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INDOOR AIR MICROBIAL POLLUTION CONTROL MEASURES IN HEALTH FACILITIES

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Regarding the fact that on humidifying by steam it is impossible to exclude oversaturation of air with a following condensation of water in pipelines, some operators of climatization instalments prefer the use of water humidifiers. Soaked surface and circulating water together with impurities from the passing air create a suitable environment for the growth of a wide spectrum of microorganisms which constitute a risk to health of man. For this reason we dealt with the possibility to suppress microbial contamination of circulating water is humidifiers.

Besides the well known oligodynamic potential of silver ions, zinc and selenium salts seem to be promising not only from the view of their oligodynamic effects but for their potential protective and immuno-stimulating effects on man desirable in hospital environment. The problem deserves careful studies and complex approaches including a transfer of Zn and Se ions from water of humidifier to air, and their bioavailability to man if inhaled in trace concentrations.

INTRODUCTION

From a physical point of view microbial air pollution does not differ substantially from the existence of other aerosols. However, it has specific properties inherent to the pathogenicity of microbes. From the very beginning of our communication we would like to emphasize the synergistic effect of microbial air pollution and other pollutants present in the indoor air. Solid aerosols become not only carriers of microorganisms in the air, but they affect, among other things, also local (respiratory ways and lungs) and, to some extent, complex defence mechanisms present in the inhaled air increase the probability of actual pathogenic effects of the pertinent microorganisms (1). In connection with microbial air pollution - besides from natural reasons emphasized risk of infection - it is necessary to consider sensibilization and other types of allergic manifestations caused by a wide spectrum of microbes. Most frequently it is the case of bacteria and their endotoxins, fungi spores including the pathogenic ones, candides etc. (2).

The most important source of pathogenic microbes usually found in the indoor air are the respiratory ways of man and animals. Microorganisms enter the air in the form of a complex system of droplets of various sizes by talking, sneezing and coughing. Aerosol formed by the microscopic droplets can persist in the air for a long period, and thus from the epidemiological point of view it is exceptionally important in spreading air-borne bacterial infections e.g. of

streptococcal infections, diphtheria and tuberculosis etc., and those of viral nature e.g. influenza, measles, parotitis, adenoviroses and others. The existence and infectivity of the air-borne microbes depends on dust particles, which prolong their vitality by preventing their desecration and, to some extent, limiting the effects of germicidal environmental factors as ultraviolet light and partially also influencing effectiveness of extreme temperatures of heat and frost.

Pathogenic germs occur and sometimes grow in humidifiers of air-conditioning. The generally known epidemic, caused by Legionella pneumophilla in the form of pneumonia was firstly described in 1976. Hospital-acquired Legionella infections have presented a considerable problem in some hospitals. Increased risk of nosocomial pneumonia caused by L. pneumophila has been associated with renal dialysis or renal homograft, immunosuppressive medication, cancer, diabetes and cigarette smoking (3). National surveillance in several countries, has shown that nosocomial Legionella pneumonia may be important in terms of both sporadic and epidemic infection. It is clear that Legionella infection may be endemic in many hospitals, a fact that was first observed in 1977 during the investigation of a nosocomial outbreak, when legionnaires' disease was found to occur with equal frequency in the "index" hospital and in three hospitals selected as controls (4). As well as, so called humidifier fever, a flue-like condition that occurs typically in the first working day after a break, subsiding in 24-48 hours has been reported. Cases of humidifier disease have been reported from hospitals, as well (5,6).

MATERIAL AND METHODS

A model study of heavy metal ions' influence on the growth activity of bacteria method of quantitative suspension test was applied. This method has currently been used in Reference Laboratory for Disinfection and Sterilization in the Institute of Hygiene and Epidemiology in Prague, modified and adapted to suit our purposes. In the given case we used test strain E. coli 234/70 from a referential collection of bacterial strains in Institute of Hygiene and Epidemiology, Prague. For Ag+ ion disinfection efficiency testing we used salt $AgNo_3$ for Zn^{2+} testing $Znso_4$. 7 H_2O and for $Se^{4+}Na_2SeO_3$.

For the testing purpose a scale of above mentioned metal salts concentrations ranging from 10^{-1}% to 10^{-6}% solution had been prepared from 1% water solution by a gradual dilution procedure. Method of preparation of bacterial suspension with in order 10^9 of microbes in 1 ml: 18 hour bacterial culture was prepared by inoculating bacterial test strain into liquid nutrient medium beefpepton (bouillon) by bacteriological loop and cultivating at 37°C for 18 hours. This 18 hour culture contains of order 10^5 bacterial cells in 1 ml. Required concentration 10^5 bacteria in 1 ml was acquired by the gradual dilution procedure. Into the test tube with pertinent concentration of tested metal salt 1 ml of the bacterial suspension with the approximate number of $10^5.ml^{-1}$ bacteria was pipetted. Thus we reached the objective of overall volume in each test tube 10 ml and bacterial suspension was thus diluted to 10 bacteria in 1 ml. This bacterial concentration is the most acceptable for a testing practice.

