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

1. First and last name:

Katarzyna Maria Jankowska

2. Awarded diplomas and academic degrees

a) 04.1996 r - Obtaining the Master of Science degree in biological oceanography from the University of Gdańsk, Faculty of Biology, Geography and Oceanology: Direction Oceanography. Diploma thesis title: *Impact of discharges of post-treatment waters on the meiobenthos community in the coastal area of the Puck Bay in the Swarzewo area.* Promoter prof. dr hab. M. Wołowicz.

b) 05.1997 r - Obtaining the diploma of completion of two-semester postgraduate studies in Geotechnics and Environmental Engineering. Faculty of Hydraulic and Environmental Engineering, (actually: the Faculty of Civil and Environmental Engineering),,

c) 12.2001 r - Obtaining the Doctor degree of technical sciences in environmental engineering with a specialization: Sanitary Biology, the title of doctoral thesis: Ecosystem of sandy beaches of the Gulf of Gdańsk as an environment of heterotrophic bacteria. Promoter prof. dr hab. inż. K. Olańczuk- Neyman. Faculty of Hydraulic and Environmental Engineering, (actually: the Faculty of Civil and Environmental Engineering), Gdansk University of Technology,

d) 05.2004 - Obtaining the diploma of completion of two-semester postgraduate studies in the field of Pedagogy. Faculty of Technical Physics and Applied Mathematics, Gdańsk University of Technology, Educational qualifications of the Ministry of Education,

e) 06.2011 - Obtaining the diploma of completion of two-semester postgraduate studies "Research project management and commercialisation of research results", Faculty of Management and Economics, Gdańsk University of Technology, project financed by the European Union from the European Social Fund.

3. Employment history in research institutes

1988 – 1989 A position trainee technician at the Faculty of Mathematics and Physics of the University of Gdańsk,

1995 – 1996 A position oceanographer at the Department of Marine Dynamics of the Institute of Oceanology of the Polish Academy of Sciences in Sopot, working within the framework of the NSC project "Marine Aerosol Flux Simulation" and the EU project "Baltic Aerosol Experiment",

2002 – 2013 A position assistant Professor in Gdansk University of Technology, the Faculty of Civil and Environmental Engineering, Department of Water and Wastewater Technology,

2013 – 2014 A position deputy head of the expedition and educationalist during the XXXVI Polar Expedition of the IGF PAS at Spitsbergen, Institute of Geophysics of the Polish Academy of Sciences in Warsaw,

2014 – 2017 A position assistant Professor in Gdansk University of Technology, the Faculty of Civil and Environmental Engineering, Department of Water and Wastewater Technology,

2017 – A position senior Lecturer 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:

Bacteriocoenosis of shallow littoral in the Gulf of Puck in the area of submarine groundwater discharge

b) Publications which are the part of scientific achievement

Monography

Jankowska K. (2018). Bacteriocoenosis of shallow littoral in the Gulf of Puck in the area of submarine groundwater discharge. Monografie Komitetu Inżynierii Środowiska PAN, Monografia nr 141, 170 s. **Appendix 6.**

Stand-alone publication, shareholding 100%.

c) A discussion of the scientific objective of the work and the results obtained, including their possible use.

In the monograph, I discussed the impact of underwater groundwater drainage on the communities of *Procaryota* of the littoral coastal zone, which has not been researched in the coastal zone of the sandy beaches of the Baltic Sea so far.

Coastal areas are particularly vulnerable to degradation due to the inflow of anthropogenic pollutants. Until recently, rivers and surface run-off were considered to be the main sources of these pollutants. Currently, the world literature pays particular attention to the direct outflow of groundwater to seas and oceans (PDWP/SGD), which is considered an important source of freshwater inflow from land to sea (Moore 1996; Burnett et al. 2006; McCoy & Corbett 2009). They are one of the key elements of marine eutrophication research (Valiela & Bowen 2002; McCallister et al. 2006; Burnett et al. 2006; Seidel et al. 2015; Fares 2016). In this respect, the location of undersea drainage in coastal areas with permeable sediments, i.e. on sandy beaches (Huettel et al., is of particular importance). 1998; Huettel and Rusch 2000; Gibbes et al. 2008; Roy et al. 2008; Beck et al. 2017). In addition, the impact of underwater drainage on microbiological water quality is highlighted in recreational areas (Haack et al. 2003; Boehm et al. 2004; Boehm et al. 2009; Yau et al. 2014). The growing number of publications shows how the interest in PDWP research is growing.

In the years 2010-2014 I conducted research in the area of shallow littoral and sandy beach located at the end of Hel Peninsula, in the town of Hel. Using microscopic, breeding and genetic methods, I analysed the number, size structure and biomass of prokaryotic cells. I determined their metabolic activity and taxonomic differentiation. Due to the recreational character of the area, I paid particular attention to the possible impact of groundwater drainage on the sanitary quality of coastal waters. The issues discussed are the focus of interest of many European programmes and directives, which considered the lack of monitoring data to be the most important gap in the full implementation of tasks related to water protection.

The scientific result of the research work described in the paper was the verification of working hypotheses (H1, H2, H3):

H1. The inflow of groundwater causes significant changes in the composition of communities of prokaryotic organisms settling coastal marine waters and sandbanks in the coastal area.

H2. The inflow of groundwater rich in biogenic substances and other chemical components, including inhibitors to coastal sea waters, causes a partial elimination of microbiological faecal contamination.

H3. The selected microbiological indicators are a sufficiently sensitive bioindicator of the inflow of groundwater to the marine environment.

The hearing was divided into two parts: the introduction and the own research.

The introduction contains two chapters based on the literature review: In Chapter 1 I described the occurrence of the Underwater Groundwater Drainage (PDWP) and I presented the historical features of PDWP observations and studies from antiquity to the present times (subsection 1.1). I described the definitions of the phenomenon adopted in world and Polish literature (subsection 1.2). I presented selected components of underwater groundwater drainage, driving forces, and factors affecting their size and the pattern of sources of underwater groundwater outflows (Taniguchi et al. 2002; Burnett et al. 2006; Szymczycha & Pempkowiak 2016). I distinguished two types of drainage: offshore and coastal (Piekarek-Jankowska 2007). Undersea drainage, which occurs as a result of groundwater pressure outstripping sea water pressure, may be of a free or ascensive nature, as shown in the drawings. As mentioned above, I described the occurrence of underwater groundwater drainage in the Baltic Sea region (section 1.3). On the basis of the data collected in the literature, I have noticed that the main areas of groundwater drainage to the Baltic Sea are located in the lake moraine uplands located on the southern coasts of the Baltic Sea. What is more, on the basis of literature data, I provided the value of underground outflows in particular areas of the Baltic Sea. Then I presented the Polish achievements in the study of underwater groundwater drainage. They are related both to the problems of obtaining water intended for consumption in coastal areas, the occurrence of submerged waters in the southern part of Baltic Sea, the hydrological classification of the coastal zone of the Gulf of Gdańsk, as well as the identification of specific PDWP discharge points in the Gulf of Gdańsk and the Bay of Puck and the Depth of Gdańsk, and the determination of their chemical composition. Further on I characterized the areas and type of groundwater drainage in the area of the Gulf of Gdańsk. I described in more detail PDWP occurring on the sandy beach from the side of the Gulf of Gdańsk in Hel, where due to shallow water table deposits and lack of isolation from the surface, the quality of groundwater is exposed to various anthropogenic pollutants, including those of faecal origin. It is possible that they are moved to the shore area along with the drainage. I then described the main objectives and results of the European BONUS-AMBER project, to which my research was complimentary.

In section 1.4, I described the PDWP test methods. Due to the complexity of this phenomenon and its high variability, the location and estimation of its total volume is difficult and requires interdisciplinary research with the use of many methods. Modern technologies develop methods of determining the intensity and area of groundwater inflow based on mathematical and numerical model simulations, combined with the use of manual or automatic collectors to extract water flowing from the seabed or piezometers. Stable water isotopes ($_{2}$H i $_{18}$O), as well as naturally occurring radioactive isotopes such as 222Rn, 228, 226, 224, 223Ra, are used as markers of groundwater outflow. Infrared imaging is used to illustrate temperature differences between drainage and seawater. The identification of PDWP can be facilitated by combining geo-referenced and environmental data using techniques based on geographic information systems (GIS). At the end of this chapter, the methods used to estimate PDWP used in the AMBER studies are described.

In Chapter 2 I described the characteristics of the prokaryotic organisms (bacteriocenosis) of the shallow littoral and sandy beach zone, which I started with the characteristics of the environment in terms of physicochemical parameters and their influence on the organisms living there, defined as micropsammonium. I described the biodiversity of beach sand, in which the biomass of all organisms in a coarse-grained sediment, with an extensive system of pores, can reach up to 40% vol (McLachlan & Brown 2006). Bacteria play a key role in the homeostasis of the ecosystem, taking an active part in the decomposition of auto- and allochthonous organic matter and in the transformation of mineral compounds, forming, together with phytoplankton and zooplankton, a complete trophic chain known as the microbiological loop (Pomeroy 1974; Azam et al. 1983). I have also described their role in biological production in freshwater, marine waters and beach sand (Slomp & Van Cappellen 2004; Santos et al. 2009; Lee et al. 2010). In the further part of this chapter, I discussed the impact of pollution on the change of biodiversity in the environment, the disappearance of sensitive species and the emergence of more adapted groups of alien organisms. I have paid particular attention to the problems related to the sanitary quality of the environment, the occurrence of the indicator and pathogenic bacteria and their survival in the marine environment. I have presented existing legal standards and regulations for assessing bathing water quality. I noted that although the epidemiological risks associated with the presence of pathogenic micro-organisms in recreational areas seem to be well identified, they are still subject to new research and analysis (Fewtrell & Kay 2015). It is, therefore, necessary to search for new markers to facilitate an instant and accurate assessment of disease risk, which would allow better management and organisation of recreational areas. Sampling methodologies adapted to specific environmental conditions are also being developed. Microbiological testing is linked to epidemiological data (e.g. collected from surveys) and creates mathematical models to monitor and predict potential microbiological risks. Increasing attention is being paid to education and raising public awareness of the proper use of recreational areas and the need to protect them. In addition, among the potential risks to human health associated with the spread of waterborne microorganisms, the increasing phenomenon of drug-resistance creates a significant problem (Tollefson & Miller 2000; Landers et al. 2012). The direct or indirect contamination of aquatic ecosystems by drug-resistant microorganisms threatens to propagate resistance genes and transfer them to other microorganisms, including saprophytic ones.

Subsequently, I pointed out that the coastal waters of the Gulf of Gdańsk and the Bay of Puck, aside from their exceptional natural values, are also particularly attractive in terms of recreation, and inadequate sanitary quality of water and beach sand may be associated with a possible epidemiological threat. In the final part of this chapter, I drew attention to the influence of submarine drainage on microbiological water quality, which is increasingly discussed in world literature, and which is particularly relevant in areas used for recreation.

In the second part of the thesis, I presented my own research. In Chapter 3 I discussed the region and methodology of the research. In section 3.1 I described the research area. It was a sandy beach located at the end of Hel Peninsula, in Hel. I described its physical and environmental characteristics and meteorological conditions, which is well known in terms of morphology and physicochemistry, for many years covered by a wide range of various research activities also conducted in the Department of Water and Waste Water Technology of the Faculty of Civil Engineering and the Environment, the Field of Environmental Engineering. In section 3.2, the methodology for sampling and in situ measurement is described in detail. Microbiological investigations included samples of seawater (WM) and pore water: taken from the area of occurrence of underground drainage (W) and from the area of its absence (BW). In four years (from 2010 to 2014), I conducted ten series of seasonal field studies. I studied the result in four seasons: winter (February), spring (April and May), summer (August and September) and autumn (October). In 2012 (spring and summer) laboratory experiments were carried out on mezzo/microcosm-type systems. Subchapter 3.3 presents a description of the microbiological testing methods used in the study. I presented the following methods: microscopic (3.3.1), including determination of the total number of bacteria (OLB), average cell volume (SOK), biomass of bacteriocenosis (BB) and metabolic activity of cells (L/D), breeding methods (3.3.2) - number of indicator bacteria, biochemical methods (3.3.3) - identification of bacterial strains and determination of their resistance with the use of an automated BD Phoenix microbiological testing system. The following section explores the description of molecular methods (3.3.4), the technique of DNA extraction and bacterial amplification of the 16S rRNA gene (PCR), and the sequencing of the new generation (NGS) of Illumina and bioinformatic analysis. In subsection 3.4 I introduce the methods of statistical analysis used in the work.

