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**ANALYSES OF BACTERIAL AEROSOL
OCCURRING IN HEALTH RESORTS
IN BOCHNIA AND SZCZAWNICA**

**BADANIA AEROZOLU BAKTERYJNEGO
WYSTĘPUJĄCEGO W OŚRODKACH SANATORYJNYCH
W BOCHNI I SZCZAWNICY**

Abstract: The main aim of the research was evaluation of the bacterial aerosol occurring in sanatorium chambers in the Health Resort of Salt Mine in Bochnia and in the sanatorium rooms of Przedsiębiorstwo Uzdrawisko Szczawnica S.A., with the definition of its particle fractions, depending on the sizes of aerodynamical diameters into: over 7.0 μm , 7.0–4.7 μm , 4.7–3.3 μm , 3.3–2.1 μm , 2.1–1.1 μm , and 1.1–0.65 μm . Microbiological research of the air was carried out during spring 2008 in healing chambers of the Health Resort of Salt Mine in Bochnia and in the sanatorium rooms of the “Health Resort Enterprise Szczawnica”. The measurements were performed using 6-step Graseby-Anderson impactor from the respiratory zone (oral and nasal cavity location) of people in the state of so-called “original sterility”, which is before introduction of the bathers and personnel into the sanatorium chambers and rooms but also during the presence of patients and during treatment operations. As a result of the analyses, significant differences were found in the amount of aerosol in various examination points. On the basis of the gained results it may be concluded, that the highest concentration of bacterial aerosol in the Health Resort of Salt Mine in Bochnia occurred in Wazyn Chamber (in the part of the gym and the bedroom), whereas in the “Health Resort Enterprise Szczawnica” – inside the mineral baths room and in the corridor leading to the bathers’ rooms in the Inhalatorium building. Significantly lower level of the bacterial aerosol was observed during the patients’ stay in relation to the period between the stays (the lack of patients).

Keywords: bacterial aerosol, sanatorium, air

The degree of air pollution plays an important role in health conditions of an environment. This becomes more and more live issue, because constantly progressing environment degradation is among others the factor which causes permanent growth of bacterial and mycological contamination of atmospheric air [1, 2].

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According to the reports, aeromicroflora of closed rooms is responsible for the respiratory system problems as well as for other health issues among children, and is considered as a direct infectious agent in hospitals [2, 3].

In relation to this, specific healing environmental conditions, which occur in underground subterraneotherapy chambers and in overground health resorts, presently become very significant. This is why in recent years a new tendency is observed for applying in therapeutics subterraneotherapy, which has become an efficient method for dealing with harmful influence of pollutants on the Earth surface on the human organism [1, 4].

According to the above-mentioned facts, the present research, aims at proving if important differences occur in the size of aerosol particles between the environment of the subterraneotherapy chambers in Salt Mine in Bochnia and in chambers of overground health resort of "Health Resort Enterprise Szczawnica".

Material and methods

The analyses concerning the occurrence of different particles of biological aerosol were carried out in spring 2008 in the air temperature above 14 °C. As an overground sanatorium, "Health Resort Enterprise Szczawnica" was appointed. It is located in one of the oldest and the most beautiful Polish health resorts – Szczawnica. The town – completely without industry, and located nearby three National Parks – has an exceptional healing microclimate and clean, allergen-free air. Presently, as a part of "Health Resort Enterprise Szczawnica" Sanatorium "Papiernik" and "Inhalatorium", Nature Treatment Institute, Spa Clinic and Pump Room operate. This resort is specialized in treatment of respiratory ways diseases, including allergic diseases of respiratory system, asthma and activity system issues.

The research concerning the occurrence of bioaerosol was carried out also in underground healing chambers in Salt Mine in Bochnia. This resort specializes itself also in respiratory ways diseases, including lingering nose and throat inflammations, voice apparatus diseases, allergies of respiratory system and asthma. In this case specific microclimate and saline aerosol floating in the air of healing chambers are the healing factors.

The measurements of bacterial aerosol were performed in two measuring sessions. In each tested resort, 6 examination points were chosen, in which samples were taken. The bioaerosol was analyzed inside the sanatorium rooms and healing chambers, during the presence of the personnel and bathers, and also in the state of so-called "original microbiological cleanliness", which was during the days off-work, when no healing operations were performed. Moreover, bioaerosol samples were taken in the external environment in the surroundings of the resort buildings.

