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A Brief Review of Impacts of Environmental Pollutants on the Public Health of Assam

Sagarmoy Phukan*
Emerson Centre of Excellence for Sustainability Studies, TERI School of Advanced Studies, New Delhi, India

***Abstract*: This review aims to identify critical environmental degradation issues affecting public health in Assam. A systematic literature search was conducted using Scopus and Google Scholar with the keywords "Environmental Degradation" AND "Public Health" AND "Assam." Relevant studies were analysed using a qualitative deductive coding approach, guided by a custom-developed codebook based on the study's objectives. The review reveals widespread contamination of drinking water, soil, and air across Assam, involving pollutants such as arsenic, fluoride, iron, manganese, lead, cadmium, organochlorine pesticides, particulate matter, and microbial agents. These exposures are linked to both acute infections and chronic noncommunicable diseases, disproportionately affecting children, women, and vulnerable communities, including rural and tribal populations. The findings provide a consolidated overview of the environmental health landscape in Assam and highlight significant gaps in the literature. This review offers a foundation for future research and policy interventions aimed at mitigating environmental health risks in the region.**

***Keywords*: Environmental degradation, Public health, Assam, Environmental health risks, Review.**

1. Introduction

The relationship between environmental degradation and public health has been central to the evolution of environmental science. Rachel Carson's seminal work Silent Spring revealed the biomagnification of DDT and its adverse effects on human health, fundamentally reshaping scientific understanding of how environmental deterioration translates into population-level health risks. This recognition marked a critical shift in viewing environmental quality not merely as an ecological concern, but as a key determinant of human health and well-being.

Assam is frequently perceived as an environmentally pristine and relatively undisturbed region. However, recent patterns of rapid and largely unplanned development have generated multiple environmental stressors that increasingly affect the daily lives of its population. Among these, public health impacts arising from exposure to environmental pollutants through contaminated air, water, and soil as well as those associated with climate change and extreme climatic events, are of growing concern (Basak, 2021; Konwar, 2024; Nath, 2025). Environmental pollutants degrade the quality of the physical environment required to sustain human physical and mental health and overall well-being (WHO, 2025).

Air pollution is recognised by the World Health Organization as the largest environmental health risk globally, contributing to an estimated 8.1 million deaths worldwide in 2021, including nearly 700,000 children (HEI, 2024). In India, more than 1.67 million deaths were attributed directly to air pollution in 2019, representing the highest national mortality burden linked to air pollution globally (Hayward, 2021). Exposure to fine particulate matter ($PM_{2.5}$) significantly elevates the risk of chronic obstructive pulmonary disease (COPD) by 32.5%, ischemic heart disease by 29.2%, stroke by 16.2%, lower respiratory infections by 11.2%, lung cancer, and contributes to an overall reduction in life expectancy of approximately 2.2 years (ISLDBIAP, 2020; Kaur & Pandey, 2021; EEA, 2025).

Soil and water contamination further exacerbate environmental health risks. Heavy metals such as arsenic, cadmium, chromium, copper, nickel, and lead, along with pesticides and insecticides from agricultural runoff, contaminate terrestrial and aquatic systems. These pollutants bioaccumulate through food chains and are associated with adverse health outcomes, including cancer, gastrointestinal disorders, hypertension, neurological impairments, and renal dysfunction (Gupta et al., 2019). In India, more than 700 districts across 17 states—including Assam, Bihar, Chhattisgarh, Jharkhand, Manipur, Uttar Pradesh, and West Bengal—are recognised as having heavily contaminated water resources (Gupta et al., 2019). Globally, over two billion people lack access to safe drinking water, resulting in unsafe consumption, inadequate sanitation, and poor hygiene practices, which together account for more than 1.4 million deaths annually (CDC, 2025). Contaminated water is a major driver of waterborne diseases such as cholera, typhoid, and diarrhoea, with diarrhoeal diseases remaining a leading cause of mortality among children under five years of age (CDC, 2025). In India alone, approximately 37.7 million people are affected by waterborne diseases each year, a situation compounded by infrastructural deficits, as only about 30% of wastewater is treated in urban areas and nearly 73% of the rural population lacks access to adequate water disinfection systems (Mudur, 2003; Bush et al., 2011).

