However, the results of the research revealed the existence of significant differences in the characteristics of the analyzed leachates in relation to the literature. The leachate from the tested objects also differ significantly.

In the leachate from the previous prisms in Łężyce, concentrations of four metals: lead, nickel, chromium and cadmium were clearly higher than those found in the leachates from the modern prisms, respectively: 27%, 302%, 802% and 38%. Particular attention is paid to large discrepancies for nickel and chromium. Only in the case of the other two metals: zinc and copper, higher concentrations were recorded in "young" leachate by 455% and 23% respectively. In the literature, in previous publications comparing the quality of young and old leachates, higher concentrations of heavy metals were always observed for young leachates, which was most often associated with their acidic reaction causing more intensive leaching of metals from waste. The results of the reaction tests of the discussed leachates presented in the works[4, 6-8] show, however, that after approx. 18 months of operation of the modern prism the pH of the leachate increased from the initial value of approx. 6.3 and stabilized at the level of approx. 7.5, so it was only slightly lower than the values observed in the drains from the previous prisms, amounting to approx. 7.8 - 7.9. Compared to the limit values set for sewage introduced into the sewerage system and introduced into waters or into the ground (respectively: Decision of the Minister of Construction in 2006 and the Minister of the Environment from 2014), the concentrations of metals in young leachate from Łężyce are relatively low: none of the metals (including maximum values) exceeds the limit values.

[6] Fudala-Książek S., Kulbat E., Łuczkiewicz A. (2012). Raport z wstępnych wyników analiz fizyczno - chemicznych ścieków i odcieków pobieranych na terenie zakładu „Eko Dolina" Sp. z o.o., maszynopis, Fundacja Rozwoju Inżynierii Lądowej.

[7] Fudala-Książek S., Kulbat E., Łuczkiewicz A. (2013). Raport obejmujący wyniki analiz fizyczno - chemicznych ścieków i odcieków pobieranych na terenie zakładu „Eko Dolina" Sp. z o.o., maszynopis, Fundacja Rozwoju Inżynierii Lądowej.

[8] Fudala-Książek S., Kulbat E., Łuczkiewicz A. (2014). Raport obejmujący wyniki analiz fizyczno - chemicznych ścieków i odcieków pobieranych na terenie zakładu „Eko Dolina" Sp. z o.o., maszynopis, Fundacja Rozwoju Inżynierii Lądowej.

However, in the case of old nickel and chromium leachate, over a dozen times during the research period they were higher than the limit value specified for sewage introduced into the sewage system of 1 mg/dm^3, and in most of the measurements exceeded the limit value set for sewage introduced into waters or soil of 0.5 mg/dm^3 (respectively 52% measurements of nickel concentrations and 80% of chromium concentration measurements).

The concentrations of all metals in the young leachate from Nowy Dwór were, however, clearly higher than those in the old drains. The biggest differences were noted for chromium and zinc - nearly four times higher concentrations of these metals were found in young leachates. Significant differences also related to nickel and copper (over 180% and 160% respectively), while for cadmium and lead they were respectively 65% and 47%. Average metal concentrations determined in both old and young leachate meet the requirements set for sewage introduced into the sewage system and introduced into waters or into the ground (respectively: Ministry of Construction's Resolution from 2006 and the Minister of the Environment from 2014). However, the analysis of all values of metal concentrations obtained during the whole research period showed that nickel and chromium concentrations in the young leachate periodically exceeded the values specified in the above-mentioned Regulations. Exceeding permissible values for sewage introduced into waters or soil (0.5 mg dm^3) concerned 44% of samples in the case of nickel and 48% of tests in the case of chromium, in addition, chromium concentrations in 24% of the samples did not meet the conditions specified for sewage entering the sewage system (1.0 mg/dm^3).

In the leachates from the modern prisms in the Stary Las, nickel and zinc were the metals with the highest concentrations. Despite the fact that the leachate was tested in the initial period of functioning of the quarters (from 9 to 25 months of operation), their pH was relatively high and amounted to approximately 7.5. This is probably one of the factors affecting the relatively low concentrations of metals in the tested leachate, comparable with the values given in the literature for old leachates. The analyzed concentrations of metals in the leachate are also low compared to the limit values set for sewage introduced into sewage systems and introduced into waters or into the ground: none of the metals (taking into account maximum values and omitting one incidental nickel exceedance) does not exceed permissible values. This is a result analogous to that observed in Łężyce and is in contradiction with the results from Nowy Dwór.

In the case of both storage units in Elbląg, the highest concentrations were characterized by chrome, and the lowest were copper and cadmium. At the same time, it is worth noting that the order of concentrations of metals in old leachates is similar to that analogously recorded for old leachates from Łężyce. The average concentrations of all metals in the leachate of the previous prism were clearly higher than those in the young leachate, and this is a relation such as that obtained in the leachate from Łężyce, but not confirmed in the literature. The biggest differences were noted for zinc and copper: the average concentrations of these metals were about 9 times higher in old leachates. Significant differences also related to nickel (3.5-fold difference). Studies on the leachates discussed[9] have shown that the leachate from the modern prism in Elbląg should be characterized as maturing or old.

[9] Fudala-Książek S., Kulbat E., Łuczkiewicz A(2015). Raport obejmujący wyniki analiz fizyczno - chemicznych odcieków pobieranych na terenie Zakładu Utylizacji Odpadów Sp. z o.o. w Elblągu, maszynopis, Fundacja Rozwoju Inżynierii Lądowej.

