RESEARCH PAPER:

A comparative study of heavy metals pollution along highways in agricultural soils from Tehran, Iran and Pune, India

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SUMMARY

Environmental pollution of heavy metals from vehicles has impact on human health in recent years. The present research was conducted to study heavy metal contamination in agricultural soils around Teheran, Iran and Pune, India. Agricultural soil samples were collected from six sites from above locations. Top soil samples (0-10 cm) were collected and analysed for eight heavy metals like cadmium, copper, lead, zinc, iron, manganese, nickel, chromium. The result from Indian soils showed that at station one, manganese, nickel, lead were maximum in concentration and iron, nickel were in minimum concentration. Station two has iron in maximum concentration while chromium was observed to be maximum at station six. At station five zinc, chromium and nickel were observed to be in minimum as compared to other stations. Also, at station three copper and chromium were more in concentration. So, overall it was observed that, station one was having more heavy metal concentration as compared to other five stations. Cd was observed to be in negligible concentrations in all the sites. Agricultural soil samples from Iran showed that at station one, manganese, zinc were maximum in concentration and iron, nickel were in minimum concentration. Station two has iron and nickel in maximum concentration while chromium in minimum concentration at station two. At station three, copper and lead has maximum as compared to other stations. At station five, chromium has more concentration while manganese minimum. The vehicular pollution around Pune and Teheran has increased day by day and naturally it affects agricultural soils.

Key Words :
Heavy metal pollution, Agricultural soils, Environmental pollution

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Heavy metal concentration in agricultural soils can affect human beings directly, through soil ingestion or through the food web by ingestion of crops and animals. An increase in heavy metal deposition in agricultural soils and crops are observed due to transport of heavy vehicles near the agricultural farm. Awofolu (2004) recorded impact of automobile exhaust on levels of lead in a commercial food from bus terminals. Vegetables constitute essential components of the diet. They are contributing protein, vitamins, iron, calcium and other nutrients which are essential for human health. Contamination of vegetables with heavy metal may be due to irrigation with contaminated water, addition of fertilizers, industrial emissions, transportation, etc. These food plants contain both essential and toxic metals over a wide range of concentration. Consumption of crops by human and animals as food and fodder are major factors of damaging human health. In India heavy metal contamination study of soil and vegetables has been carried out at Varansi by Sharma *et al.* (2007). A survey along two national highways near Lucknow was carried out and reported lead deposition as reflected by soils. Lead (pb) burden showed that decrease in concentration with increasing distance from the road margins. At both the sites, lead concentration was above back ground concentration at the soil depth of 15cm.Some plants contained high concentration of Pb over their respective controls, with more accumulation in the underground portions of

the plants. The cattle grazed near the roadside pastures, naturally milk samples contained lead at an elevated concentration (Singh *et al.,* 1997).

Metals are persistent pollutants that can be biomagnified in the food chains, becoming increasingly dangerous to human and animals. Heavy metals enter into the environment mainly via three routes: (i) deposition of atmospheric particulate, (ii) disposal of metal enriched sewage sludge and sewage effluents and (iii) by-products from metal mining process. Soil is one of the repositories for anthropogenic wastes. Biochemical processes can mobilize them to pollute water supplies and impact food chains. Trace heavy metal contamination in the soils is a major concern because of their toxicity and threat to human life and environment (Khalid *et al*., 2006).

Heavy metals studies have been conducted in soils with differing levels of anthropogenic influences such as in highly populated and industrialized cities. Sonavane *et al*. (2009) conducted seasonal variation of some micronutrient in soil around Kurkumbh area Daund from Pune district. Range of variation in pre-monsoon and post-monsoon concentration of heavy metals from 8 different locations on soil samples were carried out. Most heavy metal concentration is observed in and around urban cities. Heavy metals such as Cu, Cr, Cd, Ni, and Pb are potential soil and water pollutants. Singh and Singh (2006) carried out analytical study of heavy metals of industrial effluents at Jaipur, Rajasthan. Heavy metal studies are necessary to evaluate both soil/sediment and groundwater contamination. Karbasi (2004) reported concentration of heavy metals such as Cu, Cr, Cd, Ni, and Pb from Tehran. Hamzeh (2006) carried out analytical study of heavy metals of environment effluents at Kerman from Iran. The problem of environmental pollution due to toxic metals has caused major concern in most major metropolitan cities in Iran (Rahmani,2000). The toxic heavy metals entering the ecosystem may lead to geo-accumulation, bio-accumulation and bio-magnifications. Heavy metals like Fe, Cu, Zn, Ni and other trace elements are important for proper functioning of biological systems and their deficiency or excess could lead to a number of disorders (Taebi and Samani Majd, 2003). Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in bio-systems through contaminated water, soil and air.

