
Consequences of Environmental Pollutants on Human Health

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Abstract

Developing and Developed countries both are continuously facing the challenges to minimize environmental pollution but it is increasing day by day, which causes various chronic and health conditions. Environmental pollution's role in both chronic and acute health conditions is exacerbated by a lack of sufficient and correct data and management in both developing and developed countries. Environmental contaminants, such as air pollutants (e.g. nitrogen dioxide, particulate matter), water pollutants (e.g. chemicals, heavy metals), and soil pollutants (e.g. industrial waste, pesticides), are well-known contributors to diseases like cardiovascular conditions, respiratory illnesses and certain cancers. However, the challenge lies in the inconsistency and inadequacy of pollution monitoring and waste management systems. In developing countries, poor waste management, higher levels of poverty and slow adoption of new technologies exacerbate the risks. The incompetence to systematically quantify and monitor exposure to pollutants makes it challenging to address the root causes of pollution-related health problems. Meanwhile, in developed countries, safeguards often come very late after much harm has occurred reflecting a reactive rather than proactive approach. This paper aims to address a crucial issue by exploring the relationship between environmental toxins and human health. This Paper also discusses how pollutants affect various biological systems on major health concerns.

Keywords: Pollutants, Environment, Human health, Cardiovascular conditions, Respiratory illnesses.

Introduction

Environmental pollutants refer to harmful chemicals which are released into the environment via human activities, such as industrialization or natural events like volcanic eruptions. These pollutants may contaminate water, air, and soil making them a significant concern for public health. When Humans are exposed to these pollutants primarily through inhalation, ingestion, and skin absorption, their metabolic system got disturbed resulting into illness or diseases. The amount of a particular pollutant that enters the body referred as "dose", with its impact depending on the duration and intensity of exposure. High-level exposure and long duration of time to this exposure can lead to serious health problems, even though industrialization plays a key role in a country's development. The balance between environmental health and industrial progress is crucial to protect public well-being. Natural and man-made sources both contribute to Air pollution, introducing hazardous substances into the atmosphere. Automobile emissions, power plants, industrial activities, waste incineration, and volcanic eruptions are major sources of pollution. Severe risks to human health are caused by certain chemicals like sulfurdioxide (SO₂), carbon monoxide (CO), nitrogen oxides (NO_x) and heavy metals. Biological contaminants also pose severe risks to human health. These Chemical and Biological contaminants can lead to broad range of diseases and health conditions which depends on type and level of exposure. For example, exposure to tobacco smoke, which contains harmful chemicals like benzene, cadmium, arsenic, formaldehyde, and nicotine, is a significant cause of cancer, cardiovascular problems, and respiratory issues, not just for active smokers but also for passive smokers. It can also lead to conditions like bronchitis, asthma, eye irritation and throat infections. Biological contaminants such as bacteria, viruses, dust

mites, and pollen can trigger allergic reactions, asthma, and hay fever. Volatile organic compounds (VOCs) cause irritation to the eyes, nose, and throat, headaches, nausea and may adversely affect organs like the liver with long-term exposure. Lead primarily affects the brain and digestive system, and in extreme cases, can cause cancer. Particularly in winter Nitrogen oxides may cause respiratory issues to children. Exposure to Air pollution may lead to short-term symptoms like coughing, headaches, and dizziness to more severe conditions like lung and heart diseases, asthma, and bronchitis. Prolonged exposure can result in neurological damage, reproductive issues, and cancer. Exposure of Ozone leads to respiratory disorders^[1, 2]. Water is an essential natural resource for human uses and health^[3]. Currently the world is facing challenges to solve problems of water pollution. Water pollution is the output of organic and artificial human activities^[4]. The pollutant sources include Agricultural, domestic, industrial, and radioactive waste disposed in water^[5]. The most often discharged material includes cleaning materials, and organic industrial wastes^[6]. Disposal of industrial waste in water causes reproductive failure, immune-suppression etc.^[4]. A very huge amount of pesticides and their intermediate products including triazines and chloroacetanilides have already been found in the rivers of the United States^[7-9]. Chemical fertilizers used to enhance crop productivity contribute to heavy metal contamination in water^[10]. Hepatitis, cholera, Diarrhoea, typhoid, skin problems and kidney problems are waterborne diseases^[11,12]. Anthropogenic sources are responsible for soil contamination, which poses significant health risks due to the presence of various pollutants.