This is evidenced by the high reaction of leachate (7.1 - 7.7) and low susceptibility of organic matter to biological degradation (BOD_5/COD in the range of 0.3-0.6). The average concentrations of zinc, copper, lead, nickel and cadmium determined in both old and young effluents meet the requirements set for wastewater introduced into the sewage system and introduced into waters or into the ground.
Taking into account the average metal concentrations in the leachates from modern prisms, they can be arranged as follows:

Łężyce:	Zn > Ni > Cr > Pb > Cu > Cd
Nowy Dwór:	Cr > Ni > Zn > Cu > Pb > Cd
Stary Las:	Ni > Zn > Cr > Cu > Pb > Cd
Elbląg:	Cr > Ni = Pb > Zn > Cu > Cd

The observed order of concentration shows some similarities, but in no analyzed leachate, the sequence of concentrations is not repeated. In the majority of published surveys of leachate from Polish municipal landfills, zinc was the metal reaching the highest concentration. This fact was confirmed only in the case of leachate from Łężyce, and the metals with the highest concentrations are chromium and nickel. Only low concentrations of cadmium do not differ from the literature data: in the majority of leachate tests, it achieved (as in the present study) the lowest concentrations among the analyzed metals. Average metal concentrations in the effluents from the previous prisms, can be arranged as follows:

Łężyce:	Cr > Ni > Pb > Zn > Cu > Cd
Nowy Dwór:	Ni > Cr > Pb > Zn > Cu > Cd
Elbląg:	Cr > Zn > Ni > Pb > Cu > Cd

In all analyzed leachate from previous prisms, the lowest concentrations are found in cadmium and copper. Chromium and nickel reach the highest concentrations in the leachate from Łężyce and Nowy Dwór, and chromium and zinc in the drains from Elbląg. Similarly as in the case of young leachates, zinc in the highest concentrations in most publications on leachates from Polish landfill sites is not the most common metal here.

Ad. 2

The analysis of heavy metal concentrations in the leachate from the modern prisms showed significant differences between the four analyzed objects. This also applies to changes in metal concentrations over time. The observation of these changes was made possible by long periods of research work carried out in Łężyce and Nowy Dwór (56 and 30 months respectively). The discussed results of the concentrations of metals in young effluents are of particular value from a cognitive and practical point of view because the concentrations of metals in the effluents formed since the beginning of operation of the modern prisms have been analyzed.

The variability in the concentrations of copper, lead, chromium and cadmium in the leachate from the modern prism in Łężyce was significant, large fluctuations were observed especially during the first 18 months of operation of the prisms. Zinc concentrations decreased exponentially during the testing period ($y = 1.554e^{-0.109x}$, $r^2 = 0.87$). However, the only metal whose concentration showed a tendency to increase over time was nickel ($y = 0.0058x + 0.0465$, $r^2 = 0.47$). Because there is no observation in the literature of changes in the time of metal concentrations in the effluents from the waste storage units subjected to mechanical and biological processing, it is difficult to find an explanation for this phenomenon. Perhaps this is related to the drop in the organic matter content in the tested leachate, because nickel is a metal bound by the finest organic fraction to the highest degree among the metals analyzed by them[10] and shows almost full, negative correlation with COD of leachates[11].

Analysis of changes in concentrations of heavy metals in young leachates from Nowy Dwór indicates an increase in metal concentrations over time. Only for nickel and cadmium it was possible to select the approximation of the concentration of these metals during the function of the significant coefficient r^2 to approximate. The following values were obtained: $y = 0.0374x^{0.8893}$, $r^2 = 0.55$ and $y = 0.0301x^{0.4037}$, $r^2 = 0.48$. The similarity to changes in time in relation to metal concentrations in young effluents from Łężyce was therefore observed only for nickel. The increase in metal concentrations in the effluents in time differs from the literature data, but it should be emphasized that the described changes concern observations carried out in the initial stage of operation of the quarters, and such data is lacking in the literature. In addition, waste is stored on this quota in accordance with the amended rules (waste after sorting, with a limited content of organic matter), and changes in metal concentrations over time in the leachate from new type quarters were also not described.

Conducted for comparison analysis of changes in time of heavy metal concentrations in the leachate from previous prisms revealed that among metals marked in the leachates from the previous prism in Łężyce, zinc, similarly to young leachates, showed a decrease in concentrations over time ($y = 6.2308e^{-0.036}x$, $r^2 = 0.59$), and nickel growth ($y = 0.0165x^{-1.5309}$, $r^2 = 0.37$). Similarly, for other metals, low correlation coefficients of functions approximating the dependence of changes in concentrations over time were obtained. In the case of metals determined in old leeks in Nowy Dwór, zinc, similarly as in the case of leachates from the previous prism in Łężyce, showed a decrease in concentrations over time ($y = 0.1353x^{-0.492}$, $r^2 = 0.41$). Copper concentrations also decreased ($y = 0.0863x^{-0.489}$, $r^2 = 0.53$). However, changes in the concentration of other metals did not show any statistically significant trends. The lowering of metal concentrations in the leachate from the previous prism in the analyzed period may result from the cessation of the concentrate from leachate treatment as well as changes in the conditions occurring in the mass of deposited wastes described in the literature.

[10] Baun D.L., Christensen T.H. (2004). Speciation of heavy metals in landfill leachate: a review, Waste Management&Research, 22, 3-23
[11] Ogundiran O. O., Afolabi T. A. (2008). Assessment of the physicochemical parameters and heavy metals toxicity of leachates from municipal solid waste open dumpsite, Int. J. Environ. Sci. Tech., 5, 243-250

Leachate examinations from the previous prism were conducted in the period covering the 20th, 21st and 22th years of its existence in the methanogenic phase, in which the decrease in the solubility of calcium, iron, manganese and heavy metals compounds precipitated as sulphides and hydroxides is characteristic.