In Chapter 4, I reviewed and discussed the results of the research. I presented meteorological conditions, temperature and salinity of sea and pore waters (4.1), noting their key importance for the description of the phenomenon of groundwater drainage to the marine environment, using meteorological data on wind speed and direction, sea level, precipitation, water and air temperature obtained from the Institute of Meteorology and Water Management (IMGW – PIB)[1], I obtained data on salinity and temperature of pore waters from my own measurements. On the basis of the data analysis, I found a high variability of meteorological and environmental parameters for each of the research series. This mainly concerned the direction and velocity of the wind, and thus the change in sea level, i.e. factors that are extremely important in assessing the size of the drainage stream. I noted that the estimates of the offshore drainage flow rate made by the AMBER project show clear differences from season to season. In winter and spring, the flows were lower than those measured in summer and autumn, and one of the reasons for the differences was the changing share of recirculated sea water, pressed into the bottom sediment by the wave force. Its share in drainage water in winter was small, and in autumn it was more than ten times higher (Szymczycha & Pempkowiak, 2016).

In section 4.2 I described the research on detailed identification of the area where PDWP occurs with the use of geodetic surveys methods and ArcGIS software. In cooperation with

[1] Agreement signed between Gdansk University of Technology and IMGW-PIB

the Department of Geodesy at the Faculty of Civil Engineering and the Environment of the Technical University of Gdańsk, during the field campaign in April 2013, geodetic measurements were made, combined with measurements of temperature and salinity in the coastal area of the beach in Hel. 600 points located approximately 15 cm apart were surveyed and were then developed with ArcGIS software, which allowed for detailed visualisation of the area where PDWP occurs. This allowed for a detailed visualisation of the groundwater drainage area in the area of the shallow littoral of the municipal beach in Hel. The results showed a diversified distribution of salinity of sandy sediments in pore water, and the visualization performed clearly states the exact places of freshwater outflow to the coastal zone (Piask 2015).

Subchapter 4.3 is devoted to the analysis of the results of microbiological tests performed with the use of epifluorescence microscopy. I analyzed the number, biomass, size structure and metabolic activity of bacteriocenosis cells settling in sea water and pore water in the area of undersea drainage, I analyzed the entire period of my studies, each of ten research series and seasons (winter, spring, summer, autumn). in all research series, I found the lowest values of the analysed parameters in seawater. In pore waters, under the influence of and without drainage, they were higher and did not differ statistically considerably from each other. In pore water in both regions and in seawater, I noticed a clear correlation between biomass and cell count, which may indicate a high availability of biogens and physicochemical conditions conducive to bacteriocenosis development. In all the studied environments in specific seasons I noticed a contrasting correlation between average cell volume and cell activity. High activity of bacteriocenosis cells results from the possibility of prompt decomposition of organic matter coming from phytoplankton blooms or inflowing with drainage. The most active cellular activity and its smallest fluctuations were noted in samples of pore water under the influence of drainage, which may be caused, on the one hand, by the introduction of biogens and, on the other hand, by the need for the microorganisms to adapt to changing environmental conditions (oxygen concentration, Eh). In seawater and pore water not affected by drainage, the activity was comparable. I noticed the lowest activity in the winter season and the highest in spring. In comparison with environmental observations, I found a correlation between biomass and cell count and water temperature, the highest biomass in all the studied regions occurred in the summer season. This indicates that the physical conditions of the environment can also have a significant impact on the bacteriocenosis of pore water which is confirmed by the findings of other authors stating that temperature significantly influences the size and morphological structure of bacteriocenosis (Sjöstedt et al. 2012). I confirmed the results obtained in the field studies in the experimental studies described in Chapter 4.6.

In section 4.4 I presented the taxonomic differentiation of pore water bacteriocenosis in the area of groundwater drainage using the new generation sequencing technique (NGS - Illumina 16s rRNA). 665 107 high-quality sequences were obtained, classified as 31 phylogenetic types. The total number of readings (OTU) correlated with the total number of bacteria (OLB). On the basis of three independent indicators of species richness (biodiversity): Shannon, Simpson and Chao1, I have clearly identified the greatest diversity of environment

- winter in the area where the drain occurs, and the smallest - also in this area in summer. On the basis of the analysis of the occurrence of unique OTUs in particular seasons, I found that they occurred a little more frequently in winter than in spring and summer. I have also noticed a small number of taxis (OTUs) characteristic of only one environment (W - 3; BW - 6). On the basis of an analysis of taxa classified at genus level and found in all the studies simultaneously, I identified 89 genera belonging to 15 genera from the kingdom of Bacteria. The most numerous types were those belonging to the *Proteobacteria* types (45% in total, including 25% *Alphaproteobacteria*) and *Actinobacteria* (18%). I also found that there were significant taxonomic differences both in both regions and in the seasons. On the basis of hierarchical heat map charts generated at the class level, I noticed that pore water samples taken in three seasons can be divided into two groups. The first group included samples taken in spring in both analysed regions and in winter in the region under the influence of drainage, and the second group - samples taken in the region without the influence of drainage in summer and winter and in summer in the region under the influence of drainage. I found it difficult to determine whether the season or the impact of the drainage has a greater impact on the *Prokariota* community that inhabits the pores. In the studied region, I found the presence of representatives of both marine and freshwater species. I also noticed the interdependence between the availability of oxygen and the value of redox potential and the biochemical processes catalysed by microorganisms with specific life requirements. In conclusion, I concluded that the knowledge of taxonomic composition of bacteriocenosis settling pores waters may, therefore, facilitate the recognition of processes occurring in the sediment in the area where underground drainage occurs.

Chapter 4.5 deals with the sanitation characteristics of sandy beaches and shallow littoral zones in groundwater drainage areas. I analyzed the number of indicator bacteria - faecal streptococci and *E. coli* intestinal bacteria in seawater and pore waters (4.5.1). In winter and spring, I did not find any faecal streptococcus bacteria to be present in all tested samples. I confirmed the results of the tests by genetic methods (Illumination NGS sequencing; Chapter 4.4). Comparing the results with the water quality standards for recreational purposes (Journal of Laws 2016, item 1187), I found that the microbiological quality of seawater was generally good. Only in the summer and autumn, the number of indicator bacteria increased close to the limit values in the standards. In pore water not affected by drainage, the number of indicator bacteria was similar to or lower than that in seawater. In the pore water under the influence of drainage I did not detect the presence of faecal streptococci, but periodically *E.coli* bacteria appeared. Their lower number in pore water in this region may result from dilution of seawater with groundwater, changes in environmental conditions (salinity, Eh, pH, nutrient concentration, oxygen availability) to indicator bacteria less favourable for survival and periodic presence of substances inhibiting them (CH4, H2S).

I also analyzed the sanitation of sand on the beach in the area of underground drainage (4.5.2). The beach ecosystem has a direct impact on the adjacent coastal area and the shallow littoral area, as I have also noted in previous studies in the Gulf of Gdańsk (Olańczuk-Neyman & Jankowska 1998; 2001; Jankowska et al. 2005). The town beach in Hel is a place that is particularly popular with tourists, which has a direct impact on the microbiological quality of the sand. I found by far the most indicator bacteria in the sand samples taken under the breakwater. In the summer series, *E.coli* was well above the limit values. In both summer series, I also noted the presence of indicator bacteria in deep sediment layers (100 cm) in the saturation zone, which was associated with the occurrence of short-term but intense rainfall. The lack of faecal streptococci and the much lower number of *E.coli* in spring in seawater may indicate that reducing the inflow of pollutants results in their removal from the environment in natural self-purification processes.

In the hearing, I also took up a significant problem of the occurrence of drug-resistance traits in bacteria of faecal origin. To this end, I performed biochemical identification and drug resistance assessment of faecal streptococci isolated from seawater and beach sand in the area of underground drainage using the automatic BD Phoenix system (4.5.3). The system is widely used in clinical trials, but to my knowledge, it is the only one in Poland used in environmental trials at the Faculty of Civil Engineering and the Environment of the Technical University of Gdańsk. In samples of seawater and sand I found the presence of bacteria of the genera *Staphylococcus* and *Enterococcus,* which indicated that the substrate used in the study, in accordance with the standard specified in the current Regulation of the Minister of Health (Journal of Laws 2015, item 1510), in the case of brackish waters is not selective enough to isolate faecal streptococci.

When studying the resistance of isolated strains to thirteen antibacterial compounds, I found the presence of strains showing the features of multi-resistance (i.e. simultaneous resistance to compounds from three or more chemical classes), in seawater 17%, in wet sand 38%, and in sand 23% under the breakwater. The obtained results show that despite only temporary exceeding of the acceptable standard of faecal streptococci number in the studied region, due to their potential pathogenicity and the possessed characteristics of drug resistance, they pose a potential epidemiological threat. Nor can their contribution to the spread of environmental resistance characteristics be excluded. The results of the study clearly indicate the need for extended monitoring of the sanitary quality of the sandy beach and shallow littoral zone environment, as stated in other studies conducted at the Department of Water and Wastewater Technology of the Faculty Civil and Environment Engineering of the Gdańsk University of Technology (Łuczkiewicz et al. 2010a; Łuczkiewicz et al. 2010b; Sadowy and Łuczkiewicz 2014) which is also highlighted in world literature (de Oliveira &Watanabe 2008; Landers et al. 2012; da Costa et al. 2015; Masters et al. 2017).

In Chapter 4.6, I considered the issue of changes in the structure of pore water bacteriocoenosis in conditions of stress caused by changes in environmental conditions in the area where the offshore drainage occurs. I have conducted controlled laboratory experiments with a micro/mesocosm system. I conducted my research at the Professor Krzysztof Skóra Marine Station in Hel, belonging to the Institute of Oceanography of the University of Gdańsk, in a set of flowing aquariums, supplied with seawater directly from the Gulf of Gdańsk, collected at the site of field research, which allowed to accurately reflect the conditions prevailing in the environment. I conducted two experiments: in spring (water temperature 9.8 - 11.5 oC) and summer (water temperature 16.3 - 18.3 oC). Analysing the impact of changes in the conditions of the marine environment of the coastal zone occurring in the area where the groundwater drainage occurs on the bacteriocenosis present (4.6.1), I found that it adapts relatively quickly to the conditions of the coastal zone. The number and biomass of cells increases and their size decreases after a period of adaptation, which may indicate high activity and adaptation potential. Short-term contact of bacteriocenosis present in seawater with pore water under the influence of drainage does not significantly affect its abundance, but after the third day, it begins to decrease. The decrease in the number and growth of cells in the population functioning in seawater may result from the necessity to adapt to the environment with limited oxygen availability. Experiments have shown that the number of bacteriocenoses in seawater and pores is affected by changing environmental conditions (availability of nutrients, redox potential and dissolved oxygen concentration) with the inflow of underground drainage. However, the main parameter affecting the variability of bacteriocenosis is the temperature depending on the season, which is confirmed by the results of field studies (Chapter 4.3). My observations are also confirmed by experimental research conducted by other authors (Shiah & Ducklow 1994; Sjöstedt et al. 2012)

I also conducted an analysis of the survival rate of indicator bacteria in the marine environment and in the groundwater drainage zone (4.6.2). I conducted the experiments in two variants. In the first suspension of multiplied colonies of faecal bacteria (*E.coli, E.fecium* and *E.fecalis*) I vaccinated barren seawater and pore abstracted in the area of drainage. In the second one, I simulated the introduction of bacteria into the marine environment along with municipal wastewater, and the broth was used as the medium.