The air samples were taken by means of 6-step Anderson impactor (model 10–710, Anderson Instruments, Atlanta, Ga, USA), which during the analyses was placed 1–1.5 m over the floor, in order to take the bioaerosol from the human respiratory zone. During the measuring sessions, the measurements of the air temperature and relative humidity were performed at the same time. Microbiological analyses included evalua-

tion of the general number of bacteria on the Trypticase Soy Agar Medium (Trypticase Soy Agar, TSA, Emapol, Gdansk, Poland) with 5 % addition of defibrinated sheep blood. Conditions of air samples incubation were as following: 1 day in 37 °C, 3 days in 22 °C, and then 3 days in 4 °C. Concentration of the tested aerosol was expressed as an amount of colony forming units on the microbiological medium, present in 1 m³ of taken air [cfu/m³].

Results and discussion

The results of measurements of the bacterial aerosol occurring in the air outside and in the rooms and chambers of the two health resorts are shown in Figures 1, 2. While comparing the gained results, it may be concluded, that in the chosen examination points in the area of the underground sanatorium Health Resort of Salt Mine in Bochnia, the measured amounts of bacteria concentration, during the presence of bathers in the healing chambers, are within the ranges from 189 cfu/m³ to 11688 cfu/m³. In the state of so-called “original microbiological cleanliness”, which is the time when people are absent – from 63 cfu/m³ to 2997 cfu/m³. In relation to the measurements of the bacterial aerosol in the examination points, located in the underground sanatorium chambers, it was shown, that mean value of bacteria concentration in the air in Wazyn Chamber in the part designed for the gym, was much higher than the mean concentrations found in the other places in the mine. Basing on the results analysis, it is clearly seen, that generally the highest concentration of bacteria in the tested air was in Wazyn Chamber (in the gym and bedroom) and on the ramp between levels IV and VI (points B3, B4 and B2, respectively). However, the lowest concentration of this bioaerosol was found in the air of the gangway leading the air from the shaft Trynitis, which constitutes the “inside background” and was significantly lower than the results gained from the measurements for the “outside background” (points B6 and B7, respectively). More-

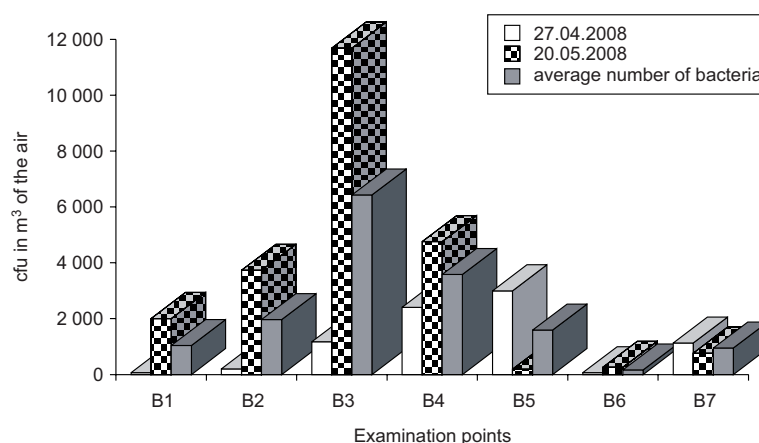


Fig. 1. Bacterial aerosol in the external environment and in the area of the underground sanatorium – “Health Resort of Salt Mine in Bochnia”

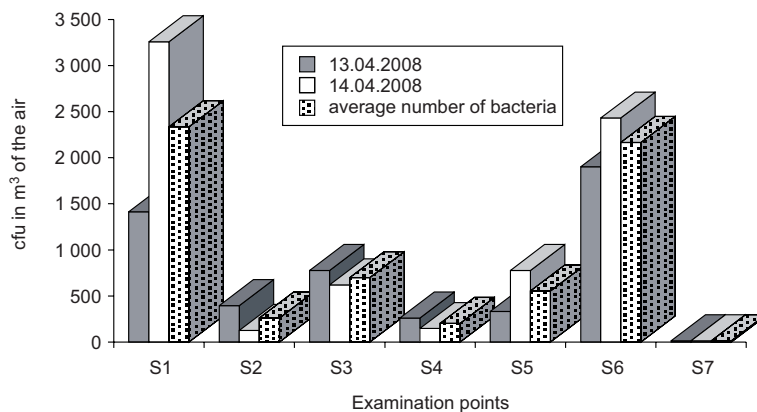


Fig. 2. Bacterial aerosol in the external environment and inside the sanatorium rooms in the overground health resort – “Health Resort Enterprise Szczawnica”

over, the concentration values of bioaerosol in healing chambers were found to be higher than the values measured for the “inside background”.

The observed trend is coherent with the present state of knowledge of the origin of the tested bacterial aerosol, in which people are considered as the biggest and constantly active source of its emission in the interiors. The above specified concentrations of bacteria occurring in the healing chambers in Salt Mine in Bochnia are also the result of constant air circulation, which occurs between the earth surface and each levels in the Mine. The appearance of microflora in the chambers is also influenced by the horizontal air flows, temperature, and the lack of sun rays and the dampness from brines [5, 6].