The analysis of seasonal changes in heavy metal concentrations in the leachate of modern and previous prisms for two rendering plants showed only some regularities in relation to young leachate: higher concentrations of heavy metals were observed in spring and summer. These seasons were also a period of quoting higher concentrations of metals in the leachates from the previous prism of the small and rural agglomeration in Nowy Dwór (except for copper). In turn, in old leachate from Łężyce (metropolitan agglomeration) metal concentrations were higher in winter and spring. However, in spite of some similarities, these are not unequivocal patterns, allowing for more general conclusions.

Ad. 3

Investigations of heavy metal concentrations in technological wastewater were carried out in sorting waste and waste composting plants mixed in four plants: in Łężyce, Nowy Dwór, Stare Las and Elbląg. Additionally, in order to compare the quality of wastewater generated during municipal waste composting with wastewater generated as a result of composting of green waste, analyzes were carried out in wastewater from a green composting plant in the plant in Łężyce.

In all technological wastewater generated in Łężyce, cadmium and lead were found at the lowest concentrations, while zinc reached the highest concentrations. The average metal concentrations recorded in wastewater from a mixed (hall) waste composting plant were many times higher than the concentrations of metals in wastewater from a green composting plant. The largest difference was in the concentration of nickel (22 times higher concentrations in sewage from the composting hall) and in turn: chromium, cadmium, zinc (all over 14 times) and copper and lead (more than 7 times). The values of metal concentrations in sewage from the sorting plant, similarly as in the case of composting plants, fluctuated in a very wide range. This is probably related to the nature of sorting work, i.e. a large uneven quality of waste to the sorting plant. Concentrations of heavy metals in wastewater from sorting and indoor composting are also much higher compared to metal concentrations in the leachate from the landfill prisms. The only exception are nickel and chromium concentrations, these metals are found in high concentrations in the effluents of the previous prism. Calculations of daily metal loads from the determined average metal concentrations and the amount of technological leachates and wastewater generated in individual installations, and then their percentage share in the total load of individual metals showed that the share of wastewater from the composting hall in the total heavy metal load contained in the technological leachate and wastewater of the plant in Łężyce is significant. These wastewater are the main source of zinc and copper (over 78% and nearly 45% respectively).

In technological sewage from Nowy Dwór, similarly as in wastewater from Łężyce, in the lowest concentrations there is cadmium and lead, and additionally in wastewater from the sorting plant, zinc reaches the highest concentrations. In the case of a composting plant, two

metals with the highest concentrations are arranged in reverse in relation to wastewater from Łężyce: here the highest concentrations were exhibited by nickel. It was also observed that concentrations of all tested metals in sewage from the waste sorting plant in Nowy Dwór are much higher compared to the leachates from the landfill prisms. In the case of wastewater from a composting plant, it is similar: metal concentrations in wastewater from this installation are higher than in leachate. Except for chromium, the concentration of which is higher in the leachate of the new component quarters. An analysis of the daily metal loads in Nowy Dwór showed, however, that the basic source of all examined metals is the new quarters. The effluents discharged from it provide 50 ÷ 60% of zinc, copper, lead and cadmium, they are also the decisive source of nickel (over 65%) and chromium (over 78%). The attention is paid to the significant (in comparison to the amount of sewage constituting only 1.5% of the total amount of sewage and leachate) the share of sorting plants in zinc (over 21%) and copper (almost 9%).

In Nowy Dwór, technological wastewater from waste sorting plants and composting plants were characterized by the occurrence of zinc and copper in the highest concentrations as well as cadmium and lead - in the lowest ones. This is the only (from the analyzed) case of the appearance of copper in relatively high concentrations. In turn, as in Łężyce and Nowy Dwór, the concentrations of metals in wastewater from the sorting plant are clearly higher compared to the leachate from the prisms. In Elblag, zinc and chromium were present in the wastewater from the sorting plant in the highest concentrations, and zinc and nickel in the wastewater from the composting plant. Comparing the concentrations of all tested metals in technological waste water and drains from the quarters, it was found that with the exception of chromium, the highest concentrations of metals occur in wastewater from a composting plant. Metal concentrations in sewage from the sorting plant were higher than concentrations in the effluents in the case of zinc, copper and lead.

Ad. 4

In three of the four plants examined, the leachate is pre-treated with the reverse osmosis method and the resulting concentrate is directed to the landfill prism. Returning the concentrate to the component quarters allows for avoiding the problem of its utilization, but it also affects the quality of the leachate generated on the component quarters. Therefore, it was considered useful to analyze the potential impact of such a procedure on the concentration of heavy metals in leachate. In Łężyce, the concentrate produced in the process of reverse osmosis was turned back to the previous prism, and after its closure - to the new one (from the sixth month of its operation). The situation in Nowy Dwór looked the same. In Stary Las, which is a new plant, built in 2012, the concentrate was also directed to the prism. Only in Elbląg, the leachate is not subjected to pretreatment, so this plant can be a comparative object. The basic difficulty, however, when attempting to determine the effect of concentrate returning to the landfill prisms on the concentration of heavy metals in the leachate is to observe significant differences in the characteristics of leachate from the three plants with pretreatment.

