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SUBTERRANEOTHERAPY AS A SUPPORTING METHOD FOR RESPIRATORY SYSTEM'S DISEASE TREATMENT IN HEALTH RESORT AT THE SALT MINE OF BOCHNIA

Health Resort at the Salt Mine of Bochnia, LTD

ABSTRACT

Subterraneotherapy is a treatment method utilized to give treatment to patients with respiratory system's diseases in a micro-climate of underground salt chambers. An analysis of aerosol in Bochnia mine proved its exceptional purity with respect to microbiology and palinology as well as stable temperature within the range of 13-16°C, a large level of humidity, correct oxygen saturation, increased but accepted concentration of the carbon dioxide, majority of negative ions. A significant agent of aerosol in the mine is sodium chloride crystallizing itself in very tiny forms. It makes basis for treatment with subterraneotherapy method. Therapeutic indications are chronic and allergic diseases of the respiratory system. Contraindications are all illnesses which can not be treated in a health resort. Researches made in Health Resort at the Salt Mine of Bochnia on children suffering from a bronchial asthma proved efficiency of this treatment method. A positive treatment effect was observed, more or less, in a half-shift period. On these grounds it can be assumed, that minimal treatment period for children suffering from bronchial asthma in salt chambers should last from 6 to 7 days. The method requires extended researches.

Key words: subterraneotherapy, respiratory system's diseases, Health Resort at the Salt Mine of Bochnia

INTRODUCTION

Underground space

Therapeutic properties of underground space atmosphere in closed salt mine's workings were discovered in Poland in 30's XIX century by D. Feliks Boczkowski. He proved in his papers that ill persons' stay in underground salt chambers, due to specific advantages of their climate is more efficient in aspect of respiratory track treatment than salt-baths (1). However, not before 50's of the last century, Professor Mieczysław Skulimowski, who continued D. Boczkowski's work, started regular treating of patients in underground salt chambers in Wieliczka. Professor Skulimowski is recognized to be the subterraneotherapy (STT) pioneer. STT is a method which puts ill persons, among others those suffering from respiratory system's diseases, to specific influence of intensive impulses of natural character, physical and chemical character, occurring in underground chambers of closed salt mines (2). The STT's birthplace is Wieliczka, where in 1958 was set up the first treatment center and in 1963 the first in the world Towarzystwo Naukowe Klimatoterapii Podziemnej (Science Association for Underground Climate-Therapy).

MATERIALS AND METHODS

Characteristics of underground salt chambers' microclimate

Temperature inside the earth is stable and independent on the temperature over-ground. About 25 m in depth is stable and is about 9°C. It increases averagely by 1°C every 33 meters. It is so called average geo-thermal degree.

Sometimes, the temperature can grow more rapidly than measures could suggest, e.g. in a salt mine, as the salt is a very good heat conductor in comparison to other rocks. Ability of heat conduction for coal is 0,3; brick wall 0,75; gypsum 1,1; sandstone 1,5 and for the salt it is 5,0.

Temperature in the mine in Bochnia about 212-250 meters in depth is about 14-16°C what responds the level of temperature according to the geo-thermal degree. In a one-year period it slightly fluctuates since it depends on temperature on an excavation's inlet, speed of air exchange and migration ways underground. It was confirmed by researches made from September 1997 to 1999 for all four seasons (3).

Table 1. Temperature measurements in 'Wązyn' chamber

Temperature (in °C)			
spring	summer	autumn	winter
15.9	16.7	13.4	14.4

In STT a significant factor is also humidity, thus, there occur the following classification:

- relative humidity of air up to 60% - dry air
- air humidity between 60-80% - normal air,
- from 80-90% - humid air
- humidity exceeding 90% - very humid air.

Salt deposit's minerals have hygroscopic properties. As a result, excavation walls, pavements and chambers which the air from the over-ground flows through become humid in a warm season.

Humid air influences clinical course of the respiratory system's diseases. Excessively dry air causes seriously increased evaporation of water from respiratory track and consequently, it additionally dries up mucous membranes of a respiratory track. It simplifies penetration by a pathologic biologic aerosol that is a virus-type or bacteria-type and organic contaminations, resulting in infecting or consequent allergic reactions.

