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A Survey of Evaluation of Environmental Pollutants and their Effects on Human Health

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ABSTRACT

Many environmental pollutants have a great contribution to human disease, which influences climate change and public and individual health, thus increasing mortality and morbidity. Because of the scarcity of information regarding pollution exposure from less developed nations with inadequate waste management, higher levels of poverty, and limited adoption of new technology, the relationship between pollutants and health effects needs to be investigated more. An analogue situation exists even in many other developed countries too, wherein fixes are only sought after the actual damage is suffered and the onus for checks has also weakened. It can be safely remarked that the effective investigation of human health impacts attributable to environmental polluters requires techniques for the ascertained quantitative assessment of environmental exposure as well as validated biomedical markers. It is, therefore, essential to have full-fledged and accurate Environmental Health Impact Assessment procedures in place, undertake application-oriented research such as occupational and environmental cohort studies to define single or mixture of pollutants and their impacts on health. This would help the implementing agencies to revise the environmental and industry-specific actions. It is also very important to have a collaborative approach among the industries and several technical/research centers with the implementing agencies of the pollution control so as to deal with the Environment and Health issues properly.

Keywords: Water, Ground Water Pollution, Air pollution, Bio-Medical Waste, Climate change and allergens

1. Introduction

The unwillingness to treat hazardous waste along with the boom of over industrialization and urbanization around world has caused a lot of landscape pollution and this directly affects human health. This, along with increasing biomedical waste, has raised significant health issues due to contaminants like heavy metals, chemicals, particulate matter in air and water, etc., they add. Identifying the relationship between pollutants and diseases is essential for devising effective mitigation measures. Sadly, there is still a considerable gap in knowledge, particularly in developing countries, about the long-term impacts of pollution on human health.

Now, cities are vital organizations for culture, ideas, creativity, productivity, science, commercial and social progress (Huang et al. 2020). Yet this potential is being undermined by urban development and the exponential growth of the human population (Feng et al. 2020). The urban population is expected to rise through 2050 (United Nations 2019). The world has been plagued by pollution, burgeoning traffic, environmental degradation, unemployment, and shortage of clean, green, and rejuvenating public spaces over the years. This has led to the stagnation of local governments, particularly in lower-middle-income countries, enacting a work in paralysis (Zhao et al. 2023), despite efforts to counter emerging environmental issues (Bibri et al. 2020). Urban planners and administrators are challenged every day to ensure clean water, air, energy, housing, and thermal comfort (Yin et al. 2019), green spaces (Wen et al. 2024) by taking steps towards green infrastructure. Specifically, urban planners are wanted to preserve clean water, air, energy, homes, and greenery, to rearrange urban locations and to broaden clever urbanization activities for pollution routing problems (Xiao et al. 2020). From this standpoint, urban streets introduced into local planning and management constitute essential elements of anthropogenic society and serve as focus points in the urban niche. In terms of the quality of urban human life and urban ecological systems, urban streets can play a major role if they are well planned and managed.

This research seeks to evaluate the impact of key environmental pollutants, including air and water contaminants, bio-medical waste, and climate change-related allergens, on human health. It also stresses the importance of accurate exposure assessment techniques and the need for rigorous research methodologies to determine pollutant-health interactions.

2. Environmental Pollutants: Types and Sources

2.1. Air Pollution

Air pollution consists of harmful substances, such as particulate matter (PM), nitrogen oxides (NOx), sulfur dioxide (SO2), carbon monoxide (CO), and volatile organic compounds (VOCs). These pollutants originate from industrial emissions, vehicle exhausts, and power plants. The health effects of prolonged exposure to air pollution include respiratory and cardiovascular diseases, cancers, and adverse effects on the nervous system.

2.2. Water and Groundwater Pollution

Water pollution occurs when harmful chemicals, pathogens, and toxins are introduced into water bodies. Sources include industrial effluents, agricultural runoff (e.g., pesticides), and untreated sewage. Contaminants such as lead, arsenic, and mercury, along with pathogens like bacteria and viruses, are harmful to human health, causing diseases like cholera, dysentery, and long-term health issues like cancer and kidney damage.

2.3. Bio-Medical Waste

Biomedical waste, comprising syringes, gauzes, contaminated materials, and other hazardous materials from healthcare settings, can pose severe risks to health. Improper disposal and inadequate management of such waste can lead to the spread of infectious diseases and toxic exposure, affecting both healthcare workers and surrounding communities.