Climate change acts as a multiplier that amplifies the health impacts of existing environmental stressors. Recent estimates

*Corresponding author: sagarmoy.phukan@terisas.ac.in

suggest that approximately 37% of heat-related deaths globally can be attributed to anthropogenic climate change (Bush et al., 2011). In India, climate-induced heat stress is particularly pronounced in high-density urban areas experiencing rapid population growth and unplanned land-use and land-cover change (LULCC), contributing to the formation of urban heat islands (Ashwini et al., 2024). These localized zones of elevated temperature, combined with changing temperature and precipitation patterns, are also facilitating the geographical expansion of vector-borne diseases, further intensifying public health risks (Bush et al., 2011).

Despite increasing national and global evidence linking environmental degradation to adverse health outcomes, integrative and region-specific assessments remain limited for Assam. Existing studies are often fragmented, focusing on individual pollutants or sectors, thereby constraining a comprehensive understanding of exposure pathways, vulnerable populations, and cumulative health risks. Addressing this gap is essential for informing context-sensitive environmental governance and public health planning. Against this backdrop, the present study maps evidence on major environmental pollutants and their associated public health impacts in Assam. Drawing primarily on published empirical studies and regional assessments, supported by targeted literature synthesis, the study identifies key pollutant sources, exposure pathways, affected demographic groups, and high-risk districts. By consolidating dispersed evidence into a coherent regional overview, the study aims to inform future research priorities and support policy development that aligns public health protection with ongoing infrastructural and industrial development in the state.

2. Materials and Methods

A. Study Site

The study focuses on the state of Assam, located in northeastern India, extending between 89°42′E to 96°00′E longitude and 24°08′N to 28°02′N latitude, and covering a total geographical area of approximately 78,438 km² (ASDMA). Assam is the most populous state in the northeastern region of India, with a population exceeding 31 million distributed across 35 administrative districts (Govt of Assam, 2025).

For descriptive purposes, these districts are commonly grouped into five geographical regions: Lower Assam (11 districts), North Assam (3 districts), Upper Assam (9 districts), Central Assam (5 districts), and the Barak Valley (3 districts) (Govt. of Assam, 2025). Physio-graphically, the state comprises three major landform units. The Brahmaputra Valley forms the dominant feature, extending approximately 1,000 km in length and 80–100 km in width (ASDMA). The Barak Valley in southern Assam represents a smaller but distinct unit, with an average length and width of 40–50 km, separated from the Brahmaputra Valley by the Karbi Anglong Plateau and the North Cachar Hills (Govt. of Assam, 2025). The Karbi Anglong Plateau and North Cachar Hills consist of residual uplands shaped by prolonged erosion and weathering processes associated with the Peninsular Plateau system and are characterised by rugged terrain (Govt. of Assam, 2025).

Assam hosts ecologically fragile riverine, wetland, and forest ecosystems, rendering the state particularly vulnerable to environmental stressors (Deka, 2024). Several studies have highlighted emerging environmental risks, including the degradation of freshwater resources due to pollution, deforestation, and rising water temperatures, particularly within the Brahmaputra Valley (IGNOU, 2024). These pressures pose significant risks to both human populations and ecological systems, raising concerns regarding environmental tipping points and long-term sustainability of water resources in the state.

