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Research Article

IMPACT OF CEMENT INDUSTRIES DUST ON SELECTIVE GREEN PLANTS: A CASE STUDY IN ARIYALUR INDUSTRIAL ZONE

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ABSTRACT

The cement dust, produced by cement manufacturing units is considered one of the most hazardous pollutants which affect the surrounding environment. Increased concentrations of the pollutants can cause progressive reduction in the photosynthetic ability of leaves, closure of leaf stomata and, mainly, a reduction in growth and productivity of plants. The Ariyalur district is being polluted by several cement industries and mining activities and is also received both point and non-point source pollution throughout the year. To find the physiochemical and heavy metal levels, we collected six sediments, three water and two different plant samples belonging to three different areas were collected from cement industrial zone of Ariyalur district. The sampling sites of S1, S2 and S3 were 0-500 m, 500-1000 m and 1000-1500 m away from the cement industry of Ariyalur industrial zone, respectively. At the same time, the two soil, one water and two different plant were collected from Jamal Mohammed College, Tiruchirappalli (sampling site (C1) - non-industrial area – control site), Tamil Nadu. In this study, the physiochemical and heavy metal parameters were high in surface sediment than bottom sediment and waters. The phytochemical parameters of the plants in control site are lower than proposed sampling sites. The heavy metal levels were higher in water and sediment and were also found in both plants. The need for guidelines to protect the water, sediment and plant quality of the Ariyalur district are imperative.

Keywords: Ariyalur, Cement dust, Pollution, *Croton bonplandianum*, *Cassia auriculata.*

INTRODUCTION

Water and soil is one of the important and valuable resources of the nature. All living things are directly and indirectly dependent on soil for day to day needs and 95 % of the human food is derived from the earth. Making plan for having healthy and productive water soil is essential to human survival. The environmental pollution as a result of cement industry could be defined as an undesirable process that is responsible to pollute water, air and land through its various activities, right from the mining activity of the raw material (limestone, dolomite etc.) to its crushing, grinding and other associated processes in cement plant. Air pollution has become a serious problem in recent times due to rapid growth of thermal power stations, cement factories, steel and coal industries. In which, the cement dust contains different particulate pollutants which affects vegetation, soil microbial population and other soil properties (Iqbal and Shafig 2001). Cement industry is a continuous source of Cement dust and their constituent gases such as SO_2, CO_2, CO, and SiO_2 adversely affect the drinking water resources like wells, ponds and mine pits.

The presence of total solids in the form of salts of Ca, Na, K, Mg, Al as hydroxides sulphates and silicates leads to hardness of water which causes gastro intestinal disorders which have been found as quite common in the area. Soil pollution is developed due to constant fall of cement dust, resulted in the formation of colloidal gels of calcium silicate and calcium aluminate. The cement dust, produced by cement manufacturing units is considered one of the most hazardous pollutants which affect the surrounding environment. These particles can enter into soil as dry, humid or occult deposits and can undermine its physicochemical properties. The deposit of these particles is complex and it is controlled by the atmospheric stability, the roughness of the surfaces as well as the diameter of the particles. Indeed, it is relevant to mention that in the arid regions, the dry deposits are particularly more important (Grantz et al., 2003). The atmospheric particles can have as consequence the reduction of biodiversity and the quality of goods and services offered by the ecosystems. The main visible pollution generated by the cement industry corresponds to the dusts. Indeed, the dusts can be emitted at every stage of the manufacturing process of the cement: extraction of the raw material, crushing, production, etc. The impact of the cement dust on soil properties and plant production has been investigated by some researchers (Saralabai and Vivekanadau 1995, Schuhmacher et al 2004., and Zerrouqi et al., 2008).