Breathing with a cool air of regular temperature and high relative humidity – as this type is met in underground salt chambers – is totally proved in aspect of treatment. Researches proved a seasonal change of humidity values in salt chambers (3).

Table II. Humidity measurement in 'Wązyn' chamber.

Humidity (%)			
spring	summer	autumn	winter
60	93	72	57

Ionization and mine aerosol

On the ground, relation of positive ions number to negative ions usually is 5: 4. Large concentration of positive ions in the atmosphere occurs with specific weather conditions such as: a foehn, or in a highly-urbanized regions and industrial ones because they are polluted by exhaust gases and industrial dusts which contain series of poisoning agents such as: sulfur dioxide SO_2 , sulfur trioxide SO_3 , hydrogen sulfide H_2S , free sulfur.

Negative ionization indicates regulating and healing properties through nervous-vegetative system, hormonal system as well as motor muscles' activity improvement. In the respiratory system it results in anti-inflammatory activity as well as anti-allergic, spasmolytic, improving the ventilation (2). Normally, in the environment it occurs near waterfalls, water reservoirs, in sea-air and underground space.

For the underground atmosphere's bio-dynamics there are significant natural aerosols, that is double-or-triple sets where the air is dispersion form and molecules or liquid molecules are the dispersed constituent. It happens due to increased air ionization with majority of negative ions; in the reality, we meet more dynamic aerosol sets, so called electro-aerosol.

A main agent of mine-aerosol is the sodium chloride. Geochemical-mineralogical analysis made in the mine in Bochnia proved that in the mine's aerosol there dominate idio and hipidiomorfic aggregates of sodium chloride crystals of sizes from blow $1\mu\text{m}$ to several-hundred μm . Larger and well-shaped granulates are effect of re-crystallization of aggregates in the mine (4). Sodium chloride aerosol in the salt mine originates from continuous process of leaching, that is salt-rock dissolving by humid air while water is picked-up by hygroscopic salt rocks.

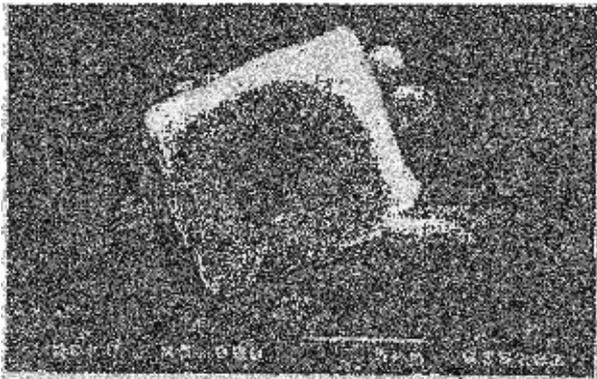


Fig. I. Atmospheric dust and aerosol from the "Lill" Salt Chamber of the Wieliczka Salt Mine – SEM photomicrograph.

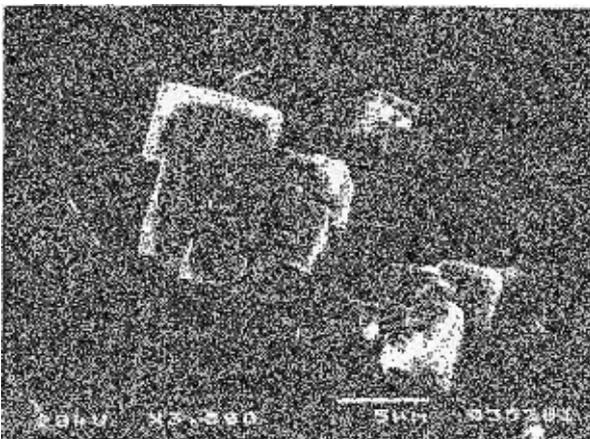


Fig. II. Atmospheric dust and aerosol from the salt chamber adapted for utilization in the Bochnia Salt Mine – SEM photomicrograph.

Sodium chloride aerosol influences a respiratory organ in an inflammatory way, anti-allergic, it stimulates mucociliary respiratory track cleaning and it regulates organism's mineral management and nervous-vegetative system (2). Apart from the sodium chloride in the salt chambers' underground space there occur calcium, magnesium, iodine and bromine in form of natural aerosols of their larger of lower content, ending with trace quantities.

