MAJOR ENVIRONMENTAL CONTAMINANTS: SOURCES AND IMPACT ON HEALTH

Abstract

Nowadays, people have been exposed to several types of contaminants which have broad spectrum. These different kind of contaminates are result of fast evolving technology. The problem of human health and environmental risks has become a key problem for all the world. The present chapter deals with major environmental contaminants, their sources and their impact on health and environment. These contaminants cause major effect on the human health and also toxic for environment due to their chronic toxicity and persistance. So, it's important to study about these contaminates and needed the efficient and ecological methods for their remedial from the environment. This chapter also provides a critical look at the major challenges posed by these emerging pollutants

Keywords: Contaminants, Environment, Pesticides, Pollution, Heavy metals, etc.

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I. INTRODUCTION

Environmental pollution stands as one of the most pressing and pervasive challenges confronting our planet today. Pollution in any form poses a grave threat to both humanity and the broader ecosystem. It represents a detrimental force upon our environment, regardless of its specific nature. As responsible stewards of the Earth, it is our duty to adopt comprehensive measures to combat, prevent, and safeguard our environment against pollution. Environmental pollution encompasses the unwelcome and adverse alterations in the physical, chemical, and biological attributes of air, water, and soil, which have detrimental implications for all living organisms. We confront diverse forms of pollution, including water pollution, air pollution, noise pollution, plastic pollution, and digital pollution. As humans, we have innovated numerous conveniences for our lives; however, the unintended consequences of these innovations were not always foreseen [1-2].

Generally, contaminants are any chemical, physical and biological substances which have adverse impact on the environment. So, contaminants, can be defined as any substances, which are present above their permissible limit fixed by regulatory authorities and negatively affect the environment by creating it toxic to the human, animals and plants. The abundance of pollutants is mainly due to the industrialization and overuse of agrochemicals, plastics and chemical fertilizers. The common sources of contaminants are fossil fuels, industries, oil spills, chemicals used in our daily use product etc. The contaminants can be natural or man-made/synthetic. Accidental release of these contaminants in the environment causes many problems for the human health and as well as mass death of population. The biggest challenge is that the environmental contaminants also polluted our food through soil, water and air mode [3].

The major harmful pollutants of concern are heavy metals like Arsenic, Lead, Mercury, Cadmium, Perchlorates, radioactive materials, Benzene, Dioxins, persistent organic pollutants, pesticides, polyhalogenated byphenyls, hazardous solvents, airborne pollutants and pear and Polyfluoroalkyl Substances (PFAS). The worldwide regulatory agency FDA regularly monitor the contamination levels in food commodities, do the risk assessment and also provide guidance to for the preventive measures to minimize the hazard to food and risk to health [4]. Environmental pollutants are now a great challenge for all the academicians and researchers all over the world [5].

Different categories of pollutants that impact on soil, air, water, animals, plants, microorganisms and humans are given in Figure-1.

