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# Heavy Metals Accumulation and Their Toxic Effects: Review

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**Abstract:** Pollution caused by heavy metals affects all forms of life. Pakistan is an agricultural country. The soil of Pakistan is rated low in fertility to fulfill our economic demand. Due to the lack of awareness in farmers, fields are irrigated by agricultural land disposals, mineral, industrial wastes and use of fertilizer. Areas especially Islamabad, Rawalpindi, Faisalabad, Lahore, Sheikhpora, Kala Shah Kaku, Multan, Kallarkahar, Kalarkahar-Lilla and Lilla-Lahore, Peshawar, Mardan, Sawabi, Nowshera, Charasda, Khyber agency, Kohat, and Karak are contaminated through industrial contamination, fertilizer, automobile, mining and natural constituents of the soil. Toxic levels of heavy metal contamination pose a serious threat to the microorganisms, animal plants and human life. Plants exposed to heavy metals result injury in terms of chlorosis along with toxic effects in the form of reduced photosynthesis, browning of root tips, growth inhibition, and finally death. Soil microbial population is highly affected by the presence of heavy metals. In human and mammals, neurological damage, immune system suppression and fetal abnormalities are reported due to the toxic effects of heavy metals. Live stock affected due to toxicity of heavy metals enters into the food chain can cause serious economic and health issue.

**Keywords:** Heavy metal; Plant; Human; Microbe; livestock

## Introduction

Toxic metals that results in polluting the biosphere are a wide spread ecological problem. Discharge of waste materials either accidentally or due to poor management aids to the transfer of contaminants to contamination-free sites. It may include accidental spillage, mining, smelting of multiferrous ores or through sewage sludge applications to agricultural soils are responsible for contaminating the environment. These contaminants can be organic or inorganic in nature including heavy metals, combustible and putrescible

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substances, hazardous wastes, explosives and petroleum products. Heavy metals are mainly responsible for the inorganic contamination (Adriana, 1986; Alloway, 1990).

Heavy metals such as lead, arsenic, selenium, cadmium, copper, zinc, uranium, mercury, and nickel are found to be responsible for posing serious health risks due to transfer of these contaminants into food chain. Nutrient enriched soil is a basic constituent for food production. Due to excessive use of agrochemicals and changing environmental conditions; heavy metals are being accumulated in soils and are posing a serious threat to human life (Wong et al., 2003; Nicholson et al., 2003). Heavy metals being toxic in nature are affecting plant growth. Therefore it is necessary to protect the soil and to make it free of heavy metal contamination. The soil contamination in industrial areas is of great concern. Many metals are essential ingredients of industries, medicine and agriculture. Both, the consumer and the producers are exposed to such metallurgic activities. Elimination of metals from environment is impossible as they cannot be decomposed (Malik and Hussain, 2006).

Pakistan is an agricultural country. The soil of Pakistan is rated low in fertility to fulfill our economic demand (Jamal et al., 2002). In order to meet the nutrient demand of soil, agricultural land disposals, mineral and Industrial wastes are utilized instead of chemical fertilizers as them are costly (Jamal et al, 2002). Food grown on such soils has risk of heavy metal accumulation causing food security issues (Munzuraglu and Geckil, 2002).

**Heavy Metals Contamination**

Industrial revolution has resulted in polluting the biosphere (Swaminathan, 2003). In soils, heavy metals are accumulated through various sources and practices. Industrial wastes aid in accumulation of toxic contaminants into the soil and are affecting the food quality and also posing adverse effects on human life as well. Heavy metals like chromium contaminate soil, sediments, and ground water (Shanker et al., 2005). Water from tanning industry has increased level of chromium. Concentration of chromium through anthropogenic discharge in water bodies is 3550mt (Nriagu, 1990).