Following individual exposure intervals of the bacteria to metal salts - 30 min., 60 min., 4 hours, 24 hours were tested. The interval was selected as the most relevant for our purpose because in practice water from humidifiers reach "the consumer" approximately by 4 hours. After the mentioned cultivation period we sampled 0.25 ml volume from each for these individual test tubes and transferred it onto solid broth medium (beefpepton agar) and spread on the whole surface by bacteriological loop (this small quantity dries much more quickly as in usually used 1 ml volume). For statistical reasons, we sampled each salt concentration simultaneously three times. After drying of inoculum these media were cultivated at 37°C for 24 hours.

Colonies reading: unkilled bacteria in individual concentrations and in individual time exposure

grown on solid broth media in the form of colonies were counted by on using a digital apparatus Biotran III automatic count-area totalizer, (New Brunswich Scientific Co., NC, Edison, N. JH., USA).

RESULTS AND DISCUSSION

The results of microbiological tests of water samples from three humidifiers in different periods showed that the growth dynamics of microorganisms did not correspond to the expected course. The highest water contamination was found to occur usually during the first week of operating regardless previous disinfection of water and inner surfaces of humidifiers. Following two of three weeks the contamination decreases to admissible level. Water quality was favourable usually even after one month of operation was detected. By this time, water in the humidifiers was considerably thickened by salts and organics.

In the detection of microbial air pollution rate, the limit value for air cleanliness is to be considered 1000 cfu.m^{-3}. The highest permissible air pollution in operating rooms is considered by some authors 700 cfu.m^{-3} of air (7). For a sterile environment, however, the required strict value is lower than 200 cfu.m^{-3} of air. The exacting character of this requirement stands out in comparison with the usual number of bacteria in the indoor air, ranging up to 10^4 cfu per m^3. In households the uppermost "normal" number of bacteria reaches approximately 4500 cfu.m^{-3} of air (8).

Exposed workplace like operating rooms or production of sterile drugs are equipped by air-conditioning with air filtration completed with ultraviolet light disinfection (turned on only in the absence of workers to prevent eye damage by ultraviolet light). Laboratory studies suggest that a number of anti-microbials may be of value, including calcium hypochlorite, dibromonitrilopropionamide, a chlorinated phenolic thioether, and some quaternary ammonium compounds, particularly if used in combination with tributyltinoxide (9-11). Air disinfection is sometimes carried out by chemical aerosols, e.g. some glycols. Their drawback is in the toxicity of sufficiently effective concentrations for humans as well as the fact that it is often difficult to achieve the necessary spreading of disinfective aerosol (1,12). For this reason adequate concentrations of chemical disinfection substances must be searched for and used regarding human health protection, but also of air filters and water in humidifying and washing sections of air-conditioners in public buildings, especially in health establishments.

Disinfectant used for the purpose must meet the following requirements:

- it must not exceed the MAC values in indoor air due to its transition from water to humidified air;
- its effect in the water are expected to be of a prolonged character;
- it should be of non-corrosive nature, i.e. it will not shorten the technical life of an air-conditioning device in a substantial way;
- it should be accessible in the required quantity to a wide circle of consumers.

The above criteria are met, among others, by oligodynamic activity of silver ions, bound in sodium chloride (SAGEN), generally used for a long term well water disinfection. At variance with the well water, the water humidifiers is aerated, saturated by both organic and inorganic substances, washed from the filtered air at approximately room temperature and thickened by salts due to gradual evaporation. Resulting effect of interaction of these influences on the growth of microorganisms in washing parts of air-conditioners cannot be exactly predicted, which leads to the implementation of orienting examinations directly on the currently used facilities. Before the application of silver compounds under testing (SAGEN or SPOLAKON) water samples from humidifiers of different health facilities were taken and the influence of different kinds of metal construction materials and disinfection solutions on the growth of microorganisms, present in the sampled devices was tested (13-15).

The long-term protection of smaller drinking water sources against accidental microbial pollution is carried out by adding SAGEN in 0.001% concentration. With regard to the results of preliminary laboratory tests the dosage of SAGEN applied into humidifier was in comparison with the concentration ensuring safe drinking water was more than one order higher, i.e. 0.013% resp. 0.011%. For the possible unfavourable effects of silver on human organism its content in air is limited by 1 g per cubic metre (MAC for not occupational environment established in th USSR). For this reason, the silver content of air was measured in ventilation inlets and in breathing zone of humans. Particles trapped on Synpor 2 membrane filters were analyzed by PIXE method. Presence of Ca, Ti, Va, Cr, Fe, Mg, Zn, Cu, Pb was determined, however, no silver was detected (detection limit 6.8 g.m under the used experimental conditions).

Besides the generally known disinfection effects of light and especially ultraviolet light (16) similar effects can be observed also with air ions. This effect is applied in the case of speleotherapy. Germs, entering the cave by air of from air-ways of the patients, all under the effect of ionized atmosphere and water aerosols quickly sediment to the ground of the cave, or they are attracted to its walls. Thus the inner air of the cave is being cleaned continuously (17). Another possibility of disinfection of humidifiers water is its heating if the construction of the operated air-conditioner enables an effective use of this procedure.

