Toxicological Impacts of Heavy Metals and Pesticides on Human Health

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ABSTRACT-This article provides a comprehensive review of how heavy metals enter and accumulate in the environment, and they can be absorbed by plants and animals that live in the contaminated areas, leading to bioaccumulation. Through the food chain, these eventually bio-accumulate inside the human body through the consumption of bio-accumulated plants and animals. Toxic heavy metals, such as lead, cadmium, mercury, chromium, and arsenic, may have detrimental effects on the environment and human health, including damage to multiple organs and the nervous system.

Keywords: Heavy metal; Environment; Human health; Toxicology; Bio magnification.

1. INTRODUCTION

Heavy metals make up a significant amount of the periodic table due to their high atomic weight and density. Heavy metals are found in biosphere region, which includes rocks, soils, and water. Other anthropogenic resources, primarily commercial and industrial, also release them into the environment. The harmful properties of heavy metals are reported by researchers and scientist time to time. However, according to the studies, some elements such as zinc, copper, and nickel are abundant in nature and essential for human health (Azeh Engwa et al., 2019). Heavy metals are primarily found in nature, while others are produced by human activities. The defining features of heavy metals are their high atomic mass and toxicity to living organisms. Most heavy metals are harmful to human health and the environment, and they can pollute the air. Food chain is the main root for the exposure of heavy metals to the humans. When they combine with other elements of the environment, such as soil, water, and air, they can become exceedingly harmful. Heavy metals, however, have lots of negative effects on the environment. For instance, when mercury is converted to methyl mercury in the presence of water, it produces highly toxic sediments (Rice et al., 2014). Chromium is used extensively in industry and has the potential to cause cancer (Coetzee et al. 2020). However, certain heavy metals are involved in controlling particular bodily physiological functions. Naturally occurring essential heavy metals enter the body through food, air, and water and regulate a number of biological functions (Chasapis et al., 2012; Roohani et al., 2013). Toxicology can broadly be defined as the fundamental science of poisons. Thus, toxicology may be defined as “A discipline of science dealing with poisonous substances which, on entering the body of organisms, cause disturbances in their normal functioning, leading to harmful effects: the most severe of which may be death of the organism”. Metallic elements with a comparatively high density compared to water are referred to as heavy metals (Fergusson, J. E. (Ed.). 1990). Assuming that toxicity and heaviness are related, metalloids that can cause toxicity at low exposure levels, like arsenic, are also considered heavy metals (Duffus J.H., 2002). Environmental contamination by these metals has become a growing ecological and global public health concern in recent years. Geological, industrial, agricultural, pharmaceutical, household effluent, and atmospheric sources are among the documented sources of heavy metals in the environment (He, Z. L., Yang et al, 2005). The primary cause of heavy metal pollution is anthropogenic activity, which includes mining, smelting, foundries, and other metal-based industries (Figure 1). Additionally, metals can leach from a variety of sources, including landfills, waste dumps, excretion, livestock and chicken manure, runoff, cars, and road construction. Mining, foundries, smelters, and other metal-based industrial operations are examples of point source areas where environmental pollution is highly prevalent (Fergusson, J. E. (Ed.). 1990, Bradl, H. (Ed.). 2005, He, Z. L., Yanget al 2005). Metal mining is regarded as one of the main causes of environmental degradation. Long-term exposure to mining pollutants harms the environment and living things (Ghosh, S et al. 2021). Environmental contamination and human health disorders are significantly impacted by certain heavy metals that are produced as waste or byproducts of mining and manufacturing operations (Azhar, U et.al, 2022).

The methods by which these substances cause harm will be examined by toxicologists, along with methods for identifying their presence in different kinds of samples. Toxicology also entails determining the best course of action for treating people and/or animals exposed to specific toxicants. Toxicology is the study of the degree to which a chemical or particular mix of chemicals may be harmful to an organism. (Definition of TOXICITY". 30 July 2023) It is possible to use the term "toxicity" to refer to the effect on an organism as a whole, such as an

animal, bacterium, or plant, or a substructure, like a cell (cytotoxicity) or an organ, like the liver (hepatotoxicity). The idea that a toxicant's effects are dose-dependent is fundamental to toxicology; even water can cause water intoxication if consumed in excess, yet even very toxic substances, like snake venom, have a dosage below which no discernible toxic impact occurs. Because toxicity varies by species, a cross-species study is challenging. While keeping the idea of toxicity endpoints, newer paradigms and measurements are developing to avoid animal testing. (Toxicity Endpoints & Tests, October 2018) There are two types of toxic substances: systemic toxins and organ toxins. A systemic toxin affects the body as a whole or numerous organs instead of just one. For instance, potassium cyanide is a systemic toxin because it interferes with the body's ability to use oxygen in almost every cell and organ. Certain tissue types, like connective tissue, which are found in multiple organs, may be impacted by toxins. In general, toxic effects are classified based on where they occur. Occasionally, the effect might only manifest at a single location. The specific target organ is the name given to this location. In other situations, poisonous effects could manifest at several locations, called systemic toxicity.
Although toxicity can be categorized in a variety of ways, a popular approach uses four severity-based levels: very toxic, moderately harmful, mildly toxic, and nearly non-toxic. Furthermore, toxicity can be classified according to the kind of impact it produces (acute, chronic, and systemic) or by its source (chemical, biological, physical, radioactive, etc.).