Fig. 1. Geopolitical map of Assam (Source: Maps of India, 2020)

B. Data Collection

A systematic literature search was conducted to identify peer-reviewed studies examining the relationship between environmental pollutants and public health outcomes in Assam. Two major academic databases; Scopus and Google Scholar were searched using the Boolean string: "Environmental Pollutants" AND "Public Health" AND "Assam." Articles were screened using the following inclusion criteria:

1. The study explicitly addresses human health impacts arising from physical environmental degradation due to environmental pollutants within Assam.
2. The environmental degradation described establishes a direct linkage between pollutant exposure and public health outcomes, rather than indirect or secondary exposure pathways (e.g., food contamination originating outside the state).

The Scopus search yielded a total of n = 110 articles, while the first n = 100 results from Google Scholar were retrieved to ensure relevance and manageability. The combined dataset (n = 210) was imported into EndNote for reference management. Following duplicate removal (n = 16), a total of n = 194 unique articles were retained for screening.

Abstract screening was conducted by the author, with support from two independent reviewers to assess relevance and consistency with the inclusion criteria and to minimise potential selection bias. Discrepancies in article eligibility were discussed and resolved through consensus. Based on this process, n=56 articles were shortlisted for full-text review. Four articles could not be accessed due to availability constraints. Of the remaining articles, n=15 articles were excluded following full-text assessment for failing to meet the inclusion criteria. The final dataset comprised n=37 articles eligible for detailed analysis. An overview of the data collection and screening process is presented in Figure 2.

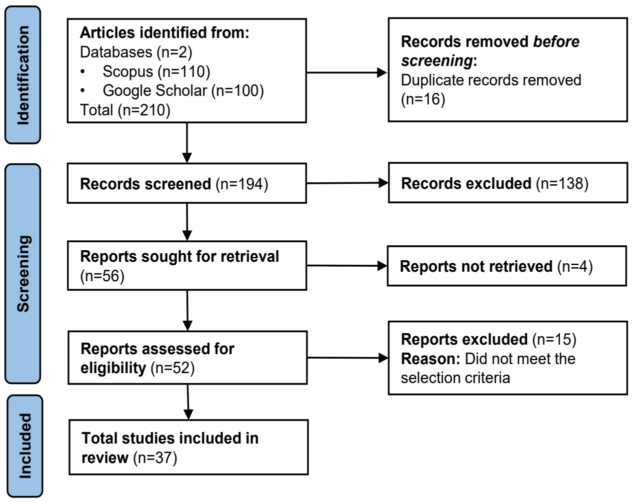

Fig. 2. Flow diagram of systematic search undertaken to identify relevant articles for the review

C. *Data Extraction*

Data extraction was undertaken using a qualitative deductive coding approach. Deductive coding is a structured, top-down method that applies predefined codes informed by existing theories, frameworks, or research objectives to systematically analyse qualitative data. This approach was selected to ensure consistency and analytical focus across studies.

A codebook was developed in Microsoft Excel specifically for this review, derived directly from the study objectives and conceptual framing (Table 1). The codes captured information on pollutant type, source, exposure pathway, health outcome, affected demographic group, and geographical location. Relevant text segments from each article were identified and extracted from the results and discussion sections and recorded in the Excel spreadsheet under the corresponding codes.

D. *Data Analysis*

The analysis aimed to identify major environmental pollutants affecting public health in Assam and to map their exposure pathways, spatial distribution, and affected populations. A systematic qualitative synthesis of the extracted data was undertaken using the predefined coding framework.

For Objective 1, articles were first categorised according to the type of environmental pollutant and its source based on information provided in the abstracts. This classification was then consistently applied across the full texts. Relevant text segments reporting pollutant concentrations, exposure mechanisms, and associated health outcomes were identified and synthesised to map linkages between pollutants and public health impacts.

For Objective 2, spatial information relating to districts or sub-regional locations was extracted to assess the geographical distribution of pollutants and associated health risks. Where available, demographic characteristics of study populations were recorded to identify vulnerable groups within the state. All extracted qualitative data were systematically organised in Excel to facilitate cross-comparison and thematic synthesis.

