



Environmental Pollution and Health Hazards after Natural Disasters: A Scoping Review

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ABSTRACT: Pollution not only affects human life, but also exerts potentially perilous effects on earth as well as the atmosphere. Pollutants which may be physical, chemical or biological agents that exert pollution. Any calamitous occurrence which is natural driven rather than human-generated, cause great loss to not only human life, but also destruction of natural resources, which is termed as natural disaster. Natural calamities like cyclone, flood, drought, heat wave, landslide and tsunami can contribute to substantial amount of pollution. Cyclones and floodwater carry hazardous chemicals and pollutants from industrial sites like lead, arsenic, asbestos, etc. harmful pesticides from agricultural areas, and waste water or sewage from household region to nearby water resources affecting aquatic life as well as wildlife. Drought and landslides lead to release of unanchored soil causing dust storms and exposure to various air pollutants. According to the World Health Organization, air pollution accounts for >6.5 million deaths worldwide per annum, equating to 11.6% of all global annual deaths. Similarly, impact of pollution on health holds a larger share in the global scenario as compared to infectious diseases like HIV-AIDS, tuberculosis, Influenza, etc. bio-terrorism, war, illegal drug consumption and alcohol consumption. Economical loss due to traditional pollution was 3.2% of the GDP in India in the year 2000, which fell to nearly 1% in the year 2019. Preventing a natural disaster from occurring may be out of human powers, but taking stringent measures to prevent the aftermath of these disasters can be planned. This scoping review focuses on the impact of pollution on the environment, atmosphere, natural resources and human life, and how calamitous changes like cyclones, floods and droughts as an etiological factor have a greater impact in imparting pollution. This review will help in understanding the after effects of natural calamities on the environment, prevalence of pollution after occurrence of a natural disaster, and various health hazards caused by exposure of pollutants to nature.

Keyword: Cyclone, Diseases, Flood, Natural calamities, Pollution, Pollutants.

INTRODUCTION

Pollution is the introduction of harmful physical, chemical and biological agents into the environment which exerts potentially perilous effects on earth as well as the atmosphere. Pollution has turned into a global menace with planetary threat involving all the countries, being it developed or developing (Kallel *et al.*, 2020). According to Lancet Commission of Pollution and Health, pollution has been a primary etiological factor leading to death of nearly 9 million individuals worldwide since 2015, characterizing it as one of the largest risk factors in the world for causing diseases and untimely deaths (Fuller *et al.*, 2022). Global Burden of Diseases, Injuries, and Risk Factors Study 2019 suggests, increased pollution related mortality is mostly attributed by pollution of air, pollution of water and toxic chemical pollution which occurs as an unintended aftermath of rapid uncontrolled urbanization and industrialization (Chen & Hoek 2020).

Biodiversity loss due to climate change and pollution, all are keenly knit to each other and require urgent attention to check pollution with great emphasis on pollution of air and water as well as pollution by hazardous chemicals to avert pollution-related morbidity (Dutta & Jinsart 2022). Agents which prompt pollution are termed as pollutants (Mathew *et al.*, 2017). Pollutants constitute of particulate matter like PM_{2.5} or PM₁₀, gases such as SO₂, CO₂, NO₃, polycyclic aromatic hydrocarbons, reactive hydrocarbons and volatile organic compounds such as xylene, toluene, benzene, etc. (Xiao *et al.*, 2023). Various toxic chemicals known as persistent organic pollutants (POPs) are present in the environment that affects life directly or indirectly (Rezania *et al.*, 2022). Since they can be transported by air and water, POPs generated in one country can also affect humans and wildlife in another country where they are released. POPs can also abide in the environment by bioaccumulation and pass on from one species to another through the food chain as they are resistant to conventional biodegradation

mechanism (Liu & Hou 2023; Popli *et al.*, 2022). Exposure to modern forms of pollution like ambient pollutants in air, pollution of the ozone layer, subjection to carcinogens, occupational particulate matter, organic and inorganic fumes have substantially increased global death ratio in the last 20 years (Boffetta, 2004). Any calamitous occurrence which is natural driven rather than human-generated, that causes great loss to not only human life, but also destruction of natural resources, public resources and properties is termed as natural disaster (Saeed & Gargano 2022). Weather driven natural disasters include floods, cyclones, famine, drought, wild fires, etc., whereas, Earth-driven natural disasters include volcanic eruptions, tsunami and earthquakes. Natural disasters like cyclone, flood, wildfires and tsunamis can contribute to substantial amount of pollution (Ojuederie & Babalola 2017; Young *et al.*, 2004). High speed wind, heavy rain and flowing water can carry organic and inorganic wastes, large structures, etc. to the natural resources and cause destruction of forests, wildlife as well as aquatic life (Elgendy *et al.*, 2023). According to USGS Coastal and Marine Geology Programme, cyclones can disrupt the natural ecosystem by affecting the native wildlife, aquatic life, plants, insects, birds and mammals endemic to the region (Boldrocchi *et al.*, 2023).