Due to rapid and unchecked population increase in Pakistan the population has strike index of 170 million whereasthe per capita water a vailability is approximately 980m. For this reason industrial waterisused for the irrigatio n purposehas increased and is expected to in crease in the future. The areas of central Punjab near the industrial zones are found to be contaminated with heavy metals like Ni, Cu, Cr, Cd and Pb. A study conducted at Faislabad by Qadir et al. (1998) indicated accumulation of lead above the recommended level in plants and soil being irrigated by city effluents. Furthermore the industrial zones of Lahore, Sheikhopura and Kala Shah Kaku indicated soil and water contamination of salts and heavy metals in their respective areas (Lone et al., 2000). Similarly**,** in Rawalpindi, the soil is contaminated with cadmium and chromium. In addition, the electroplating and tannery industries are found to contain toxic metals such as Ni, Cr, As, Hg, Pb etc. According to the Environmental Protection Agency (EPA1990), the soils and biota of Faisalabad and Lahore are contaminated with toxic heavy metals. Khan et al. (1992) reported that Faisalabad city effluent comprises of toxic heavy metals like Pb, Cu and Cd Plant species located near the industrial zone of Islamabad are accumulated with higher concentration of Pb, Cu and Zn than normal limits in shoots causing toxic symptoms.

Shan and Ikram studied contamination of heavy metals during a study conducted at Multan in human scalp hair and nail samples and found Cu, Cd and Pb were observed in hair and nail sample from jewelry, automobile and industrial workers . Striking results were observed when smokers had Cd in their hair and nail samples in contrast to non-smokers. Through results it was inferred that hair/nail concentrations of heavy metals can be used as an indication of heavy metal exposure in human.

**Automobile Source**

Automobile emission is directly related to metal contamination at the neighboring roadside ecosystem. Metal contaminants like Pb, Cd, Zn and Cu are mobile in nature and are found in engines, tiers and petrol of vehicles. Toxic metals are accumulated in top soils and vegetation near the road ecosystem. Countryside areas of Pakistan are connected through road channels and thus the soil of such areas is accumulated with heavy metal toxicants. Studies show that heavy metal contamination of different water sources, soil and vegetables in Rawalpindi area. Ahmad and Irum (2010) reported heavy metals (Zn, Pb, Ni, Cd and Cr) concentration in three regions, Islamabad-KallarKahar, KalarKahar-Lilla and Lilla-Lahore (M2) with the exception of iron, decreased with the increase in distance. Atmospheric depositions also increase the level of heavy metals during transport and marketing aiding to the contamination of vegetables at the market sites. Adil et al. (2013) showed that vegetables exported from Pakistan to Afghanistan have more heavy metals as compare to production site.

**Fertilizer**

Long term use of phosphate based fertilizers, dust from smelters, sewage sludge application, industrial waste and bad watering practices in agricultural lands contaminate agricultural soil (Passariello et al., 2002; Schwartz et al., 2001; Bell et al., 2001). Phosphatic fertilizers are made from rocks containing phosphates. It is found as sedimentary, igneous and metamorphic rock in the earth's crust. In Pakistan phosphate rock deposits are found in Hazara division and are of sedimentary origin, such rocks are also found in Tarnawai village and exist in the form of limestone and mica schist. In Kakul, they are present in the form of phophorites and in Thandiani in the form of orthoquartizites. Sedimentary rocks contain high concentration of Uranium, Thorium, and REE (rare earth elements) (Hurst, 1989). Higher concentrations of lead were found in phosphate rock at Abbottabad region.

**Minning**

Copper in ecosystem is due to industrial and mining activities. Mining and smelting of ores of copper aid to the copper contamination into the soil. Farmable land has increased concentration of mercury that leads to the contamination of food chain.Presence of lead in soil are also due to mining and smelting activities. Moreover cobalt is also a part of earth crust’s and exists in the form of cobaltite, erythrite and smaltite. High level of nickel is being present in soil due to increased mining activities (Gimeno-García et al., 1996). Soil contamination is also found to be due to use of fertilizers incineration of municipal wastes, sewage sludge and other human activities. Such activities impart copper and zinc to the soil as contaminants. Heavy metals like copper also act as micronutrients for soil and aid in ATP synthesis (Thomas et al., 1998).

