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A comprehensive review: Heavy metals pollution sources, effects in Indus River and strategy how to improve of heavy metals pollution

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Abstract
Contamination of heavy metals have permeated several parts of the world, exclusively emerging nations like as Pakistan Aquatic life requirements appropriate harmless environment for the existence of normal life. The Indus River approximately 300 kilometer long and stays one of the prime and the most significant river system of Asia and largely flows through Pakistan towards the western brim of the land mass India and Pakistan. Indus River is providing life nourishment to agriculture and environment for the Pakistani peoples. In the circumstance of heavy metal contamination, disturbance happens and deteriorations the aquatic flora and fauna. Anthropogenic actions have caused vital alterations in aquatic surroundings throughout the previous eras. Progression of anthropological civilization has set solemn questions to the nontoxic usage of the river water for domestic and other consumptions purpose. Toxicity of heavy metals inflowing in the environment can central to accumulation of organic tissue of organism. Heavy metals exposure have been associated to develop-mental retardation, allergy and damage of kidney, respiratory diseases, severe types of cancer, heart diseases, blood pressure abnormality and even death in illustrations of identical high exposure. This review article presents the results of the work accomplished through the many scientists in the past on the pollution of heavy metals in the Indus River.

Keywords: Anthropogenic, transformation, contamination, Indus, mental retardation

Introduction
The Indus River basin area is 944,574 sq. kilometer (Asianics Agro-Dev. International (pvt) Ltd, 200) made the 12th largest among the rivers of the world. Its deltaic zone is 3 X 104 km^2 and ranking 7th in the world. Also Indus positions at 4th amongst in the world river system having wave influence at the delta coastline of approximately 13 joules/sec/unit crest width and 1st in having a tendency power at a distance from the shore at which reaches the depth of water 10 meters of around 950 joules/sec/unit width of crest (Pakistan Water Gateway, 2003). Worldwide water capitals are under stress, though in the Asia situation is abundant intricate. Owing to high population development, agricultural practices, urbanization, industrialization, deprived sanitation facilities, unplanned solid waste management and unsuitable water consumption practice has affected both water resources quantity and quality (Haydar, 2012). River water, a natural resource forms the sustenance of all existing organisms. Water contamination, which is a foremost environmental concern of Pakistan, is the overview of contaminating pollutants into natural water leading to an adverse modification. However various data and statistics that privilege that the earth's water resources are existence exhausted, contaminated and rendered un-potable at a distressing rate. By the year of 2025, two third of the world's population will be facing the shortage of water situation. According to the UN survey reports, Pakistan is probable face serious levels of water stress through 2025 and there will be grave water deficiencies (UN Climate Report, 2014). The Indus River is the furthermost significant rivers system in Pakistan. Owed to the abundant water availability across the year has acted a chief part in the development of Pakistani economy and cultivation (Paul and Sinha, 2013) [2]. Measured the heavy metals as serious lethal pollutants for maritime ecosystem and due to their elevated prospective to enter in food chain accumulation and makes it toxic (Olojo *et al.,* 2005) [4]. But heavy metals venomousness accretions in biota and determination the contamination

DEGREE of heavy metals in profitable fish species have usual significant consideration in many countries (Wariaghi *et al.*, 2013). The generally common heavy metals contaminants are Chromium (Cr), cadmium (Cd), Copper (Cu), Nickel (Ni) Lead (Pb), Zinc (Zn) and Manganese (Mn). The statistic that heavy metals cannot be decomposed by biological degradation and have the capability to accrue in the surroundings (Olowu *et al.*, 2010) [5]. Heavy metals are among the most common environmental contaminants, their occurrence in rivers and biota representing the existence of natural or anthropogenic cause (Esmaeilzadeh *et al.*, 2016) [14].

