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PHYTOREMEDIATORY POTENTIAL OF GUAVA AND ASHOK TREE AT THREE DIFFERENT SITES OF BAREILLY DISTRICT-A CASE STUDY

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ABSTRACT

Technologies can be generally classified as in situ or ex situ. Treatment of the contaminated material at the site called in situ, while ex situ involves the removal of the contaminated materials to be elsewhere. Some examples of bioremediation related technologies are rhizofiltration, phytoremediation, bioleaching, bioreactor, composting, land farming, bioventing and bio-stimulation. Phytoremediation involves the removal pollutants from the environment with the help of plants. The evolution of physiological and molecular mechanism of phytoremediation developed biological strategies to improve the performance of both phyto-stabilization and heavy metal phyto-extraction. Over the past 20 years, this technology has become popular and has been employed at sites with soils contaminated with lead, copper, uranium, and arsenic.

Keywords: phytoremediation, copper, lead, environment, quality and industries.

INTRODUCTION

The quality of life on earth is linked inextricably to the overall quality of the environment. Air, water and land are precious natural resources on which the sustainability of agriculture and the civilization of mankind rely. Air is one of the most important constituents of the human environment. The prevention of air quality has become one of the top environmental priorities in the world. Air quality is generally described as a combination of physical and chemical characteristics that make air as a healthful resource for a living one which enable man to continue his domestic, social, industrial and recreational activities. With the increasing industrialization and globalization, both physical and chemical characteristics are changing (Adriano, 2001).

Natural forces are responsible for physical change while chemical changes are caused mainly by human activities. The air quality is influenced whenever energy consumption takes place, either under human direction or by natural forces. Automobiles, domestic waste, indiscriminate use of insecticides and pesticides, electric power generation, space heating, manufacturing practices, chemical reaction in radioactive nuclides and burning of fossil fuels are by far the greatest offenders, which are altering air quality. Air pollution is a significant risk factor for multiple health conditions (Adriano *et al*., 2005). The human health affected by poor air quality are far reaching, but principally affect the vegetation, human beings, animals and materials, have been recognized as a respiratory system. Effects of air pollution on agriculture, forestry are serious economic and environmental problem. Amongst air pollutants, an increasing concern with the potential effects of metallic contaminants on human health and on environment, the research on fundamental, applied and health aspects of metals is increasing (Adeniyi, 1996).

Moreover, metals are probably the oldest known toxins to living system and their increasing level in the ecosystem and in biological tissues in recent past, as revealed by environmental monitoring and epidemiological surveys, has made metal exposure a global concern. The use of metal-accumulating plants to clean soil and water contaminated with toxic metals are the most rapidly developing component of this environmental friendly and cost-effective technology. The metals such as Pb, Cu and Cd are non-essential for plants (Gaur and Adholeya, 2004). The metal contamination of environment reflects both natural sources and contribution from industrial activity including the hazardous waste. The assessment of the impact of metal exposure on human health is a challenging task for toxicologist. In addition, heavy metals are ubiquitous environmental contaminants in industrialized societies. Metal contamination levels in plants are increasing in serious proportions in most cities of India. In fact, metal pollution is a product of urbanization, industrialization, and mechanization where norms are not strictly followed. The reason for this increase in metals in vegetables could be due to either by air borne precipitation or from water bodies or could be form both.

Furthermore, both anthropogenic materials and vehicle exhaust particles, (lubricating oil residues, tire wear particles, SPM and brake linings wear particles) that can be pulverized by the passing traffic are direct contributors to dust on the road (Ackerman, 2009). Due to accelerated industrialization and urbanization, nearly half of the population in the world now lives in urban

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agglomerations. These activities results in the increasing amount of contaminants in the urban environment. Consequently, a variety of environmental problems have emerged, of which potentially toxic metal pollution is a major issue, especially in urban soils and roadside dust (Brown and Sturchio, 2000; Barnes *et al*., 1976). As typical contaminants in urban environment, metals are useful indicators of environment pollution levels (Lester, 2006). For instance, Pb and Zn could indicate traffic pollution. Therefore, potentially metal pollution in urban environment has given rise to growing concerns from scientists during the past decades, and a large amount of researchers have been done all over the world (Banerjee *et al*., 2008). In recent years, metal contamination of soils, food crops and vegetables has been reported frequently (Adhikari and Ajay, 2011).

