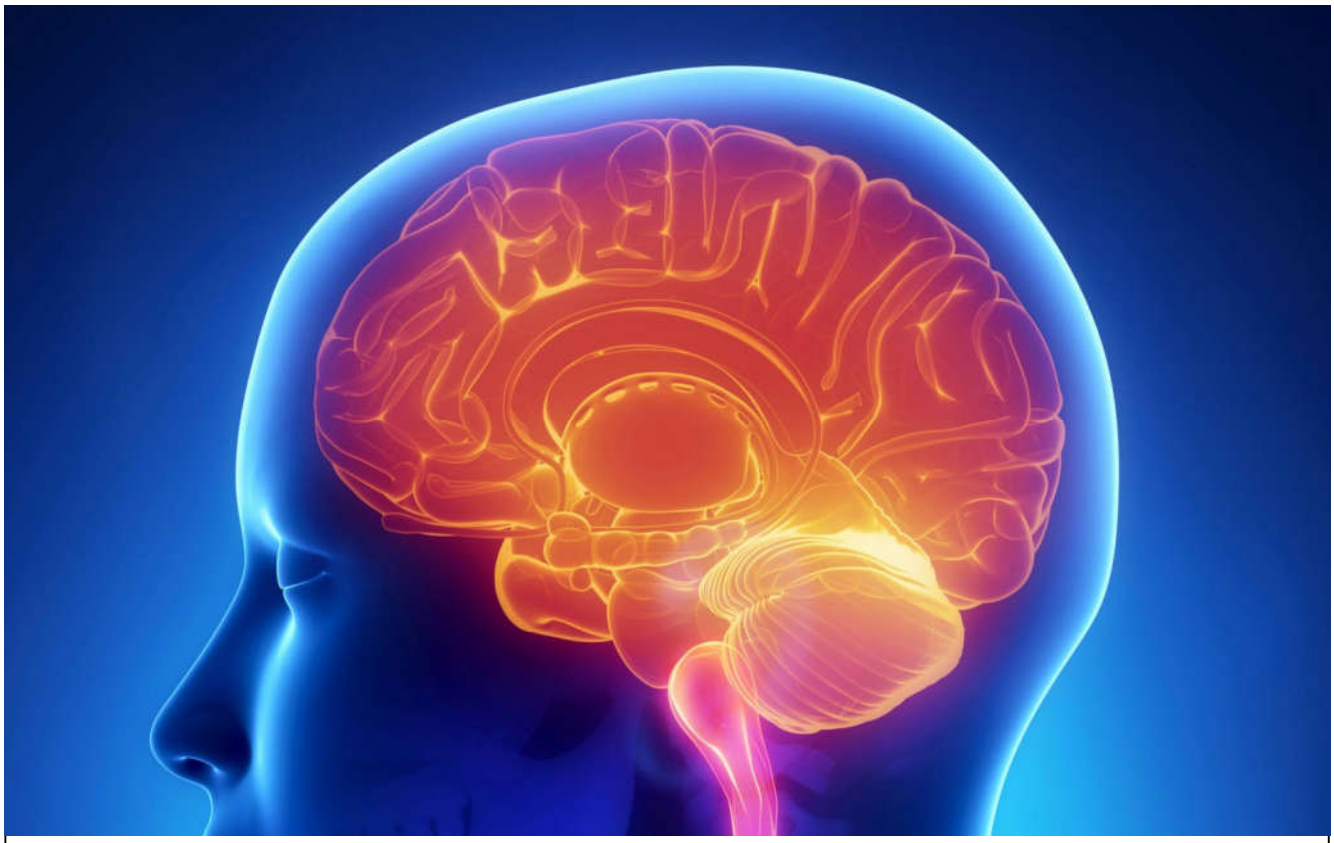

International Journal Of

Recent Scientific Research

ISSN: 0976-3031

Volume: 6(12) December -2015

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THE OFFICIAL PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR)
http://www.recentscientific.com/ recentscientific@gmail.com

ISSN: 0976-3031

Available Online at http://www.recentscientific.com

International Journal of Recent Scientific Research
Vol. 6, Issue, 12, pp. 7752-7755, December, 2015

International Journal of Recent Scientific Research

RESEARCH ARTICLE

HEAVY METALS POLLUTION AND IT, S EFFECT ON ENVIRONMENT AND HUMAN HEALTH

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ARTICLE INFO

Article History:

Received 06thSeptember, 2015
Received in revised form 14th October, 2015
Accepted 23rd November, 2015
Published online 28st December, 2015

Key words:

Heavy metals, Environment, Biotoxic, Pollution

ABSTRACT

Heavy metal is a general collective term which is applied to the group of metal and metalloids, many of them have biotoxic effects due to which they became harmful. These metals are released into environment by both natural and arthropogenic sources such as mining and industrial activities. Urban sewage and industrial effluents are the main factor for the pollution by heavy metals. They leach into underground water, move along water pathway or washed away by run off into surface water there by results into water and soil pollution. Heavy metals are known to cause serious health problems, they combine with the body's biomolecules and form stable biotoxic effects on humans and environment.

