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Bioaerosols on Tri-city (Gdańsk–Sopot–Gdynia) beaches

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ABSTRACT

Bioaerosol formation is an important process of mass and energy exchange between the sea and the atmosphere by means of droplets of marine dust. Studies of marine aerosol activity developed in the last decades of the 20th century. Those studies revealed that concentrations of bacteria in aerosol droplets were hundreds of times higher than were those measured in superficial marine waters. Moreover, it was determined that aerosol activity at sea can influence the sanitary condition of the air, especially in seaside areas. Examinations of air composition in coastal regions were performed on the beaches of the Tri-city, Sobieszewo, and Komary. Airborne microorganisms were also investigated in the marine zone at the Vistula river mouth. The air samples were collected by a filtration method using Sartorius apparatus. The exposed filters were then placed onto agar media in Petri dishes and incubated. All measurements are expressed in CFU/m3, i.e. colony forming units per cubic metre of examined air. Meteorological parameters such as temperature, humidity, and wind speed and direction were also measured. The obtained results revealed statistically significant trends between the total number of bacteria and fungal spores, and the sampling season. The greatest number of microorganisms was noted in spring and autumn. Correlation analysis showed that a statistically significant relationship exists between the microbial abundance and the wind direction, wind speed, and the sampling site location. The maximum number of fungal spores was detected in the areas of Gdynia and Gdansk Brzeźno when south-west winds were blowing from the land. The highest number of bacteria was observed at the sampling stations located closest to the Vistula river mouth (Sobieszewo and Komary).

Key words: bioaerosol, mesophilic bacteria, psychrophilic bacteria, fungi

INTRODUCTION

Wind, wave action, and physicochemical processes result in the formation of aerosols at the water-air interface. In general, aerosol formation is connected with the mechanisms of air bubble bursting due to wind-induced wave breaking, snowfall, rain, and the creation of splatter droplets. Air bubbles can also form on the water surface because of abrupt warming in the spring period or increased biological production.

The phenomenon of bacterial enrichment of aerosols was discovered by Blanchard and Syzdek. In a number of laboratory studies they demonstrated the existence of the potential for the occurrence of aerosols enriched with both bacteria and viruses [1–5]. The above-mentioned authors measured under laboratory conditions the number of bacteria of the species Serratia marcescens that were present in aerosol droplets emitted via gas bubbles travelling through an aqueous medium of known bacterial concentration. During the experiment the number of bacteria in the first droplet generated from a single bubble that had travelled through the water column was measured. The obtained results indicated that the bacterial enrichment coefficient increases with the increasing distance travelled by a bubble through the water column. For the suspension of Serratia marcescens, the bacterial enrichment coefficient was 1000 times higher than the bacteria concentration in the water column. This phenomenon is explained by the propensity of gas bub-

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bles travelling towards the water surface to scavenge bacteria from the water column.

Blanchard et al. estimated the enrichment coefficient under laboratory conditions to be 600 times for bubbles travelling through the water column over a distance of more than 10 cm [4]. Ulevicius, in an experimental study, determined that the enrichment coefficients for film droplets and jet droplets are 1000 times higher than the concentration of bacteria suspended in water [6].

A team led by Aller conducted experiments on the enrichment of marine aerosols in bacteria and viruses originating from the microsurface of seawater. The enrichment coefficient values measured for pathogenic bacteria in marine aerosols during the experiment reached couple tenfolds, while for viruses they were several times greater than the respective concentrations in surface water [7].

Research on the selection of bacteria from the water column and marine aerosol enrichment in psychrophilic and mesophilic bacteria was also conducted during in situ experiments in the Gulf of Gdansk as well as in laboratory studies. The number of microorganisms in aerosols in the Gulf of Gdansk ranged from 37 to 2545 and from 14 to 585 CFU/m^3 for mesophilic and psychrophilic bacteria, respectively. Moreover, the studies revealed that fungal spores are transferred by air masses from land to the areas over the Gulf of Gdansk basin [5]. Studies conducted on the Gulf of Gdansk shoreline showed that the mean number of mesophilic bacteria was 308 CFU/m^3, while the mean number of psychrophilic bacteria and fungal spores ranged from 1 to 190 and from 5 to 1100 CFU/m^3, respectively [8]. From the perspective of human health, it is important to assess the impact that bioaerosols originating over the Gulf of Gdansk have on the Tri-city municipal area. The aim of this study was to establish concentration levels of bacterial and fungal bioaerosols on the Tri-city beaches.

MATERIAL AND METHODS

Samples of atmospheric air were collected from beaches in Gdynia, Sopot, Gdańsk Brzeźno, and from Sobieszewo Island in Sobieszewo and Komary.

Air samples were collected by filtration method. The air was filtered using a Sartorius MD8 Air Sampler and sterile gelatin filters.

Following the filtration procedure, the filters were placed onto sterile microbiological media, i.e. nutrient agar and Sabouraud agar in Petri dishes, which were later incubated at 20, 25, and 37°C. The total number of specific bacteria was estimated depending on the incubation conditions, as follows: for mesophilic bacteria after 24-hr incubation at 37°C, for psychrophilic bacteria after 72-hr incubation at 20°C, and for fungal spores after 14 days at 25°C. The obtained results were recorded as the number of colony forming units in one cubic metre of examined air (CFU/m^3). Meteorological parameters such as air temperature, air humidity, wind direction, and wind speed were measured concurrently with sample collection.