Area under study:

Pune city has, earlier famous as Poona is one of the most important cities of Western India aptly called the 'Queen of Deccan' after its elevated position atop the Deccan Plateau. Pune lies on the leeward side of the Sahyadri *i.e.* the Western Ghats and is hardly 50 km from the crest of ghat region . It is situated at a height of 560 m above the mean sea level. The city is surrounded by hills on the east and the south.During the last four decades, innumerable developmental projects in and around Pune has created an adverse impact on the environment. It has also increased the chances of grave health risk due to continual air, water, and soil pollution. It is likely that the annual mean surface temperature in this state may increase by between 1.6°C and 3.0°C by the middle of this century. A decline in monsoon rainfall is also projected leading to more frequent droughts and resulting decline in agricultural productivity. As a consequence, many of the habitat and species could also be threatened and some may even become extinct in the event of climate change. Several vehicles are coming into Pune city by all highways and transportation of goods from Pune to other long distances. This change is a major factor of vehicular pollution around Pune city.

Tehran province is one of the 31 provinces of Iran. It covers an area of 18,909 square kilometers and is located to the north of the central plateau of Iran. Tehran province borders Mazandaran province in the north, Qom province in the south, Semnan province in the east, and Qazvin province in the west. The metropolis of Tehran is the capital city of the province and of Iran. This province includes 13 townships, 43 municipalities and 1358 villages. Tehran province is the richest province of Iran as it

Area under study: The area around Pune and Tehran were selected for data collection

No	Name of station around Pune- India	Name of station around Tehran- Iran
1.	Shivapur Toll collection centre- Pune to Bangalore	Saidi high way (Shahid beheshty complex)
2.	Bhugaon- Pune to Mangaon-Konkan	Saidi high way(Shah Tareeh)
3.	Telegaon- Chakan- Connecting road to Bombay Pune old highway to Nasik Highway	Tehran-Qom high way (Turouz Abad)
4.	Nasik- Pune highway, Near Hotel Vedant	Tehran-Qom high way (Jalil Abad)
5.	Pune- Ahmednagar Highway- Harshraj Garden Dhaba	Tehran-Varamin high way(near Amin Abad road)
6.	Pune-Solhapur highway- Near village Yavat.	Tehran high way (Firooz Abad)

contributes approximately 29 per cent of the country's GDP. Furthermore, it houses approximately 18 per cent of the country's population. Tehran province is the most industrialized province in Iran. About 86.5 per cent of its population resides in urban areas and 13.5 per cent of its population resides in rural areas.Today, Tehran, with a population of more than 7 million, is ranked amongst the 20 most populous metropolitan cities of the world.

Tehran's air quality is impacted by the stationary and mobile sources as well as its location and topography. It is estimated that about 30 per cent of Iran's industrial establishments are located around Tehran (BBC Persian.com, January 2, 2005). Of these establishments, metal and chemical factories are located mostly up wind to the west of the city, a refinery to the south, and small factories throughout the city. Stationary sources (industries and residential/commercial services) accounted for approximately 29 per cent of the air pollution while approximately 71 per cent of Tehran's air pollution was related to mobile sources (Hastaie, 2000b).Tehran had about 1.3 million motor vehicles. Approximately, 700,000 of the total were privately- owned cars. In addition, there were 350,000 motorcycles in the city (Tehran Comprehensive Transportation and Traffic Studies Company, 2007). By 2000, the number had reached to about 2 million vehicles operating in an extremely congested road network with an average vehicle speeds below 18 km/h (Hastaie,2000a). The most recent data indicates that approximately 2.5 million of Iran's 7.5 million vehicles are located in Tehran (33 %) while the city has about 10per cent of Iran's total population of 69.51 million United Nations, Department of Economic and Social Affairs/Population Division, 2005).Iran's auto industry has boomed in recent years to become one of the biggest sectors outside of oil. Iran boasts the largest car industry in the Middle East and Central Asia. Since 2000, Iran's auto manufacturers have increased their annual production from approximately 300,000 to about 1 million vehicles (BBC Persian.com, 2005). According to The Economist reported,' Every day 1200 vehicles and 600 motorcycles join the existing fleet in Tehran, clogging the streets with traffic and choking everyone with fumes. The cost of traffic congestion in the capital is put at 2 billion hours of time wasted each year. It is estimated that about 1.5 million old vehicles (20 years and older) are operating across the country. The high number of old and polluting vehicles is a major cause of the air pollution in Tehran. The local winds are often not strong enough to circulate the air. In addition, the major winds blow from the west, south, and southeast, where most of the industries are located. Rather than cleaning the air, they can pollute the air further (Madanipour, 1998). Each year, Tehran faces the problem of temperature inversion for about 250 days. The temperature inversions push dense clouds of stagnant smog down onto the city. The Government of Iran and Tehran Municipality have actively participated in an effort for the reduction of local and global air pollution