It is also well known that metals are absorbed by plants from contaminated soil as well as from exposed plant parts (Christophor *et al*., 2004). Some elements are indeed essential for plant metabolism but their higher concentration in vegetables causes risk to human health (Zhang, 1990). There is an increasing concern regarding food safety due to environmental pollution also. Non-essential metal element is believed to cause damage even at very low concentrations and can be taken up by crops easily (Zhang, 2000). Studies have shown that vegetables are capable of accumulating relatively high levels of metals from the soil (Chen and Gong, 1996) and their accumulation in plant tissues is influenced by the availability of metals in the soil and their interaction (Zhang and Burard, 1998).

Heavy metal

The term heavy metal refers to any metallic chemical elements that have a relatively high density and is poisonous or toxic at low concentrations. Excessive levels can be damaging to all the organisms. Specific gravity is also a measure of density of a given amount of a solid substance when it is compared to an equal amount of water. The specific gravity of water is 1 at 4°C (39°F). Some well-known toxic metallic elements with a specific gravity that is 5 or times more that of water are arsenic, 5.7; cadmium, 8.65; iron 7.9; lead, 11.34 and mercury, 13.546 (Chen, 1990). Many different definitions have been proposed some of which are based on density, some on atomic atomic number or atomic weight, and some on chemical properties or toxicity. Heavy metals are dangerous to health or to the environment because they tend to bioaccumulation.

Source of toxic metals

"Toxic" refers to chemical elements or substance that is harmful to biological systems. Heavy metals are the serious threat to the health of our body. Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues of organisms including plant and animals both. Metals may enter the human body through food, water, air, or absorption through the skin when they come in contact with humans. Industrial pollutants, pesticides, herbicides and insecticides, all affect the air we breathe, the water we drink and the food we consume.

Children may develop toxic levels activity who come in contact with contaminated soil or by actually eating objects that are not food (paint chips and colored toys) (Chakraborti and Rahman, 2009). Often the effects of prenatal exposure to chemicals are expressed late in life and the growing children are more susceptible to adverse effects of chemicals like lead and manganese (Chaudhuri *et al*., 2008). There are 35 metals of concern, 23 of them called the 'heavy metals'. Toxicity can result from any of these metals are most likely encountered in our daily environment.

Copper

Pure copper is soft and malleable and a constituent of various metal alloys. The concentration of copper in soils ranges from 2 ppm to 100 ppm (on dry weight basis) with a mean value of 20 ppm. In Indian soils, copper concentration up to 175 ppm has been estimated (Dong, 1999). Cu can inhibit root elongation, block the photosynthetic electron transport chain and degrade chlorophyll (Gangulee, 1976). There are several sources of copper emission in the atmosphere. The main use of copper is in the production of electrical wire, piping utensils and the manufacture of a large number of alloys like brass and bronze. It is used extensively, in products such as, copper wire, electromagnets, printed circuit boards, and lead- free solder, alloyed with tin, electrical machines, especially electromagnetic motors, generators and transformers, electrical relays, vacuum tubes, cathode ray tubes, and the magnetrons in microwave ovens, wave guides for microwave radiation, integrated circuits.

It has been estimated that total copper emission in the atmosphere is approximately 74500 tons per year, of which 25% are natural sources like wind, dust, volcanic emission, sea salt spray and remaining 75% are from anthropogenic sources which include metal production, wood and fossil fuel combustion and waste incineration. Copper reaches environment through wet and dry deposition, mining activities, land run off, and industrial, domestic and agricultural waste disposal. Copper is an essential element of plants and humans. The main physiological process, in which copper takes part, is the formation of blood and utilization of iron in haemoglobin synthesis.

Lead

Lead is fairly abundant and is derived from ore bearing minerals. Automobiles and leaded gasoline are major sources of atmospheric lead. Lead is a poisonous substance to animals, including humans. The neurotoxin effects of lead are well- known. Exposure to lead among battery workers leads to adverse effects on renal system resulting into hypertension and damage to kidneys. It damages the nervous system and causes brain disorders (Du *et al*., 1999). Lead has been classified as 2B carcinogen and cases of renal adenocarcinoma in workmen with prolonged occupational exposure to lead have been reported. It interferes with the development of the nervous

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system and is, therefore particularly toxic to children, causing potentially permanent learning and behavioural disorders. Symptoms includes abdominal pain, headache, anaemia, irritability, and in severe cases of seizures, coma, and death (Duan, 1995).