The chemicals from industrial processes, pesticides, fertilizers, untreated sewage, oil spills, and plastic additives are major pollutants for soil contamination. Heavy metals, plastic-derived compounds, phthalates as well as pharmaceuticals and biological contaminants, can enter the human body through inhalation, ingestion, or skin contact. People who live near polluted areas or work with contaminated soil are particularly vulnerable. Most common problems include respiratory issues, headaches, nausea, and skin irritation. Long-term exposure to heavy metals and carcinogenic substances like Poly aromatic hydrocarbons and PCBs, can damage the central nervous system, organs, and may increase the risk of cancer. Prevention and remediation of soil contamination are necessary to minimize these risks, and continuous monitoring of pollutants is crucial, especially with emerging contaminants that are not traditionally tracked^[13]. Lead, polychlorinated biphenyls, Arsenic, and Mercury used in industries referred to as neurotoxic contaminants^[14].

Objective: The objective of this study is to find out the impact of environmental pollutants such as sulphur dioxide, nitrogen dioxide, particulate matter etc. on human health and provide suggestions to promote healthier environments to improve health conditions.

Limitation of the study: There are few limitations of the study 'the consequences of environmental pollutants on human health' is made considering pollutants like air pollution, soil pollution and water pollution in general such as there are many pathways through which humans can be exposed to environmental pollutants, including ingestion, dermal exposure, and mother-to-fetus. It can be expensive and time-consuming to expose large numbers of animals to multiple pollutants at the same time. The relationships between environmental variables and health outcomes are often non-linear, which can lead to inconsistent estimators if not controlled for.

Scope of further study: There are many areas of study that could be further explored to understand the effects of environmental pollutants on human health. Here are some potential research directions within each area:

- 1) Air Pollution- Mitigation Techniques, Monitoring and Exposure Assessment
- 2) Occupational and Medical Exposures-Workplace Pollutant Sources, Immunological Responses

- 3) Interactions with Other Factors- Policy and Regulation, Social Determinants of Health.
- 4) Effects on Vulnerable Populations- Women and Children, Elderly and Immuno-compromised Individuals.

METHODOLOGY AND LITERATURE REVIEW:

Literature review summarizes and analyses primary information created and provided by other academic and professional researchers who studied pollutants and their effects on health.

The review comprises the study in following heads:

1) **Cardiovascular health:** Exposure to pollutants, particularly air pollution for long duration, has been linked to a wide range of illness and cardiovascular diseases (CVDs) accounts for a substantial portion of pollution-related health impacts. Fine particulate matter like (PM_{2.5}), nitrogen dioxide (NO₂), sulfur dioxide (SO₂) and other pollutants are major contributors to cardiovascular health concern. Globally, CVDs account for approximately **17.9 million deaths yearly**, representing about 32% of deaths in all cases, according to the World Health Organization (WHO). More than **75%** of these deaths occur in poor and developing countries, where pollution levels are often higher, and access to healthcare may be limited. The number of deaths due to cardiovascular diseases (CVDs) ascribable to **environmental causes**, particularly air pollution, has been shown to be larger than those ascribable to some of the traditional risk factors like metabolic disorders (e.g., high blood pressure, diabetes), tobacco use, and behavioral factors (e.g. poor diet, physical inactivity). Airborne particulate matter (PM) enhances the risk of cardiovascular diseases (CVDs). Smaller particles of particulate matter tend to be more harmful because they can penetrate deeper into the respiratory system and enter the bloodstream. Exposure to nitrogen dioxide (NO₂), elemental carbon (EC), and particulate matter (PM_{2.5} and PM₁₀) all leads to cardiovascular disease, stroke, and alterations in blood pressure. These pollutants primarily come from vehicle emissions, industrial processes, and burning of fossil fuels. Upon inhalation of fine and ultra fine particles, may have profound negative impacts on the heart and blood vessels. These particles enter into systemic circulation via the alveolar epithelium and initiate harmful biological processes which lead to cardiovascular disease. **Reactive oxygen species (ROS) production and alteration of calcium (Ca²⁺) levels** drives cardiovascular effects. According to research by the **American Heart Association (AHA)**, exposure to particulate matter (PM), specifically fine particles like **PM_{2.5}**, triggers a significant **inflammatory response** that affects cardiovascular health. This inflammatory response results in the endothelial dysfunction, elevation of acute phase reactants, and increase blood coagulation, even in **healthy individuals**.