**Heavy Metals toxic effects**

Khair (2009) showed that heavy metals contamination as a grave issue of our

environment and are major contaminating agents of our food supply. Microorganisms, plants and animals all are affected by the presence of heavy metals (Igweet al., 2005).Toxic heavy metals affecting microorganisms are involved in impairment of biochemical systems of plants and animals. As the contaminants are released into water channels that are used for the irrigation purpose are observed to contaminate the plants as well as their products. Occupational workers and consumers both are at risk of exposure to such activities (Adachi and Tainosho, 2004). Certain metals like cadmium, arsenic, and zinc are harmful contaminants once they enter the soil and water.

**Toxic Effects of Various Heavy Metals in Plants**

Contamination of agricultural soil by heavy metals has posed a serious threat to the environment and toxicity effects of heavy metals are observed in plants in terms of both acute and chronic infections. The soils of Pakistan represent low fertility to support economic crop production (Rashid, 1993, Jamal et al., 2002). Younas and Shahzad (1998) reported the waste generation in Pakistan has increased 120% between 1980 and 1996 with a total of 16.2 TG generated in 1995.

Nriagu and Pacyna (1988), Younas and Shahzad (1998) and Jamal et al. (2002) conducted studies show that in waste amended soils Cu, Pb and Zn are mostly found. Several human activities resulting in an increase of the regulatory limit of cadmium (Cd) in agricultural soil is 100 mg/kg soil. Plants exposed to Cd results injury in terms of chlorosis along with toxic effects in the form of reduced photosynthesis, browning of root tips, growth inhibition, and finally death. The effects of heavy metal on medicinal plant Ecliptaalba and showed that medicinal plant growth is impaired by the heavy metals contamination.

Contaminated soils when checked for zinc concentrations had its measurement from 150 -300mg/kg. Zinc inhibits metabolic pathways due to which the growth of plants is reduced. Both the roots and shoots are reduced. Chlorosis is observed in young leaves due to long term exposure to zinc. Excess of zinc leads to reduced levels of Manganese and copper deficiencies. The adverse effects due to high level of copper involved stress, injuries, retarded growth, chlorosis and affect seed germination

Accumulation of chromium in plants results in reduced growth. Similarly, biomass accumulation induces structural alterations .Cr disrupts photosynthetic and respiration processes, and water and minerals uptake mechanism. Enzymatic activities related to starch and nitrogen metabolism are decreased due to Cr toxicity either by direct interference with the enzymes or through the production of reactive oxygen species. It also causes oxidative damage by disrupting of membrane lipids and DNA damage and may cause death of plant species. Plants accumulate cobalt from soil and its uptake varies with species. Phytotoxic effects of cobalt were noticed in barley.

The food chain is being contaminated due to mercury insertion from ploughable land. Mercury is distinctive as it has variable forms of existence and mercury in its ionic form is found in farmable soils. It has been observed under various studies that mercury in its ionic form has the ability to accumulate in higher and aquatic plants. Mercury in excess leads to phytotoxic effects in plants and can further cause apparent injuries and physiological disorders. Mercury has the ability to bind to the proteins involved in water channel and as a result stoma of the leaves close and water is obstructed to flow. Increased

concentrations level of mercury disrupts mitochondrial activity and further triggers ROS. Resultantly, oxidative stress is observed. Thus lipid bio membrane is disrupted. It was noticed that seed germination of lentil is affected due to increase in the concentrations of copper, cadmium and mercury (Ayaz and Kadioglu, 1997).