PREVALENCE OF NATURAL DISASTER

As a specific case, the state of Odisha in India is prone to many natural calamities like cyclones, flood, drought, heavy rainfall, landslides, heat waves and hailstorm (Das *et al.*, 2024). Climatically, Odisha is located in the tropical region with south-west monsoon and retreating north-east monsoons determining the climatic conditions in the state. Odisha is also situated in the cyclonic zone. Late monsoon winds and changing climatic conditions culminates to cyclonic wind development in the Bay of Bengal affecting the eastern coastal belt of India. Due to the topography of the region, low channel capacity and drainages system of the rivers, low flood slope, sand banked mouths and heavy rainfall, Odisha is prone to flood like situations round the year. Out of all the natural calamities, the greatest havoc was created by Super cyclone of the year 1999. It created massive loss of human life and property affecting nearly 12 districts, 97 blocks, twin cities Bhubaneswar and Cuttack and 28 NACs causing devastation of around 1200 kilometers (Khuntia *et al.*, 2021; Mishra *et al.*, 2021).

POLLUTION AND DISEASES AFTER NATURAL DISASTER

Certain type of natural disasters is endemic to specific geographic locations and occurs on a regular basis, like cyclones in Odisha and landslides in the Himalayan region (Jha *et al.*, 2016). Human activities and changing atmospheric conditions create favorable situation of occurrence of natural disasters, and, natural disasters in turn lead to air pollution, water pollution and soil pollution.

Cyclonic storms and overflowing rivers can lead to flood like situation. The aftermath of flooding can be

devastating. Floodwater can affect the landscape as well as the ecosystem by eroding riverbanks; suspended sediments in the water can affect aquatic life and also lead to blooming of algae (Mozo *et al.*, 2021). Standing stagnant water after flood can suit as a propagation area for microbes (Shabarova *et al.*, 2014). Damp soil, damp buildings, furniture, etc. can promote growth of dust mites, microbes, molds, fungi and act as breeding ground for vectors like mosquitoes, cockroaches, flies, etc (Wurster *et al.*, 2022). Cyclones and floodwater can carry pollutants from industrial sites like pesticides, hazardous chemicals from industries, sewage, etc. that not only affects the ecosystem, but, also contaminated the ground water table, watersheds and oceans. Long standing water with harmful chemicals in them cause water acidification (Kularatne *et al.*, 2003). Exposure to this acidified water increases the concentration of reactive oxygen species (ROS) in living organisms, which is one of the important features of carcinogenesis initiation in humans as well as life stock (Nakamura & Takada 2021). Acidification of agricultural fields affects oxygen uptake for photosynthesis in plants as well as nitrogen fixation (Yan *et al.*, 2022). Property damage especially concrete and asbestos possesses a harmful effect on the environment. Broken and wet asbestos pieces can release asbestos fibers to the environment. Exposure of human beings and animals to asbestos by inhalation of asbestos fibers leads to entrapment of the fibers in the lungs, which causes shortness of breath, scarring and inflammation of the tissues and if not eliminated then can initiate carcinogenesis causing cancer of larynx, fibrosis of the lungs, cancer of lungs, pleural thickening, and cancer of ovaries (Clin *et al.*, 2022; Curiel-García *et al.*, 2023). Another important issue which is related to cyclones and floods like situations is damage to waste water system. Strong cyclonic winds and flowing water can damage waste water systems like septic tanks, aerated waste water systems, plastic leach drains and connection pipes (Lin *et al.*, 2013). Mixing of waste water with natural water system can lead to contamination of water by various microorganisms like viruses, bacteria, fungi, amoeba, etc. Lack of sanitation and unsafe water can increase prevalence of diseases like cholera, diarrhea, schistosomiasis and helminthiasis, can cause skin diseases and also lead to carcinogenesis in humans (Morris, 1995). Adverse effect of water pollution on health is one amongst the prominent parameters of morbidity as well as mortality in developing and under developed countries (Cantor, 1997).

