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INDOOR AIR QUALITY – IN THE PERSPECTIVE OF VOC

K. Vinoth Kumar[1]

[1]*Lecturer, Department of Mechanical Engineering,219 Valivalam Desikar Polytechnic college, Nagapattinam*

Abstract - *This study has been undertaken to investigate the indoor air quality in the perspective of VOC, its sources, harmful effects and remedies are studied*

Key Terms *– IAQ, VOC*

1.INTRODUCTION

Indoor air quality [IAQ]is the air quality within and around buildings and structures. IAQ affects health, comfort, and well-being of building occupants. Poor indoor air quality has been linked to sick building syndrome, reduced productivity, and impaired learning in schools.

Air quality depends on levels of volatile organic compounds (VOCs) which are constantly changing, The Environmental Protection Agency (EPA) list of VOCs is a comprehensive starting point to identify and reduce hazardous substances.

Air quality is paramount for people's well-being, as well as the environment. Poor air quality, both indoors and outdoors, can lead to numerous adverse health problems, such as Covid-19, nausea, headaches, skin irritation, sick building syndrome, kidney failure, and even cancer. In fact, since people spend around 90% indoors, indoor air quality has a significant impact. Hence it is essential to set strict standards and guidelines in order to maintain people's environmental health. For some pollutants there are no safe levels of exposure. The threshold limit values vary between countries and organizations, the EPA outlines several common VOCs and substances and their threshold limit values in India.

2.Volatile Organic Compounds [VOC]

In indoor air quality studies, the term "volatile organic compounds" is typically deals with all vapor-phase organic compounds. VOCs exhibit a wide range of boiling points, they further can be subdivided into very volatile organic compounds (VVOCs; gaseous) with a boiling point ranging from <0 to 50–100°C, volatile organic compounds (50–100 to 240–260°C boiling point), and semi-volatile organic compounds (SVOC; 240–260 to 380–400°C boiling point).

The VOC class of indoor air pollutants consists of more compounds than any other class, and hundreds of individual compounds have been identified at concentrations of 1 μg m−3 or more. Total VOC concentrations typically range from 50 to 1000 μg m−3 over long periods. However, some newly built offices and houses have higher source emissions, and over 130 individual compounds have been measured at a total VOC concentration of 13 mg m−3 in these buildings. VOC sources are ubiquitous in the office and home environment, and include evaporative surfaces (such as vinyl flooring, carpets, or soft furnishings), building products, pressed wood products, adhesives, sealants, cleaning agents, paint, ventilation systems, combustion sources, cooking and space heating activities, tobacco smoke, or the infiltration of outdoor air.

Emissions of VOCs are either continuous (long-term, constant-strength-release sources dependent on temperature, relative humidity, and air velocity) or discontinuous (time-dependent, variable-strength, short-term emissions). Consequently, the variety of sources and emission characteristics confers on VOCs the most dynamic behavior of all indoor pollutants. Table I summarizes the common indoor VOCs and their sources.

Table I. Sources of Volatile Organic Compounds

Compound	Source materials
Aromatic hydrocarbons (benzene, toluene, xylenes, naphthalene) and aliphatic hydrocarbons	Paints, adhesives, sealants, gasoline, combustion products, damp-proof membranes, wallpaper, carpets, vinyl floor covering, creosote-impregnated timbers, tobacco smoke
Styrene	Insulation foam, jointing, textiles, disinfectants, plastics, paints, carpets, rubber floor tiles
Hexane	Floor covering, wallpaper, insulation foam, tobacco smoke
Chloroform	Chlorinated water
Terpenes (limonene, α-pinene)	Scented deodorizers, polishes, fabrics, fabric softeners, cigarettes, food, beverages

Polycyclic aromatic hydrocarbons and polychlorinated biphenyls	Combustion products(tobacco smoke, burning wood, kerosene heaters, burning paint)
Acrylic acid	aerosols, window cleaners, paints, paint thinners, cosmetics, adhesives, vinyl flooring
Ketones (e.g., acetone)	Lacquers, varnishes, polish removers, adhesives
Ethers	Resin, paints, varnishes, lacquers, dyes, soaps, cosmetics
Esters	Plastics, resins, plasticizers, lacquer solvents, flavors, perfumes

One of the most researched individual VOCs is formaldehyde, a low-molecular-weight aldehyde found at variable concentrations indoors, ranging from 0.01 to 1.2 mg m−3 within homes. Formaldehyde is commonly used in urea-formaldehyde- or phenol-formaldehyde-based resins, in foam insulation, as a binder in particleboard and wood paneling, and in many other building and household materials. Formaldehyde emitted from these materials into the building behaves as a common odorant at low concentrations. and 25% of indoor formaldehyde can be accounted for by environmental tobacco smoke.

