*Original Article*

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# Do Industrial Wastes is a Reason for Water Pollution?

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**Abstract**

Industrial effluents can be classified into waste rich in organic matter and waste rich in inorganic matter. Heavy metals are naturally occurring elements that have a high atomic weight and a density at least 5 times greater than that of water. The use of heavy metal in multiple industries likedomestic, agricultural, medical and technological applications have led to their wide circulation in the Environment and this leads to various harmful effects on human health and ecosystem. The toxicity of heavy metals dependson numerous factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals. Because of the high degree of toxicity of heavy metals like arsenic, cadmium, chromium, lead, and mercury rank among the different metals that areof public health significance. These metallic elements are considered to be universal toxicants that are known to induce multiple organ damage, even at lower levels of exposure and also classified as human carcinogens (known or probable).

**Keywords:** Heavy metals, Industrial waste, pollution, Environment, Exposure.

## Introduction

Industrial waste plays a foremost part for the water pollution, usually lots of water used in industries and lots of waste water generated from the industries due to their working procedures, this waste water contains heavy metals that is hazardous for the environment and public health also[1]. Heavy metals are natural component of the Earth Crust that cannot be degraded or destroyed. Heavy Metal refers to any metallic components that have high density and it is poisonous and toxic at low concentrations, some of the heavy metals that are creating mess in the environment Example: Mercury (Hg), Cadmium (Cd), Arsenic (As), Chromium (Cr), Thallium (Tl), Zinc (Zn) and Lead (Pb) [2]. Different metal have different properties to affect the environment, large volume of waste water that contain heavy metals are discharged from the industries in water bodiesand contaminate the water, because in low concentration they enter in our bodies via food , air and water and create harmful effects [3].And some trace metals that are essential to maintain the metabolism of the human body **(e.g. copper, selenium, zinc),** However at higher concentration they can be carcinogenic.

Industrial waste leads to heavy metal excretion in the water bodies, though heavy metals are naturally occurring elements that are found in the earth's crust [4]. Mostly contamination in the environment and human exposure result from usage of heavy metals in industries like electroplating industry, tannery, automobile and steel and discharge large volume of heavy metal from the industries.

### Effect of different metals on the environment:

#### *Arsenic*

It is an abundant element that is identified at very low concentrations in nearly all

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environmental matrices. Arsenic present in two inorganic forms that include the trivalent arsenite and the pentavalent arsenate, and the organic form are methylated metabolites monomethylarsonic acid (MMA), dimethylarsinic acid (DMA) and trimethylarsine oxide [5]. The pollution caused by arsenic such as volcanic eruptions and soil erosion. Arsenic also have lots of industrial application like insecticides, herbicides, fungicides, algicides, sheep dips, wood preservatives, and dye-stuffs and also used in veterinary medicine.

It is assessed that millions of people are exposed to arsenic chronically throughout the world, especially in countries like Bangladesh, India, Chile, Uruguay, Mexico, and Taiwan, where arsenic is present in high concentration in ground water and exposure to Arsenic occur via oral route inhalation, ingestion, dermal contact and parental route to some extent. Its water concentration is generally less than 10μg/L, although higher levels can occur near natural mineral deposits or mining sites [6].

The average intake of arsenic is about 50 μg per day. Workers who work in industries are more prone to exposed substantially higher levels of arsenic. It has also been identified at 781 sites of the 1,300 hazardous waste sites that have been proposed by the U.S. EPA for inclusion on the national priority list. Contamination with high levels of arsenic is of concern because arsenic can cause a number of human health effects. A number of epidemiological studies have described a strong suggestion between arsenic exposure and increased risks of both carcinogenic and systemic health effects [7].

***Cadmium***

Cadmium is a heavy metal that is widely distributed in the earth's crust at an average concentration of about 0.1 mg/kg [8]. In the Environment the highest level of cadmium compounds is accumulated in sedimentary rocks, and marine phosphates. Cadmium is commonly used in various industries like alloys, pigments and batteries, because of various application this show considerable growth in recent years, But some of the developed countries has declined the use of cadmium in response to Environmental concern [9]. The toxicological properties of cadmium derive from its chemical similarity to zinc i.e. an essential micronutrient for plants, human and animals.

