Pollution and Public Health: A Comprehensive Overview

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Abstract

A significant worldwide problem, environmental pollution is caused by human activity that affects the quality of the air, water, soil, noise, and light. Essential resources are contaminated by pollution from urbanization, industry, and agriculture, which leads to various health problems like cancer, neurological disorders, infectious illnesses, and asthma. In low- and middle-income countries, majority of pollution-related deaths are caused by air and water pollution, the effects are more acute. Light and noise pollution also have an impact on cognitive function and mental wellness. It is expected that pollution-related issues would worsen as urbanization and industrialization increase, demanding immediate action to safeguard the environment and public health. Early human development is also impacted by air pollution, which raises the risk of cardiovascular and mental illnesses. Each year, 1.8 million people lose their lives to waterborne diseases, primarily diarrheal ones, which are made worse by polluted water and inadequate sanitation, particularly in countries with lower incomes. Scabies and typhus are examples of water-washed illnesses that are prevalent in places with little access to freshwater. In some areas, increased incidences of cancer have been linked to soil contamination and pollution. Pregnant women, young children, and the elderly are among the vulnerable populations who are most at danger from air and water pollution. Pollution control techniques include sustainable drainage systems, improved waste management, and public health regulations are examples of mitigation tactics.

Keywords: Pollution, Public Health, Diseases, Control Measures

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Introduction

The release of toxic compounds into the environment that have a negative impact on ecosystems, human health, and other living things is known as pollution. It includes the discharge of waste of human origin into the air, land, water, and seas, sometimes with little consideration for the long-term effects. The health of people and the earth is seriously threatened by this occurrence. With an estimated 9 million deaths each year, or 16% of all deaths worldwide three times the combined number of deaths from AIDS, TB, and malaria it is the world's biggest environmental cause of disease and premature mortality (Landrigan et al., 2017). More than 25% of mortality rates in the most affected nations are due to pollution. Children are particularly susceptible to the damaging effects of pollution (Suk et al., 2016).

Significant environmental degradation is caused by human activity, which contaminates important resources including soil, drinking water, and air all of which are necessary for plant and animal life. Human activities are the main causes of environmental contamination (Nadal et al., 2016). One of the most important sources of pollution in the world nowadays includes toxic chemicals. Pollution can take many different forms, such as freshwater pollution, ozone, Sulphur and nitrogen oxides, and tiny particulate matter contaminating the air.

While the Industrial Revolution marked a significant turning point in technological advancement, society, and the provision of various services, it also led to the widespread production of pollutants harmful to human health. Undoubtedly, environmental pollution became a global issue as a result, scale has become a major public health concern with several aspects. Social, economic, legislative, and lifestyle aspects are all intricately linked to this problem. Urbanization and industrialization are growing at a rate that is unprecedented and alarming on a global scale in the modern age (WHO, 2019).

Pollutants are compounds that contaminate and degrade the environment, whether they are man-made or naturally occurring. These pollutants, which might be gases, liquids, or solids, are created in quantities higher than usual and have a negative impact on the environment. Harmful elements (PHEs) such as lead (Pb) and mercury (Hg) are prominent examples of harmful contaminants. Children around the world are especially susceptible to the negative consequences of environmental pollution since even small amounts of exposure can cause permanent abnormalities and, in certain situations, early death (Kumar et al., 2017).

Numerous health problems, particularly infectious diseases like cholera and typhoid, which are mostly waterborne, have long been associated with environmental pollution. Furthermore, environmental pollution has been linked to non-communicable diseases (NCDs), such as asthma, cancer, and genetic disorders. The negative health impacts of pollution are particularly severe in low-income countries, where it is estimated that 90% of pollution-related deaths occur. In these regions, air and water pollution are the primary sources of environmental contamination (Xu et al., 2018). Pollution and its health and environmental effects are given in Fig. 1.