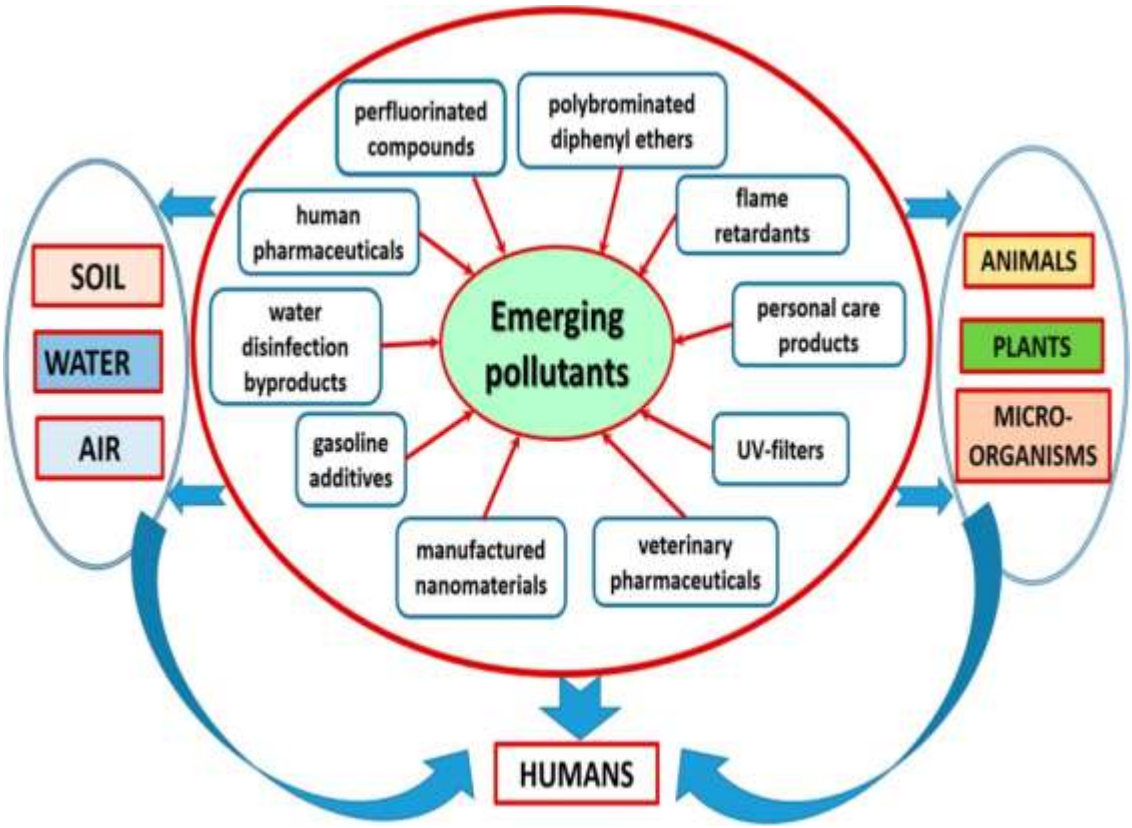

Figure 1: Different categories of pollutants that impact on soil, air, water, animals, plants, microorganisms and humans [6]

II. SOURCES OF CONTAMINANTS

Urbanisation led to the several industries that constrained the climate change crisis in spite of knowing the dangers caused by industrial effluents. Caustic soda, cement, brewing, dyes, fertilizers, iron and steel, oil refineries, paper and pulp, food, pesticides, pharmaceuticals, textiles, thermal power plants, leather, and other significant sectors are some of the leading producers of pollutants. Along with their primary product, all of these industries also produce hazardous byproducts. The primary sources of chemical contaminants include packaging materials, personal care items, ambient pollutants, soil contaminants, and disinfection byproducts. Numerous chemical pollutants can be found in everyday care goods, including plastics, detergents, deodorants, disinfectants, and cosmetics. If we take the example of only energy industry which produce approximately 30% of greenhouse gasses [7], it clearly shows the picture. To make products like plastics and medicines, we also need oil and coal. The fashion industry also effect people directly and directly across the world. The carbon emissions produce by the wasted and dumped clothes wastes is very high.

Within this context, the agriculture and forestry sectors introduce environmental contaminants in the form of pesticides, nitrates, phosphates, greenhouse gases, and mineral salts. Meanwhile, mining and mineral processing activities yield heavy metals, cyanide, acidic substances, hydrocarbon byproducts stemming from spills and coal extraction, as well as metallic salts. Fossil fuel combustion releases hazardous chemicals such as sulfur dioxide, carbon dioxide, nitric oxide, various acids, acid rain, ozone, polycyclic aromatic

hydrocarbons, and volatile organic compounds. Virtually every industry produces a diverse array of both organic and inorganic compounds, including dioxins, heavy metals, hydrocarbons, chlorinated phenols, sulfides, surfactants, solvents, acids, bases, salts, pharmaceuticals, plastics, resins, and explosives. It is essential for the progress of our nation to sustain these industries; however, it is equally imperative to mitigate the looming perils they pose.

We should implement the green chemistry and green solution to overcome these problems. The green solutions are very much needed because with the increase in production and use of chemical compounds, man has become more exposed to the adverse effects and chemical toxicity, so remedies are needed to lower overall costs associated with environmental health and safety. Pollutants are categorized on the basis of their mode of action, toxicity, their chemical composition and their origin (natural/synthetic). Some of them is discussed in this chapter.

III. HEAVY METALS

1. **Brief Introduction:** Aquatic ecosystems are exposed to heavy metals from both natural and human-made origins, including atmospheric precipitation, wastewater, and industrial effluents. The sources of heavy metals in the environment encompass geological weathering, industrial ore processing, metallic compound production, and the presence of heavy metals in animal and human waste. Furthermore, heavy metals can leach into the environment from garbage and solid waste disposal sites. This introduction of toxic heavy metals such as cadmium, mercury, lead, copper, and arsenic into the environment often occurs via industrial waste, leading to food contamination. Zheng and his research team identified a highly contaminated industrial zone in China that exhibited elevated levels of heavy metals such as zinc, copper, lead, and cadmium, with corresponding contamination observed in food products. Fish, being a crucial component of the aquatic food chain, frequently accumulate substantial amounts of these metals. A nationwide survey aimed at monitoring arsenic, copper, cadmium, chromium, lead, mercury, and zinc concentrations in fish, shellfish, and fisheries products revealed the presence of these metals in all samples, regardless of their habitat. Heavy metals originating from industrial areas enter the food chain and taint the primary food sources. These heavy metals can manifest in various forms, including hydroxides, oxides, sulfides, sulfates, phosphates, silicates, and organic compounds. Among the most prevalent heavy metals are arsenic (As), lead (Pb), nickel (Ni), chromium (Cr), cadmium (Cd), mercury (Hg), zinc (Zn), and copper (Cu).