In relation to the total concentration of bacterial aerosol in sanatorium chambers of the overground health resort “Health Resort Enterprise Szczawnica”, the tested bioaerosol values during the presence of patients and therapeutic procedures were found to be within the range between 127 cfu/m³ and 3258 cfu/m³. It is also noticeable, that the concentration of bacteria in the air inside the tested rooms in the day off-work was lower and was from 261 cfu/m³ to 1901 cfu/m³. The highest concentration of the tested bacterial aerosol was in the room in the Nature Treatment Institute, in which mineral baths are performed and in the corridor leading to the rooms of bathers in the Inhalatorium building – “inside background” (points S1 and S6, respectively). However, the lowest bioaerosol value was found in the chamber inhalations room and in the room, in which whirl massage of limbs was performed (points S4 and S2, respectively). The results, shown in the graph 2 indicate, that the mean values of bacteria concentration in the air inside the mineral baths room and in the corridor of the Inhalatorium building, were significantly higher than in the other measuring points. The comparison of the measurement results for the “inside background” and “outside background” shows, that the concentration of bacterial aerosol in the outside environment was significantly lower than the values of “the background” measured inside the tested sanatorium chambers. On the other hand, the concentration values of the tested bioaerosol measured in chosen rooms were lower than the values measured for the “outside background”.

It is known from the literature, that in normal conditions in rooms, in which people stay, bacterial concentrations are higher than in the outside environment, and generally they do not transgress the range of 10000 cfu/m^3 . The degree of air pollution in closed rooms depends on the size of rooms, furnishings, amount of people who use the room, location and outdoor air properties. The range of impact of the external meteorological factors and the penetration speed of these influences inside the room depends on the way of air exchange, character of rooms and on their isolation from the surroundings [7–9].

On the basis of the results of the measurements of the bacterial aerosol concentration, it may be noticed that generally higher concentrations of bacteria occurred in the air during the presence of bathers in the underground sanatorium chambers than in rooms of the overground health resort. It should be noticed, that in this period the maximum bacterial aerosol concentration in Salt Mine in Bochnia, which was 11688 cfu/m^3 (Fig. 1), was over three times higher than the maximum concentration of the tested bioaerosol – 3258 cfu/m^3 , found in the sanatorium rooms of “Health Resort Enterprise Szczawnica” However, concerning the measured values of bacterial aerosol concentrations for the “inside background”, in both health resorts, the mean amount of bacteria in the tested “background” air inside the rooms in the overground sanatorium was found to be significantly higher than the mean amount of bacteria found in the “background” air of the underground sanatorium chambers. The analysis of the gained results reveals clearly the low level of bacteriological contamination in the state of so-called “original microbiological cleanliness”, which is before the introduction of the bathers into the sanatorium rooms or chambers. Such result may be explained by better environmental conditions. The above observations emphasize the value of underground treatment, in which avoiding the superinfection of the patients is essential. The presence of small biological environmental contamination is considered to be one of the most important factors of pulmonological subterranean therapy, because it allows the temporary isolation of the patient from the harmful influence of the external environment [1].

The usage of 6-step Anderson impactor in the research has allowed to collect data about fractional (grain size) distribution of the bacterial aerosol in the tested rooms. Tables 1 and 2 show grain size distribution of the air microflora found in the external environment, in the air of the sanatorium rooms and in the underground healing chambers. The analysis of fractional distribution occurring in the rooms of the overground sanatorium as well as in the underground healing chambers indicates the presence of bacteria mainly in the range of diameters from 1.1 to $4.7 \mu\text{m}$. The gained result shows, that bacterial microorganisms were present there mainly as single cells (bacteria 1.1 – $3.3 \mu\text{m}$) and small bacterial or dust-bacteria aggregates (2.1 – $4.7 \mu\text{m}$). The share of large microorganisms’ aggregates in the bioaerosol composition ($>3.3 \mu\text{m}$) was lower than their smaller forms. Such distribution of the particles’ aerodynamic diameters indicates the additional emission from the reservoir, which is human organism (the increased emission during breathing and exfoliation of the epidermis during the bathers and personnel presence in the sanatorium rooms or chambers) [6].

