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HEAVY METAL POLLUTION AND IMPACT ON THE HUMAN BODY

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ABSTRACT

Heavy metals viz Cu, Zn, Mn, Pb, Cd, Hg, As have biotoxic effects in human body are of great concern. Hence, there is the need for proper understanding of the conditions, such as the concentrations and oxidation states, which make them harmful for human. It is also imprtant to know their sources, leaching processes, chemical conversions and their modes of deposition to pollute the environment, which essentially supports the living beings. Heavy metals are released into the environment by both natural and anthropogenic sources viz mining, mines operation, smelting, industrial activities and exhausts from automobile. These heavy metals leach into underground waters, moving along water path ways and depositing in the quifer or are washed away by run off into surface water and resulting in water pollution and subsequently soil pollution. Poisoning and toxicity in animals occurs frequently through exchange and co-ordination mechanism. When ingested they combine with the body's biomolecules like proteins and enzymes to form stable toxic compounds and multiplating their structures and hindring them from the bioreaction of their functions.

Keywords- *Biochemical, biotoxic, environments, heavy metal, pollution, anthropogenic.*

I. INTRODUCTION

"Heavy metal" means any metallic elements that has a relatively high density and in toxic or poisonous even at low concentration[1]. "Heavy metal" is a group of metals and metalloids with atomic density greater than 4 gm/cm^3 or 5 times or more greater than water[2-7]. Heavy metals includes lead (Pb), Cadmium (Cd), mercury (Hg), Chromium (Cr), Zinc (Zn), Arsenic (As), Silver(Ag), Copper (Cu), Iron (Fe) and Platinum group elements.

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 organisms[8]. It consists of the flora, fauna and the abiotic and includes the aquatic, terrestrial and atmospheric habitats. The environment is considered in terms of the most tangible aspects like air, water and food and the less tangible, the communities we live in[9]. A pollutant is substance in the environment, which causes objectionable effects, impairing the welfare of environments, reducing the quality of life and may eventually cause dealth. Such a substance has to be present in the environment beyond a set or tolerance limit, which could be either a desirable or acceptable limit. Therefore, environmental pollution is the presence of a pollutant in the environment air, water and soil, which may be poisonous or toxic and will cause harm to living beings in the polluted environment.

Occurance And Recovery Of Heavy Metals

Heavy metals occurs as natural constituents of the earth crust and are persistent environmental contaminant since they cannot be degraded or destroyed. To a small extent they enters the body system through food, air and water and bio-accumulate over a period of time[1,10]. Heavy metal exists in their rocks as they exist as their ores in different chemical forms, from which they are recovered as minerals. Heavy metal ores include oxides such as Aluminm, Mangenese, Gold, Selenium and Antimony oxide. Sulphides such as Iron, Arsenic, Lead, Lead-zinc, Cobalt, Gold-Silver and Nickel sulphides. Some exist and can be recovered as both sulphide and oxide ores such as iron, Copper and Cobalt. Therefore sulphide of lead, cadmium, arsenic and mercury would naturally be found occuring together with sulphide of iron (Pyrite FeS_2) and Copper (Chalcopyrite $CuFeS_2$) as minors, which are obtained as byproducts of various hydrometallurgical process or as part of exhaust fumes. In pyrometallurgical and others processes that follow aften mining to recover them.

During mining and mines operation some metals are left behind as tailings scattered in open and partially covered pits; Some are transported through wind and flood water, creating various environmental problems[11]. Heavy metals are basically recovered from their ores by mineral processing operations[10,12,13]. Heavy metals can be emitted into the environmental by both natural and anthropogenic causes. The majer causes of emission are the anthropeogenic sources specially mining and mining operations[2,3,5].

In come causes, even long after mining activities have ceased, the emitted metals continue to persist in the environment.

Apart from mining operations, mercury is introduced into the environment through cosmetic products as well as manufacturing processes like making of sodium hydroxide. Heavy metals are emitted both in elemental & compound

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(organic and inorganic) forms. Cadmium is released as a by product of Zinc and Lead refining. Lead is emitted during its mining, mines operation and smelting activities, from automobile exhausts and from old lead paints.