Nickel (Ni) being a transition metal is present in natural soils at trace amounts except in ultramafic or serpentinic soils. Due to activities such as discharge of smelters, burning of coal mining works, sewage, oil, pesticides and phosphate fertilizers, Ni concentration is being increased (Gimeno-García et al., 1996). In natural soil, its concentration is found to be overall range (10–1000 mg/kg) less than in polluted 20- to 30-fold (200–26,000 mg/kg) (Izosimova, 2005). High level concentration of nickel in soil leads to adverse effects such as physiological changes and toxic signs and symptoms like chlorosis and necrosis. Research on increased concentration of nickel has further revealed deterioration in terms of nutritional imbalance and altered cell membrane functions. Studies conducted on *Oryza sativa* showed that nickel has the ability to affect the cell membrane by effecting the lipid composition and H-ATPase activity. Increased level of nickel enhances MDA concentration. Such changes disturb the functions of plasma membrane and ion balance inside cell. Increased concentration of nickel affects the water concentration of dicot and monocot species.

**Heavy Metals Toxic Effects on Microorganisms**

All forms of life whether microorganisms, plants or animals; all are affected by the toxic effects of heavy metals. It was found by researchers that heavy metal can alter microbial populations (Barkayet al., 1985; Doelmanet al., 1994; Roane and Kellogg, 1996). Kelly et al., 2003) has shown the alterations in the population ration of microbes residing in soil due to metal toxicity effects. Further studies have shown the inverse relation of the growth of microbial populations to the increasing levels of heavy metal concentrations (Jordan and LeChevalier, 1975; Brookes and McGrath, 1984; Chander and Brookes, 1991; Konopka et al., 1999).

The immediate toxic effects of metal can be controlled if the mobility of the metals is checked in the soil. The mobility of heavy metals is due to generalized/localized conditions of the soilthat might be of physical or chemical nature of the soil texture or due to decreased level of pH, redox potential or organic matter decomposition(Gupta, 1992; Hattori, 1996; Kelly et al., 2003). According to Pawlowska and Charvat (2004), the toxic effects of heavy metals on soil results in altering the population size and activities of microbes (Smejkalovaet al., 2003; Gupta, 1992; Hattori, 1996; Kelly et al., 2003).

Gasper et al. (2005) also worked on the adverse effects of heavy metals with special reference to chromium, zinc and cadmium involved in disturbing the metabolism of soil microbes in all cases. It was found that As (V) was dominant in soil species (Cullen and Reimer, 1989; Pongratz, 1998; Turpeinen et al. 1999). The soil pollution can be detected in examining the respiration rate and enzymatic activity but due to the increased levels of metal toxicity, the process is disturbed.

**Toxic effects of heavy metals on health (this section should be re-written)**

When heavy metals are taken up in higher concentrations they can affect liver, brain, bone and lungs, although each metal has its own particular signs and symptoms (Besser et al., 2007). If the concentration is lower as compared to the normal

requirement then it may cause chronic lung disease, cancer, nervous impairment, bone abnormalities and sterility. Occupational workers are at risk of exposure to heavy metal toxicity while working in industries.Non-occupational and children too are exposed to heavy metal pollution by inhaling airborne particulates and ingesting dissolved metals in contaminated food and water (Nath, 2000). Occupational workers when exposed to cadmium can lead to glomerular and bone damage and pose increased risk of cancer (Jarup and Akesson, 2009). Lead present in fuels has contributed a lot for human exposure and diagnostic signs and symptoms of lead are found to be depression, reduced appetite, gastric abnormalities and muscular pains. Lead toxic affects observed in adults are reproductive abnormalities in males, weakness, pains, headache, abdominal cramps and loss of memory (Pearce, 2007).

Microbes alter the form of arsenic to dimethylarsenate that gets accumulated in fish; human depending on fish meat are thus exposed to aresinc (ATSDR, 2005). One of the adverse effects of arsenic is that it replaces the phosphorous concentration present in human bones (Bartolome et al., 1999).Studies show that aging results due to extinguishing concentration of inorganic methylated arsenic thus depositing arsenic in soft tissues (Tseng et el. 2005). The toxic effects of arsenic have been related to few types of cancers (Peschet al., 2002).