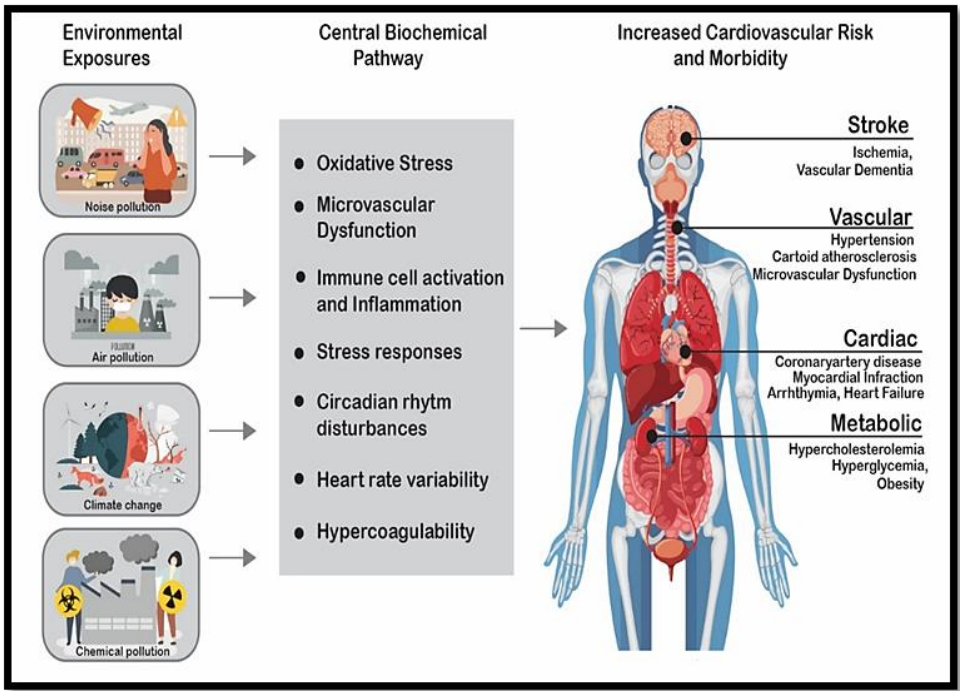

Fig. 1: Pollution and its effects on Human Health

Urbanization and industrialization have increased to the levels that rarely seen in the modern era, having a substantial negative influence on the environment and world health. Anthropogenic air pollution is one of the greatest threat to global public health, with an estimated 9 million deaths annually. Air pollution is defined as the detrimental consequences that arise from any cause that leads to environmental or atmospheric disturbance (Azam et al., 2016). Although pollutants can come from a number of sources, burning fossil fuels is root cause of air pollution. Regarding human health, air pollution can cause or worsen death, severe disease, and present and future risks to people's health (Lancet, 2016).

The source, chemical nature, severity, and indoor or outdoor origin of air pollution are frequently used to classify it. According to a source-based approach, there are two main types of air pollution: anthropogenic and natural, as well as stationary and mobile. Natural pollutants are directly emitted from natural sources, such as forest fires, volcanic eruptions, dust storms, pollen grains, radon gas (from the radioactive break down of the Earth's bedrock), microorganisms, natural radioactivity, fog, mist, and ozone (Appannagari, 2017).

Additionally, air pollution has detrimental effects on early human development, including perinatal, mental, cardiovascular, and respiratory issues that might result in newborn mortality or chronic adult diseases (Kelishadi & Poursafa, 2010). Concerns about water quality are linked to many of the global challenges humanity faces in the twenty-first century. It is anticipated that the impacts of climate change will exacerbate the contamination of freshwater resources such as lakes, rivers, and groundwater worse in the future. Rising water temperatures, glacier melting, and water cycle modifications are some of these factors that contribute to an increase in floods and droughts (Huntington, 2006).

Over one-third of the global population faces poor sanitation and limited access to safe drinking water, which are among the most visible and severe impacts of water pollution on human health. It is expected that chemical pollution of natural water sources has grown to be a major global public problem, given the majority of these activities result in water contamination by a variety of synthetic and naturally occurring chemicals. According to a 2009 Gallup poll, the top environmental problem in the US was drinking water pollution. Hypoxia, eutrophication, bioaccumulation, and the spread of pathogens within aquatic ecosystems are among the environmental problems caused by the untreated discharge of hospital waste, fertilizers, pesticides, potentially hazardous metals, industrial waste, and other organic pollutants into water bodies (Rath & Patra, 2018).