Industrial and occupational control of VOCs is achieved through health and safety legislation, but in the indoor environment no standards exist, although guidelines have been suggested in many industrialized countries (e.g., the WHO has recommended a guideline concentration of formaldehyde of 0.1 mg m−3 as a 30-minute average). Control is most often achieved through good ventilation practice and by the regulated prohibition or restricted use of products that emit VOCs, such as insulation foams or particleboards.

3.OTHER POLLUTATNS THAT AFFECT IAQ

PM: Particulate matter is one of the most dangerous forms of pollution as the size of the particles is so small that they can get into the lungs causing numerous adverse effects. PM, in particular, are particles which are 2.5 µm or less in diameter. Their threshold limit value is 25 µg/m3, based on 24-hour data.

CO: Being an odorless and colorless lethal gas, carbon monoxide (CO) is one of the most dangerous compounds in indoor environments. The National Institute for Occupational Safety and Health (NIOSH) has estimated a recommended exposure limit of 35 ppm.

CO2: CO2 is a natural compound in the air, with an average outdoor concentration of 300-400 ppm. Note that indoor levels are higher due to the confinement of indoor spaces. Human health effects can be observed at levels over 7,000 ppm. Therefore, the occupational limits set by ACGIH are 5,000 ppm TLV-TWA* and 30,000 ppm TLV-STEL**.

Radon: Radon is a radioactive gas formed by the decay of (natural) Uranium in the soil. As radon is carcinogenic, there are no safe levels of exposure. Yet, the EPA has set an action level of 4 p Ci/L.

PAHs: Polycyclic aromatic hydrocarbons (PAHs) are semi-volatile organic compounds, which are hazardous for people's environmental health. Each PAH has different threshold limit values. Naphthalene, in particular, is the most volatile PAH. The recommended threshold limit value is 10 ppm.

Formaldehyde: One of the most common VOCs – formaldehyde – can be emitted from numerous sources, such as furniture, incense burning, and cooking. Note that its threshold limit value is 0.1 ppm TLV-TWA* and 0.3 ppm TLV-STEL**.

Methylene chloride: Methylene chloride or dichloromethane can be found in products like solvents. It has an odor threshold of 250 ppm. Note that a long-term exposure can lead to problems with the central nervous system.

NO2: Due to the adverse effects associated with nitrogen dioxide (NO2), the EPA strengthened its health guidelines and set a 1-hour standard at the level of 100 ppb.

*TLV-TWA: Threshold Limit Value - Time Weighted Average (usually 8 hours)

**TLV-STEL: Threshold Limit Value - Short Term Exposure Limit (usually 15 minutes)

4.MOST COMMON VOCS AT HOME

Volatile chemical emissions can be found in all environments and concentrations and can be especially damaging in the home environment. Interestingly, all VOCs are compounds of carbon accept carbon monoxide and carbon dioxide . Here are some of the most common home VOCs and their threshold limit values are given in following table-2

TABLE-2: VoC's and threshold limit values

Various VoC's	Threshold limit values
Ethanol-Ethanol is most commonly found in cleaning products, such as glass cleaners, dishwasher detergents, and laundry detergents.	TLV: 1,000 ppm
Formaldehyde- Formaldehyde is found in a number of molded plastics as well as plastic finishes such as on wooden products	TLV: between 0.1 and 0.3 ppm
Acetone-Acetone is prevalent in polish and in most homes can be found in furniture polish, wallpaper and nail polish.	TLV: between 750 and 1,000 ppm
Benzene-Benzene can be found in any furniture made with paint or glue.	TLV: 0.1 ppm
Dichlorobenzene-Often found in mothballs and deodorant.	TLV: between 25 and 50 ppm

5. UNDERSTANDING AND IMPROVING IAQ

From smoking to auto exhaust, sources of VOCs, PM and NO2 are everywhere around us. Understanding the origins of dangerous gases and particulates matter is essential to help people decrease pollutants concentrations and reduce any health problems associated with poor air quality. There are a few fundamental steps, which can help individuals improve indoor air quality.