The central sources of the heavy metal contamination are anthropogenic activities and geological (Dembitsky, 2003) [6]. Anthropogenic causes of the heavy metal pollution come from fuel production, utilization of agricultural chemicals, smelting process, mining, military operations, brick kilns, industrial effluents and coal combustion (Zhen-Guo *et al.*, 2002) [7]. One of the leading sources taking part increased budget of water and soil pollution contain municipal waste disposal, this may be wayside dumping or end up in landfills, though sewage disbursed for irrigation purpose. These pollutants are though a handy source of nutrients but are showed to be carcinogenic agents. Other type of contamination come from insecure or excess application of pesticides, fertilizers and fungicides (Zhen-Guo *et al.*, 2002) [7]. Water contamination with sewage and industrial emissions, subsequent in polluted vegetables and soils are specific other sources of heavy metals pollution (Bridge, 2004) [8].

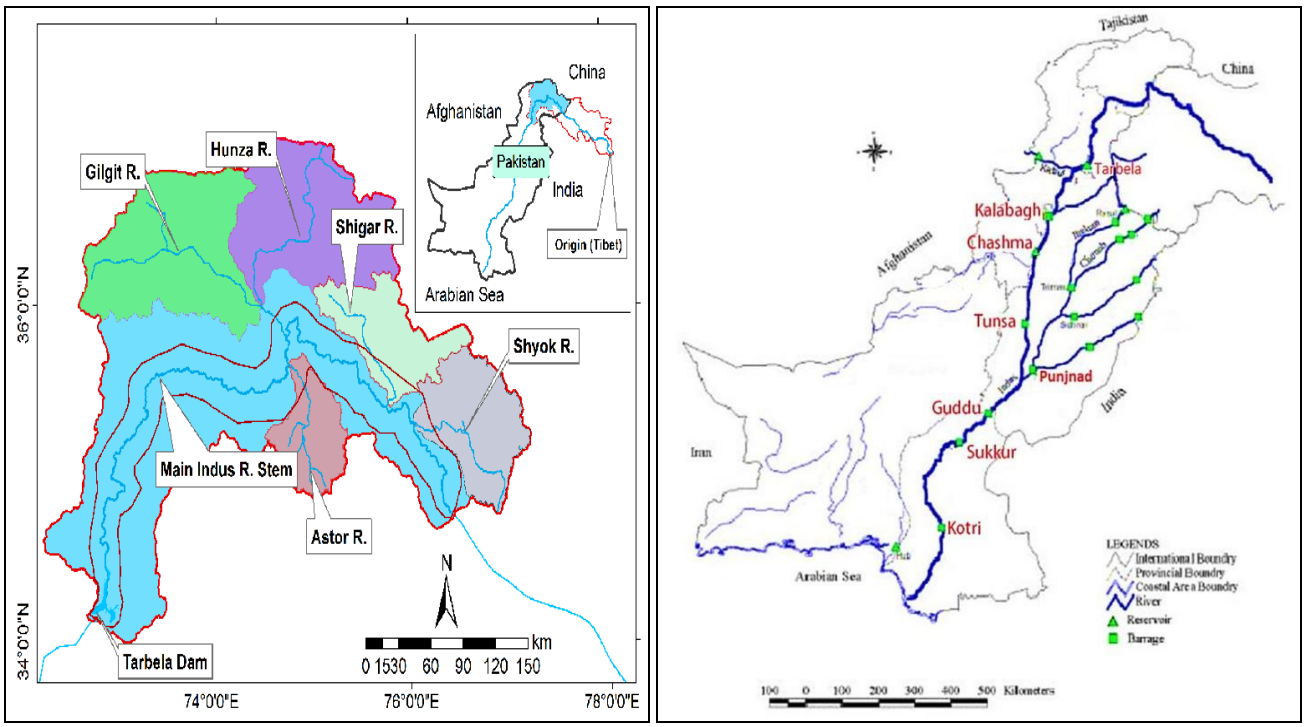

Fig 1: Indus river map (Took from Imran Ahmed and Areba Syed, 2015) [12]

