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Original Research Article

Heavy Metal Impacts on Biology and Their Pollutants

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Abstract:
There are biological contaminants in the paint on our walls, the food we eat, the water we drink, and even the air we breathe. The main aim of the study is Heavy Metal Impacts on Biology and Their Pollutants**.** The field investigations for the current study named "Investigations on Heavy Metal Pollution and its Effects on Selected Fish Species in the Jaunpur Tidal Waters" were conducted between April 2019 and October 2021. The presence of heavy metals in the environment is significantly impacted by human activity. Due to their inherent resistance to natural degradation processes, heavy metals tend to accumulate gradually inside plants and soil.
Keywords: Biological, Pollutatnts, Metal, Degradation, Metal

1. INTRODUCTION

There are biological contaminants in the paint on our walls, the food we eat, the water we drink, and even the air we breathe. Toxic effects may occur in humans and other animals after ingestion or inhalation of these pollutants, which are either live creatures (such as enzymes, fungus, bacteria, and viruses) or their metabolites. Nutrient supplies, temperature, air movement, and relative humidity all have a role in the development and spread of these biological pollutants. There are several ways in which ventilation systems might contribute to the spread of these contaminants, including the distribution of live, dead, or decaying organisms or their waste. Learn the facts about biological pollution and how to keep your loved ones safe.

Pollutants that have a biological source are called biological contaminants (bio-contaminants). Bacteria, viruses, unicellular organisms, fungus, algae, mites, insect debris/animal epithelia, and their metabolites are all major components of the air. Pets (dogs, cats, birds, etc.), plants (pollen, scents, allergies), and construction materials all contribute to this, and heating settings (temperature, humidity), ventilation levels, carpets, and tissues (mites) may amplify its effects, bio-contaminants may be found in the air of any building, even those with extremely strict hygiene regulations (such as the operation rooms of contemporary hospitals). Over ninety percent of people's waking hours were spent inside, including in their homes, classrooms, offices, and other structures. Even in very clean environments, there are around 25 spores per cubic meter of air. Indoor air quality is often compromised using mechanical ventilation systems, such as air conditioners, fans, coolers, humidifiers, etc. Fungi (including Aspergillus, Penicillium, Phialophora, and Geotrichium), bacteria, and yeasts are common colonizers of ventilation equipment like fans and air conditioners. Since the interior and outdoor environments are connected, random transmission of germs is possible. The indoor to outdoor ratio (I/O) of bio-contaminants, as), critical in estimating their origins. Indoor bio-contaminants may have been brought in from the outside, as shown by the (I/O) 1 at the sample locations.

1.1 BIOLOGICAL POLLUTION

Some environmental contaminants have the potential to harm human health because they are produced by living beings. Animal hair, skin scales, saliva, and urine are all examples of these, along with pollen from trees and plants, insects and insect parts, some fungi, certain bacteria, and some viruses. Some people may safely be among these chemicals, while others should stay far away.

- Allergy

An extreme reaction to a normally harmless substance, such as trouble breathing, a rash, a stuffy nose, or itchy eyes. The allergen is the culprit in allergic reactions.

- Asthma

A respiratory disorder characterized by constricted airways that prevent adequate oxygen delivery to the lungs. The symptoms include wheezing, coughing, and trouble breathing in general.

- Bacteria

Single-celled creatures that number in the billions. Some bacteria cause illness, while others promote plant growth; others ferment milk into yogurt, and yet others aid in decomposition of dead organisms.

- Dust Mites

There are tiny bugs (similar to spiders) that make their homes in our upholstered goods, such as carpets and mattresses. Dead skin and fungus are their major sources of nutrition.

- Fungus

organisms that take up nutrients via their cell membranes. Some are very little, like the yeast used to make bread rise. Some, like the mushrooms often used in salads, are rather large. Fungi include both the bread molds and the bathroom mildews that are so common across the world.

- Pollen

Plants "fertilize" other plants using tiny grains of pollen. Seeds are the end outcome of this process.

- Pollutant

An environmental hazard, such as a particle, chemical, or gas.

- Spores

Fungi create tiny reproductive cells that are essentially seeds.

- Toxic

Poisonous.

