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ORIGINAL ARTICLE

Determination of Heavy Metals Concentration in Water and Soil at Various Locations in Lahore and their Harmful Impacts on Human and Plants life

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ABSTRACT

Heavy metals poisoning of soil and water has resulted from industrial expansion in Lahore, Pakistan, creating a significant environmental hazard. As a result, monitoring the contamination of soil and water around industrial sites is critical. The fact that higher concentrations of heavy metals have a negative influence on both plants and human life and this cannot be ignored. Higher heavy metal concentrations have a direct impact on human health due to their presence in drinking water. Consumable plants and vegetables cultivated in these polluted areas may collect higher concentrations of heavy metals from soil and water via the phytoremediation process. Its worth mentioning that the accumulation of toxic metals in edible plants and vegetables also has a direct negative impact on human and animal health. The purpose of this study is to find the heavy metals concentration in the soil and ground water in the Lahore area. Five industrial zones were evaluated for water and soil throughout the research period of December 2021 to January 2022 (pre-monsoon). pH and heavy metals content measurements were performed on the collected soil and water samples. We discovered that the water had a higher pH and that the soil was heavily contaminated with significantly higher concentrations of toxic heavy metals. According to the research, there is a gangrenous influence of pollution caused by industrial waste and the surrounding environment on soil and water resources, which affects living creatures.

Keywords: Environmental Pollution, Heavy Metal, Pollution, Water pollution, Soil pollution

INTRODUCTION

The origins and impacts of pollution on the environment are explored in a quick introduction to air, water, and soil contamination (Payne, 2018). Pollution happens when a substance is put into the environment that has a negative impact on the water or soil (Sanchez, 2008). Globally, environmental degradation is rising quickly. Heavy metals such as lead, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Pb, and Hg pollute soil, posing substantial environmental issues since these metals are non-essential and poisonous to plants and animals, as well as having a significant detrimental effect on human health. Through their direct absorption from contaminated soils, eating of vegetables cultivated on contaminated soils, and drinking wastewater that has percolated through such soils, the potential introduction of these elements has led to the rising prevalence of heavy metals in the environment.

When ingested in excess of the allowed limits, heavy metals are extremely hazardous to both plants and people. Through several human activities, considerable amounts of these heavy metals are discharged into the environment. When ingested in excess of the allowed limits, heavy metals are extremely hazardous to both plants and people. Through several human activities, considerable amounts of these heavy metals are discharged into the environment. Surface runoff water and sewage sludge from industrial water-water outputs are the main sources of these heavy metals and trace elements (Kurniawan,T. A et al., 2006)

Water is deemed contaminated when dangerous chemicals and organisms contaminate it. Chemicals or bacteria in the water can render it unhealthy for people or aquatic life, including plants. Pollution can occur in any body of water. Polluted groundwater is not only unfit for human consumption, but it also has the potential to affect other water sources such as lakes and streams. Polluted water may contaminate soils, and the same is true in the other direction. Heavy metals and chemicals from personal care items and medications are among the most frequent soil pollutants. Pollutants build up in the soil and have an impact on plant development, particularly the plants that humans eat. Many industries contribute to the contamination of water and soil. Although oil spills receive the greatest attention as a source of water contamination, they are far from the only one. Larger bodies of water can readily be contaminated by waste from industry and companies. When fertilisers, herbicides, and insecticides collect in the soil and run off into surrounding streams and lakes, agriculture is another important source of pollution. Soils can become contaminated by heavy metal and metalloid emissions from industrial areas, mine tailings, the disposal of high metal wastes, leaded gasoline and paints, fertiliser land application, animal manure and sewage effluent, pesticides, sewage irrigation, coal combustion residues, petrochemical spills, and atmospheric deposition. The most often found heavy metals in contaminated areas include lead (Pb), chrome (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni) (Wuana and Okieimen,2011). People in the area where industries are located are suffering from poor health owing to pollution from the environment (Hussain et al., 2020; Afzalet al., 2013).

