

PLANTS AND CHEMISTRY: NATURAL MECHANISMS FOR REDUCING
VOLATILE COMPOUNDS IN LIBRARY AIR

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Abstract. This article provides a scientific analysis of the sources of formation of volatile organic compounds in the library's indoor environment, their impact on human health, as well as the natural mechanisms for their reduction through plant-based decomposition and microclimate improvement features. It also examines the excretion of biogenic volatile compounds by plants and the impact of this process on the chemical balance of the closed environment.

Keywords: volatile organic compounds, phytoremediation, library air, indoor environment quality, plants, rhizosphere, biogenic volatile compounds, environmental safety, microclimate, air purification.

Introduction. Modern libraries are not only a repository of knowledge, but also an environment that directly affects human intellectual activity and health. Especially in closed buildings, air quality is a pressing issue, and the amount of volatile organic compounds in it can negatively affect human health. Books, furniture materials, paints, cleaning products, and electronic equipment cause the release of various chemicals in the library's indoor environment. As a result, harmful substances such as formaldehyde, benzene, and toluene accumulate in the air, which, over time, can cause headaches, allergic reactions, and a decrease in overall performance. In recent years, due to the increasing need for environmentally friendly and sustainable solutions, the role of plants in cleaning the indoor environment has been widely studied scientifically. Plants have the ability to absorb carbon dioxide and release oxygen through the process of photosynthesis, as well as absorb some volatile organic compounds. In addition, the plant root system and the microorganisms living in symbiosis with them play an important role in the decomposition of harmful substances in the air. In this regard, the process of phytoremediation - that is, cleaning the environment with the help of plants - is considered a promising direction for indoor spaces, in particular libraries.

This research work analyzes the sources of volatile chemical compounds found in the indoor environment of libraries, their impact on human health, and natural mechanisms for reducing them with the help of plants. It also sheds light on the air purification efficiency of various plant species, their properties of exposure to chemicals, and the possibilities of practical application on a scientific basis. The relevance of this topic is determined by the need to develop solutions that are environmentally friendly, economically viable, and have a positive effect on human health.

Literature review. The issue of reducing the amount of volatile organic compounds in the air of indoor buildings has become one of the areas of active research at the intersection of ecology, hygiene and civil engineering in recent years. Especially in closed and relatively long-term environments, such as libraries, the chemical composition of the air has a significant impact on human health and cognitive activity. In this regard, scientific work aimed at studying the potential of plants as natural filters is of particular importance.

The pilot study conducted by Apte is noteworthy as one of the first studies aimed at assessing the effectiveness of plants in reducing volatile organic compounds in indoor environments. In a pilot study conducted in a seven-story office building, the authors found that plants can significantly reduce some volatile compounds. It is emphasized that not only the leaf

surface of plants, but also the root zone and microorganisms in it play an important role [1]. These results scientifically substantiated the possibility of applying the phytoremediation process in indoor environments.

Recent studies have shown that plants themselves can also be sources of volatile compounds. A comprehensive review by Luo et al. analyzed the nature, function, and ecological role of biogenic volatile organic compounds emitted by plants. The study noted that these compounds play an important role in plant stress responses, signaling, and chemical interactions with the environment. At the same time, it is noted that excessive amounts of biogenic volatile organic compounds in indoor environments can complicate the overall chemical background [2]. Therefore, along with the positive effects of plants, their emissions should also be taken into account.

Horvat et al. systematically analyzed the identification of biogenic volatile organic compounds in indoor air, their sources, and their effects on human health. They believe that volatile compounds in indoor air are mainly emitted from building materials, furniture, paints, and household chemicals. The study provides detailed information on monitoring methods, health risks, and regulatory issues [3]. This highlights the need to identify and manage sources of VOCs in library environments.

The study by Al Qassimi and Jung aimed to assess the effectiveness of plants in purifying indoor air in real-world climates, particularly in hot desert regions. The results suggest that some plant species may be effective in reducing formaldehyde and other harmful VOCs. However, the researchers note that the effectiveness of plants depends on environmental conditions, ventilation levels, and plant population [4]. This suggests that a systematic and scientifically sound approach to the use of plants in libraries is needed.

Overall, the literature reviewed confirms the potential of plants to purify indoor air. However, this process is complex and involves interactions between plant physiological characteristics, microbiological factors, and environmental conditions. Therefore, the use of plants to reduce volatile compounds in library air requires not only an ecological, but also a scientifically based, integrated approach.