Exposure of cadmium to human beings is possible through a number of ways like inhalation, ingestion of food, smoking the cigarettes and several sources include like employment in metal industries, cadmium contaminated places, smelting and manufacturing of batteries, pigments,

Stabilizers and alloys [10]. Long term exposure to cadmium generally associated with the renal dysfunction and changes in Pulmonary function and lung disease that later become lung cancer[11].

***Chromium***

Chromium is a Heavy metal; Atomic number 24 is naturally occurring and most abundant element in the earth crust and is widely dispersed in the Environment [12]. The oxidation states of Chromium ranging from -2 to +6 but in environment the stable form of chromium is trivalent and hexavalent form. Chromium which is present in 0 oxidation state are biologically inert and are not naturally present in earth crust, while +3 and +6 are originated from industries. Normally the concentration of Cr(VI) in industrial effluents ranges from as low as 1mg/l to as high as >1000mg/l [13]. The Indian statutory limit of Cr (VI) for industrial effluent discharge in inland forsurface water is 0.1mg/l.

Hexavalent chromium is the second most stable form of chromium that have strong oxidising property and very hazardous for ecosystem, when binds to oxygen form a chromate i.e.$CrO_4^{-2}$ (an oxyanion), it will act as electron acceptor for microorganisms and dichromate i.e. $K_2CrO_4$. Cr (VI) has three half-life excretion i.e., 7h, 15-30 days and 3-5 years [13]. Chromium in the radioactive form is used in medicine to tag, or label, red blood cells inside the human body. The labelling of that cell is permanent for the lifetime, so that it is a useful way to look at long-term patterns of blood cell turnover in the body, to look for evidence of internal bleeding and for similar studies [14].

According to the Toxics Release Inventory, in 1997, the approximate releases of chromium were 708,205 pounds to the air from 3,399 large processing facilities which accounted for about 2.5% of total environmental releases. Coal and oil combustion contribute an estimated 1,725 metric tons of chromium per year in atmospheric emissions; however, only 0.2% of this chromium is Cr(VI) [15]. In contrast, chrome-plating sources are estimated to contribute 700 metric tons of chromium per year to atmospheric pollution, 100% of which is believed to be Cr(VI) [ATSDR 2000]. In water chromium was 111,384 pounds to water from 3,399 large processing facilities which accounted for about 0.5% of total environmental releases [16]. Electroplating, leather tanning, and textile industries release relatively large amounts of chromium in surface waters. Leaching from topsoil and rocks is the most important natural source of chromium entry into bodies of water. A Disaster is also reported because of chromium pollution in pacific gas and electric company. From 1952 to 1966, PG & E dumped [5].

"roughly 370 million gallons" hexavalent chromium wastewater" into unlined wastewater spreading ponds around the town of Hinkley, California. PG&E used Cr (VI) one of the cheapest and most efficient commercially available [17]. In July 2014 California became the first state to acknowledge that ingested hexavalent chromium is linked to cancer. (Erin Brockovich movie) .In soil the contamination of chromium was 30,862,235 pounds to soil from 3,391 large processing facilities accounted for about 94.1% of total environmental releases. Total chromium has been identified in 939 soil and 472 sediment samples collected from 1,036 hazardous waste sites [18].