I have found that E.coli has a longer life expectancy in lower-temperature seawater, as can also be seen from field studies, which have shown that, despite the limited spring influx of contaminants, *E.coli* is present in the environment. For two species of faecal streptococci (*E.fecium* and *E.fecalis*) I found a clear decline in abundance, which is also confirmed by field studies, where I reported a significantly lower number of faecal streptococci in seawater and pore water than for E.coli. In the pore water abstracted in the area of drainage, I found a significant decrease in the number of indicator bacteria, which may indicate dilution and contact with the pore inhibitors for these bacteria periodically brought in with water (H2S, CH4), which I also demonstrated in my field studies. In laboratory experiments, I have noticed an increase in the survival rate of faecal bacteria in the presence of organic substances that can be introduced into the marine environment along with pollutants. This is particularly important in areas used for recreational purposes in view of their pathogenicity and the transferability of drug-resistance characteristics, which I have also noted (Chapter 4.5.3).

In the last chapter of the hearing, I summarized the results of the research and presented the conclusions that I drew from the research hypotheses that had been put forward at the beginning. I concluded the hearing with a list of the literature used and abbreviations used.

The most important achievements resulting from the conducted research:

- The paper deals with the impact of underwater groundwater drainage on the communities of *Procaryota,* the littoral coastal zone, and sandy beaches. Research of this type in the Baltic Sea region has not been conducted so far.
- The results of our own research confirm that in environmental studies auto- and allochthonous bacteriocenosis develops under the influence of numerous factors, most of which can be described as "environmental stress". It was found that although the inflow of groundwater in the coastal area does not cause significant changes in the number, size and biomass of bacterial cells settling in coastal sea waters and sandbanks, it does affect their activity and diversity. The intensity of these changes depends on the season (mainly temperature and oxygenation).
- For the first time, taxonomic analyses were performed using the new generation sequencing (NGS) of Illumina, a prokaryotic organism settling pores in the area of groundwater drainage in the shallow littoral zone of the sandy beach of the Gulf of Gdansk.
- The interdependence between the availability of oxygen and the value of redox potential and the biochemical processes catalysed by microorganisms with specific life requirements has been noted. It has been demonstrated, among others, that selected groups of microbiological indicators, e.g. methanogenic *Archaea*, identified by genetic methods (NGS) may be a sufficiently sensitive bioindicator of the impact of groundwater drainage on the marine environment.
- Exceedances of the limit values in the standards (faecal streptococci and *E.coli*) were found only during the summer and autumn seasons. In pore water not affected by drainage, the number of indicator bacteria was similar to or lower than that in seawater. However, the lowest values were recorded in pore water under the influence of drainage. This may be due to dilution of seawater with groundwater, changes in environmental conditions (salinity, Eh, pH, nutrient concentration, oxygen availability) and periodic presence of inhibitors (CH_4, H_2S). Not without significance is also the effect of allochthonous antagonistic microflora, which may affect the partial elimination of microbial contamination of faecal origin.
- In experimental studies, it was observed that the presence of organic substances significantly increased the survival time of faecal bacteria, both in seawater and in pore waters under the influence of drainage. This is important in terms of the sanitary quality of coastal waters.
- However, detailed biochemical identification of the strains showed that the substrates used in accordance with the standard specified in the current Regulation of the Minister of Health (Journal of Laws 2015, item 1510), in the case of brackish waters, were not selective enough to isolate faecal streptococci, as besides enterococci other bacteria were also found, mainly of the *Staphylococcus* genus, including Staphylococcus aureus.

- Antibiograms made for *Enterococcus spp*. strains isolated in the region were similar to clinical ones and reflected the consumption of antibiotics in Poland. The observed presence of drug-resistant bacteria could be related to their selective advantage in conditions of exposure to environmental factors (e.g. UV radiation).
- The study also concluded that due to the complexity of the processes between biotic and abiotic factors in the sandy beach environment and the shallow littoral zone, short-term studies could lead to erroneous conclusions. In order to identify and understand these correlations, cyclical and detailed monitoring over a long period of time is necessary.

The research was financed from the project of the National Centre of Science No. N305 316140 entitled "The research of the Polish science sector in Poland". "The impact of groundwater exudations on the communities of microorganisms found in the shallow littoral zone of the sandy beach (2010-2014), of which I was the manager (Appx. 4.II.J.b.12; Appx. 4.II.F.b.11).

Some of the research described in the paper was presented at scientific conferences in Poland and abroad (Appx. 4.III.B. 56,69,71,78) and as part of the X and XIII Baltic Science Festivals.

Some results were used in engineering works prepared by students of the Faculty of Civil Engineering and Environment of the Technical University of Gdańsk:

Magdalena Lorenz; Assessment of abundance and biomass of bacterial communities settling coastal sea waters and sandbanks in the coastal zone, defence 21.01.2013

Radosław Marszałek; The survival of Enterococcus bacteria in coastal sea waters in the area of groundwater exudation, defence 21.01.2013

Tomasz Lemke; Bacteria Escherichia coli as an indicator of the sanitary status of coastal sea waters in the area of groundwater exudation, defence 06.02.2013

Agnieszka Piask; Visualization of salinity measurements of a specific part of the Gulf of Gdańsk seabed using the ArcGIS program defence 06.2013.

4. Discussion of other research achievements

a) Before obtaining a doctoral degree

Even before I started my studies, I started working as a trainee technician in a photography studio at the Faculty of Mathematics and Physics of the University of Gdańsk. Thanks to the experience gained there, I was able to develop my interest in photography, which I use in my teaching and popularization activities.

In 1991 I started studying Oceanography at the Faculty of Biology, Geography and Oceanology. My scientific interests have always been connected with the microbiology of the environment. During my studies, I completed a six-month internship at the Marine Biology Centre of the Polish Academy of Sciences in Gdynia, where, in the Microbiological Studio under the direction of prof. dr hab. Modesta Maciejowska I was able to improve my skills related to classical breeding methods. Thanks to the opportunity to supplement my theoretical knowledge gained during my studies with practical skills, I was able to take up the position of an oceanographer at the Department of Marine Dynamics of the Institute of Oceanology of the Polish Academy of Sciences in Sopot, where I took part in field and laboratory research as part of three projects: one financed by the National Centre of Scientific Research (KBN) entitled "Simulation of the stream of sea aerosols" and the other financed by the Vth EU FP entitled "Baltic Aerosol Experiment" - BAEX and "Baltic Sea System Study" - BASYS (Appx. 4.II.Ja.1. and 2. and 4.II.Jb.1.). As part of the projects, I took part in field campaigns and laboratory tests. The projects concerned the transferability of various types of pollutants from seawater to air and their transfer over long distances. We conducted our research in the coastal region of the Gulf of Gdansk and the Baltic Sea. The results clearly indicated the presence of mesophilic and psychrophilic bacteria and mould spores in marine aerosols in the coastal zone as well as in the open sea. We also found that although the number of microorganisms in the coastal zone was significantly higher than in the open sea, there are more mesophilic bacteria (associated with potential pollution that psychrophilic species (associated with the environment)). We also noticed that saturation of surface waters with oxygen may contribute to the increased transport of bacteria trapped in seawater drops to the air, especially during the summer phytoplankton bloom in the Gulf of Gdańsk, in the area of mixing the Vistula water with the Baltic water. The results of field studies were confirmed in experiments conducted in the laboratory, in which we noted that the enrichment ratio of mesophilic bacteria thrown away with drops of aerosols could be 12 times higher than for psychrophilic bacteria. I presented the results of my research at two scientific conferences (Appx. 4.II.L.1. and 4.II.L.2.). I am also a co-author of 4 scientific publications (Appx. 4.II.A.1. and 3. and 4.II.E.a.1. and 4.II.F.a.1.).

In 1996 I graduated from the Faculty of Biology, Geography and Oceanology of the University of Gdańsk with a Master's degree in Biological Oceanography. I defended my diploma thesis entitled "*Impact of the discharge of post-treatment waters on the meiobenthos community in the coastal area of the Puck Bay in the area of Swarzewo"* under the supervision of prof.dr hab. Maciej Wołowicz. I analyzed the impact of the discharge of treated wastewater on the taxonomic composition and abundance of small bottom organisms (meiobenthos) in the coastal area of the Bay of Puck. I compared the vertical distribution of individual taxa in the sediment and determined the relationship between the occurrence of benthic organisms and the physicochemical parameters of the environment. Until the 1990s, the Puck Bay region was a receiving area for wastewater discharged directly there and carried away with the waters of the rivers Reda, Gizdepka, Płutnica and Błądzikowska Struga. It was a highly biologically degraded region with declining natural biocoenosis and low biodiversity. Cutting off the direct discharge of untreated wastewater, regulation of water and wastewater management and construction of the sewage treatment plant significantly improved the sanitary and epidemiological condition of the Bay of Puck. However, a new threat has emerged in the form of the point discharge of a large load of nutrients, which increases primary production and thus the content of organic matter in water and periodic oxygen deficiencies. The research was conducted in the period after the start-up of the wastewater treatment plant, where works were carried out to improve the treatment process because the reactors of the "Biooxyblok" type did not meet the design requirements as a result of technical difficulties and periodically the values of BOD5, ammonium nitrogen and phosphates were exceeded. I took samples at three stations, located at different distances from the outlet of the wastewater collector treated at the Sewage Treatment Plant in Swarzewo.

In the paper, in addition to determining the number and taxonomic composition of meiobenthos, I conducted in situ measurements of temperature and dissolved oxygen concentration, as well as laboratory granulometric analyses and organic matter content in the sediment. Comparing the results with the literature, I noticed an overall improvement in the quality of the benthic environment. Fine-grained sands were predominant in the study area, medium sized sorting, and the share of <0.063 mm fraction usually did not exceed 2%. The content of organic matter was low (it ranged from 0.48 to 1.16%). The taxonomic composition of meiobenthos was typical of similar regions with a strong domination of *Nematoda* (56.1 to 86.8%). I have noted the resurgence of the oxygen-sensitive *Gastrotricha* taxa and *Turbellaria.* On the basis of the statistical analysis, I found that the number and taxonomic composition of the meiofauna varied at individual stations and depended on their location in relation to the collector's mouth, but these differences were not statistically significant.

The experience gained during my studies and preparation of my master's thesis led me to undertake two-semester postgraduate studies in Geotechnics and Environmental Engineering at the Faculty of Hydraulic and Environmental Engineering, (actually: the Faculty of Civil and Environmental Engineering). They were continued with the doctoral studies "Geotechnics and Environmental Engineering" at the same Faculty. On December 12, 2001, I obtained a PhD degree in technical sciences in the field of Environmental Engineering, specialization: Sanitary Biology. Under the direction of prof. dr hab. Krystyna Olańczuk- Neyman, I presented a doctoral thesis entitled: *"Ecosystem of sandy beaches in the Bay of Gdańsk as an environment of heterotrophic bacteria"* (Appx. 4.II.F.a.3). Thanks to obtaining funding from the Ministry of Science and Higher Education in the form of a promotional grant (Appx. 4II.Jb.2.) I was able to significantly expand the set of analyses originally planned.

At the hearing, I analyzed the occurrence of bacteria with different nutritional requirements settling sandy beaches in the area of the Gulf of Gdansk. At the end of the twentieth century, a sandy beach area was the focus of research worldwide and microbiologically poorly known (McLachlan & Brown, 2006). The main field of research was the beach located on the Bay of Gdańsk in Sopot, and some of the research was also conducted on two beaches located at the end of the Hel Peninsula. I have shown that sandy sediments building beaches of the Gulf of Gdańsk are inhabited by numerous bacterial flora capable of decomposing various organic pollutants. I noticed that the total number of living heterotrophic bacteria cells in the sand in the surface layer of the aeration zone is similar to the values recorded in soils and higher than in shallow coastal waters. The prevalent aerobic bacteria were not spore-forming. Among the various enzymatic abilities of heterotrophic bacteria, the ability to decompose sugars and proteins comes first, and only a few are capable of decomposing fats. The distribution of heterotrophic bacteria in beach sand depends on the distance from the water line and the depth below the surface. Their number increases as they move away from the seashore towards the dunes, but decreases with depth. In the beach sand, I did not find a clear seasonality of heterotrophic bacteria, with the exception of mesophilic bacteria, the number of which decreased significantly with the decrease in the temperature of the environment. I also noticed that heterotrophic bacteria found on sandy beaches are adapted to growth in environments with limited nutrient content and may grow in the presence of specific anthropogenic pollutants: mineral oil and heavy metals (lead, copper and cadmium). Analysing the sanitary condition of sandy sediments, on an annual basis, the worst quality of sand was recorded in the period from May to August. Among the identified species of faecal bacteria, the predominant ones were of human origin. The results were published in three publications from the JRC list (Appx. 4.II.A.2; 4.IIA4; 4.IIA.8) and presented at national and international scientific conferences (Appx. 4.II.L.3; 4.II.E.b.1-2; 4.III.B.1-4; III.B.8).