The immediate result of metals bound to particulate matter (PM), such as heavy metals (e.g. lead, arsenic, cadmium), contributes to its **hyper-coagulable** effect, leading to enhanced blood clot formation. These metals switches inflammatory responses, oxidative stress, and changes in cellular signaling, which result in the body's tendency to form blood clots, posing a serious cardiovascular risk. Cohort research from the UK tells us that long-term exposure to **nitrogen dioxide (NO₂)** and **particulate matter (PM)**, particularly **PM_{2.5}**, is associated with a significant increase in the risk of **heart failure**. This research underscores the long-term cardiovascular effects of chronic air pollution exposure, particularly in urban and industrial areas where these pollutants are in abundance. According to a meta-analysis of 35 studies, a PM_{2.5} level increase of 10 microgram per cubic meter being associated with a 2.12% rise in hospitalization or fatalities from heart attacks suggests that even modest rises in pollution levels can have notable health impacts. PM_{2.5} refers to fine inhalable particles that are 2.5 micrometers or smaller in diameter, which can invade deep into the lungs and even enter the bloodstream. These particles can initiate inflammatory responses, resulting in increase the risk of heart attacks, especially in vulnerable populations. Exposure to lead shows a high risk of hypertension and

increased blood pressure in animal models, which is reversible with chelation. The cross-sectional study suggests a concerning relationship between elevated blood lead levels and the development of cardiovascular diseases, which includes formation of carotid artery plaques and conditions like coronary heart disease, myocardial infarction (heart attack), or stroke. Lead exposure affects the nervous system, but its role in cardiovascular health has gained more attention in recent years. The association between higher cadmium (Cd) levels and an increased risk of hypertension and stroke, as observed by NHANES (National Health and Nutrition Examination Survey) data from Korea, points to the toxic effects of cadmium on cardiovascular health. Long-term exposure to air pollution, particularly to fine particulate matter (PM_{2.5}), is strongly associated with an increased risk of fatal and nonfatal coronary artery disease (CAD) both. CAD occurs when the arteries that supply blood to the heart become thinner or blocked due to the build-up of plaques, leading to heart attacks. Both short-term and long-term exposure to air pollution is linked to several cardiovascular conditions, including chronic ischemic heart disease, acute ischemic events, and heart failure. These associations highlight how air pollution affects increases the risk of both immediate and chronic heart issues. Pesticide exposure has been linked to several adverse cardiovascular outcomes such as acute myocardial infarction, heart failure, and arterial hypertension, particularly during pregnancy. However, the evidence from studies shows some **heterogeneity**, in findings due to differences in study design, population characteristics, types of pesticides, and exposure levels.

Figure-1: shows types of cardiovascular diseases which is caused by inhalation of nitrogen dioxide, sulfur dioxide, particulate matter etc.

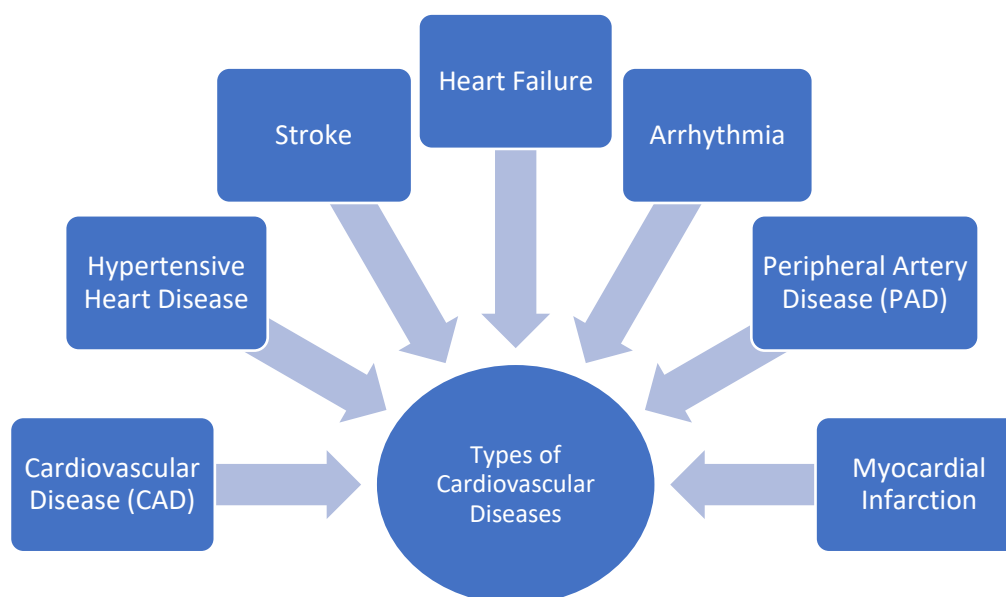


Figure: 1

(Source: Compiled by researchers; Figure: Created by researchers)