Table 2

Bacterial aerosol concentration in the external environment and inside the healing chambers in the area of the underground sanatorium – "Health Resort of Salt Mine in Bochnia" on 20th May 2008 (measure during the stay of the bathers) and on 27th April 2008 (measure without the bathers)

Examination point	Concentration [cfu/m ³] of each fraction of bacterial aerosol (the range of particle diameters [µm])											
	≥ 7		7.0-4.7		4.7-3.3		3.3-2.1		2.1-1.1		1.1-0.65	
	27.04.2008	20.05.2008	27.04.2008	20.05.2008	27.04.2008	20.05.2008	27.04.2008	20.05.2008	27.04.2008	20.05.2008	27.04.2008	20.05.2008
B1 The Koldras Chamber – the middle	7	289	14	431	7	184	21	558	21	544	0	0
B2 ramp between levels IV and VI	64	558	49	686	28	749	49	947	7	700	7	92
B3 The Wazyn Chamber – the gym	403	926	283	1194	184	2226	191	4346	113	2869	0	127
B4 The Wazyn Chamber – the bedroom	417	318	318	283	445	1011	537	1767	678	1364	14	14
B5 The gangway behind the Wazyn Chamber in the direction of Sutoris shaft	862	35	297	42	403	21	841	14	509	49	85	28
B6 Inside background – the gangway leading the air from the Trynitatis shaft	0	85	7	57	21	21	7	64	14	35	0	0
B7 Outside background in the open area, nearby the Trynitatis shaft	120	375	163	127	219	67	297	85	113	64	219	49

Analyzing the grain size distribution for the “outside background”, chosen for the underground as well as for the overground health resort, it may be stated, that in the external environment bacteria were most often present as dust-bacteria aggregates. Other researchers gained similar results, for example Lis et al [9], who found, that the most particles of the bacterial aerosol in the external environment have the diameter larger than 5 μm . This is probably due to the dust pollutants, emitted in cities to the atmosphere from the low emission sources [9, 10].

Conclusions

1. The research has shown, that concerning microbiological cleanliness, the state of the air in the tested overground sanatorium rooms and in the underground subterranean-therapy chambers is good.

2. It was found, that the environment in the underground healing chambers, as well as in the rooms of the overground sanatorium is bacteriologically less contaminated in the state of so-called “initial microbiological cleanliness”, which is before entering the bathers.

3. The research shows the purposefulness of using the environment of Wazyn Chamber in Salt Mine in Bochnia in the subterranean-therapy treatment.

4. Data gained in the research shows that the tested health resort in Szczawnica has profitable biological factors which determine its role in allergic diseases treatment.

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BADANIA AERAZOLU BAKTERYJNEGO WYSTĘPUJĄCEGO W OŚRODKACH SANATORYJNYCH W BOCHNI I SZCZAWNICY

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Abstrakt: Zasadniczym celem pracy było określenie charakterystyki aerozolu bakteryjnego występującego w komorach sanatoryjnych Uzdrowiska Kopalnia Soli Bochnia oraz w pomieszczeniach sanatoryjnych Przedsiębiorstwa Uzdrowisko Szczawnica, z jego rozkładem na poszczególne frakcje cząstek w zależności od średnic aerodynamicznych: powyżej 7,0 μm , 7,0–4,7 μm , 4,7–3,3 μm , 3,3–2,1 μm , 2,1–1,1 μm i 1,1–0,65 μm . Badania mikrobiologiczne powietrza przeprowadzone zostały w okresie wiosny 2008 r. w komorach leczniczych Uzdrowiska Kopalni Soli w Bochni oraz w pomieszczeniach sanatoryjnych Przedsiębiorstwa „Uzdrowisko Szczawnica” S.A. Pomiaru zostały przeprowadzone za pomocą sześciostopniowego impaktora Graseby-Andersena ze strefy oddechowej (położenie jamy ustnej i nosowej) człowieka w stanie tzw. pierwotnej jałowości, tj. przed wprowadzeniem kuracjuszy i personelu do komór oraz pomieszczeń sanatoryjnych, a także w czasie trwania turnusu i wykonywania zabiegów leczniczych. W wyniku przeprowadzonych analiz wykazano znaczne różnice w ilości występującego aerozolu bakteryjnego na różnych stanowiskach pomiarowych. Na podstawie otrzymanych wyników można stwierdzić, że największe stężenie aerozolu bakteryjnego w Uzdrowisku Kopalni Soli w Bochni występowało w Komorze Ważyn (w części hali sportowej oraz sypialnej), natomiast w Przedsiębiorstwie „Uzdrowisko Szczawnica” wewnątrz pomieszczenia, w którym są przeprowadzane zabiegi kąpieli mineralnej i na korytarzu prowadzącym do pokoi kuracjuszy w budynku Inhalatorium. Zaobserwowano wyraźnie wyższy poziom występującego aerozolu bakteryjnego w trakcie trwania turnusów leczniczych i wykonywania zabiegów w porównaniu z okresem międzeturnusowym (brak kuracjuszy).

Słowa kluczowe: aerozol bakteryjny, sanatorium, powietrze