Moreover, one of the largest threats to children is lead paints that exist in many homes, especially older ones; thus children in older houses with chipping paints are at greater risk. Most of this lead is used for batteries .the remainder is used for cable, plumbing, ammunition, and fuel additives. Other uses are paint pigments and in PVC plastics, x- ray shielding, crystal glass production, and pesticides (Duan and Wang, 1992). Target organsare the bones, brain, kidneys, and thyroid glands. It accumulates in their bodies and can cause brain or kidney damage. Plants have to be considerably more adaptable to the stressful environment and must acquire great tolerance to multiple stresses than animals and humans. The air pollution stress led to significant reduction in photosynthetic area and pigment concentration. Chemical and biochemical analysis of plants revealed that there was a considerable reduction in different physiological parameters in the pollution-affected leaves. Nitrogen (N), phosphorus (P) and potassium (K) also decreased considerably and sulfur (S) content increased in the polluted atmosphere.

Moreover, Duan and Wang, (1995) made an attempt to establish the relationship between air pollution and the protein contents in a few plants growing in the vicinity of industrial area. Plants responses to specific environmental stresses such as drought and flooding, light intensity, high heat, chilling and freezing and other. Plants are well known to accumulate higher level of metals due to their specific biology (Phillips, 2000).

Besides this, heavy metal treated plants showed significant decline in N, protein, carbohydrate and chlorophyll content and other metabolic activities of plants. Carbohydrate, protein and N are sensitive indicators of stress and act as a key substrate for metabolism (Duflo *et al*., 2008). Long-term treatment of metals caused a decrease in protein content, which may be due to the breakdown of soluble proteins or due to the increased activity of proteins or other catabolic enzymes, which were activated and destroyed the proteins (Pehlivan *et al*., 2009). Changes is chlorophyll and carotenoids content and pigment ratios are important indicators of environmental stress and described about the tolerance status of the species, as earlier reported (Gangulee, 1974).

Industries, vehicles, increase in population, and urbanization are some of the major factors responsible or the increasing concentration of pollutants in air. Over the past 20 years, this technology has become increasingly popular and has been employed at sites with soils contaminated with lead, uranium, and arsenic. While it has the advantage that environmental concerns may be treated *in situ*; one major disadvantage of phytoremediation is that it requires a long-term commitment, as the process is dependent on a plant's ability to grow and thrive in an environment that is not ideal for normal plant growth (Hubers and Kerp, 2012).

Advantages and limitations of higher plants as bio-monitor

Bio monitors are organisms that provide quantitative information on environmental quality. Apart from phytoremediation, plants can also be used to detect metal pollution. Different plant species have been proposed and used for bio monitoring of air pollutants from traffic and other sources in tropical and subtropical countries (Vaizey, 1890).

Tree bark

Heavy metals in bark may originate from different sources, such as atmospheric depositions (wet and dry); soil, through fall, etc., but mainly from the atmosphere. Effects of sulphur and nitrogen compound were determined on tree bark. Use of tree bark as an indicator of SO_2 concentration is an old practice. However, a number of other regional surveys were carried out throughout 1990s in Europe on micronutrient concentrations of bark (Nelson *et al*., 1995).

Advantages

(i) Plants can be easily monitored, (ii) The possibility of the recovery and re-use of valuable metals (by companies specializing in “phyto mining”), (iii) It is potentially the least harmful method because it uses naturally, (iv) The cost of the phytoremediation is lower than that of traditional, (v) Processes both *in situ* and *ex situ*, (vi) The occurring organisms and preserves the environment in a natural state.

Limitations

Phyto-remediation is limited to the surface area and depth of the roots. Low biomass and slow growth require a long-term commitment with plant-based systems of remediation; it is not possible to completely prevent the leaching of contaminants into the groundwater (without the complete removal of the contaminated ground water). The survival of the plants is affected by the toxicity of the contaminated land and the general condition of the soil.

Bio-accumulation of contaminants, especially metals, into the plants which then pass into the food chain, from primary level of consumers upwards or requires the safe disposal of the affected plant materials. Metals are important components of our home, automobiles, appliances, tools, computers and other electronic devices, and are essential to our infrastructure including highways, bridges, railroads, airports, electrical utilities and food production and distribution. Metals are present in the environment occurring in varying concentrations in parent rock, soil, water, air and all biological matter. Moreover, metals are also released into the environment from a wide spectrum of anthropogenic sources such as smelting of metallic ores, industrial fabrication and commercial application of metals, agro-chemicals pesticides as well as burning of fossil fuels. Numerous investigations have demonstrated that roads exert various detrimental effects on their environment (Rupassara *et al*., 2002). Stress should be specifically laid on heavy metals e.g., lead, zinc, cadmium, iron, copper, and nickel. This metal pollution

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affects flora, fauna and other abiotic components of the ecosystem and leads to various metabolic alterations and undesirable changes, which in many cases may cause severe injury and health hazards (Singh *et al*., 2008). Therefore, effective large-scale monitoring networks for metals need to be developed to prepare strategy to mitigate the problem (Singh and Singh, 2007).

