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A REVIEW ON CONTAMINATION PROFILE OF HEAVY METALS AND ITS ROLE IN ENVIRONMENT

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Abstract

Heavy metal pollution has become a worldwide environmental issue. Metal contamination includes all types of pollution like soil, water, air and ground water. Heavy metals are nowadays the most ubiquitous in the environment. The sources of Heavy metals are both natural as well as anthropogenic. Once heavy metal gets accumulated in high concentrations in various components of environment, they turn into danger for humans, animals and vegetation. Some metals like Lead (Pb), Mercury (Hg), Copper (Cu), Cadmium (Cd), Arsenic (As), Chromium (Cr) are very toxic in nature and affects metabolic activities of living being. Metal accumulation in soil, water and air are of a great concern as they affect the food we eat, the water we drink and the air we breathe. The present review article is focused on the profile of heavy metal, its implications and possible solution for remediation of heavy metal pollution.

Key words : Heavy metal, accumulation, impacts, toxicity, contamination, remediation.

Introduction

Heavy metal is a metal whose specific density is more than 5g/cm^3 (Jarup, 2003). Heavy metals are essential metals to plants and animals for various metabolic activities, if present in low concentration. They become toxic if the threshold concentration increases. Waste water from industries contains some heavy metals like nickel, zinc, arsenic, copper, chromium, mercury which have significant toxic consequences on human wellbeing and environment (Lambert *et al.*, 2000). Toxicity of heavy metals becomes more significant problem at environmental, ecological and evolutionary issues (Jaishankar *et al.*, 2014, Nagajyoti *et al.*, 2010). Once these heavy metals enter in the environment via air, water, land or from industrial waste and chemicals, it gets accumulated in the environment and persists for a longer period of time. It can penetrate into the human body through ingestion, inhalation and through skin. If the level of heavy metal increases inside the body as compared to its disposition, these toxic metals become poisonous and risky for human health (Suruchi *et al.*, 2011). Heavy metal pollution has become a big problem that every country is facing today. This is all due to rapid urban and industrial development of cities, town, with the increased number of vehicles, usage of chemicals and fertilizers, spraying of pesticides in the agriculture (Radwan and Salama, 2006; Tuzen and Soylak, 2007; Duran *et al.*, 2007). Earth natural resources are harnessed by various anthropogenic activity these days. Fresh water sources of earth surface are mainly from flowing rivers, streams, ponds, lake. Water, soil, sediment samples which are not only contaminated with heavy metals but also with pesticides like DDT and HCH as reported by Rai *et al.* (2016). Based on studies of CSE DDT and HCH residues were reported in Delhi soil, water and fauna (Alam *et al.*, 2017). Due to overexploitation and industrialization the quality of water in cities are deteriorating everyday. Water is contaminated with heavy metals which are dangerous for human health (Jadon *et al.*, 2016). Heavy metals have detrimental effect when accumulate in excess quantity in soil, sediment and water. It also disturbs the balance of ecosystem (Tilwankar *et al.*, 2016). Heavy metals are persistent in the environment and once accumulated in food chain they cannot be removed or disposed off (Fytianos *et al.*, 2001). Heavy metal contamination do not have an effect solely on the standard and production of crops however additionally disturb or deteriorate the atmosphere and water bodies that successively affects the lifetime of animal and human. It enters into the food chain and has long term irreversible damage to the

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environment.