In the case of leachate analyzes from Łężyce, taking into account that the concentrate from the treatment of the mixture of young and old leachate is directed to the modern prism, it could be expected that the composition of the old leachate will affect the distribution of metal concentrations in the young leachates. Lack of statistically significant similarities (with the exception of copper), however, does not confirm the decisive influence of recirculation of concentrate on metal concentrations in young leachate, which may be caused by, among others, difficult to estimate a shift in time. Similar observations were noted in the case of leachate from Nowy Dwór. In the case of three plants using concentrate recirculation, concentrations of four heavy metals (zinc, copper, nickel and chromium) were present in young leachate at relatively higher concentrations compared to Elbląg leachates, but there is no such pattern for lead and cadmium. However, lead is a metal that appears in the plant in Elbląg in higher concentrations than in other facilities also in old leachates and process wastewater from the sorting plant and composting plant. It is likely that the waste currently reaching the plant in Elbląg contains more lead than it is in Łężyce, Nowy Dwór or Stary Las.

In order to assess the existence of similarities between metal concentrations in the leachate of modern and previous prisms, statistical analysis was used in individual facilities. The results of non-parametric tests carried out for young leachates showed statistically significant differences ($p < 0.05$) between the concentrations of zinc, copper, lead and nickel, but they did not allow the hypothesis to be rejected of the similarity of the distributions for chromium and cadmium. Statistically significant differences ($p < 0.05$) between the concentrations of all tested metals showed a similar analysis made in the leachates from the previous prism.The analysis of the potential impact of recirculation of concentrate on heavy metal concentrations in the effluents from the landfill prisms showed no dependence that could indicate such a relationship. Probably against other factors affecting the quality of leachate, recycling of concentrate is not critical.

The most important achievements that result from the research:

- Six concentrations of heavy metals (zinc, copper, lead, nickel, chromium and cadmium) were tested in all types of leachate and technological wastewater generated in modern municipal waste treatment plants in selected four facilities.
- For the first time, heavy metal tests were carried out in the leachate of modern landfill prisms, on which sorted waste and mechanical-biological treatment processes are collected, with limited content of organic matter. It was shown that the concentrations of heavy metals in the leachate from such prisms differ from the data reported in the literature for young leachates.
- A parallel study of heavy metal concentrations in leachates from previous and modern landfill prisms was performed, showing that in currently operated facilities, depending on the specificity of the rendering plant and the type of metal, metal concentrations can be higher in both old leachates (in two plants), as well as and leachates from modern prism (one plant).
- It was found that the metals present in the highest concentrations in the leachates from the modern prisms are chromium and nickel (in two plants), nickel and zinc (in one

plant), and zinc and nickel (in one plant). In the leachates from the previous prisms, these are (different for each of the plants): chrome and nickel, chrome and zinc, nickel and chrome.

- Analyzes of changes in time of heavy metal concentrations in leachates from modern and previous landfill prisms were made, in two plants conducting monthly tests for a period of 30 and 56 months. It was found that changes in concentrations of most of the analyzed heavy metals over time are also not regular. In the leachates of modern prisms, nickel concentrations increased over time, while the loss of zinc concentrations was characteristic of the previous prism.
- Assessment of the potential impact of concentrate recirculation (generated during leachate treatment by reverse osmosis) on heavy metal concentrations in the effluent from the landfill prism showed no dependence that could indicate such a relationship.
- It was shown that technological wastewater from sorting and waste composting plant is a serious source of heavy metals. Comparisons in the amount of metal concentrations in leachates and technological wastewater carried out for individual rendering plants revealed that in most cases wastewater from the sorting plant and composting plant is characterized by clearly higher and very variable concentrations compared to the leachate from the landfill prisms.
- The share of heavy metal loads from individual leachates and wastewater in total metal load calculated for two rendering plants (Łężyce - metropolitan agglomeration and Nowy Dwór - small town and rural agglomeration) revealed that the first source of zinc and copper is the composting hall (respectively: over 78% and nearly 45%, due to less than 12% share in the amount of wastewater), and in the second the total share of sorting and composting in the load of these metals is over 40% in the case of zinc and over 25% - in copper (compared to about 9% share in the total amount of wastewater).

In conclusion, it should be stated that the concentrations of heavy metals in the leachate of modern and previous landfill prisms differ significantly, which is influenced, inter alia, by the age of the prisms, but also the specificity of the landfill where they are generated. The composition of the leachate from the currently operated modern landfill differs from the data given so far in the literature. The results presented in the dissertation show that these leachates can be characterized by lower concentrations of heavy metals than old leachates. Also, changes in heavy metal concentrations over time show a different nature depending on the type of leachate and place of their formation and the type of metal. It was also shown that technological wastewater generated in sorting and composting of municipal waste constitutes a significant source of heavy metals with varying concentrations over time. It should be emphasized that the choice of the method of dealing with leachate from the landfill prisms and wastewater from the municipal waste sorting plant and composting plant always requires their testing.

5. Description of other scientific and research achievements

a) Before receiving the doctor degree

In 1991, I began my studies at the Gdańsk University of Technology at the Faculty of Hydraulic Engineering (presently the Faculty of Civil and Environmental Engineering). In 1996 under the supervision of Prof. Irena Kulik-Kuziemska, I defended my master thesis entitled: “Application of peat filter for sorption of heavy metals from industrial wastewater”.

From October 1996, I continued my studies as a student of the Ph. D. Studies "Geotechnics and Environmental Engineering" at the Faculty of Environmental Engineering at the Gdańsk University of Technology (presently the Faculty of Civil and Environmental Engineering). I conducted the first research work under the supervision of Prof. Irena Kulik-Kuziemska. They concerned the possibility of removing heavy metals and biogenic substances by algae and water quality in natural and artificial water reservoirs [Works II.E 1-4]. As a result of these works, I directed my interests towards the issues of heavy metals accumulation in bottom sediments of water reservoirs. This subject has become the subject of my doctoral dissertation. I started research for this work in 1998 under the supervision of Prof. Bernard Quant at the Department of Water and Wastewater Technology.