Workers who work in chromium bearing industries are come in contact with hexavalent chromium containing material and were reported to have chronic ulcers of the skin and irritative dermatitis and if inhaled it cause irritation in respiratory tract, perforation in nasal system and ulceration. It is already been reported that Chromium and its compound gets absorbed in human body through the exposure to oral ,dermal and inhalation routes Cr(III) is less absorbed than Cr(VI) and this leads the difference in their transport to the cell, because of its high oxidising potential, Cr(VI) cause mutagenic and carcinogenic effect on biological organisms [19]. Cr(VI) does not interact directly with DNA, Hence its genotoxicity is attributed to its intracellular reduction to Cr(III) via reactive intermediates. As chromate $CrO_4^{2-}$ is structurally similar to sulphate $SO_4^{2-}$ crosses the cell membrane in some species via sulphate transport system. Under normal physiological conditions, after crossing the membrane Cr(VI) reacts spontaneously with intracellular reductants (e.g., ascorbate and glutathione) to generate the short-lived intermediates Cr(V) and/or Cr(IV), free radicals and the end-product Cr(III) [20].Cr (V) undergoes a one-electron redox cycle to regenerate Cr (VI) by transferring the electron oxygen. The process produces reactive oxygen species (ROS), including single oxygen (O) and superoxide (O2) hydroxyl (OH) and hydrogen peroxide (H2O2) radicals that easily combine with DNA-protein complexes. Therefore, Cr(IV) binds to cellular materials and deters their normal physiological functions. The genotoxic effects of the Cr ion however cannot be solely explained by the action of ROS. Intracellular cationic Cr(III) complexes also interact electro statically with negatively charged phosphate groups of DNA, which could affect replication, transcription and cause mutagenesis [21].

***Lead***

Lead is naturally occurring heavy metal found in the earth crust in very less amount, arises from both natural and anthropogenic activity like fossil fuel burning, mining etc., and this is the first metal that is used by humans and recorded the first disease in a 4th century BC, named lead colic, (Metal worker) [22], Because of so many industrial, Agriculture and domestic application, It is currently used in batteries production, ammunitions, metal products and devices to shield. In 2004, the estimated 1.52 million metric tons of lead is used in industries for various applications in U.S. An estimated 1.6 million metric tons of lead in 2012 is used by USA industries for different application. Of that amount, 342,000 metric tons of lead is produced in U.S mines [23].

It is widely used as a corrosion inhibitor and pigment in paints but disquiets over its toxic properties. This led to the Consumer Product Safety Commission (CPSC) in 1977 to ban the use of lead in paint for residential and public buildings [24]. Exposure to lead during the removal, renovation, or demolition of structures painted with lead pigments. Workers may also be exposed during installation, maintenance, or demolition of lead pipes and fittings, lead linings in tanks and radiation protection, leaded glass, work involving soldering, and other work involving lead metal or lead alloys. Inindustry, workers come in contact with lead in solder, plumbing fixtures, rechargeable batteries, lead bullets, leaded glass, brass, or bronze objects, and radiators [25]. Lead exposure can occur not only in the production of these kinds of objects but also in their use (e.g., firing ranges), repair (e.g., radiator repair), and recycling (e.g., lead-acid battery recycling).

In daily life, lead may be present in small but hazardous concentrations in food, water, and air. Children under the age of six are at risk of developing mental health effects even at very low blood lead levels. Pregnant women or those who might become pregnant must avoid lead exposure because it is toxic to the foetus [26]. Exposure to lead, leads to damage the organ system as this enters through inhalation and ingestion and mostly adults are exposed to lead by inhaling the lead containing dust and fumes while working in the industries. This may develop variety of ailments neurological effects, gastrointestinal effects and kidney disease.

Another source for identifying where lead exposure occurs at work is the NIOSH Adult Blood Epidemiology & Surveillance (ABLES) program [27]. ABLES currently has 41 states participating in the collection of elevated blood lead levels in adults. This program identifies industries and occupations where workplace exposure to lead is occurring [28].