2. SEVERITY-BASED TOXICITY LEVELS:

I. **Very Toxic:** These compounds are extremely harmful and, even in small concentrations, can cause death or serious injury. They are quite annoying.

II. **Moderately Toxic:** These compounds have the potential to cause moderate injury and irritation, albeit not as severe as a very toxic substance.

III. **Mildly Toxic:** These compounds are less dangerous and irritate the skin less.

IV. **Nearly non-Toxic:** These compounds are extremely non-toxic and unlikely to irritate or damage people.

3. TOXICITY BASED ON ITS IMPACT:

I. **Acute Toxicity:** It occurs very quickly (seconds, minutes, hours, or days) after an interaction. Acute exposures usually involve one or more doses administered over a day. There is a significant chance of fatality from acute exposures.

II. **Chronic Toxicity:** It is defined by cumulative damage to certain organ systems and may not show up as a clinically discernible sickness for months or years. Individual exposures that are subclinical may result in undetected harm. With repeated exposures or extended continuous exposure, the harm from this type of exposure progressively builds up (cumulative damage) until it exceeds the threshold for chronic toxicity. Eventually, the damage becomes so severe that the organ is no longer able to function correctly, and there may be several detrimental long-term effects.

III. **Systemic Toxicity:** Multiple organs and systems inside the body are affected by it.

IV. **Organ-Specific Toxicity**: Impacts certain organs, such as the cardiovascular system, liver, or kidneys.

V. **Developmental Toxicity**: The development of a fetus or embryo is impacted by it in humans.

VI. **Genetic Toxicity:** Affects the genetic material of cells.

4. TOXICITY BASED ON SOURCE:

I. **Chemical toxicity:** It describes the detrimental effects of chemicals on living things.

II. **Biological Toxicity:** Biological toxins are those produced by living organisms, including bacteria, fungi, plants, and animals.

III. **Physical toxicity:** It includes harmful effects from physical agents like radiation.

IV. **Radioactive toxicity:** It can be brought on by exposure to radioactive materials.

5. ASPECTS OF TOXICOLOGY:

Various critics subdivide toxicology in different ways. Some branches of toxicology are aquatic toxicology or water toxicology, genetic toxicology, industrial toxicology, analytical toxicology and behavioral toxicology, etc.

I. **Environmental Toxicology:** Environmental toxicology deals with the adverse effects of the chemicals encountered by the organisms either incidentally, owing to their presence in the environment or by contact during occupational or recreational activities or by ingestion as food additives.

II. **Economic Toxicology**: It is a branch that is directly or indirectly related to the economy of the country. It is caused by the chemicals that are generally used to eradicate undesired and uneconomic organisms. Many of these chemicals cause specific toxic effects.

III. **Clinical Toxicology:** It is a discipline of science in which efforts are made to treat patients exposed to occupational, accidental or intentional poisoning. Antidotes are developed to curb the effects of intoxicants. Antidotes are substances that prevent the toxic actions of poisons.

IV. **Forensic Toxicology**: Forensic toxicology deals with the medico-legal aspects of the harmful effects of chemicals on animals and human beings. This branch of toxicology tries to establish the cause of death in suspected cases, as well as elucidating its circumstances in post-mortem investigation.