(b) After obtaining a doctoral degree

I am constantly trying to broaden my knowledge and research skills. After obtaining my PhD degree, I took part in nine specialist courses concerning, among others, molecular biology techniques, epifluorescence microscopy, identification of marine microorganisms by direct and indirect breeding methods, or improvement of the microbiological laboratory (Appx. 4.III.L.c). I also obtained a diploma of completion of two-semester postgraduate studies "Research project management and commercialization of research results" at the Faculty of Management and Economics, Gdańsk University of Technology (Appx. 4.III.L.b.3).

My research interests after obtaining a PhD can be divided into three basic research areas:

I. Coastal areas as areas particularly exposed to anthropogenic pollution.

II. Microbiological processes occurring in drinking water transmitted through the water supply system and in modern urban wastewater treatment systems.

III. Microbiology of polar environments in the context of climate change.

Re I. Coastal regions as vulnerable areas for pollutants of anthropogenic origin.

Microbiological environmental quality is one of the priorities of the World Health Organisation (WHO), the American Environmental Protection Agency (US EPA) and the European Commission (EC) (Bartram & Rees 2002). Recommendations and methods for assessing these risks have been further developed for more than two decades (Noble et al. 2003; Caruso et al. 2004; Kay et al. 2004; Soller et al. 2017). The regulations on the monitoring of recreational areas point to faecal streptococcus bacteria and intestinal bacteria (*E.coli*) as sensitive and accurate indicators of the sanitary status of the environment. Currently, in force in Poland, the Regulation of the Minister of Health (Journal of Laws 2015, item 1510) allows the number of 4.0 x 102 CFU/100 cm3 enterococci and 10.0 x 102 CFU/100 cm3 intestinal sticks *(E.coli*) in water intended for bathing. Last but not least, the growing clinical importance of these bacteria is also important. In the last decade, both *E. coli* and Enterococcus spp. were among the important factors of nosocomial infections, causing numerous secondary infections, among others as a result of translocations (displacements from the intestine light, where they are part of commensal bacteriocenosis, to places where they play the role of pathogens). For example, pathogenic *E. coli* strains cause between 25 and 50% of in-patient urinary tract infections and 90% of out-patient infections, and selected *E. fecalis* and *E. fecium* strains cause one in two hospital bloodstream infections.

It should be noted that the area of the coastal waters of the Gulf of Gdańsk and the Bay of Puck, apart from its exceptional natural values, is particularly attractive in terms of recreation (Węsławski et al. 2011). There are more than 20 bathing places here, which are used by up to 4 million people a year. Currently, the area of Hel Peninsula is very popular with numerous tourists. For years, the inadequate sanitary condition and potential epidemiological threat associated with it in the coastal area have been the cause of the inclusion of the Gdańsk Bay bathing grounds in recreational use (Sobol & Szumilas 1998; Sobol & Szumilas 1994) and this has also been demonstrated in my doctoral thesis (Appx.4.II.F.a.3). And after its completion, this topic is still in the centre of my research interests, especially that although epidemiological threats related to the presence of pathogenic microorganisms occurring in recreational areas seem to be well recognized, they are still the subject of new research and analysis (Fewtrell & Kay 2015). The presence and number of the indicator and pathogenic bacteria can change rapidly in time and space (Boehm et al. 2003). It is still necessary to search for new markers facilitating quick and accurate risk assessment (Wade et al. 2010; Napier et al. 2017) and to develop fast diagnostic tests (Kong et al. 2002; Colford et al. 2012), allowing for proper organisation and management of recreational areas (Leecaster and Weisberg 2001). A methodology for sampling adapted to specific environmental conditions is also being developed (Boehm et al. 2009; Costa-Dias et al. 2018). Microbiological testing is linked to epidemiological data (e.g. collected from surveys) and creates mathematical models to monitor and predict quantitative microbial risk assessments (QMRAs) (Feng et al. 2015; Fewtrell & Kay 2015; Palazón et al. 2017). Increasing attention is also paid to education and raising public awareness of the proper use and necessity of protection of recreational areas (Farnham et al. 2017).

In 2003, I received funding for the project *"Assessment of the sanitary condition of the sandy beach ecosystem subjected to strong anthropogenic pressure on the basis of the presence of indicator and pathogenic bacteria"* (Appx 4.II.F.1.) so that I could continue my research. The main objective of the project was to investigate to what extent the intensity of tourist traffic in the area of the bathing water affects the sanitary condition of the environment, including the presence of selected groups of pathogenic bacteria. The subject of the research was coastal sea waters and sandy sediments of Tri-City, coastal recreational areas, namely the beach in Sopot. The results of the research were to be used for extended characterisation of the sanitary condition of the studied environment and to be helpful in formulating guidelines concerning location and scope of research for monitoring of coastal recreational areas. The results of the study showed that the number of indicator bacteria correlates with the contamination of the environment with selected pathogenic bacteria, such as intestinal bacteria of the *Enterobacteriaceae* family, of the *Salmonella* genus, mannitol-positive and manitolousian *staphylococci* and haemolytic bacteria. The results were published and presented at scientific and technical conferences (Appx II.L.9, 4.II.E.d.1-2, 4.III.B.14). However, microbiological conditions for sand used for recreational purposes are still not defined and the sanitary condition of sandy beaches is examined only periodically and applies to selected areas. This topic is currently of great interest in the world's scientific literature. It was observed that a much higher number of the indicator and pathogenic bacteria in the sand is associated with a longer time of human presence on the beach than with bathing. This has an impact on the increased likelihood of infection after contact with contaminated sand (Bonilla et al. 2007; Sabino et al. 2014). In addition to the existing bacteriological indicators, research should also cover intestinal viruses and pathogenic protozoa (e.g. Giardia). Due to frequently observed skin infections after contact with sand, it is also worth noting pathogenic fungi (*Aspergillus sp.*, *Candida sp.*, *Microsporum sp*. and *Trichophyton sp*.) (Solo-Gabriele et al. 2016).

In my research, I also dealt with the influence of streams flowing into the coastal zone on its sanitary quality. We analyzed small watercourses discharging into the sea in the Sopot region and the influence of the Oliwa Stream and the Reda River. We found that they could bring significant amounts of anthropogenic pollution into the coastal zone (Appx. 4.II.A.7; 4.II.E.e.4; 4.II.E.f.1; 4.II.L.10; 4.III.B.11-12). In 2009, the Sopot authorities undertook an investment project to collect outlets from the waters of six Sopot streams (the Border, Karlikowski, Haffner, Dworski (Central), Bohaterów Monte Cassino and stream no. 2 - located between the Border and Karlikowski) and lead them 400 m deep into the Gulf of Gdańsk, which significantly improved the sanitary condition of bathing areas. Unfortunately, the Reda River and the Oliwa Stream, especially after heavy rainfall, bring considerable amounts of anthropogenic pollution (Appx. III.B.64).

My next work was related to my participation in the international project "*Coastal Sands as Biocatalytical Filters"* (COSA) (Appx. 4.II.J.a.3), whose Polish partners were colleagues from IOPAN in Sopot. The aim of the project was to investigate the role of marine sands in the functioning of coastal ecosystems, in order to enable their rational exploitation.

The project was financed from the funds of the Thematic Programme "Environment and Sustainable Development" implemented under the 5th Framework Programme for Research, Technical Development and Presentation of the European Union and was a part of the EU project group "European Land-Ocean Interaction Studies". (ELOISE), the European contribution to the International Geosphere-Biosphere Programme (IGBP) in the framework of the "*Land-Ocean Interactions in the Coastal Zone*" (LOICZ) flagship initiative. My main task was to examine the sanitary condition of the water and sandy sediments on the beach of Hel and to try to answer the question of whether, and how quickly, faecal contamination can be removed from the beach ecosystem as a result of the natural dynamics of the coastal zone. In the study, I confirmed my previous observations concerning the presence of faecal bacteria in water and beach sand. The number of psychrophilic bacteria was dependent on the season, and indicator bacteria occurred mainly in summer, during the period of increased tourist traffic, which makes it possible to assume that in the absence of fresh supply of pollutants they are eliminated from the environment (Appx. 4.II.L 5; 4.III.B.1; 4.III.B.9; 4.III.B.15). The project also plans social activities to improve awareness of potential health risks among beach users. I am a co-author of a popular science brochure presenting the sandy beach ecosystem and ways to use it safely (Appx. 4.II.E.g.1).

My field and methodological experience allowed me to become a co-author of the chapter devoted to bacteriobenthos research in the methodological guide describing physical, chemical and biological studies of marine sediments published in 2010 and edited by prof. dr hab. Jerzy Bolałek (Appx. 4.II.E.c.2).

Another issue of interest to me relating to the microbiological risks of coastal areas is the phenomenon of increasing drug resistance among waterborne microorganisms. It is caused, among other things, by not fully justified use of antibiotics for therapeutic purposes, as well as by serious abuses of antibiotics in animal breeding (Tollefson & Miller 2000; Landers et al. 2012). This practice has led to the selection of drug-resistant, opportunistic and pathogenic strains in the environment. Direct or indirect contamination of aquatic ecosystems with such microorganisms poses a potential risk of propagation of resistance genes and their transfer to other microorganisms, including saprophytic ones. Sewage is an important reservoir of drug-resistant bacteria as well as of the antibiotics themselves. Drug-resistant bacteria also enter surface waters as a result of rainwater inflow, sewage of zoonotic origin, surface runoff and leaky septic tanks in unregulated water and sewage management areas. I was a contractor in two projects carried out in the Department of Water and Wastewater Technology CEE GUT *pressure"* (Appx. 4.II.J.b.4), and in the years 2010-2013 it was a project entitled "Research on drug resistance, virulence and genetic diversity of indicator bacteria in outflows from sewage treatment plants and their reservoir - marine coastal waters" (Appx 4.II.J.b.11). The results of the research were published in a journal from the JCR list (Appx 4.II.A.10) and in three other reviewed articles (Appx 4.II.E.d.3; 4.II.E.d.5-6), of which I am a co-author. They were also presented at 13 international and national conferences (Appx 4.III.B.13; 4.B.23-24; 4.B.29-30; 4.B.41-42; 4.B.13; 4.B.48; 4.B.55; 4.B.57-58; 4.B.64).

Currently, I am a contractor in the Model Areas for Removal of Pharmaceutical Substances in the South Baltic - MORPHEUS project, also implemented by prof. Łuczkiewicz, as part of InterReg South Baltic EU funds (Appx 4.II.J.a.11). The aim of the project is to prevent pharmaceutical pollution of the aquatic environment in the Baltic Sea Region. Seven partners from Sweden, Germany, Lithuania and Poland participate, as do nine associated partners (mainly wastewater treatment plant operators and local authorities). The main objective of the project is to provide information on the consumption of pharmaceuticals in coastal regions with an estimation of their further emission to the environment (in this case, to the coastal waters of the Baltic Sea). A report will also be prepared on the existing and advanced methods of wastewater treatment to reduce the emission of pharmaceutical compounds to the receiver's waters, to help the managing authorities and the operators of wastewater treatment plants understand and assess the risks associated with the emission of pharmaceuticals to the receiver's waters.