As per reports by World Health Organization, lack of clean drinking water attributes to 80% of the world diseases and 50% of world's child death (Lin *et al.*, 2022). Using contaminated water for drinking or other day to day activities is linked with transmission of preventable diseases like amoebic dysentery, diarrhea, cholera, typhoid, hepatitis A, etc. Natural presence of chemical elements in water like chlorine, sodium, fluorides have health significance, but presence of excessive inadequate harmful chemicals like lead, arsenic, chromium, potassium, benzene, etc. can have serious implications on health (Li *et al.*, 2023). In the

year 2021, 251.4 million people were treated for schistosomiasis, a disease caused by parasitic infestation of drinking water according to reports by World Health Organization (Hong *et al.*, 2024). Spoiled food, waste from septic tanks, agricultural wastes, organic wastes, dead livestock, animal and human carcasses require proper disposal to prevent contamination of natural resources and ground water table. Long standing organic wastes if not disposed properly will be decomposed naturally (Perera *et al.*, 2023). Natural decomposition process creates an unhygienic environment and emits foul odor by releasing methane gas into the atmosphere. Methane is a common natural gas present in earth's atmosphere, but, high levels of methane when inhaled can decrease oxygen saturation level in the body. Decreased oxygen saturation on the other hand creates breathlessness, slurred speech, nausea, vomiting, memory loss, vision loss and unconsciousness. Minimal exposure to methane gas on a daily basis can have a significant effect on the mental health. Prolonged exposure to methane gas is associated with respiratory distress, gastrointestinal disorders, cardiovascular issues, euphoria, coma and even death (Mendoza-Cano *et al.*, 2023; Triantafyllou *et al.*, 2014). Microorganisms involved in the process of putrefaction are not pathogenic, but, contamination of soil and water bodies by decomposed tissues can lead to gastroenteritis (Hoegenauer *et al.*, 2022). Various agents related to water pollution and diseases caused by them are illustrated in Fig. 1.

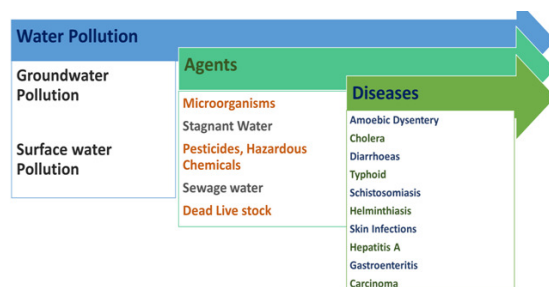


Fig. 1. Illustration of types of water pollution, agents causing water pollution and diseases related to them.

The health effects of drought are more indirect and occur after long-term exposure as compared to other natural disaster like floods, cyclones, etc. Drought and unanchored soil can lead to dust storms and cause exposure to various air pollutants (Chandrappa & Chandra Kulshrestha 2015). Ambient pollutants along with occupational pollutants can be an etiological factor for various life-threatening diseases, some of which namely lung cancer, pulmonary diseases, chronic kidney diseases, etc. Ambient pollutants especially particulate matter (PM_{2.5}) caused by combustion and occupational pollutants like lead, asbestos, carbon, etc. are related to lung and respiratory diseases, and was accountable for nearly 4.9 million deaths in 2019 (Pozzer *et al.*, 2023). It carries increased risk of detection and death due to lungs cancer, as well as hinders development and proper functioning of lungs in children. According to the World Health Organization, pollution of atmosphere reckons for >6.5 million mortalities across the globe per annum, accounting to

11.6% of all worldwide annual deaths (Borchert *et al.*, 2023). Occupational respiratory diseases due to work place exposure include Chronic Obstructive Lung Disorder (COPD), idiopathic pulmonary fibrosis, lung carcinoma, and granulomatous diseases like sarcoidosis, malignant mesothelioma, pulmonary alveolar proteinosis, pneumoconiosis, tuberculosis, work-related-asthma (WRA), chronic bronchitis, and hypersensitivity pneumonitis (Blanc *et al.*, 2019; Calaras *et al.*, 2024; Rieder, 2020) various agents related to air pollution and diseases caused by them are illustrated in Fig. 2.

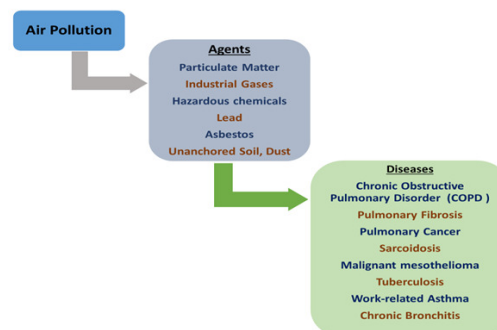


Fig. 2. Illustration of air pollution, agents causing air pollution and diseases related to them.