2. **Impact on Health:** Arsenic ranks first among the heavy metals that are harmful. One metalloid that has been found all over the world is arsenic. Inorganic arsenic was listed as the top priority hazardous chemical to human health in the ATSDR rankings from 2011 and 2013 [13]. Numerous investigations revealed that arsenic levels over WHO guidelines exist globally and have an impact on people's health [14]. While acute exposure to inorganic arsenic can potentially be fatal, short-term exposure can cause nausea, lung irritation, vomiting, diarrhoea, exhaustion, and bruises [15].

   One heavy metal that can be found in both biological and inorganic forms is lead (Pb). Environmental exposure to lead poses a serious risk to human health [16]. Lead can have a number of undesirable effects when present in very small concentrations,

including disruption of hemoglobin biosynthesis, blood pressure rise, kidney damage, miscarriages, nervous system disruption, brain damage, decreased male fertility due to sperm damage, and behavioral problems in children such as hyperactivity, aggression, and impulsive behavior [17]. Because lead can reach a fetus through the mother's placenta, it can seriously harm the developing child's nervous system and brain [18].

A extremely hazardous, non-essential metal that is also ecotoxic is cadmium. Its buildup in the kidney, liver, bone, blood, and muscles may have a chronic impact on human health. Human activity is responsible for almost half of the cadmium that ends up in rivers and the oceans (industrial waste, fertilizer including phosphate from animals) [19]. Numerous health risks, including diarrhea, vomiting fits and stomachaches, bone fractures, infertility, central nervous system damage, immune system dysfunction, psychological issues, potential DNA damage, and cancer development, can be brought on by cadmium.

One naturally occurring metal that can be found in both organic and inorganic forms is mercury. The only metal that is a liquid at ambient temperature is mercury. Mercury is one of the most well-known and mysterious metals in the environment at the same time. Despite significant differences in characteristics, all species of mercury are poisonous [20]. For aquatic creatures, the organic forms of mercury are typically more poisonous than the inorganic forms. Common home items, pharmaceuticals, and chemical products all contain mercury. Exposure to metallic mercury can cause acute consequences such as breathing difficulties, eye and lung irritation, coughing, nausea, vomiting, diarrhoea, and elevated blood pressure [21].

IV. PESTICIDES

1. **Brief Introduction:** Pesticides are an indispensable tool for the sustainable production of high-quality food, fodder and fibers. The use of pesticide helps to reduce the crop loses, provide benefits to farmer, reduce soils erosion and ensure the food safety and security for the nation. Overuse, carelessness, and disregard for recommended pesticide usage can have a negative impact on human health. Approximately 3 billion kg of pesticides are used annually worldwide, which is a major concern because the chemicals contaminate food's unprocessed sources [22]. Pesticides contributed to a rise in food production, but they also brought about a number of unintended consequences, including the presence of pesticide residues in food and feed, pollution of the environment, pest resistance, pest resurgence, secondary pest outbreaks, and killing of natural enemies and pollinators. Despite this, the overall quality of the ecosystem, ground water, and wild life are all seriously threatened by the presence of pesticide residues. All national and international governments are concentrating on the monitoring of pesticide residues in various food commodities and environmental samples like soil and water because food safety is a major concern for all consumers.

The persistence of pesticides and their residues in food commodity at harvest or foods depends of several factors such as nature and amount of pesticide used, number of applications, type of crop, method of application, weather condition, interval between application and harvest etc. The pesticides residues in food are rigorously regulated in many countries to address the domestic food safety and trade issues / disputes under SPS Agreement of WTO. The Codex Committee on Pesticide Residues (CCPR) is in charge at

the international level of setting maximum limits on the amount of pesticide residues in particular foods or food groups. The chemical composition of pesticides, such as organochlorine, pyrethroids, organophosphorus, carbamates, phenol herbicides, neonicotinoids, and others, is another factor used to classify pesticides, including insecticides, fungicides, herbicides, and rodenticides [23].