INTRODUCTION

The pollution is caused by a variety of pollutants in water, air and soil. One of the major concerned globally distributed pollutants of living environment is hazardous metals. Metals occurs naturally in the earth crust. The distribution of metals in the environmental is governed by the properties of the metal and influences of environmental factors (Khlifi and Hamzachaffai, 2010). Metals are notable for their wide environmental dispersion from such activity. Out of the 92 naturally occurring elements, approximately 30 metals and metalloids are potentially toxic to humans.

Heavy metals refers to any metallic element that have relatively high density and is toxic or poisonous even at low concentration (Lenntech, 2004). Heavy metal is collective term which is applied to the group of metals and metalloids with atomic density greater than 4g/cm^3 or 5 times or more greater than water (Huton and Symon, 1986; Battarbee *et al*., 1988; Nriagu and Pacyna 1988; Niragu, 1989; Garbarino *et al*., 1995; Hawkes, 1997).

Environment is defined as the totality of circumstances surrounding an organism or group of organisms especially the combination of external physical conditions that affect and influence the growth, development and survival of organism (Farlex, 2005). Heavy metals enter the environment by the natural and anthropogenic means such as natural weathering of the earth's crust, mining, soil erosion, industrial discharge, urban runoff, sewage effluents, pest or disease control agents applied to plants, air pollution fallout and a number of others (Ming – Ho, 2005). The contamination chain of heavy metals almost always follows a cyclic order ie. Industry → Atmosphere → Soil → Water → Foods → Humans. Therefore concern about exposures, intakes and absorption of heavy metals by humans are increasing day by day in developing world.

Chemistry of Heavy Metal Pollution

Mining activites and other geochemical processes often result in the generation of acid mine drainage (AMD), a common phenomenon associated with mining activities. It is generated when pyrite (FeS_2) and sulphide minerals in the aquifer and present and former mining sites are exposed to air and water in the presence of oxidizing bacteria such as Thiobacillus ferrooxidans and oxidized to produce metal ions, sulphate and acidity (Ogwuegbu and Muhanga, 2005).

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2FeSO_4 + 2H_2SO_4$$
$$2FeSO_4 + 2H_2SO_4 \rightarrow Fe(SO_4)_3 + SO_2 + 2H_2O$$
$$Fe(SO_4)_3 + 2FeAsS + 9/2\ O_2 + 3H_2O \rightarrow 2H_3ASO_4 + 4FeSO_4 + S$$

Heavy metals at mining sites are leached and carried by acidic water downstream. They can be acted upon by bacteria and

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methylated to yield organic forms, such as monomethyl mercury and dimethylcadmiunm. This conversion is effected by bacteria in water, in the presence of organic matter, according to the following simplified equation.

M + organic matter H2O, bacteria CH3 M and (CH3)2 M

The organic forms have been reported to be very toxic and adversely affect water qualities by seepage to pollute underground water sources. Low pH values do not need to be established for metals to be released from mine wastes at adverse concentrations because near neutral pH have been established for some metals such as Zn, Cd ad As (INECAR, 2000; Lenntech, 2004). Factors such as downstream distances from the mining sites, colloid loads, pH perturations and dilution ultimately control the quality of water sources.

Table 1 Recommended Dietary Allowances (RDA) of the Food and Nutrition Board (Published by the National Acadmey of Science, Washington, DC, U.S.A).

	Age (years)	Weight (Kg)	Ca (mg)	Fe (mg)	Mg (mg)	Zn (mg)
Infants	0 – ½	6	360	10	60	3
Children	½ - 1	9	540	15	70	5
	1 – 3	13	800	15	150	10
	4 – 6	20	800	10	200	10
	7 -10	30	800	10	250	10
Males	11 -14	44	1200	18	350	15
	15 – 18	61	1200	18	350	15
	19 +	67+	800	10	350	15
Females	11 – 18	44 – 54	1200	18	350	15
	19+	58	800	18 (10)*	300	15
Pregnant			1200	18+**	450	20
Lactating			1200	15	450	25

(10)* for female above 50 years, ** figure cannot be met by ordinary diets. Therefore, use of supplemental iron is recommended.