3. Results and Discussion

A. *Overview*

The systematic review identified 35 peer-reviewed studies published between 1999 and 2025, indicating a gradual but uneven development of evidence on environmental pollutants and public health in Assam. Three principal exposure pathways were identified: contaminated water and soil (n=27), air pollution (n=5), and climate-related processes (n=2), with one cross-sectional study addressing all three pathways. The literature is therefore strongly skewed towards water- and soil-mediated pollution, particularly heavy metal contamination. The predominance of water and soil studies reflects both the severity of groundwater-related risks in Assam and the relatively greater availability of hydrogeochemical data. In contrast, limited attention to air pollution and climate health linkages suggests persistent constraints related to data availability and resolution, especially for long-term and spatially explicit analyses.

Across the reviewed studies, environmental pollutants were rarely linked to singular sources. Instead, multiple interacting drivers including geogenic processes, anthropogenic activities, and climate variability were commonly reported to cause

Table 1
Code guide for data extraction from the selected articles. (n=number of articles)

Codes/Objectives	**Objective 1: Identify critical environmental pollutants and their sources affecting public health in Assam**	**Objective 2: Map the impacted public and regions from environmental pollutants in Assam**
Environmental Pollutant (n=37)	Type of pollutant reported (e.g., arsenic, $PM_{2.5}$, heavy metals, pesticides)	-
Source of Pollutants	Reported sources of pollutants (e.g., industrial discharge, vehicular emissions, agricultural runoff)	
Health Impacts and Risks (n=37)	Reported or inferred public health outcomes associated with pollutant exposure	-
Demographic Information (n=34)*	-	Identification of vulnerable or high-risk population groups.
Geographical Focus (Area/Districts) (n=37)	-	Spatial distribution of pollutants and associated health impacts across Assam

**Not all studies reported demographic information; hence, the sample size varies across code categories* pollution. For example, poor waste management contributed to both soil and air contamination, while flooding and hydro-climatic variability exacerbated groundwater contamination, sanitation challenges, and vector-borne disease risks.

In total, 24 distinct environmental pollutants were identified across the studies. Arsenic was the most frequently examined pollutant (10 studies), reflecting its significance as a major public health concern in the state. Assam has the highest number of arsenic-affected districts in India, with groundwater contamination attributed to both geogenic conditions and anthropogenic interventions, including intensive groundwater extraction and land-use change (Arun & Premkumar, 2021). Spatially, the studies covered multiple districts across Assam, with recurrent focus on Brahmaputra floodplain districts, tea-growing regions, riverine islands, and urban centres. District coverage was uneven, with several areas appearing repeatedly as contamination hotspots, while others were sparsely represented.

Reported health impacts included chronic toxicity and carcinogenic outcomes, neurological and developmental effects, respiratory morbidity, vector-borne diseases, and child growth and nutritional outcomes. Vulnerable populations particularly rural households reliant on shallow groundwater, children, tea garden workers, indigenous communities, and urban slum populations were consistently highlighted across districts.

B. Key Environmental Pollutants and their Health Impacts in Assam

1) Contamination of Soil and Water

The reviewed literature indicates that soil and water contamination in Assam arises primarily from unregulated industrial discharges, municipal solid wate dumping, agricultural runoffs, and geogenic processes. Exposure pathways are dominated by surface water bodies (rivers, streams, ponds, wetlands) and shallow groundwater aquifers, which are widely used for drinking and domestic purposes. Several studies report extensive use of pesticides and fertilisers during cropping seasons, with contaminants mobilised into soil and groundwater through rainfall and irrigation.