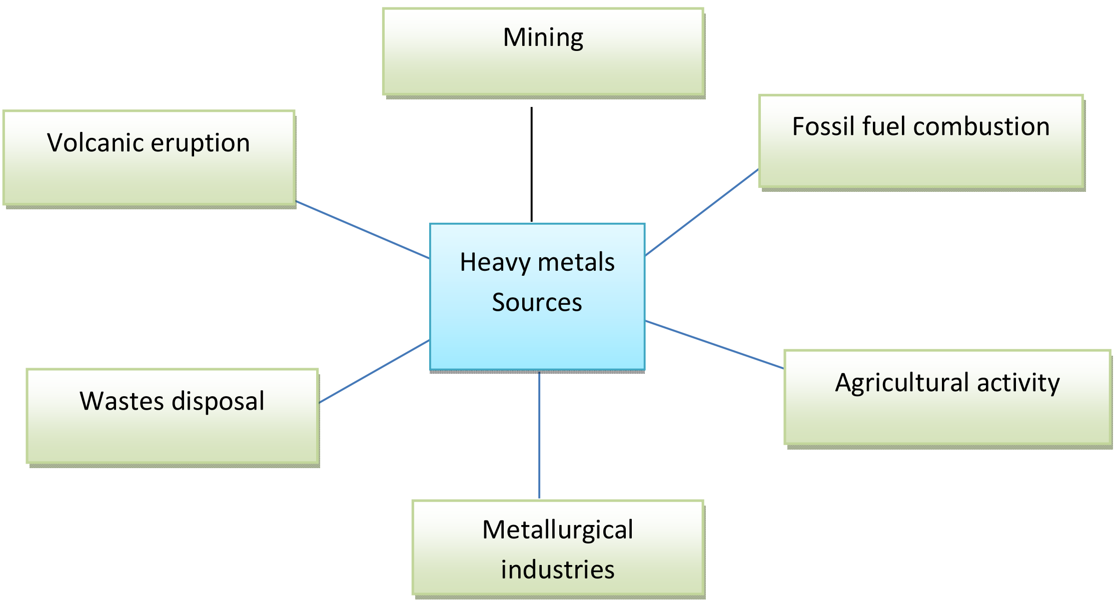


Figure 1: Sources of Heavy Metals in Environment

V. **Descriptive Toxicology:** It is that branch of science which is directly concerned with the toxicity testing. Information is also collected from such toxicity tests on the other factors that might disturb the balance of the ecosystem.

VI. **Mechanistic Toxicology**: This branch of science is concerned with the explanation of the mechanism by which chemicals induce their toxic effects on living organisms.

VII. **Regulatory Toxicology**: It is that branch which deals with the imposition of certain restrictions on the entry of chemicals into the environment with the help of law.

VIII. **Analytical Toxicology**: It correlates with the development of new technologies to determine the presence or absence of toxicants in the atmosphere, food or drinking water.

IX. **Industrial Toxicology:** It is compatible with environmental toxicology. It is concerned with the study of the nature and types of chemicals released by the industries in the ambient air and water, and their possible effects on the organisms, including human beings.

X. **Genetic Toxicology:** This branch of toxicology deals with the study of the effects of xenobiotics on chromosomes and, more precisely, on the genetic material genome of the individuals.

XI. **Preventive Toxicology:** It is a branch that deals with the evaluation and recommendation of suitable measures for the protection of the environment and its living resources.

XII. **Behavioral Toxicology:** This branch of toxicology is concerned with the study of changes in the behavior of organisms following exposure to various toxicants.

6. SOURCES AND TOXICITY OF HEAVY METALS:

Heavy metals are found in food sources. The most common types of heavy metals include zinc, arsenic, copper, lead, nickel, chromium and cadmium. All of these cause certain risks to human and environmental health. These metals have an important role in maintaining certain biochemical and physiological functions in living organisms when present in very low concentrations, but they become noxious when they exceed certain threshold concentrations.

Table 1 Heavy Metals and their effect on human health

S.N.	Heavy Metal	Harmful effects on human health
1	As	Cancer, cardiovascular diseases, neurological and development effects, skin lesion, diabetes, reproductive problem, anorexia, colitis, circulatory disease.
2	Pb	Impact brain development, leading reduced IQ in children, nerve damage, kidney damage, reproductive problem in both man and women, cardiovascular problem, anemia, cancer, muscle and joint pain, fatigue.
3	Hg	Headaches, insomnia, tremors, mood swings, nervousness, kidney disorder, cancer.
4	Cd	Kidney diseases, bone weakening, cancer risk, damage to the liver, heart and lungs.
5	Cr	Respiratory issues, skin problems, nose ulcers, skin ulcers, eye irritation, gastrointestinal effects, stomach tumors.

Arsenic: The 12th most prevalent element in nature is arsenic, which typically occurs in three allotropic forms: black, yellow, and grey. It quickly oxidizes to arsenic trioxide (As_2O_3) when heated, and it smells like garlic (Fendorf et al., 2010). As a very toxic element that ranks first on the WHO's 2001 priority list of dangerous compounds and disease registries, arsenic is also referred to as the "king of poison. Arsenic (Fatoki, J. O., & Badmus, J. A., 2022), one of the most important heavy metals, causes health problems in both ecological and human systems. As may potentially pollute groundwater and drinking water due to man-made releases of As from various industrial and agricultural processes.