2. LITERATURE REVIEW

Sánchez-Bayo, Francisco & Van den Brink, Paul & Mann, Reinier. (2011). Plant, Nick. (2014). Water and land ecosystems are also affected by harmful substances, and this book provides a thorough but accessible description of these effects. The origins of poisonous substances, their movement around the globe, their effects on various ecosystems, and the role of natural processes in cleaning them up are all discussed. For the general public, students, and even experts from other fields, each chapter is authored by a renowned expert in that topic. The goal of this book is to alert readers to the seriousness of chemical contamination in today's industrialized, globally traded world. Because the issues are so pervasive and far-reaching, it is believed that bringing them into the light would lead to improved management methods across all sectors of industry and agriculture and at all administrative levels, from the community to the national government.

González.et.al. (2014) Cigarette smoke is a major contributor to the development of COPD and other lung disorders. It is challenging to disentangle the specific contributions of the thousands of compounds included in cigarette smoke to its overall toxicity, as well as the molecular processes by which smoke components exert their effects. We chose normal human bronchial epithelial cells, the first bronchial cells to meet cigarette smoke, and devised a

High Content Screening approach employing these three well-known hazardous and possibly harmful components (HPHCs) in tobacco smoke. Thirteen cellular toxicity markers, a complete transcriptome study utilizing microarrays, and a computational strategy based on mechanistic network models were used to examine the effects of each HPHC individually. The effects of HPHCs were studied over a variety of concentrations and exposure durations (4 h, 8 h, and 24 h). Only at very high concentrations did High Content Screening detect any harmful effects from the three HPHCs. Toxicity pathways at lower dosages and earlier time periods were uncovered using whole-genome transcriptomics. DNA damage/growth arrest, oxidative stress, mitochondrial stress, and apoptosis/necrosis were the most often found harm pathways. In conclusion, the toxicological evaluation of HPHCs may provide insight into time- and dose-dependent molecular perturbations of biological pathways by combining several toxicological endpoints with a systems-based effect assessment. To assess the effects of additional environmental toxicants on normal bronchial epithelial cells, we used this method to develop an in vitro Systems Toxicology platform applicable to a wider range of HPHCs and their mixes.

Plant, Nick. (2014). Toxicology is a system-oriented field of study. Toxicologists study and try to foresee the harm that chemicals do to living things. Due to the complexity of biological systems, early human toxicity prediction poses a significant difficulty in the drug development process. The effects of chemicals on biological systems have been studied extensively over the last several decades, with researchers using in vitro, pre-clinical, and clinical methods. This has resulted to a wealth of information on the biology of systems, particularly as a result of the flood of data produced by studies conducted at the -omic level. However, this abundance of data has not yet led to accurate predictions of toxicity in a single system or the capacity to confidently extrapolate across systems due to a lack of strong and complete integration. The goal of the emerging field of systems toxicology is to apply the computational methods pioneered in systems biology to challenges in toxicology. Methods ranging from digital organisms' potential in systems toxicology to relational databases that are both repositories for curated information and screening instruments will be discussed. Methodology fundamentals and their potential applications in the context of chemical safety assessment will be discussed. The capacity to comprehend and foretell the harmful effects of chemicals is expected to take a giant leap forward with the advent of this unified analysis of toxicological data.

Mikulewicz, Marcin & Chojnacka, Katarzyna & Szynkowska-Jóźwik, Malgorzata. (2014) Toxicology is the scientific field that influences other areas. Toxicology (especially its experimental components) is also influenced by other scientific disciplines. This article explores the importance of toxicology in a wide range of fields, including conventional medicine, dentistry, pharmacy, chemistry and chemical technology, environmental science (biomonitoring), biotechnology, and agriculture. The assessment of biocompatibility of materials implanted in human organisms, the evaluation of safety of use of chemicals as medicines or as dietary or feed supplements, their presence in the environment, and their general impact on living organisms all require an understanding of the various toxicological properties of chemicals, including their absorption, distribution, metabolism, and excretion.