In the team of the Department of Water and Wastewater Technology at CEE GUT, we also undertook research on microbiological hazards associated with discharging treated wastewater into the environment (Appx 4.II.E.e.2). Particularly large municipal wastewater treatment plants due to their significant load of microbial contaminants, including pathogenic organisms, may pose a serious threat to the sanitary quality of the environment despite highly effective treatment technologies. From 2007 to 2010 I was a co-contractor of the *"New methods of emission reduction of selected pollutants and application of by-products from sewage treatment plants"* financed by EEA Norway Grants (Appx. 4.II.J.a.8). The aim of the project was to compare and select the most effective method of disinfection of treated wastewater. Three technologies were selected for comparison: ozone, UV radiation and microfiltration. The research was carried out on a laboratory and semi-technical scale in the facilities of the two largest treatment plants in the Tri-City: the wastewater treatment plant in Gdańsk-East and the wastewater treatment plant in Gdynia Dębogórze. All methods have proven to be very effective in improving the quality of treated wastewater. In the case of UV disinfection, the reduction in the number of bacteria reached 4 orders of magnitude. It was also found that faecal coliforms were more sensitive to UV radiation than faecal streptococci. Microfiltration reduced the indicator bacteria count by 3-5 orders of magnitude. Suspension, turbidity, total phosphorus and COD were also effectively removed; and to a lesser extent, total nitrogen was removed. The results of which I am a co-author were published in three articles from the JCR list (Appx 4.II.A.9; 4.II.A.11-12) and in five other reviewed articles (Appx 4.II.E.d.6-8;4.II.E.e.3; 4.II.E.f.7) and was presented at 9 international and national scientific conferences (Appx. 4.III.B.26-28; 4.III.B.38-39; 4.III.B.44-45; 4.III.B.60; 4.III.B.62). The final result of the project is also a book entitled "The future of the city". "Disinfection of Sewage" edited by prof. Krystyna Olańczuk-Neyman and prof. Bernard Quant, published in 2015, of which I am also a co-author (Appx.4.II.E.c.2).

Re II. Microbiological processes in drinking water transmitted through the water supply system and in modern urban wastewater treatment systems.

Working in the Department of Water and Wastewater Technology of the Faculty of Civil Engineering and the Environment, I take an active part in projects concerning microbiological processes in drinking water transmitted through the water supply system and in modern urban wastewater treatment systems implemented within our team.

In the years 2010-2013, I was a co-executor of the NCN project entitled "Study of the susceptibility of water distributed in the water supply system to secondary bacterial growth" (Appx. 4.II.J.b.10). The main task of water supply systems for human consumption, apart from meeting the quantitative and quality requirements, is to minimize the risk of deterioration of its quality in the water supply network. An important feature of water in the water supply system is its biological stability, i.e. the lack of development and secondary growth of the number of various microorganisms, often accompanied by adverse changes in physical (e.g. turbidity, smell, taste, colour) and chemical characteristics (e.g. increase in the concentration of iron, manganese, nitrite, nitrate). The research was conducted using fluorescent and molecular methods in water samples taken from the Gdańsk water supply network supplied from the surface intake of the OWF Straszyn and from Gdynia supplied from two groundwater intakes of the OWF Wiczlino and the OWF Sieradzka. Raw water, water after treatment fed to the network and water distributed through the water supply network was examined. The results of the research showed that technological processes applied in water treatment plants have a significant impact on the physiological state and activity of living bacterial cells remaining in the water after its treatment. The potential secondary growth of these cells in water distributed through the water supply system depends both on the activity of bacterial cells in the water after treatment and on the environmental conditions of the water distributed (concentration of organic substances susceptible to biological decomposition and biogens, temperature, the concentration of the disinfectant). The final result of the project was a comprehensive report (Appx. 4.II.F.b.10), two publications on the JRC list (Appx. 4.II.A.13; 4.II.A.17) and reports at scientific conferences (Appx. 4.III.B.59; III.B.61; III.B.65; III.B.68).

In the years 2010-2012 I was the head of the task in the project "*Innovative source of coal to support denitrification in municipal wastewater treatment plants - INCAS"* implemented under the Operational Programme Innovative Economy under sub-measure 1.3.1. (Appx. 4.II.J.a.9). Evaluation of the possibility of supporting in the process of denitrification the biological treatment of sewage with an external source of carbon in the form of by-products of alcohol production (e.g. fuselage oils and syrup). Methanol, ethanol and acetic acid were used as a comparative material for external sources of carbon. Laboratory, pilot and technical tests were carried out at the "Wschód" sewage treatment plant in Gdańsk, Dębogórze in Gdynia, GOŚ in Łódź and LOŚ in Poznań. The analyses of adaptation possibilities of active sludge biomass using external carbon sources were carried out, as well as measurements of the speed of the denitrification process and measurements of phosphate release and anoxic uptake. The task of my team was to analyze the composition of the population of procarioric organisms building flocs of activated sludge using the "in situ" hybridization method. FISH and genetic methods (PCR -DGGE). The obtained results allow us to look optimistically at the possibility of using alternative coal sources to support denitrification processes in activated sludge chambers. It is described in the publication from the list of JCRs (Appx. 4.II.A.15), and another reviewed publication (Appx. 4.II.E.f.5), six reports (Appx. 4.II.F.b.2; 4; 6-9), and many conference reports (Appx. 4.II.L.12; 4.III.B.18; 37; 46; 47; 49; 51; 53; 66; 67; 70), of which I am a co-author.

Re III. Microbiology of polar environments in the context of climate change

Another issue I deal with in my research is the relationship between the prokaryotic communities in the environment of polar regions. These areas are often referred to as research laboratories for monitoring and forecasting climate change. The anthropogenic impact causes major changes in areas that do not seem to be exposed to it. Extreme meteorological conditions and short trophic relationships, however, make even a slight change in the previous relations clearly visible there. The effects of these changes can be traced at every level of the trophic chain, and the lower the chain, the stronger the impact on the ecosystem as a whole.

Thanks to the cooperation with the employees of the Department of Ecology of IO PAS in Sopot and Prof. dr hab. Jan Marcin Węsławski, established during my studies, in 2003 I was able to take part in a research cruise on the German research icebreaker R/V "Polarstern" belonging to the Alfred Wegener Institute in Bremen (Appx..4.II.Ja.4.). During the three week cruise together with prof. dr hab. Barbara Urban Malinga I conducted research on the Greenland Sea from Longyearbyen (Svalbard Archipelago) to Tromso (Norway). The main objective of the project was to determine the diversity of the benthic fauna in the depth gradient in the deep water Hausgarten area. This is a specific area between the island of Western Spitsbergen and Greenland where the seabed is lowered by more than 4000 m over a relatively short distance. This interesting region has been researched for several years by scientists from AWI. Samples of bottom sediments were collected at nine stations in the transect of depth from 1000 m to 5500 m. Samples were taken with different types of tools such as box-corer 50x50cm and core multicores. The main questions of the project were the statement: Is there a pattern for the vertical distribution of the benthic fauna that inhabits the sediment along the gradient of water depth? If so, how can this pattern be associated with a changing biotic/abiotic environment such as sediment structure, quality and food availability? Microbiological testing played a small but significant role in this project. Considering the fact that I was only just beginning to work with fluorescence microscopy techniques as a success, I can say that the results confirmed the results obtained by my colleagues from AWI. Some differences result mainly from different properties of fluorescent dyes used by us in our research. German friends used acridine orange and we used Sybr Gold. At AWI, only samples of the surface layer of sediments were tested and we also tested samples at a depth of 15 cm of sediment. Here I have clearly noticed that the number and biomass of bacteria increase with the depth. The research was repeated in 2017 by colleagues from IOPAN participating in the next cruise and its analysis is underway (Appx. 4.II.E.f.2).

I was able to develop my interest in further Arctic microorganisms by analyzing samples of sandy sediments taken on two beaches of the Svalbard Bear Island. I presented the results at the conference (Appx. 4.III.B.7.) and co-authored a scientific publication (Appx. 4.II.A.1.).

The next stage of my research on the Arctic was connected with the 4th International Polar Year. In 2005 I was invited to participate in the *project "Structure, evolution and dynamics of the lithosphere, cryosphere and biosphere in the European Arctic sector and in the Antarctic*" part of the National Polar Programme 2005-2007 "Biosphere" (Appx. 4.II.J.b.14). In addition, I obtained funds from the Ministry of Science and Higher Education for the project *"Impact of climate change on the functioning of the microbiological loop in the polar fjord"*, of which I was the head of (Appx. 4.II.J.b.3). I organized and participated in three field expeditions to the Polish Polar Station Hornsund located in the southern part of the island of Western Spitsbergen in the Svalbard Archipelago (Appx.4.III.L.a.11; 13; 14). The project was carried out in cooperation with dr Dorota Górniak of the Faculty of Biology at the University of Warmia and Mazury in Olsztyn, where in 2004 I completed a scientific internship (Appx.4.III.L.a.9) during which I perfected my skills related to microscopic analysis. The main objective of the project was to verify one of the research hypotheses:

H1 The melting of glaciers causes the death of marine stenohaline organisms, which in turn leads to the growth of a pool of easily assimilated organic matter in the water of the fjord. This, in turn, causes an increase in the number of heterotrophic bacteria and their activity, which leads to an intensification of processes occurring within the microbiological trophic loop.

H2: Fresh post-specification water limits the growth of heterotrophic bacteria and therefore the front zones of glaciers are not areas of increased bacteriocenosis development. This leads to permanent changes in the functioning of the microbiological trophic loop in the coastal areas of the polar fjord.

We have selected 7 research stations in different regions of the fjord. Water samples were taken in-depth profiles from 0 to 50 or 120 m (depending on the point). We analyzed physicochemical parameters such as temperature, salinity, the concentration of mineral suspension and dissolved organic carbon. The microbiological research focused on viral plankton abundance, the activity of bacterial cells using the Life/Death method, as well as we determined the total number of bacteria and cell size and their biomass. We also classified taxonomic groups using in situ fluorescence (FISH) and compared the structure of microbial communities on the basis of analysis using electrophoresis in the gradient of denaturing agent - PCR- DGGE. The research partly confirmed the first hypothesis, as it turned out that the central part of the fjord, where the fresh water of glacial origin is intensively mixed with ocean water masses, is not the area of direct influence of glaciers, but the place of the most intensive bacterioplankton development. In this area the largest numbers of people, taxonomic diversification and activity were recorded. The numerous occurrence of microorganisms may also be related to the presence of many very numerous bird colonies on the mountain slopes surrounding the fjord, which results in the runoff of a significant amount of organic matter and nutrients (mainly nitrogen) into the waters of the fjord. The flat coastal terrace in this area is a place of nutrient accumulation which, combined with the high flows, causes the fjord water to be used in this area. We also found a relatively small taxonomic variation of bacterioplankton in the inner part of the fjord, which seems to confirm the assumption that with a significant dynamics of water masses caused by the inflow of melting glacial water there is a complex of microorganisms well adapted to the prevailing conditions.

In 2007, I received funding from a Norwegian research institution, the European Centre for Arctic Environmental Research (ARCFAC V) (Appx. 4.II.J.a.6), and we conducted similar research in the second Spitsbergen Kongsfiorden fjord, located much further north. Analysing water samples taken in a similar spatial arrangement as in Hornsund, we have also found here that there are regions which differ significantly in terms of microbiology (Appx.4.II.A.2).

The next stage is further cooperation with dr Górniak and colleagues of hydrogeologists from the Wrocław University, prof. dr hab. Henryk Marszałek and dr Mirosław Wąsik. Dr Górniak implemented the project *"Processes shaping the formation of microbiocoenoses of freshwater reservoirs in the foreground of the glacier under accelerated degradation conditions"* (Appx.4.II.J.b.9). With the logistic support of the Polish Polar Station Hornsund, for 3 weeks we lived in a field station in the Hyttevika Bay, which is an excellent starting point for research in the foreground area of the Werenskiold Glacier. The research site was chosen not by chance because the front moraine formed as a result of the glacial withdrawal creates very interesting freshwater reservoirs inhabited by various types of bacteriocenosis. We also conducted studies on the presence and diversity of microorganisms in the Arctic river and lake system. We have chosen the Bratteggdalen valley as our survey site. We found that the presence and diversity of microorganisms were determined by changing environmental conditions. The upper lake was strongly influenced by ablation water. In the central lake, the reduction of most of the measured physicochemical and microbiological parameters was noted. Lake Myrktjørna, on the other hand, is a typical example of an ultra-oligotrophic Arctic lake with a well-developed trophic network and ecological dependencies. In conclusion, we noted that the ecological succession of planktonic prokaryotes in the Arctic lake and river system takes place in two stages. The first is selection of microorganisms from glaciers associated with the change of environmental conditions and then through the colonization of selected groups of microorganisms after their adaptation. The result of the project is a publication from the list of JCRs (Appx. 4.II.A.18) and many conference reports (Appx. 4.III.B.20; 21; 63; 79), of which I am a co-author.