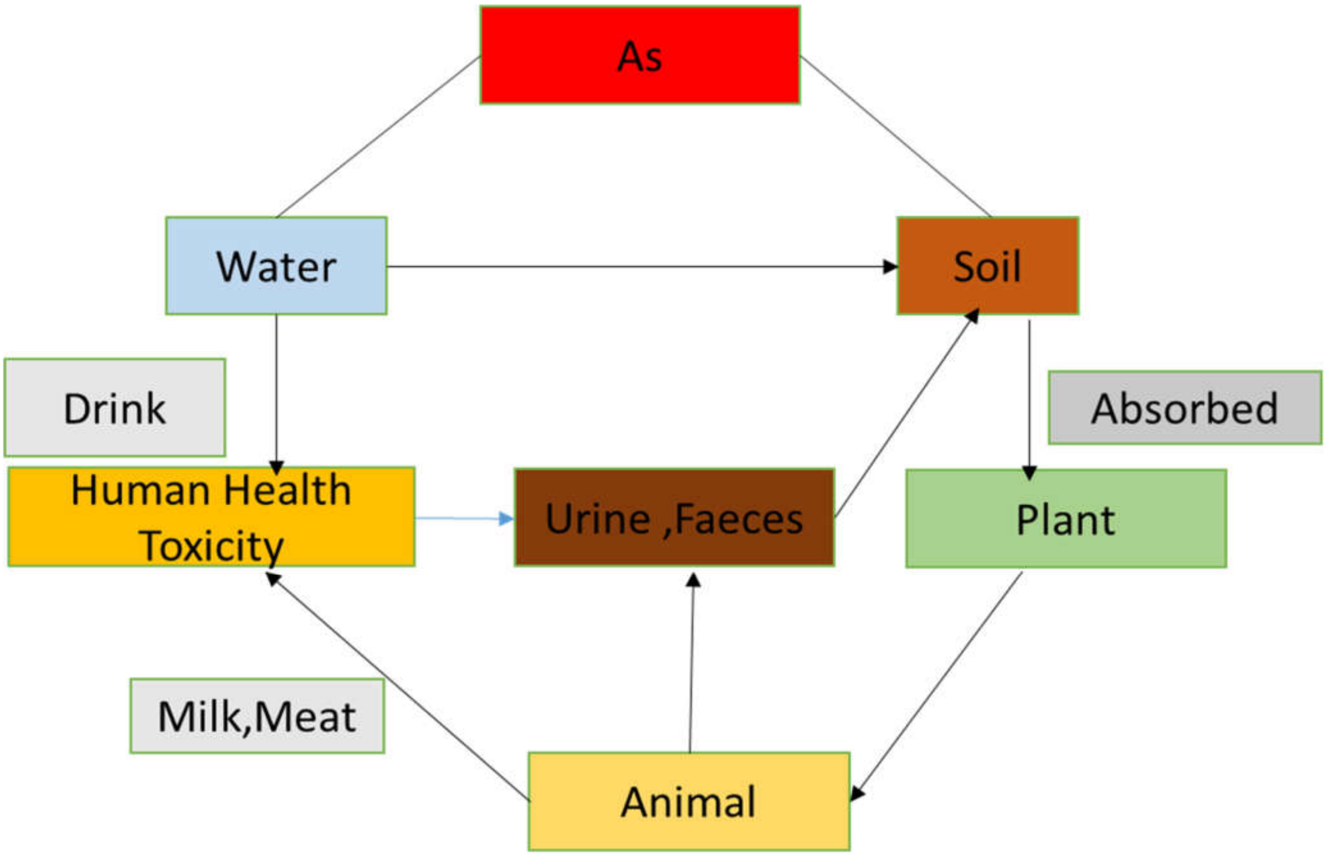


Figure 2: Flow of Arsenic in Environment

The primary anthropogenic sources of As pollution of groundwater are mining operations, burning fossil fuels, the use of pesticides, fungicides, herbicides, wood preservatives, crop desiccants, and livestock additives (Garelick et al., 2009).It is prominently toxic and carcinogenic and is extensively available in the form of oxides or sulfides. It is also the most abundant element here on earth, and its specific organic forms are very dangerous to living creatures (animals, plants and humans) and the environment. Arsenic can negatively affect the body's organ systems in a number of ways. Intestinal, cardiovascular, respiratory, gastrointestinal, endocrine, reproductive, neurological, developmental problems, and malignant are some examples of these organ systems (Chakraborti, D. et al, 2017). It can have either immediate or long-term harmful consequences, depending on the exposure amount. Severe symptoms brought on by a single high dose of arsenic are known as acute arsenic poisoning. Muscle aches and weakness are the first signs of acute as poisoning, which is followed by severe nausea, vomiting, diarrhoea, cyanosis, cardiac arrhythmia, disorientation, and hallucinations

(Vahidnia, A. et al, 2007). Additional acute symptoms include bone marrow depression that results in leucopenia and anaemia, chilly, clammy skin, renal failure, encephalopathy, and peripheral neuropathy, which manifests as altered sensation, movement of glands, or organ function (Saha, J C et al, 1999). One of the major areas in which humans are exposed to arsenic is through contaminated water, which is a problem in more than30countriesintheworld.

Lead:The environment naturally contains lead. However, human activity is the primary cause of the majority of lead concentrations in the environment. An artificial lead cycle has resulted from the use of lead in gasoline. Lead salts, which include oxides, bromines, and chlorines, are produced when lead is consumed in automobile engines. One of the four metals with the greatest detrimental impacts on human health is lead (Tiwari Seema and Tripathi I.P 2012). There are two main types of lead pollution sources in India: residential and industrial. The particles produced by burning coal and roasting minerals such iron pyrites, dolomite, alumina, etc. are the primary cause of industrial lead exposures. Lead (Doan Ngoc Hai, D. N. H., et al, 2018) has been known to cause “extensive environmental and health problems in many parts of the world.” The physical appearance of lead is a bright, coloured metal. Some sources of lead pollution in the environment include metal plating and fishing creations, soil waste, factory chimneys, smelting of ores, fertilizers and many more. Unlike other metals such as copper, lead only plays a physiological role and has no logical functions. The majority of plants absorb lead from the soil, and unique biogeochemical parameters, such as pH, microbial conditions, and the type of plant species present, limit the flexibility and solubility of lead on Earth (S. Mohanty et al., 2017).Humans come into contact with lead through mining and fossil fuel burning. In burning, lead and its compounds are released into the air, soil and water. Lead can have different effects on the body, and effects the central nervous system that has come in contact with lead can have either acute or chronic lead poisoning.