Environmental pollution by heavy metals is very prominent in areas of mining and old mine sites and pollution reduces with increasing distance from mining sites[12]. The potential for contamination is increased when mines ores are dumped on the earth surfaces in manual dressing processes. Through rives and streams, the metals ae transported as either dissolved species in water or as an integral part of suspended sediments. They may then be stored in river bed sediment or seep into the underground water thereby contaminating water from underground sources, particularly wells. Contamination will depend on the distance of the well from the mining site. Wells located near mining sites have been reported to contains heavy metals at levels that exceed drinking water criteria[6,12].

According to United State Environments Protections Agency (USEPA) the tolorence limit (or maximum cantaminating level) of some heavy metal concentration in air, Soil & water are show in Tabel-1.

Table-1 United State Environmental Protection Agency (USEPA) maximum contamination levels for heavy metal concentration in air, soil and water.

Heavy metal	Max conc. in air (mg/m^2)	Max. conc. in sludge (soil) (mg/Kg or ppm)	Max. conc. on drinking water (mg/1)	Max conc. in H_2O supporting aquatic life (mg/1 or ppm)
Cd	01.-0.2	85	0.005	0.008
Pb	--	420	0.01	0.0058
Zn2	1.5	7500	5.00	0.0766
Hg	--	<1	0.002	0.05
Ca	5	Tolerable	50	Tolerable>50
Ag	0.01	--	0.0	0.1
As	--	--	0.01	--

WHO, adapted from US-OSHA, EPA, July 1992, USEPA, 1987, Georgia Code, 1993, Florida Code, 1993, Washington Code, 1992, Taxas Code, 1991, North Carolina, 1991.

II. CHEMISTRY OF HEAVY METAL POLLUTION

Mining activities and other geochemical processes often result in the generation of Acid Mine Drainage (AMD), Acid Mine Drainage (AMD) is a potentially severe pollutions hazard that can contaminate surrounding soil; ground water and surface water. The formation of Acid Mining Drainage is a functions of the geology, hydrology and mining technology employed at a mine site. The primary sources for acid generation are sulfide minerals such as pyrite (iron sulfide, FeS_2) which decompose in air and water in the presence of oxidiging bacteria such a Thiobacillus ferrooxidans and oxidised to produce to metal ions, sulphate and acidity[14].

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2FeSO_4 + 2H_2SO_4$$
$$2FeSO_4 + 2H_2SO_4 \rightarrow Fe_2(SO_4)_3 + SO_2 + 2H_2O$$
$$Fe_2(SO_4)_3 + 2FeAsS + 9/2\ O_2 + 3H_2O \rightarrow 2H_3AsO_4 + 4FeSO_4 + S$$

Heavy Metals (M) at mining sites are leached and carried by acidic water downstream. They can be acted upon by bacterial and mithyllated to yield organic forms such as monomethyl- mercury and dimethylcadmium. This conversion is affected by bacteria in water, in presence of organic matter, according to following equation.

$$M + \text{Organic matter} \xrightarrow{H_2O\ \text{bacteria}} CH_3M \text{ and } (CH_3)_2M$$

in the non-biological conversion, the following reactions have been identified for mercury

$$Hg^{2+} \xrightarrow{H_2S} HgS \xrightarrow{\text{aeration}} Hg_2SO_4 \xrightarrow[\text{Eutropic}]{} CH_3Hg^{2+}$$

condition — less soluble — more soluble — methyl mercury

These organic forms are very toxic and adversely affect water qualities by seepage to pollute under ground water sources.

Human Exposure Through Food, Air And Water

Heavy metal pollution of surface and underground water sources results in considerable soil pollution and pollution increases when mined ores are dumped on the ground surface for manual dressing[6,25]. Surface dumping exposes the metals to air and rain thereby generating much AMD. When agricultural soils are polluted, these metals are taken up by plants and consequently accumulate in this tissues[15]. Animals that graze on such contaminated plants and

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drink from polluted waters, as well as marine lives that breed in heavy metal polluted waters also accumulate such metals in their tissues and milk, if lactating [6,11,12,16]. Humans are in turn exposed to heavy metals by consuming contaminated plants and animals and this has been known to result in various biochemical disorder. In summery, all living organisms within a given ecosystem are variously contaminated along their cycles of food chain.

Human Exposure Through Industrial Products

Industrial products that are used in homes and which have been produced with heavy metals are sources of human exposure to such heavy metals. Cadmium exposure is through Nickel / Cadmium batteries and artists paints Mercury exposure is through disinfectants anti fungal agents toiletries, creams and organo-metallics[17]. Lead exposure is through wine bottle wraps, mirror coatings, batteries, old paints and tiles and linolein amongst others. Infants are more susceptible to the endangening effects of exposure to heavy metals.