Sources of heavy metals

Heavy metals present both by geological and anthropogenic sources in environment. Geological sources from volcanoes or weathering of rocks and sometime found in oceans. Anthropogenic sources which comes from industrial effluents, fuel combustion, smelting process, mining, brick kilns, usage of fertilizers, pesticides and chemicals in agriculture (Fytianos *et al.*, 2001). Industries play major role in polluting our environment and disturbing our biogeological balance. Mining industries emit heavy metals in large quantity (Nriagu, 1989). After mining operations some metals found scattered as mine tailings which lie in open or being dumped in the pit. These are then transported by wind, rains and soil in the surroundings and contaminate soil and water. Heavy metals are emitted in, organic and inorganic forms in the environment. Major industries like mining, textile, smelting are the anthropogenic sources of heavy metals (UNEP/GPA, 2004). Cadmium in environment comes from zinc refining as a by-product, lead released in atmosphere through the automobile exhaust and also from paint industries (Nriagu, 1989). Some heavy metals are vital and are essential for various physiological functions in man and animals (Lenntech, 2004). If adequate quantities of these metals are not supplied, it may leads to deficiency diseases. Heavy metals are the content in enzymes which take part in oxidation-reduction reaction (Lenntech, 2004). For ex-copper is an essential heavy metals which is required as co-factor for enzymes such as peroxidase, ferroxidase, monoamine oxidase and dopamine B-monoxygenase (WHO, 1996; Stern, 2010, Harvey *et al.*, 2008). It is required for hemoglobin formation, hair keratin, catecholamine synthesis. Copper is toxic when it changes from oxidized state Cu (II) to reduced Cu (I) which generate intermediate hydroxyl radicals (ATSDR, 2002). Over use of copper cause cellular damage which leads to Wilson disease in humans (Harvey *et al*., 2008). There are other necessary heavy metals, which are toxic and may lead to cellular and central nervous system damages and causes diseases in human. Heavy metals affect several cell organelle, lysosome, cell membrane enzymes, which are involved in physiological activity (Tchounwou *et al.*, 2008). Various studies showed that creation of reactive oxygen species and oxidative stress of metals such as lead, chromium, mercury, arsenic and cadmium are vital in causing toxicity and carcinogenity. Due to high risk of toxicity these metals are studied widely. These metals result in multiple organ damage. The United States Environmental Protection Agency (USEPA) and The International Agency for Research on Cancer (IARC) classified heavy metals as probable or known carcinogens when studies carried on animals.

Natural sources

Natural sources of heavy metal contamination are through volcanic eruption and emission, forest wildfires, gaseous exchange in oceans. Concentration of heavy metal in soil via natural weathering process may contain high concentration of Pb, Cd, Mn, Cu, Cr, Hg, Co and Ni. It will depend on the soil type and various environmental conditions. Volcanoes emit high level of toxic metals and gases which are hazardous to our environment (Wang *et al.*, 2001). Natural sources of heavy metal include volcanic eruption, windblown dust, weathering of rock and forest fires (Seaward and Richardson, 1990). The geographical level of substantial metals found in soil is low (Pacyna, 1986). Major contamination of water, air and land are due to increased man made activities like mining, coal combustion, sewage sludge, use of leaded gasoline and paints, petrochemicals. All these activities deposit heavy metals in environment (Wei *et al.*, 1991; Khan *et al*., 2008; Zhang *et al*., 2010).

Anthropogenic souorces

Coal combustion : Main cause of heavy metal pollution in environment is through coal combustion. It will depend on the intensification of trace metals emitted into air and the properties of elements during combustion (Seaward and Richardson, 1990).

Fertilizers : Soil is provided with agricultural supplement for better farming worldwide. A large amount of fertilizers are used which contain suitable quantities of N, K, P for good crop. These fertilizers may contain small amount of trace metals but their continuous use may amplify the quantity and concentration of trace element in land (Basta *et al*., 2005). Some phosphate containing fertilizer provides cadmium and other heavy metal like lead, mercury in addition to the soil (Jones and Jarvis, 1981).

Pesticides : A few bug sprays and pesticides utilized as a part of farming contain impressive measure of substantial metals in it. Some pesticides are Bordeaux mixture which contains copper sulphate (Jones and Jarvis, 1981). Lead arsenate was used to treat some parasitic pest on fruit orchards and a tick of livestock was treated with arsenic containing compounds.

Biosolids and Manures : Various municipal solid wastes, animal manures which are directly dumped on land contains many heavy metals like arsenic, chromium, cadmium, copper, lead (Zhang *et al*., 2010). Many of this type of compost are important fertilizers for poultry industry. Many heavy metals are added in food as growth boosters, which have the ability to cause metal pollution in soil (Basta *et al*., 2005, Jones and Jarvis, 1981).

Aerial sources

Emissions from power plant chimney, vehicle exhaust, open burning of waste materials discharges heavy metal particular in atmosphere. This air is circulated by air flow and thus increases their concentration in air which affects human health.

Impacts of heavy metals and health issues

Heavy metals are useful in small quantity but toxic in above required amount. Some heavy metals are vital for growth, biochemical and metabolic functions of living beings. It functions as co factors for enzymes, act as regulators of osmotic pressure in plants as a micronutrients. Some heavy metals other than essential heavy metals are toxic when present in high concentration level (Raven *et al*., 1998). Metals are said toxic due to some undesirable effects on living organism and environment. Its toxicity depends upon the exposure time and dose of toxic elements (Summer, 2000). Heavy metal poses serious threat to human health because of its persistent nature in environment. Toxicity increases in acidic environment which is nutrient deficient such as in mining environment (Chaney and Oliver, 1996).