Numerous studies have documented the harmful or toxic consequences of heavy metals. By directly influencing biochemical and physiological processes, inhibiting growth, degrading cell organelles, and obstructing photosynthesis in agricultural plants, they are harmful to both macro and microbes. Even though heavy metals are not necessary for plant growth, plants absorb and store them at greater levels, which results in toxic harm to cells and tissues as a result of intricate interactions between key hazardous ions and other required or non-essential ions (Ahmadpour P et al., 2012). Plant systems absorb and accumulate these harmful elements when these heavy metals and trace elements pollute the soil and water. Because these effluents are highly contaminated with dangerous metals and metallic compounds, using industrial waste water to grow vegetables is a very significant problem in Pakistan. (Singh et al., 2004). A major environmental worry has been the heavy metal poisoning of nearby agricultural land and crops caused by mining. Kalali A, et al (2011).

All living forms, including humans and bacteria, are poisonous when heavy metal concentrations are high. Free radicals and reactive oxygen species are produced in high concentrations by bioavailable forms of heavy metals in plant cells. Following this, cellular macromolecules including nucleic acids, proteins, and lipids begin to oxidize uncontrollably and set off a chain reaction that eventually results in oxidative stress and cellular damage. As a result, sensitive plants exposed to heavy metals exhibit altered metabolism, decreased growth, decreased biomass output, and decreased yield (Goyal et al., 2020).

The presence of heavy metals in soil and water can be harmful to humans. Because of its persistence, toxicity, bioaccumulation, and non-biodegradability, contamination of soil and groundwater near industrial dumps has become one of the most difficult environmental and health challenges (Shams et al., 2022). Heavy metals can become very hazardous when they come into contact with other elements in the environment, such as water, soil, or air, and humans and other living animals can be exposed to them through the food chain. (Mitra, S., et al 2022). Many small businesses in Lahore lack access to wastewater treatment facilities, forcing them to dump their waste in open fields or ditches (Hussainet al., 2020). Heavy metal poisoning has rendered large sections of land in the Lahore region unfit for agriculture. Heavy metal poisoning of groundwater is one of the most serious hazards to human health in these locations (Hussain et al., 2020; Saeed, 2016). Soil and groundwater in Lahore have been contaminated by industrial wastewater, which contains elevated concentrations of heavy metals. As a result, soils with high concentrations of heavy metals suffer, as do crops that are grown in such areas. For industrial regions, heavy metal pollution in soil and groundwater has to be monitored closely (Hussain et al., 2020; Afzal et al., 2013). The purpose of this study is to determine the amounts of heavy metals in water and soil using Atomic Absorption Spectrometry.

MATERIALS AND METHODS

Sample collection: Soil and ground water samples were collected from five Area different area of Lahore, the majority of which have been adversely affected by the disposal of industrial garbage and sewage. Five sampled for ground water and soil were collected from (1) Kot Gujra (2) Defence Road (3) Kasur (4) Block L Gulberg III (5) Shahdara town. Water samples were collected in polypropylene bottles, while soil samples were collected in polypropylene bags. Samples were gathered from both private and public water sources in the town. Each group gathered a total of ten water samples. Sample was taken and delivered to the laboratory in sterilized plastic containers. At least six inches of soil was dug out from neighbouring fields and used as a starting point for the analysis. A total of 200 g of soil was obtained and sealed in a sterile plastic bag after it had been well mixed and completely mixed.

Reagents and apparatus: Reagents and solutions were bought from Merck in the AR grade. The glassware and apparatus were properly cleansed and dried in the oven. The samples were pre-concentrated, and the residue was leached using 0.1M HNO_3 acid solution. The Atomic Absorption Spectrophotometer (Model AA203-Thermo Fisher Make) was used for all analyses. Atomic Absorption Spectrophotometer was used to determine the concentrations of Zn, Fe, Ni, Cu, Cd, Pb, Hg and Cr in this solution. Copper (Cu), cadmium (Cd), lead (Pb), zinc (Zn), mercury (Hg), chromium (Cr), iron (Fe), and nickel (Ni) were analysed using hollow cathode lamps with wavelengths of 324.8, 228.8, 217.0, 213.9, 253.6, 257.9, 248.3, and232 nm, correspondingly.

RESULTS AND DISCUSSION

Water samples from the research location were found to be colourless and odourless after examination. The analytical results of metals in soil and water samples are reported in Table 1 and 2. However metal concentrations in all study locations had no significant differences in concentrations when compared to WHO-defined allowed range of metal ions. According to average values, the content of heavy metals in soil samples decreases in descending order Cd> Cu> Hg>Pb> Zn. the content of heavy metals in water samples decreases in descending order Ni> Cr> Fe> Zn>Pb> Cd. Moreover, pH value of Shahdara town is maximum (alkaline). In Table 3, pH of Underground water in different areas of Lahore is shown below.