MATERIALS AND METHODS

Total three different locations have been selected from all over Bareilly city to know the metal concentration in the surrounding environment. Bareilly is the large city in the northern Indian state-Uttar Pradesh, located between 28.55: N and 80.12:E. Different study sites selected and can be categorized as polluted, non-polluted and semi-polluted area.

a) **Polluted area:** highway areas between Bareilly and C.B. Ganj on Delhi highway.
b) **Semi- polluted area:** in Bareilly city and Rampur garden.
c) **Non-polluted:** Bhojipura village area.

Two different types of higher plants have been selected from all over Bareilly to know the metal accumulation in the higher plants is Guava, *Psidiumguava* L. *(Myrtaceae)* and Ashoka, *Saracaindica* L. (Caesalpiniaceae). The leaves and bark of the plant was extensively washed with water to remove soil and adhering dust particles. The samples were collected from a uniform area and sorted out by hand. Individual plant species were weighed and expressed as fresh weight. This known weight of plants was then dried in hot air oven at 55°C. The dried samples were weighed and calculated in gm. A known amount of sample was taken in a crucible and incinerated at 400-500°C for 3 hours in a muffle furnace. After that crucible was cooled to room temperature by placing it in a desiccators and the ash content was weighed. From the average values of fresh weight, dry weight and ash weight, the biomass was calculated. To estimate heavy metals in plant material, atomic absorption spectrophotometer (AAS) was used after digestion of samples. Samples were oven dried for 5 to 8 days and from this dried sample 1.0 gm sample was digested for 3-4 hours in 20 ml of concentrated HNO_3 and $HCLO_4$ (4:1, V:V). It was digested for 3-4 hours and the final volume was made to 50 ml with distilled water following filtration. Distilled water blank was also prepared in the same way. The total concentrations of Pb, and Cu were determined by the flame AAS. All samples were analyzed by AAS at the laboratory of G.B. Pant University of agriculture and technology, Pantnagar, Uttrakhand, India.

RESULT

The observations during this experiment have been shown in forms of table and graphs in order to assess the ability of phyto-remediator plants (Guava and Ashok) to remove toxic heavy metals (Cu and Pb) from surrounding environment. The total metal analysis was done by AAS and the metals Pb and Cu were determined. The Wavelengths at which Pb and Cu are determined at 283.3 and 324.7 A, respectively. In the industrial areas Pb in plants has maximum value from Delhi highway while the values were lowest in Bareilly city (Rampur Garden), while minimum in Bhojipura village (Figures 1-3). Values of Cu in different leaves and bark of others had low to moderate concentration then Pb in the plants (Figure 4-6). Pb and Cu values of the leaves and bark of plants was found maximum in urban areas near highways while value of Pb and Cu were found minimum in village areas (Tables 1-6).

Table-1. Concentration of lead in polluted leaves and bark.

	Pb concentration	Pb absorption
Blank	---	0.001
Standard 1	2	0.002
Standard 2	4	0.004
Standard 3	6	0.007
Standard 4	8	0.01
Standard 5	10	0.011
Gauva leaf	9.605	0.012
Gauva bark	8.087	0.009
Ashok leaf	0.502	0.008
Ashok bark	0.729	0.012

Table-2. Concentration of lead in semi-polluted leaves and bark.

	Pb concentration	Pb absorption
Blank	---	0.001
Standard 1	2	0.002
Standard 2	4	0.004
Standard 3	6	0.007
Standard 4	8	0.01
Standard 5	10	0.011
Gauva leaf	0.757	0.012
Gauva bark	0.238	0.004
Ashok leaf	0.327	0.005
Ashok bark	0.522	0.008

Table-3. Concentration of Pb in non-polluted leaves and bark.

	Cu concentration	Cu absorption
Blank	---	0.001
Standard 1	2	0.002
Standard 2	4	0.004
Standard 3	6	0.007
Standard 4	8	0.01
Standard 5	10	0.011
Gauva leaf	0.263	0.003
Gauva bark	0.138	0.002
Ashok leaf	0.442	0.001
Ashok bark	0.098	0.001

Table-4. Concentration of copper in polluted leaves and bark.

	Cu concentration	Cu absorption
Blank	---	0.001
Standard 1	1	0.074
Standard 2	2	0.152
Standard 3	3	0.209
Standard 4	4	0.286
Standard 5	5	0.336
Gauva leaf	0.123	0.009
Gauva bark	0.056	0.004
Ashok leaf	0.096	0.007
Ashok bark	0.065	0.005

Table-5. Concentration of copper in semi-polluted leaves and bark.

