APPENDICES

Survey Questionnaire

Questionnaire for Indoor Air Quality Assessment in Households

This is a questionnaire survey on Indoor Air Quality in different households of Guwahati. The data collected for the survey is solely for academic and research purposes. The survey responses are strictly confidential. Thank you for your cooperation.

Anamika Nath

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Personal Details

1. **Name/নাম**.....
2. **Gender/লিংগ**.....
3. **Age/বয়স**
   a) 20-29/২০-২৯.....
   b) 30-39/৩০-৩৯ .....
   c) 40-49//৪০-৪৯ .....
   d) 50-59/৫০-৫৯ .....
   e) 60-69/৬০-৬৯
   f) >70/>৭০.....
4. **Raising children at your household/**আপোনাৰঘৰতসৰুলৰা-ছোৱালীআছেনেকি?
   a) Yes/আছে
   b)No/নাই
5. **Smoking/** ধূমপানকৰেনে?
   a) Yes/কৰোঁ
   b) No/নকৰোঁ
6. **Medical history, if any/**চিকিৎসাৰইতিহাস, যদিআছে
   a) Asthma/হাঁপানী .....
   b) Atopic dermatitis (It is a condition that causes dry, itchy and inflamed skin)/দীর্ঘদিনীয়া (দীর্ঘস্থায়ী) ৰোগযিয়েছালৰপ্রদাহ, ৰঙাপৰাআৰুখজুৰুতিৰসৃষ্টিকৰে।
   c) Allergic rhinitis (inflammation of the inside of the nose caused by an allergen, such as pollen, dust, mould, or flakes of skin from certain animals)/এলার্জেন, যেনেৰেণু, ধূলি, ছাইৰাকিছুমানপ্রাণীৰছালৰটুকুৰাৰ ফলতহোৱানাকৰভিতৰপ্রদাহ... .....
   d) Allergic conjunctivitis/ চকুউঠা,জয়বাংলা.....
   e) Food allergy/খাদ্য.এলার্জী.....
   f) Mental stress/illness/ মানসিকচাপ/ অসুস্থতা .....
   g) None/একোনাই .....

Neighborhood/Housing:

1. **Age of the Residential Building (years)/**আৱাসিকভৱনটোকিমানপুৰণি (বছৰ)
   a) <1 / <১1 to <3.....
   b) 1- <3 / ১- <৩.....
   c) 3- <5/ ৩- <৫.....
   d) 10-<20/ ১০- <২০.....
   e) >20/>২০.....
2. **Residence history (years)/**কিমানদিনৰপৰাএইঘৰটোতবস বাসকৰিআছে((বছৰ)
   a) <1 / <১ 1 to <3.....
   b) 1- <3 / ১- <৩ .....
   c) 3- <5/ ৩- <৫ .....
   d) 10-<20/ ১০- <২০.....
   e) >20/>২০....
3. **Neighborhood environments (within 50 m)/** ওচৰৰপৰিৱেশতআচে (ঘৰৰপৰা৫০মিটাৰৰভিতৰত)
   a) Houses/ঘৰ .....
   b) Store/দোকান .....
   c) Factory/Industry/কাৰখানা/উদ্যোগ.....
   d) Highway/Main Road/ ঘাইপথ/মূলপথ.....
   e) Playground/ Paddy field/Field/Forest/Pond etc খেলপথাৰ/ ধাননি/ পথাৰ/অৰণ্য/পুখুৰীআদি.....
4. **Floor type/** মজিয়াৰধৰণ
   a) Concrete/পকা .....
   b) Katcha /মাটিৰ .....
   c) Tiles/টাইলছ.....
   d) Wooden/কাঠৰ/বাঁহৰ.....
   e) Carpet flooring/ কাৰ্পেটৰ.....
   f) If other, please specify/যদিঅন্য, অনুগ্রহকৰিনিৰ্দিষ্টকৰক .....
5. **Ceiling type/** চিলিঙৰধৰণ
   a) Concrete/পকা....
   b) Asbestos/এছবেষ্টছ.....

c) Wooden/কাঠৰ/বাঁহৰ.....
d) Straw / খেৰ.....
e) If other, please specify/যদিঅন্য, অনুগ্রহকৰিনির্দিষ্টকৰক.....