2) **Nervous system health:** Environmental pollutants particularly fine particulate matter (PM_{2.5}) and ultra fine particulate matter (UFPM) have been strongly linked to neurotoxicity and the development of various **nervous system disorders**. These pollutants arising from industrial waste, automobile exhaust, pesticides, laboratory waste, and burning of terrestrial waste, can infiltrate the brain and central nervous system through multiple pathways, leading to oxidative stress, neuro-inflammation, and cellular damage. In nearly all neurological disorders, several interconnected pathogenic mechanisms often occur simultaneously which

contributes to disease progression and neural dysfunction. These mechanisms include **blood-brain barrier (BBB) disruption, protein aggregation, oxidative stress, mitochondrial dysfunction, and DNA damage**. These processes collectively drive the onset and progression of numerous neuro-degenerative and neuro-developmental disorders. Epidemiological studies have shown that exposure to **particulate matter (PM)** significantly increases the risk of developing neurological conditions, including **Alzheimer's disease**. This association is based on the observation that long-term and chronic exposure to air pollution leads to detrimental effects on the CNS, accelerating cognitive decline and the onset of neuro-degenerative diseases. **Biomass smoke produced by burning cow dung** can have significant health implications, particularly regarding **inflammation** at the cellular level. Pesticide exposure is a significant concern for human health regarding its effects on the nervous system. Many pesticides are designed to target the neurochemical processes of pests, and their mechanisms of action can adversely affect humans due to similarities in neurobiological pathways. Children are more vulnerable to this. The statistics shows that **17% of youngsters under the age of 18 are suffering from developing disabilities** highlights a significant public health concern. Industrial chemicals and pesticides show neurotoxic effects, particularly during critical developmental periods such as pregnancy. Organophosphates and Organochlorine compounds show neurotoxicity. Concerns regarding **developmental neurotoxicity** and its impact on **prenatal exposure** to certain chemicals, such as **polybrominated diphenyl ethers (PBDEs)**, highlight significant public health issues. Production of plastics and resins utilizes Bisphenol A. BPA exposure can impact activity of brain and behaviour, as well as its association with numerous neurological and developmental disorders. The children upto twelve years of age who have higher urine concentrations of phthalate metabolites had worse behaviour and cognitive outcomes like Parkinson's' disease, Wilson disease, and Alzheimer's disease. The neurotoxic effects of **arsenic** and **lead** are significant concerns in public health, especially due to their capacity to accumulate in the brain and malfunctioning it .Thallium is a highly toxic heavy metal that can have severe neurotoxic effects, as well as various systemic effects like fatigue, hallucination, lack of sensation, emotional changes. The adverse effects of heavy metals such as **lead (Pb), arsenic (As), and methylmercury (MeHg)** on the nervous system (CNS) are well studied in experimental research. The combination of these heavy metals can lead to collegial effects, exacerbating neurotoxic damage. Heavy metals such as **mercury (Hg) and lead (Pb)** have significant implications for cognitive function and neurological development, particularly during critical periods such as pregnancy and in early childhood. During feeding by infants breast milk transfers lead from the mother's skeleton to the fetus. The accumulated Pb will hinder the development of the fetus's central nervous system.

Figure-2: shows effects of pollutants on C. N. S.

Effects of pollutants on C. N. S.	
• Acute Stroke	• Nausea
• Dysguesia	• Ataxia
• Headache	• Dizziness
• Insomnia	• Impaired consciousness
• Convulsion	• Acute hemorrhagic necrotizing
• Encephalopathy	• Vomiting

Figure: 2

(Source: Compiled by researchers; Figure: Created by researchers)

Figure-3: shows various neurological disorder caused by pollutants.