The main task from the view of consistent prevention of excessive microbial air pollution with the aim to reduce the occurrence of at least part of nosocomial infections lies with health establishments. The importance of this task is growing together with the increasing ratio of infections caused by microorganisms with a low or facultative pathogenicity, occurring predominantly in persons with a lowered natural resistance. Exceptionally strict requirements are layed on microclimate of persons with pathological conditions of immune deficiency of suffered from heavy polyvalent hypersensitivities. In these cases, demanding technical measures create almost microbeless environment with a minimum of antigens of a chemical nature (18). These situations, however, have so far been rather exceptional. The objective of our communication is to show that by currently accessible means it is possible to achieve satisfactory conditions in hospitals and other health establishments from the view of microbial pollution. At the same time, basic hygienic requirements were set forward to ensure adequate quality of water in the humidifiers of air-condition instalments.

CONCLUSIONS AND RECOMMENDATIONS

Even though the given tests had to a certain extent, only an orientational character, it is possible to draw the following conclusions:

- A disinfection effect can be expected from metals with oxygenated surface and thus a corroded construction material of humidifiers can influence microbial contamination of recirculating water.

- Construction of humidifiers must enable the simplest possible cleaning, independent of the attendance, i.e. humidifiers should be equipped with automatic system of inner surface cleaning, e.g. stream of degreasing solutions from suitably arranged jets.

- Construction of humidifiers should resist to corrosive disinfection agents (up to pH 12) in case of the necessity of radical disinfection.

- Regarding the occurrence of highly resistant microorganisms, it is necessary to test systematically the microbial effectiveness of currently used disinfection agent.

- It is desirable to verify the rate of transmission of different disinfectants from water

It is desirable to verify the rate of transmission of different disinfectants from water solution in the humidifier into treated air with the aim of better understanding of a health risk of extended usage of disinfectants in humidifiers.

It is necessary to carry on in researching the dynamics of microorganisms multiplication in humidifying water, especially in the period the ascertained concentration is the highest. In this connection are then specified the requirements for the frequency of water exchange.

In the surroundings of instalments requiring a high standard of microbial cleanliness such as in hospitals and some premises of pharmaceutical works cooling towers should not be placed in their proximity.

REFERENCES

1. Bencko V (1987) Microbial Air Pollution in: Symon K, Bencko V et al. Air Pollution and Health (in Czech). Avicenum, Prague. p. 131-133.

2. WHO/EURO (1988) Biological Contaminants in Indoor Air. Report on a WHO meeting, Rautavara.p. 1-42.

3. WHO/EURO (1986) Environmental Aspects of the Control of Legionellosis. Environmental Health 14, Copenhagen.p. 1-24.

4. Marks JS et al. (1979) Nosocomial Legionnaires' disease in Colombus, Ohio. Ann Inter Med 90: 565-569.

5. Smith PW, Massanari RM (1977) Room humidifiers as the source of Acinetobacter infections. JAMA 237: 795-797.

6. Finnegan MJ, Pickering CAC, Davies PS, Austwick PKC, Warhurst DC (1987) Amoebae and humidifier fever. Clin Allergy 17: 235-242.

7. Gybelova T, Moravec R, Volekova J, Lacova M, Hulikova I (1982) Microbial characteristics of air in operating theatres during surgery activity (in Slovak). Brat Lek List 78: 129-156.

8. Nevalaine A (1989) Bacterial Aerosols in Indoor Air. NPHL A3, Kuopio (Finland).p. 1-85.

9. Skaliy P et al. (1980) Laboratory studies of disinfectants against Legionella pneumophila. Appl Environ Microbiol 40: 697-700.

10. Grace RD et al. (1981) Susceptibility of Legionella pneumophila to three cooling tower microbicides. Appl Environ Microbiol 41: 233-236.

11. Kurtz JB et al. (1982) Legionella pneumophila in cooling water systems. J Hyg 88: 369-381.

12. Tichâček B (1968) Theoretical and Methodological Bases of Disinfection (in Czech) Avicenum, Prague.p. 1-216.

13. Wirth Z, Melicherčíková V, Melicherčík J (1989) Contribution to the disinfection of circulating water humidifiers (in Czech) Prague.Proc Conf Optimal Air-Condition p. 33-37.

14. Melicherčík J et al. (1989) Hitherto data on the influence of heavy metals on microorganisms in drinking water (in Czech) Vod Hosp 39: 14-16.

15. Sládečková A, Vymazal J (1988) Quality of water in water humidifying air condition instalments (in Czech). Zdrav Tech Vzduchotech 31: 129-137.

16. Melicherčík J, Melicherčíková V (1988) Germicide radiators - possibilities for their efficient use in health establishments. Cs Hyg 33: 448-452.

17. Hlinomazova L, Feikova A (1983) Study of climatic, chemical and microbiological conditions in selected caves of Moravian Karst for the needs of speleotherapy (in Czech) Cs Hyg 28: 191-197.

18. WHO/EURO (1983) Indoor Air Pollutants: Exposure and Health Effects. Reports and Studies 78, Copenhagen.p. 1-42.