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ADVERSE EFFECTS OF CHEMICAL FUMIGATION ON TEACHERS AND LEARNERS HEALTH AND MICROBIAL PESTICIDE AS AN ALTERNATIVE

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Abstract

Fumigation is a pest control method that uses chemical pesticides, known as fumigants, to eliminate harmful organisms such as pests, weeds, insects, and microorganisms. It is commonly applied in farms, homes, offices, schools, churches, and mosques. While effective, improper use or prolonged exposure to chemical fumigants can pose serious health risks to humans and animals. An alternative method, biological fumigation, involves using natural substances derived from microbial metabolites or plant exudates to control pests and pathogens. This approach is more environmentally friendly and safer for both human and animal health. When properly regulated, fumigation helps prevent the spread of diseases in both people and crops. However, continuous use of chemical fumigants, especially in populated areas like schools, may result in adverse health effects among vulnerable groups such as teachers, students, and staff. This paper highlights the associated health hazards and stresses the need to replace chemical fumigants with microbial alternatives. It also emphasizes the importance of implementing strict safety regulations and training professionals in proper application. Promoting microbial fumigants as a sustainable solution is recommended to reduce health risks and minimize environmental impact.

Keywords: Fumigation, pesticides, exudates, microbial, suffocate.

Introduction

Fumigation is the process of spraying insecticide on germs and insects to kill or eliminate them. The World Health Organization (WHO) strongly advises against fumigation or direct spraying with disinfectants of humans, as deleterious effects far outweigh benefits (WHO, 2020). Even in healthcare settings, where fumigation or other “no-touch” methods may be used for terminal disinfection, these are recommended only as supplements and not as a replacement for manual cleaning procedures (Rutala, and Weber, 2013). The use of fumigants are natural or synthetic chemical compounds that are applied to kill, prevent and control, weeds, and pests that affect humans and plants. According to (Ahamad and Kumar, 2023) compounds are classified according to their mode of action, chemical structure, hazards, and application. Excessive use and uncontrolled use of fumigants can result in chronic or acute health and contamination of food, polluted environment (Cech *et al,* 2023). Acute and chronic health effects from agricultural pesticides and dietary exposure are serious public health concerns, especially in developing countries. For human health, chemical pesticides can be carcinogenic, cytotoxic, and mutagenic

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(Fang *et al.*, 2023). Pesticides mode of action is not specific to a single species, they frequently eradicate or harm organisms other than pests, including humans. According to a World Health Organization (WHO) and United Nations Environment Programme (UNEP) report as cited by (Boedeker et al., 2020), worldwide, three million people are poisoned and 200,000 die due to exposure to pesticides, mostly in developing countries. Synthetic pesticides are made from chemicals and carriers, such as polymers (Rakhimol et al., 2020), which are specific for different pests. They range from those employed in the control of weeds (herbicides), algae (algicides), fungi (fungicide), mites or ticks (miticides/acaricides), bacteria (bactericides), rodents (rodenticide), termites (termiticides), insects (insecticides), molluscs (molluscicides), and nematodes (nematicides), which form the basis of their classification (Anakwue, 2019).

Objectives of the Study

i. To identify various Classes of pesticides based on their active ingredients
ii. To identify the effects of fumigation on human health
iii. To identify the microbes that can be used as pesticides alternative to chemical fumigation
iv. To recommend safety precautions are taken by teachers and learners at every fumigation procedure

Statement of the Problem

Fumigation is essential for removal or eradication or control of pests, insects, weeds, and harmful pathogens in farms and places such as schools, homes, and offices. While chemical fumigants help reduce disease-causing organisms, research shows that their regular or improper use can cause harm to human health and damage the environment. These chemicals not only affect pests, it can equally harm people, animals, and other important organisms.

In most developing countries, poor regulation, weak enforcement of safety rules, and lack of proper training have resulted in unsafe fumigation practices. This exposes vulnerable groups, especially students, teachers, and school workers — to harmful pesticide fumes and residues. Exposure can cause short-term problems like coughing, headaches, dizziness, and skin irritation, as well as long-term health issues such as nerve damage, hormonal problems, reproductive disorders, cancer, and weakened immunity. Children face higher risks because their bodies are still developing and they breathe in more air relative to their body weight.