Arsenic was the most frequently reported pollutant. Across studies, an average of 53% of sampled sites exceeded the WHO guideline value of 10 µg/L. High exceedance rates were reported in districts such as Golaghat (67%; Chetia et al., 2011) and Majuli (80%; Goswami et al., 2019), although spatial variability in exposure risk was evident (Nath et al., 2022). Chronic arsenic exposure in Assam has been associated with skin lesions, pigmentation, keratosis, cardiovascular disease, neuropathy, gastrointestinal distress, cancers (skin, bladder, lung), and adverse cognitive and developmental outcomes in children (Dutta et al., 2022; Ganesh et al., 2020; Goswami et al., 2019; Gupta and Singh, 2019; Jena, 2018; Nath et al., 2022; Sarma and Saikia, 2021).

Iron (n=6) was the second most contaminant and frequently co-occurred with arsenic. This association has been attributed to the adsorption of arsenic onto iron hydroxides in alluvial sediments (Chetia et al., 2011). Approximately 86% of sampling sites exceeded the WHO guideline value of 0.003 mg/L, with mean concentrations of 0.0657 mg/L in Majuli and 0.03–0.05 mg/L in the Barak Valley districts (Goswami et al., 2019; Gupta and Singh, 2019). Elevated iron exposure has been linked to hemochromatosis and associated liver, cardiac, and pancreatic disorders, as well as fatigue and gastrointestinal symptoms (Singh et al., 2020), although none of the reviewed studies conducted direct health impact assessments.

Fluoride (n=4) contamination was reported at marginally elevated levels across several districts, with Karbi Anglong identified as the most affected. Hanse et al. (2019) reported exceedances in 20% of samples from this district, whereas fluoride levels in tea gardens of Darrang were within permissible limits (Borah et al., 2009). Chronic fluoride exposure poses risks of dental and skeletal fluorosis (Dutta et al., 2022).

Other water contaminants included copper, manganese, cadmium, zinc, lead, and aromatic hydrocarbons (n = 2) (Chakrabarty et al., 2011; Sahariah et al., 2015). These pollutants are commonly associated with municipal solid waste (MSW) leachates, particularly in urban centres such as Guwahati, Tezpur, and Silchar. MSW not only contaminates soil and water but also creates breeding habitats for disease vectors, contributing to illnesses such as malaria (Dutta et al., 2022; Handique et al., 2016), and generates psychosocial stress and reduced quality of life among populations living near dumpsites (Gogoi and Sharma, 2013).

In rural areas, soil contamination was primarily attributed to intensive use of organochlorine and organophosphate pesticides (e.g., endosulfan, dicofol, ethion, DDT, lindane, HCH) and fertilisers (Dey et al., 2013; Hazarika and Hazarika, 2013; Mishra and Sharma, 2011a). Biomonitoring studies detected substantial pesticide residues in human blood samples, particularly in Nagaon and Dibrugarh, indicating significant bioaccumulation (Mishra and Sharma, 2011a). Additionally, coal mining and oil drilling activities have contributed to soil and water contamination through acid mine drainage and metal mobilisation following rainfall events (Choudhury et al., 2021).

2) Polluted Air

Only n=5 studies examined air pollution and related health impacts in Assam, addressing both outdoor and indoor exposures. Outdoor air pollution was primarily associated with oil drilling activities, which emit suspended particulate matter, respirable suspended particulate matter, sulphur dioxide, and nitrogen dioxide. Exposure to these pollutants was associated with altered liver enzyme profiles, including elevated alanine transaminase (ALT) and aspartate transaminase (AST) and reduced alkaline phosphatase (ALP), indicating potential hepatocellular injury (Dey et al., 2015).

Indoor air pollution studies focused largely on children and women, particularly in low-income settings. Two studies reported a high prevalence of acute respiratory infections (ARI) among children in Guwahati and Tinsukia (26.22% and 39%, respectively), with the highest burden among children under five years of age (Islam et al., 2013; Phukan et al., 2022). Key exposure pathways included overcrowding, inadequate ventilation, attached kitchens, and biomass fuel use. Biomass combustion was further linked to eye infections, musculoskeletal strain from fuel collection, and elevated long-term cancer risk among women (Sarmah et al., 2014). These impacts were most pronounced in economically disadvantaged urban and rural populations.