Air pollution has been described as an additional stress on plants since they often respond to atmospheric contamination in the same way as they respond to drought and other environment stress. Especially, the role of cement pollutants causing injury to plants either by direct toxic effect or modifying the host physiology rendering it more susceptible to infection (Gupta and Mishra 1994). In severe case of pollution, the injury symptoms were expressed as foliar necrosis or completely disappearance of the plant. (Samal and Santra 2002) have also previously studied the impact of air pollution on plants with reference to foliar anatomical and biochemical changes by experimenting on various sensitive plants. Increased concentrations of the above pollutants cause

progressive reduction in the photosynthetic ability of leaves, closure of leaf stomata and, mainly, a reduction in growth and productivity of plants (Larcher 1995). These dust particulates are causing large scale deforestation destruction of Biota (Panda et al., 1996) and other natural resources. Among these deposition of cement kiln dust in large quantities around cement factories causes changes in soil physical chemical properties (Prasad et al., 1991). The effect of such deposition affects the growth and biochemical characteristics of field crops has also been widely studied (Saralabai 1993).

In this study, water and soil samples of Ariyalur cement industrial zone were collected for chemical/ physical/ heavy metals component analysis and are very important parameters in monitoring environmental pollution. Simultaneously, the research is to assess the impact of the dusts given out by a cement factory on the biochemical and physical characteristics of some selective plants at the vicinity of the cement factory.

MATERIALS AND METHODS

Sampling and processing

In Monsoon (October) 2013, six soil and three water samples belonging to three different areas were collected from cement industrial zone of Ariyalur district. The sampling sites of S1, S2 and S3 were 0-500 m, 500-1000 m and 1000-1500 m away from the cement industry of Ariyalur industrial zone, respectively. At the same time, the two soil and one water sample were collected from Jamal Mohammed College, Tiruchirappalli (sampling site (C1) - non-industrial area – control site), Tamil Nadu. At each site, samples were collected at two soil depths (0-5 (surface) and 10-15 cm) and one ground water by sterile spatulum and 2,500 ml sterile container, respectively. The soil samples were stored in sterile plastic bags. Physicochemical parameters ie., pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured using field kit (Thermo Orion 5-Star pH Multi-Meter) on the site and other parameters were measured in the laboratory using the standard procedure (APHA, 1998). All samples were collected with precautions required for microbiological analysis, held on iceboxes, and processed within 12 hrs of collection. For heavy metal analysis, one liter of sea water sample was acidified immediately with concentrated nitric acid (HNO_3).

The studies were conducted on *Croton bonplandianum* and *Cassia auriculata* plants growing under natural conditions. The selected plant samples were selected at three different locations from the cement factory areas (wide reference above) of Ariyalur and control site from JMC, Tiruchirappalli. The leaves were carefully removed from the bark, using a snapper blade and washed with sterile distilled water to remove the dust on the surface of the leaf samples. About 1g of leaves, torn into small pieces in a mortar ground with a pinch of quartz sand and a total of 10 ml of absolute acetone. Initially, add only a small amount of acetone to begin the grinding process. It is much easier to grind the leaves if the extract is a pasty consistency. Add more solvent in small increments while continuing to grind the leaves. For some species may need to add more than the suggested 10ml of acetone. Pour the extract into a 15ml centrifuge tube and centrifuge in the bench top centrifuge at 5000 rpm for 3 to 5 min. Remove the extract to a 10ml graduated cylinder using a Pasteur pipette. Transfer an aliquot of the clear leaf extract (supernatant) with a pipette to a 1-cm-pathlength cuvette and take absorbance readings against a solvent blank in a UV-VIS spectrophotometer at 662, 645, 470, 435 and 415 nm wavelength to determine the concentrations of photosynthetic pigments like chlorophyll-a, chlorophyll-b and carotenoids (Lichtenthaler 1987). This extract was also used to quantify phytochemistry parameters.

Sample analysis

Water samples were filtered by Whatman No.1 filter paper and were used for analysis. Soil samples were air-dried and gently crushed and sieved through a 2 mm sieve and stored for chemical and physical analysis. The concentrations of soluble cations and anions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, CO_2^{-}, HCO^{-}, Cl^{-} and SO_4^{2-}) were determined according to the method described by APHA (1998). Also, total concentrations of Fe, Cu, Zn, Pd, Cd, As, Cr, Ni and Hg in soil samples were determined by aqua-regia mixture (James 2000). The extraction of the studied metals in the solutions was determined by the 797 VA Computrace voltametry, Metrohm.