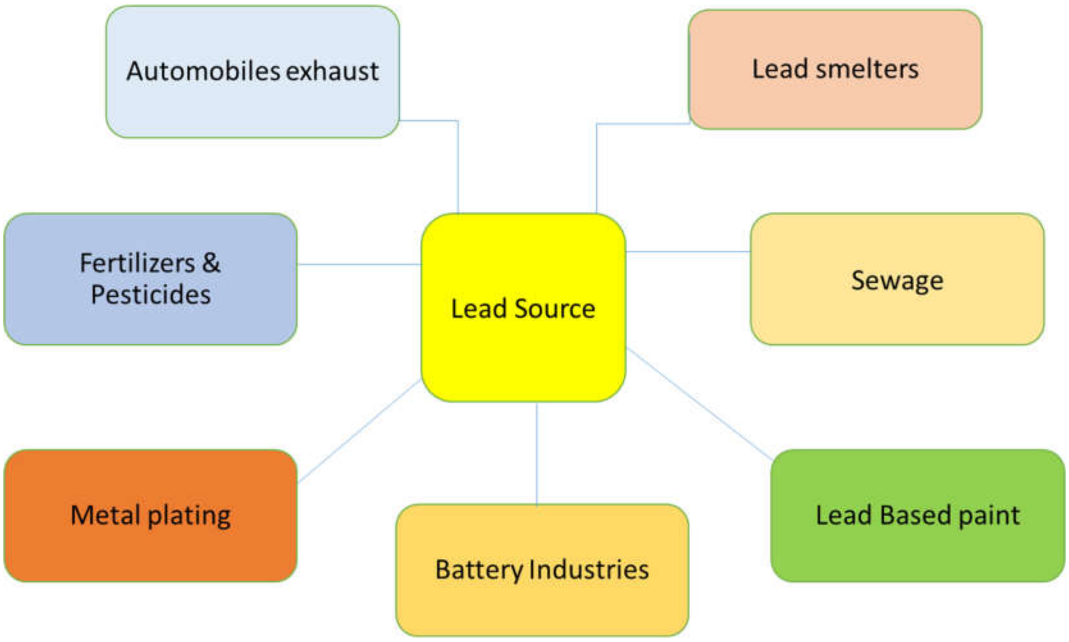


Figure 2: Sources of Lead in Environment

The non-biodegradable metal lead is present in nature in comparatively small amounts. Lead levels in the atmosphere are steadily rising as a result of human activities, including mining, manufacturing, and burning fossil fuels. When exposed to levels over the recommended threshold, lead is hazardous to the human body. Children are more susceptible to lead poisoning, and the severity of the illness worsens when they come into contact with dust that contains environmental lead (Loh et al., 2016). Those acute poisoning have symptoms such as, appetite, headache, hypertension, abdominal pain, fatigue, sleeplessness, arthritis, hallucination sand vertigo." Chronic exposure on the cause more severe symptoms such as, "mental retardation, birth defects, psychosis, autism, weight loss, hyperactivity, paralysis, muscular weakness, brain damage, kidney damage and death.