I was able to carry out subsequent stages of my research thanks to my participation in the XXXVI Polar Expedition of the Institute of Geophysics of the Polish Academy of Sciences at Spitsbergen (Appx. 4.III.L.a.21).. As the deputy head of the expedition, I spent a whole year at the Polish Polar Station Hornsund, and apart from many duties related to the direct operation of the station and my work in the educational project EDUCIENCE, as a didactic (as described in section 6) I also completed several small scientific projects.

Probably the greatest success I can consider to be the research done during the polar night. Biological processes taking place during periods of total darkness are currently the subject of interest of many scientific teams. In January 2014 at the Station in Ny Alesund my colleagues from the Institute of Oceanology of the Polish Academy of Sciences in Sopot worked on a large project called "Marine Night". My idea was to compare bacteriocenosis in the depth profile at the time of total darkness and the moments when sunlight appears. This was possible because Hornsund fjord was free from sea ice all year round. In mid-January (the period of total darkness) and February, after sunrise, we were able to find ourselves in the "weather window" and take samples on the fjord. Unfortunately, in March this was impossible due to very strong winds. We took samples in the area of Hansa Glacier forehead, and at the Station's laboratory, I was preparing them for further analysis in Poland. In both months there were no differences in the temperature and salinity of the water in the whole column. In January, on the other hand, we noticed a greater number of bacterial cells, they were also larger and had greater biomass. Comparing the microbiological parameters with the content of total organic carbon, I noticed a strong correlation in January, but in February I did not find such a correlation. On the basis of a comparison of bacteriocenosis composition using the NGS Illumina technique, I found slight differences in the species composition. Interestingly, after a detailed analysis of taxa, I noticed more than 60% of the population consists of 9 species. The results I presented at scientific conferences (Appx. 4.II.L.13 and 4.III.B.82), and the publication is in preparation.

In the summer of 2013, together with prof. Aneta Łuczkiewicz, we analyzed the structure of bacterioplankton of shallow lakes in the Hornsund PSP region. We sampled water from two shallow lakes in the vicinity of the Station. One of them serves as a source of drinking water for the station in summer, where we collected water in two points on the tributary to the lake and in the place of the intake for the Station, the other is a receiver of sewage in the Stationary Water Treatment Plant. We analyzed samples of wastewater discharged directly from a stationary treatment plant. Using a microscopic method, we determined the indices of bacteriocenosis structure and cell activity and compared the structure of microbial communities on the basis of analysis of Illumina NGS sequence. By far the smallest number of bacteria and their biomass were found in drinking water lakes almost one million more in outflow lakes and the highest values in treated wastewater. The results of the sequence comparison show that 5,7 % Planctomycetes and Chloroflexi thread bacteria occur in the medium. We can clearly see the impact of the treatment process on the microbiological community. The results I presented at scientific conferences (Appx. 4.II.L.13 and 4.III.B.82; 84) and the publication is in preparation.

During my stay at the Station, I also took part in a project carried out by the IOPAN team from Sopot, entitled "*Growing of the Arctic Marine Ecosystem - GAME"*. The aim of the project was to verify the hypothesis of maturation or "ageing" of the Arctic marine ecosystem as a result of global warming. In ecological theory, the maturity of ecosystems is measured by the way in which energy flows through them. In evolutionary mature old ecosystems, energy flows are dispersed, with small amounts of unused organic matter. These are usually complex and highly biodiverse systems. Young or disturbed marine ecosystems tend to have a simpler structure, fewer trophic links between organisms and often store unused organic matter (carbon) in them. Microbiological processes are an excellent indicator of such differences. The project provided for a comparison between the two polar fjords exposed to different pressures from Atlantic waters at different levels of 'maturity'. Fiord Hornsund is considered "colder" compared to Kongsfjorden, which is considered a warmer fjord. The research carried out on the Oceania research vessel was attended by a student of the Faculty of Vilnius and now by a doctoral student, Agnieszka Kalinowska, in whose leadership I am a supporting promoter. On the basis of seawater and seabed sediment samples, we found higher bacterial production in the waters of the colder Hornsund fjord than in the waters of Kongsfjorden. A similar trend (higher values in Hornsund) was observed for the abundance and biomass of bacterioplankton. In addition to temperature, the waters of both fjords differ in the amount and availability of dissolved organic matter (DOM). This organic matter may originate from primary production, land runoff during the polar summer or large quantities of nutrients from the tundra, melting glaciers and numerous bird colonies flowing into the waters of the Hornsund Fjord. The results show that in both fjords the most important factors affecting the bacterial production of marine bacterioplankton are: temperature, the concentration of pheophytin (which is a product of phytoplankton decomposition) and dissolved organic carbon content. Dissolved organic matter from the HOUSE may originate from herbivorous stairs of zooplankton or from surface run-off. Primary production seems to have a lower impact than previously thought. The results were presented at conferences (Appx. 4.III.B.76; 77) and published in scientific articles of JCR (Appx. 4.II.A.19) and others (Appx. 4.III.E.e.5), of which I am a co-author.

After my return from the expedition, I got in touch with my colleagues from the Department of Analytical Chemistry of the Faculty of Chemistry of the Gdańsk University of Technology. I analysed the influence of chemical parameters modifying the environment on the diversity of bacteriocenosis in the area of Arctic river basins. The research area was selected to be close to PSP Hornsund, the Revvattnet catchment area. Samples were taken at 14 points, divided into three categories: river waters, Revatnet Lake and tributary waters. Based on the analysis of samples taken in 2015, we have clearly noticed that the number of bacterial cells in the water depends on the meteorological conditions. In river water, we found a very high correlation between the number of bacteria and such chemical parameters, pH value or presence of heavy metals and formaldehyde. Concentrations of polycyclic aromatic hydrocarbons, on the other hand, correlated at a high level with both river and lake water. This research resulted in two JCR publications (Appx. 4.II.A.20; 21) and conference reports (Appx. 4. IV.III.B.81; 83;87). We are currently analysing the material for comparative genetic testing.

In December 2008, I was invited by prof. dr hab. Marek Zdanowski, to take part in a special project entitled *"The impact of degradation on the formation and shaping of polar* *ecosystems by microorganisms"* (Appx. 4.II.J.b.15).) carried out in the Department of Antarctic Biology of the Polish Academy of Sciences in Warsaw also as part of the 4th International Polar Year under the ClicOPEN programme (Appx. 4.II.J.a.7). Additionally, I received MNiI co-financing in the form of a project entitled *"The impact of degradation on the formation and shaping of polar ecosystems by microorganisms"*. I took part in the XXXIII polar expedition to the Polish Antarctic Station named Henryk Arctowski on the island of King George on the Southern Shetland where I spent three months (Appx..4.III.L.a.17). The main area of the study was the bay at the head of the Glacier of Ecology. A unique place due to its semi-closed character. The seawater flowing in there with the tidal wave, which reaches up to 1.5 metres in height, alters completely the environmental conditions, which are definitely freshwater at the time of runoff due to a large amount of water melting down from the glacier. We analyzed microorganisms settling the stone bottom of the lagoon periodically free from water. Molecular research has shown a considerable diversity in the taxonomic structure of the Ecology lagoon bacteriocenosis. PCR-DGGE analysis presented The occurrence of 50 dominant taxa. About 30% of the isolated sequences were found in all tested samples of water and bacteriooperifitin. The remaining DNA sequences detected for the specific species were unique for the different habitat types. Bacteria settling the stones were characterized by a very diverse and very wide variety of groups of microorganisms. The distribution of individual species in individual samples of bacteriooperifitone was very similar. In water samples, the number of dominant species was much lower. A statistically significant difference was found in the taxonomic structure of ocean and lagoon waters. The results indicate a very high metabolic activity of bacteria observed in the coastal zones of the lagoon, which in turn influences the intensity of processes, microbiological decomposition and mineralization of organic matter deposited in the reservoir. These phenomena are crucial for stimulating and regulating the pace at which the lagoon ecosystem processes take place. The results were presented at scientific conferences (Appx. 4.B.31; 32; 36) and published in articles: from the list of JCRs (Appx. 4.II.14) and others (Appx. 4.II.E.e.1), of which I am a co-author.

Apart from the research under the glacier of Ecology, we also implemented a project which was a continuation of the work carried out in the Arctic (on Spitsbergen). In a study I conducted in 2009 and continued in 2010 in the Gulf of Admiralty by Dr Górniak, we identified three distinct microbiologically distinct areas. The research resulted in conference reports (Appx. 4.III.B.43; 54) and an extensive report (Appx. 4.II.F.5), of which I am a co-author.

So far, I have spent a total of almost two years in the Arctic and Antarctic regions, and I am now planning another round of field studies.

6. Information on didactic and organisational activities, scientific cooperation and popularisation of science

Since 1998 I have been teaching environmental biology at the Faculty of Civil Engineering and the Environment of the Technical University of Gdańsk for the first and second degree students of full-time and part-time studies in the field of Environmental Engineering (Appx. 4.III.J.a):

- "Biological and chemical processes" (laboratory - single degree studies until 2005),
- "Biology and chemistry of the environment (laboratory - evening studies) 2005/2007,
- "Environmental Biology and Ecology" (lecture, exercises, laboratory - Engineering course, full-time studies),
- "Environmental Biology and Ecology" (lecture, laboratory - Engineering course, part-time studies),
- "Engineering microbiology" (exercises, - Masters course, full-time studies),
- "Environmental Monitoring and Management" (Master's Degree course, exercises, - Master's Degree II full-time studies)

My classes are very well evaluated. In the student surveys, my average score for the last 10 years is 4.7 (on a scale of 0-5). I am constantly trying to improve my teaching skills, among others, in 2004 I obtained pedagogical qualifications of the Ministry of Education and a diploma of completion of four-semester postgraduate studies in Pedagogy, organized at the Faculty of Technical Physics and Applied Mathematics of the Technical University of Gdańsk (Appx..4.III.L.b.2).

Since 2002 I have been a promoter of 23 diploma engineering theses as well as a promoter of 23 and a reviewer of 38 Master's theses. Two master's theses, which I was a promoter of, were awarded in a competition for master's theses organized by the Provincial Fund for Environmental Protection and Water Management in Gdańsk (Appx. 4.III.J.c):

- MSc.Eng. Renata Chylińska, 2010, *"Comparison of the effectiveness of disinfection methods for treated wastewater (ozone, UV irradiation, membrane filtration) using an epifluorescence microscope",*

- MSc.Eng. Daria Bieńkuńska, 2013, *"Sanitation of individual water intakes for consumption, and problems of water and sewage management in areas with dispersed development. Analysis of selected cases".*

MSc.Eng. Daria Bieńkuńska, continues her education during her doctoral studies, and I was also a co-promoter of the project she was implementing entitled "Analysis and verification of threats to the land and water environment in areas with dispersed development", which was awarded in the competition organized by the Ministry of Science and Higher Education: "*Generation of the Future"*[2] (Appx. 4.III.J.d).

[2] https://www.wprost.pl/400123/Studentka-Politechniki-Gdanskiej-laureatka-I-edycji-programu-Generacja-Przyszlosci.html

I also took care of MSc.Eng. Agnieszka Kalinowska's thesis, which received the Santander Universidades Award for the best student of the Gdańsk University of Technology in the academic year 2014/15, and in the *"Red Rose Award"* Competition received the second prize in the *"Best Student of the Pomorskie Voivodeship"* category[3]. Currently, I am an auxiliary promoter of her doctoral thesis (Appx. 4.III.K.3).

I am also an assistant promoter in the doctoral thesis of MSc.Eng. Paweł Wielgat, from the Faculty of Civil Engineering and the Environment, and MSc.Eng. Klaudia Kosek, from the Faculty of Chemistry (Appx. 4.III.K.1 and 2).