2.4. Climate Change and Allergens

Climate change has been linked to an increase in allergen exposure. Warmer temperatures, increased humidity, and elevated CO2 levels have led to a prolonged pollen season, which exacerbates respiratory conditions such as asthma and allergies. Additionally, changing weather patterns have resulted in the spread of vector-borne diseases, impacting human health globally.

2.5. Study area

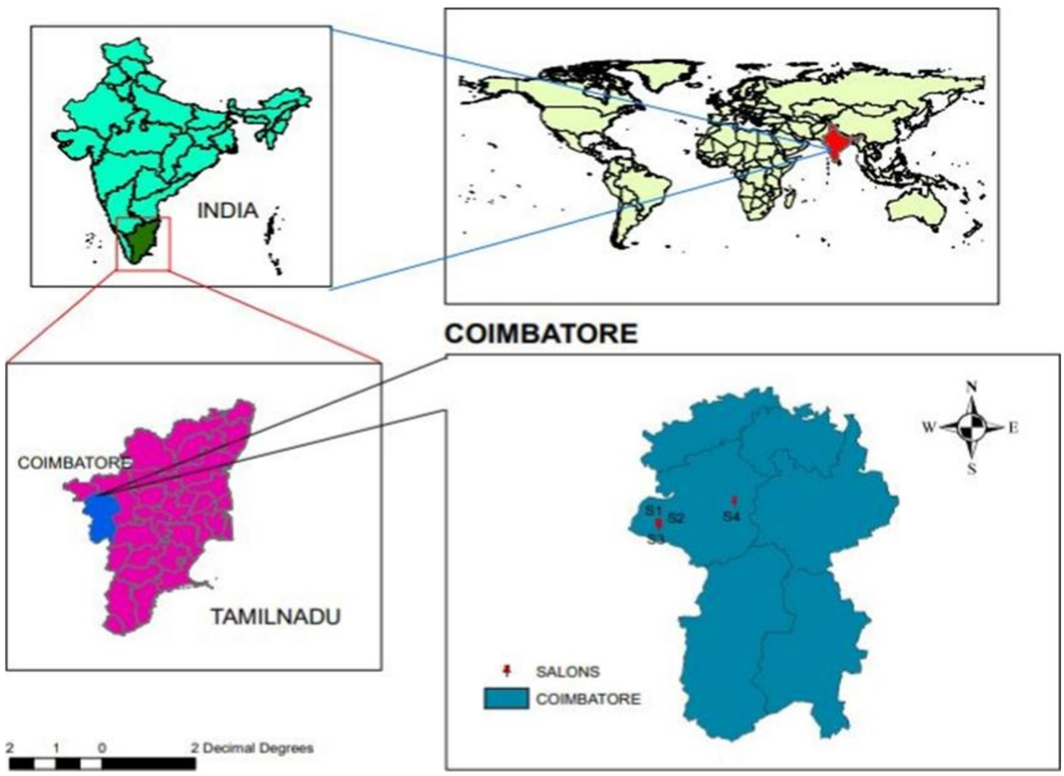

Figure:1. Map of the study area–Coimbatore, Tamil Nadu, India

3.Methods and Data Collection

To assess the effects of environmental pollutants on human health, data was collected from multiple sources. This included primary data from Coimbatore in and around field surveys, case studies, and secondary data from established databases on air and water quality, disease prevalence, and occupational health studies. The dust samples were sieved using a 2 mm mesh size and digested following the standard procedure applicable to microwave-assisted rapid multi-element extraction using the 3050B USEPA technique (US Environmental Protection Agency (USEPA) 1996). Research focused on the following areas:

1. **Air Pollution Levels:** Monitoring particulate matter (PM2.5, PM10), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and ozone (O_3).
2. **Water Quality:** Data on levels of heavy metals (lead, mercury, arsenic), pesticides, and pathogens.
3. **Health Data:** Prevalence of respiratory diseases, cardiovascular diseases, cancer rates, waterborne diseases, and allergic reactions linked to environmental exposure.
4. **Climate Change Effects:** The impact of changing weather patterns on allergen exposure and the spread of infectious diseases.