Other indoor pollutants were examined by Gohain et al. (2020), who identified trace metals originating from soil and street dust, deteriorating wall paints, and vehicular emissions within residential buildings at Tezpur University. However, measured concentrations were below established risk thresholds.

3) Climate Change

Only two studies explicitly examined climate-related health impacts in Assam (Borah et al., 2013; Ashwini et al., 2024). Both reported that land-use change and urban expansion, particularly the replacement of vegetation with impervious surfaces, have increased land surface temperature and altered rainfall patterns. These changes were associated with thermal discomfort in Silchar and an increased incidence of Japanese encephalitis in Dibrugarh, highlighting emerging climate-sensitive health risks in the state.

C. Key Impacted Districts and Communities

The selected studies spanned a wide range of districts across Assam, encompassing both rural and urban contexts. Of the n=36 articles reviewed, n=8 focused exclusively on urban settings, n=13 on rural settings, and n=15 examined combined rural and urban contexts. Table 3 presents a district-wise synthesis of key environmental pollutants and associated health outcomes reported across the reviewed literature.

Across districts, the evidence consistently indicates that children and women, particularly from rural, tribal, and socio-economically marginalised communities, bear a disproportionate burden of environmental health risks. Children (under five and school-aged) emerged as the most vulnerable demographic to heavy metal exposure, especially through contaminated drinking water and soil, with reported outcomes including dermatological manifestations, neurodevelopmental impacts, and gastrointestinal morbidity (Dutta et al., 2022; Goswami et al., 2020; Jena, 2018; Nath et al., 2022). Women, especially those residing in rural areas and tea-garden communities, were reported to have substantially higher vulnerability compared to their urban counterparts.

Dominant pollutant exposure pathways included indoor air pollution from biomass fuel use and occupational and environmental exposure to pesticides in agricultural and plantation settings. Associated health outcomes comprised chronic respiratory conditions, ocular irritation, musculoskeletal disorders, reproductive health issues, and increased cardiovascular risk (Chetia et al., 2011; Gogoi et al., 2015; Goswami et al., 2020; Kalita et al., 2023; Mahanta et al., 2016; Mishra and Sharma, 2011b; Nath et al., 2022; Sarma and Saikia, 2021).

Rural populations, particularly indigenous and tribal communities, were consistently identified as highly vulnerable due to a convergence of lower human development indicators, culturally mediated hygiene practices, limited access to safe drinking water and sanitation, and constrained health infrastructure (Chutia, 2015; Ghosh et al., 2023; Phukan et al., 2022). Several studies also highlighted low awareness and unsafe handling of toxic substances, notably pesticides. Common practices such as storing pesticides within living spaces and the absence of personal protective equipment during

Table 2

Key health impacts, pollutants, and exposure pathways impacting public health in Assam based on the selected articles

Identified Health Impacts	Identified Pollutants	Key Exposure Pathways
Cancer	1. Arsenic 2. Uranium 3. Organochlorines	1. Drinking water 2. Chronic ingestion of pesticides through occupational exposure
Respiratory illnesses a. Acute Respiratory Infection (ARI) b. Asthma c. Chronic Obstructive Pulmonary Disease (COPD)	1. PM2.5 2. NO_2 3. SO_2 4. Pesticides	1. Ambient air pollution 2. Biomass smoke from indoor cooking 3. Poor household infrastructure 4. Occupational exposure
Diarrhoeal disease and GI infections	1. Iron 2. Microbial contamination	1. Drinking from pond water 2. Open defecation (OD) 3. Poor hygiene and sanitation practices
Neurological Disorder	1. Lead 2. Mercury 3. Pesticide	1. Drinking water 2. Occupational exposure
Vector-borne disease a. Malaria b. Japanese Encephalitis		1. Mosquito breeding in stagnant water. 2. Unhygienic waste disposal. 3. Change in land-use pattern. 4. Climate variability
Liver dysfunction	1. PM2.5 2. NO_2 3. SO_2	Long-term exposure to oil drilling polluted sites
Skeletal Fluorosis effects	Fluoride	Ingestion of water high level fluoride in groundwater
Eye infections, burns and cataract	1. Biomass smoke 2. Pesticide	1. Indoor cooking 2. Spraying insecticides without personal protection equipment