### *Mercury*

Mercury is a transition metal in the periodic table and found in nature in three forms Elemental, Inorganic, and Organic. It is a global Pollutant with complex physical and chemical properties with each having its own toxicity [29]. The Natural Source of mercury is earth crust, emission of volcanoes and evaporation form water bodies. It is an environmental toxicant which brings severe alteration in the body and cause harmful effects. Mercury exist as a liquid in room temperature which is having high vapour pressure and is released into the environment as vapour.Mercury also exists as a cation with oxidation states of +1(mercurous) or +2 (mercuric) [30]. Methylmercury is the most commonly encounteredcompound of the organic form found in the environment, and is formed as a result of themethylation of inorganic (mercuric) forms of mercury by microorganisms found in soil andwater [31]. Bothhumans and animals are exposed to various chemical forms of mercury in the environment. These include elemental mercury vapour (Hg0), inorganic mercurous (Hg+1), mercuric(Hg+2), and the organic mercury compounds [32]. Because mercury is ubiquitous in theenvironment, humans, plants and animals are all unable to avoid exposure to some form of mercury. Mercury is exploited in the electrical industry (switches, thermostats, batteries), dentistry(dental amalgams), and various industrial processes including the production of causticsoda, in nuclear reactors, as antifungal agents for wood processing, as a solvent for reactiveand precious metal, and as a preservative of pharmaceutical products [33]. The industrialdemand for mercury peaked in 1964 and began to sharply decline between 1980 and 1994 asa result of federal bans on mercury additives in paints, pesticides, and the reduction of itsuse in batteries [34]. It is toxic substance which has no known function in human Biochemistry, and not naturally occurring in living organism. Poisoning from Inorganic form of mercury leads to tremors and minor psychological changes and together with abortion and congenital malformation, one form of mercury that is Monomethylmercury caused damage to brain and central nervous system.

World-wide mining of the metal leads to unplanned expulsions into the Environment. Mercury is used in industries processes and in various products e.g. lamps, thermometer and batteries. It is also used in dentistry as an amalgam for fillings and by the pharmaceutical industry. It is mostly present in the atmosphere in an unreactive form of gaseous element.

Natural biological processes can cause methylated forms of mercury to form which bio-accumulate over a million-fold and concentrate in living organisms, especially fish. These forms of mercury: monomethylmercury and dimethylmercury are highly toxic, causing neuro-toxicological disorders. The main pathway for mercury to humans is through the food chain and not by inhalation.

The main sources of mercury emissions in the UK are from the manufacture of chlorine in mercury cells, non-ferrous metal production, coal combustion and crematoria UK emissions of mercury are uncertain and it is estimated that the range is from 13 to 36 tonnes per year (DERA). Emissions are estimated to have declined by around ¾'s between 1970-1998 (NAEI), mainly due to improved controls on mercury cells and their replacement, and the fall in coal use [35].

Whilst there has been a decline in the level of European emissions of mercury, emissions from outside of Europe have started to increase – increasing the level of ambient concentrations in the continent

### Prospects

A wide-ranginginvestigation of available data shows that heavy metals such as arsenic, cadmium, chromium, lead, and mercury, occur naturally in the environment. However, anthropogenic activities contribute significantly to environmental contamination. These metals are total toxicants known to bring adverse health effects in humans, including cardiovascular diseases, developmental abnormalities, neurologic and neurobehavioral disorders, diabetes, hearing loss, hematologic and immunologic disorders, and various types of cancer. The main pathways of experience include ingestion, inhalation, and dermal contact. The brutality of adverse health effects is related to the type of heavy metal and its chemical form, and is also time- and dose-dependent. Among many other factors, speciation plays a key role in metal toxicokinetics and toxicodynamics, and is highly influenced by factors such as valence state,particle size, solubility, biotransformation, and chemical form. Several studies have shown that toxic metals exposure causes long term health problems in human populations [36].

Although the acute and chronic effects are known for some metals, little is known about the health impact of mixtures of toxic elements. Recent reports have pointed out that these toxic elements may interfere metabolically with nutritionally essential metals such as iron, calcium, copper, and zinc However, the literature is scarce regarding the combined toxicity of heavy metals. Simultaneous exposure to multiple heavy metals may produce a toxic effect that is additive, antagonistic or synergistic [37].

A recent review of a number of individual studies that addressed metals interactions reportedthat co-exposure to metal/metalloid mixtures of arsenic, lead and cadmium produced moresevere effects at both relatively high dose and low dose levels in a biomarker-specific manner. These effects were found to be mediated by dose, duration of exposure andgenetic factors [38].

Also, human co-exposure to cadmium and inorganic arsenic resulted in amore pronounced renal damage than exposure to each of the elements alone. In manyareas of metal pollution, chronic low dose exposure to multiple elements is a major publichealth concern. Elucidating the mechanistic basis of heavy metal interactions is essential forhealth risk assessment and management of chemical mixtures. Hence, research is needed tofurther elucidate the molecular mechanisms and public health impact associated with humanexposure to mixtures of toxic metals [39].