Impact on plants : Heavy metals present in low concentration generally does not affect the plant metabolic activities and its growth etc, but if the concentration exceeds the threshold limit, it hinders the plant growth and other metabolic activities, even lead to death of the plant. It was reported by Chilvers and Peterson (1987) that in Florida when copper content in soil exceeded 50 mg/kg, it affected the citrus seedlings and if exceeded to 200 mg/kg, it would wither. High concentration of heavy metals would inhibit plant growth, chlorosis and also interfere in photosynthesis and protein synthesis etc.

Impact on humans : Human affected by heavy metals through inhalation, intake and also through skin absorption. Cadmium found to damage the metabolism of calcium which results in calcium deficiency in bones and cartilage damage. Lead (Pb) enters through digestive and respiratory tract in the human body. It accumulates in the bones and affects many body organs such as central nervous system, immune system, liver, kidney etc (Bansal, 2004). It was reported that the nickel dust in environment is responsible for respiratory cancer in humans and also major cause of nasopharyngeal carcinoma. Major Heavy metals and their health effects on humans are described in table 1. The effects of different heavy metals are given as under.

Arsenic : It is found in soil, groundwater and rock throughout the world. Some arsenic compounds are also found in fishes which are the route to the human exposure. Burning of fossil fuels, smelters are the main industries which result in arsenic contamination in air, water and soil (Patel *et al*., 2004). Arsenic is also used in wood preservation and pesticides. Human beings are exposed to arsenic contamination through inhalation and through intake from food and water. Food and water are the important sources of arsenic contamination in humans. Arsenic intake or contamination in humans lead to gastrointestinal symptoms and acute poisoning which would affect cardiovascular system and central nervous system leading to the death of individual. If arsenic contaminated water is used for drinking then it would lead to the cancer of lung, bladder and kidney. It also leads to pigmentation and hyperkeratosis. Ingesting inorganic arsenic which is reported in Taiwan leads to peripheral vascular disease and in extreme cases it changes to gangrenous diseases like black foot disease. The WHO reported that arsenic contaminated drinking water leads to cancer of lung, kidney and bladder.

Lead : Today, lead emitted from the vehicles is the major cause of air pollution. Lead also is emitted from mines and smelting process from battery plants. These airborne lead particles pollute air and it also gets deposited on soil, water and reaching in the food chain. These inhaled lead particle absorbed by the lungs. Once lead is accumulated in the body, it is very difficult to remove completely. In adults with well developed blood brain barrier, penetration of lead would not be possible. Whereas in children these barriers are still in developing stage, so the children are more susceptible to any such exposure. Organic lead particles are so harmful that they even cross the blood barrier and cause encephalopathy. Acute lead poisoning will lead to gastrointestinal diseases related to nervous system. One common disease related to lead is lead encephalopathy, which is mainly related to sleeplessness and restlessness. Acute renal damage and kidney dysfunction is caused by lead poisoning.

Mercury : It was found as cinnabar (HgS) compound in ancient times used to treat cosmetic allergies. In medicine also mercury used to cure syphilis, used as teeth filling in some countries. It is used in thermometers, barometers and other instruments. It is also used in chloro-alkali industry. Humans exposed to mercury via food through fish and also from dental amalgam (Mupa, 2013). Minimata in Japan is the incident which broke in 1950 due to leakage of methyl mercury in the bay which was ingested by fishes and thus via fishes it entered in human food chain. Mercury poisoning leads to neurological,

Table 1 : Heavy metal health effects on human on exceeding the permissible limit.

Pollutant	Effects on humans	Permissible limit (mg/l) WHO (2007)
Cadmium (Cd)	Renal dysfunction, lung disease, lung cancer, bone defects (osteomalacia, osteoporosis), increased blood pressure, kidney damage, bronchititis, gastrointestinal disorder.	0.06
Lead (Pb)	Fatal infant encephalopathy, mental redardness in children, congenial paralysis, liver, kidney.	0.1
Copper (Cu)	Stomach and intestinal irritation, liver kidney damage.	0.1
Chromium (Cr)	Irritability, fatigue, damage to nervous system.	0.05
Zinc (Zn)	Corrosive effect on skin due to zinc fumes.	15
Mercury (Hg)	Gingivitis, acrodynia characterized by pink hands and feet, damage to nervous system, protoplasm poisoning, tremors.	0.01
Manganese (Mn)	Contact or inhalation causes damage to CNS.	0.26
Arsenic (As)	Dermatitis, bronchitis.	0.02

psychological disease such as tremors, restlessness, depression, sleep disturbances, ataxia, memory problem, gastrointestinal problem, renal failure.