Quality control and data analyses

Due care was taken to avoid metal contamination in the process of sampling, extracting and analysis. Before analysis, the devices were rinsed with acidified water (10% HNO_3) and weighted to dissolve metals. Also, all equipments and containers were soaked in 10% NHO_3 for 24 h then rinsed thoroughly in de-ionized water before use. Moreover, quality control was assured by performing duplicate analyses on all samples and by using reagent blanks and standards. Also the values of the studying metals below the detection limits of the 797 VA Computrace voltametry, Metrohm were refused.

RESULT AND DISCUSSION

A substantial and unfortunate fact about industrialization and industrial production is generation and release of toxic waste products. Unfortunately, the inadequate information regarding waste toxicity and post-disposal behavior, poor planning, improper disposal and poor management of disposal sites stimulates serious contamination problems at industrial and hazardous waste disposal sites. In this study, the physiochemical and metal contents were high in the water and soil samples and it can be classified either polluted or unpolluted. At the same time, both of the plants uptakes some amount of nutrients, metals and other substances which is directly affects the growth and phytochemistry of plant species. The phytochemistry results of the test plants were reported in Figure 1. The phytochemical parameter levels from the Ariyalur (sampling site) plants were lower than the Tiruchirapalli (control site) area plants due to the cement dust pollution.

In water, the concentration of pH in S1, S2 and S3 were 6.8, 7.0 and 6.9 respectively. But in surface sediment, the concentration of pH in S1, S2 and S3 were 7.4, 7.1 and 7.6, and similarly the concentration of bottom sediment is 7.1, 6.9 and 7.0 respectively. The alkaline soil reaction was noticed in soils contaminated by cement and other industries waste. This might be attributed to the addition of alkali metals like Na and earth metals like Ca & Mg in the discharge from these industries (Srinivasachari et al., 2000). Soil pH is important because it influences the availability and plant uptake of micronutrients including heavy metals (Kirkham 2006). In the ground water, the EC ranged from 240.15 - 364.28 µS/cm while the TDS concentrations ranged from 151.3 - 229.5 mg/l during the study (Figure 2). The ranges of EC in surface sediment and bottom sediment of study area were 635.55 – 903.33 mg/L and 445.07 – 621.42 mg/l, while TDS ranges were 400.4 – 569.1mg/l and 280.4 – 391.5 mg/l, respectively which might be due to waste water effluents of cement industry (Kirkham 2006).

The alkalinity of the soil and water sample is determined by the direct measure of bicarbonate (HCO_3) concentration. The bicarbonate concentration varies between 24.4 and 50.2 mg/l and 73.1 to 176.9 mg/l in water and soil sample, indicating that intense chemical weathering and drained waste materials from various sources are taking place in study during monsoon season. The mean values of Sulphate concentration in water and soil samples were 60.125 and 87.175, respectively. The average concentration of chloride and H_4SiO_4 in the water sample is 7.52 and 4.7, respectively. Chloride is the second major anions after HCO_3 in the aquatic environment. The mean concentration of Sodium and Potassium in the water samples of the study area is 10.55 and 9.85 mg/l. In monsoon, the Ca concentration range from 11 to 38 mg/kg in the surface sediment and 9 to 21 mg/kg in the bottom sediment. Commonly, the anions were highly found in the water and sediment column than cations. Similarly, the same pattern was also reported in our study. Minimum amount of nutrients like Nitrate and ortho-phosphate were present in both the samples. The physiochemical parameters were easily dissolve in nature and were ability to exchange the materials between water and sediment column.