III. OCCUPATIONAL EXPOSURE

Heavy metal exposure occurs significantly by occupational exposure. Workers of the mining and production of Cadmium, Chromium, Lead, Mercury, Gold and Silver have been reported to be thus exposed, also inhabitants around industrial sites of heavy metal mining and processing are exposed through air by suspended particulate matters (SPM)[13,14,18].

Bio-importantance Of Heavy Metals

Some heavy metal viz Fe, Zn, Ca and Mg have been reported to be bio-importance to man and their daily medicinal and dietary allowances had been recomended and is presented in Table-2. This tolerance limits in drinking and portable waters have also been reported and are indicated in Table-3.

Table-2 Recomended (Daily) Dietary Allowance (RDA) of food and nutritions board (published by the National Academy of Science Washington DC, USA.

	Age(Years)	Weight (Kg)	Ca (mg)	Fe (mg)	Mg (mg)	Zn (mg)
Infants	0-1/2	6	360	10	60	3
	1/2-1	9	540	15	70	5
Children	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	400	15
	19+	67+	800	10	350	15
Females	11-18	44-54	1200	18	300	15
	19+	58	800	18(10)*	300	15
Pregnant	--	--	1200	18+**	450	20
Lactating	--	--	1200	15	450	25

*(10) for females above 50 years; ** Figure can not be met by ordinary diet. Therefore use of supplemented iron is recomended.

Table-3 Guideline in drinking water by the World Health Organisation (WHO) and Natural Agency for Food and Drugs Adminitrator and Control (NAFDAC), Nigeria.

Heavy metal	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	0.0 mg/l
Silver	0.0 mg/l	0.0 mg/l
Mercury	0.001 mg/l	0.0 mg/l

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However, some others viz As, Cd, Pb and methylated forms Hg have been reported to have no known bio-importance[10] in human biochemistry and Physiology and consumption even at very low concentration can be toxic[17,19-24].

Even for those that have bio-importance, dietary intakes have to be maintained at regulatory limits, as excesses will result in poisoning or toxicity; which is evident by certain reported medical symptoms that are clinically diagnosable[20,23-24].

Zinc in a 'masculine' element that balances copper in the body and is essential for male reproductive activity[23]. It serves as a co-facter for dehydrogenating enzymes and in carbonic enhydrase[19]. Zinc deficiency causes anaemia and retardation of growth and development[17]. Calcium is a very vital element in human metabolism. It is the chief element in the production of very strong bones and teeth in mammals. Its tolerance limits is high relative to other bio-useful metals that is, at 50 mg/l of drinking water as shown in table-3. The daily dietary requirement of calcium soars at the highest across both sexes and all ages of humans as shown in table-2 and it can be accomodated at higher doses in the body because its concentration in the blood is well regulated by thyrocalcitonin and parathormone hormones[19]. Magnesium is an important electrolytic constituents of the blood, present in the blood plasma and body fluids viz interstitial and cell fluids. Its daily dietary requirement increases from infants to adults and from males to females, with the highest daily requirements for pregnant and lactating woman[19]. Arsenic has been reported to be a trace element of netritional importance to humans but its functions in the biological system is not clear[19]. Any level of concentration of silver in drinking water has been disallowed both by the World Health Organisation (WHO) and National Agency for Food and Drugs. Administrator and Control (NAFD) Nigeria. Lead, Cadmium and Mercury have been reported not to have any known functions in human biochemistry or physiology and do not occurs naturally in living organisms[1]. Hence, dietary intakes of these metals even at very low concentration can be very harmful because they bioaccumulate.

Heavy Metal Poisoning And Biotoxicity

The biotoxic effects of heavy metals refers to the harmful effects of heavy metals in the body when consumed above the bio-recommended limits. Although individual metals exhibits specific signs of their toxicits, the following have been reported as general signs associated with Cadmium, Lead, Arsenic, Mercury, Zinc, Copper and Aluminium poisonings, gastrointestinal (GI) disorder, diarrhoea, stomatitis, tremor, homoglobinuria. Causing a resist-red colour to stool, ataxia, paralysis, vomiting and convulsion, depression and pneumonia when volatile vapours and fumes are inhaled[17].