Numerous studies have shown that drinking and agricultural water frequently contains bacteria resistant to antibiotics, which poses serious health hazards to people. Wastewater is the principal source of antibiotics in the environment. Three main pathways allow antibiotics to enter water bodies: insufficient wastewater treatment, agricultural runoff, and inappropriate disposal of unneeded antibiotics. Although trace levels of potentially harmful metals are necessary for a number of physiological and biochemical processes in humans, animals, and plants, high concentrations in groundwater can cause a number of major health problems. These include high blood pressure, lung cancer, memory issues, depression, liver cirrhosis, hair loss, renal failure, gastrointestinal diseases, diarrhea, stomatitis, tremors, haemoglobinuria, pneumonia, raised blood pressure, and neurobehavioral disorders (Chowdhury et al., 2016).

Particularly in metropolitan areas, mining regions, industrial zones, and areas impacted by war operations, soil contamination, and in particular the presence of heavy metals, has serious health consequences (Tepanosyan et al., 2018). Also, long term accumulation of heavy metals in the body may result in slowing the progression of physical, muscular and neurological degenerative processes that mimic certain diseases such as Parkinson's disease and Alzheimer's disease (Monisha et al., 2014).

A higher incidence of chronic illnesses like diabetes, cancer, and asthma has been associated with the usage of pesticides in agriculture. Furthermore, those exposed to pesticides frequently experience short-term health problems as headaches, nausea, dizziness, and irritation of the skin and eyes (Kim et al., 2017). An estimated 25 million agricultural laborers are poisoned by pesticides each year. Herbicides like

glyphosate, which is categorized as a carcinogen for both humans and wildlife, have also been acknowledged for its detrimental effects on health. Diseases like cancer and leukemia are linked to radionuclides, which can be naturally occurring or the consequence of human activity (such as nuclear and medical waste) (Mittal et al., 2018).

Through consuming food, skin absorption, or inhalation, humans can be exposed to pollutants, pathogens, and minerals found in soil (Steffan et al., 2018). Inhaling soil particles carried by the wind has been connected to a number of respiratory conditions, such as asthma, pulmonary disease, and pulmonary fibrosis. Furthermore, dust particle like those that contain arsenic raise the possibility of health issues. Skin conditions including rashes and itching can result from skin contact with heavy metal-contaminated soils (Dixit et al., 2015).

Dust exposure is becoming more common in many areas due to human activities such mining, road construction, urbanization, and agriculture (Rahman & Singh, 2019). Heavy metals can enter the food chain due to the large quantities absorbed by plants. This problem has been most noticeable in wastewater-irrigated areas, as well as in farms and gardens close to mining, industrial, and urban areas (Qureshi et al., 2016).

Excessive or detrimental noise levels that disrupt the natural acoustic equilibrium and have a detrimental effect on human health and well-being are known as noise pollution, also known as environmental or sound pollution. It has grown to be one of the biggest environmental hazards over time, mostly as a result of the quick rise of industry and the expansion of transport networks. Both industrialized and developing countries, including Pakistan and India, are affected by this problem (Ravindra et al., 2016). Noise pollution keeps rising in parallel with population density and industrial growth. As a direct result of industrial development, traffic noise has grown to be a global issue. The main causes of noise pollution are anthropogenic activities (Templeton et al., 2016).

Public health is seriously threatened by environmental noise pollution, which is a subcategory of air pollution. It is anticipated that as transportation networks, such as roads, trains, and aeroplanes, grow, they will continue to be major contributors of noise pollution in the environment. Both auditory and non-auditory health problems are among the many consequences of industrial and transportation noise. Hearing loss, psychological issues, hypertension, irregular heartbeats, sleep disruptions, stress, irritability, reduced productivity at work, and trouble understanding speech during talks (Potgieter et al., 2018). Additionally, noise pollution impairs cognitive function and mental health. Children's academic performance and learning capacities may be hampered by high environmental noise levels (Stansfeld & Clark, 2015).

The excessive or improper use of artificial light, known as "light pollution," poses serious environmental problems that have an impact on people, wildlife, and the climate. Rapid industrialization and urbanization have made this new problem worse. According to research, light pollution is expected to grow at a pace of 2.2% each year in the near future (Kyba et al., 2017). Lamps and ceiling lights that emit white light, as well as gadgets like computers and cellphones that emit blue light, are common causes of light pollution. Particularly concerning has been the use of Light Emitting Diodes (LEDs), whose global market share has grown from 5 to over 60% in the past ten years and is expected to reach 80% by 2025 (Gaffuri et al., 2021).