	Cu concentration	Cu absorption
Blank	---	**0.001**
Standard 1	1	0.074
Standard 2	2	0.152
Standard 3	3	0.209
Standard 4	4	0.286
Standard 5	5	0.336
Gauva leaf	0.058	0.002
Gauva bark	0.047	0.001
Ashok leaf	0.079	0.006
Ashok bark	0.055	0.004

Table-6. Concentration of copper in non-polluted leaves and bark.

	Cu concentration	Cu absorption
Blank	---	**0.001**
Standard 1	1	0.074
Standard 2	2	0.152
Standard 3	3	0.209
Standard 4	4	0.286
Standard 5	5	0.336
Gauva leaf	0.029	0.003
Gauva bark	0.019	0.001
Ashok leaf	0.033	0.002
Ashok bark	0.020	0.001

Legends to figure

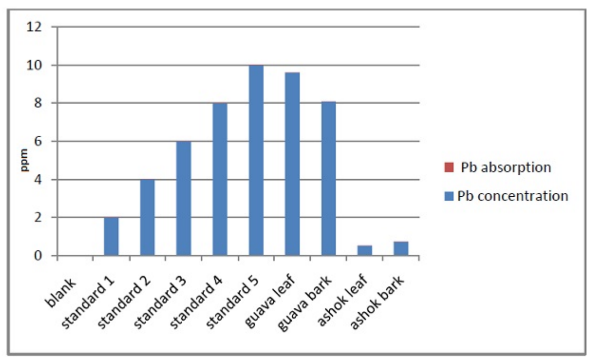

Figure-1. Absorption and concentration of lead in polluted area.

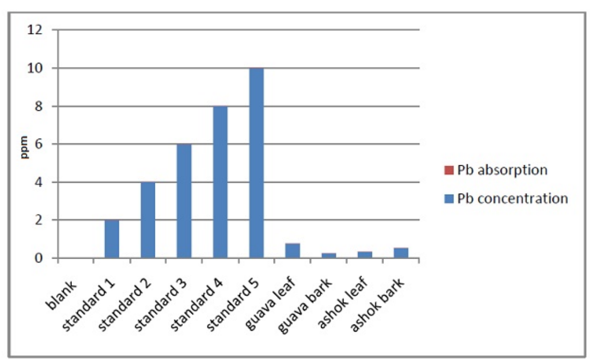

Figure-2. Absorption and concentration of lead in non-polluted area.

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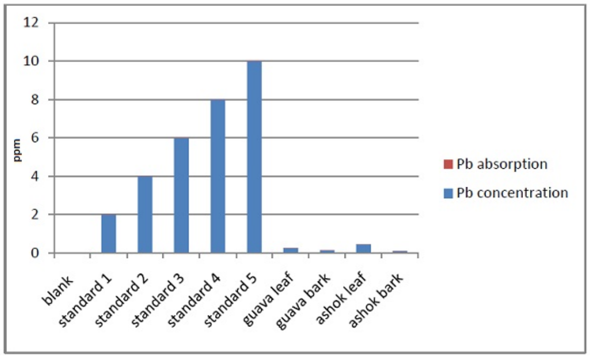

Figure-3. Absorption and concentration of lead in semi-polluted area.

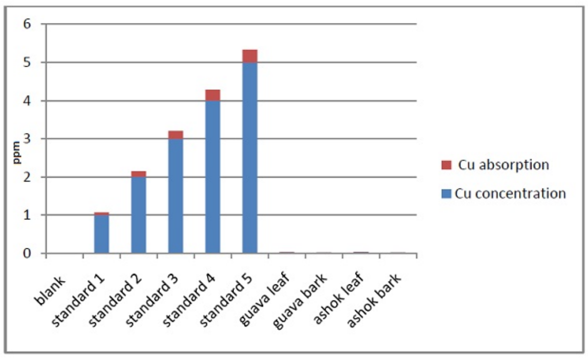

Figure-4. Absorption and concentration of copper in non-polluted area.

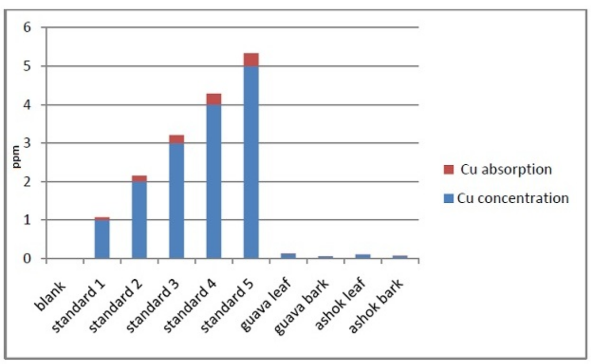

Figure-5. Absorption and concentration of copper in polluted area.