Heavy metals and chemicals are a main group of soil pollutants and their contamination in environment affects all ecosystem components (White and Claxton 2004). Concentrations of various heavy metals in the different water and sediment samples are shown in Figure 3. In water, concentration of Cd was found in the range from 0.09 - 0.38 mg l^{-1} and its minimum concentration was detected in S3W1 and the maximum concentration was in S1W1. For sediment, Cr concentration ranged from below detectable limits (BDL) - 0.025 mg kg^{-1}. Unfortunately, the nil value of trace metals was not observed in any sampling sites as well as both the water and sediment samples. The concentration of Cu in water, surface sediment and bottom sediment ranged from 0.47 - 0.89 mg l^{-1}, 1.25 - 3.35 mg l^{-1} and 0.77 – 1.05 mg kg^{-1}, respectively. The Fe concentrations of water and sediment ranged from 0.9 – 2.18 mg l^{-1} and 1010 - 3560 mg kg^{-1}, respectively. The average Ni concentration in water and sediment was 0.03 mg l^{-1} and 0.17 mg kg^{-1}, respectively. In water, lead (Pb) concentrations were in the range of 0.23 - 0.51 mg l^{-1} with an average of 0.17 mg l^{-1} while in sediment average was 0.21 mg kg^{-1}. The Zn concentration in water was varied from 0.3 - 0.91 mg l^{-1} and the sediment mean value was 4.34 mg kg^{-1}.

Heavy metals such as Cu, Zn, Mn and Fe are essential for plant growth, many of them do not have any significant role in the plant physiology (Shaw 1990). Contaminated sites often support some plant species, which are able to accumulate or tolerate high concentrations of metals such as Pb and Zn (Kumar 1995). A small number of species are capable of growing on soils containing high levels of metals, and also accumulate these pollutants in high concentrations in the parts above ground. These plants are known as hyper accumulators (Brooks et al., 1977). The uptake of these heavy metals by plants is an avenue of their entry into the human food chain with harmful effects on health (Ihekoronye and Ngoddy 1985). The concentrations of metals in the plant samples analysed are reported in Figure 4. Metal contents of plant samples Cd, Cr, Cu, Fe, Ne i, Pb and Zn concentrations are between BDL – 0.1, BDL – 0.02, BDL – 0.6, 0.02 – 0.7, BDL – BDL, BDL – 0.06 and 0.05 – 0.7 mg kg^{-1}, respectively. The metal concentrations in Tiruchirapalli (control site) samples (water, soil and plant) got 2 – 10 fold lower values than the proposed study (Ariyalur) areas. The results indicates that the three different samples from the Ariyalur industrial area shows high level of heavy metals and physiochemical parameters when compare to control site. The presence of these materials would reduce the enzymatic activity of the biota, and in consequence, incompletely decomposed organic material accumulates in the ecosystems.

CONCLUSION

The water/soil and plant samples from three different cement industrial area of Ariyalur were scrutinized for physiochemical/ heavy metal and phytochemical analysis. In this study, the physiochemical and heavy metal parameters were high in surface sediment than bottom sediment and waters. The surrounding environment drained lot of waste materials from the cement factory effluents, gas and other solid wastes. The phytochemical results indicated that the plant samples from the control sites got higher amount of chl a, b, c, amino acid, protein and etc. than Ariyalur site plants. Unfortunately, certain heavy metal levels were higher in plants which are situated nearby industries. The results of pollutions reveal the order of samples are Sediment > water > plant. The samples are interconnected with each other which is being maintained the pollution level until the treatment process and it also causes the biomagnifications on the living things.

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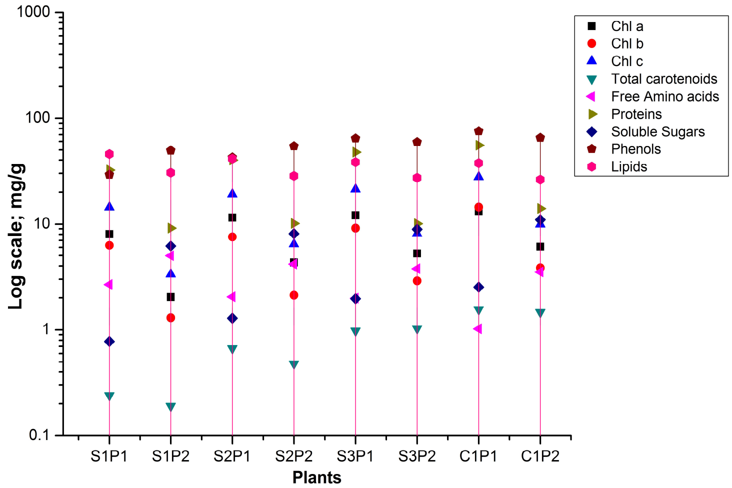