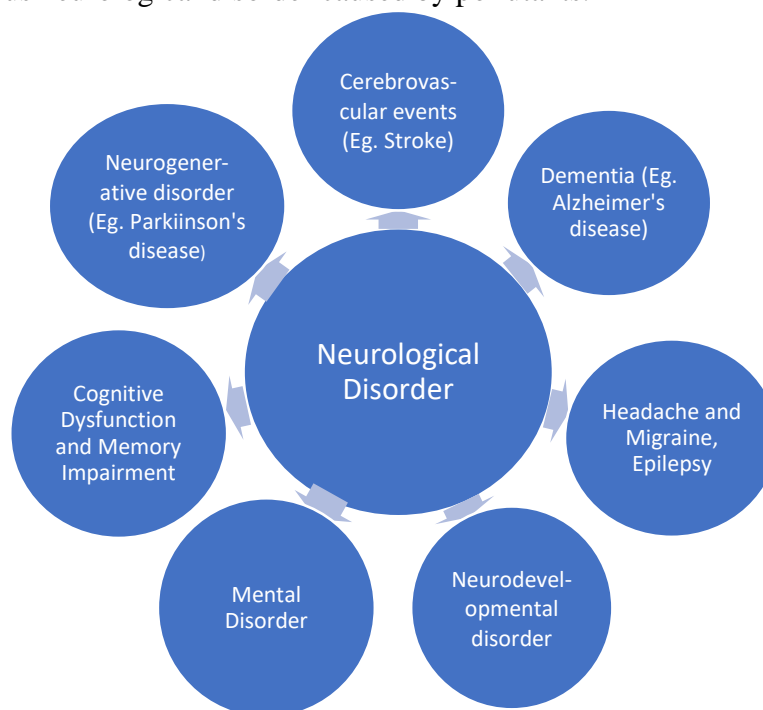


Figure: 3

(Source: Compiled by researchers; Figure: Created by researchers)

3) Reproductive effect: Environmental contamination can indeed have a significant impact on reproductive health. Even low levels of exposure to contaminants, such as heavy metals, endocrine-disrupting chemicals, pesticides, and industrial pollutants, interfere with reproductive functions like sperm quality, hormone Disruption, Testicular Damage, Menstrual Irregularities, Ovarian Dysfunction and Pregnancy Complications. These environmental toxicants play a significant role in increasing oxidative stress within the body. This is primarily linked to the down regulation of key antioxidant enzymes, such as superoxide dismutase (SOD), catalase, and glutathione peroxidase. These enzymes are crucial for neutralizing reactive oxygen species (ROS) and maintaining health of cells. When their activity is reduced, oxidative stress levels increase, which causes potential cellular damage. Germ cells, which are responsible for sperm production, are highly sensitive to oxidative damage due to their high content of polyunsaturated fatty acids (PUFA) and relatively low levels of antioxidant defenses. Sperm DNA quality is crucial for successful fertilization and normal embryo development. If DNA of sperm is affected then genetically abnormal embryo will form. Maternal exposure to particulate matter, especially PM_{2.5} is indeed linked to a reduction in antioxidant defenses in reproductive organs, resulting in enhanced oxidative stress and a decline in reproductive function. PM_{2.5} or fine particulate matter smaller than 2.5 micrometers in diameter can penetrate deeply into the lungs and enter into bloodstream where it can show systemic effects including on reproductive organs. When PM_{2.5} enters into bloodstream, it can trigger the production of chemokines and pro-inflammatory cytokines. These small and fine particles can penetrate deeply into the respiratory system and enter circulation, where they can stimulate an inflammatory response that affects reproductive organs.

Exposure to PM_{2.5} can lead to dysfunction of power house of cell in granulocytes and oocytes which triggers the apoptosis pathway and ultimately inducing cell apoptosis. Both granulocytes and oocytes are highly susceptible to oxidative damage and inflammation, both of which are increased with PM_{2.5} exposure. Exposure to PM_{2.5} can indeed initiates a complex cascade of cellular reactions, which may lead to systemic inflammation, immune responses and genomic variations. PM_{2.5} exacerbates oxidative stress and triggers