Table 1: Concentration of heavy metal in soil (mg/kg)

Element	Kot Gujra	Defence Road	Kasur	Block L	Shahdara Town	Mean
Hg	0.97	0.84	0.94	0.91	0.96	0.924
Pb	0.89	0.72	0.64	0.97	0.56	0.756
Cu	1.98	1.24	1.67	1.24	1.17	1.46
Zn	0.90	0.37	0.90	0.18	0.48	0.566
Cd	2.51	1.24	1.41	1.37	1.67	1.64

Table 2: Concentration of heavy metal in water (mg/L)

Element	Kot Gujra	Defence Road	Kasur	Block L	Shahdara Town	Mean
Cd	0.07	0.04	0.05	0.09	0.04	0.058
Pb	0.09	0.06	0.05	0.08	0.07	0.07
Cr	0.60	0.78	0.83	0.94	0.82	0.794
Zn	0.17	0.20	0.24	0.26	0.23	0.22
Ni	0.07	0.01	0.05	0.11	0.98	0.244
Fe	0.42	0.99	1.27	0.98	0.76	0.884

Table 3: pH of underground water in the different area of Lahore

Area	pH range
Kot Gujra	7.41-7.87
Defence Road	7.65-8.32
Kasur	7.95-7.85
Block L	7.41-8.22
Shahdara town	7.98-8.51

Heavy metals impact on Human Life: Cadmium is a highly poisonous metal. Cadmium is found in all soils and rocks, as well as coal and mineral fertilizers. Cadmium and cadmium compounds have been linked to cancer in humans. Cigarette smokers are exposed to much higher quantities of cadmium than non-smokers. Breathing excessive doses of cadmium can cause serious harm to the lungs. Ingesting excessive doses irritates the stomach and causes vomiting and diarrhoea. Long-term exposure to lower levels causes a build-up in the kidneys, which can lead to kidney disease, as well as lung damage and brittle bones. Martin, S., & Griswold, W. (2009). Mercury is a toxic heavy metal that may be present in the biosphere. It has also become an ubiquitous pollutant and is rising in the atmosphere as a result of anthropogenic activities. When mercury comes into touch with aquatic sediments, it transforms into the very poisonous methylmercury (Gworek et al., 2020).

Lead is a non-biodegradable metal present in small concentrations in nature. Because of human activities such as manufacturing, mining, and burning fossil fuels, atmospheric lead levels have been steadily rising. When exposed to concentrations higher than the optimal, lead is hazardous to the human body. Children are more vulnerable to lead poisoning, and the degree of poisoning rises when they come into touch with dust contaminated with environmental lead (Loh et al., 2016). Nickel is a naturally plentiful element with several industrial applications. It is released into the atmosphere by both natural and manmade sources. As a result of inhaling polluted air, it causes allergies, nasal and lung cancer, renal and cardiovascular illness, and kidney and cardiovascular disease in humans (Genchi et al., 2020). Zinc is a necessary and widespread metal. It functions as a cofactor in a wide range of enzyme processes. Zinc toxicity is determined by the method and amount of exposure. Zinc is mostly obtained through smelting and mining. Mineral processing releases a considerable quantity of zinc into the environment, which has an impact on ecosystems as well as living creatures (Zhang, et al 2012). Cu in excess produces toxic effects on the gut and liver, as well as stomach damage16–18. Skin cancer, cutaneous blisters, angiosarcoma, peripheral neuropathy, and vascular illness can occur if eaten in greater amounts. 19,20

Heavy metals impact on Plants Life: Chlorosis, growth restriction, browning of the root tips, and eventually death are all evident signs of harm in plants cultivated in soil with high levels of Cd (Wojcik and Tukiendorf 2004; Guo et al. 2008). A decrease in water content can result from metal poisoning altering the plasma membrane's permeability; in particular, Cd has been shown to impact the water balance (Costa and Morel 1994). According to

Thomas et al. (1998), copper (Cu) is regarded as a micronutrient for plants and is crucial for ATP production and CO2 uptake. An excessive amount of copper in the soil has cytotoxic effects, stresses plants, and harms them. Plant development is slowed as a result, and leaf chlorosis results (Lewis et al. 2001). Damage to macromolecules and disruption of metabolic processes are both brought on by oxidative stress (Hegedus et al. 2001).