Air samples were collected by filtration method using Sartorius apparatus. Airborne microbes were deposited onto sterile gelatin Sartorius filters.

Following the filtration procedure, the filters were placed onto the agar media in Petri dishes and incubated. All measurements were expressed in CFU/m^3, i.e. colony forming units in 1 m^3 of examined air. Meteorological measurements included temperature, humidity, wind speed and wind direction.

RESULTS

Based on the obtained measurements, the maximum numbers of bacteria at the Tri-city beaches were determined as follows: 943 CFU/m^3 in Gdynia, 786 CFU/m^3 in Sopot, and 538 CFU/m^3 in Gdańsk Brzeźno; the respective numbers of fungal spores were 266, 2030, and 588 CFU/m^3, respectively. The above-mentioned maximal values were observed in June, July, September, October, and November on days with prevalent southwesterly winds. Another scenario was observed at the beaches in Sobieszewo and Komary. Maximal concentrations of bacterial bioaerosol of 3285 and 3590 CFU/m^3 were measured in Sobieszewo and Komary, respectively, while the maximum concentration of fungal spores was 1522 CFU/m^3 in Sobieszewo and 1566 CFU/m^3 in Komary. These values were observed in July, August, September, and October on days with southeasterly and easterly winds (Figure 1). Correlation analysis of the measured parameters revealed the existence of statistically significant trends between the total number of bacteria and fungal spores and the month of sample collection, and a statistically significant relationship between the number of microorganisms and wind direction. The largest numbers of bacteria and fungal spores were observed at the beaches in Gdynia and Gdańsk Brzeźno when southwesterly winds were blowing from the land, and in Sobieszewo and Komary on

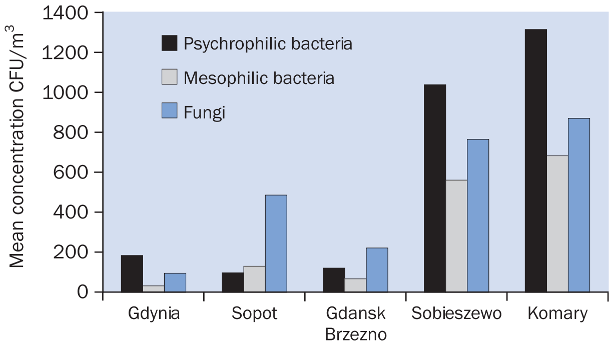

Figure 1. The mean number of microorganisms in 1 m^3 of air in beaches

days with prevalent 3–4°B winds from the north-east and east direction. It has been determined that northeasterly and easterly winds move masses of contaminated air from the area where the Vistula river waters mix with marine waters in the direction of municipal areas located in the Vistula river mouth (Gulf of Gdansk). Moreover, the obtained results indicate that there is a statistically significant relationship between the number of psychrophilic and mesophilic bacteria and fungal spores, and the air temperature.

DISCUSSION

The above-mentioned statistical relationships suggest that the microorganism concentrations in air during cold seasons are lower than are those during warm seasons. Similar results were also reported by Kruczalak et al. [8] in their study of atmospheric air in Sopot. The authors observed the highest concentrations of psychrophilic bacteria in April and May, while mesophilic bacteria peaked in September and October when winds were blowing from the east. Such findings can be explained by the fact that east winds bring air masses from the Vistula river mouth area, where marine waters mix with riverine freshwaters, and push them in the direction of the open sea. Similar data have been reported by Mitakakis [9], Nowak [10], and Zmysłowska [11]; all these authors confirmed that the maximum concentrations of microorganisms in air occur in the beginning of summer and autumn.

Based on the results of their study on air quality of city environments in France and India, Maron et al. [12] and Mouli [13] determined similar statistical relationships between the bacterial numbers and wind velocity, air temperature, and relative humidity. Moreover, increased concentrations of fungal spores in air were observed in the spring/ /summer and fall seasons. The latter finding has been confirmed by the studies conducted by others, e.g. Medrela-Kuder [14] detected the highest number of fungal spores in October in the air in Krakow, Poland, while Yankova and Peneva [15] and Juozaitis [16] measured the highest mould concentrations in atmospheric air in the autumn in Sofia and Vilnius, respectively.

CONCLUSIONS

- The study results showed that the highest numbers of bacteria and fungal spores were present at the beaches in Sobieszewo and Komary, which are both settlements proximal to the Vistula river mouth.
- Statistical analysis of the data revealed that the numbers of psychrophilic and mesophilic bacteria and fungal spores in the air in the investigated areas were firstly influenced by the site and month of sampling, and secondly by meteorological conditions.
- The obtained results indicated the existence of a strong correlation between the fungal spore numbers and the wind direction, wind speed, and air temperature. A statistically significant relationship was also determined for the total bacterial numbers and the wind direction, wind speed, and air temperature.

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