Cadmium : Found naturally in the form of ore in combination with lead, copper and zinc. Cadmium widely being used in PVC products, color pigments and now a day's cadmium is used in re-chargeable nickel cadmium batteries. It is also present in fertilizers. These cadmium containing products and pollutants cannot be recycled and dumped with waste and thus contaminating the environment. Cadmium present in cigarette smoking is the major exposure to human. It also increases the blood cadmium levels in humans. Cadmium exposure via inhalation leads to pulmonary disorders. It may cause kidney damage. Long term cadmium exposure results in skeletal damage. Itai-Itai (ouch ouch) disease was reported in Japan (it is a combination of disease osteomalacia and osteoporosis) in 1950.

Distribution and profile of heavy metals

Some of the Major contaminated heavy metals sites in India are discussed here. According to a report by CPCB (2009), Lead (Pb) found in Bandalamottu Mines (AP), Vadodara (Gujrat), Korba (chattisgarh) and Ratlam (MP). Arsenic (As) found in Balia and other districts (UP), tuticorin (TN) and gangetic plain (WB). Mercury found in jharkhand, kodaikanal (TN), ganjam (orissa) and singraulli (MP).Toxicity of heavy metals now a day's become major environmental threat to humans, animals and plants. It becomes even more dangerous when it get bioaccumulated via food chain (WHO/FAO, 2007). It affects the health of human, animal and damages plant life. Toxic nature of heavy metal depends on the concentration of element intake in the body of the living organism (Aycicek *et al.*, 2008). Heavy metal pollution increases as result of Industrial and agricultural advancement. The consumption of contaminated water with heavy metals leads to death of peoples (Ascjner, 2002). Heavy metals contaminated sites distributed all over world. Some of the heavy metal studies are being summarized in table 2.

Heavy metals in water

In the study carried on river Musi near Hyderabad it was found that the heavy metal concentration was higher in the untreated sewage water of the river samples collected along the river. It contains Ni-0.062 ppm, Cd-0.025 ppm, Pb-0.021ppm, Cr-traces, Zn-0.003 ppm, Co-0.053 ppm, Fe-traces, Cu-0.011 ppm, Mn-traces. It was found in the study that these heavy metals exceed the WHO permissible limit (Raj *et al.*, 2005). Heavy metals in the water of industrial area of Jeetimetla Andhra Pradesh contain heavy metals as Cu-4.2-13.7 ppb, Pb-0.10-0.50 ppb, As-1.5-23.3 ppb, Cd-.060-31.8 ppb (Govil, 2001). Heavy metal contamination in ground water of Jeedimetla in Andhra Pradesh was highly contaminated with heavy metal and was found unfit for any use. Water from the tube well of residential localities was found polluted by the industrial effluents discharge from chemical factory in Calcutta India, with Arsenic (As) ranges from 0.05-23.08 ppm and was above the WHO permissible limit of 0.01 ppm (Chakraborti *et al.*, 1998).

Heavy metal concentration in a fertilizer factory of Punjab were reported the presence of Cu-0.500 ppm, Cd-0.006 ppm, Pb- 1.464 ppm, Zn -2.500 ppm (Dey *et al.*, 1997). Heavy metals from the industrial effluent of Ambarnath area of Maharashtra state were found as Cu-8.0-10.2 ppm, Cd-1.0-9.1 ppm, Pb-0.1-10.4 ppm

Table 2 : Various Studies conducted on Heavy Metal in different places in India and abroad.