Figure 1: illustrates the effect of several heavy metals on human

The extensive incidence of mercury contamination across the whole food chain is the result of the significant intake of mercury (Hg) into the arable soils. Growing data indicates that higher and aquatic plants can easily collect Hg2+ (Wang and Greger 2004). Strong phytotoxicity is caused by high levels of Hg2+ in plant cells. Hg2+ toxicity can cause physical harm and physiological problems in plants (Zhou et al. 2007). For instance, Hg2+ can bind to water channel proteins, causing plants to physically restrict water flow by forcing the stomata on their leaves to shut (Zhang and Tyerman 1999). A high Hg2+ concentration inhibits mitochondrial function and causes oxidative stress by causing the production of ROS. This results in the disruption of cellular metabolism and biomembrane lipids in plants (Messer et al. 2005). Compounds containing chromium (Cr) are extremely harmful to plants' growth and development. One well-documented consequence of heavy metals in trees and crops is a reduction in root development (Tang et al. 2001). The effects of chromium stress on CO2 fixation, electron transport, photophosphorylation, and enzyme activity during photosynthesis are significant (Clijsters and Van Assche 1985).

According to Cakmak and Marshner (1993), zinc (Zn) is a crucial micronutrient with a lengthy biological half-life that influences a number of plant metabolic processes. A reduction in growth and development, metabolism, and an induction of oxidative damage in diverse plant species are signs of Zn and Cd's phytotoxicity. High soil Zn concentrations impair a variety of plant metabolic processes, slow development, and hasten senescence. Zinc poisoning in plants inhibited root and shoot development (Ebbs and Kochian 1997; Fontes and Cox 1998). When exposed for an extended period of time to high soil Zn levels, zinc poisoning also results in chlorosis in the younger leaves, which can progress to older leaves (Ebbs and Kochian 1997). One of the most prevalent and widely dispersed hazardous minerals in soil is lead (Pb). Plant morphology, growth, and photosynthetic processes are negatively impacted by it. Seed germination is known to be inhibited by lead. Lead's interaction with crucial enzymes may prevent germination from occurring. Maitra and Mukherji (1976). Lead also prevented the expansion of roots, stems, and leaves. The concentration of lead, the ionic content, and the pH of the medium all affect how much root growth is hindered (Goldbold and Hutterman 1986).

Many plant species exhibit aberrant morphology when there is a high lead content in the soil. Lead, for instance, results in uneven endodermal cell walls, lignification of cortical parenchyma, and radial thickening of pea roots (Paivoke 1983). By preventing the action of carboxylating enzymes, lead is also known to influence photosynthesis (Stiborova et al. 1987). In addition to disrupting mineral nutrition, high levels of Pb can induce water imbalance, changes in membrane permeability, and suppression of enzyme activity (Sinha et al. 1988a, b). With the exception of ultramafic or serpentinic soils, nickel (Ni), a transition metal, is present in trace amounts in natural soils.

In biological processes as diverse as photosynthesis, chloroplast formation, and chlorophyll manufacturing, iron, an essential element for all plants, plays a number of significant functions. The development of iron toxicity symptoms in leaf tissues only happens under flooded circumstances, which requires the microbial reduction of insoluble Fe3 insoluble Fe2 (Becker and Asch 2005), despite the fact that the majority of mineral soils are rich in iron. Iron toxicity in plants manifests as a result of increased root absorption of Fe2 and its subsequent transfer to leaves and through the transpiration stream. The excess Fe2 produces free radicals, which permanently damage membranes, DNA, and proteins as well as cellular structure (Arora et al. 2002)

CONCLUSION

Soil and water samples from different parts of Lahore show that heavy metals with intermediate amounts are present, which means that the animal world could be harmed as well as humans. In order to avoid heavy metal pollution in ground water and soil, firms must closely monitor the pre-treatment of sewage sludge and other wastes before releasing them into the environment. As a result, it's critical to constantly evaluate and learn new things. According to several study studies, even in moderation, heavy metals have hazardous effects on plants, animals, and other living things, and these impacts only become apparent at specific levels. To preserve the ecological balance of the planet, it is essential to strengthen research programs to understand the effects of heavy metal toxicity on plants and related ecosystems.

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