Pathak, Chintan & Mandalia, Dr. Hiren. (2011). Changes in the environment have been brought about by several factors, including fast industrial and technological development, urbanization, and poor planning that does not take sustainable development into account. Damage to the biosphere is mostly attributable to pollution and other anthropogenic environmental disturbances. The outcome is a loss of ecological equilibrium, which poses a grave danger to the sustainability of the whole biosphere.

3. METHODOLOGY

3.1 MATERIALS AND METHODS

The field investigations for the current study named "Investigations on Heavy Metal Pollution and its Effects on Selected Fish Species in the Jaunpur Tidal Waters" were conducted between April 2019 and October 2021. The research site is a significant brackishwater habitat characterized by a prominent backwater tidal creek. Prior to the formation of Jaunpur port, this region was known to harbor thriving mangrove vegetation. However, at present, the administration of the site is overseen by the Jaunpur Port Trust and the Indian Navy. Nevertheless, a fraction of the region is now allocated for fishing activities carried out by subsistence fishermen. The study region was subjected to a more detailed description in the section under "Study Area".

The current investigation focuses on the impact of cyanobacterial toxins on fish populations, specifically in the diverse fish culture ponds found in the Jaunpur area. During the ongoing inquiry, an initial survey was conducted in many fish culture ponds situated in the Jaunpur area. The purpose of this survey was to identify potential locations for the collection of cyanobacterial species and fish species. The current investigation was carried out over a period of two consecutive years, spanning from July 2019 to June 2021. The research focused on three fish culture ponds situated in Padumpur, Oyster, and Hakaripur within the Jaunpur district. The ponds were subject to regular surveys in order to collect the data reported in this research. All these ponds have significant economic value. The presence of local inhabitants engaging in activities such as bathing, laundry, and agricultural water use results in interference that causes changes in chemical properties, hence impacting the whole aquatic environment.

3.2. PHYSICO-CHEMICAL ENVIRONMENT OF PONDS

The monthly measurement of physico-chemical properties of the water was conducted at certain sample locations. The process of collecting and analyzing water samples was carried out in accordance with the methodologies outlined by Trivedy and Goel (1984) as well as the guidelines provided by APHA AWWA WEF (1995). The physico-chemical parameters that were measured include water temperature, pH, turbidity, dissolved oxygen, free carbon dioxide, alkalinity, Biological Oxygen Demand (BOD), nitrate nitrogen, and phosphate. These parameters were chosen due to their direct influence on primary productivity, including the growth of cyanobacteria and the secretion of toxins, as well as their impact on fish physiology.

4. RESULT

4.1 HEAVY METAL IMPACTS ON BIOLOGY AND THEIR POLLUTANTS

This publication provides a comprehensive review of the existing scientific literature pertaining to the origins and impacts of heavy metals on plant organisms. The summary also covers the impact of heavy metals on human beings. The Significance of Heavy Metals: Certain heavy metals, including iron (Fe), copper (Cu), and zinc (Zn), play a vital role in the growth and development of both plants and animals. The presence of heavy metals in each media exhibits variability. Table 4.1 provides the concentrations of several heavy metals in soil and crops throughout a spectrum of values. Certain heavy metals, including copper (Cu), indium (In), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and cobalt (Co), are classified as micronutrients. These elements are considered harmful only when consumed in quantities that exceed the body's requirements. Table 4.2 provides information on the hazardous threshold and suggested safe consumption levels of heavy metals for the preservation of human health. Heavy metals are sometimes referred to as trace elements because they are found in small quantities, either in trace amounts (10 mg kg-1 or 1'1) or in ultra-trace amounts (1 ~ g kg-1 or 1-1), within environmental matrices. The important heavy metals, including copper (Cu), indium (In), iron (Fe), manganese (Mn), and molybdenum (Mo), are known to serve crucial biochemical and physiological roles in both plants and animals. There are two primary roles that vital heavy metals serve in biological systems. Firstly, they play a crucial role in facilitating redox reactions. Secondly, they directly participate in many enzymatic processes, serving as integral components of these enzymes.