Country	Heavy metals	Soil (ppm)	Water (ppm)	Vegetable (ppm)	References
India (Tamilnadu)	Cr	17.85	1.45	59.33	Sujatha *et al.* (2017)
	Cd	0.41	0.04	1.34	
	Cu	20.68	0.01	10.43	
	Ni	1.93	0.03	1.25	
	Pb	2.97	0.004	17.01	
	Zn	93.8	1.07	55.25	
Iran	Al	4139.5	0.1	47.8	Maleki *et al.* (2014)
	As	3.8	0.1	0.10	
	Cd	0.10	0.1	0.010	
	Co	14.8	2.0	0.6	
	Cr	28.7	4.7	3.9	
	Cu	42.6	0.3	3.0	
	Ni	47.9	0.2	2.6	
	Pb	25.4	1.3	0.3	
	Zn	77.2	1.6	17.0	
India (Assam)	Fe	1793.90	-	-	Pronil Kumar Bora *et al.* (2012)
	Cu	81.21	-	-	
	Zn	205.28	-	-	
	Cd	8.71	-	-	
	Cr	8.08	-	-	
	Ni	2.63	-	-	
	Pb	102.17	-	-	
	As	20.20	-	-	
India (Guwahati)	Pb	43.03	-	-	Jayashree Deka *et al.* (2012)
	Mn	171.78	-	-	
	Zn	4.23	-	-	
	Fe	9.57	-	-	
Nigeria	Cd	0.71	-	0.09	Odohrapheal *et al.* (2011)
	Mn	105.91	0.0022	4.79	
	Cu	15.24	0.0013	1.91	
	Ni	13.08	-	0.76	
	Pb	6.95	0.001	0.22	
	Zn	24.50	0.024	5.21	
China	Cd	17.1	-	-	Luo c *et al.* (2011)
	Cu	11	-	-	
	Pb	140	-	-	
	Zn	4500	-	-	

(Lokhande *et al.*, 2001). It was found in Lucknow district of UP, that water bodies were contaminated with Cr, Mn, Cu, Fe, Pb and Pb, Cr and Fe was found in higher concentration (Rai *et al.*, 2003). In the water samples collected from industrial area of Bangalore, high concentration of Zn-41.09 ppb, Cd-0.05 ppm, Pb-0.17 ppm, Cu-33.63 ppm were found in samples (Gowda *et al.*, 2003). High concentration of Fe, Cd, Pb, Cr, was found in Hussainsagar lake Hyderabad (Rani et al 2003). Surface water of lower lake of Bhopal MP was found to be contaminated with Zn- 0.086 to 0.163 ppm, Cd-0.014 to 0.41 ppm, Pb- 0.03to 0.12 ppm, Cu- 0.12 to 0.165 ppm and the concentration of Pb and Cd was found above the permissible level especially at the time of idol immersion in the lake (Gupta *et al.*, 2005). The concentration of Fe -10488 μgL^{-}, Cu-2151.80 μgL^{-}, Zn-1500.70 μgL^{-1}, Cd-47.60 μgL^{-1},Pb-116.40 μgL^{-1},Ni-375.50 μgL^{-1},Cr-147.10 μgL^{-1} in river Yamuna Delhi was found above the permissible limit. Critical value of metal pollution index *i.e.* 149.15 was detected in river Yamuna (Bhardwaj *et al.*, 2017).

Heavy metals in soil

Heavy metal level of As-19.5 mg/kg, Cr-72.2 mg/kg, Cu-29.9 mg/kg, Ni-115 mg/kg, Zn-77.2 mg/kg was found in the soils of hazardous waste disposal site of Hyderabad. It was concluded in the study that As, Cr, Pb exceeds the natural background limit and Cu, Ni, Zn was above the prescribed limit (Parth *et al.*, 2011). Soil samples collected from Jeedimelta Industrial area of Andhra Pradesh contain higher concentration of Zn-10000 ppm, Ni- 700 ppm, Cu-400 ppm, Pb- 1600 ppm (Govil, 2001). Heavy metal toxicity was higher in the soil samples of Mysore lake Karnataka (Sujatha *et al.*, 2001). Soil of Industrial area of Bangalore contains higher amount of heavy metal like Zn-69.0 ppm, Pb-35.30 ppm, Cu- 95.30 ppm than non-industrial areas. Soils irrigated with effluents have higher concentration of heavy metal as compared to the fields which are irrigated with well or underground water (Parth *et al.*, 2011). Soils of Jharia coalfield in Jharkhand contain high concentration of heavy metal (Sujatha *et al.*, 2001).

Heavy metals in vegetables

Heavy metals in vegetables not only affect nutritive properties, but also affect the human health and sometimes prove to be carcinogenic. Higher concentration of Cd was detected *Beta vulgaris* in summer but Ni and Pb level are higher in the summer and winter (Sharma *et al.*, 2007). It was noted that heavy metal are present in high amount in the vegetable at the market site than the original production site. High

Table 3: Different Remediation techniques for heavy metal contamination.