**Toxic Effects on Livestock**

Fish has the ability to accumulate heavy concentrations of toxic metals (Mansour et al., 2002; Hadson, 1988). Heavy metal assimilation in fish is through ion-exchange process from gills, or when dissolved metals are adsorbed on tissues and membrane surfaces. Metal assimilation in fish also takes place by ingesting suspended particulates or food materials. Fish contain long chain of fatty acids in their lipids along with micro/macro nutrients involved in nutrition, disease prevention and health in humans (Szlinder-Richert et al., 2011). Ingestion of food material and suspended particulates play their part in accumulation of metals (Ikem and Egilla, 2008). In humans health risk assessment depends upon the fishing activities taking place nearby fish farms. Various factors among different species of fish affect the toxic metal accumulation in fish. These factors are environmental contamination, quality of water, altering seasons, sexual maturity, size and trophic levels. (Saha et al., 2006).

**Conclusion**

Heavy metals like zinc, lead, cadmium, chromium, copper etc. are the inorganic contaminants. They find their route for existence in our environment through anthropogenic activities and geological cycles. Heavy metals being toxic in nature show pronounced toxicity effects in terms of bioaccumulation and bio magnification in tissues and food webs, respectively. In Pakistan, the main sources of heavy metal contamination/accumulation are industrial, agricultural and automobile. Naturally, they are found in earth's crust and are also present in sediments resulting in marine contamination.

Pakistan being a developing country has still an unplanned industrial infrastructure due to which discharge of toxic heavy metals; either accidentally or through poor management of wastes have resulted in increased contamination in biosphere .The industrial contamination has further lead to soil contamination due to the effluent discharge from tanneries and textile Industries. Various studies have been conducted to find metal contamination among fresh water bodies in Pakistan .The heavy metal contamination content observed at Lloyd barrage indicated arsenic (7452

ug/g) in sediment and manganese (0.038ug/g) in water. Similarly, studies showed Mercury (5.710ug/g) and lead (2.709ug/g) respectively. Heavy metals are also found to be present in earth's crust and are indirectly involved in contamination of food chain.

Toxic levels of heavy metal contamination pose a serious threat to the microorganisms, animal plants and human life. Plants exposed to heavy metals results injury in terms of chlorosis along with toxic effects in the form of reduced photosynthesis, browning of root tips, growth inhibition, and finally death. Soil microbial population is highly affected by the presence of heavy metals. In human and mammals, neurological damage, immune system suppression and fetal abnormalities are reported due to the toxic effects of heavy metals. Live stock affected due to toxicity of heavy metals enters into the food chain can cause serious economic and health issue. The current study has wakeup call for contamination and toxicity of heavy metals pollution worldwide especially Pakistan.

**References**

Adhikari, S., Ghosh, L., Rai, S. P and Ayyappan, S. 2009. Metal concentrations in water, sediment, and fish from sewage-fed aquaculture ponds of Kolkata, India. Environ. Monit. Assessment, 159, 217–230.

Agency for Toxic Substances and Disease Registry (ATSDR). 2005. Toxicological Profile for Nickel (update). U.S. Department of Health and Human Services, Public Health Services, ATSDR, Atlanta, Georgia.

Alam, M. G. M., Tanaka, A., Allinson, G., Laurenson, L. J. B., Stagnitti, F and Snow, E. T. 2002.A comparison of trace element concentrations in cultured and wild carp (Cyprinuscarpio) of Lake Kasumigaura, Japan.Ecotoxicol. Environ. Safety, 53: 348–354.

Alasalvar, C., Taylor, K. D. A., Zubcov, E., Shahidi, F and Alexis, M. 2002.Differentiation of cultured and wild sea bass (Dicentrarchuslabrax): Total lipid content, fatty acid and trace mineral composition. Food Chem. 79: 145–150.

Alloway, B. J. 1995. Heavy metals in soils. Blackie Academic and Professional, Glasgow.

Anonymous. 2001. SAS Users' Guide, R 8.2, SAS Institute, Inc., Cary, NC. Arbuscular Mycorrhizal Fungi. Appl. Environ. Microbiol. 70: 6643-6649.