Contamination of heavy metals sources in the Indus River

Heavy metals like as zinc (Zn), lead (Pb), manganese (Mn), cadmium (Cd), chromium (Cr) and mercury (Hg) usually raise to metalloids and metals having densities more than 5g/cm^3 (Oves *et al.*, 2012) [9]. Many sources of heavy metals contain natural weathering of earth's crust mining, soil erosion, insect and disease control agents applied on crops, sewage discharge, industrial effluents and urban runoff (Morais *et al.*, 2012) [18]. The industries which trait contamination of metals in the water of river are usually metal industries, dye and color, paper and pulp, viticulture, viscose and fabric, rubber, tannery, steel plants, vanishes, thermal power plants, paints, mining industries, products of iron galvanization as well as irregular usage of heavy metals comprising organic fertilizers, pesticides and fungicides in agriculture fields and steel plant (Banerjee *et al.*, 2016) [16]. Accumulative effects of heavy metals have at low degree in ground and drinking water (Sindern *et al.*, 2016) [36]. Pollution of heavy metals is not a current issue rising out of industrialization it arose after human's ongoing processing ores (Sharma *et al.*, 2003) [10]. Generally, may heavy metals enter the in river from diverse causes, it can be both through weathering, soil erosion and anthropogenic activities (Gupta *et al.*, 2013) [11]. Heavy metals from urban discharges and industrial are deposited in various components of the aquatic ecosystem, such as water, soils, biota and sediments (Du Laing *et al.*, 2008) [15] (Table. 1).

Table 1: Different sources of heavy metals

Arsenic (As)	Fungicide, Pesticides, metals smelters
Cadmium (Cd)	Batteries, fertilizer, electroplating, pesticides, plant of nuclear fission, welding
Chromium (Cr)	Cotton Textiles, electroplating, mining, tannery industries
Copper (Cu)	Electroplating, Pesticides, mining
Lead (Pb)	Automobile emission, burning of coal, mining, paint, batteries
Manganese (Mn)	Welding plants, fuel addition, Ferro-manganese production

Mercury (Hg)	Paper Industries, batteries, fungicides and pesticides
Nickel (Ni)	Electroplating, batteries industry, zinc base casting,
Zinc (Zn)	Metal plating, brass manufacture, refineries, immersion of painted idols

Effects of heavy metals

The furthermost significant heavy metals from the fact of view of water contamination are chromium, nickel, mercury, cadmium, lead, copper, arsenic and zinc. Some of these metals (for example zinc, nickel, iron, manganese and copper) are mandatory as nutrients in trace quantity for survival life process in the organism and plants but these convert into toxic at elevated concentration (Table 2).

Effects of heavy metals on aquatic environment

Contamination of metals in water are predominantly hazardous for fish juveniles and may noticeably lessen the size of fish populations or even cause death of entire fish population in contaminated basins. The data of various authors indicate that metals reduce survival, development and growth of fish larvae (Sun *et al.*, 2010) [49]. Pollution of waterway may source devastating impacts on the ecological and biological stability of the maritime surroundings and the diversity of aquatic creatures develops inadequate with the level of pollution (Ayandiran *et al.*, 2009) [50]

Table 2: Heavy metals acceptable limits in drinking water (Kumar *et al.*, 2012) [22]

Heavy metals Acceptable Limits					
	WHO	**USEPA**	**PSI**	**CPCB**	**EPA**
Copper (mg/l)	1.0	1.3	0.05	1.5	1.5
Mercury (mg/l)	0.001	0.002	0.001	No relaxation	0.001
Cadmium (mg/l)	0.005	0.005	0.1	No relaxation	0.01
Arsenic (mg/l)	0.05	0.05	0.05	No relaxation	0.05
Lead (mg/l)	0.05	-	0.10	No relaxation	0.05
Zinc (mg/l)	5.0	-	5.0	15.0	0.10
Chromium(mg/l)	0.1	-	0.05	No relaxation	-
Iron (mg/l)	0.1	-	0.3	1.0	1.0

WHO: World Health Organization, USEPA: United States Environment Protection Agency, PSI: Pakistan Standard Institution, CPCB: Central Pollution Control Board, EPA: Environmental Pollution Act

Heavy metals effects on human health

The utmost generally found metals in the water comprise copper, nickel, chromium, cadmium, lead, zinc and arsenic causes serious hazards for health of human (Lambert *et al.*, 200) [19] (Table 3). Enter the heavy metals in the environment through natural resources and by anthropogenic happenings. Due to their properties such as persistence, non-biodegradation and toxicity, contamination with metals has become a widespread environmental and serious threat, mainly in metropolitan areas such as mental retardation, allergy, and kidney damage, respiratory diseases, various cancers, heart diseases, even death and blood pressure abnormality (Yang-Guang *et al*. 2016) [20].