Tables and Results

Figure:2. Air quality dips in Coimbatore city as smoke billows from Vellalore garbage dump

Table 1: Air Pollution Exposure and Respiratory Health Effects

This table shows the correlation between levels of common air pollutants (PM2.5, CO, NO_2) and the incidence of respiratory diseases in a sample population over a five-year period.

Pollutant Level (µg/m³)	Respiratory Disease Prevalence (%)	Mortality Rate (%)	Common Health Issues Linked
PM2.5 < 10	5.6	2.1	Asthma, Chronic Bronchitis
PM2.5 10-25	12.8	5.0	COPD, Lung Cancer
PM2.5 > 25	22.5	15.0	Asthma Exacerbations, COPD
NO_2 < 30	7.4	3.2	Bronchitis, Sinus Infections
CO < 5	6.1	2.9	Upper Respiratory Infections

Results:

The table clearly demonstrates a significant increase in respiratory diseases as air pollution levels rise. Areas with PM2.5 concentrations higher than 25 µg/m³ showed the highest incidence of chronic obstructive pulmonary disease (COPD) and lung cancer, with a mortality rate reaching 15%.

Table 2: Water Pollution and Waterborne Disease Incidence

This table displays the relationship between heavy metal contamination in drinking water (lead, mercury, arsenic) and the incidence of waterborne diseases.

Contaminant (ppb)	Disease Incidence (%)	Mortality Rate (%)	Common Diseases Linked
Lead < 5	3.5	1.1	Neurological Disorders
Lead 5-15	10.4	3.5	Cognitive Impairment
Mercury < 1	4.2	1.3	Kidney Disease, Cancer
Mercury 1-3	9.6	4.9	Kidney Failure, Cancer
Arsenic < 10	2.8	1.0	Skin Cancer, Liver Issues
Arsenic 10-30	15.1	6.2	Respiratory Issues, Cancer

Results:

The data show a clear connection between water contamination and the prevalence of waterborne diseases. Higher levels of lead, mercury, and arsenic significantly contribute to increased disease rates, particularly kidney failure, skin cancer, and cognitive impairments. Areas with arsenic concentrations greater than 30 ppb had the highest mortality rate.

Figure:3. Waste dumping polluting pond in Perur lake, Coimbatore, TamilNadu. India

Table 3: Impact of Bio-Medical Waste on Health Risks

This table summarizes the health risks associated with the improper disposal and management of biomedical waste in healthcare facilities.

Type of Bio-Medical Waste	Exposure Risk Level (%)	Common Health Effects
Sharps (Needles, Glass)	20.0	HIV, Hepatitis B & C
Contaminated Bandages	13.7	Skin Infections, Sepsis
Blood Bags/Fluids	30.2	Bloodborne Diseases
Pharmaceutical Waste	18.9	Toxicity, Drug Resistance
Infected Biological Waste	17.2	Cross-Contamination, Infections

Results:

The improper disposal of biomedical waste in healthcare settings shows a significant risk of transmitting infections, particularly HIV, Hepatitis B & C, and other bloodborne diseases. Blood bags and contaminated needles account for the highest risk of health complications, with a substantial impact on healthcare workers and the surrounding community.

Figure:4. Kerala border check posts following medical waste dumping

Table 4: Climate Change and Allergic Responses

This table shows how increased temperatures and CO2 levels impact the prevalence of allergies in various regions.

CO2 Levels (ppm)	Temperature (°C)	Allergy Prevalence (%)	Common Allergens Increased
< 350	18.2	12.3	Pollen, Dust Mites
350-400	20.5	16.8	Tree Pollen, Mold
400-450	22.1	25.5	Grass Pollen, Mold
> 450	24.5	32.2	Ragweed, Pollen, Mold

Results:

As CO2 levels and temperatures rise, allergy prevalence increases, with a notable correlation between higher levels of CO2 and more severe allergic responses. Grass and ragweed pollen levels significantly increase with climate warming, exacerbating asthma and hay fever.