In the last few decades, light pollution has become a major problem for health (Davies & Smyth, 2018). Currently, various forms of light pollution impact over 80% of the global population, disrupting the body's natural circadian rhythms, which regulate hormone production, sleep-wake cycles, and other physiological functions are disturbed by light pollution. From sleep issues to more serious illnesses including cancer and mental disorders, the variety of possible health effects has grown (Clarke et al., 2021).

Artificial light exposure, especially at night, has also been connected to cognitive impairment, including problems with concentration and memory, and symptoms of depression, all of which are closely related to mood disorders (Siraji et al., 2022). Weight gain and an elevated body mass index (BMI) are associated with inadequate or erratic sleep patterns, which are frequently caused by light pollution. An increased risk of heart disease, and hypertension disorders frequently linked to metabolic syndrome is also linked to disturbed sleep patterns. Long-term exposure to light pollution can raise the risk of cardiovascular conditions such heart failure and coronary artery disease and contribute to chronic stress (Stevens & Zhu, 2015).

A Swedish cohort research reveals that long-term exposure to air pollution may contribute to the development of diabetes. Furthermore, air pollution has been demonstrated to significantly influence childhood human development, causing respiratory, cardiovascular, mental, and perinatal abnormalities, which can result in newborn death or chronic diseases later in life (Eze et al., 2014).

2. Respiratory and Cardiovascular Diseases from Air Pollution

Air pollution is increasingly acknowledged as the primary environmental cause of early mortality, surpassing both inadequate sanitation and a lack of access to clean water. The most recent WHO estimate states that outdoor air pollution from combined urban and rural sources killed over 3.7 million people in 2012 (WHO 2014). The reasons are as follows: lung cancer (6%), chronic obstructive pulmonary disease (COPD) (11%), ischemic heart disease (40%), stroke (40%), and acute lower respiratory infections in children (3%). Health effects of pollution described in Fig. 2.

3. Waterborne Diseases and Contaminated Drinking Water

Water-borne ailments are illnesses that are spread by drinking water polluted with hazardous germs. When contaminated water is used to produce food, the germs in the water might cause foodborne illnesses when consumed. The majority of waterborne infections are characterized by diarrhea, which causes frequent, voluminous feces, contaminated drinking water can lead to dehydration and, in severe cases, death. The World Health Organization reports that diarrheal diseases account for about 4.1% of the global disease burden and cause 1.8 million deaths annually. Further estimates suggest that 88% of this burden is linked to unsafe water, sanitation, and hygiene practices, particularly affecting children in developing countries (Pruss-Ustun et al., 2008).

Most waterborne infections are spread through the fecal-oral route, which occurs when human feces are ingested through contaminated water or food, often due to poor sewage management and sanitation. Fecal contamination of drinking water can vary in frequency and severity. In areas with low pollution levels, water may not pose a significant threat, and local populations may have relied on the same water source for

generations. However, visitors, young children, the elderly, and those with weakened immune systems are particularly at risk in areas with high pollution. In rural African regions, water pollution often results from runoff from nearby forests and bushes used as open defecation sites. Waterborne illnesses can be caused by protozoa, viruses, bacteria, and intestinal parasites. Key pathogens responsible for these diseases include Cholera, Amoebic dysentery, Bacillary dysentery (shigellosis), Cryptosporidiosis, Typhoid, Giardiasis, Paratyphoid, Balantidiasis, Salmonellosis, Campylobacter enteritis, Rotavirus diarrhea, *E. coli*, diarrhea, Hepatitis A, Leptospirosis, and Poliomyelitis (Cheesbrough et al., 2006).