6. **Type of House/ঘৰৰপ্রকাৰ**
   a) Detached house/বিচ্ছিন্ন.....
   b) Apartment/Flats/এপার্টমেণ্ট/ফ্লেট...
   c) If other, please specify/যদিঅন্য, অনুগ্রহকৰিনির্দিষ্টকৰক
7. **Structure of House/ঘৰৰগঠন**
   a) Reinforced Cement Concrete house (RCC house) /আৰচিচিঘৰ...
   b) Katcha House/মাটিৰঘৰ...
   c) Assam type (Ikra house)/ অসমটাইপঘৰ....
   d) If other, please specify/যদিঅন্য, অনুগ্রহকৰিনির্দিষ্টকৰক....
8. **Locality type/এলেকাৰপ্রকাৰ**
   a) Residential area/আৱাসিকঅঞ্চল
   b) Industrial area/ঔদ্যোগিকঅঞ্চল
   c) Commercial area/বাণিজ্যিকঅঞ্চল।
   d) If other, please specify/যদিঅন্য, অনুগ্রহকৰিনির্দিষ্টকৰ

Lifestyle/ Description Indoor Activities:

1. No of occupants/ঘৰৰবাসিন্দাৰসংখ্যা.....
   a) School Children/ স্কুলীয়াল'ৰা-ছোৱালী
   b) Office goers/কার্যালয়ৰকর্মী
   c) Stay at home/গোটেইদিনটোঘৰতেথকা
2. **Smokers present/ধূমপায়ীৰউপস্থিতি**

   Yes/আছে.....No/নাই.....

3. **Incense Burning/ধূপজ্বলাইনে**

Yes/জ্বলাওঁ .....No/নজ্বলাওঁ.....

4. **Use of Mosquito Repellent (Burning)/মহআঁতৰোৱাঔষধৰব্যৱহাৰ কৰেনে**

   Yes/কৰোঁ.....No/নকৰোঁ.....

5. **Pets present/পোহনীয়াজন্তুৰউপস্থিতি**

   Yes/আছে.....No/নাই

6. **Type of cooking fuels used/ব্যৱহৃতৰন্ধনইন্ধনৰপ্রকাৰ**
   a) LPG/এলপিজিচিলিণ্ডাৰ
   b) Biogas/গোবৰগেছ
   c) Firewood/খৰি
   d) If other, please specify/যদিঅন্য, অনুগ্রহকৰিনির্দিষ্টকৰক
7. **Spray products used (e.g. room freshener)/** স্প্রেপ্রডাক্টযেনেৰুমফ্রেছনাৰৰব্যৱহাৰকৰেনে?

   Yes/কৰোঁ.....No/নকৰোঁ.....

8. **Cracks on floor/মজিয়াতফাটআছেনে?**Yes/আছে ..... No/নাই.....
9. **Condition of wall painting/দেৱালৰৰঙৰঅৱস্থা**
10. Good/ভাল.....Bad/বেয়া.....Average/ঠিক-ঠাক.....
11. **Moulds on walls/**বেৰতভেঁকুৰ আছেনে? Yes/আছে No/নাই
12. **Regular sweeping and mopping done/নিয়মীয়াকৈঝাড়ুদিয়াআৰুমোছাহয়নে?** Yes/হয়.....No/নহয়
13. **Frequency of cleaning (mopping/sweeping)?** কিমানসঘনাইচাফাইকৰাহয়?
    a) Everyday/প্রতিদিন
    b) Once a week/সপ্তাহতএবাৰ
    c) Twice a week/সপ্তাহতদুবাৰ
    d) Thrice a week/সপ্তাহততিনিবাৰকৈ
14. **Visible dust in the house/ঘৰতধূলিদেখাপাইনে?** Yes/দেখাপাওঁ....No/দেখানাপাওঁ....

Perception of Indoor air

1. **Intensity of Indoor air pollution /** ঘৰৰভিতৰৰবায়ুপ্রদূষণউপস্থিতআচেনেHigh/অধিক.....Medium/মধ্যম..... Low/কম.....

   Negligiable/নগণ্য.....

2. **Ventilation inside the house/ঘৰৰভিতৰতবায়ুচলাচলকেনেকুৰা**
   Well ventillated/ভাল.....
   Poorly ventilated/ভালনহয়.....
3. **Pollution comes from outside/প্রদূষণবাহিৰৰপৰাআহেনে?** Yes/আহে.....No/নাহে.....
4. **If yes, pollutants remain inside the house for a longer time? /যদিহয়,**

তেন্তেপ্রদূষকবোৰঘৰৰভিতৰতবেছিসময়থাকে নে?
Yes/থাকে.....