2. **Health Effects on Non-Target Organism:** Pesticide residues finding their way into food products is a big global problem these days. It can have extremely harmful effects on non-target organisms like humans. Pesticide exposure in humans refers to the ingestion or application of pesticides to the body. The amount of pesticide used and the length of time it is there determine how harmful the exposure is. There are four primary ways that pesticides can enter our bodies:

    - ***Oral exposures*** are frequently brought on by failing to wash hands before eating, drinking, smoking, or chewing food, as well as by unintentionally splattering pesticide in the mouth or applying pesticide to food.
    - ***Inhalation exposures*** are frequently brought on by extended contact with pesticides in poorly ventilated areas, inhaling fumigant and other harmful pesticide vapors without wearing the proper protective gear, and breathing in fumes that are present right after a pesticide is applied.
    - ***Eye exposures*** are brought on by pouring dust, granule, or powder formulations without using eye protection, rubbing eyes or foreheads with contaminated gloves or hands, and spraying pesticides in windy conditions without using eye protection.
    - ***Dermal exposures*** are frequently brought on by handling insecticides without washing your hands. putting on pesticide-contaminated clothes, using pesticides in windy conditions, handling pesticides without enough personal protection equipment, and coming into contact with surfaces treated with pesticides.

3. **The Safer alternative of Persistence and Synthetic Pesticides:** Bio-pesticides, which occur naturally, are substances that exert biological control over detrimental pests, particularly in the context of field crops. Bio-pesticides encompass living organisms, such as bacteria, viruses, and algae, along with their metabolic byproducts and plant-derived substances. These bio-pesticides offer several advantages, including environmental friendliness, specificity in targeting particular pest groups, biodegradability, and the requirement of minimal quantities for effectiveness. Some notable bio-pesticides include Bacillus thuringiensis, Bacillus sphaericus, Trichoderma viride, and Trichoderma harzianum. Bio-pesticides have the potential to mitigate crop losses and reduce adverse environmental impacts. These natural pest control agents account for approximately 3% of the pesticide market in the country. In India, 14 bio-pesticides have been officially registered under the Insecticide Act of 1968.

Several pressing concerns require immediate attention to enhance the domestic pesticide industry and ensure the safe utilization of pesticides. First and foremost, there is a need for the regulation and promotion of cost-effective and environmentally friendly pesticide products. To avoid adverse consequences, it is crucial to establish uniform testing procedures (including parameters, laboratories, and stakeholders) and discontinue the use of outdated and hazardous pesticides. Secondly, emphasis should be placed on fostering safe application practices and raising awareness among farmers. The third

concern pertains to assessing the potential impact of an enhanced patent regime on the pesticide industry, with specific attention to its probable effects on product prices.

Now it become a major challenge in-front of agricultural scientist, farmers, pesticide industries and other stake holders to ensure the food availability from declining agricultural land so it is very crucial to know and assess the risk involved with use of chemical pesticide to ensure proper pest management, food safety, risk management, consumer safety, compliance with sanitary and Phyto-sanitary requirements on food hygiene and plant health has gained importance and such vital issues need attention of scientific community and whole world.

V. MYCOTOXIN

Mycotoxins are fungal secondary metabolites produced by various fungi species, and they pose significant public health risks due to their carcinogenic and mutagenic properties [24]. These toxins are naturally occurring and inevitable, which means they can easily enter the food chain through direct means (contaminated plant-based food components) or indirect routes (growth of toxic mycotoxins on food and feed) [25]. Notably, mycotoxins remain chemically and thermally stable throughout various food processing stages, including cooking, boiling, baking, frying, and roasting. They can also contaminate food through animal-derived products like meat, eggs, and milk [26]. Numerous studies have shown that mycotoxins tend to accumulate primarily in cereals and oilseeds, both in the field and during storage and transportation. Improper storage and prolonged exposure to humidity can make crops susceptible to mycotoxin contamination [27]. Consuming mycotoxin-contaminated food or feed can lead to toxicity in both humans and animals. Additionally, there is a growing public health concern regarding the potential ingestion of animal-derived food products (e.g., meat, milk, eggs) containing residues or metabolites of mycotoxins. Mycotoxin contamination of food remains a persistent global issue.