Table 3: Effects on human health of heavy metals (Bagchi *et al.*, 2002) [21].

Sr. No	Pollutants	Effects on Human Heath
1	Lead	Cognitive impairment of in children, Developmental delay
2	Copper	Kidney malfunctioning, Nausea, vomiting and Diarrhea
3	Zinc	Liver and kidney damage, Headache
4	Nickel	Genotoxic, carcinogenic agent, neurotoxic,
5	Cadmium	Renal dysfunction, Gastrointestinal damage
6	Chromium	Hepatic, Neuronal damage
7	Arsenic	Progressive weakness of lower limbs, Leucopenia, fatigue
8	Mercury	Insomnia, memory loss, neuromuscular changes, tremors
9	Manganese	Attack on nervous system, Clinical effects like central and peripheral neuropathies

Heavy metals status in Indus River water

Considerable studies have been examined through many scholars and researchers on metals contamination of Indus River. The discharge of municipal sewage, industrial effluents, urban and farm waste conceded through canals and drains to rivers aggravate and extend the pollution of water (Tariq *et al.*, 2006, Midrar- Ul- Haq *et al.*, 2005) [24, 23] Residue studies show a critical contribution in evaluating the contamination level of metals and the proceeding health hazard linked with the food web (McAlister *et al.*, 2002) [25]. Littoral areas adapt glowing over 60% of the industries of Karachi city and comprising greater than 7000 various units of industries like as oil refineries, textiles manufacturing, metals, petrochemicals and pharmaceutics industries, oil refineries, tanneries and chemical industries (Saifullah *et al.*, 2002) [26]. Enormous amounts of domestic sewage and discharges of industrial effluents, more than 400 million gallons every day are discharged directly in the shore regions through the Malir and Layri waterway into Indus River (Hasnie *et al.*, 2002) [27]. Water capitals (3 to 6 percent) having Arsenic pollution degree of above 50 *µg/L* are described in Sindh and Punjab correspondingly whereas 20 % and 36 % resources of water of Sindh and Punjab are polluted with arsenic (As) over 10 µg/L (Ahmad *et al.*, 2004) [9]. Accordingly the occurrence of Arsenic polluted water 10-200 µg/L has been reported in some areas of Indus River, in Punjab particularly (PCRWR, 2002) [28]. Nevertheless the examination of 848 samples out of 8712

displays the concentration of arsenic (As) above 10µg/L in nearly 30 % of samples and 7% above 50 µg/L.

The maximum concentration of Cadmium (Cd) 5.35 mg/L in the Indus water stated from Guddu basin zone (Arain, *et el.*, 2009) [30], surpassed the acceptable limit of 0.10 mg/L put by NEQS-Pak for sewage and industrial waste water (Baig *et al.*, 2012) [30]. Furthermore, in east and north regions of Suhkar and Kotri the reported cadmium (Cd) concentration in Indus water was too over the permissible limit put by NEQS-PK and is in assortment of 0.18 to 0.37 mg/L (Mahmood and Malik, 2014) [32].

Anthropogenic and natural causes contribute to the degree of cadmium found in sediments, water, e.g. sources such as sewage sludge, phosphate fertilizers, mine and smelters waste and metropolitan waste landfills are the notable (Mashiatullah *et al.*, 2013) [33]. On the level of worldwide the stated concentration in sediments of cadmium range from 0.03 – 1 mg/kg in aquatic sediments and as high as 5 mg/kg in river and freshwater sediments (Bukhari *et al.*, 2012) [34]. Heavy metals assessment was examined through (Afridi *et al.*, 2017) [47] in the common carp (Cyprinius carpio) taken samples from two different water ways at the Chashma Indus basin Pakistan. The noticed metals concentrations found in many tissues of same species diverse for Manganese: 0.43-4.96 *µg/g*, Nickel: 0.49- 1.60 *µg/g*, Cadmium: 0.06-0.08 *µg/g*, Copper: 0.36 -0.81 *µg/g*, Lead: 0.50-0.74 *µg/g*, Zinc: 0.59-3.74 *µg/g*, wet wt. (Afridi, 2017) [47]. The metals concentrations reported were in the range such as Lead: 0.06-4.41 ppm, Zinc: 4.11-7.11 ppm, Cadmium: 0.42-1.46 ppm, Copper: 1.07-3.86 ppm, Manganese: 0.06-2.11 ppm and Chromium 0.05-2.11 ppm. Also Concentrations of heavy metals was reported by (Usman *et al.*, 2017) in the Indus river Kotri water way, the found concentration of Zinc: 1.2-2.0 ppm, Copper 0.17-1.48 ppm, Cadmium: 0.2-0.69 ppm, Lead: 1.01-1.23 ppm, Chromium 0.04-2.01 ppm and Manganese: 0.01-0.82 ppm correspondingly.