The research was possible, among others thanks to obtaining financing in the form of own grant No. 6 P04 G 00 615 titled "Migration and accumulation of heavy metals in the waters and bottom sediments of the Straszyn Reservoir" (1998-1999) and the targeted subsidy from the Voivodship Fund for Environmental Protection and Water Management in Gdańsk WFOŚ/D/201/103/2001 (2001-2002). Doctoral thesis "The study of occurrence of heavy metals in the Straszyn Lake as a source of drinking water for Gdańsk" was defended on June 25, 2002. The purpose of the work was to assess the degree of heavy water pollution and bottom sediments of the Straszyński Reservoir in terms of the potential impact on the quality of waters recorded and transferred to the Gdańsk water supply system. The results presented in the paper were obtained during two-year tests of metal concentrations in water and content in bottom sediments: zinc, copper, lead and cadmium as well as iron and manganese. It was found that due to the concentration of copper and zinc the water of the reservoir can be classified into class II and III, water purity, lead concentrations correspond to class I, and cadmium - II. The analyzed metals occurred in similar amounts in dissolved and suspended forms. It was also shown that there is a clear accumulation of metals in bottom sediments in the reservoir area. However, metal speciation studies revealed that the share of individual chemical fractions in the binding of metals in sediments is different for different metals, but the inert and organic fractions prevail. The metal most strongly associated with these factions was copper. The fraction of residual fraction in the binding of lead was nearly 65% and iron 60%. Zinc and manganese were characterized by a significant tendency to bind to hydrated iron and manganese oxides. The only metal bound to a significant extent by the ion exchange fraction was cadmium, but mainly bound by the organic fraction.

b) After receiving the doctor degree

My research interests after obtaining my PhD degree can be categorized into three basic areas:

- Accumulation and speciation of heavy metals in bottom sediments of water reservoirs.

- Municipal wastewater treatment in the aspect of the impact on the water quality of the receiver.

- Quality and possibilities of treatment of leachates from municipal waste landfills.

Accumulation and speciation of heavy metals in bottom sediments of water reservoirs

[These issue were discussed in: II.A.2 poz.3, II.E.2 poz.2, 4, 15, 21, II.F.2.9]

Interests in issues of accumulation and speciation of heavy metals in sediments of bottom water reservoirs initiated during the analyzes performed in the doctoral thesis resulted in the continuation of research. In the years 2011-2015, as the head of own grant No. N N305 143840 Fri "Accumulation and speciation of heavy metals in sediments of bottom dam reservoirs in the aspect of water quality", I carried out research on bottom sediments of reservoirs located in Gdańsk and Straszyn.

Many studies describe the impacts of heavy metals on aquatic communities, including those in the bottom sediments of rivers and lakes. Numerous natural and anthropogenic factors affect the chemical composition of surface waters and sediments. Sediments accumulate contaminants, including metals, and can serve as secondary sources of pollution to the ecosystems with which they are connected. According to Annex II of Directive 2008/105/EC, some heavy metals (e.g., lead) are on the list of 33 priority substances because of their toxicity. Bottom sediments are good indicators of the degree of contamination of aquatic environments. To assess the contamination of sediments, the concentrations of heavy metals are measured in the sediments, and these concentrations are compared with background or reference values. Numerous sediment quality criteria exist, and some of them have been found to be relatively good predictors of site contamination. Müller's index of geoaccumulation (Igeo) is the most commonly applied criterion; however, regional criteria are also used in some countries (e.g., Poland and Germany). The main objectives of this study are to determine the concentrations of the heavy metals Zn, Cu, Pb, Cd, Ni and Cr in the surface sediments of Straszyn Lake; to assess the level of contamination with heavy metals in the sediments using the sediment quality criteria; and to determine the abundance of heavy metal-resistant bacteria in the bottom sediments, the raw water and the drinking water. This reservoir was constructed in 1910, primarily to produce energy. A small hydroelectric power plant with a capacity of 2450 kW is situated here. This power plant is the oldest one on the Radunia River, and it remains in operation today. The catchment area of the Radunia River equals 837 km^2, and as much as 67,6% of the area is agricultural land. The total volume of the Straszyn Reservoir is 3 mln m^3, its surface area is 0.75 km^2, and its average retention time is 170 hours. Since 1986, the main function of this reservoir is the provision of drinking water to several districts of Gdańsk. The Straszyn surface intake is one of the biggest in Gdańsk, and the reservoir supplies drinking water to more than 30% of the inhabitants. During the period