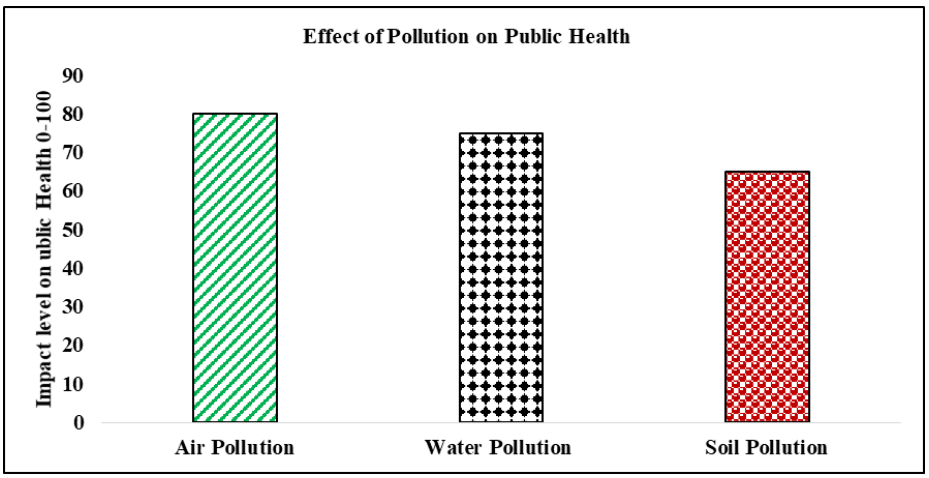

Fig. 2: Effect of Pollution on Public Health

Countries around the world are becoming more concerned about the effects of contaminated drinking water, as waterborne infections are a leading source of sickness and death. Availability to safe drinking water is important for general health and the survival of newborns and children (Vidyasagar et al., 2007). The World Health Organization (WHO, 2005) estimates that over 1.8 million people die each year from diarrheal illnesses, many of which are linked to the ingestion of polluted water and seafood. Persons with weaker immune systems, such as those with AIDS, are more susceptible to waterborne infections, even ones that are normally mild and not hazardous to healthy persons (Kgalushi et al., 2008).

4. Soil Pollution and Food Chain Contamination

Water and soil pollution not only harms food safety, but it also raises health concerns and has been connected to the establishment of "cancer villages." The term "cancer village" refers to a neighborhood with a much higher cancer rate than usual, most likely owing to environmental contamination. This study presents comprehensive data on cancer villages, including details such as village title, place of residence, prevalent ailments, water quality, and pollution sources. The results show that cancer villages are frequently clustered in eastern China, a significant grain-producing region. Extensive environmental contamination, especially water pollution, has been implicated as a primary contributor to the incidence cancer in towns (Liu, 2010).

5. Effects on Pregnant Women

It is unclear what causes pre-eclampsia. However, aberrant placentation, blood vessel damage, inflammation, oxidative stress, and immune system alterations can all contribute to elevated blood pressure and the onset of pre-eclampsia and other hypertensive disorders. These processes have also been proposed as possible paths for dealing with the health impacts of air pollution (Pedersen et al., 2014).

Pregnant women may face greater exposure to the effects of air pollution because of the hazards to fetal development posed by its influence on parental cardiovascular health. Pregnancy causes considerable alterations in maternal cardiovascular and endothelial health. For example, by the thirty-fourth week of pregnancy among first-time moms, plasma volume has increased by 50% but red blood cell mass has increased just little, resulting in physiologic anemia and decreased the thickness of the blood. This causes less inhibition of blood flow and a thrombophilic condition. Although cardiac output rises it is insufficient to counteract the natural vasodilation, which often results in a drop in blood pressure. Considering these modifications to the body, effect of air pollution, blood pressure in pregnant women could vary from those who are nonpregnant ladies. Furthermore, the susceptibility of pregnant women's cardiovascular function to air pollution may fluctuate during pregnancy (Kaaja et al., 2005).

5.1. Effects on Children

It is believed that over half of premature pneumonia-related deaths in children are due to indoor exposure to particulate matter (PM). Indoor pollution, primarily from tobacco smoke (TS), is a major contributor. the combustion of biomass and coal, caused an estimated 4.3 million premature deaths in the same year. Pollution lowers the amount of productive life years in addition to increasing mortality rates. According to a global survey, outdoor pollution caused more than 3% of lost productive life years in 2010, one of the top ten leading causes of disability and death worldwide. Furthermore, contact with smoke from cigarettes, particularly passive smoking, was identified as the second biggest cause of productivity losses in the study (Lim et al., 2012).

Fetuses, babies, and infants are highly sensitive to environmental contamination, especially during these important stages of development (Suk et al., 2015). Pollution exposure in infancy and early childhood can cause long-term harm to cells and tissues, raising the risk of illness in youth and potentially influencing health through lifetime (Barker, 2004).