Even with these known risks, chemical fumigants are still widely used in crowded places where safer options are available. Microbial or biological fumigants, made from natural sources like bacteria and fungi, are safer and more environmentally friendly. However, they are not widely used due to low awareness, weak policies, and lack of proper implementation systems.

Therefore, this study focuses on the ongoing use of harmful chemical fumigants in sensitive places like schools, despite health concerns and the presence of safer biological alternatives. There is a strong need to examine the health effects of chemical exposure, increase awareness of safer options, and enforce stricter safety rules and professional training to protect vulnerable people while still controlling pests effectively.

Methodology

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This study adopted a descriptive review and analytical approach to examine the health implications of chemical fumigants and the potential of microbial pesticides as safer alternatives. The methodology focused on synthesizing existing scientific evidence, policy documents, and public health reports related to fumigation practices and pesticide exposure.

Exposure to Fumigants and Associated Health Risks Among Vulnerable Populations: Teachers, Students, and other School Staff

According to (Buralli, et al., 2020) respiratory and allergic health outcomes in children exposed to pesticides, relevant to understanding fumigant exposure impacts in school-age populations.

Recent epidemiological study linking pesticide exposures to respiratory outcomes, supporting the vulnerability of children in high-exposure contexts (Van Horne, et al., 2024)

According to the World Health Organization (WHO, 2020), exposure to fumigants among school communities represents a significant public health concern. Students, teachers, and school staff are considered vulnerable populations due to their varying levels of exposure, physiological sensitivity, and environmental conditions within school settings. Their exposure can be categorized as follows:

Vulnerable Populations

- **Students:** Children, particularly younger pupils, are more vulnerable because of their smaller body size, developing organs, and higher breathing rates relative to body weight. These factors increase the amount of chemical fumes they may inhale and heighten their sensitivity to toxic substances (WHO, 2020).
- **Custodial and Spraying Staff:** Maintenance workers and applicators often experience longer and more direct exposure during mixing, spraying, or handling fumigants. This repeated exposure raises the likelihood of both immediate and long-term health complications (WHO, 2020).
- **Teachers and Support Staff:** Staff members who enter or remain in recently treated classrooms or buildings may inhale residual fumes, especially where ventilation is poor or re-entry intervals are not strictly observed (WHO, 2020).

Acute Exposure Risks

Short-term exposure to fumigants may lead to immediate health symptoms, including:

- **Respiratory irritation:** coughing, throat tightness, shortness of breath, and bronchospasm, particularly among children and individuals with asthma or other respiratory conditions (WHO, 2020).
- **Eye and skin irritation:** burning sensation, redness, itching, and rashes resulting from contact with contaminated surfaces or airborne particles (WHO, 2020).
- **General systemic symptoms:** headaches, dizziness, nausea, fatigue, and weakness due to the toxic effects of inhaled chemicals (WHO, 2020).

Potential Chronic Effects

Repeated or prolonged exposure to chemical fumigants may contribute to more serious long-term health outcomes, such as:

- **Neurological effects:** Organophosphate compounds (e.g., DDVP) can interfere with nerve signal transmission. Chronic low-level exposure has been linked to memory problems, reduced cognitive performance, and other neurological disturbances (WHO, 2020).
- **Hormonal and reproductive effects:** Some pyrethroids and organophosphates may disrupt the endocrine system, potentially leading to developmental abnormalities, fertility issues, and reproductive complications (WHO, 2020).
- **Immune suppression and oxidative stress:** Continuous exposure to pesticides may weaken the immune system and increase oxidative damage in body tissues, which can contribute to chronic diseases (WHO, 2020).

Classes of Pesticides Based on Their Active Ingredients

Organochlorines (OCs) and organophosphates (OPs), known for their high toxicity, affect the nervous system and can lead to severe health issues, including cancer and damage to multiple organs. Exposure routes include dietary intake and environmental contact, posing risks of cytotoxic effects and various organ damages (Hou *et al.*, 2019).