Table 3
District-wise distribution of key health impacts and affected communities in Assam

District	Key pollutants / environmental stressors	Health Impacts	Affected Communities
Baksa	Vector proliferation linked to foothill ecology and land use	Acute febrile illness, anaemia, fatigue; increased malaria incidence	Rural and tribal populations in foothill areas; agricultural workers; children and pregnant women
Bongaigaon	Arsenic and iron in groundwater from Holocene alluvium	Arsenicosis, skin lesions, keratosis, gastrointestinal distress, increased cancer risk	Rural households dependent on shallow tube wells; economically weaker sections
Cachar	PM2.5, ozone, municipal solid waste, urban heat island effects	Respiratory morbidity, long-term cardiopulmonary risks, degraded urban environmental quality	Urban population of Silchar; residents of high-density neighbourhoods
Darrang	Arsenic, iron, lead, fluoride in drinking water	Neurodevelopmental effects (Pb), arsenicosis, gastrointestinal morbidity, dental caries	Tea garden workers; rural households using tube wells and ring wells
Dhemaji	Iron, manganese, fluoride; indirect environmental deprivation	Neurological effects; child undernutrition, stunting and wasting	Rural households; children (3–6 years) enrolled in Anganwadi centres
Dibrugarh	Vector breeding due to flooding and paddy cultivation; faecal contamination; pesticides	Japanese Encephalitis; waterborne diseases; neurological and carcinogenic risks	Farming communities; households with pig rearing; rural and peri-urban residents
Golaghat	Arsenic, iron, manganese in groundwater; pesticide exposure	Chronic arsenicosis, neurological impairment, skin lesions, cancers	Rural households relying on tube wells; tea-growing and agrarian communities
Jorhat	Arsenic in groundwater; microbial contamination; indoor air pollution; occupational stressors	Developmental effects in children; gastrointestinal disease; respiratory morbidity; musculoskeletal strain	Slum residents, tea garden workers, rural households; school-age children; women engaged in post-harvest work
Kamrup (incl. Kamrup Metro)	Arsenic, manganese, iron, lead, cadmium; indoor biomass smoke	Arsenicosis, cardiovascular and neurological effects; acute respiratory infections	Urban and rural households using shallow aquifers; slum populations; children
Karbi Anglong	Fluoride from granitic aquifers (deficient and excess zones)	Dental caries (low F); dental and skeletal fluorosis; thyroid and renal effects	Predominantly rural population; children most vulnerable
Karimganj	Arsenic in shallow alluvial aquifers	Skin lesions, keratosis, cancers, cardiovascular effects	Rural and peri-urban households dependent on tube wells
Kokrajhar	Vector breeding in foothill and agricultural landscapes	Febrile illness, anaemia, fatigue; malaria risk	Tribal and rural populations; agricultural workers
Lakhimpur	Iron, manganese, fluoride in floodplain aquifers	Neurological effects; fluorosis; renal and hepatic stress	Rural populations dependent on shallow groundwater
Nagaon	Organochlorine pesticides (DDT, HCH, lindane)	Endocrine disruption, neurological disorders, reproductive toxicity, cancers	Rural and urban residents; agricultural households
Sivasagar	Iron, manganese, nickel from floodplain geology	Neurological disorders; hepatic and renal toxicity	Rural households relying on groundwater
Sonitpur	Iron, lead, chloride, trace metals from agricultural runoff and river systems	Haemochromatosis risk; cardiovascular and renal stress	Rural and peri-urban populations; students and residents near Tezpur
Tinsukia	Acid mine drainage, heavy metals, indoor biomass smoke	Chronic respiratory disease; dermatological and gastrointestinal effects; childhood pneumonia	Coal-belt communities; char area households; under-five children, tribal populations
Udalguri	Arsenic contamination; vector-favourable foothill ecology	Chronic arsenic-related morbidity; high malaria incidence	Rural and tribal populations; children and women