Early-life pollution exposure poses a considerable risk of undermining attempts to improve children's development through better nutrition, early education, and healthcare is essential. Traditional environmental pollutants, such as coliform bacteria in water and air pollution from solid fuel use and also have been associated to diseases such as diarrhea, pneumonia, and other infectious ailments. On the other hand, current environmental risks are more directly linked to noncommunicable illnesses such as asthma, neurodevelopmental disorders, birth abnormalities, obesity, diabetes, cardiovascular disease, mental health problems, and pediatric cancer (WHO, 2018). Children in rapidly industrializing countries suffer an array of traditional and new environmental health concerns (Laborde et al., 2015).

5.2. Effects on Elderly

As the amount of births decreases and lifespan rises, older individuals make up a higher proportion of the population. Population aging is a tremendous demographic transition, and we must adjust to this new reality. Globally, the proportion of older people aged 80 and more (the "oldest old") among the senior population was 14% in 2013, and it is expected to climb to 19% by 2050. If this tendency continues, there would be 392 million individuals aged 80 and older by 2050, over three times the current figure.

Epidemiological investigations show that health difficulties associated with aging populations impact a rising and extensive section of the worldwide population. The rise in chronic illnesses is one of the century's most important epidemiological trends. Enhancing our understanding pertinent the health impacts of various risk factors is essential, especially for vulnerable groups like the elderly. Long-term illnesses are more common among older persons, and there is proof that already present chronic ailments, such as lung, heart, or circulatory diseases, may deteriorate owing to prolonged exposure to environmental toxins (Goldberg et al., 2013).

Studies shows that being exposed to external air pollution raises the risk of hypertension and other cardiovascular events affect both adults and the elderly (Shah et al., 2013). Research indicates that elevated levels of ambient air pollution negatively impact cardiovascular health, with high blood pressure (BP) being a well-known risk factor for heart disease., researchers have investigated how air pollution affects BP, however the results have been mixed (3-7). The majority of these epidemiological investigations were done on senior adults, regardless of their already present cardiovascular problems (Hooven et al., 2011).

6. Control Measures

Rapid growth in population and higher levels of activity have resulted in a rise in impermeable surfaces throughout many cities. The change of permeability terrain to impermeable surfaces increases runoff volumes, peak flows, and pollution loads. Surface runoff when rainfall washes a higher variety and amount of contaminants off these surfaces, transporting them into drainage systems and downstream aquatic bodies, resulting in considerable non-point source contamination. There are numerous techniques for reducing and handling water contamination. Preventative measures, actual efforts, participation in initiatives or programs, regulation and monitoring, and the implementation of control measures all contribute to reducing or minimizing waste.

To protect the environment, avoid washing your car near drains and never dispose of garbage, chemicals, or solvents in sewage systems. Regularly inspect your septic system every 3–5 years to ensure it functions properly. Reduce the use of pesticides and fertilizers to prevent harmful runoff into waterways. Another option is to either conduct pollution avoidance on your own or participate in pollution control initiatives or programs, many of which are offered by the Environmental Prote ction Agency. Effective pollution control relies on strong oversight and regulation. Many countries have implemented laws to limit different forms of pollution and mitigate their harmful effects. Pollution reduction practices include recycling, reusing, trash reduction, minimizing damage, avoiding damage, and decomposition (Owa et al., 2014).

Conclusion

Pollution is a growing global crisis, responsible for 9 million deaths annually and posing severe hazards to health of People and surroundings. Anthropogenic activities like industrialization, urbanization, and chemical use are the primary contributors, with pollution affecting air, water, soil, and oceans. Vulnerable groups, particularly children, suffer long-term health consequences from minimal exposure. Pollution is linked to non-communicable diseases like cancer, asthma, and cardiovascular conditions, especially in minimal and countries with middle incomes. Air pollution from fossil fuels is a major health risk. Addressing pollution requires global efforts, including stricter regulations, better pollution management, and raising awareness. Water contamination, exacerbated by climate change and poor sanitation, contributes to diseases like diarrhea and antibiotic resistance. Soil pollution, caused by heavy metals and pesticides, leads to chronic diseases. Pollution also affects mental health and sleep patterns.

To mitigate these risks, pollution control, sustainable urban planning, and public awareness campaigns are essential for protecting ecosystems and human health. Effective strategies and global collaboration are needed to ensure a sustainable future.

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