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Overview on the indoor air pollution sources of the ship cabins and the hyperbaric chambers

E R Avram[1*], M R Apetroaei[2], D V Atodiresei,[3] and E I Avram[4]

[1] Ph D. Dipl. Eng., "Mircea cel Bătrân" Naval Academy, Constanta, Romania
[2] Ph D. Dipl. Eng., Lecturer, "Mircea cel Bătrân " Naval Academy, Constanta, Romania
[3] Ph D. Dipl. Eng., Associate Professor, "Mircea cel Bătrân " Naval Academy, Constanta, Romania
[4] Dipl. Eng, Diving Center Constanta

[*]corresponding author: rita.avram@anmb.ro

Abstract. The present paper will be focused on analyzing the factors that influence indoor air qualityof the ship cabins and the hyperbaric chambers taking into account the specific degree of pollution, as oxidation of metal surfaces, vaporization, nature of the paints used, respiration, gases or particles coming from the combustion of fuels, chemicals, and allergens. The article will present a synthesis of the influence of characteristic parameters, such as ventilation rate and exposure to mold or chemicals on indoor air quality, as this is strictly and directly related to health, comfort, and ability to work.

Keywords: indoor air pollution, ship cabins, hyperbaric chambers, ventilation rate, damp, mold

1. Introduction

The article presents the environmental indoor health risk factors that are common in indoor air. The aspects regarding their sources, the dangers they represent and the ways to avoid and eliminate them will be analyzed.

The quality of the air in the premises where people spend a large part of their lives, whether it is work or school, and here we refer to ship cabins and hyperbaric premises, is an essential factor of healthy living. Both substances emitted as a result of indoor human activities, excessive humidity and mold, as well as those from building materials, interior equipment, burning of cooking or heating fuels, can cause health problems, which can sometimes be fatal.

At present, great importance is given to outdoor air pollution, and to a minor extent to indoor air pollution. The vast majority of scientific work seeks [1] to raise awareness of the dangers posed by these substances and to establish actions needed to avoid and reduce the adverse impact of these pollutants on health. Many of the studies refer to the association between exposure to an agent and its outcome on health, some of these studies being of high quality the results indicate a positive association and others are inconclusive because they do not provide adequate or sufficient evidence to determine if there is an association, the results thus become inconsistent.

The results of epidemiological studies, controlled exposure studies and professional studies are presented in the literature. [1]

Worldwide, European, and national level there are standards for ideal temperatures and indoor air quality to ensure a healthy and comfortable indoor climate that are mandatory for building designers, because the energy efficiency of the building/construction must be taken into account from the design phase, in order to obtain the building permit. These standards are important because they specify the parameters that must be observed in the design of heating, cooling, ventilation and lighting systems, in order to make them more energy efficient and increase the degree of comfort in buildings. In this sense, the building/construction is considered less polluting if most of the materials inside have low emissions. The materials that have low or very low emissions are stone, glass, ceramics and untreated metal, which do not show emissions into indoor air [2].

At the same time, in terms of energy efficiency in buildings this approach is one of the most effective ways to increase energy savings, and buildings with high energy performance offer the advantage of low environmental impact.

2. Polluting factors for indoor air

It is essential to know the factors that cause lower quality of indoor air in the cabins on the ship and in the hyperbaric chambers to prevent diseases related to indoor air pollution. The issue of indoor air pollution is a constant concern of scientists around the world who have made recommendations for the development of guidelines and standards in the field. Thus, the main pollutants of indoor air, relevant to health, considered in this article fall into two broad categories:

- biological pollutants;
- chemical pollutants.

Biological pollutants of indoor air

Microbial pollution is a key element of indoor air pollution. Health-relevant microbial pollutants in indoor air are very heterogeneous, from pollen and plant spores mainly from the outside to bacteria, fungi, algae and some protozoa emitted outside or inside. They also include a wide variety of microbes and allergens that spread from person to person. People are often exposed to several agents simultaneously resulting in a large number of symptoms. The presence of many biological agents in the indoor environment is due to inadequate humidity and ventilation. Excess moisture on almost all indoor materials leads to the growth of microbes, such as mold, fungi and bacteria that subsequently emit spores, cells, fragments and volatile organic compounds into the indoor air. Moreover, moisture initiates the chemical or biological degradation of materials, which also pollutes the air inside. The most important effects of biological pollutants are the increased prevalence of respiratory symptoms, allergies and asthma, as well as disruption of the immune system.