examined in this study, the raw water was pretreated with ozone (0.5 – 0.8 g O_3/m^3, 3 min.). After coagulation (which was performed using a 10% solution of $Al_2(SO_4)_3$ in summer or a 5% solution of NaOH in winter) and flocculation in two-staged labyrinthine chambers, the water was filtered through sand; additional ozone and filtration through activated carbon (up to 6 m/h) were then applied. Prior to delivery to the network, polyphosphates and lime water were added to the treated water, which was then disinfected with a mixture of Cl_2 and ClO_2. The grain-size analyses revealed that the sediments obtained from site 1 (in the upper part of the reservoir) were coarser (with sand and silty clay fractions of 47% and 49%, respectively) than the sediments taken from sites 2-4. The sediments from the middle and lower parts of the reservoir were finer, and the 'silty clay' fraction (0.05-0.002 mm) represented approximately 83%-91% of the sediment mass there. The content of organic matter displayed a range of variability of 10,6-14,8%. The concentrations of heavy metals varied widely. The contents of Zn in the sediments of the Straszyn Reservoir were characterized by considerable variability (15.31-92.47 mg kg-1dry wt). The mean Zn contents for the sampling points in the upper part of the reservoir were lower compared to the middle and lower parts. The concentrations of Cu were in the range of 2.34-25.65 mg kg-1dry wt; similar concentrations were measured at stations 2-4 (mean values 20.40-22.05 mg kg-1dry wt), and lower values were obtained for station 1 (mean value 3.81 mg kg-1dry wt). The highest Pb content (mean value 33.75 mg kg-1dry wt) was detected in the sediments from the middle part of the reservoir. The concentrations of Cd fell within the range of 0.04-1.70 mg kg-1dry wt. Higher contents of Cd were also found in the middle and lower parts of the reservoir. The nickel content in sediment samples varied from 1.2 mg Ni / kg s.m to 22.2 mg Ni / kg s.m. The total chromium content in sediment samples ranged from very wide limits from 14.4 mg Cr / kg s.m. up to 260.9 mg Cr / kg s.m. and showed a tendency to increase along the lake current, reaching the highest average content at the dam.

The earlier studies (1999-2000) of heavy metals in the sediments of Straszyn Lake indicated that the concentrations of Zn, Cu, Pb and Cd in were higher than the average values for the region of Pomerania. In this research (which was conducted 14 years later), the concentrations of Zn, Pb and Cd were significantly lower, whereas the concentrations of Cu were comparable. The improvement in the quality of the sediments likely occurred due to the modernization and expansion of municipal facilities located in the catchment of the Radunia River, particularly the wastewater treatment plants of Przodkowo (2001 – 2002) and Somonino (2008 – 2009). Two reports of the Gdańsk Inspectorate of Environmental Protection (2000 and 2003) concluded that the water quality in 2000 corresponded to classes I and II, according to the Polish standards, but the concentration of copper was too high. A report for 2013 assessed the condition of the water of the Radunia River water as good, in accordance with the European Water Framework Directive (WFD). The degree of enrichment of the sediment with metals was assessed using the Polish geochemical classification and Müller's geoaccumulation index Igeo. According to the first geochemical classification of river and lake sediments in Poland published by the Polish Geological Institute, the sediments deposited at the sampled sites in the Straszyn Reservoir were classified as follows:

- The concentrations of Zn and Pb corresponded to the first category at all of the sampling points.

- With respect to their Cu concentrations, 47% of the samples were assigned to category I, and 53% of the samples were assigned to category II.
- With respect to their Cd concentrations, 75% of the samples were assigned to category I, and 25% of the samples were assigned to category II.

Müller's geochemical index varied over a wide range. The lowest values for each metal were observed at sampling point 1, whereas the highest values were obtained near the dam. The largest values of Müller's geochemical index were determined for copper. These values fell within the range of 3-4, indicating that the sediment was 'strongly polluted'. The values of Igeo for Zn and Pb corresponded to grades 1-3, indicating that the sediment samples in the middle and lower parts of the reservoir were 'moderately or strongly polluted'. The sediments of the Straszyn Reservoir were classified as 'unpolluted to moderately polluted' with respect to the Igeo values for Cd, which were <1.

The bacteria isolated from the sediments, raw water and drinking water displayed the highest levels of resistance to Zn at a concentration of 0.2 mM (88%, 62% and 83%, respectively). In the case of lead (0.2 mM) and copper (0.2 mM), the percentages of strains resistant to these metals were lower and corresponded to 81% and 70% of the bacteria isolated from the sediment, 54% and 50% of the bacteria isolated from the raw water and 75% and 66% of the strains isolated from the tap water, respectively. Sixty percent of the strains isolated from the sediments, 35% of the strains isolated from the raw water and 58% of the strains isolated from the tap water displayed resistance to the higher concentration (2 mM) of Cu. In the case of Zn and Pb (2 mM), the percentages of resistant strains were 67% and 69% for the deposits, 49% and 42% for the raw water and 64% and 64% for the tap water, respectively. Speciation forms of six selected heavy metals (zinc, copper, lead cadmium, nickel and chromium) were also investigated in sediments (ion-exchange fraction, carbonate fraction, fraction associated with iron and manganese oxides, organic fraction, residual fraction). Analyzing the obtained results, it showed that zinc showed a significant tendency to bind with hydrated iron and manganese oxides (fraction III). The carbonate and residual fraction showed almost identical share in zinc binding. Copper was most strongly bound by residual and organic fractions (V and IV). The copper content in the ion exchange, carbonate and iron and manganese fractions (I, II and III) was low and variable; there were fluctuations in the ordering of these fractions in terms of copper content. Lead in sediment samples collected at stations 2, 3 and 4 was most strongly bound in the residual fraction (V - about 65%); only at position No. 1, fraction III was the dominant fraction. Cadmium was the only metal bound to a significant extent by the ion exchange fraction (I - about 19%), although the largest share in the bonding of this element had a carbonate fraction. In studies conducted in the years 1999-2000, as in the case of copper, the organic fraction (IV - almost 50%) had the largest share in cadmium binding, the share of which is currently the lowest. However, the forms of zinc, copper and lead binding did not change significantly in relation to the values obtained in earlier studies. The chromium showed a significant tendency to bind to hydrated iron and manganese oxides (fraction III) and the residual fraction. The ion exchange and carbonate fractions, on the other hand, showed a very low share in the binding of chromium. Nickel, like copper, was most strongly bound by residual and organic fractions (V and IV).

The nickel content in the ion exchange, carbonate and iron and manganese fractions (I, II and III) was similar.