Similarly, harmful chemicals are now widely disseminated in the living world due to increased manufacturing rate and improper disposal. More than 200 types of chemicals like lead, arsenic, organophosphates, methylmercury, polychlorinated biphenyls, etc. are known to possess neurotoxic effects. Lack of disposal facilities and occurrence of natural calamities like flood and cyclones causes dispersion of these toxic chemicals to water bodies as well to underground water table leading to water pollution. On an average, greater than 2.6 billion people *i.e.*, nearly 40% of the global population have lack of basic sanitation facilities and more than 1 billion people lack access to clean drinking water (Pandey, 2006). Exposure to toxic chemicals even in low percentage in prenatal as well as postnatal period can lead to infertility and complications in reproductive health (Levine *et al.*, 2017). Water pollution is mainly brought about by agricultural facilities, industries, human wastes, natural calamities and improper sewage disposal. Various toxic chemicals like arsenic, cadmium, chromium are contributors of pollution and can affect human beings, plants and animals if they are released into the aquatic ecosystem without proper treatment (Cheung *et al.*, 1990; Chowdhary *et al.*, 2020). Impact of pollution on health holds a larger share in the global scenario as compared to infectious diseases, terrorism, war, illegal drug consumption and alcohol consumption (Chowdhury *et al.*, 2023). As per Global Burden of Disease 2019, the repercussion of pollution on health varies according to sex. Mortality in men is more likely due to exposure to air pollutants, toxic chemicals and occupational pollutants as compared to female who are more exposed to water pollution (Dhimal *et al.*, 2021).

ECONOMIC IMPACTS OF POLLUTION AFTER NATURAL DISASTER

Economic development and per capita income took off with industrialization. But increased pollution can also affect the economic development by work absence, reduced productivity, decreased work efficiency due to health issues and decreased labor due to premature deaths. In 2019, air pollution in India resulted in economic detriment of \$28.8 billion from premature deaths and \$8 billion from morbidity. This total financial damage of \$36.8 billion was 1.36% of gross domestic product (GDP) of India. The economic out-turn of pollution of the atmosphere are especially devastating in Eastern regions of Asia along with Pacific, where economic losses accounts for 9.3% of their GDP, and in Southern part of Asia the losses are nearly equivalent to 10.3% of the GDP. (India State-Level Disease Burden Initiative Air Pollution Collaborators, 2021) Output loss due to conventional pollution was 3.2% of the GDP in India in the year 2000, which fell to nearly 1% in the year 2019.¹ Recurrent cyclones, floods, droughts and other natural calamities have had a significant implication on the economic regression in the state of Odisha. These natural calamities have caused a significant damage of property, natural resources and human life affecting all round social and economic development of Odisha (Das *et al.*, 2024).

ADDRESSING POLLUTION, NATURAL DISASTER AND POLLUTION RELATED DISEASES

India with massive pollution and its effects has been asserting considerable efforts in monitoring pollution and reducing its effects. It has forged many equipment and regulatory measures to control pollution, but, lack of centralized control system has contributed towards decreased substantial results (Ganguly *et al.*, 2020). A proper waste disposal system should be followed after occurrence of natural calamities to reduce health hazards following it. Industries should follow an efficient storage system for toxic gases and hazardous chemicals to limit their exposure after a disaster. Decontamination of water bodies by spraying bleaching powders and chlorine can to some extent prevent growth of microbes like viruses, bacteria, fungi, vectors like mosquitoes, flies and cockroaches in them. Switching over from inorganic hazardous chemical pesticides to organic fertilizers will reduce poisoning of water bodies after flood like situation. Afforestation not only prevents desertification, but also improves quality of air by preventing air pollution and managing carbon levels in the atmosphere. Flood like situations can be avoided by implementing proper water flow management and preserving embankments by planting more trees in river banks and preserving forest to prevent them from eroding. Extensive tree plantation, proper irrigation system and grassland extension can have a positive implication in preventing desertification and subsequently avoiding drought like situation to a larger extent (Stern *et al.*, 2023).

FUTURE SCOPE

Preventing a natural disaster like flood, cyclone, drought, etc from occurring is not under human control, but taking stringent measures for preventing the aftermath of these disasters can be planned. Natural disaster not only affects the environment, but, also leads to introduction of various microbes, dusts and pollutants to the surrounding. Knowledge and understanding of various pollutants causing air, water or soil pollution and awareness about after effects of these pollutants on human beings leading to various health hazards can help in reducing clinical features of these diseases as well as preventing death due to these diseases to some extent.

CONCLUSIONS

Preventing a natural disaster from occurring may be out of human powers, but taking stringent measures to prevent the aftermath of these disasters can be helpful. Proper manpower, regular training and effective post-calamitic handling measures can to some extent help in reducing pollution and contamination of natural resources like soil and water bodies after natural calamities. An efficient and in advance weather forecasting system as well as cogent disaster management system can help in preserving human life, wildlife, decrease livestock destruction and reduce the burden of organic waste after a disastrous event.

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