## References


1. Fergusson, JE., editor. The Heavy Elements: Chemistry, Environmental Impact and Health Effects. Oxford: Pergamon Press; 1990.
2. WHO/FAO/IAEA. World Health Organization. Switzerland: Geneva; 1996. Trace Elements in Human Nutrition and Health.
3. Heavy Metals Toxicity and the Environment Paul B Tchounwou*, Clement G Yedjou, Anita K Patlolla, and Dwayne J Sutton.
4. https://www.lenntech.com/processes/heavy/heavy-metals/heavy-metals.htmHeavy Metals
5. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for ArsenicTP-92/09. Georgia: Center for Disease Control, Atlanta; 2000.
6. Tchounwou PB, Wilson B, Ishaque A. Important considerations in the development of public health advisories for arsenic and arsenic-containing compounds in drinking water. Rev EnvironHealth. 1999; 14(4):211–229. [PubMed: 10746734].
7. Centeno, JA.; Tchounwou, PB.; Patlolla, AK.; Mullick, FG.; Murakat, L.; Meza, E.; Gibb, H.;Longfellow, D.; Yedjou, CG. Environmental pathology and health effects of arsenic poisoning: acritical review. In: Naidu, R.; Smith, E.; Smith, J.; Bhattacharya, P., editors. Managing Arsenic Inthe Environment: From Soil to Human Health. Adelaide, Australia: CSIRO Publishing Corp.; 2005.
8. Gesamp. IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on theScientific Aspects of Marine Pollution: Report of the seventeenth session. Geneva, Switzerland:World Health Organization; 1987. (Reports and Studies No. 31).
9. U.S Environmental Protection Agency (EPA). Cadmium Compounds. 2006.
10. Paschal DC, Burt V, Caudill SP, Gunter EW, Pirkle JL, Sampson EJ, et al. Exposure of the U.S.population aged 6 years and older to cadmium: 1988–1994. Arch Environ ContamToxicol. 2000;38:377–83. [PubMed: 10667937].
11. Agency for Toxic Substances and Disease Registry (ATSDR). Draft Toxicological Profile forCadmium. Atlanta, GA: 2008.
12. Chromium-6: 'Erin Brockovich' chemical threatens two-thirds of Americans, https://www.theguardian.com/lifeandstyle/2016/sep/20/chromium-6-erin-brockovich-chemical-threatens-two-thirds-of-americans-erin-brockovich.
13. Hinkley groundwater contaminationhttps://en.wikipedia.org/wiki/Hinkley_groundwater_contamination.
14. Joutey, N. T., Sayel, H., Bahafid, W., & El Ghachtouli, N. Mechanisms of hexavalent chromium resistance and removal by microorganisms. In Reviews of

Environmental Contamination and Toxicology 2015;233:45-69. Springer International Publishing.