I am the initiator and since 2010 the scientific guardian of the Students' Scientific Group of the Gdańsk University of Technology "Microbiology in Environmental Engineering" (Appx. 4.III.J.5). Together with my students, I take an active part in activities promoting our universities, organized as part of the Open Days of the Gdańsk University of Technology, the "Girls for the University of Technology" campaign and the Academic Forum of Scientific Group (FOKA).

Together with the Scientific Group of Students Chemists of the Gdańsk University of Technology and the Blue School in Władysławowo and the Seaside Landscape Park in Władysławowo, I co-organized and am the second scientific supervisor of the summer student scientific camps, which have been held so far in July 2015, 2016 and 2017. I also try to involve students in the research carried out within the framework of scientific projects. As a result, over 40 people took part in 12 campaigns of field and laboratory research conducted by me at the Prof. K. Skóra Marine Station in Hel, belonging to the Institute of Oceanography of the University of Gdańsk. I have also been an organiser and guardian of student technical trips to, among others, the Group Oakwater Treatment Plant in Gdynia, Waste Neutralisation Plant Ekodolina Sp. z o.o. in Łężyce, surface water intakes and treatment plants in Straszyn, the Maritime Fisheries Institute in Gdynia (Appx..4.III.J.f).

I was an active member of the organising committees of scientific conferences. In 2010 I was the secretary of the 6th National Hydro-Microbiological Conference "Microorganisms in the Environment - from Ecology to Technology" organized by the Department of Water and Wastewater Technology at the University of Gdańsk at the Faculty of Biology, Oceanography and Geography at the University of Gdańsk under the honorary patronage of prof. dr hab. Henryk Krawczyk, the Rector of the University of Gdańsk at the Faculty of Marine Biology, Oceanography and Geography at the University of Gdańsk, and prof. dr hab. Bernard Lammek (Appx. 4.III.C.1). In 2015 I was a member of the organizing committee of the nationwide conference *"Industrial wastewater. Technological and Economic Challenges",* which has been granted honorary patronage of the Rector of the Gdańsk University of Technology, the Rector of the Gdańsk University, and the Marshal of the Pomorskie Voivodeship (Appx.

[3] https://pg.edu.pl/aktualnosci/-/asset_publisher/hWGncmoQv7K0/content/studentka-roku-—-gratulacje-dla-agnieszki-kalinowskiej-

4.III.C.2). Our activities were rewarded with a second and third-degree team prize for outstanding achievements in organisational activities (Appx. 4.II.K.4 and 4.II.K.5).

Since 2016, I have been helping in the organization and membership of the scientific committee of the Interdisciplinary Academic Conference on Environmental Protection (IACOŚ) (Appx. 4.III.C.3-5). It is a very interesting initiative of students and doctoral students from four Scientific Group at three Faculties of Gdańsk University of Technology. In 2016, 2017 and 2018 I conducted thematic sessions and in 2017 I gave a lecture closing the Conference.

By raising funds for research projects I was able to contribute to the enrichment of scientific and didactic laboratories of the Department of Water and Wastewater Technology at WILISH (Appx. 4.III.Q.b) with research and field equipment. Thanks to the knowledge gained during scientific internships, courses and joint work in research projects with dr. Dorota Górniak from the Department of Microbiology and Mycology, Faculty of Biology, University of Warmia and Mazury in Olsztyn, I was able to prepare a stand for microscopic observations consisting of the Nikon 80i epifluorescence microscope, a digital camera and an image analysis system used to analyse the structure of the bacteriocenosis population (number, size, biomass, cell activity) and for systematic analysis (in situ hybridisation - FISH), as well as a site for the preparation of preparations for the in situ hybridisation method - FISH (baths, hybridization chambers and others) and an electrophoresis station in the PCR-DGGE denaturing gradient (BIORAD electrophoresis apparatus, gel preparation apparatus and others). On the other hand, together with prof. Aneta Łuczkiewicz, we have prepared a position for biochemical identification and assessment of drug resistance of bacterial strains (an automated system for microbiological testing of BD Phoenix, optical density evaluation device for suspension, etc.). I also developed an automatic colony counting station (tripod, digital camera, software) and three types of independent stations for simultaneous filtering of multiple samples (Nalgan, Millipore, DHI Filtration Equipment). In order to conduct research in polar regions, it is necessary to have specialist equipment ensuring full safety. As part of two projects I was the manager of (Appx. 4.II.J.3 and 8), I purchased a pontoon boat with an engine, protective suits of the Viking type and a portable measurement system allowing to work in field conditions (meters and probes).

I actively participate in scientific consortia and research networks. I am a member of the Task Force for Opinions and Development of Marine Biology of the Marine Biology Section of the Polish Academy of Sciences (KBM) during the term of 2016-2020 and a delegate from the Gdańsk University of Technology to the Council of the Polish Polar Consortium (since 2015) (Appx. 4.III.E.1). I took part in the preparation of the study "Strategy of Polish polar research - a concept for the years 2017-2027" prepared by the Polish Polar Consortium in cooperation with the Polar Research Committee of the Polish Academy of Sciences and the study "Polish Svalbard Snow Programme" Red. K. Migała, M. Grabiec, J. Jania, Warsaw 2016 (Appx..4.III.Qa). I belong to the Polish Polar Club, and between 2010 and 2013 I was a member of the International Water Association (Great Britain) (Appx. 4.III.H.).

Since 2000 I have also been involved in actions promoting science. First, there were the stands and shows as part of the Gdynia Science Picnic (2000, 2002) held for a few days in June at Kościuszko Square in Gdynia. He is currently preparing shows, exhibitions and presentations as part of the Baltic Science Festival (2003 - 2018), which usually takes place in May at the Gdańsk University of Technology (Appx. 4.III.Q.c). In recent years, students have also been willing to participate in these activities. As part of the 10th and 11th Baltic Science Festivals (2012 and 2013), we have jointly prepared exhibitions presenting the work of the Scientific Circle. Also in 2013, we managed to obtain funding from the Provincial Fund for Environmental Protection and Water Management in Gdańsk for the event "ECO - SURVIVAL: Festival of Sustainable Energy and Economy", in 2017 for the Interdisciplinary Knowledge Picnic of the Faculty of Civil Engineering and the Environment "Be EKO - Education, Use, Protect! (Appx. 4.III.F.3 and 4).

During a one-year stay at the Polish Polar Station Hornsund at Spitsbergen during the XXXVI Polar Expedition of the Institute of Geophysics of the Polish Academy of Sciences, in addition to being the deputy head of the Expedition, I was also an educator in a project co-financed by the EU within the European Social Fund "Man - the best investment" entitled "*Raising student competencies in the field of mathematical-natural and technical sciences using innovative methods and technologies - EDUSCIENCE*". My duties included preparing didactic materials placed on the digital platform available for schools, students and teachers. These were films, presentations, lesson plans, educational games, interactive materials, I prepared a total of 140 items. I also conducted a total of 60 hours of online lessons for children and youth in Poland and ran an educational blog with information on the life and work at the Polish Polar Station Hornsund for 12 months - a total of 87 pieces of information[4] (Appx. 4.III.Q.c).

I have always believed that scientific work should be directly linked to the dissemination of knowledge, not only in a purely scientific form. Since 2010 I have been conducting popular science lectures. I gave lectures as part of the projects: the Open University of Technology, Polish Academy of Children, Academy of EXPERIENCES, Lectures with Evidence, Sopot University of the Third Age and Senior Citizens' Club of the University of Gdańsk (Appx. 4.III.Ic). I have also taken part in radio interviews and other forms of media reporting. I have conducted many hours of lessons for students at all levels of education (Appx. 4.III.Qc). I organized and prepared exhibitions promoting science (Appx. 4.III.Ib). I also presented my scientific passions at photographic exhibitions (Appx.4.III.Ia), and one of my photographs took second place in the category of "Polar Nature - Hidden Beauty" in the photographic competition *"The Face of the Arctic and the Antarctic"* is organized by the Lublin magazine LAJF (Appx. 4.III.D)[5]. For my work, I have been awarded five times the Rector of the Gdańsk University of Technology Award for my special achievements in scientific and organizational activity (Appx. 4.II.K).

[4] http://www.eduscience.pl/blogi/polska-stacja-polarna-hornsund-na-spitsbergenie
[5] http://lajf.info/?p=13130

Summary of achievements in scientific research, didactic and organisational activities, as specified in Appendix No. 4

l.p.	Type of achievement	Before obtaining a PhD degree	After obtaining the PhD degree
	Scientific publications including:	11	54
	- scientific publications in journals accessible through the Journal Citation Reports (JRC),	4	18
	- articles in other peer-reviewed journals,	2	5
	- publications in peer-reviewed collective publications and conference proceedings,	2	7
	- chapters in book,		2
	- chapters in monographs,		8
	- publications in peer-reviewed publications,		3
	- collective studies, collection catalogues, documentation of research works, expert opinions, works of art and works of art.	3	11
	Summary impact factor by the Journal Citation Reports (JCR) list, as specified in the year of publication. 31,633		
	Total points MNiSW 614 Self contribution 153,5		
	Number of citations to publications by database (08.2018): Web of Science (WoS): 224 Scopus: 286 ResearchGate: 353		
	Hirsch Index by Basis (08.2018): Web of Science (WoS): 8 Scopus: 10 ResearchGate: 10		

Leading and participating in international and national research projects**:**		
- international projects,	2	9 (leader – 1)
- projects financed by the Ministry of Science and Higher Education and the National Science Centre,	2	12 (leader – 3)
- special projects financed by the Ministry of Science and Higher Education,		2
- projects co-financed by the Provincial Fund for Environmental Protection and Water Management in Gdańsk,		4 (leader – 2)
International and national awards for scientific or artistic activities,		5
International and national conferences:		
- lecture		
internationl	4	4
nationwide	1	5
- active involvement		
internationl	3	50
nationwide	1	35
- participation in organisational committees,		5
Participation in research consortia and networks.		2
Membership in international and national scientific organizations and societies.		2
Educational and popularisation achievements in science or the arts		
- Student care:		
promotion of Engineering diploma theses		23
promotion of the Master's degree theses		23
reviews of diploma Engineering theses		38
reviews of the Master's theses		1
- academic support for doctoral candidates as an auxiliary promoter		3
- photographic exhibitions,		2
- popularisation exhibitions,		5
- popular science lectures,		11
- popular science lectures for schools,		56 h

- internet lessons for schools,		60 h
- teaching materials on the digital platform,		140
- educational blog and other media reports.		99
Internships and research works in foreign and domestic scientific or academic centres	3	22
Post-graduate studies	1	2
Courses and training	1	9
Expertise or other studies carried out on request		2
Reviewing publications in international and national journals		5