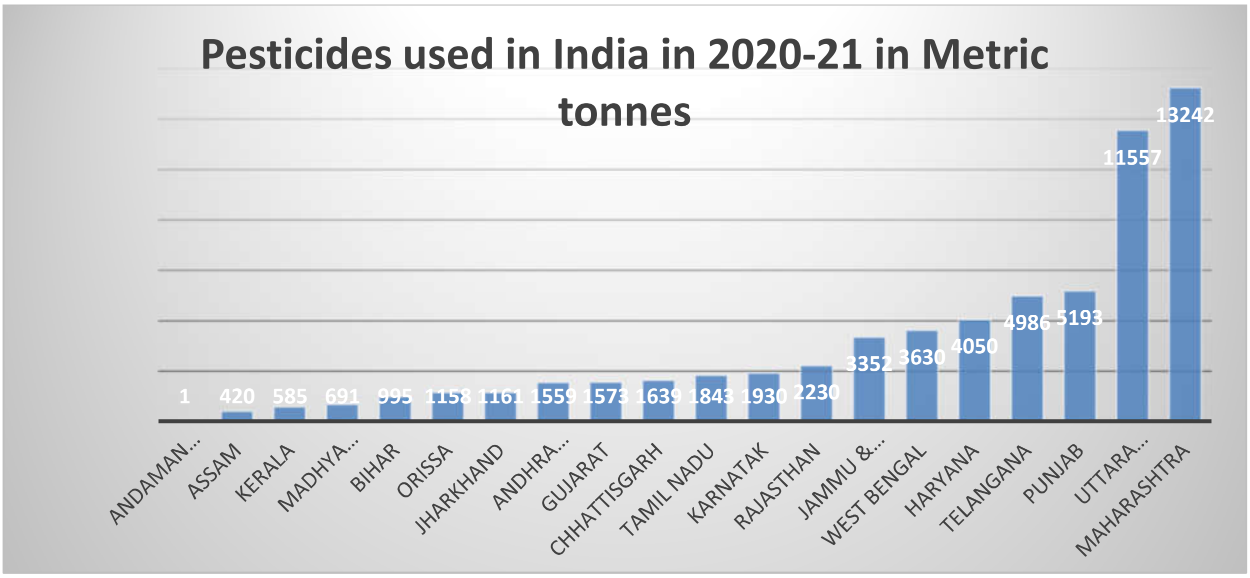
Mercury: Human activities like the creation of power and the burning of garbage contribute to the release of two-thirds of the mercury in the world's environment. The majority of this mercury is discharged into the atmosphere, where it flows through soils and surface waters before finding its way into lakes, streams, and estuaries. Mercury exists in three different forms, and all three possess different levels of bioavailability and toxicity. The three forms include organic compounds, metallic elements and inorganic salts. They are present in water resources such as oceans, rivers and lakes. They are absorbed by microorganisms and go through "bio-magnification causing significant disturbance to aquatic lives. Higher levels of mercury exposure can change many brain functions. It can "lead to shyness, tremors, memory problems, irritability and changes in vision or hearing. One of the most dangerous heavy metals that can be present in the biosphere is mercury. It has also expanded far and is becoming more prevalent in the atmosphere as a result of human activity. When mercury comes into contact with aquatic sediments, it transforms into the very hazardous methylmercury (Gworek et al., 2020). The human body is exposed to methylmercury through the food chain, which includes fish, shellfish, and animals that have been poisoned by consuming harmful microbes. It enters the bloodstream after being absorbed by the body and results in several neurological issues (Rice et al., 2014). As stated by the U.S. According to the Environmental Protection Agency's 2014 National Emissions Inventory report, power plants that generate electricity by burning coal are the biggest emitters, making up over 42% of all emissions of mercury caused by human activity.

Cadmium: Cadmium is the 7th most toxic heavy metal. The earth's crust is rich in sources of Cd, which are typically found in conjunction with copper, zinc, and lead ores (K. Cheng et al. 2014). However, anthropogenic activities like electroplating, mining, stabilizing plastics, alloy, cement, pigment, battery manufacturing, burning fossil fuels, high phosphate fertilizers, and burning municipal and sewage sludge are the main causes of its widespread presence in large quantities (G. Maynaud et al. 2014). The United Nations Environment Program (UNEP) reported that between 150 and 2600 tons of Cd are emitted into the environment each year (UNEP, 2008).Cadmium is interesting in that once it is exposed to humans (at work) or animals in their environment, it will accumulate inside the body throughout the life of the human and animal. Both natural and man-made activities can emit cadmium into the atmosphere, and there are differences in the ways that humans and animals might be exposed to it. Absorption, surface runoff, and industrial waste all contribute to cadmium poisoning of the aquatic environment. Cadmium poisoning can occur through ingestion of food, inhalation of air, or consumption of water contaminated with the metal. There is nothing about cadmium that is beneficial to plant growth and metabolism (Genchi, G et al., 2020). As stated by the Agency in the US, more than 500,000 workers are exposed to toxic cadmium each year. "It is also stated that the highest exposure to cadmium can be seen in China and Japan.The effect of cadmium on the kidneys and bones is huge. It can cause bone mineralisation, which is the process of laying down minerals on a matrix of the bone". This can happen through renal function or bone damage.

Chromium: The 7th most abundant element, chromium, can occur naturally when one burns soil and coal and is released into the environment through sewage and fertilizers. Chromium usage can be seen in industries such as metallurgy, electroplating, the production of paints and pigments, and tanning. Humans need Cr(III), which is essential for the metabolism of fat, protein, and glucose. Furthermore, it has been observed that Cr(VI) form poses a health risk to humans, especially through acute and chronic inhalation exposures, aggravating respiratory tract issues, which are the main organ of toxicity (Cabral-Pinto et al., 2020). It increases the risk of lung cancer by acting as a carcinogen. Animal studies have shown that long-term inhalation exposure to Cr(VI) forms can result in lung cancers (Lewicki et al., 2014; Alves, I.A., 2021). The atmospheric conditions and species of chromium determine its translocation in the environment, absorption, accumulation in plants, and toxicity to people. The toxicity of chromium to plants varied greatly based on the physiological characteristics of plants.Wood preservation, chemical production and pulp and paper production." Chromium toxicity affects the biological processes in various plants such as maize, wheat, barley, cauliflower, and in vegetables". Chromium toxicity causes chlorosis and necrosis in plants.