No/নাথাকে.....

During the last year have you had any of the following symptoms?
যোৱাএটাবছৰৰভিতৰতআপোনাৰতলতদিয়াকোনোলক্ষণদেখাগৈছেনে?

If yes, do you believe that this is due to your home environment দিহয়, তেন্তেআপোনাৰঘৰৰপৰিৱেশৰবাবে ইএনেহৈছেবুলি আপুনিবিশ্বাসক ৰেনে?

Sl. no.	Symptoms of the health problems তলতস্বাস্থ্যজনিতলক্ষণৰতালিকাদিয়াহ'ল	Yes **(Once a week)** Yes (once a week)/হয় (সপ্তাহতএবাৰ)	Yes **(Sometimes)** Yes (sometimes)/হয় (কেতিয়াবা)	Yes হয়
i.	**Nasal problems নাকৰসমস্যা**			
	Sinus problem/চাইনাছ			
	Sneezing/Runny nose/হাঁচি, নাকবেয়োৱা			
	Nose bleeding/নাকৰপৰাতেজওলোৱা			
	Dry nose/শুকাননাক			
ii.	**Throat symptoms ডিঙিৰসমস্যা**			
	Sore throat/ডিঙিৰবিষ (চর্দিবাঅন্যভাইৰাছৰবাবেপ্রদাহৰফলতহোৱা)			
	Dry cough/শুকানকাহ			
iii.	**Eye symptoms চকুৰসমস্যা**			
	Redness of eyes/ চকুৰঙাপৰা			
	Burning of eyes/চকুজ্বলা-পোৰা			
	Watery eyes/Dryness/ চকুপানীওলোৱা/শুকান			
	Irritation in the eyes/চকুবিষহোৱা			
	Blurred vision/দৃষ্টিশক্তিঅস্পষ্ট			
iv.	**Problems wearing contact lenses কনটেক্টলেন্সপিন্ধাসমস্যা**			
	Discomfort/Burning of eyes/ অস্বস্তি/চকুজ্বলা-পোৰা			
	Pain in the eyes/চকুতবিষ			
v.	**Dermatology problems ছালৰসমস্যা**			
	Skin irritation/ছালজ্বলা-পোৰা			
	Dryness of skin/ছালৰশুকানতা			
	Flakiness/ ছালশুকানআৰুৰুক্ষহোৱা			
	Dandruff in hair/চুলিতউফি			
vi.	**Aches and pains বিষৰসমস্যা**			
	Headaches/ Migraines/মূৰৰবিষ/ মাইগ্রেইন			
	Joint pain/Muscle pain/ গাঁঠিৰবিষ/ মাংস-পেশীৰবিষ			
vii.	**General complaints সাধাৰণঅভিযোগ**			
	Drowsiness/টোপনিঅহাআৰুঅলসহোৱাৰঅনুভৱ			
	Dizziness/Faintness/মূৰঘূৰোৱা/অজ্ঞানতা			
	Breathing problem/উশাহ-নিশাহৰসমস্যা			
	Digestion problem/পাচনতন্ত্ৰৰসমস্যা			

Conference attended

1. **Characterization of indoor settled dust in schools of Tezpur, Northeast India** in International Conference on Recent Trends in Natural & Applied Sciences (ICNAS-2025), organized by Guwahati College Teachers' Unit in collaboration with IAQC, Guwahati College & Zoological Society of Assam (March 21-22, 2025) (Best Presenter)
2. **Concentration of $PM_{2.5}$ and CO_2 in selected schools of Tezpur, Northeast India** in Tezpur University Science Graduate Research Conclave, organized by School of Sciences, Tezpur University (February 10-11, 2025). Awarded the best presenter of the respective session.
3. **Levels of $PM_{2.5}$ and CO_2 in a University of Assam** at the One-Day National Seminar on 'Advances in Environmental Science', organized by the Department of Environmental Science, Tezpur University in collaboration with the Students' Science Council (March 10, 2023).
4. **Sources and Effects of Bioaerosols in the Indoor Environment of Educational Institutions** at the National Conference on Climate Change: Science and Technology Innovations (NCCCSTI-2022), organized by the Department of Environmental Science, Tezpur University (December 15-16, 2022).