inflammation, which in turn produces a number of free radicals and inflammatory mediator which intensifies cellular damage. The study in Barcelona found a statistically significant correlation between enhanced traffic-related air pollution and reduced conception rates highlights a concerning impact of environmental factors on reproductive health. Traffic emissions are a major source of air pollutants such as including PM_{2.5}, nitrogen dioxide (NO₂), and numerous volatile organic compounds (VOCs). These pollutants may disrupt hormonal function, increase oxidative stress, and induce inflammation which is responsible for infertility. Specific levels of pesticide exposure are associated with numerous reproductive and developmental health risks, impacting both male and female fertility as well as fetal and new born development. Pesticides contain chemicals that disrupt endocrine function, induce oxidative stress and cause DNA damage, all of which contributes to a range of adverse outcomes. The exposure of cotton field workers to pesticides has been well-documented as a significant risk factor for numerous adverse reproductive outcomes. Pesticides which are used in cotton farming may have detrimental effects on reproductive health which leads to complications such as stillbirths, abortions, neonatal deaths, and congenital defects. Phthalate exposure is a significant concern for male reproductive health. Phthalates are a group of synthetic chemicals used primarily as plasticizers in numerous products including vinyl flooring, toys, food packaging, and personal care items. The findings of increased miscarriages, infertility, and poor reproductive outcomes in women working in the plastics industry highlight the significant health risks associated with exposure to hazardous substances found in plastics and related chemicals.

Figure- 4: shows consequences of environmental pollutants on infants and newborns.

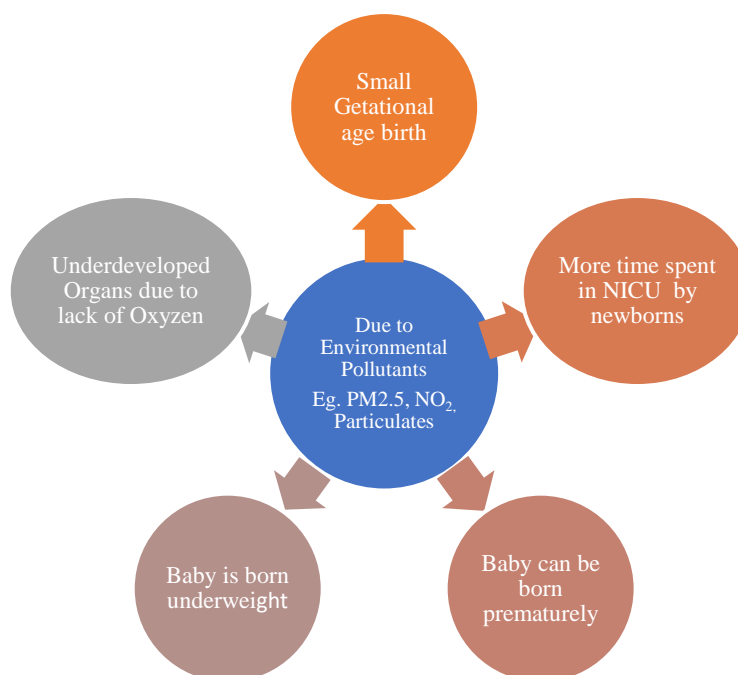


Figure: 4

(Source: Compiled by researchers; Figure: Created by researchers)

4) Cancer:

Environmental contaminants are linked approximately to 70-80% of all cancer forms. These contaminants include a range of substances such as pesticides, heavy metals, industrial chemicals and air pollutants. Many environmental pollutants possess mutagenic properties that can cause DNA damage. This damage ultimately

lead to mutations that initiate cancer development. Carcinogenesis typically involves three stages as initiation, promotion and progression. Molecular Processes affected by Environmental Pollutants are Gene Silencing and Mutation, inactivation of Tumour Suppressor Genes (TSGs), Activation of Oncogenes, Cell Proliferation, Inhibition of Apoptosis, Chromosomal Instability, Alterations in Cell Cycle Regulation, Energetic Dysregulation. The link between exposure to combustion products of fossil fuels and increased lung cancer incidence is a significant public health concern. Polycyclic aromatic hydrocarbons (PAHs) are a significant class of organic pollutants which are primarily generated from the combustion and processing of coal. The study by Lloyd and colleagues on coke oven workers highlights a critical association between exposure to coal combustion products and risk of lung cancer. The association between pesticide applicators and bladder cancer, particularly concerning herbicides like imazethapyr and imazaquin a significant area of research in occupational health. The association between pesticide exposure and breast cancer risk particularly noted in studies like the one conducted in Australia, raises notable concerns about the health impacts of agricultural practices on surrounding communities. The relationship between phthalate metabolites, such as MBzP (monophthalate) and MiBP (mono-isobutyl phthalate), and breast cancer risk has gained attention in past years. The findings from a systematic review and analysis suggesting a negative association between these metabolites and breast cancer risk raise several very important considerations. The disruption of intracellular processes by heavy metals like arsenic (As), cadmium (Cd), chromium (Cr), and nickel (Ni) is an area of concern in cancer research. Heavy metals are known to induce toxic effects through various complex pathways. The processes affected by these metals can provide insight into the mechanisms underlying heavy metal-induced carcinogenesis.