7. PESTICIDES TOXICITY

Pesticides are a major source of environmental toxicity. These chemically synthesized agents have been known to remain in the environment long after their administration. The poor biodegradability of pesticides can result in bioaccumulation of chemicals in various organisms along with bio-magnification within a food web. Pesticides pose considerable risks to the environment and non-target organisms, particularly affecting pregnant women and their developing fetuses (Saxena et al., 2018).Pesticides can be categorized according to the pests they target. Insecticides are used to eliminate agricultural pests that attack various fruits and crops. Herbicides target herbaceous pests such as weeds and other unwanted plants that reduce crop production e.g. Atrazine. Nematicides are used to deal with nematodes e.g. Methyl bromide, Ethylene bromide. Fungicides chemicals like Thiram, Ziram and dithane S-21 etc. The uses of pesticides, herbicides and fungicides began in India during the starting of Green revolution period in 1960 (Chandra and Singh 2021)



Sources: Statistical Database Directorate of Plant Protection, Quarantine and Storage (GOI, 2021)

Figure: Pesticide use in India 2020–21

I. **DDT**–Being very persistent in the environment and human body, DDT was the first synthetic pesticide to be employed extensively. Paul Muller identified its insecticidal effects in 1939 after Zeidler synthesized it for the first time in 1874 (Mischke et al, 1985). In 1943, DDT was first produced (Pretty and Hine, 2005). This chemical agent was created to eradicate weeds, insects, rodents, fungi, and other nuisances to humans (UNEP, 2004). DDT was the first contemporary synthetic insecticide used in the 1940s to combat insect-borne diseases in humans and to control insects in housing, institutions, and agriculture (Environmental Protection Agency – EPA, 2012).