Ayaz, F. A. and Kadioglu, A. 1997.Effects of Metals Zn, Cd, Cu and Hg on the soluble protein bands of germinating Lens esculenta L. seeds. Turk. J. Bot. 21: 85-88.

Barceloux, D. G. 1999. Cobalt. J. Toxicol. Clinical Toxicol. 37: 201–206.

Barkay, T., Tripp, S. C. and Oslon, B. H. 1985.Effect of metal-rich sewage sludge application on the bacterial communities of grasslands. . Appl. Environ. Microbiol. 49: 333-337.

Bartolome, B., Cordoba, S., Nieto, S., Fernandez-Herrera, J and Garcia-Diez, A.1999.Acute arsenic poisoning, clinical and histopathologic features. British J. Dermatol. 141: 1106-1109.

Bell, F. G., Bullock, S. E. T., Halbich, T. F. J. and Lindsay, P. 2001. Environmental impacts associated with an abandoned mine in the Witbank Coalfield South Africa. Int. J. Coal Geol. 45: 195–216.

Besser, J. M., Mebane, C. A., Mount, D. R., Ivey C. D., Kunz, J. L., Greer, I. E., May, T. W and Ingersoll, C. G. 2007. Sensitivity of mottled sculpins (Cottusbairdi) and rainbow trout (Onchorhynchusmykiss) to acute and chronic toxicity of cadmium, copper, and zinc. Environ. Toxicol. Chem. 26: 165765.

Brookes, P. C. and McGrath, S. P. 1984.Effects of metal toxicity on the size of the soil microbial biomass. J. Soil Sci. 35: 341–346.

Burger, J., Gaines, K. F., Boring, C. S., Stephens, W. L., Snodgrass and Dixon, C. 2002. Metal levels in fish from the Savannah River: Potential hazards to fish and other receptors. Environ. Res. (Section A) 89: 85–97.

Cullen, W. R. and Reimer, K. J. 1989. Arsenic speciation in the environment. Chem. Rev. 89: 713–764.

Doelman, P., Jansen, E., Michels, M and Til, M. V. 1994.Effects of heavy metals in soils on microbial diversity and activity as shown by the sensitivity resistance index. Biol. Fertil. Soil, 17: 177-184.

Hurst, F.J. 1989. The recovery of uranium from phosphoric ccid, IAEA, Vienna, IAEATECDOC: 553.

Fallah, A. A., Saei-Dehkordi, S. S., Nematollahi, A and Jafari, T. 2011.Comparative study of heavy metal and trace element accumulation in edible tissues of farmed and wild rainbow trout (Oncorhynchusmykiss) using ICP-OES technique. Microchem. J. 98: 275–279.

Gaspar, G. M., Mathe, P., Szabo, L., Orgovanyl, B., Uzinger, N and Anton, A. 2005. After-effect of heavy metal pollution in brown forest soils. Proceedings of the 8 Hungarian Congress on Plant Physiology and the 6 Hungarian Conference on Photosynthesis. *Acta Biol.* Szegediensis, 49: 71-72.

Gimeno-García, E., Andreu, V and Boluda, R. 1996 Heavy metals incidence in the application of inorganic fertilizers and pesticides to rice farming soils. Environ. Pollut. 92: 19–25.

Gingell, S. M., Campbell, R and Martin, M. H. 1976.The effect of zinc, lead and cadmium on the leaf surface microflora.Environ. Pollut. 11: 25-37.

Gupta, S. K. 1992. Mobilizable metal in anthropogenic contaminated soils and its ecological significance.In: Impact of heavy metals on the environment. (Ed.): JVernet, .P. Elsevier, Amsterdam, Netherlands. pp. 299-310.

Hadson, P. V. 1988. The effect of metal metabolism uptake, disposition and toxicity in fish.Aquatic Toxicol.11: 3-18.