Table 2 Guidline in driking water by the World Health Organization (WHO) and National Agency for Food and Drugs Administration and control (NAFDAC), Nigeria.

Heavy Metals	Max. acceptable conc. (WHO)	Max. acceptable conc. (NAFDAC)
Zinc	5 mg/l	5 mg/l
Arsenic	0.01 mg/l	0.0 mg/l
Magnesium	50 mg/l	30 mg/l
Calcium	50 mg/l	50 mg/l
Cadmium	0.003 mg/l	0.0 mg/l
Lead	0.01 mg/l	0..0mg/l
Silver	0.0 mg/l	0.0 mg/l
Mercury	0.001 mg/l	0.0 mg/l

Heavy metals toxicity

Lead, Cadmium, Mercury and Arsenic are widely dispersed in the environment. These elements have no beneficial effects in humans, and there is no homeostasis mechanism for them (Draghici *et al*, 2010; Vieira *et al*, 2011). Eve there low concentration are known to have neurotoxic and carcinogenic actions (ATSDR, 2003a, 2003b, 2007, 2008; Castro – Gonzalez and Mendez – Armenta, 2008; Jomova and Valko, 2011; Tokar *et al*, 2011).

Lead

Lead has been mined and used in industries and in household products. The dominant sources of worldwide dispersion of lead into the environment and into people for the past 50 years has clearly been the use of lead organic compounds as antiknock motor vehicle fuel additives. In humans, lead ingestion may arise from eating lead contaminated vegetation or animal food, another source is through the use of lead containing vessels or lead based pottery glazes (Ming-Ho, 2005). Children are particularly sensitive to this metal because of there more rapid growth rate and metabolism, with critical effects in the developing nervous system (ATSDR, 2007; Castro – Gonzalez and Medez – Armenta, 2008). Serious effect of lead toxicity is its teratogenic effect. Lead poisoning also causes inhibition of the synthesis of haemoglobin, dysfunctions in the kidneys, joints and reproductive system, cardiovascular system and acute and chronic damage to central nervous system ad peripheral nervous system (Ogwuebgu and Muhanga, 2005).

Table 3 Optical and the electrochemical methods applied for heavy metals determination (Karadjova *et al*., 2007, Draghici *et al*., 2010).

Technique	Principle	Type of analysis	Applications
Atomic Absorption Spectrometry (AAS)	Absorption of radiant energy produced, by a special radiation source, by atoms in their electronic ground state.	Single element, Multi element analysis (2-6 elements)	Widely used
Inductively coupled plasma with atomic emission spectrometry (ICP – AES)	Measures the optical emission from excited atoms.	Simultaneous, multi elements analysis	Widely used method for environmental analysis.
Inductively coupled plasma with mass spectrometry (ICP- MS)	Argon plasma used as ion sources used for Separating ions based on their mass to charge ratio.	Simultaneous multi elements analysis.	Widely used isotope determination.
Atomic fluorescence spectrometry (AFS)	Measures the light that is reemitted after absorption.	Single element	Mercury, Arsenic and Selenium
X – ray fluorescence (XRF)	x- rays primary excitation source, elements emit, secondary X- rays of a characteristic wavelength.	Simultaneous determination of most elements.	Non – destructive analysis, less suitable for analysis of minor and trace elements.
Neutron activation analysis (NAA)	Conversion of stable Nuclei of atoms into radioactive ones, measurement of the characteristic nuclear radiation emitted by the radioactive nuclei.	Simultaneous multi element analysis.	Most elements can be determined, highly sensitive procedure.
Electro chemical methods	Controlled voltage or current, polarography, potentiometry, stripping voltammetry.	Consecutive analysis of different metal ions.	Analysis for transition metals and metalloids or speciation analysis.

Mercury

Mercury is one of the most toxic heavy metal in the environment (Castro – Gonzalez and Mendez – Armenta, 2008). Man released mercury into the environment by the action of the agriculture industries, by pharmaceuticals, as pulp and paper preservatives, catalysts in organic synthesis, in thermometers and batteries, in amalgams and in chlorine and caustic soda production. Inorganic form of mercury cause spontaneous abortion, congenital malformation and GI

disorders (like corrosive esophagitis and hematochezia). Organic forms such as monomethylmercury and dimethylmercury result in abnormal irritation, acrodynia, gingivitis, stomatis, neurological disorders and congenital malformation

Table 4 Relevant separation methods and hyphenated techniques for metal speciation.