Publications

1. Khundrakpam, N., Binong, B., Mushahary, R., **Nath, A**., Nonglait, M. L., and Deka, P. Levels of elements in road dust of Shillong, Northeast India: characterization, source apportionment and health risk assessment. *Environmental Geochemistry and Health*, 47(10): 441, 2025. DOI: https://doi.org/10.1007/s10653-025-02741-0
2. **Nath, A**., Saikia, D., Nonglait, M. L., and Deka, P. Assessment of indoor air quality and characterization of indoor settled dust in schools of Tezpur, Northeast India. *Air Quality, Atmosphere & Health*, 18(3): 793-814, 2025. DOI: https://doi.org/10.1007/s11869-024-01679-z
3. **Nath, A.,** Paul, B., and Deka, P. Chemical characterization of road dust during diwali festival in Guwahati city of Assam, Northeast India. *Environmental*

Monitoring and Assessment, 196(5): 484, 2024. DOI: https://doi.org/10.1007/s10661-024-12628-9

4. Mushahary, R., **Nath, A.,** Chutia, S., and Deka, P. A systematic review on phytoremediation of indoor air pollution. *Journal of Air Pollution and Health*, 2024. DOI: https://doi.org/10.18502/japh.v9i2.15928
5. **Nath, A**., Baruah, N., Nonglait, M. L., and Deka, P. Biological contaminants in indoor environments of educational institutions. *Aerobiologia*, 39(1): 1-20, 2023 DOI: https://doi.org/10.1007/s10453-022-09771-6
6. **Nath, A**., Bhuyan, P., Gogoi, N., and Deka, P. Pesticides and chemical fertilizers: role in soil degradation, groundwater contamination, and human health. In *Xenobiotics in Urban Ecosystems: Sources, Distribution and Health Impacts* (pp. 131-160). Cham: Springer International Publishing, 2023
7. **Nath, A**., and Deka, P. A case study on practices and acute toxicity symptoms associated with pesticide use among the farmers of mid Brahmaputra valley of Assam. In *Environmental Degradation: Challenges and Strategies for Mitigation* (pp. 329-344). Cham: Springer International Publishing, 2022

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ORIGINAL PAPER

Levels of elements in road dust of Shillong, Northeast India: characterization, source apportionment and health risk assessment

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Abstract The study analyzed eleven elements in road dust from residential areas, traffic areas, commercial areas, and plastic paper and e-waste collection sites in Shillong, Northeast India. Elemental concentrations followed the order: Al > Fe > Mg > Mn > Zn > Pb > Cu > Cr > Co > Ni > Cd. Among these, Cd showed the highest enrichment (EF = 63.01), followed by Pb (EF = 24.78), and contributed 92% and 6% of the ecological risk, respectively. Pollution indices confirmed significant contamination in all sites. The geoaccumulation index (I_{geo}) indicated extreme pollution for Cd, moderate to extreme for Pb, and low to moderate levels for other elements. Strong positive correlations were observed among Al–Mg, Co–Cu, Co–Mn, Pb–Zn, and Pb–Cd, with moderate correlations (r = 0.4–0.6) for Cd–Zn, Cu–Zn, and Fe–Cr. PCA revealed three major sources: anthropogenic and crustal, traffic and e-waste, and geogenic. The hazard index exceeded 1 for children at all sites, indicating potential non-carcinogenic risk, primarily via ingestion. Chromium was the main contributor to cancer risk, though overall levels remained within safe limits. FTIR and PXRD analyses confirmed quartz as the dominant mineral, along with silicate, carbonate, and others. The study recommends pollution control measures to aid urban planning and safeguard public health.