15. Jacobs, JA.;Testa, SM. Overview of chromium(VI) in the environment: background and history. In: Guertin, J.; Jacobs, JA.;Avakian, CP., editors. Chromium (VI) Handbook. Boca Raton, Fl:CRC Press; 2005.pp.1-22.
16. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile forChromium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.
17. IARC. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Vol. 49. Lyon,France: IARC Scientific Publications, IARC; 1990. Chromium, nickel and welding.
18. Velma V, Vutukuru SS, Tchounwou PB. Ecotoxicology of hexavalent chromium in freshwaterfish: a critical review. Rev Environ Health. 2009;24(2):129–45. [PubMed: 19658319].
19. Cohen MD, Kargacin B, Klein CB, Costa M. Mechanisms of chromium carcinogenicity andtoxicity. Crit Rev Toxicol. 1993;23:255–81. [PubMed: 8260068].
20. Guertin, J. Toxicity and health effects of chromium (all oxidation states). In: Guertin, J.; Jacobs,JA.;Avakian, CP., editors. Chromium (VI) Handbook. Boca Raton, FL: CRC Press; 2005. pp.216-34.
21. Occupational Safety and Health Administration (OSHA). Federal Register. Vol. 71. Washington,DC: Final rule; Occupational exposure to hexavalent chromium; 2006.p.10099-10385.
22. Gabby, PN. Lead: in Mineral Commodity Summaries. Reston, VA: U.S. Geological Survey;2006. available at http://minerals.usgs.gov/minerals/pubs/commodity/lead/lead_mcs05.pdf.
23. Gabby, PN. "Lead." Environmental Defense "Alternatives to Lead-Acid Starter Batteries, Pollution Prevention Fact Sheet. 2003. available at http://www.cleancarcampaign.org/FactSheet_BatteryAlts.pdf.
24. Jacobs DE, Clickner RP, Zhou JY, et al. The prevalence of lead-based paint hazards in U.S.housing. Environ Health Perspect. 2002;110:A599–A606. [PubMed: 12361941].
25. Centers for Disease Control and Prevention CDC). Managing Elevated Blood Lead Levels Among Young Children: Recommendations From the Advisory Committee on Childhood LeadPoisoning Prevention. Atlanta: 2001.
26. Charney E, Sayre J, Coulter M. Increased lead absorption in inner city children: where does thelead come from? Pediatrics. 1980;6:226–31. [PubMed: 7354967].
27. Agency for Toxic Substances and Disease Registry (ATSDR). Case Studies in EnvironmentalMedicine - Lead Toxicity. Atlanta: Public Health Service, U.S. Department of Health and HumanServices; 1992.
28. United States Environmental Protection Agency (U.S. EPA). Lead Compounds. TechnologyTransfer Network- Air Toxics Website. 2002. Online at: http://www.epa.gov/cgi-bin/epaprintonly.cgi.
29. Clarkson TW, Magos L, Myers GJ. The toxicology of mercury-current exposures and clinicalmanifestations. New Engl J Med. 2003;349:1731–37. [PubMed: 14585942].
30. Guzzi G, LaPorta CAM. Molecular mechanisms triggered by mercury. Toxicol. 2008;244:1–12.
31. Dopp E, Hartmann LM, Florea AM, Rettenmier AW, Hirner AV. Environmental distribution,analysis, and toxicity of organometal (loid) compounds. Crit Rev Toxicol. 2004;34:301–333.[PubMed: 15239389].
32. Sarkar BA. Mercury in the environment: Effects on health and reproduction. Rev Environ Health. 2005; 20:39–56. [PubMed: 15835497].
33. Holmes P, Hames KAF, Levy LS. Is low-level mercury exposure of concern to human health? SciTotal Environ. 2009;408:171–82. [PubMed: 19850321].
34. Tchounwou PB, Ayensu WK, Ninashvilli N, Sutton D. Environmental exposures to mercury andits toxicopathologic implications for public health. Environ Toxicol. 2003;18:149–75.[PubMed: 12740802].
35. Guzzi G, LaPorta CAM. Molecular mechanisms triggered by mercury. Toxicology. 2008;244:1–12. [PubMed: 18077077].
36. Valko M, Morris H, Cronin MTD. Metals, Toxicity, and oxidative Stress. Curr Medici Chem. 2005; 12:1161–1208.
37. López Alonso M, PrietoMontaña F, Miranda M, Castillo C, Hernández J, Luis BeneditoJ.Interactions between toxic (As, Cd, Hg and Pb) and nutritional essential (Ca, Co, Cr, Cu, Fe, Mn,Mo, Ni, Se, Zn) elements in the tissues of cattle from NW Spain. Biometals. 2004;17(4):389–97.[PubMed: 15259359].
38. Abdulla M, Chmielnicka J. New aspects on the distribution and metabolism of essential traceelements after dietary exposure to toxic metals. Biol Trace Elem Res. 1990;23:25–53. [PubMed:2484425].
39. Wang G, Fowler BA. Roles of biomarkers in evaluating interactions among mixtures of lead,cadmium and arsenic. ToxicolApplPharmacol. 2008; 233(1):92–99. [PubMed: 18325558].