Cadmium is toxic at extremely low levels. In humans, long term exposure results in renal dysfunction. High exposure can lead to obstructiv lung disease. Cadmium pneumonitis, resulting from inhaled dusts and fumes. It is characterized by chest pain, cough with foamy and bloody sputum and death of the lining of the lung tissues because of excessive accumulation of watery fluids. Cadmium is also associated with bone defect viz. ostemolacia, osteoporosis and spontaneous fracturers, increased blood pressure and myocardic dysfunctions. Depending on the severity of exposure, the symptoms of effects include nausea, vomiting, abdominal cramps, dyspnea and muscular weakness. Severe exposure may result in pulmonary, odema and death. Pulmonary effects (emphysema bronchiolities and alveolitis) and renal effects may occur following subchronic inhalation exposure to Cadmium and its compounds[17,22,24-25].

Lead is the most significant toxin of heavy metals and the inorganic forms are absorbed through ingestion by food and water and inhalation[21.] A Serious affect of lead toxicity is the teratogenic effect. Lead poisoning also causes inhibition of the synthesis of haemoglobin dysfunctions in the kidneys, Joints and reproductive systems cardiovascular system and acute and chronic damage to Central Nervous System (CNS) and Peripherial Nervous System (PNS)[14] others effects include damage to the gastrointestinal Tract (GIT) and Uninary tract resulting in bloody urine, neurological disorder and can cause severe and permanent brain damage. While inorganic forms of lead typically affect the CNS, PNS, GIT and other biosystems, organic forms, predominantly affect the CNS[1,17,21,25].

Lead affect children by leading to the poor development of the grey matters of the brain thereby resulting in poor intelligence quotient (IQ)[26]. Its absorption in the body is enhanced by Ca and Zn deficiencies. Acute and chronic effects of lead result in psychosis.

Zinc has been reperted to cause the same sign of illness as does lead and can easily be mistakenly diagnosed as lead poisoning[17]. Zinc is considered to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction[23,25]. The clinical signs of Zinc toxicosis have been reported as vomiting, diarrhea, bloody urine, icterus (yellow mucus membrance), liver failure, kidney failure and anemia[20].

Mercury is toxic and has no known function is human bio-chemistry and physiology. Inorganic forms of mercury cause spontaneous abortion, congenital malformation and GI disorder. Poisining by its organic forms which include monomethyle and dimethylemercury presents with erethism (an abnormal irritation or sensitivity of an organ or body part to stimulation), acordynia (pink disease which is characterized by rash and desquamation of the hands and feet), gingivitis, stomatitis, neurological disorders, total damage to the brain and CNS and are aslo associated with congenital malformaton[1,21].

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Arsenic (As) with lead and mercury, arsenic toxicity symptoms depends on the chemical form ingested[19,21]. Arsenic acts to cogulate protein, forms complexes with coenzymes and inhibits the production of Adenosine Triphosphate (ATP) during respiration[25]. High level exposure of Arsenic can cause death[13,27]. Arsenic toxicity also presents a disorder which is similar to and often confused with Guallain Barre Syndrome, an anti immune disorder that occurs when the body's immune system mistakenly attacks part of the PNS, resulting in nerve inflammation that causes muscle weakness[28-29].

Biochemistry Of Toxicity

The poisoning effects of heavy metals are due to their interference with normal body biochemistry in normal metabolic processes. When ingested in the acid medium of the stomach, they are converted to there stable oxidation states (Zn^{2+}, Pb^{2+}, Cd^{2+}, As^{2+}, As^{3+}, Hg^{2+} and Ag^{+}) and combine with the body's biomolecules such as proteins and enzymes to form strong and stable chemical bonds. The most toxic forms of these metals in their ionic species are the most stable oxidation states. For example Cd^{2+}, Pb^{2+}, Hg^{2+}, Ag^{+} and As^{3+}. In there most stable oxidation state, they form very stable biotoxic compounds with the body's bio-molecules which become difficult to be disscociated, due to their bio-stabilities, during extraction from the body by medical detoxification therapy.

IV. CONCLUSION

Heavy metals are important in many respects to man especially in the manufacturing of certain products of human use. Such as accumulaters (Pb), mercury Arch Lamps and thermometers (Hg), utensils (Al) and a wide range of other products[17,30]. But the biotoxic effects, when unduly exposed to them could be potentially life threatening, hence can not be neglected. While these metals are in many ways indispensable, good precuation and adequate occupational hygiene should be taken in handling them. Although heavy metal poisioning could be clinically diagnosed and medically treated, the best option is to prevent heavy metal pollution and the subsequent human poisoning.