EXPERIMENTAL METHODOLOGY

Thirty six soil samples (6 stations and every station 3 samples 5m, 10m, 15m and opposite site) were collected at surface level (0–10 cm in depth). The areas were selected for collection from various locations to cover industrial, commercial and residential zones. The collected soil samples were air-dried and sieved into coarse and fine fractions. Well-mixed samples of 2 g each was taken in 250 ml glass beakers and digested with 8 ml of aqua regia on a sand bath for 2 hours. After evaporation to near dryness, the samples were dissolved with 10 ml of 2 per cent nitric acid, filtered and then diluted to 50 ml with distilled water. Heavy metal concentrations of each fraction was analyzed by Atomic Absorption Spectrophotometer. Quality assurance was guaranteed through double determinations and use of blanks for correction of background and other sources of error. EC of the soil samples were determined from saturation extract by conductivity meter. Measurement of pH of the soil samples was done with help of a glass electrode pH meter. The amount of pH ranged from 7.64 to 6.89 with the mean value of 7.30.

EXPERIMENTAL FINDINGS AND DISCUSSION

Heavy metal analysis of various soil samples collected from six different locations around Pune and Tehran are reported.

Zinc:

The amount of zinc in the agricultural soils around Pune ranged from 1.19 to 3.03 µg/g with the mean value of 1.82 µg/g . Maximum zinc concentration was observed at station four 3.03 µg/ g (Pune- Nashik highway) whereas minimum zinc concentration was observed at station two 1.19 µg/ g (Bhugaon-Pune-Mangaon-Konkan). The amount of zinc in Tehran agricultural soils around ranged from 6.27 to 10.98 µg/g with the mean

value of 8.01 µg/g .Maximum zinc concentration was observed at station one,10.98 µg/ g Saidi high way (Shahid beheshty complex) whereas minimum zinc concentration was observed at station two ,6.27 µg/g Saidi high way.(Fig. 1).

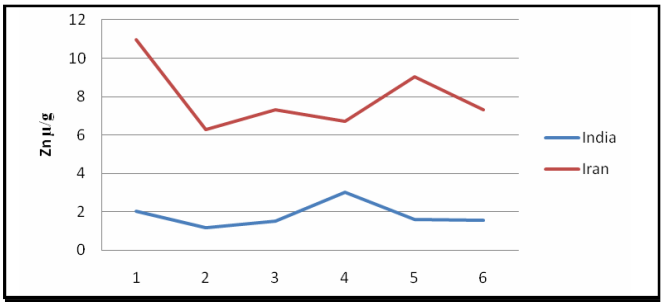

Fig. 1: Concentration of Zn in different stations Iran and India winter

Normal concentrations of zinc in soil range from 1 to 900 µg/gr (Alloway 1995). So, in this study, all sampled were in the normal range and none exceeded.