application were reported, substantially increasing exposure risks among farming households (Gupta and Singh, 2019; Mahanta et al., 2016; Nath et al., 2022).

In urban contexts, environmental health risks were concentrated among economically disadvantaged populations, particularly those residing in informal settlements and slums. These communities exhibited elevated risks of acute respiratory infections, diarrhoeal diseases, and vector-borne illnesses, driven by overcrowding, intermittent water supply, inadequate sanitation, solid waste accumulation, and untreated sewage, which together create localised exposure hotspots (Hazarika, 2015; Islam et al., 2013; Singh et al., 2020).

Finally, populations residing in proximity to industrial activities, including coal mining and oil drilling operations, were identified as facing distinct exposure risks. Long-term residents near oil extraction sites demonstrated altered liver enzyme profiles, indicative of hepatocellular injury and systemic toxicant exposure, underscoring occupational and environmental health vulnerabilities in these districts (Choudhury et al., 2021; Dey et al., 2015).

4. Conclusion

This systematic review highlights critical gaps that constrain the effectiveness of environmental health interventions in Assam, reflecting both operational and deeper structural limitations. The evidence base is largely composed of cross-sectional studies conducted in localized areas, restricting understanding of temporal health trajectories. Establishing longitudinal cohort studies is essential to track exposure to health outcome relationships over time, assess cumulative exposures, and enable targeted interventions (Vandenbroucke & Pearce, 2012). A key constraint for such studies is the absence of real-time environmental surveillance systems, which limits early detection and timely response to emerging health risks. Participatory approaches, including citizen science methodologies, offer a pragmatic solution, enabling community-based data collection and real-time monitoring (Kullenberg & Kasperowski, 2016). Such approaches have proven effective in public health contexts, including infectious disease surveillance during the COVID-19 pandemic in Kerala, where community monitoring enhanced detection and accelerated responses (Ulahannan et al., 2020)

The review also identifies significant communication and awareness gaps. Public health research findings often fail to translate into effective risk communication for affected populations. Unsafe practices, such as storing and applying pesticides without protective equipment or persistent open defecation due to cultural norms and inadequate sanitation facilities, remain prevalent despite known risks (Sai et al., 2019; Atreya et al., 2021). Interventions must address behavioural and cultural dimensions, including gender considerations, as the review shows that women disproportionately while being among the most impacted demography.

Policy and governance gaps further constrain environmental health outcomes in Assam. National programmes, such as the Pradhan Mantri Ujjwala Yojana and Swachh Bharat Mission, face implementation challenges, including affordability barriers, supply chain fragmentation, and cultural preferences for traditional fuels (Bahn, 2023; Singh & Kumar, 2021). The review showed that sanitation infrastructure often suffers from inadequate maintenance and low behavioural uptake, particularly in marginalized populations, such as slum or char area communities. In addition, on-ground experience of the author suggests fragmentation between environmental monitoring agencies and public health surveillance systems, thus limiting the capacity for coordinated, evidence-based policy action.

Addressing these challenges requires integrated, multi-sectoral interventions that are grounded in robust evidence and local context. Government of Assam should enforce stringent industrial and agricultural environmental regulations and strengthen health surveillance systems. Government can also focus in incorporating environmental health into development programs by encouraging policy coordination with health department through culturally appropriate strategies. The current scenario suggests that it is critical to interrupt the cycle of environmental degradation in Assam while advancing health equity in Assam.

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