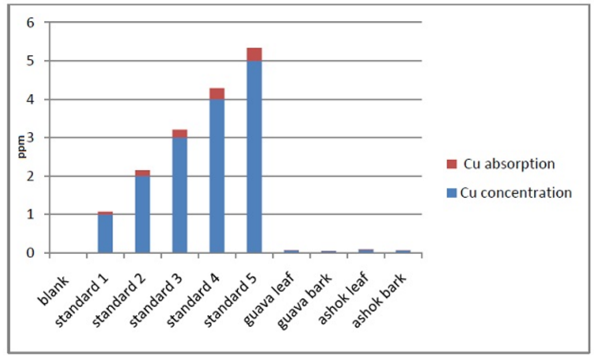

Figure-6. Absorption and concentration of copper in semi-polluted area.

DISCUSSIONS

All the three sites are polluted according to metal concentrations. The plants used for proposed study due to its abundance and its occurrence in extreme conditions. It grown in agricultural land, kitchen garden as well as the bounders of the agricultural land and road sides in everywhere. Since, it is common and affordable plants therefore it is largely used by rich and poor people. Pollutant can easily settled on broad leaves. Therefore they are easily exposed to pollutants. Pb concentration was found in those sites which were near to the highways as well as near to the urban sites. This mainly reflected the traffic activity. Cu concentration was found near in the sites where electroplating plants are situated (Meagher, 2000).

Moreover, heavy metals in the atmosphere could easily travel from one site to another. The concentration of Pb was higher from C.B Ganj Delhi highway followed by Bareilly city and its minimum to moderate concentration was in village Bhojipura. High concentration of Pb is different from other sites due to industrial activities at site 1 (Bareilly and Delhi highway) as it shows high concentrations with respect to Zn, Cu and Co (Al-Asheh and Duvnjake, 1997). High concentration of the metal Pb was reflected from most polluted sites like from highways; while minimum to moderate concentration was found in the villages. Pb was mainly used as lubricant in automobiles, paints and in agricultural practices. High concentration of lead may be due to its multifarious uses i.e., in pigment, as drying agents in primers, paints, inks, oils, resins and other surface coatings for centuries. Interior timber or metal surfaces are likely to be covered with lead paint. Besides, it is an integral constituent of exhaust and abrasion of automobile parts. It is also part of the anthropogenic variables of the environment. Furthermore, Proximity of road had high metal value which could be associated with high deposition of metals, spewed out from automobiles, motor oil, tear and wear of vehicle parts and abrasion of tyres, as earlier as described by Singh (2008).

Plants from roadside had higher degree of Pb which could be from frequent use of Pb in vehicular traffic and could be the reason for its discharge in the atmosphere. Pb accumulation is not altered by environmental factors. In present findings, the high value of Pb present in plants in urban field as well as soil could be due to the influence of aerosol Pb, while soil Pb availability could be evaluated by the level of Pb in plant. Singh and Singh, (2010), also reported significantly higher crop Pb and Cd when crops were grown in urban soils and found very high Pb. On the other hand, road dust and associated metals are an increasing problem for agricultural land of both urban and rural highways is observed in present work. Source of the Pb pollution in proximity of road cannot be ruled out due to high emission from combustion of fuel and same finding was cited by (Michael Hogan, 2010). For Pb, control site shows non-significant values over to Bareilly-Delhi highway. However, in Bareilly city areas like Rampur garden and other sites are significant with control sites. They reason could be probably that at control site plants do not get direct exposure to metal load. Monitoring of air, water and soil in the vicinity of the toxic metal processing units to be carried out more rigorously for the specific metal (Nelson *et al*., 1995).

High level of Pb in Bareilly could be due to, exemption to motorway, junctions, petrol pumps followed by road congestion. Long range atmospheric transport from very much from the heart of the town and from densely areas is also main cause of the same. Pb contamination also arises from lead connectors, lead pipes, lead- soldered joints in copper and lead containing brass faucets and other fixtures. Lead does not biodegrade and it remains in dusts, soils and sediments and therefore is again absorbed.

CONCLUSIONS

The major hazardous metals of concern for India in terms of their environmental load and health effects are Pb, mercury (Hg), chromium (Cr), cadmium (Cr), Cu and aluminium (AL). Metal accumulation on native field analysis was done in different sited of Bareilly as distance wise. The study revealed that Bareilly Delhi highway was most polluted site due to automobile and vehicular traffic load.