Hattori, H. 1996. Decomposition of organic matter with previous cadmium adsorption in soils.Soil Sci. Plant Nutrit. 42: 745-752.

Igwe, J. C.,Nnorom, I. C. and Gbaruko, B. C. G. 2005. Kinetics of radionuclides and heavy metals behaviour in soils: Implications for plant growth. African J. Biotechnol. 4: 1541-1547.

Ikem, A. and Egilla, J. 2008. Trace element content of fish feed and bluegill sunfish (Lepomismacrochirus) from aquaculture and wild source in Missouri. Food Chem. 110: 301-309.

Jamal, A., Ayub, N., Usman, M and Khan, A. G. 2002. *Arbuscular mycorrhizal* fungi enhance Znand Ni uptake from contaminated soil by soybean and lentil. Int. J. Phytoremed. 4: 205-221.

Jarup, L. and Akesson, A. 2009. New Insights into the mechanisms of cadmium toxicity-advances in cadmium research. Toxicol. Appl. Pharmacol. 238: 201-208.

Jordan, M. J and LeChevalier, M. P. 1975. Effects of zinc-smelter emissions on forest soil microflora. Canadian J. Microbiol. 21: 1855–1865.

Kelly, J. J., Haggblom, M. M and Tate, R. L. 2003. Effects of heavy metal contamination and remediation on soil microbial communities in the vicinity of a zinc smelter as indicated by analysis of microbial community phospholipids fatty acid profiles. Biol. Fertil. Soil, 38: 65-71.

Khair, M.H. 2009. Toxicity and accumulation of copper in Nanno chloropsisoculata (Eustigmatophycea, Heterokonta). World Appl. Sci. J. 6: 378-384.

Khan, M. A. and Khan, S. A. 1989.Environmental pollution; A Menace to Public health. Sci. Int. 1: 400-408.

Konopka, A., Zakharova, T., Bischoff, M., Oliver, L., Nakatsu, C and Turco, R. F. 1999 Microbial biomass and activity in lead-contaminated soil. Appl. Environ. Microbiol. 65: 2256–2259.

Lone, M. I., Aslam, R and Khan, K. S. 2000.Water quality and soil contamination in some industrial areas of Pakistan. Pak. J. Social Sci. 18: 1-6.

Maliszewska, W., Dec, S., Wierzbicka, H and Wozniakowska, A. 1985. The influence of various heavy metal compounds on the development and activity of soil micro-organisms. Environ. Pollut. (Ser. A) 37*:* 195

Mansour, S.A and Sidky, M. M. 2002.Heavy metals contaminating water and fish from Fayoum Governorate, Egypt. Food Chem.78: 15–2

Mitchell, G. A., Bingham, F. T. and Page, A. L. 1978. Yield and metal composition of lettuce and wheat grown on soil amended with sewage sludge enriched with Cd, Cu, Ni, and Zn. J. Environ. Qual. 165-171.

Munzuroglu, O. and Geckil, H. 2002.Effects of metals on seed germination, root elongation, and coleoptiles and hypocotyls growth in *Triticum aestivum* and *Cucumis sativus*. Arch. Environ. Contaminat. Toxicol. 43: 203-213.

Nath, R. 2000. Health and Disease: Role of Micronutrients and Trace Elements. APH Publishing Corporation, New Delhi. pp. 650.

Nicholson, F. A., Smith, S. R., Alloway, B. 2003. An inventory of heavy metals imputs to agricultural soils in England and Wales. Sci. Total Environ. 311: 205–219.

Nriagu, J. O. and Pacyna, J. M. 1988.Quantitative assessment of worldwide contamination of air, water and soil by trace-metals.Nature, 333: 134-139.

Nriagu, J. O. 1990. Trace metal pollution of lakes: a global perspective. Proceeding of 2nd International Conference on Trace Metals in Aquatic Environment. Sydney, Australia.

Passariello, B., Giuliano, V., Quaresima, S., Barbaro, M., Caroli, S., Forte, G., Garelli, G and Iavicoli, I.2002 Evaluation of the environmental contamination at an abandoned mining site. Microchem. J. 73: 245–250.