Microbiological and Palynological researches

Microbiological and palynological researches over salt chambers' aerosol made in the past (5) and recently in 2001 (1) prove its exceptional purity in microbiological aspect, meeting norms for operation rooms. Practically it doesn't contain any plant's pollens or fungal spores despite the researches were made in the period from June to August that is in the period, when a high concentration of plants' pollens was observed (over 100 per m³/24h) and fungal spores (*Cladosporium* up to several thousands per m³/24h; *Alternaria* over 100 spores per m³/24h).

Table III. Results of microbiological and palynological researches over 'Wązyn' chamber's aerosol in Health Resort At The Salt Mine Of Bochnia

Investigated parameter	
1 st microbiological analysis	
general number of microorganisms / m ³	2.0-3.64 x 100
type of bacterium	<i>Micrococcus</i> <i>Bacillus sup.</i> <i>Corynebacterium</i> <i>Staph. epider.</i>
Fungus' number/m ³	0-9.1 x 10
2 nd microbiological analysis	
plant's pollens/m ³	0-3
Fungal spores number/m ³	0-11

Chemical air content

Underground salt chamber's atmosphere is correctly saturated with oxygen, similarly like atmospheric air over-ground, however, partial oxide pressure (pO₂) is increased what results in its better diffusion in lungs (2). In underground chambers the carbon dioxide is 3-5 times increased but it doesn't exceed acceptable mining norms (below 1%) and is about 0.1 – 0.2% (over-ground it is 0.03%). The carbon dioxide is a physiological and biochemical breathing stimulator.

Indications for subterranotherapy:

- bronchial asthma
- chronic and allergic rhinitis
- chronic sinuses inflammation
- chronic throat and larynx inflammation
- chronic bronchial inflammation
- bronchiectasia

- pulmonary emphysema
- chronically returning upper and lower respiratory track inflammations

Counter indications:

In underground salt chambers all illnesses which can not be treated in a health resort because of clinical or epidemiological reasons are not accepted, especially:

- diseases of rapid course, e.g. rapid inflammations, myocardial infraction
- insufficiency of circulation, breathing, kidneys, liver
- cardiac aneurysm or arteries aneurysm
- instable angina pectoris
- not-regulated arterial hypertension
- malignant neoplasm and preneoplastic states
- mental disorders, claustrophobia included
- epileptic attacks requiring regular treatment
- symptomatic forms of hyperthyroidism
- pregnancy and feeding period

RESULTS

The salt mine in Bochnia was set up in 1248 and it is the oldest salt mine in Poland. In 1990 its deposits run down. After 750 years of activity in the mine there occurred 16 exploitation levels and 60 km of mine pavements as well as chambers with specific, underground micro-climate of therapeutic properties. In 1995 there was set up the Health Resort at the Salt Mine of Bochnia, LTD which made efforts heading for adaptation of the underground chambers for treatment purposes. At the earliest, in 1995 'Ważyn' chamber was adapted 250 m depth. Its dimensions: 250 m length, 5-6 m height and 10-12 m width. It is equipped with a part for pulmonologic rehabilitation, recreation part (sports ground), restaurant, conference room and nigh-accommodation part. In 2001 in 212 depth a Ruszard Kołdras chamber was adapted, it contains 40 beds in 2, 3, and 4-persons boxes, consulting room and rooms to run pulmonologic rehabilitation. The last STT chamber is 'Manna' (at the 'Ważyn' chamber's level) equipped with equipment for kinesis therapy. In the Health Resort at the Salt Mine of Bochnia's over-ground there is localized a Rehabilitation Center including a consulting room, operation room, gym, rooms equipped with equipment for electrotherapy, magnet therapy, cryotherapy, laser therapy, thermotherapy and hydrotherapy department.

Therapeutic shifts as a rehabilitation of respiratory system's diseases

Since 2004 in Niepubliczny Zakład Opieki Zdrowotnej Uzdrowiska Kopalnia Soli Bochnia (Private Health Center of Health Resort at the Salt Mine of Bochnia) there are organized therapeutic shifts in scope of rehabilitation provided for persons suffering from respiratory track diseases, re-funded by the Narodowy Fundusz Zdrowia (National Health Fund).

