IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Rethinking Air Filtration: Health Risks And Environmental Concerns Of Fiberglass-Based HEPA Filters And Advantages Of Natural Sustainable Alternatives

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Abstract

HEPA (High-Efficiency Particulate Air) filters, primarily composed of borosilicate fiberglass fibers, offer high-efficiency filtration of airborne contaminants but pose latent health and environmental risks. This paper explores the potential health hazards of fiberglass particle release from HEPA filters, evidence from experimental studies and case reports associating fiberglass and silica dust with respiratory diseases like silicosis. It also addresses economic and environmental issues of cartridge disposal and replacement costs. The need for transitioning to natural fiber-based sustainable filters that offer safer, biodegradable, and cost-effective alternatives is underscored.

Introduction

Since their inception during World War II to protect against chemical and radioactive hazards, HEPA filters have become synonymous with cleanliness in healthcare, aerospace, and indoor air purification. Constructed from fine borosilicate glass fibers, HEPA filters trap particles down to 0.3 microns with efficiencies exceeding 99.97% (Camfil, 2023; Wikipedia, n.d.). However, growing evidence highlights the risks inherent in the fiberglass makeup of these filters, including the potential for fiber shedding into breathing air, the high cost and environmental challenges of cartridge replacement, and risks to vulnerable populations such as infants and the elderly.

Risk of Fiberglass Composition in HEPA Filters

HEPA filters rely on densely arranged borosilicate glass fibers to physically trap particles. Experimental data indicate that although designed to retain particulates, small amounts of fiberglass fiber particulates can be mechanically dislodged and released during air flow, especially under high pressure or filter degradation conditions. Fiberglass particles, along with borosilicate dust, can cause immediate respiratory irritation, bronchitis exacerbation, and potentially contribute to chronic lung diseases when inhaled over time (BalCon TAB Services, 2000; SmartAirFilters, n.d.). Epidemiological and clinical case studies document health risks especially related to silicosis caused by crystalline silica, with cases reported among workers exposed to silica dust in glass manufacturing and related industries (Yang et al., 2014; Li et al., 2025). Fiberglass fibers do not biodegrade in lung tissue, increasing the risk of persistent inflammation and lung function decline.

Experimental and Case Study Evidence

Studies show fiberglass inhalation causes short-term lung irritation and may worsen existing respiratory conditions. However, occupational exposure levels that cause lasting effects greatly exceed typical HEPA fiber shedding levels under proper maintenance (BalCon TAB Services, 2000). A clinical case of silicosis in a glass factory worker highlights the progressive lung damage linked to prolonged silica exposure, often misdiagnosed initially due to symptom overlap with other lung diseases (Yang et al., 2014). Experimental filters made from natural biodegradable fibers have demonstrated promising filtration efficiencies while eliminating risks of fiber dust emissions, confirmed by filtration performance tests comparing cellulose and hemp-based filters to traditional fiberglass (Gao et al., 2024; Journal of Agricultural Engineering, 2025).

Economic and Environmental Concerns

HEPA filters have significant operational costs due to frequent cartridge replacement—typically every 6 to 12 months depending on usage. Replacement cartridges are costly, limiting accessibility in resource-constrained settings (Sylvane, 2025). Their disposal raises environmental concerns as fiberglass and synthetic components are non-biodegradable, persisting in landfills and potentially leaching contaminants. Inadequate disposal protocols risk contaminating air and soil ecosystems (Cleanroom Equips, 2025; uBreathe, 2024).

Natural Sustainable Filter Alternatives

Natural fiber filters made from cotton, hemp, coir, and other renewable sources offer compelling alternatives. Studies reveal comparable filtration efficiencies for particulate matter with considerably improved biodegradability and lower health risks due to the absence of fiberglass dust emissions. They offer lower environmental impact due to compostability and ease of disposal and reduced replacement cost enhancing affordability (Gao et al., 2024; Journal of Agricultural Engineering, 2025; ScienceDirect, 2024). These natural filters constitute safer indoor air solutions, especially impactful in environments housing sensitive populations like newborns and the elderly.

Conclusion

While HEPA filters play a crucial role in modern air purification, their fiberglass composition introduces health risks from fiber and silica dust exposure, which may contribute to lung diseases including silicosis, especially with poor maintenance or disposal practices. The high cost and environmental footprint from non-biodegradable cartridges emphasize the urgent need to seek safer, sustainable filtration solutions. Natural fiber-based filters present a scientifically viable, economically feasible, and environmentally responsible path forward for protecting human health and Earth's ecosystems.

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