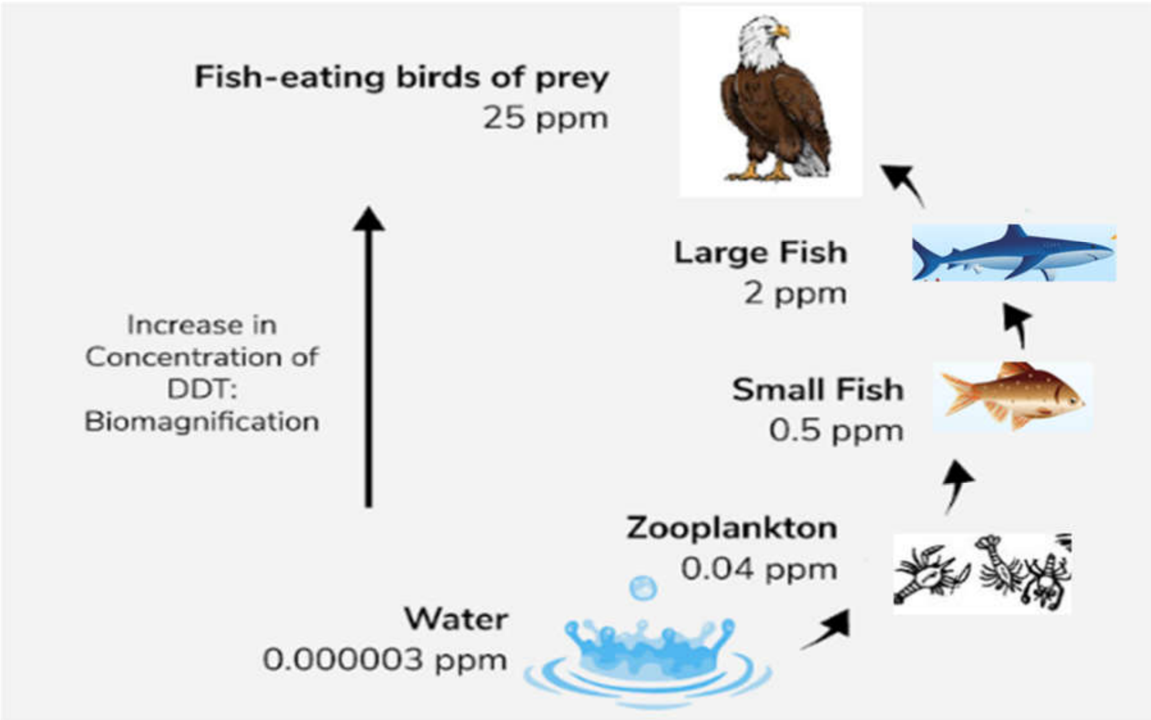


Figure 3 Bioaccumulation DDT pesticide

DDT rose to prominence during World War II as a miracle chemical for all types of pest problems; in fact, "if there is a single pesticide that practically everyone can name, it's DDT" (Pesticide Action Network, 2012). But more harmful substances were discovered as a result of the extensive use of DDT (Carson, 1962). With mounting evidence of its harmful effects, DDT was identified as a reproductive toxin (Longnecker et al, 2005). Consequently, DDT has been prohibited in the majority of Western nations since the 1970s (Biscoe, 2004).In addition to revolutionizing agricultural production, DDT is credited for eradicating malaria in both Europe and the United States (WHO 2011). DDT, however, is also known to have had significant negative effects on the ecosystem and to have contributed to sharp drops in a variety of animal populations. Dichlorodiphenyltrichloroethane (DDT) is an organochlorine insecticide that has been banned due to its adverse effects on both humans and wildlife. DDT’s insecticidal properties were first discovered in 1939. Dichlorodiphenyltrichloroethane (DDT), arguably the most well-known and practical pesticide in the world, has harmed wildlife and may be harmful to human health due to decades of unregulated use. Human tissues contain DDT because of its durability and tendency to build up in adipose tissue; now, not a single living thing on Earth is free of DDT. Following this discovery, DDT was widely used by farmers in order to kill agricultural pests such as the potato beetle, coddling moth and corn earworm. DDT is not easily biodegradable and thus the chemical accumulates in soil and sediment runoff. Water systems become polluted, and marine life such as fish and shellfish accumulate DDT in their tissues. Although DDT tends to accumulate in the adipose tissues of humans, animals, and insects, it doesn't seem to have any negative impacts during this process. DDE, DDD4, and DDA5 are among the breakdown products that are produced when DDT is metabolized in the body. When fat reserves are depleted during famine, DDT breakdown products are released into the bloodstream, where they may be harmful to the liver and nervous system. Three nations now produce DDT: China, India, and the Democratic People's Republic of Korea (DPRK; North Korea). For the purpose of controlling disease vectors, India produces by far the most. China produced 4,500 metric tons of DDT annually on average between 2000 and 2004; however, 80–90% of that amount was utilized to make the acaricide Dicofol, and about 4% was added to antifouling paints. The rest was exported and used to combat malaria. DDT is exported to African nations by both China and India, either as a formulation or as a technical product for vector control.Ingredients supplied from China are used in the formulation of DDT in South Africa and Ethiopia. A portion of South Africa's manufactured goods are exported to neighboring African nations. The detrimental effects of DDT on human health were compiled by Eskenazi et al. (2009) and included significant findings like the link between DDT exposure and an increase in diabetes cases, pregnancy loss, changes in gestational length, birth weight, and time to conception, shorter lactation duration, urogenital birth defects, an earlier menarche age, changes in male and female fertility, a decrease in triiodothyronine, and immune system effects.Once DDT has built up in the body, it is removed through the urine, faeces, or breast milk. Breast milk is a common way to measure a population's exposure to DDT.

Furthermore, this effect is amplified when animals that consume the fish also consume the chemical, demonstrating bio-magnification within the food web. The process of bio-magnification has detrimental effects on various bird species because DDT and its metabolites accumulate in their tissues, inducing egg-shell thinning. Rapid declines in bird populations have been seen in Europe and North America as a result.Humans who consume animals or plants that are contaminated with DDT experience adverse health effects. Various studies have shown that DDT has damaging effects on the liver, nervous system and reproductive system of humans. By 1972, the United States Environmental Protection Agency (EPA) banned the use of DDT in the United States. Though DDT was banned in 1972, some of the pesticides lingered in the environment.

II. **Sulfuryl Fluoride:** The insecticide and rodenticide sulfuryl fluoride was first registered in 1959. As soon as the gas leaves the building during ventilation, it dissipates in the atmosphere. (Office of Prevention, U.S. Environmental Protection Agency, 1996),recent studies have shown that sulfuryl fluoride has a longer half-life than previously thought. According to research, sulfuryl fluoride has a 30- to 40-year atmospheric lifetime (Mühle, J. et.al 2009). Global sulfuryl fluoride concentrations in the troposphere increased by 5 ± 1% between 1978 and 2007 (Mühle, J. et al. 2009). Sulfuryl fluoride has also been found to have a considerable potential to contribute to global warming. Its ability to cause global warming is unclear, but (Papadimitriou, V. C. et al. 2008, Sulbaek Andersen, M. P. et al. 2009). According to RED Sulfuryl Fluoride (1993), the current use pattern and volatility of sulfuryl fluoride make groundwater contamination unlikely. It is hydrolyzed into fluoride and sulfide ions, and it is also broken down by ultraviolet light and reactions with solid particles in the atmosphere (General Information on Vikane Gas Fumigant 1994).Sulfuryl fluoride is an insecticide that is broken down into fluoride and sulfate when released into the environment. Fluoride has been known to negatively affect aquatic wildlife. Elevated levels of fluoride have been proven to impair the feeding efficiency and growth of the common carp (Cyprinus carpio). Fluoride exposure alters ion balance, total protein and Lipid levels within these fish, which changes their body composition and disrupts various biochemical processes. Sulfuryl fluoride enters the body through the respiratory system and is quickly absorbed. It decomposes there into fluoride, fluorosulfate, and sulfate. These substances travel throughout the body in the bloodstream. Together, these comprise the brain, nasal tissues, kidneys, spleen, and lungs. Sulfuryl fluoride is emitted into the atmosphere and quickly spreads across it. It is thought to last at least 4.5 years in the atmosphere. This is the typical time it would take for the atmospheric concentration of sulfuryl fluoride to return to pre-release levels following a single emission. Ocean water gradually extracts it from the atmosphere. However, clouds, rain, fresh water, and terrestrial plants do not readily absorb sulfuryl fluoride. Sulfuryl fluoride degrades quickly in water; half-lives ranging from around 10 minutes to three days have been documented. Urine quickly removes sulfate and fluorosulfate from the body; half-lives of one to four hours have been documented. Fluoride levels in urine rose rapidly following exposure in one study. However, after 12 to 24 hours, these levels stabilized. Fluoride levels in bones and teeth can accumulate above a specific daily dosage.

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