From 2004 to 2007 they included 10 five-hours stays in salt chambers (totally 50 hours) coupled with intensive kinesis therapy run by qualified physiotherapists. Since 2008 shifts have included 14 rides to the mine lasting 6 hours (totally 84 hours) coupled with kinesis therapy and in case of therapeutic indications they are supplemented with physiotherapy (treatment) in the over-ground Rehabilitation Center.

Table IV. Number of patients treated in scope of therapeutic shifts re-funded by NFZ

Year	Number of patients
2004	211
2005	404
2006	542
2007	639

The lung diseases rehabilitation's objective is:

- improvement in breathing mechanics in long-standing lung diseases
- prevention from consequences of respiratory track diseases
- prevention from complications and consequences resulting from respiratory track rapid diseases
- utilization of breathing reserves in case of irreversible changes in lungs
- prevention from lung-based complications in course of other organs' diseases.

Kinesis therapy programme in scope of the therapeutic shift in the salt mine includes:

- breathing exercises
- study over diaphragm path breathing
- positional drainage and a chest tapping
- study over effective cough
- interval training
- exercises regarding extended breathing out
- general-fit exercises, individual and group
- relaxing training

Physical exercises are individually recommended for every patient after a preliminary investigation. Exercises for children are run in form of a play.

Among patients-tourists about 85% are children, qualified to be treated by this form of treatment since they are 3 years old.

As interesting given by patients suffering from respiratory system's diseases grows up, especially among those with respiratory track allergic diseases, directors of the Health Resort At The Salt Mine Of Bochnia makes permanent efforts to increase number of contracts with NFZ.

Researches over bronchial obturation in the period of rehabilitation shift for children suffering from bronchial asthma.

In 2006 in NZOZ of the Health Resort At The Salt Mine Of Bochnia there was made researches over bronchial obturation rate in the period of 10-days shift including 5-hours stays at salt chambers coupled with kinesis therapy utilized in case of the bronchial asthma.

In order to monitor respiratory system's activity a commonly-available device was exploited, that is peak expiratory flow meter – pikflometr. It enables measuring of expiratory peak flow (PEF). PEF value corresponds well to basic parameter of spirometrical test FEV1: value of an intense first-second expiratory capacity.

The test included group of 40 children aged from 6 to 16 suffering from asthma.

Table V. Rate of asthma was determined according to GINA 2005 classification

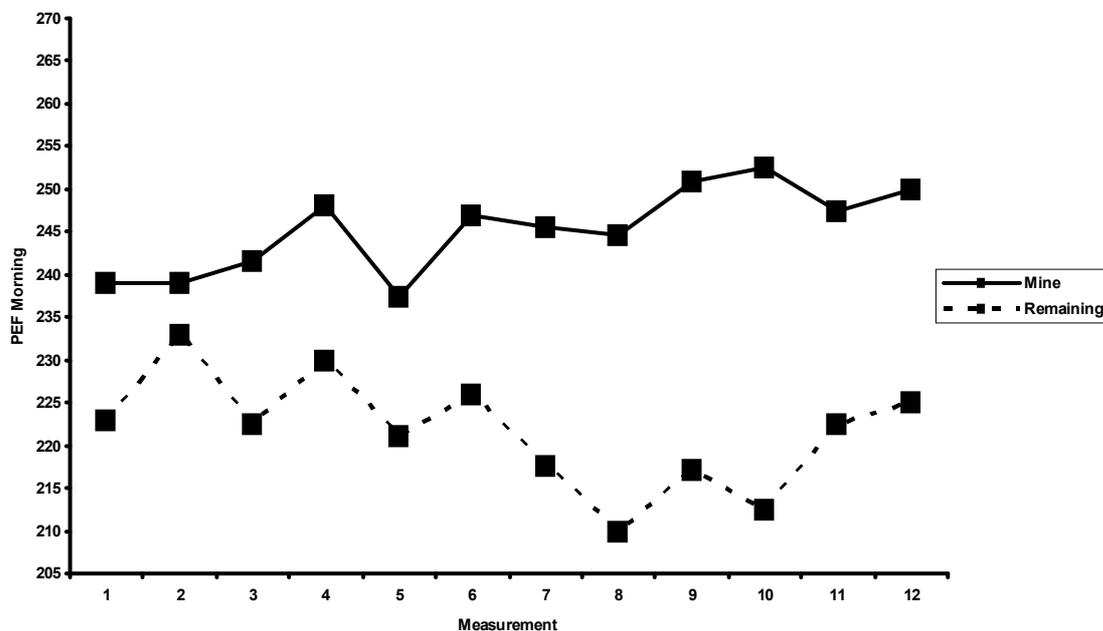
rate	Number of children	percent
I episodic	24	60
II chronic-light	10	25
III chronic average	6	15