Table 4: Concentrations of heavy metals (mg/L) mean in Indus River, Pakistan

worked Location	Zn	Cu	Mn	Cd	Cr	Ni	Pb	As	Ref.
Kotri	-	0.07	-		0.03	-	0.52	0.52	(Ullah *et al.*, 2013) [41]
Chashma	0.0-0.239	0.01-0.77	0.01-1.11	0.002-0.09	0.01-0.12	0.0-0.18	0.0-0.34	0.34	(Ilyas Sarwar, 2003) [42]
Tunsa	0.6-0.29	0.01-0.84	0.05-0.57	0.002-0.07	0.03-0.29	0.02-1.06	0.09-0.32	0.016-0.071	(Midrar-Ul-Haq *et al.*, 2005) [23]
Kalabagh	0.02-0.06	0.90-1.20	0.77-0.85	0.15-0.20	0.16-0.29	0.53-0.72	0.43-0.62	0.0395-0.038	(Ishaq *et al.*, 2013) [44]
Punjnad	0.167	0.063	1.451	0.004	0.0082	0.005	0.026	1.29	(Nazif *et al.*, 2006) [45]
Guddu	0.016	0.009	-	0.001	0.004	0.012	0.009	0.06	(Wattoo *et al.*, 2006) [46]

Strategy how to improve of heavy metals contamination

The metals contamination of the Indus River has worn the attention of the researchers and other scientist concerned with the risk of the environment. Standards of monitoring for discharge and emission from many industries should be rigorous. Wastewater recycling comprising metals needs to assumed considerable significance not only from ecological and health concern but also as a resource management initiative. Monitoring of waste water poisonous metals processing units of the many industries needs to be effecting further dynamically. Government should framework an approach to widely inspection the Indus in order to recognize and identify the source of contamination. Industries should install highly functioned or established apparatuses to eliminate pollutants from their discharged waste water and effluents. One of the best strategies to do is so installation of Effluent Treatment Plant (ETP); this cans restraint contamination at the source itself (Islam *et al.*, 2015) [35]. The municipalities and urban areas should too have services to wash the effluents of sludge. Whole cities and towns must have Sewage Treatment Plants (STP) that cleanup the sludge (Sindern *et al.*, 2016) [17]. Farmers should give up pesticide in farming and chemicals and should instead assume organic techniques of farming consequently reducing chemicals contamination of the rivers (Madhuri and Govind, 2014) [37]. Appropriate sewage and drainage system should be adopted that will not allow the contaminated water to mix with the river water (Mishra *et al.*, 2015) [38]. Should be ban on Dhobi Ghats alongside the river (Khan *et al.*, 2017) [39].

Conclusion

This review article encapsulates the current situation of metals contamination in the Indus river. Many heavy metals contamination studies displays that the level of river Indus water are far over the permissible concentration. Heavy metals enter in the environment by maritime life systems, fauna and flora surrounding the river. The risk of bioaccumulation and bio magnification of the metals makes them a greater danger to human health and welfare. However, it is compulsory that steps be taken to decrease the metallurgical discharged load dumped into the Indus River. This suggested that different heavy metals sources in the water and sediments of Indus River should be strictly monitored, enhancement of circumstances and industrial effluent and domestic sludge, sewage discharge should be minimized.

Conflict of interest

Authors declare that they have no competing interest.

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