Pearce, J. M. 2007. Burton's line in lead poisoning. European neurol. 57: 118–119.

Pesch, B., Ranft, U., Jakubis, P., Nieuwenhuijsen, M. J., Hergemoller, A., Unfried, K., Jakubis, M., Miskovic, P and Keegan, T. 2002. Environmental arsenic exposure from a coal-burning power plant as a potential risk factor for non melano mask in carcinoma: results from a case-control study in the district of Prievidza, Slovakia. Am. J. Epidemiol.155: 798–809.

Pongratz, R. 1998. Arsenic speciation in environmental samples of contaminated soil. Sci. Total Environ. 224: 133–141.

Qadir, A., Malik, R. N. 2009. Assessment of an index of biological integrity (IBI) to quantify the quality of two tributaries of river Chenab, Sialkot, Pakistan. Hydrobiol. 621: 127–153.

Rashid, A.1993. Nutritional disorder of rapeseed mustard and wheat grown in pothowar Area.Land Resources Institute, NARC, Islamabad, Pakistan.pp.105.

Roane, T. M and Kellogg, S. T. 1996. Characterization of bacterial communities in heavy metal contaminated soils. Canadian J. Microbiol. 42: 593-603.

Saha, M., Sarkar, S. K and Bhattacharya, B. 2006. Interspecific variation in heavy metal body concentrations in biota of Sunderban mangrove wetland, Northeast India. Environ. Int. 32: 203-207.

Schwartz, C., Gerard, E., Perronnet, K and Morel, J. L. 2001 Measurement of in situ phytoextraction of zinc by spontaneous metallophytes growing on a former smelter site. Sci. Total Environ. 279: 215–221.

Shan, U. and Ikram, N. 2012. Heavy metals in human scalp hair and nail samples from Pakistan: Influence of working and

smokinghabits. *Int.* J. Contemporary Business Studies, 1: 54-58.
Shanker, A. K., Cervantes, C., Loza-Tavera, H and Avudainayagam, S. 2005. Chromium toxicity in plants. Environ. Int. 31: 739-753.
Smejkalova, M., Mikanova, O. and Boruvka, L. 2003.Effect of heavy metal concentration on biological activity of soil microorganisms. Plant Soil Environ. 49: 321-326.
Swaminathan, M. S. 2003. Biodiversity: an effective safety net against environmental pollution. Environ. Pollut. 126: 287–291.
Szlinder-Richert, J., Usydus, Z., Malesa-Ciecwierz, M., Polak-Juszczak, L and Ruczynska, W. 2011. Marine and farmed fish on the polish market: Comparison of the nutritive value and human exposure to PCDD/Fs and other contaminants. Chemosphere, 85: 1725–1733.
Thomas, F., Malick, C., Endreszl, E. C and Davies, K. S. 1998.Distinct responses to copper stress in the halophyte, Mesembryan-themumcrystallium. Physiol. Plant. 102: 360–368.
Tseng, C. H., Huang, Y. K., Huang, Y. L., Chung, C. J., Yang, M. H and Chen, C. J. 2005. Arsenic exposure, urinary arsenic speciation, and peripheral vascular disease in blackfoot disease- hyperendemic villages in Taiwan. Toxicol. Appl. Pharmacol. 206: 299-308.
Turpeinen, R., Pantsar-Kallio, M., Häggblom, M and Kairesalo, T. 1999. Influence of microbes on the mobilization, toxicity and biomethylation of arsenic in soil. Sci. Total Environ. 236: 173-180.
Wong, S. C., Li, X. D. and Zhang, G. 2003. Heavy metals in agricultural soils of the Pearl River Delta South China [J]. Environ. Pollut. 119: 33-44.
Younas, M. and Shahzad, F. 1998.Assessment of Cd, Ni, Cu, and Pb pollution in Lahore, Pakistan.Environ. Int. 24: 761-766.