Copper:

The copper content in the agricultural soils around Pune ranged from 7.41 to 3.58 to µg/g with the mean value of 5.57 µg/g. Maximum Cu concentration was observed at station two7.41 µg/g Bhugaon- Pune to Mangaon-Konkan while minimum Cu concentration was observed at station five, 3.58 µg/g (Pune- Ahmednagar Highway-Harshraj Garden Dhaba). In Tehran agricultural soils around ranged from 4.91 to 13.49 µg/g with the mean value of 8.27 µg/g. Maximum Cu concentration was observed at station three- 13.49 µg/g Tehran-Qom high way(Turouz abad), while minimum Cu concentration was observed at station four - 4.91 µg/g Tehran-Qom high way (Jalil Abad) (Fig. 2).

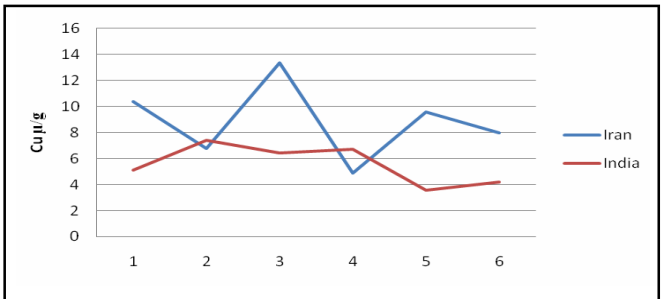

Fig. 2: Concentration of Cu in different stations Iran and India in winter

The normal Cu content in agricultural soils is 5 to50 µg/g. Concentrations below 8 µg/g could indicate a deficiency for some crops as Cu is an essential micronutrient (McBride, 1994; Kabata-Pendias and Pendias, 2001). In this study, all sampled were in the normal range and none exceeded.

Iron and manganese:

In general, the soil Fe and Mn concentrations are not reported in earlier studies on soil heavy metal content because they are not contaminant elements. Both metals are important in plant nutrition as they are essential crop micronutrients. These elements can be insoluble forms in calcareous soils causing deficiencies (e.g. ferric chlorosis). In spite of an elevated soil content, total Fe or Mn are not a good indicator of their plant availability. For example, Fe is mainly present in precipitated forms, such as oxides and hydroxides in these soils. Therefore, Fe deficiency does not seem to be due to an insufficient soil Fe content but to the formation of insoluble compounds. The Iron content in the agricultural soils around Pune ranged from 3.05 to 11.93 µg/g with the mean value of 5.93 µg/g (Fig. 3) . Maximum Fe was observed at station two 11.93 µg/ g (Bhugaon-Pune-Mangaon-Konkan) and minimum Fe was observed at station four 3.05 µg/g, (Nasik- Pune highway, Near Hotel Vedant).The iron content in the agricultural soils around Tehran ranged from 2.748 to 10 µg/g with the mean value of 6.69 µg/g. Maximum Fe was observed at station two 10 µ/g Saidi high way(Shah Tareeh) and minimum Fe was observed at station three -2.74 µg/g,Tehran-Qom high way(Turouz abad) (Fig. 3).

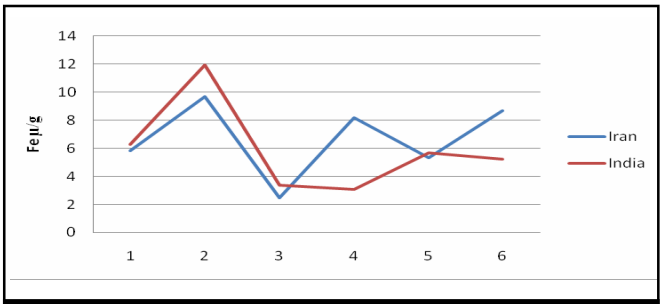

Fig. 3: Concentration of Fe in different stations Iran and India in winter

Manganese concentration ranged in Pune between 41.21 to 52.76 µg/ g , with the mean value of 46.26 µg/g (Fig. 4). Maximum Mn concentration was observed at station two-63.6 µg/g (Bhugaon- Pune to Mangaon-Konkan) and minimum concentration was observed at station five- 34.1µg/g (Pune- Ahmednagar Highway-Harshraj Garden Dhaba).In Tehran manganese concentration ranged between 22.03to 42.40 µg/g, with the mean value of 29.13 µg/g (Fig. 4). Maximum Mn concentration was observed at station one- 56.30 µg/g Saidi high way (Shahid beheshty complex) and minimum concentration was observed at station three, 10.30 µg/g (Tehran-Qom high way (Turouz Abad).