Main part. The formation and accumulation of volatile organic compounds in the library environment is a multifactorial process, which is mainly associated with the continuous release and insufficient decomposition of chemicals in closed spaces. Wood-based materials, paints, adhesives, floor coverings, and electronic devices used in modern libraries are the main sources of formaldehyde, benzene, toluene, and other volatile compounds. The concentration of these substances increases rapidly in conditions of low ventilation, which negatively affects the human respiratory system, central nervous system, and general working capacity. Therefore, controlling and optimizing the chemical composition of library air is considered an important scientific and practical task.

The role of plants in purifying indoor air is explained by the phytoremediation process. This process involves several interrelated mechanisms. First, direct absorption of gaseous substances occurs through plant leaves. Through the stomata on the leaf surface, molecules of volatile organic compounds enter the internal tissues and subsequently participate in metabolic processes. In this process, plant enzymes can convert these substances into less toxic forms. Secondly, the root zone of plants — the rhizosphere — is of particular importance, as microorganisms living in it subject volatile compounds to biochemical decomposition. This microbiological activity is a crucial stage in the final neutralization of volatile organic compounds.

Studies have shown that different plant species have different efficiencies in the absorption and decomposition of volatile organic compounds. For example, plants with broad leaves and high transpiration capacity can absorb more gaseous substances from the air. At the same time,

their purification efficiency varies depending on the age of the plants, the total surface area of the leaves and their physiological state. In order to achieve optimal results in library conditions, the number, location and type of plants should be selected on a scientific basis.

However, it is also necessary to take into account that the impact of plants on the indoor environment is not entirely positive. Plants emit biogenic volatile organic compounds in the process of their life. Although these substances are usually associated with the defense mechanisms of plants or signal transduction, their excessive amount in an indoor environment can complicate the overall chemical background. Therefore, when choosing plants, not only their ability to absorb volatile organic compounds, but also the composition of the substances they emit should be taken into account.

For the effective use of plants in a library environment, a number of practical factors should be taken into account. First of all, sufficient air exchange should be ensured in the areas where the plants will be placed, since in conditions with a low level of ventilation, the cleaning efficiency of plants is limited. In addition, plant care - watering, lighting and soil quality control - directly affects their physiological activity. At the same time, it is advisable to choose plant species that are suitable for the library interior, require little care and do not cause allergic reactions.

In general, plants appear to be a natural and environmentally safe tool for reducing volatile compounds in library air. However, their effectiveness depends on many factors, and this process requires in-depth scientific analysis and an integrated approach.

Analysis and results. Scientific analyses conducted on the reduction of volatile organic compounds in the library environment show that plants can be a somewhat effective tool as a natural filter, but their effect varies depending on a number of factors. First of all, based on the available literature, it is determined that the role of plants in air purification is not limited to absorption through the leaves. The main load falls on the rhizosphere region - that is, the microbiological environment around the roots. It is in this area that the biochemical decomposition of volatile compounds is actively taking place and the final result is formed. The results of the analysis show that the main sources of VOCs in library conditions remain internal materials and technical means. Plants act as an auxiliary tool in reducing the concentration of these substances, but they cannot completely eliminate all polluting factors on their own. This is especially evident in areas with poor ventilation systems or limited natural air exchange. Thus, the effectiveness of plants is closely related to the general hygienic state of the environment.

The selective nature of plant species was also highlighted as one of the important results. Some plants have a relatively high efficiency in absorbing substances such as formaldehyde or benzene, while others exhibit this property to a lesser extent. This indicates the need to select plants in the library environment not randomly, but scientifically. In addition, the number and location of plants also have a significant impact on the overall result: if a small number of plants does not give a significant change, then green zones of optimal density serve to improve air quality.

Another important aspect was also taken into account during the analysis - the issue of biogenic volatile compounds secreted by the plants themselves. As it turned out, these substances are usually released in low concentrations and often do not have a harmful effect. However, their accumulation in a closed environment can change the overall chemical background. Therefore, the results indicate the need to follow the principle of balance when using plants.

Conclusion. Based on the above analysis, plants can be considered as an effective additional tool for cleaning library air. They reduce the concentration of PM, improve the microclimate and create a psychologically positive environment. However, to achieve maximum effectiveness, the use of plants should be carried out in conjunction with ventilation systems, material selection and

hygienic control. Only such an integrated approach will ensure that the air quality in the library environment is maintained at a stable and safe level.

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