For office buildings, HVAC systems can improve IAQ, leading to better health outcomes. Note that the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards are carefully developed to help professionals assess and improve ventilation of private and commercial buildings. In addition, the Occupational Safety and Health Administration (OSHA) has strict standards regarding ventilation, especially when it comes to educational and medical facilities

6.IAQ PROBLEMS AND PERSPECTIVES

Strict IAQ and ventilation standards can improve the quality of the air. Measuring VOC concentrations in private homes is a challenging task. Factors, such as location, moisture content, and airspeed, can affect the levels of emission. The World Health Organization (WHO) also provides clear guidelines for indoor air quality and proper ventilation.

• Updating the threshold limit values of VOCs and pollutants is the first step towards better industrial hygiene.

• Knowing how VOCs affect the environment, as well as people's occupational health, is essential.

• Testing for VOCs on a regular basis is advised to improve environmental and health outcomes.

7.ENVIRONMENTAL EFFECTS OF VOCS

There is a wide variety of volatile organic compounds. While many of these chemicals occur in the atmosphere naturally, a significant portion of VOC emission come from manmade sources. Outdoor sources of VOCs can include the following

- Traffic from cars, boats, and trains.
- Chemical production and storage facilities.

The use of products that emit high VOCs concentrations.

Building materials are also known to release a number of VOCs. Paint, for example, is particularly hazardous and can contain a number of organic chemicals in high concentration for indoor spaces. Additionally, harmful VOCs, such as methylene chloride, can also be found in paint strippers.

8.Acid rain

Acid rain is classified as any precipitation with acidic components. It can fall to the ground as wet as well as dry as rain, snow, fog, hail or acidic dust. Acid rain is primarily the result of nitrogen oxides (NOX) and sulfur dioxide (SO2) being emitted into the atmospheric environment and reacting with water. Acid rain can also be identified by its pH

level, which is usually between 4.2 and 4.4, while normal rain has an approximate pH level of 5.6 (it is usually slightly acidic due to dissolved carbon dioxide). The primary sources of acid rain are

- Vehicles, such as cars.
- Power stations that burn fossil fuels.
- Oil refineries.
- Manufacturing processes.

As mentioned above, acid rain can also fall to the ground dry as well as wet, in what is known as a 'dry deposition'. This is where acidic particles fall from the atmosphere without any moisture. These particles, in some conditions, can form larger compounds that can be harmful to people's health. When it finally does rain, these acidic compounds can be picked up and washed away to harm plant life and animals.

The most serious environmental damage is acid rain, that can cause is to the planet's ecosystem. Some of the most adverse effects take place in aquatic environments. Acid rain can also indirectly kill aquatic wildlife as well as it also can kill vegetation that the animals eat. Other animals that use the water can also be at risk and soil contamination is also possible.

Acid rain is also particularly harmful to trees in a number of ways.

[1] when acid rain lands on soil, it can wash away vital nutrients the trees need to survive.

[2] it can release aluminum in the soil, which not only harms trees, but also other animals.

[3] in the form of acidic fog, leaves can be stripped away or damaged which makes it harder for them to absorb sunlight.

[4] acid rain can also have a significant impact on infrastructure people depend on, which can lead to some structures needing to be replaced or repaired.

9.WAYS TO REMOVE CHEMICALS FROM THE AIR

The removal of VOCs from polluted air is essential for our protection. Removing VOCs can be achieved in a number of ways by utilizing any of the following

- **Houseplants -** many absorb unhealthy pollutants in our air.
- **Air purifiers** - such devices can clean the air around you.
- **Air out new furniture** - many VOCs are emitted from new furniture, make sure they receive plenty of air to carry away these chemicals.
- Open your windows fully - the simplest way to remove VOCs.

10.CONCLUSION

In this study the indoor air quality, VoC. -its sources, acceptable tolerance limits are studied. Harmful effects of volatile organic compounds and remedies are studied.

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