Keywords Road dust · Elemental concentration · Pollution load index · Geo-accumulation index · Ecological risk index · Mineralogy · Health risk assessment

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Introduction

Road dust is a complex mixture of fine particles originating from both natural and anthropogenic sources. Natural contributions include soil from unpaved areas, windblown dust, biological matter, and mineral particles from rock weathering. Anthropogenic sources include vehicular emissions, tire and brake wear, construction activity, and industrial processes

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Assessment of indoor air quality and characterization of indoor settled dust in schools of Tezpur, Northeast India

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Abstract
This study aims to assess the indoor air quality along with the elemental concentrations of indoor settled classroom dust across nineteen schools in Tezpur, Northeast India. The average indoor temperature and relative humidity were 24.53 °C and 60.61%, respectively which is within the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE's) recommended comfort limits. The overall average $PM_{2.5}$ concentrations were 134.69 ± 70.71 μg/m^3 indoors and 122.89 ± 61.55 μg/m^3 outdoors, significantly exceeding the WHO's 24-hour recommended guideline of 15 μg/m^3. However, CO_2 concentrations were within the standards established by ASHRAE 62.1. The elemental concentrations in decreasing order were: Fe > Al > Mg > Mn > Zn > Ni > Cr > Pb > Cu > Co > Cd. The average Enrichment Factor (EF) values were 16.01 (Zn), 12.43 (Pb), 9.52(Cd), 7.27 (Ni), 1.63 (Cu), 1.54 (Mn), 1.31 (Cr), 0.92 (Co), 0.73 (Mg), and 0.48 (Al). Urban schools had the highest average EF for traffic-related elements (TREs) followed by suburban schools and rural schools. The degree of contamination (C_{degree}) values indicated moderate contamination levels, while all schools had pollution load index (PLI) values below 1, signifying low to negligible pollution and acceptable classroom environmental quality. A strong significant correlation at $p < 0.05$ was found between Mg-Mn (0.55), Mg-Fe (0.54), Mg-Ni (0.56), Mg-Co (0.48), Mg-Cu (0.63), Al-Cr (0.79), Al-Mn (0.79), Al-Fe (0.60), Al-Ni (0.54), Al-Co (0.80), Cr-Fe (0.78), Cr-Ni (0.74), Cr-Co (0.81), Mn-Fe (0.48), Mn-Co (0.64), Mn-Cu (0.64), Fe-Ni (0.99), Fe-Co (0.80), Ni-Co (0.75), Cu-Zn (0.50), and Cd-Pb (0.62). Hierarchical cluster analysis (HCA) and principal component analysis (PCA) identified consistent pollutant distribution patterns and their probable sources. Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction (XRD) analyses of classroom dust samples showed that quartz, calcite, and haematite were the most common minerals. This suggests that the source of classroom dust could be soil, chalk dust, and anthropogenic activities. The health risk assessment indicated that non-cancerous risks from heavy metals were within acceptable ranges. However, the total lifetime cancer risk (TLCR) for rural (1.37E-04), suburban (1.09E-04), and urban (1.08E-04) areas slightly exceeded the acceptable limits.

Keywords Classroom dust · Indoor air quality · $PM_{2.5}$ concentration · Elements · Mineralogy · Health risk assessment

Introduction

Clean air is essential for health and well-being, making indoor air pollution (IAP) a significant concern today (World Health Organisation (WHO 2010). IAP refers to the presence of a broad array of pollutants, including particulate matter ($PM_{2.5}$ and PM_{10}), volatile organic compounds (VOCs), aldehydes, bioaerosols, inorganic compounds (such as heavy metals), and other physical and chemical aspects (Argunhan and Avci 2018; Madureira et al. 2016). The indoor air quality (IAQ) in residences, workplaces, educational institutions, and other public and private structures critically influences the health and well-being of individuals (WHO 2010).

Schools serve as a second home for school-going children, where they spend a significant portion of their time, up to 12–30% time of a day (Abdel-Salam, 2019; Sadrizadeh et al. 2022). Consequently, IAQ in educational institutions has become a crucial priority. The indoor air quality in classrooms significantly contributes to children's daily exposure

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RESEARCH

Chemical characterization of road dust during diwali festival in Guwahati city of Assam, Northeast India