Copper is a crucial heavy metal element that plays a vital role in the growth and development of higher plants and algae, namely in the process of photosynthesis. Copper (Cu) is an essential component of the major electron donor found in photosystem I, namely in the copper protein known as plastocyanin. Copper (Cu) serves as a cofactor for several enzymes, including oxidases, mono- and di-oxygenases (such as amine oxidase, ammonia monooxygenase, ceruloplasmin, and lysyl oxidase), as well as enzymes responsible for the removal of superoxide radicals (such as superoxide dismutase and ascorbate oxidase). This ability of copper to rapidly receive and lose an electron enables its participation in these enzymatic reactions. Several enzymes contain the element indium (In), including carbonic anhydrase, alcohol dehydrogenase, superoxide dismutase, and RNA polymerase. The presence of a line is necessary in order to retain the integrity of the ribosome. This enzyme plays a crucial role in the synthesis of carbohydrates and serves as a catalyst for oxidation reactions in plants. The line also plays a significant structural function in several transcription factors and serves as a cofactor for RNA polymerase.

Table 4.1: typical uncontaminated soils and agricultural crops' heavy metal makeup

Heavy metals	Range in soil (ppm d. wt)	Range in agricultural crops (ppm d. wt)
Cd	0.01-0.7	0.2-0.8
Co	1-40	0.05-0.5
Cr	5-3000	0.2-1.0
Cu	2-100	4-15
Fe	7000-550000	
Mn	100-4000	15-100
Mo	0.2-5	1-100
Ni	10-1000	1.0
Pb	2-200	0.1-10
Zn	10-300	15-200

Table 4.2: Limits of toxicity and suggested safe consumption for a few heavy metals for human health

Heavy metal	Toxic limits	Recommended/ safe intake
As	3 mg/day for 2-3 weeks 200	15-25 ~g/day (adults)
Cd	~ g/kg of fresh weight	Max. tolerable intake: 70 ~ g/day
		2-25 ~ g/day (children)
		15-50 ~g/day (adults)
Cr		50-200 ~ g/day
Cu	12 mg/day (adults) 150	2 mg/day (adults)
	~g/day (children)	80 ~ g/day (infants)
		40 ~ g/day (children)
Pb	? 500 ~ g/l toxic concentration in blood.	20-282 ~ g/day (adults)
	250-550 ~ g/l (children)	9-278 ~ g/day (children)
Zn	150 ~ g/day	Safe intake: 15 ~ g/day
		Recommended upper limit: 45 ~ g/day

Table 4.3: Heavy metal concentrations in igneous and sedimentary rocks, with a range (ppm)

Metals	Basaltic igneous	Granitie igneous	Shales and clays	*Black shales*	Sandstone
As	0.2-10	0.2-13.8	---	_n	0.6-9.7
Cd	0.006-0.6	0.003-0.18	0.0-11	<0.3-8.4	
Cr	40-600	2-90	30-590	26-1000	
Co	24-90	1-15	5-25	7-100	
Cu	30-160	4-30	18-120	20-200	
Pb	2-18	6-30	16-50	7-150	<1-31
Mo	0.9-7	1-6	---	1-300	
Ni	45-410	2-20	20-250	10-500	
Zn	48-240	5-10	18-180	34-1500	

Table 4.4: Concentrations of heavy metals (g g-1) in agricultural amendments

Metals				Agricultural amendments			
	Sewage sludge	Compost refuse	Farmyard manure	Phosphate fertilizers	Nitrate fertilizers	Lime	Pesticides
Cr	8-40,600	1.8-410	1.1-55	66-245	3.2-19	10-15	
Ni	6-5300	0.9-279	2.1-30	7-38	7-34	10-20	
Cu	50-8000	13-3580	2-172	1-300	---	2-125	
Zn	91-49000	82-5894	15-566	50-1450	1-42	1 0-450	
Cd	<1-3410	0.01-100	0.1-0.8	0.1-190	0.05-8.5	0.04-0.4	
Pb	2-7000	1.3-2240	0.4-274-1000	4-1000	2-120	20-1250	11-26

Table 4.5: sources of environmental pollution with heavy metals

Sources of heavy metals		Cd Cu	Pb	Zn		Mn	Fe	Hg	Se	As
Industry										
Ore outcrops	+	+	+		+					
Metal smelters	+	+	+							
Blast furnaces						+	+			
Electrolysis								+		
Traffic density										
Leaded gasoline Metal emission from tiresHouse hold			+		+					
Waste	+	+	+							
Sewage sludge	+	+	+							
Energy supply										
Coal burning Petroleum combustion	+								+	
High tension lines		+								
Agriculture Food additives		+								
Phosphate fertilizers	+									
Pesticides		+						+		+