Municipal wastewater treatment in the aspect of the impact on the water quality of the receiver

[These issue were discussed in: II.A.2 poz.1, 2, 4 i 5, II.E.2 poz.1-2, 6, 7, 9-14, 16, 17, 19, II.F.2 poz. 4-6, 8]

The first studies on the quality of municipal wastewater and sewage sludge and wastewater treatment processes started just after graduating from doctoral studies. I was a co-contractor in project No. 3 T09C 062 18 titled "Analysis of the work of multi-phase activated sludge system with the system of generating volatile fatty acids in the aspect of elimination of microbial and parasitological contaminants from municipal wastewater". The work carried out as part of this grant covered, first and foremost, studies on the effectiveness of pollution removal in the modernized Gdańsk East sewage treatment plant. " The quality of raw and treated wastewater was tested, the effectiveness of elimination of nitrogen and phosphorus compounds and removal of microbiological impurities. The analysis of chemical and microbiological quality of sewage sludge was also carried out. It was indicated that the concentrations of seven heavy metals (Zn, Cu, Pb, Cd, Cr, Ni, Ag) in wastewater were rather low. After treatment, the metals concentration met criteria given in the Regulation of the Minister of Environmental Protection of Aug.1, 2002, that was valid at the time of the investigations. Analysis of effectiveness of metals removal during wastewater treatment processes undoubtedly indicates the fundamental role of biological treatment stage in metals removal. Analysis of heavy metals concentrations in primary and biological sludge have proved that the sludge from the WWTP “Wschód” can be utilized in land-farming and land reclamation. This study indicates that in the wastewater treatment plant “Wschód” in Gdańsk, working in the modified UCT system, the effectiveness of bacteria pollutant removal varies from 92 to 99% and almost 100% of parasites are removed. Despite this, the number of indicator bacteria and periodical presence of Salmonella in the effluent indicates that it is strongly bacteriologically polluted. It was discovered that the number of indicator bacteria in primary sludge was by 1 to 3 orders of magnitude higher than in the excess activated sludge. Also, *Salmonella* was twice more frequently detected in the primary sludge than in excess activated sludge (70% and 30%, respectively). In contrast, the average number of invading helminths’ ova (ATT) was over two times higher in excess activated sludge than in primary sludge. An efficient method for controlling activated sludge bulking resulting from intensive growth of *Microthrix parvicella* was dosing of PAX-16 (the doses from 2.5 to 4.8 g Al^{3+}/kg d.m.·d).

The presence of very numerous pathogenic, opportunistic and drug-resistant microorganisms in the treated municipal sewage poses a serious threat to the quality of the receiver's water and human health. Therefore, more and more attention is paid to issues

related to the possibilities of wastewater disinfection. In the Department of Waste Water and Sewage Technology in the years 2007-2010 research was conducted using three disinfection technologies: ozonation, UV radiation and microfiltration for disinfection of biologically treated wastewater. The work was carried out as part of the EEA Grants E007/P01/ 2007/01/85 project „New methods of emission reduction of selected pollutants and application of by- products from sewage treatment plants". The tests were carried out with the use of wastewater treated from the mechanical and biological wastewater treatment plant "Wschód" in Gdańsk and "Dębogórze" in Gdynia. Three disinfection technologies were used: ozonation, UV radiation and microfiltration. All methods showed high efficiency of wastewater disinfection. Microfiltration has also proved to be a process that effectively removes suspended matter, turbidity and general phosphorus and COD from wastewater; minor general nitrogen was removed. It was found that microfiltration caused a reduction in the number of indicator bacteria by 3-5 orders of magnitude. The obtained effects were independent of the number of bacteria in treated wastewater prior to membrane filtration. Disinfection with UV radiation was carried out on biologically purified sewage collected directly after settling tanks of secondary treatment plants and sewage after additional cleaning on quartz sand. The device is equipped with a low-pressure heater with a power of 33 W, emitting radiation in the wavelength range of 254 nm. A reduction in the number of bacteria reaching 4 orders of magnitude was achieved and faecal coliforms were observed to be more sensitive to UV radiation than faecal streptococcus.

Based on the results of the research carried out, the manual "Wastewater Disinfection" was edited by Krystyna Olańczuk-Neyman and Bernard Quanta, published in the "Seidel-Przywecki" Publishing House in 2015, of which I am the co-author.

In 2010-2013, I participated in research conducted as part of the project No. UDA-POIG.01.03.01-22-140 / 09-00 An innovative source of carbon for the support of denitrification in municipal wastewater treatment plants" (Project of the Operational Program Innovative Economy 2007-2013 under Sub-measure 1.3.1). Project was concern the use of e.g. fusel oil as an "alternative" carbon source for denitrification in the mainstream and sidestream treatment processes. Methanol, ethanol and acetic acid were used as a comparative material constituting an external carbon source. The investigations were conducted at the "Wschod" and "Dębogórze" wastewater treatment plant (WWTP) in the city of Gdansk and Gdynia (northern Poland) and at the wastewater treatment plants in Łódź and Poznań. The research included the observation of the adaptation possibilities of activated sludge biomass to the used external carbon sources as well as the measurement of the denitrification rate and the measurement of release and anoxic uptake of phosphates. The tests were carried out on a laboratory, pilot and technical scale. Designed for the needs of the project, the containerized external coal source metering station won the distinction in the Innovation 2012 competition at the 18th Industrial Technology, Science and Innovation Fair. Technicon Innovations. The obtained results confirmed the possibility of using alternative carbon sources to support the processes of denitrification in the activated sludge chambers.