REFERENCES

1. *Lenetech water treatment and air purification (2004), water treatment published by Lenetech Rotter damseweg Netherlands.*
2. *Huton Mand Symen (1986) The quantities of Cadmium Lead, Mercury and Arsenic. Entening the V.K. Environment from Human Activities SCI total environment 57; 129-150.*
3. *Battarbee; R et al, 118 Internation Journal of Physical Sciences.*
4. *Nriagu J.O, Pargna J (1988), Quantitative Assessment of Worl Wide Centamination of Air, Water and Soil by Trace Metals, Nature, 533, 134-139.*
5. *Nriagu J.O. (1989) A global Assessment of Natural sources of atmosphere Trace metals Nature, 338, 47-49.*
6. *Garbarino J R et al 1995, Contaminants in Mississippi River, U.S. Geological Survey Cercular 1133, Virginia USA.*
7. *Hawke J S (1997) Heavy Metals Journal of Chemical Education 74(11); 1374.*
8. *Farles Incorporated (2005). Definition Environment. The free dictionary, Farlex. Inc. Publishing USA.*
9. *Gore A (1997) Repeat the Land, our precious plant. Time magazine, 150 (17AJ; 8-9.*
10. *UNEP/GPA (2004) United Nations Environmental protection / Global program of Achon (2004) why the Marina Environment need protection from heavy metals, heavy metals 2004 UNEP/ GPA.*
11. *Habashi F (1992), Environmental Co-ordinator Office issues in the Metallurgical Industry, Progress and problems Environmental issue and waste management in energy soil mineral Production, Balkama, Relherdam PP 1143-1153.*
12. *Peblow D (1999) Environmental impacts of mining in Eastern Washington, center for water and watershed studies fact sheat, Uni of Washington Seattle.*
13. *United States Department Labour (USDOL) (2004); occupational safety and health administration (OSHA) Safety and Health Topics Heavy metals (USDOL) publication Washington D.C.*
14. *Ogwuegbu MOC, Muhangu W (2005), Investigation of Lead concentrator in the blood of people in the Copper belt Province of Zambia, J Enviren (I) 66-75.*
15. *Trueby P (2003) Impact of Heavy Metals on Forest Trees from mining areas. International conference on mining and the Environment III Sudburg Ontario.*

ISSN 2348 – 8034
Impact Factor- 4.022

16. *Horsfall MN and Spift Al (1999) Speciation of heavy river system (Nigeria) Bulb, Chem, SOC. Ethiop 13(I) 1-9.*

17. *Mechuggage D (1991) Heavy metal poisoning NCS Magazine published by the Bird Hospital CO USA.*

18. *Heyer NJ (1985) Neurological disorder in three Aluminium smelten werlsess, Arch intern Med 145 (ii) 1972-1975.*

19. *Holum JR (1983) Elements of general and Biological chemistry 6th Edition, John Wiley and sons N Y PP 324, 326, 353, 469.*

20. *Fosmire GJ (1990) Zinc toxicity, Am J.Clin, Nutr 51(2); 225-227.*

21. *Ferner D.J. (2001) Toxicity, heavy metal emed of 2(5); 1*

22. *European Union (2002).*

23. *Nolan K (2003) Copper Toxicity Syndrome. Journal orthomol Psychatry 12(4) 270-282.*

24. *Young RA (2005) Toxicity profiles. Toxicity summery for Cadmium. Risk assessment information system (RAIS) University of Tennessee.*

25. *INECAR (2000).*

26. *Udadi SS (2003) From Guinea worm scourge to Metal Toxicity in Ebonyi state, Chemistry in Nigeria as the new mill ennium untolds 2(2), 13-14.*

27. *Ogwuegbue MO and Igioma MA (2003) Effect of certain heavy metals on the population due to mineral exploitation. International conference on scientific and environmental issues. The population, environment and sustainable development in Nigeria University of ADo Ekits, Ekits state, Nigerian PP 8-10.*

28. *Kantor D (2006) Guillain-Barre syndrome the medical encyclopedia Nahonal library of Medicine and Nahonal Institute of health.*

29. *NINDS (2007) Guillain-Barre syndrome Guillain - Barre syndrome fact sheet.*

30. *Yaw AO (1990) New school Chemistry Africana FEP Publisher Ltd. Onifisha, Nigeria pp 437-472.*