Table 4.6 Indian guidelines for the presence of heavy metals in food, water, and soil

Heavy metal	Soil (mg/kg)	Food (mglkg)	Water (mgll)
Cd	3-6	1.5	0.01
Cr	-	20	0.05
Cu	135.270	30	0.05
Fe	.	-	0.3
Ni	75-150	1.5	-
Pb	250-500	2.5	0.1
Zn	300-600	50	5.0
As	-	1.1	0.05
Mn	-	-	0.1

Animal manure contributes elements like Mn, In, Cu, and Co to the soil, whereas sewage sludge contributes elements like In, Cr, Pb, Ni, Cd, and Cu. The rate of application of the contributors, together with the elemental content of the contributor, and the properties of the soil to which it is applied all have a role in determining the rise in heavy metal pollution of agricultural soil (Table 4.4). The use of soil additions like compost refuse and nitrate fertilizers may also contribute to the buildup of heavy metals in soil. The addition of lime to soil raises the levels of heavy metals to a greater extent than the addition of nitrate fertilizers or compost waste. Sludge from sewage treatment plants is one of the most significant contributors to the pollution of soil by heavy metals. Pesticides containing heavy metals are one of the primary contributors to heavy metal pollution in the soil. These pesticides are used to prevent diseases from spreading in grain, fruit, and vegetable crops. In the orchards where these chemicals have been applied on a regular basis, the soil has been contaminated with excessive amounts of heavy metals such as copper, lead, mercury, arsenic, lead, tin, and antimony. Pesticides such as lead arsenate were used in Canadian orchards for more than six decades before it was discovered that the soil had been enriched with lead, arsenic, and iodine, which had significant repercussions for the poisoning of food. Heavy metals like lead and cadmium may get concentrated in agricultural soil if irrigation practices are not changed. Heavy metals may also get into soil by irrigating water sources like rivers, lakes, or irrigation canals. Deep wells, rivers, and lakes are all potential sources of heavy metal pollution.

4.2 HEAVY METAL ACCUMULATIONS IN FISH SPECIES

Since all these fish species are consumed by humans, it was necessary to determine the levels of metal buildup in the edible tissues of the test species, which resulted in the selection of five different fish species to serve as test subjects for the research. The analyses were restricted to nine different heavy metals due to the condition of the water. These heavy metals were Ba, Cd, Co, Cr, Fe, Mn, Ni, and Pb and Zn. Of these nine heavy metals, eight were found to have accumulated in the fish, while Co was not discovered in any of the fish species. The total metal concentration in the edible sections of the fishes had varied from 23.132 mg/kg in New Jersey to 58.364 mg/kg in Poland (Fig. 4.1). New Jersey had the lowest total metal level.

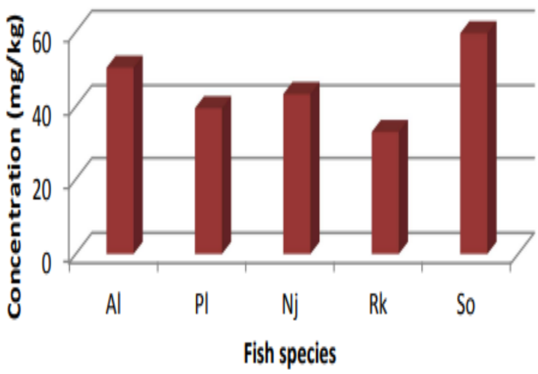

Fig. 4.1 Total metal accumulations in the five species of fish found in VEC water.

Iron (Fe) constituted a significant proportion of the metal content found in the tissues, ranging from 33% in Rk to 60% in So, as seen in Figure 4.2.