The group was divided into halves. The first group ‘Mine’ included 20 children who in the two-week period (with exception of Saturdays and Sundays) traveled to the mine for 5-hours stay, supplemented with kinesis therapy of respiratory system. The second group ‘Remaining’ participated in analogical breathing exercises run over-ground in the Rehabilitation Center.

All patients in the period of 12 days were taking measures in the morning (between 7 am – 9 am) and in the evening (between 6 pm and 6.30 pm) of peak expiratory flow (PEF) due to pikfometr of Mini Wrigt type, and next, they jotted down the best result of 3 following trials. The most numerous group consisted of children aged 6 and 7 (40% of investigated persons), with disease lasting 3 years (25%).

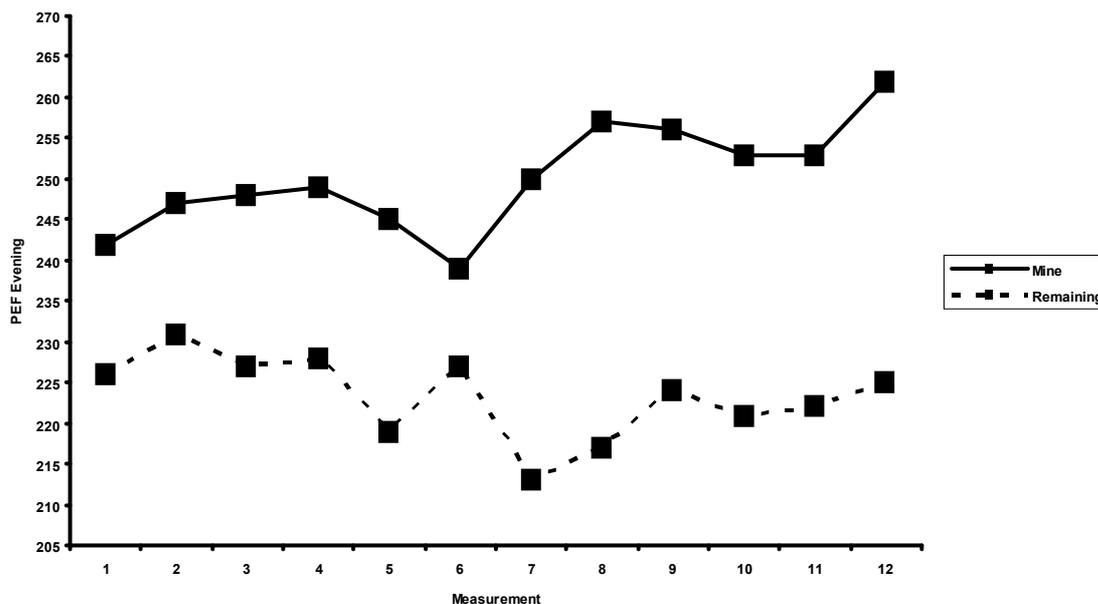
Measurements’ analysis

Average morning and evening PEF for the ‘Mine’ and analogical PEF for ‘Remaining’ group were calculated.



Fig

III. PEF measured in the morning.



Fig

IV. PEF measured in the evening. (Source: own evaluation).

CONCLUSIONS

A stay of 50-hour duration of children in the underground salt chambers in Bochnia significantly increased value of morning and evening PEF measurements. A positive treatment effect was observed, more or less, in a half-shift period. On these grounds, it can be assumed that minimal treatment period for children suffering from the bronchial asthma in salt chambers should last from 6 to 7 days. The researches should be continued in order to determine optimal in scope of therapeutic effect stay's duration for children suffering from asthma in salt chambers. It would be recommended to observe and analyze a time-period of positive therapeutic effect persistence.

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