Humidity varies depending on climatic zones, the amount of water on or in materials is the trigger for the growth of microorganisms, including fungi and bacteria. Microorganisms are omnipresent, and microbes spread rapidly in high humidity conditions being favored by the existence of dust and dirt, thus developing a greater number of spores, cell fragments, allergens, mycotoxins, endotoxins, β-glucans and volatile organic compounds in the indoor air. Most of the humidity enters a room through the outside air and the activities of the occupants. Also, allowing surfaces to become colder than the surrounding air can lead to unwanted condensation. Thermal bridges formed in the metal frames of windows, inadequate insulation, sewerage can lead to surface temperatures below the dew point of the air and thus to moisture and the appearance of condensation and mold, and the health risks associated with moisture exposure are high and must be taken into account [2]. Capillarity allows water to flow in all directions, creating a "drying" effect. The action of capillarity depends on the surface tension of the water, the hydrophilicity of the surface of the construction material and the thickness of the porous material. Along with water, water vapor can pass through porous materials by diffusion.

Experiments on common building and finishing materials indicate that sensitive surfaces can be kept free of fungal growth if the relative humidity is kept below 75–80%. Mold fungi do not grow below a relative humidity of less than 75% in a temperature range of 5 °C to 40 °C [2]. According to [1] it is

recommended to keep the relative humidity below 75% in order to limit the growth of fungi in the rooms. Ideal temperatures for office and administrative buildings, the optimum temperature is 20 °C, except in the locker rooms, where the temperature should be 22 °C.

Chemical pollutants

Over the last 25 years, several studies have been carried out on the exposure of benzene and carcinogens on oil tanks and on ships carrying oil chemicals [1], on indoor air pollution on ships from emissions from fuel evaporation and emissions from the operation of main and auxiliary engines and boilers [3], as well as on indoor air quality on board of two newly built ships, a large passenger ship and an oil tanker, which show that the results showed high levels of CO and CO_2 on both ships as a result of the combustion sources present in the living spaces. However, more knowledge is needed on personal exposure to indoor pollutants on board and its potential health effects.

Benzene is a very light, volatile and water-soluble aromatic compound, which exists in the air predominantly in the vapor phase, with residence times varying between one day and two weeks, depending on the environment, climate and concentration of other pollutants. It is a human carcinogen, classified in class A1 of toxicity that produces harmful effects on the central nervous system [4].

Both in ship's cabins and in hyperbaric chambers, benzene can come from outside air and also from indoor sources, such as building materials and furniture, heating systems, stored solvents and various human activities [5]. Indoor concentrations are also affected by climatic conditions and air exchange rate due to forced or natural ventilation. Inhalation is the main route of human exposure [6].

The materials used in construction and decoration contribute greatly to the concentrations of benzene inside [7]. Certain furniture and polymeric materials, such as vinyl, Polyvinyl chloride and rubber floors, as well as latex nylon carpets, may contain traces of benzene. Benzene is also present in metal furniture, plywood, fiberglass, floor adhesives, paints, wood panels, carpets and paint removal [1,8]. Benzene is also associated with human activities such as be cleaning [9], painting [10,11], use of consumer products, photocopying and printing, storage and use of solvents. [12]

The reference method for measuring benzene is that provided in the standard SR EN 14662 "Ambient air quality. Standardized method for measuring benzene concentrations" - parts 1, 2 and 3. Annual limit value for the protection of human health, according to Law no. 104/2011 is 5 μg / m^3. The literature indicates a higher concentration of benzene measured in offices than those measured in rooms, due to the presence of sources such as photocopiers and printers.