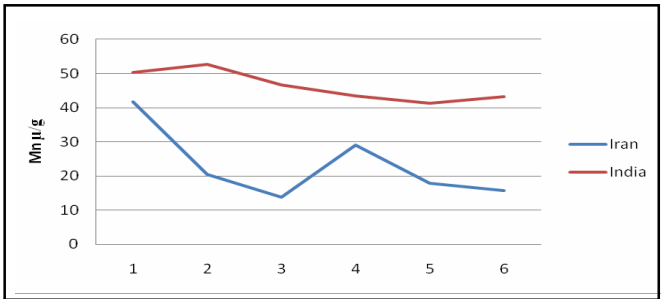

Fig. 4: Concentration of Mn in different stations Iran and India in winter

Chromium:

The concentration of chromium in the agricultural soils around Pune ranged from 0.51 to 1.19 µg/g with the mean value of 0.81 µg/g (Fig. 5). Maximum Cr was observed at station three - 1.19 µg/g (Telegaon- Chakan-Connecting road to Bombay Pune old highway to Nasik Highway) and minimum concentration was observed at station five- 0.51µg/g (Pune-Ahemadnagar Highway). The concentration of chromium in the agricultural soils around Tehran ranged from 0.54to 0.89 µg/g with the mean value of 0.58 µg/g (Fig. 5). Maximum Cr was observed at station five- 1.577 µg/g Tehran-Varamin high way (near Amin Abad road) and minimum concentration was observed at station two- 0.24 µg/g Saidi high way(Shah Tareeh).

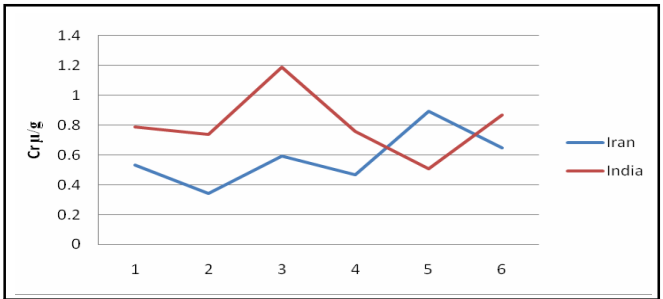

Fig. 5: Concentration of Cr in different stations (µg/g)

Nickel:

The nickel content in the agricultural soils around Pune ranged from 0.35 to 0.87 µg/gr with the mean value of 0.66 µg/g (Fig. 6). Maximum Ni concentration was observed at station one- 0.87 µg/g (Talegaon Chakan Road) and minimum concentration was observed at station five -0.35µg/g (Pune-Ahemadnagar Highway). The nickel content in the agricultural soils around Tehran ranged from 0.28 to 0.40 µg/g with the mean value of 0.32 µg/g (Fig. 6). Maximum Ni concentration was observed at station three- 0.40 µg/g Tehran-Qom high way (Turouz Abad) and minimum concentration was observed at station five- 0.28 µg/g (Tehran-Varamin high way(near Amin Abad road). The normal soil Ni content varied from 1 to 100 µg/g (Kabata-Pendias and Pendias, 2001). In this study all sampled were in this range.

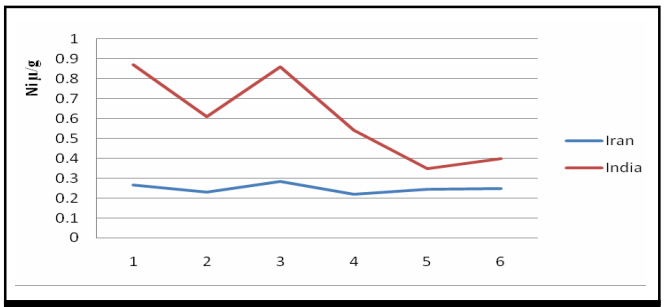

Fig. 6: Concentration of Ni in different stations (µg/g)

Lead:

In the last decades, much attention has been directed towards lead in the roadside environments as a result of its widespread use as an anti-knocking agent in gasoline (Davies and Holmes, 1972). In the recent years, the lead content in gasoline was markedly decreased in the world. This decrease has reduced the addition of lead to the environments by motor vehicles. However, the previously deposited lead remains a major contaminant of the roadside environments. Although the lead content in gasoline is minimized these days, the increased traffic has caused an increase in the lead emission in the roadside environments .