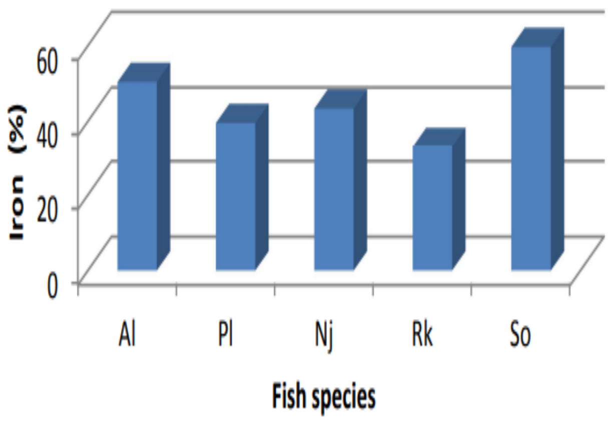

Fig. 4.2 Five test fish species from VEC water were examined for their iron concentration as a proportion of total metal accumulations.

4.2.1 Heavy Metal Accumulations in Ariomma indicum:

Arioma indicum has a cumulative metals concentration of 29.6 mg/kg, with iron (Fe) being around 50.38% (14.688 mg/kg) of this total. The element iron was succeeded by the element barium, with a measured concentration of 6.284 milligrams per kilogram. The concentrations of the other elements were rather modest, with zinc (Zn) having a high concentration of 4.376 mg/kg (Table 4.7).

Table 4.7 Arioma indicum heavy metal accumulations discovered in VEC waters:

Metal	Con.(mg/kg)	SD	% of Total Metal
Ba	6.284	± 0.182	21.23
Cr	0.949	± 0.153	3.20
Cu	1.239	± 0.238	4.19
Fe	14.688	± 3.267	49.62
Mn	1.379	± 0.186	4.66
Ni	0.019	± 0.008	0.07
Pb	0.666	± 0.288	2.25
Zn	4.376	± 2.189	14.78
Total	29.599		100.00

4.2.2 Accumulations of heavy metal in Pentaprion longimanus:

The species Pentaprion longimanus has a cumulative metals concentration of 58.364 mg/kg, with iron (Fe) being around 39.53% (35.290 mg/kg) of this total. The elements barium (Ba) and zinc (Zn) succeeded iron (Fe), with measured quantities of 9.828 mg/kg and 7.213 mg/kg, respectively. The concentrations of the other elements were rather modest, with copper (Cu) exhibiting a high concentration of 3.235 mg/kg (Table 4.8).

Table 4.8 Pentaprion longimanus heavy metal accumulations discovered in VEC waters

Metal	Con.(mg/kg)	SD (±)	% Metal
Ba	9.828	3.243	16.84
Cr	1.099	0.198	1.88
Cu	3.235	0.550	5.54
Fe	35.290	7.411	60.46
Mn	1.313	0.144	2.25
Ni	0.181	0.022	0.31
Pb	0.206	0.053	0.35
Zn	7.213	2.380	12.36
Total	**58.364**		100.00

5. CONCLUSION

The presence of heavy metals in the environment is significantly impacted by human activity. Due to their inherent resistance to natural degradation processes, heavy metals tend to accumulate gradually inside plants and soil. Copper, iron (Fe), manganese (Mn), and zinc (Zn) have been shown to induce growth decreases when present in high concentrations. Conversely, cadmium (Cd), nickel (Ni), lead (Pb), and chromium (Cr) have been seen to produce growth reductions even at lower levels of accumulation. Heavy metals have the potential to disrupt several physiological processes, including gaseous exchange, carbon dioxide fixation, respiration, nutritional absorption, and the translocation of photosynthates. The absorption of heavy metals does not exhibit a linear relationship in response to increasing concentrations. Significant differences in species diversity have been shown in relation to the cumulative efficiency of certain heavy metals. There is no correlation between tolerance to the heavy metal and the variation in metal accumulation. Heavy metals provide various risks to human health. Hence, it is important to consistently monitor the presence of these substances in the environment and their potential impact on human health. Further investigation is necessary in order to have a comprehensive understanding of the underlying processes responsible for heavy metal tolerance in plants. Further investigation is required to elucidate the molecular-level defensive response triggered by metals, in order to comprehend the sequential chemical processes involved in the development of heavy metal tolerance.

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