Figure-5: shows types of cancer and factors by which it is caused.

Types of Cancer	Caused by
• Brain Cancer	• Pesticide, Vinyl chloride
• Lung Cancer	• Phthalate, Pesticides, Biophenol
• Liver Cancer	• Tobacco Smoke, Vinyl chloride
• Breast Cancer	• Pesticide
• Scrotal cell carcinoma	• Polyaromatic Hydrocarbon
• Prostate Cancer	• Bisphenol A
• Bladder Cancer	• Pesticides

Figure: 5

(Source: Compiled by researchers; Figure: Created by researchers)

Suggestion: Healthier environment for a healthy individual can be accomplished by tracking environmental pollutants, reducing pollution through laws and policies and preventing serious health problems and deaths.

Conclusion: Pollutants, though long present in the environment, continue to be a major threat to human health and are a significant cause of environmental illness and mortality. Human activities like urbanization, industrialization, mining, and exploration have exacerbated environmental pollution on a global scale. While developed countries have made strides in controlling pollution through stricter regulations and greater awareness, the issue remains a shared global responsibility, as both developed and developing nations continue to contribute to and are affected by pollution.

Despite growing attention and action to mitigate pollution due to its severe long-term consequences, pollutants still exert a profound influence on ecosystems and human health. The persistence of pollutants in the

environment, their potential to bioaccumulate, and the emergence of new contaminants pose ongoing challenges that require global cooperation, stronger legislation, and sustainable practices to address.

References:-

- 1) Ghorani-Azam A., Riahi-Zanjani B., & Balali-Mood M. (2016). Effects of air pollution on human health and practical measures for prevention in Iran. *Journal of research in medical sciences*, 21(1), 65.
- 2) Manisalidis I., Stavropoulou E., Stavropoulos A., & Bezirtzoglou E. (2020). Environmental and health impacts of air pollution: a review. *Frontiers in public health*, 8, 14.
- 3) Haseena, M., Malik, M. F., Javed, A., Arshad, S., Asif, N., Zulfiqar, S., & Hanif, J. (2017). Water pollution and human health. *Environ Risk Assess Remediat* 1 (3): 16–19.
- 4) Arif, A., Malik, M. F., Liaqat, S., Aslam, A., Mumtaz, K., Afzal, A., ... & Javed, R. (2020). 3. Water pollution and industries. *Pure and Applied Biology (PAB)*, 9(4), 2214-2224.
- 5) Owa F. W. (2014). Water pollution: sources, effects, control and management. *International Letters of Natural Sciences*, 3.
- 6) Sarker B., Keya K. N., Mahir F. I., Nahiun K. M., Shahida S., & Khan R. A. (2021). Surface and ground water pollution: causes and effects of urbanization and industrialization in South Asia. *Scientific Review*, 7(3), 32-41.
- 7) Gilliom, R. J. (2007). Pesticides in US streams and groundwater.
- 8) Paul M. J., & Meyer J. L. (2001). Streams in the urban landscape. *Annual review of Ecology and Systematics*, 32(1), 333-365.
- 9) Juneja T., & Chaudhary A. (2013). Assessment of water quality and its effects on the health of residents of Jhunjhunu district, Rajasthan: A cross sectional study. *Journal of public health and epidemiology*, 5(4), 186-191.
- 10) Ali H., Khan E., & Ilahi I. (2019). Environmental chemistry and ecotoxicology of hazardous heavy metals: environmental persistence, toxicity, and bioaccumulation. *Journal of chemistry*, 2019(1), 6730305.
- 11) Cutler D., & Miller G. (2005). The role of public health improvements in health advances: the twentieth-century United States. *Demography*, 42(1), 1-22.
- 12) Gilliom, R. J. (2007). Pesticides in US streams and groundwater.
- 13) Rodríguez, Eugenio N., McLaughlin M. J., & Pennock D. J. (2018). Food and Agriculture Organization of the United Nations, Global Soil Partnership, 2018. Soil pollution: a hidden reality.
- 14) Grandjean, P., & Landrigan, P. J. (2006). Developmental neurotoxicity of industrial chemicals. *The Lancet*, 368(9553), 2167-2178