Carbamates, considered less hazardous, are linked to respiratory conditions and developmental issues, while pyrethrins and pyrethroids, though less persistent, can lead to systemic and even fatal effects (Zhang *et al.*, 2019). These group of pesticides aimed the brain and nervous system, disorganizing the transmission of nerve signals. Some of the symptoms that are peculiar to this exposure are headaches, nausea, dizziness, vomiting, chest pain, diarrhea, muscle aches, and illusion. However there are more serious detrimental cases such as poisoning which can lead to convulsions, breathing difficulties, involuntary urination, coma, and even death. This nervous system poisoning has caused more damaged to thousands of people globally.

Fumigants are broad-spectrum chemical pesticides that once injected into the soil, vaporize and easily diffuse through soil pores, eliminating most soil organisms (Rokunuzzaman et al., 2016). Many fumigants with various chemical structures, physical properties, and pest elimination mechanisms, such as methyl bromide (MeBr), 1,3-dichloropropene (1,3-D), chloropicrin, metam-sodium, and dazomet, have been developed for use in agriculture. MeBr previously dominated the agricultural fumigant market, but was phased out due to increased recognition of the damage it causes to the ozone layer (Sun et al., 2018). Liangang Mao et al. (2024) reported that combinations of dazomet and 1,3-dichloropropene effectively control major soilborne pests in tomato production after the phase-out of MeBr, highlighting their role as viable MeBr alternatives.

Chemically, pyrethroid pesticides are synthetic organic insecticides derived from natural pyrethrins and are typically esters of chrysanthemic acid (ethyl 2,2-dimethyl-3-(1-isobutenyl)cyclopropane-1-carboxylate), with structural modifications that enhance stability and insecticidal activity compared to their natural counterparts **(Hołyńska-Iwan, and Szewczyk-Golec,** 2020). Pyrethroid pesticides are a type of synthetic organic insecticide that has been utilized around the world since the 1980s due to their high efficiency and low toxicity when compared to the organophosphate and carbamate groups of pesticides (Yoo et al., 2016). Pyrethroid pesticides are neurotoxins that specifically target the voltage-gated sodium channel's receptor site (Valmorbida et al., 2022). They kill insects by binding to sodium channels, which results in excitatory paralysis. Also, they change the membrane potential, causing an abnormally stable state of hyperexcitability in nerve cells. Pyrethroid insecticides act on the voltage-gated sodium channels in insect nerve cells, prolonging the opening of these channels and causing rapid paralysis or "knockdown," a sub-lethal incapacitating effect that precedes death in many target pests. (Ahamad et al., 2023).

Negative Consequences of Chemical or Synthetic Pesticide on Human Health

On a daily bases, human body is exposed to chemical pesticides directly or indirectly. It can either be through pesticides in crops or in direct contact with some body parts such as skin, eyes, mouth, and respiratory tract, and cause acute reactions such as headache, irritation, vomiting, sneezing, and rashes on the skin.

Cancer is a deadly terminal disease. A strong correlation exists between pesticide exposure and an increased risk of various cancers, supported by numerous studies indicating heightened risks of leukemia, multiple myeloma, and other cancers among those exposed to chemical pesticides (El-Nahhal, and El-Nahhal, 2021).

Diabetes is in fact, a life threaten and a terminal illness too. An alarming increase in diabetes prevalence has been linked to pesticide exposure, with epidemiological studies pointing to a higher risk associated with organochlorine and organophosphate pesticides (Mamane *et al.*, 2015).

Respiratory disorders is associated with chemical pesticide. Chemical pesticide exposure is linked to various respiratory issues among farm workers, including asthma and chronic lung diseases, with several studies indicating an increased risk from regular pesticide interaction (Bortoli and Coumoul, 2018).

Neurological disorders exposure to chemical pesticides has been implicated in the development of neurological disorders like Parkinson's and Alzheimer's disease. Research shows a clear association between pesticide exposure and an increased risk of these conditions (Ahmed *et al.*, 2017).

Reproductive syndromes that is expose to chemical pesticides can adversely affect fertility in both men and women, disrupting hormonal signaling and leading to reduced semen quality, increased risk of neural tube defects, and other reproductive issues (Mehrpour *et al.*, 2014).