Techniques	Principle	Type of analysis	Application
Liquid Chromatograpy	Repartition of the analyte between a stationary phase and a mobile liquid one.	Simultaneous multi element analysis.	Environmental metal speciation, Hyphenated techniques for speciation LC-AAS, LC – AES, LC – ICP – MS.
Gas Chromatography (GC)	Repartition of the analyte between a stationary phase and a mobile gas one.	Simultaneous multi element analysis.	Volatile or thermally stable compound (Hg, Sn, Pb alkyl compounds), techniques for speciation GC – AAS, GC – AES, GC – MS.
Ion Chromatography (IC)	LC technique which use ion – exchange resins.	Simultaneous multi element analysis.	Lack of selectivity control, hyphenated techniques for metal speciation IC – AAS, IC – ICP – AES, IC – ICP – MS.
Capillary Electrophporesis	Differential migration of charged analytes along a capillary filled with a suitable conducting electrolyte.	Simultaneous multi element analysis.	Cations, organic and inorganic compounds of same metal, metalloids, hyphenated techniques. CE – MS, CE – ICP – MS.

Arsenic

It is a metalloid. It is rarely found as a free element in the environment. It commonly occurs as sulphur containing ores as a arsenides. Arsenic occurs in natural waters in oxidation states III and V, in the form of arsenous acid (H_3AsO_5) and its salts, respectively. Arsenic acts to coagulate protein, forms complexes with coenzymes and inhibits the production of adenosine triphosphate (ATP) during respiration (INECAR, 2000). It's all oxidation forms are carcinogenic and high level exposure can cause death (Ogwuegbu and Ljioma, 2003; USDOL, 2004).

Cadmium

Cadmium is naturally present in the environment in air, soil, sediments and even unpolluted sea water. Cadmium is emitted by mines, metal smelters and industries using cadmium compounds for alloys, batteries, pigments and in plastics. Tobacco smoke is one of the largest single sources of cadmium exposure in humans. Cadmium accumulates in human body affecting negatively several organs: liver, kidney, lungs, bones, placenta, brain and central nervous system (Castro – Gonzalez and Mendez – Armenta, 2008). Other damages that have been observed include reproductive, hepatic, haematological and immunological effects (Apostoli and Catalani, 2011; ATSDR, 2008).

Zinc

Zinc considered to be relatively non toxic, especially if taken orally. However, excess amount can cause system dysfunctions that results in impairment of growth and reproduction (INECAR, 2000; Nolan, 2003). The clinical signs of zinc toxicosis include vomiting, diarrhea, bloody urine, liver failure, kidney failure and anemia (Fosmire, 1990).

Heavy Metals Analytical Methods

Quantitative Determination

Research has been carried out in sample collection, preservation, storage, pretreatment, quantitative, determination, speciation and microscopic analysis. Table 3 summarizes the optical and the electrochemical methods applied for heavy metals determination (Karadjova *et al*., 2007; Draghici *et al*., 2010).

Speciation Analysis

The main analytical challenges concern speciation determination of redox and organometallic forms of arsenic and antimony, protein- bound cadmium, organic forms of lead (ie alkyl lead compounds), organomercury compounds, inorganic and organometallic compounds of selenium, organometallic forms of tin and redox forms of chromium and vanadium. Recently speciation analysis plays a unique role in the studies of biochemical cycles of chemical compounds, determination of toxicity and ecotoxicity of selected elements.

CONCLUSION

Heavy metals are important in many respect to man, especially in the manufacturing of certain important products of human use such as accumulators, mercury – arch lamps and thermometers, utensils and a wide range of other products (Yaw, 1990; Mc Cluggage, 1991). But the biotoxic effects, when unduly exposed to them could be potentially life threatening hence, cannot be neglected. While these metals in many ways indispensable, good precaution and adequate occupational hygiene should be taken in handling them. Although heavy metals poisoning could be clinically diagnosed and medically treated, the best option is to prevent heavy metals pollution and the subsequent human poisoning.

Acknowledgement

We sincerely thank prof. (Mrs.) Padma singh, Head of Department of Kanya Gurukul Campus, Gurukul Kangri Vishwavidyalaya, Haridwar, for her support and encouragement. We owe our sincere gratitude to Gurukul library for finding literature on our work, we also wish to acknowledge DST for for providing the financial support by providing INSPIRES fellowship.

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How to cite this article:
Vani Sharma and Padma Singh., Heavy Metals Pollution And It, S Effect On Environment And Human Health. *International Journal of Recent Scientific Research Vol. 6, Issue, 12, pp. 7752-7755, December, 2015*

ISSN 0976-3031