Anamika Nath · Baishali Paul · Pratibha Deka

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Abstract The present study focuses on the elemental analysis of road dust in Guwahati, the largest city of Assam and the largest metropolis of Northeast India during the Diwali festival. Road dust samples were collected on pre-Diwali (PD), the Day after Diwali (DaD), and one week after Diwali (WaD) from two sites (Lankeshwar; LKW and Patharquarry; PTQ). Three composite samples were collected from 3 points at each site. The elemental concentration was analyzed using inductively coupled plasma mass spectrometry (ICP-MS). The concentrations of Ba and Sr increased by 1.6 and 1.7 times, respectively, after Diwali. Among other firework-related elements (FREs), Mg, Al, K, and Cu increased at LKW following Diwali (both DaD and WaD), whereas Mg, Al, and K increased in DaD dust at PTQ. The average concentration of Traffic Related Elements (TREs) at PTQ was significantly higher than at LKW ($p<0.05$; 75.40 mg/kg vs 63.96 mg/kg). Cd had the highest enrichment (EF), followed by Ni and Zn. EF for Cd, Ni, and Zn ranged from high to extremely high enrichment. Ni and Cd exhibited moderate contamination (CF). The ecological risk (ER) values for Cd at LKW and PTQ were 54.32 and 56.71, respectively, indicating a moderate ER. Pearson's correlation was performed to study the relationship between elements, while PCA analysis was used to identify the main sources of these elements. Although the health hazard indices presently do not suggest any immediate danger, hazard quotient (HQ) values for ingestion, inhalation, and dermal exposure were higher for children than adults. In children, the contribution of HQ_{ing} to HI (total risk) was the highest, accounting for more than 65% of all elements. There is no apparent lifetime cancer risk due to road dust exposure through inhalation.

Keywords Road Dust · Elements · Traffic-Related Elements · Fireworks Related Elements · Pollution Indices · Health Risk Assessment

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Introduction

Road dust refers to particulates that generally originate from the Earth's crust and are formed through the secondary processes of alteration and erosion of natural and anthropogenic materials (Khodadadi et al., 2022). Metals in road dust are a matter of concern due to their inherent toxicity, bioavailability, and ability to withstand degradation (Mummullage et al., 2016). Studies have shown that the primary contributors to heavy metal contamination in dust are anthropogenic sources, including vehicle exhausts from high traffic load, industrial emissions, and the combustion of fireworks during festivities or celebrations (Ahamad et al., 2021; Gunawardana et al., 2012; Kolawole & Olatunji, 2023; Yang et al., 2019). Due to the enrichment of potentially toxic metals (PTMs) in firecrackers, firework displays may contribute

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Review Article

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A systematic review on phytoremediation of indoor air pollution

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ABSTRACT

Degradation of Indoor Air Quality (IAQ) due to confined spaces and insufficient ventilation has become a serious concern to human health. Published literature has established phytoremediation as an efficient removal mechanism of indoor air pollutants such as formaldehyde, Benzene, Toluene, Ethyl benzene, Xylene (BTEX), Volatile Organic Compounds (VOCs), and Particulate Matter (PM) using potted plants. This review discusses both conventional and enhanced phytoremediation for removing air pollutants and the parameters influencing the removal efficiencies. A literature review was conducted following the PRISMA guidelines to identify published literature on indoor air phytoremediation. After eliminating duplicates and reviewing articles, the articles related to indoor air phytoremediation from 2011 to the present were selected. The database was managed using Mendeley reference manager. Indoor air pollutants can be removed efficiently through phytoremediation using potted plants. *Chlorophytum comosum* removed the broadest range of contaminants, whereas *Epipremnum aureum* is the frequently used plant species for pollutant removal. Adding enhancing factors to the plant enhances their ability to remove pollutants. Inoculation of plants with soil bacteria such as *Bacillus cereus* ERBP is the most common enhancement method reported. The present study highlighted advancements in phytoremediation and factors affecting the pollutant removal efficiencies of plants. The findings demonstrated that enhanced phytoremediation is more effective at removing pollutants than the conventional method. Depending on the plant species used, the removal of indoor air pollutants may vary. The findings suggested that a combination of various plant species could be used to remove indoor air pollutants more efficiently.

Review

Indoor Air Quality (IAQ) is a significant problem as the increased concentration in a confined space makes it more dangerous than the outside air [1]. The tightly sealed building constructions maximize thermal efficiency

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REVIEW PAPER

Biological contaminants in indoor environments of educational institutions

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Abstract Biological contaminants mainly consisting of living or dead microorganisms and compounds or fragments of plants and animal origin are gaining widespread research interest in recent years due to their ubiquitous presence along with their health effects on humans. Students spend a significant time of the day in educational institutions, which increases the cumulative health risk over the years. This review discusses the major biological contaminants, sampling strategies, health effects, and the factors affecting their prevalence in educational institutions. Fungi and bacteria were the most reported bio-contaminants followed by allergens and endotoxins. Exposure to bio-contaminants may result in acute and chronic respiratory diseases, infectious diseases, allergies, building-related illnesses, and even cancer. More research is needed to know the susceptibility of different age groups of students, formulation of guideline values, standard protocols for sampling, and proper diagnostic tests for diseases caused by bio-contaminants. Students should be made aware of the various aspects of indoor air quality such that they become inquisitive towards the same and become responsible for safety and hygiene.