Microbial Pesticide as an Alternative to Chemical Fumigation

Microbial pesticides can be referred to as biopesticides. Microbial pesticides consist of substances derived from microorganisms like bacteria, fungi, viruses, protozoa, and algae, which are used in the control of pests (Adeleke *et al.*, 2022a). In this process, microorganisms produce a toxic natural substance known as metabolite that is capable of killing or preventing the pests. There are some major categories of microorganisms that are used as biopesticides as reported by (Adeleke *et al.*, 2022b), such as bacteria genera, *Chromobacterium, Pseudomonas,* and *Yersinia,* fungal genera *Beauveria, Paecilomyces, Verticillium, Hirsutella, Metarhizium*, and *Lecanicillium* and nematodes belonging to the genera *Steinernema and Heterorhabditis*. Xiao and Wu, 2019, reported a Gram-positive bacteria called *Bacillus thuringiensis* that acts as an insecticide by producing exudates, such as poisonous parasporal crystals and endospores which when consumed by insects get dissolved in their midgut by the alkaline environment and release delta-endotoxin, a protein that has a lethal effect on insects. Pest management is not about eradicating pests; it is about finding strategies that are effective and economical, ensuring that environmental damage is minimized (Fahad et al., 2021).

Benefits of Microbial Fumigants Over Chemical Fumigants

Biopesticides are cheap, environment-friendly, specific in their mode of action, sustainable, do not leave residues, and are not associated with the release of greenhouse gases (Borges et al., 2021). These biopesticides can be in the form of phytopesticides (plant origin; Idris et al., 2022), microbial pesticides (microbial origin; Harish et al., 2021), and nanobiopesticides (nanoparticles produced from biological agents; Abdollahdokht et al., 2022). Unlike synthetic pesticides, microbial pesticides are specific in action, can be easily sourced without the need for expensive chemicals, and are environmentally sustainable without residual effects (Harish et al., 2021).

Conclusion

This review agrees strongly with previous researchers that, although fumigation remains an important method for pest and pathogen control, the health and environmental risks associated with chemical fumigants are substantial, particularly in sensitive environments such as schools. Earlier studies and global health bodies, including WHO (2020), Rutala and Weber (2013), and Boedeker et al. (2020), emphasize that pesticide exposure is linked to significant morbidity and mortality worldwide. Similarly, the present review confirms that both acute effects (respiratory irritation, headaches, skin and eye reactions) and chronic outcomes (neurological damage, endocrine disruption, reproductive disorders, immune suppression, and cancer) are consistently reported in populations exposed to synthetic pesticides. This aligns with the findings of Fang et al. (2023), Cech et al. (2023), and other researchers who describe the carcinogenic, cytotoxic, and mutagenic potential of many chemical pesticides.

Consistent with Buralli et al. (2020) and Van Horne et al. (2024), this study further highlights that children, teachers, and school workers represent highly vulnerable groups due to developmental, physiological, and environmental factors. The paper reinforces previous evidence that pesticide modes of action are rarely species-specific, meaning non-target organisms, including humans are frequently affected. Thus, the risks identified in earlier agricultural and occupational studies are equally relevant in institutional settings such as schools.

In comparison with earlier research advocating safer pest control methods, this review supports the growing scientific consensus that microbial (biological) pesticides provide a safer and more sustainable alternative. As reported by Adeleke et al. (2022), Harish et al. (2021), and Borges et al. (2021), microbial pesticides are target-specific, biodegradable, environmentally friendly, and associated with lower toxicity and minimal residual effects. This supports the position of Fahad et al. (2021) that pest management should focus on effectiveness with minimal environmental and health damage rather than eradication through hazardous chemicals.

Therefore, in agreement with previous scholars but extending their implications to school environments, this paper concludes that the continued heavy reliance on chemical fumigants in schools contradicts public health guidance and environmental safety principles. The findings strengthen earlier calls for policy reform, increased awareness, professional training, and the adoption of microbial pesticide alternatives. Transitioning toward safer biological control methods is not only scientifically justified but also ethically necessary to protect vulnerable populations while maintaining effective pest management.

Recommendation

1. This paper review necessitates the need for strict regulatory measures and application of pesticides in minimum amount to avoid negative implication on human health.
2. It is also important to ensure safe practices such as the use of nose and face covers to avoid inhaling the residual chemicals from the pesticides used.
3. More importantly, the use of microbial pesticides should be embraced and gradual elimination to the use of chemical pesticides should be our priority.

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