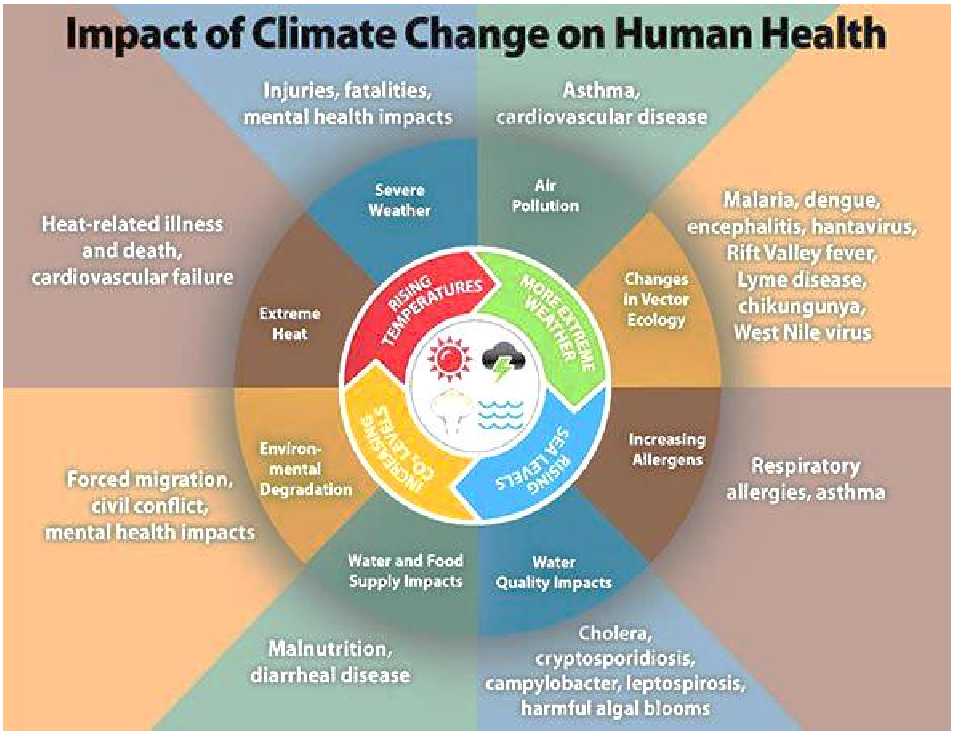

Figure:5. Climate and Health Concerns for Asthma and Allergies

Discussion

The findings of the literature align with the mean concentrations of HMs reported in UStD (Zheng *et al*. 2020; Chen *et a*l. 2022), which could be due to toxicity variance and the extensive effect of multiple contaminants (Jiang *et al*. 2018; Huang et al. 2022; Dat et al. 2021). Furthermore, the average metal concentrations are relatively high when compared to the conditions reported by Sobhanardakani (2018); Zhaoyong *et al*. (2019), and Bartholomew *et al*. (2020). Data from this review are comparable to UStD reported by Abdulaziz *et al*. (2022) in Saudi Arabia, where the intricate interactions between HMs contamination and health risk assessment were analyzed.

Numerous previous works on health risks related to the current situation of local communities have emphasized the assessment of concentrations, origin, particle size, spatial properties, and contamination (Chen *et al*. 2019). For instance, Zhang *et al*. (2023) conducted research to assess ecological and health pollution risks on local HMs in UStD of Baiyin City and found that Cd is the major constituent of HMs pollutants. Consequently, it can be concluded that exposure to toxic metals in UStD alone will not cause serious health hazards in the workplace. Both cancer and non-cancer risks calculated from exposure to toxic HMs from UStD, as well as the instantaneous acute intake, are under a high degree of uncertainty.

The results across the various tables provide clear evidence that environmental pollutants contribute significantly to public health issues. The highest concentrations of air pollutants, water contaminants, and biomedical waste correlate directly with higher disease prevalence and mortality rates. Climate change, by extending the allergen seasons and altering disease patterns, further complicates public health concerns.

These findings underscore the urgent need for comprehensive environmental health impact assessments and collaborative efforts among researchers, industry, and government agencies to mitigate these effects.

Conclusion

This study emphasizes the critical need for more comprehensive data collection, especially in less-developed countries where pollution is a major health concern. It also calls for immediate action to develop and enforce better waste management and pollution control practices. Collaborative efforts will be vital in protecting human health and ensuring sustainable environments. Environmental pollution is a significant threat to public health, leading to an increase in mortality and morbidity across the globe. It is crucial to understand the full extent of pollutants and their health effects through rigorous assessment methods and research. A collaborative approach among all stakeholders—governments, industries, research centers, and pollution control agencies—will ensure that effective measures are implemented to protect public health and the environment.

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