In the present study, the lead content in the agricultural soils in Pune ranged from 0.00 to 2.34 µg/g with the mean value of 1.27 µg/g. Maximum Pb concentration was observed at station one (Shivapur toll plaza Pune-Bangalore highway) and minimum concentration was observed at another station three (Talegaon-Chakan Road).

The lead content in the agricultural soils in Tehran ranged from 0.18 to 1 µg/g with the mean value of 0.486 µg/g . Maximum Pb concentration was observed at station three 0.655 µg/g Tehran-Qom high way (Turouz abad) and minimum concentration was observed at station four 0.29 µg/g Tehran-Qom highway (Jalil Abad).

Cadmium:

Cadmium concentration ranged between 0.000 µg/g, 0.002 µg/g, respectively for all the stations with the mean value of 0.00025 µg/g .Cd was observed to be in negligible concentrations.

The concentration of the cadmium in the agricultural soil in Tehran ranged between from 0.001 to 0.004 µg/g with the mean value of 0.002 µg/g (Fig. 7) .

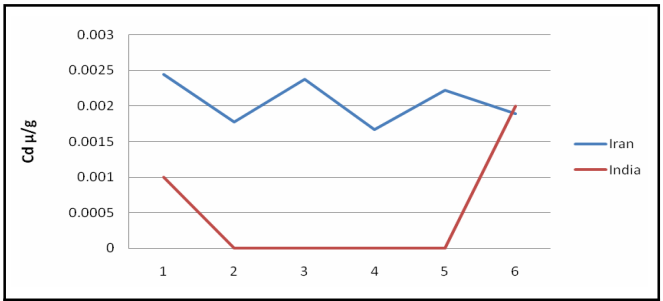

Fig. 7: Concentration of Cd in different stations Iran and India in winter

Conclusion:

The study reveals that six stations in Pune and Teheran were studied for heavy metal pollution due to vehicles. Different stations had varied concentration of metals such as station one , nickel and lead were maximum in concentration also iron, manganese and copper were in maximum concentration in station two. Station four has Zinc in maximum concentration while chromium was observed to be maximum at station three. Station five, manganese , copper, chromium and nickel were observed to be in minimum as compared to other stations. Cadmium was observed to be in negligible concentrations in all the six stations. Stations one, three , four, five and six showed less heavy metal concentration. Station three showed moderate heavy metal deposition as compared to station one and rest all stations of the study area.

While comparing with Tehran stations, maximum zinc concentration was observed at station one where as minimum zinc concentration was observed at station two. Maximum Cu concentration was observed at station three while minimum Cu concentration was observed at station four. Maximum Fe was observed at station two and minimum Fe was observed at station three. Maximum Mn concentration was observed at station one and minimum concentration was observed at station three. Maximum Cr was observed at station five and minimum concentration was observed at station two. Maximum Ni concentration was observed at station three and minimum concentration was observed at station five. Maximum Pb concentration was observed at station three and minimum concentration was observed at station four. The concentration of the cadmium in the agricultural soil in Tehran ranged between from 0.001 to 0.004 µg/g with the mean value of 0.002 µg/g.

At some stations it was showing such trend of decrease in concentrations of metals. In some stations it we go away from high way on both sides there was no such trend observed but few of sites showed increase in concentrations of metals though the distance is more from the high way. This may be due to naturally soils have heavy metal concentration (Farhad, 2007).

The vehicles passing from station one are more than 8000-10000 per day. The station three was observed to have more metal concentration after station one. This region is nearer to industrial area and ultimately more metal deposition was seen.

The reasons for more metal concentration in soil are mainly discharge of large quantities of industrial effluent wastes or by products in the environment, excessive fertilizer and pesticide application. Sewage sludge are discharges of city wastes in form of semi-liquid to agricultural land. These sludge contain heavy metals of lead, cadmium, chromium, zinc, etc. Particulate lead from automobile exhaust settles on soil along side of high way with heavy automobile traffic. Metals are major category of globally distributed pollutants. It is important to understand metal toxicity of road side soil and vegetation. The effect of heavy pollution can be minimized by plantation of suitable hyper-accumulator plants to rehabilitate contaminated areas and regulate metal emissions effectively (Alloway,1995).

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