Metal	Removing agent	Removal Method
Heavy metals in water	Conductive electroactive natural zeolites, polymers, dithiocarbamates, Calcium alginate, Chitosan capped gold nanoparticles	Ion exchange,Biosorption, Bioremediation, immobilization in matrix
Chromium ions	Activated carbon	Ion exchange, adsorbents Chemical sedimentation, surface absorption, ion exchange and reverse osmosis.
Mercury	Activated carbon, bentonite	Ion exchange,Reduction, precipitation, extraction and ion exchange
Arsenic	Hydroxypropyl cellulose, polypyrrole, vinyl alcohol	OxidationOxidation by adsorbents and surfactants, capacitive deionization.

level of Cu and Zn was found in *Brassica oleracea,* lead (Pb) in *Beta vulgaris* in Varanasi (Sharma *et al*., 2009). Lead and cadmium was detected in vegetables like tomato and spinach in Amravati city (Chaitali, 2015).

Heavy metal remediation

Heavy metals in water and soil are present ubiquitously through natural or anthropogenic sources. Excessive levels of heavy metals in soil affects the crop yield and leads to significant health hazard to human, animal, and plants. It is essential to eliminate these metals from environment as much as possible. Complete removal of heavy metal is not possible yet. Different methods of removal of heavy metals have been summarized in table 3.

There are many different remediation technologies which are being used from years, which include physical, chemical and biological namely soil excavation, incineration, soil washing, stabilization of electro kinetic system, soil flushing, etc (Sheoran *et al*., 2011; Wu *et al*., 2010). These techniques have its limitations i.e. expensive and sometimes it disturbs the soil properties. Some researches gave us new techniques to decontaminate soil from heavy metals, which are phytoremediation and bioremediation. Different techniques in phytoremediation are phytostablization, phytofiltration, phytoextraction, phytovolatization and phytodegradation (Gripsson, 2011).

Phytoremediation

Phytoremediation is a Greek word, which is composed of two words *i.e.* Phyto means plants and Latin word Remedium means to correct or remove an evil. This is one of the remediation techniques which use plants. It is actually a technique in which soil and plants microbes are utilized to reduce the toxicity of heavy metals from environment (Suresh *et al*., 2004). It is a green technology which is cheap, efficient and environment friendly (Vangronsveld *et al*., 2009). In phytoremediation the soil properties remain intact and soil remains fertile. This technique has minimum cost, minimum installation and minimum maintenance when compared with other techniques (Khan *et al*., 2004). It is used to clean various pollutants present in environments like surfactant, aromatic hydrocarbons (PAHs), organophosphate insecticide, explosives, heavy metals, polychlorinated biphenyls (PCB) radionuclide (Alkorta *et al*., 2004) .

Bioremediation

Bioremediation is the remediation of contaminated site by using microorganism. It is biotransformation of contaminated environment into its natural state by the microorganism (Adhikari *et al*., 2004). These minute organism develops various processes to eradicate the contaminants from the contaminated soil and water. Some such processes are biotransformation, bioleaching biosorption, biomineralization, and bioaccumulation. Bioremediation is a microbial process of microorganism to detoxify the environment. It can transform hazardous pollutants to less toxic substance (Hussein *et al*., 2001). Microorganism act on heavy metals through adsorption and bioaccumulation (Garbisu *et al*., 2003). Cell wall of microorganism binds heavy metal ion which is made of polysaccharides, protein and lipid. In bioremediation, remediation of heavy metals achieved only by transformation of metals to some other form which is less toxic. Sometimes it could be transform into volatile gas (carbon-di-oxide), sometimes as water soluble leachate which could be removed easily from the contaminated site (Scott *et al*., 1992). There are two types of bioremediation techniques in-situ bioremediation (at the contaminated site) and ex-situ bioremediation (outside the contaminated site) (Nandi *et al*., 2012).

Conclusion

Heavy metals are common everywhere in the environment due to increased industrial activity, expansion of cities and overexploitation of resources. Persistent nature of these metals in the environment and accumulation in the food chain causes serious health risk to humans. To control this big pollution problem some stringent actions on national and international level should be taken to stop further deterioration of environment and its component. There is a need to develop most sensitive methods and technology to remove these metals from all the components of environment.

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