Fig. 1: Concentration of biochemical contents in two different plants during monsoon season

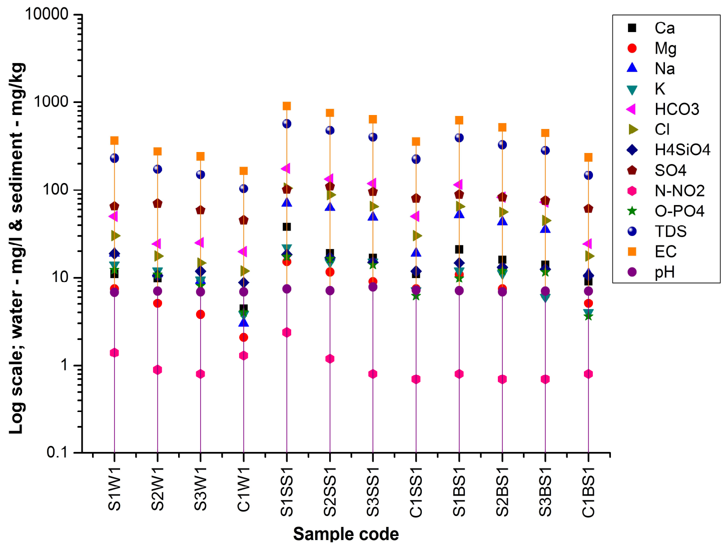

Fig. 2: Concentration of physiochemical parameters in water and sediments during monsoon season

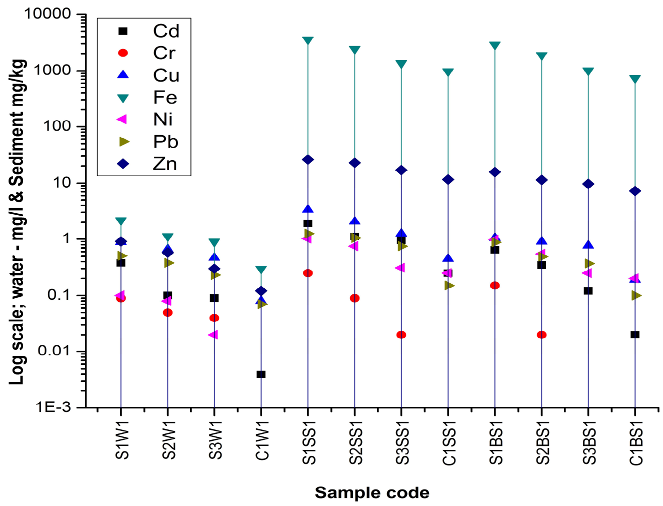

Fig. 3: Concentration of trace metals in water and sediment samples during monsoon season

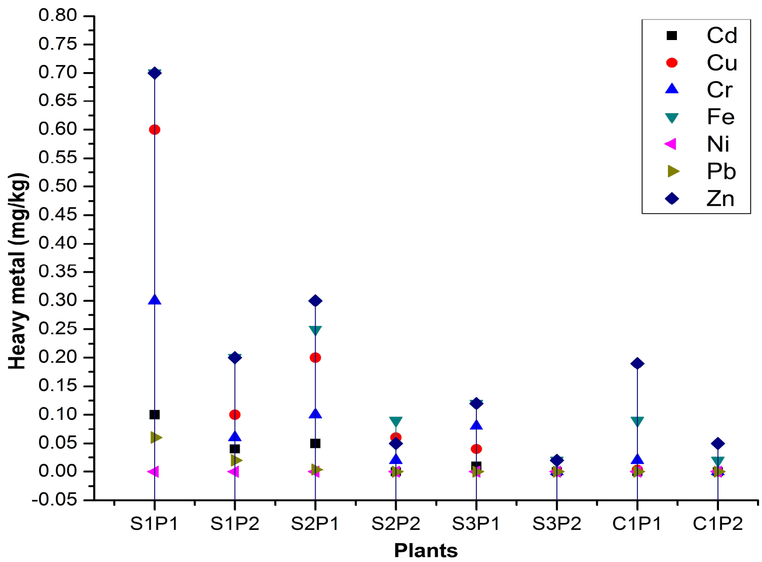

Fig. 4: Concentration of trace metals in two different plants during monsoon season