Quality and possibilities of treatment of leachates from municipal waste landfills

[These issue were discussed in: II.A. poz.7-9, II.E.2 poz.18, 20, II.F.2 poz.3]

In the work on the quality of leachate from municipal waste landfills, I joined in 2010, carrying out research under the project N 523 077 32/2900 Fri "Variability of ecotoxicological and microbiological hazards associated with the biological treatment of leachate from municipal waste landfills". The research was carried out in cooperation with the Department of Environmental Biotechnology of the Faculty of Environmental Engineering and Power of the Silesian University of Technology. One of the main goals of this work was to assess the possibility of co-treatment municipal wastewater and landfill leachate. Material for research conducted at the Gdańsk University of Technology was wastewaater from the "Wschód" wastewater treatment plant in Gdańsk and leachate from two Tri-City landfills: Eko Dolina in Łężyce and ZUT Szadółki in Gdańsk. Co-treatment of wastewater and leachate was carried out in the flow models of the treatment plant in the A_2O system. It was found that the maximum share of leachates in the mixture subjected to biological treatment depends mainly on the quality of leachate and can reach even 10%, with the addition of 3% leachate as the value ensuring effective treatment of the mixture. The research was also continued using a sequential biological reactor. Even with the addition of 10% leachate, the efficiency of removing the total suspension and BOD_5 was over 90%. However, the total nitrogen reduction ranged within 70% and the efficiency of the nitrification and denitrification processes varied. The total concentration of all heavy metals in leachate was below 1.8 mg/dm3. The concentrations of five heavy metals: Cd, Cr, Cu, Pb and Zn decreased markedly, with exception of Ni, as the result of mixtures cotreatment in the SBR. The highest reduction was observed for zinc (at the range from 76% to 88%) and cooper (from 25% to 62%). It was shown that the total concentration of all heavy metals in the leachate was below 1.8 mg / dm3. Of the analyzed heavy metals, the concentration of five Cd, Cr, Cu, Pb and Zn decreased significantly, the exception being only Ni. The greatest reduction was observed for zinc (in the range of 76% to 88%) and copper (from 25% to 62%).

The quality tests of leachate from landfill prism and technological wastewater from sorting and composting of municipal waste were then carried out in five Pomeranian municipal solid waste plants. It has been shown that the changing principles of municipal waste management have a significant impact on the quality of leachate generated on modern prisms collecting waste sorted at source and subjected to mechanical-biological treatment processes. The leachates from modern prisms as a result of faster maturation of waste deviate from the typical young leachate from the existing, traditional landfills, described so far in the literature. It was also found that wastewater from sorting and composting plants can be a source of significant amounts of pollution. They are present in higher concentrations of ammonium nitrogen, phosphorus, BOD_5 and COD than in the leachate from the landfill prisms.

The effect of research on the quality of leachate and cooperation undertaken with the operators of municipal solid waste plants is, among others, implementation and patent application pt. "Method of removing sulphides from wastewater of a reducing conditions ".

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

I have been teaching classes at the Faculty of Civil and Environmental Engineering at the Gdańsk University of Technology from 1997 to the present. These are classes for first- and second-cycle students of full-time and part-time specializations: Environmental Engineering, Civil Engineering and Geodesy and Cartography in the following subjects:

- Environmental protection (lectures and auditorium exercises, full-time engineering course)
- Engineering and environmental protection (lectures and auditorium exercises, full-time engineering course)
- Water and wastewater technology (laboratory exercises)
- Chemistry (laboratory exercises)
- Environmental chemistry (exercises)
- Chemical and biological processes (exercises)
- Monitoring and environmental protection (exercises)
- Environmental monitoring (exercises)

Since 2007 I have been a thesis advisor in 11 master's theses and 7 engineering theses and reviewer of about 46 theses. I am also an assistant advisor in the doctoral dissertation of M.Sc. Eng. Magda Kasprzyk "Research on the effectiveness of phosphorus removal from wastewater using selected sorption materials".

I take active part in classes organized as part of the Open Days of the Gdańsk University of Technology, the "Girls at Politechniki" and the Baltic Science Festival. I also work with student science clubs by organizing field classes for students from the "Microbiology in Environmental Engineering" circle and conducting sessions at the Interdisciplinary Academic Conference on Environmental Protection (IAKOŚ - conference organized by students and PhD students working in the scientific circles of the Gdańsk University of Technology).

In the years 2005 - 2008 I was the guardian of the directional (hydraulic and hydrochemical) practice of environmental engineering students, and from 2008 to the present day I have been the Dean's Representative for internships in the field of Environmental Engineering. I was also a member of the Faculty Council (NA representative) for the 2008-2012 term of office. From 2013 to the present day I participate in the work of the Faculty Recruitment Commission WILiŚ PG (from 2017 as secretary), and from 2016 to the present day I am the vice-chairman of the Disciplinary Disciplinary Commission for Student Affairs.

Owing to conducting and participating in research projects, I had the opportunity to develop scientific laboratories of the Department of Water and Wastewater Technology by equipping the positions used in engineering, master's and doctoral dissertation (stations for the mineralization of wastewater and leachate samples, sewage sludge, bottom sediments, soils and plants; performing analyzes with the production of fumes and to work with materials with a significant odor nuisance).

In 2015, I was a member of the organizing committee of the conference "Industrial wastewater. Technological and Economic Challenges ", which was covered by the honorary patronage of J.M. Rector of the Gdańsk University of Technology, J.M. Rector of the

University of Gdańsk, and the Marshal of the Pomeranian Voivodeship. My activity was awarded the third degree team prize for special achievements in organizational activity in 2015.

Eliza Kulbat