Several national and international public health and governmental authorities, including the US Food and Drug Administration (FDA), the World Health Organization (WHO), the Food Agriculture Organization (FAO), and the European Food Safety Authority (EFSA), have recognized the seriousness of mycotoxin contamination in food and feed. To address this global issue, they have implemented stringent regulatory guidelines for major mycotoxin classes in food and feed [28]. Numerous research studies conducted in India have revealed that AFB1 is the most commonly encountered mycotoxin in food, followed by AFB2, with the occurrence of AFG1 and AFG2 being almost negligible. Aflatoxin poisoning is a significant contributor to conditions such as cancer, kidney disorders, neonatal jaundice, and various other diseases.

VI. POLYCYCLIC AROMATIC HYDROCARBONS

Organic compounds consisting of two or more aromatic fused rings, such as naphthalene and anthracene, fall into the category of polycyclic aromatic hydrocarbons (PAHs). These compounds exhibit a lipophilic nature [29]. Polycyclic Aromatic Hydrocarbons are commonly found in coal tar, mineral oils, and various construction-related products. Primarily, PAHs make their way into the environment through human activities and sources [30]. Individuals employed in industries involving coal melting, combustion, and coal product burning face potential exposure to high levels of PAHs through inhalation or

skin contact [31]. High-level exposure to PAHs or mixtures of PAHs can result in skin and eye irritation, respiratory difficulties, nausea, vomiting, diarrhea, and, in severe cases, fatality. Prolonged exposure to PAHs can lead to immunosuppression, teratogenicity, cytotoxicity, and genotoxicity [29]. Due to their widespread presence and harmful health effects, Polycyclic Aromatic Hydrocarbons remain a significant area of concern for researchers in the field of environmental pollution.

VII. POLYFLUOROALKYL SUBSTANCES (PFAS)

A large family of hydrocarbon compounds known as perfluorinated substances have had all of their hydrogen atoms swapped out for fluorine molecules [32]. Perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), Gen X, and numerous more compounds are examples of perfluorinated substances [33]. These compounds have fluorine atoms attached to alkyl group. Perfluorinated chemicals are used in cookware, textile industry, construction, electronic industry and many more product. PFAS has been reported to contaminate food and water because PFAS break down very slowly and persist in the environment. Due to its persistence and impact on health of people and animals, it comes under the category of toxic pollutant and needs an immediate concern of the researchers and scientists [34]. Structure of PFOA is given in Figure 2.

Chemicals containing per and polyfluorinated compounds have been linked to hormone imbalances, elevated hepatic enzyme levels, and elevated cholesterol [36]. Prostate, kidney, liver, and bladder cancer have also been reported in populations that have been exposed to these substances to a greater extent [37].

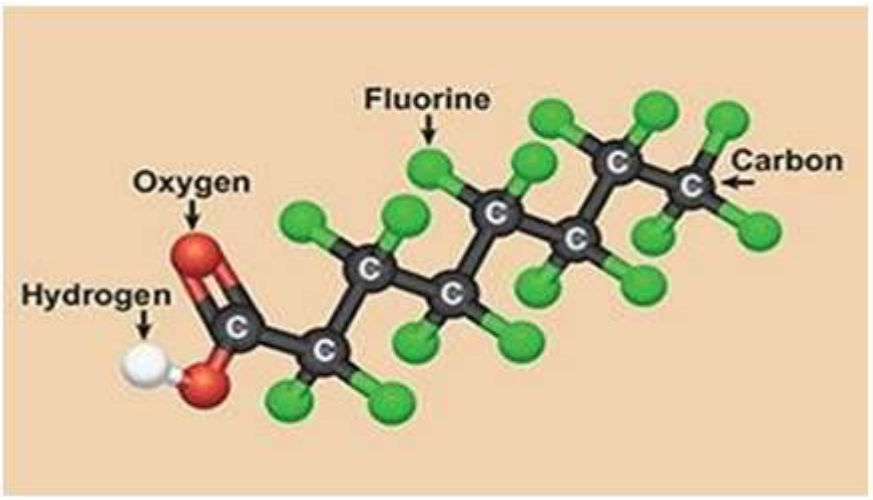

Figure 2: Structure of PFOA [35].

VIII. CONCLUSIONS

The present chapter has given a brief overview of the various types of contaminants and their impact on human health. The presence of contaminates in the environment is always being a matter of concern for human health. The impact of persistent and toxic contaminants is significant on environment and health and they all need considerable attention due to their impacts on environment and people health. More studies on the

Persistence, dissipation, consumer risk assessment and also on their remedial and elimination is much needed. New methods and technologies need to be effective and environmentally friendly. Keeping in mind the long-term health hazards contaminates, it is advisable to regularize the monitoring programmes of the contaminants. A joint effort including the participation of government agencies, non-government agencies, industries stake holders and the people is needed to overcome this problem.

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