REFERENCES

1. Brooks RR, Lee J, Reeves RD and JaGre T. Detection of nickeliferous rocks by analysis of herbarium specimens of indicator plants. Journal of Geochemical Exploration.1977;7:49–58.
2. Grantz DA, Garner JHB and Johnson DW. Ecological effects of particulate matter. Environ. Int. 2003;29:213-239.
3. Gupta AK and Mishra RM. Effect of lime kiln's air pollution on some plant species. Pollution Research. 1994;13(1):1-9.
4. Ihekoronye AI and Ngoddy PO. Integrated Food Science and Technology for the Tropics. Macmillan Publishers. 1985;75 – 77.
5. Iqbal MZ and M Shafig. Periodical effect of cement dust pollution on the growth of some plant species. Turk J Bot. 2001;25: 19-24.
6. James RA. Environmental Biogeochemistry of Tamiraparani river basin, South India. Ph.D. Thesis submitted to Anna University, Chennai, 2000.
7. Kirkham MB. Cadmium in plants on polluted soils: Effects of soil factors, hyper accumulation and amendments. Geoderma. 2006;137(1-2): 19-32.
8. Kumar PBAN, Dushenkov V, Motto H and Raskin I. Phytoextraction: the use of plants to remove heavy metals from soils. Environmental Science and Technology. 1995; 29:1232–1238.
9. Larcher W. Physiological plant ecology. Springer-Verlag, Berlin, Germany.1995.
10. Lichtenthaler HK. Chlorophylls and carotenoids Pigments of photosynthetic biomembranes. Methods Enzymol. 1987;148:350-382.
11. Mishra GP and Tiwari SB. Effect of Cement dust on the human population Indian J Envoron Protection. 6:92-94.
12. Panda AKS Murlidhar J and Shahoo BN. Seasonal water quality assessment of jajang Iron and mining area Jr. of Industrial pollution control 1996;12(1):9-14.
13. Prasad MSV Subramanian RB and Inamdar JA. Effect of cement kiln dust on Cajanus cajan (L.) Mill. Species. Indian Jr Environ Hlth. 1991;33:11-21.
14. Samal AC and SC Sautra. Air quality of Kalyani township and its impact on surrounding vegetation. Indian J Environ Hlth. 2002;44:71-76.
15. Saralabai VC. Effect of cement kiln exhaust (Electrostatic precipitator dust) on growth, root nodule biochemistry and crop productivity in legumes through simulation studies Ph.D thesis. Bharathidasan University. Thiruchirapalli. 1993.
16. Saralabai VC and Vivekanadau M. Effect of application cement kiln -exhaust or selected soil phyico-chemical and biological properties. Fert Res. 1995;40:193-196.
17. Schuhmacher MJL, Domingo and J Garreta. Pollutants emitted by a cement plant: health risks for the population living in the neighborhood. Environ Res. 2004; 95: 198-206.
18. Shaw AJ. Heavy Metal Tolerance in Plants: Evolutionary Aspects. CRC Press, Boca Raton, FL, 1990.
19. Srinivasachari MM, Dhakshinamoorthy G and Arunachalam. Accumulation and availability of Zn,Cu,mn& Fe in soils polluted with waste water. Madras Agric J. 2000; 87:237-240.
20. White PA and LD Claxton. Mutagens in contaminated soil:a review. Mutation Research- Reviews in Mutation Research. 2004;567:227-345.
21. Zerrouqi ZM, Sbaa M, Oujidi M, Elkharmouz S, Bengamra and Zerrouqi A. Assessment of cement's dust impact on the soil using principal component analysis and GIS. Int J Environ Sci Tec. 2008;5:125-134.