Keywords Biological contaminants · Educational institutions · Indoor air quality (IAQ) · Human health

1 Introduction

Exposure to indoor air pollutants can adversely affect human health as humans spend about 90% of their time indoors (Gohain & Deka, 2020; Pitarma et al., 2017). Indoor air pollutants are more inflated than outdoor pollutants (Branco et al., 2015; Kankaria et al., 2014). These pollutants include tobacco smoke, radon, and its decay products, fibers from asbestos, fiberglass, formaldehyde (HCHO), volatile organic compounds (VOCs), particulate matter (PM), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), and bio-contaminants (Tran et al., 2020).

Among indoor pollutants, the particulate matter associated with the biological origin is a matter of concern for being hazardous to human health and needs control (Ghosh et al., 2015). These biological contaminants or bio-contaminants include living or dead bacteria, viruses, fungi, animal dander and cat saliva, allergens from house dust, mites, and cockroaches, pollen, and compounds or fragments of plants and animals (Kumar et al., 2021; USEPA, 2022). Most bioaerosols are respirable and range in

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Pesticides and Chemical Fertilizers: Role in Soil Degradation, Groundwater Contamination, and Human Health

Anamika Nath, Pranamika Bhuyan, Nirmali Gogoi, and Pratibha Deka

Abbreviations

AOA	Ammonia-oxidizing archaea
AOB	Ammonia-oxidizing bacteria
CKD	Chronic kidney diseases
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichloro-diphenyl-trichloroethane
EDC	Endocrine-disrupting chemicals
EM	Effective microorganism
ETL	Economic threshold level
F	Fungicides
FAO	Food and Agriculture Organization
FFS	Farmer field school
GHG	Greenhouse gas
H	Herbicides
HCH	Hexachlorocyclohexane
HYV	High-yielding varieties
I	Insecticides
ILO	International Labour Organization
IPM	Integrated pest management
IRM	Insecticide resistance management
N	Nitrogen
NGO	Nongovernmental organization
NPK	Nitrogen phosphorous potassium
OCPs	Organochlorine pesticides

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Chapter 16
A Case Study on Practices and Acute Toxicity Symptoms Associated with Pesticide Use Among the Farmers of Mid Brahmaputra Valley of Assam

Anamika Nath and Pratibha Deka

Abstract In this study, an attempt was made to assess the knowledge, attitude, practices regarding pesticide handling and acute toxicity symptoms of pesticide use among the farmers of mid Brahmaputra Valley of Assam. The study included a sample size of 90 farmers taken from 6 villages of Sonitpur district of Assam, India. The farmers include both full-time and part-time agriculturists. Data collection was done through a questionnaire survey. Of the total samples, 82.2% used chemical pesticides and majority acknowledged them as harmful. Despite awareness of the health risk by the handling of pesticides, 75.68% reported not using any personal protective measures. 13.51% stated that they did not have separate work clothing, neither they washed them separately. Of the pesticides used, 52% belong to WHO class II (moderately hazardous), 8% belong to class III (slightly hazardous), and 4% belong to class Ib (highly hazardous). We had found that 59.46% of the farmers complained of Acute Pesticide Poisoning (APP), 24.32% sometimes complained of APP whereas 16.22% never complained of APP. The main self-reported toxicity symptoms include headache, nausea, burning of eyes, vomiting, shortening of breath, vision disturbance, and excessive sweating. The study revealed that lack of adequate knowledge and risky behavior during handling; storage and disposal of pesticides were a common scenario among the farmers. The use of pesticides in modern times cannot be stopped but certainly can be checked with proper training and Government initiatives.

Keywords Agriculture · Chemical pesticides · Knowledge of farmers · Safety measures · Acute Pesticide Poisoning

16.1 Introduction

Present-day farming is highly dependent on pesticides. It played a major role in increasing agricultural production. Pesticides are used in agriculture to manage

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