The following conclusions can be drawn from this work: (i) Bioremediation as well as physiochemical solutions are being tried to reduce the environmental load, preferably at the site of generation, (ii) Heavy metal uptake by plants using phytoremediation technology seems to be a prosperous way to remediate heavy-metals contaminated environment, (iii) A variation in the intensity of metal accumulation was observed in the leaves and bark of different plant sites in Bareilly city, (iv) Metals content found in samples varied in different study sites, a high metal accumulation was found in plants collected in the industrial areas, (v) The reduction in heavy metals increased with phytoremediation period, (vi) Plants accumulate variety of metals in different concentrations. Some metals are absorbed in higher concentrations while some are in minute quantities. The availability and absorbing capacity also plays a great role in metal pollution in higher plants, (vii) The concentration of each undertaking metal accumulation in plants varied greatly during exhibited the narrowest range of variation, (viii) The increase in the metal concentration in the air affected the overall removal efficiency of the system. The most polluted locations with high annual concentrations of overall metals are national highway (Bareilly Delhi highway) because it is a pilot spot with very high vehicular density and pollution load. Automobiles i.e., buses, car and other motor vehicles are the most common source of transportation of goods as well as human connecting these areas (ix) The maximum reduction of heavy metal was observed in lead (Pb) then in copper (Cu).

REFERENCES

Ackerman R. 2009. A Bottom in Sight for Copper. Forbes.

Adeniyi A.A. 1996. Determination of cadmium, copper, iron, lead, manganese, and zinc in water leaf (*Talinumtriangularia*) in dump sites. Environ. Int. 6(22): 1-4.

Adhikari T. and Ajay 2011. Effect of Nickel on physiological a characteristics of castor plant (*Ricinuscommunis* L.). Indian J. Plant Physiol. 16: 321-325.

Adriano D.C. 2001. Trace Elements in the Terrestrial Environment. A History of Metals. Interscience, New York, USA.

Adriano D.C., Bolan N.S., Vangronsveld J. and Wenzel W.W. 2005. Heavy metals. In: Encyclopedia of Soils in the Environment. D. Hillel (Ed). Elsevier, Amsterdam. pp. 175-182.

Al-Asheh S. and Duvnjake Z. 1997. Sorption of cadmium and other heavy metals by pine bark. J. Hazard Mater. 56: 35-51.

Banerjee M., Sarma N. and Biswas R., *et al*. 2008. Deficiency in DNA repair leads to arsenic susceptibility: Evidence from Comet assay and challenge assay. Int. J. cancer. 123(2): 283-287.

Barnes D., Hammadah M.A. and Ottaway J.M. 1976. The lead, copper, and zinc contents of tree rings and barks, a measurement of local pollution. Sci. Total Environ. 5: 63-67.

Brown Jr G.E. and Sturchio N.C. 2002. Applications of synchrotron radiation in low-temperature geochemistry and environmental science. In: Reviews in Mineralogy and Geochemistry 35. Fenter P.A., Rivers M.L., Sturchio N.C., Sutton S.R. (Eds). Mineralogical Society of America, Washington, DC, USA. pp. 1-115.

Chakraborti D and Rahman M.M. 2009. Status of groundwater arsenic contamination in the state of West

ARPN Journal of Agricultural and Biological Science

Bengal, India: a 20-year study report. Mol. Nutr. Food Res. 53: 542-551.

Chen C. and Gong H. 1996. Effects and mechanism of cadmium on the quality of mulberry leaves and physiological and biochemical characteristics. Chinese J. Applied Ecology. 7(4): 417-423.

Chen G. 1990. Effects of heavy metals on the growth of cucumber seedlings. Chinese Bulletin of Botany. 7(1): 34-39.

Christopher H.G., Stacey A.N., Jonathan S.S., Lianne S. and Joel D.K. 2004. Effect of Ambient Air Pollution Pulmonary Exacerbations and Lung Function in Cystic Fibrosis. American Journal of Respiratory and Critical Care Medicine. 169(7): 816-821.

De Chaudhuri S., Ghosh P. and Sarma N., *et al*. 2008. Genetic Variants Associated with Arsenic Susceptibility: Study of Purine Nucleoside Phosphorylase, Arsenic (+3) Methyl Transferase and Glutathione S Transferase Omega Genes. Environmental Health Perspective. 116: 501-505.