Bibliography

1. Bartram, J., & Rees, G. (2002). Monitoring Bathing Waters – A Practical Guide to the Design and Implementation of Assessments and Monitoring Programmes. Urban Water. Padstow, Cornwall: E & FN Spon is an imprint of the Taylor & Francis Group. doi.org/10.1016/S1462-0758(02)00006-7
2. Boehm, A. B., Fuhrman, J. A., Mrše, R. D., & Grant, S. B. (2003). Tiered Approach for Identification of a Human Fecal Pollution Source at a Recreational Beach: Case Study at Avalon Bay, Catalina Island, California. Environmental Science & Technology, 37(4), 673–680. http://doi.org/10.1021/es025934x
3. Boehm, A. B., Griffith, J., McGee, C., Edge, T. A., Solo-Gabriele, H. M., Whitman, R., … Weisberg, S. B. (2009). Faecal indicator bacteria enumeration in beach sand: A comparison study of extraction methods in medium to coarse sands. Journal of Applied Microbiology, 107(5), 1740–1750. http://doi.org/10.1111/j.1365-2672.2009.04440.x
4. Bonilla, T. D., Nowosielski, K., Cuvelier, M., Hartz, A., Green, M., Esiobu, N., … Rogerson, A. (2007). Prevalence and distribution of fecal indicator organisms in South Florida beach sand and preliminary assessment of health effects associated with beach sand exposure. Marine Pollution Bulletin, 54(9), 1472–1482. http://doi.org/10.1016/j.marpolbul.2007.04.016
5. Caruso, G., Denaro, R., Genovese, M., Giuliano, L., Mancuso, M., & Yakimov, M. (2004). New methodological strategies for detecting bacterial indicators. Chemistry and Ecology, 20(3), 167–181. http://doi.org/10.1080/02757540410001690333
6. Colford, J. M., Schiff, K. C., Griffith, J. F., Yau, V., Arnold, B. F., Wright, C. C., … Weisberg, S. B. (2012). Using rapid indicators for Enterococcus to assess the risk of illness after exposure to urban runoff contaminated marine water. Water Research, 46(7), 2176–2186. http://doi.org/10.1016/j.watres.2012.01.033
7. Costa-Dias, S., Machado, A., Teixeira, C., & Bordalo, A. (2018). Urban Estuarine Beaches and Urban Water Cycle Seepage: The Influence of Temporal Scales. Water, 10(2), 173. http://doi.org/10.3390/w10020173
8. da Costa Andrade, V., Del Busso Zampieri, B., Ballesteros, E. R., Pinto, A. B., & Fernandes Cardoso de Oliveira, A. J. (2015). Densities and antimicrobial resistance of Escherichia coli isolated from marine waters and beach sands. Environmental Monitoring and Assessment, 187(6), 1–10. http://doi.org/10.1007/s10661-015-4573-8
9. de Oliveira, A. J. F. C., & Watanabe Pinhata, J. M. (2008). Antimicrobial resistance and species composition of Enterococcus spp. isolated from waters and sands of marine recreational beaches in Southeastern Brazil. Water Research, 42(8–9), 2242–2250. http://doi.org/10.1016/j.watres.2007.12.002
10. Dz.U.2015 poz.1510. Rozporządzenie Ministra Zdrowia z dnia 3 lipca 2015 r. zmieniające rozporządzenie w sprawie prowadzenia nadzoru nad jakością wody w kąpielisku i miejscu wykorzystywanym do kąpieli (2015). Warszawa: Ministerster Zdrowia. Retrieved from http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20150001510/O/D20151510.pdf
11. Dz.U.2016 poz. 1187. Rozporządzenie Ministra Środowiska z dnia 21 lipca 2016 r. w sprawie sposobu klasyfikacji stanu jednolitych części wód powierzchniowych oraz środowiskowych norm jakości dla substancji priorytetowych. (2016). Warszawa: Ministerster Środowiska. Retrieved from http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20160001187/O/D20161187.pdf
12. Farnham, D. J., Gibson, R. A., Hsueh, D. Y., McGillis, W. R., Culligan, P. J., Zain, N., & Buchanan, R. (2017). Citizen science-based water quality monitoring: Constructing a large database to characterize the impacts of combined sewer overflow in New York City. Science of the Total Environment, 580, 168–177. http://doi.org/10.1016/j.scitotenv.2016.11.116
13. Feng, Z., Reniers, A., Haus, B. K., Solo-Gabriele, H. M., Wang, J. D., & Fleming, L. E. (2015). A Predictive Model for Microbial Counts on Beaches where Intertidal Sand is the Primary Source. Marine Pollution Bulletin, 94, 37–47. http://doi.org/doi:10.1016/j.marpolbul.2015.03.019
14. Fewtrell, L., & Kay, D. (2015). Recreational Water and Infection: A Review of Recent Findings. Current Environmental Health Reports, 2(1), 85–94. http://doi.org/10.1007/s40572-014-0036-6
15. Jankowska, K., Olańczuk-Neyman, K., Sokołowska, A., Skucha, M., & Misiec, A. (2005). The sanitary quality of water and sandy sediments of selected streams and the coastal area of Gdańsk Bay. Polish Journal of Environmental Studies, 14(6).
16. Kay, D., Ashbolt, N., Wyer, M. D., Fleisher, J. M., Fewtrell, L., Rogers, A., & Rees, G. (2004). Derivation of numerical values for the World Health Organization guidelines for recreational waters. Water Research, 38, 1296–1304. http://doi.org/10.1016/j.watres.2006.02.009

17. Kong, R. Y. C., Lee, S. K. Y., Law, T. W. F., Law, S. H. W., & Wu, R. S. S. (2002). Rapid detection of six types of bacterial pathogens in marine waters by multiplex PCR. Water Research, 36(11), 2802–2812. http://doi.org/10.1016/S0043-1354(01)00503-6
18. Landers, T. F., Cohen, B., Wittum, T. E., & Larson, E. L. (2012). A Review of Antibiotic Use in Food Animals: Perspective, Policy, and Potential. Public Health Reports, 127(1), 4–22. http://doi.org/10.1177/003335491212700103
19. Leecaster, M. K., & Weisberg, S. B. (2001). Effect of sampling frequency on shoreline microbiology assessments. Marine Pollution Bulletin, 42(11), 1150–1154. http://doi.org/10.1016/S0025-326X(01)00130-8
20. Łuczkiewicz, A., Jankowska, K., Fudala-Książek, S., & Olańczuk-Neyman, K. (2010). Antimicrobial resistance of fecal indicators in municipal wastewater treatment plant. Water Research, 44(17), 5089–5097. http://doi.org/10.1016/j.watres.2010.08.007
21. Łuczkiewicz, A., Jankowska, K., Kurlenda, J., & Olańczuk-Neyman, K. (2010). Identification and antimicrobial resistance of Enterococcus spp. isolated from surface water. Water Science and Technology, 62(2). http://doi.org/10.2166/wst.2010.909
22. Masters, N. M., Wiegand, A., Thompson, J. M., Vollmerhausen, T. L., Hatje, E., & Katouli, M. (2017). Enterococci populations of a metropolitan river after an extreme flood event: prevalence, persistence and virulence determinants. Journal of Water and Health, 15(5), 684 LP-694. Retrieved from http://jwh.iwaponline.com/content/15/5/684.abstract
23. McLachlan, A., & Brown, A. (2006). The ecology of sandy shores. San Diego, California: Elsevier Inc.
24. Napier, M. D., Haugland, R., Poole, C., Dufour, A. P., Stewart, J. R., Weber, D. J., … Wade, T. J. (2017). Exposure to human-associated fecal indicators and self-reported illness among swimmers at recreational beaches: A cohort study. Environmental Health: A Global Access Science Source, 16(1), 1–15. http://doi.org/10.1186/s12940-017-0308-3
25. Noble, R. T., Moore, D. F., Leecaster, M. K., McGee, C. D., & Weisberg, S. B. (2003). Comparison of total coliform, fecal coliform, and enterococcus bacterial indicator response for ocean recreational water quality testing. Water Research, 37 (7), 1637–1643. http://doi.org/https://doi.org/10.1016/S0043-1354(02)00496-7
26. Olańczuk-Neyman, K., & Jankowska, K. (1998). Bacteriological investigations of the sandy beach ecosystem in Sopot. Oceanologia, 40(2), 137–151.
27. Olańczuk-Neyman, K., & Jankowska, K. (2001). Bacteriological quality of the sand beach in Sopot (Gdansk Bay, southern Baltic). Polish Journal of Environmental Studies, 10(6), 451–455.
28. Palazón, A., López, I., Aragonés, L., Villacampa, Y., & Navarro-González, F. J. (2017). Modelling of Escherichia coli concentrations in bathing water at microtidal coasts. Science of the Total Environment, 593–594, 173–181. http://doi.org/10.1016/j.scitotenv.2017.03.161
29. Piask, A. (2015). Wizualizacja pomiarów zasolenia specyficznego fragmentu dna Zatoki Gdańskiej przy wykorzystaniu programu ArcGIS. In M. Przyborski & A. Janowski (Eds.), Przetwarzanie i analiza danych z wykorzystaniem metod geodezyjnych na potrzeby opisu środowiska wodnego (pp. 57–109). Gdańsk: Wydawnictwo Polskiego Internetowego Informatora Geodezyjnego. Retrieved from http://www.geomatyka.eu/publikacje/isbn9788393460922/isbn9788393460922.pdf
30. Sabino, R., Rodrigues, R., Costa, I., Carneiro, C., Cunha, M., Duarte, A., … Brandão, J. (2014). Routine screening of harmful microorganisms in beach sands: Implications to public health. Science of the Total Environment, 472(December), 1062–1069. http://doi.org/10.1016/j.scitotenv.2013.11.091
31. Sadowy, E., & Luczkiewicz, A. (2014). Drug-resistant and hospital-associated Enterococcus faecium from wastewater, riverine estuary and anthropogenically impacted marine catchment basin. BMC Microbiology, 14(1). http://doi.org/10.1186/1471-2180-14-66
32. Shiah, F. K., & Ducklow, H. W. (1994). Temperature and substrate regulation of bacterial abundance, production and specific growth rate in Chesapeake Bay, USA. Marine Ecology Progress Series, 103(3), 297–308. http://doi.org/10.3354/meps104297
33. Sjöstedt, J., Hagström, Å., & Zweifel, U. L. (2012). Variation in cell volume and community composition of bacteria in response to temperature. Aquatic Microbial Ecology, 66(3), 237–246. http://doi.org/10.3354/ame01579
34. Sobol, Z., & Szumilas, T. (1994). Przyczyny złego stanu sanitarnego morskich wód przybrzeżnych i Zatoki Gdańskiej. [w:] Błażejewski J., Schuller D. (red.) Zanieczyszczenie i odnowa Zatoki Gdańskiej., Wydawnictwo UG Gdańsk s. 104 - 111. In J. Błażejewski & D. Schuller (Eds.), Zanieczyszczenie i odnowa Zatoki Gdańskiej (pp. 104–111). Gdańsk: Wydaw. Uniwersytetu Gdańskiego.

35. Sobol, Z., & Szumilas, T. (1998). Ocena stanu sanitarnego wód przybrzeżnych Morza Bałtyckiego w latach 1995-1997 na podstawie wyników badan Instytutu Medycyny Morskiej i Tropikalnej w Gdyni oraz województw nadmorskich. Medycyna Środowiska, 1(1), 21–28.
36. Soller, J. A., Schoen, M., Steele, J. A., Griffith, J. F., & Schiff, K. C. (2017). Incidence of gastrointestinal illness following wet weather recreational exposures: Harmonization of quantitative microbial risk assessment with an epidemiologic investigation of surfers. Water Research, 121, 280–289. http://doi.org/10.1016/j.watres.2017.05.017
37. Solo-Gabriele, H. M., Harwood, V. J., Kay, D., Fujioka, R. S., Sadowsky, M. J., Whitman, R. L., … Brandão, J. C. (2016). Beach sand and the potential for infectious disease transmission: Observations and recommendations. Journal of the Marine Biological Association of the United Kingdom, 96(1), 101–120. http://doi.org/10.1017/S0025315415000843
38. Szymczycha, B., & Pempkowiak, J. (2016). State of Art and Theory of Submarine Groundwater Discharge (SGD) Submarine Groundwater Discharge. In GeoPlanet: Earth and Planetary Sciences (p. 22). Springer International Publishing, Switzerland. http://doi.org/10.1007/978-3-319-25960-4
39. Tollefson, L., & Miller, M. A. (2000). Antibiotic use in food animals: Controlling the human health impact. Journal of AOAC International, 83(2), 245–254. Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-0034152089&partnerID=40&md5=782d085defa3ea785b45ff88c5989958
40. Wade, T. J., Sams, E., Brenner, K. P., Haugland, R., Chern, E., Beach, M., … Dufour, A. P. (2010). Rapidly measured indicators of recreational water quality and swimming-associated illness at marine beaches: A prospective cohort study. Environmental Health: A Global Access Science Source, 9(1), 66. http://doi.org/10.1186/1476-069X-9-66
41. Węsławski, J. M., Kotwicki, L., Grzelak, K., Piwowarczyk, J., Sagan, I., Nowicka, K., & Marzejon, I. (2011). Przemysł turystyczny i przyroda morska na Półwyspie Helskim. Wstępna ocena wpływu turystyki i przemysłu rekreacyjnego na wartości naturalne przybrzeżnego ekosystemu morskiego na przykładzie Półwyspu Helskiego. Sopot: Agencja Wydawnicza EkoPress Andrzej Poskrobko.