Formaldehyde is a dangerous chemical with a proven carcinogenic effect. It is a colorless, flammable gas, with a strong pungent odor, very unstable in the gaseous state due to the tendency of polymerization. In 2008, the World Health Organization (WHO) reclassified formaldehyde to include it in Category 1 of potentially carcinogenic substances. It is a substance considered toxic, may have an irritating and necrotizing action on the skin and mucous membranes, prolonged exposure leading to dermatitis, conjunctivitis, allergic reactions, rashes, nosebleeds, asthma and other respiratory problems. Formaldehyde is used as a raw material in the production of products such as ethylene glycol (antifreeze), soil fertilizers, disinfectants, dyes, cosmetics, wallpaper adhesives, paints, durable textiles, and foams for insulation, in furniture made of semi-finished wood, deodorants for scented rooms, candles and chopsticks. etc. [14] As for wood and wood-based boards, there is formaldehyde chemically bound in the structure of the adhesives used for gluing, but also formaldehyde in the form of gas, unbound, both in the adhesive and in the wood. Unbound formaldehyde is the dangerous one because it tends to go outside, the formaldehyde emission being the main quality indicator of wood-based products. Formaldehyde emissions are standardized, according to European Standard EN 13986/2004 wood-based boards can be in classes E1 or E2, depending on the amount of formaldehyde emitted determined by testing. Class E1 represents an amount of 0.1 ppm, a level considered safe by the WHO in 2010, which is more than 0.1 ppm enters the emission class E2.

Indoor air is contaminated with polycyclic aromatic hydrocarbons PAHs that come not only from infiltration or intrusion of outdoor air, but also from sources of indoor emissions, such as smoking, combustion of fossil fuels (diesel engines) in its gaseous particle form, and candle emissions [14], the most studied being benzo(a)pyrene, polynuclear aromatic hydrocarbons are known to be carcinogenic

to humans. The reference method for benzo(a)pyrene sampling and measurement is that provided in the standard SR EN 15549 - Ambient air quality. In the absence of CEN standards for the sampling and analysis of PAHs, the method described in the standard SR ISO 12884 - Ambient air is used.

Naphthalene is an aromatic hydrocarbon used in the chemical industry, mainly in the synthesis of thinners, dyes or adhesives in the plastics industry such as polyvinyl chloride, which is also found in households as insecticides. The highest internal concentrations come from consumer products. , such as multipurpose solvents, lubricants, herbicides, hair sprays, tobacco smoke, rubber materials and, insecticides. The main health problems of naphthalene exposure are respiratory tract injuries, including upper respiratory tract tumors. At room temperature it is a white crystalline solid with a characteristic and intense smell. Slightly soluble in water, it melts well enough in ethanol and even better in organic solvents. It can be easily sublimated. Under the conditions of preparation and use it can cause acute or chronic intoxications, of an accidental or professional nature. It enters the body through the respiratory tract, skin and rarely through the digestive tract. After absorption, it is metabolized oxidatively in the body by hydroxylation. Naphthalene is a toxic hemolyzer that causes leukopenia, anemia, hepatotoxic, nephrotoxic, and generates cataracts in the eye. Inhalation of vapors causes headaches, nausea, sweating, kidney damage, optic neuritis. [5]

3. Conclusions

It should be noted that on ship board, seaferers spend most of their time indoors, so indoor air quality could have a significant effect on their health. Poor indoor air quality can be a significant factor in determining diseases especially of the respiratory system. Pollution of indoor air from many different sources, including dirty ventilation systems, mold, volatile organic chemicals, carbon monoxide and formaldehyde can cause problems for people living and working in previously mentioned environments. Wet indoor environments may contain bacteria, bacterial endotoxins, and other microorganisms, such as amoebae, but less information is available about these agents and further research is needed. The components of the ventilation system can support the growth of fungi, bacteria and other microorganisms as well as fragments of mites and other arthropods and aerosols formed from feces and urine. Rooms can contribute to the spread of viral diseases in the air, either by overcrowding or by the spread of airborne viruses through the ventilation system.

The presence of biological contaminants in indoor air, even in small quantities, can have a strong effect on occupants. By reducing biological contaminants in indoor air, acute infections and allergic episodes could be significantly reduced. Wet building materials can increase their chemical degradation, resulting in more emissions of volatile organic compounds, including formaldehyde.

Ventilation systems and pipes are a major source of indoor air pollution, therefore, it is necessary to clean and maintain ventilation pipes both on board ships and in hyperbaric chambers, possibly building new air conditioning systems, periodic inspection and cleaning/complete sanitation of ventilation systems. Recording indoor humidity and temperature readings should be part of the normal routine, along with performing air quality tests for mold. All factors that may contribute to indoor air pollution must be taken into account when purchasing furniture, paints and cleaning agents to minimize contamination.

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