Dong H. 1999. Influence of heavy metals on the activity of Spirodelapolyrrhiza catalase (CAT). Yunnan Environmental Science. 1: 13-15.

Du W., Zhang X. and Jiang W., *et al*. 1999. The significance and the determination of the chromium content of the food in Qingdao District. Res. Trace Elements and Health. 16(3): 42-49.

Duan C. 1995. Plant adaptation to environmental pollution and its micro-evolution. Chinese J. Ecology. 14(5): 43-50.

Duan C. and Wang H. 1992. Effects of heavy metals on the content of nuclear acids and nuclear enzymatic activities in the root tips of bean (*Viciafaba*). Environmental Science. 13(5): 31-35.

Duan C. and Wang H. 1995. Studies on the cell gene-toxicity of heavy metals to beans and micro-nuclear techniques. Acta Botanica Sinica. 37(1): 14-24.

Duflo E., Greenstone M. and Hanna R. 2008. Indoor air pollution, health and economic well-being. S.A.P.I.EN.S. 1(1): 08-29.

Gangulee H.C. 1974. Mosses of Eastern India and adjacent regions: A monograph, Fac. 4. Calcutta.

Gangulee H.C. 1976. Mosses of Eastern India and adjacent regions: A monograph, Fac. 5. Calcutta.

Gaur and Adholeya A. 2004. Prospects of arbuscular mycorrhizal Fungi in phytoremediation of heavy metal contaminated Soils. Current Science. 86: 528-534.

Hubers M. and Kerp H. 2012. Oldest known mosses discovered in Mississippian (late Visean) strata of Germany. Geology.

Lester B. 2006. Plan B 2.0: Rescuing a Planet under Stress and a Civilization in Trouble. New York: W.W. Norton. p. 109.

Meagher R.B. 2000. Phytoremediation of toxic elemental and organic pollutants. Current Opinion in Plant Biology. 3(2): 153-162.

Michael Hogan C. 2010. Heavy metal. Encyclopedia of Earth. National Council for Science and the Environment. Monosson E. and Cleveland C. (Eds.). Washington, D.C., USA.

Nelson Y.M., Lo W., Lion L.W., Shuler M.L. and Ghiorse W.C. 1995. Lead distribution in a simulated aquatic environment: Effects of bacterial biofilms and iron oxide. Water Res. 29: 1934-1944.

Pehlivan E., Zkan A.M.O., Dinc S. and Parlayici S. 2009. Adsorption of Cu^{2+} and Pb^{2+} ion on dolomite powder. Journal of Hazardous Materials. 167(3): 1044-1049.

Phillips M. (Eds.). 2000. Transport, Environment and Health. Copenhagen, WHO Regional Office for Europe. WHO Regional Publications, European Series, No. 89.

Rupassara S.I., Larson R.A., Sims G.K. and Marley K.A. 2002. Degradation of Atrazine by Hornwort in Aquatic Systems. Bioremediation Journal. 6(3): 217-224.

Singh D.K. 2008. Red-listing of Hepaticae and Anthocerotae in India. In: Bryology in the New Millennium,. Kuala Lumpur: University of Malaya. Mohamed H, Baki BB, Nasrulhaq-Boye A, Lee PKY (Eds.). pp. 451-458.

Singh D.K. and Singh S.K. 2007. Hide and seek of Monosoleniumtenerum Griff. (Hepaticae: Monosoleniaceae) in India bryoflora. Current Science. 92: 11-19.

Singh D.K., Singh D. and Dey M. 2008. A Catalogue of the Hepaticae and Anthocerotae of Sikkim. In: Bryology in the New Millennium, Kuala Lumpur: University of Malaya. Mohamed H, Baki BB, Nasrulhaq-Boye A, Lee PKY (Eds.). pp. 93-135.

Singh S.K. and Singh D.K. 2010. A catalogue of the Liverworts and hornworts of Himachal Pradesh, India. Archieve for Bryology. 61: 18-29.

Vaizey JR. 1890. On the Morphology of the Sporophyte of Splachnumluteum. Annals of Botany. 1: 1-8.

ARPN Journal of Agricultural and Biological Science

Zhang Y. 1999. Expression analysis of polyubiquitin gen from beans in response to heavy metals. Acta Botanica Sinica. 41: 1052-1057.

Zhang Y. 2000. DNaJ-like protein eDNA cloning and its Expression under heavy metal stress. Advances of Nature Science. 10: 135-140.

Zhang Y. and Burkard G. 1998. Heavy metal responsive genes in kidney beans: cloning of cDNAs and gene expression analysis. Acta Phytophysiologica Sinica. 24(4): 399-404.