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Heavy metals contamination in roadside soil near different traffic signals in Dubai, United Arab Emirates

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Abstract The present research was conducted to study heavy metal contamination in roadside soil viz. (i) at sites having more than two traffic signals (ii) roads having only one traffic signal and (iii) roads having no traffic signals. The samples were collected and analyzed for seven heavy metals i.e. cadmium (Cd), lead (Pb), copper (Cu), nickel (Ni), iron (Fe), manganese (Mn) and zinc (Zn) by Atomic Absorption Spectroscopy (AAS) following the acid digestion of the respective soil samples. The range of the metals observed in soil having more than two traffic signals were Cd (0.17–1.01), Pb (259.66–2784.45), Cu (15.51–65.90), Ni (13.31–98.13), Fe (325.64–5136.37), Mn (57.95–166.43), and Zn (91.34–166.43) mg kg^{-1} respectively. Similarly, the range of metals analyzed in samples collected from the roadside having only one traffic signal were Cd (nd–0.80), Pb (145.95–308.09), Cu (0.82–18.04), Ni (18.29–59.36), Fe (88.51–3649.42), Mn (25.88–147.34) and Zn (8.97–106.11 mg kg^{-1}) respectively. However, the range of metals at roads having no traffic signals were Cd (0.0–0.57), Pb (8.34–58.20), Cu (2.88–5.81), Ni (3.34–73.80), Fe (55.34–332.81), Mn (2.98–98.73) and Zn (1.23–46.6 mg kg^{-1}) respectively. Cd, Cu, Ni, Fe, Mn and Zn in soil were present within the normal range of background levels, whereas lead was reported in high concentration. The level of lead had a correlation with the traffic density attributing its origin to vehicular exhaust. The values

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from three different sites of monitoring suggest that automobiles are a major source of the studied metals for the roadside environment.

1. Introduction

Heavy metals enlist a relatively large series of elements with specific density over 5 g cm^{-3} and relative atomic mass above 40. Environmental pollution by metals became extensive with the fillip in mining and industrial activities during the last two centuries. The current worldwide mine production of Cu, Cd, Pb and Hg is considerably huge (Jarup, 2003). These pollutants, ultimately derived from a growing number of diverse anthropogenic sources, have had enormous impact on different ecosystem (Macfarlane and Burchett, 2001; 2002). Fifty-three of the ninety naturally occurring elements are heavy metals (Weast, 1984). Of these, Fe, Mo and Mn are important as micronutrients, while Zn, Ni, Cu, Co, Va and Cr are toxic elements, but have importance as trace elements. Ag, As, Hg, Cd, and Pb have no known function as nutrients, and seem to be toxic to plants and microorganism (Nies, 1999). The majority of the heavy metals are toxic to the living organism and even those considered as essential can be toxic if present in excess. The heavy metals can impair important biochemical process posing a threat to human health, plant growth and animal life (Jarup, 2003; Silva et al., 2005; Ali et al., 2008; Yoshinori et al., 2010). Studies have shown that such pollutants can be harmful to the roadside vegetation, wildlife and the neighboring human settlements (Muskett and Jones, 1980; Khan and Frankland, 1983; Ndiokwere, 1984; Iqbal et al., 1994; Ferretti et al., 1995; Turer and Maynard, 2003; Nakayama et al., 2010).

The pollution of soils by heavy metals from automobile source is a serious worldwide environmental issue. These metals are released during different operations of the road transport such as combustion, component wear, fluid leakage and corrosion of metals. Lead, cadmium, copper and zinc are the major metal pollutants of the roadside environments and are released from burning of fuel, wearing out of tyres, leakage of oils, and corrosion of batteries and metallic parts such as radiators etc. (Akbar et al., 2006; Dolan et al., 2006; Baker et al., 2007; Yoshinori et al., 2010). It has also been vastly documented that rapid industrialization, increasing vehicular traffic and application of fertilizers result in the release of large quantities of metals in the biosphere (Motto et al., 1970; Turer and Maynard, 2003). In soil, metal concentration is mainly influenced by the industrial activity or by the application of sewage sludge. However, in urban areas automobile exhaust is one of the potent contributions especially of lead (Fergusson, 1991). The toxicity of lead and its chronic effect on human and its immediate effect on the environment have been extensively studied including deposition and accumulation (Baker and Senft, 1995; Nakayama et al., 2010). Therefore, the present study was undertaken to study the heavy metals (cadmium, lead, copper, nickel, iron, manganese and zinc) contamination in soil near the roadside traffic, to check, whether the heavy metals exist within the range tolerance limit or not.

2. Experimental

2.1. Study material

Twenty two sites at roadsides covering major areas of Dubai city were selected for sampling of the present study i.e. roadside soil having more than two traffic signals (1–6), roadside soil having only one traffic signal (7–11) and roadside soil from the roads having no traffic signals (12–22). At each point four surface soil samples were collected within 5 m distance. In each case, the surface soil was scraped into a plastic bag using a steel spatula. Samples were air dried and sieved through 2 mm screen.

2.2. Sample preparation

One-gram of air dried soil was placed in 50 ml beaker with 5 ml of concentrated nitric acid and heated at 95–100 °C for 30 min followed by adding a 5 ml mixture of concentrated nitric and perchloric acid (3:1 v/v) and heated again. After proper digestion, the digest was made up to 50 ml with deionised water.

2.3. Standard preparation

Seven heavy metals were selected for the analysis including; Cd, Pb, Cu, Ni, Fe, Mn and Zn. The standard used for the atomic absorption analysis of these metals was multi- elements system, which was prepared from the stock standard (BDH spectrosol, UK) by appropriate dilution with 0.5 N nitric acid.

2.4. Atomic absorption analysis

A GBC atomic absorption spectrometer (model, 906) fitted with an eight lamp turret, equipped with a graphite furnace and an auto sampler was employed for the analysis, using Avanta Sigma software.

2.5. Statistic analysis

The data on analysis of seven heavy metals at various points near roadside soil were analyzed by one way analyses of variance (ANOVA).Values are means of four replicates from two experiments, and the presented mean values were separated using Duncan's Multiple Range Test (DMRT) at $p \geqslant 0.05$.

3. Results and discussion

In the present study, monitoring on selected heavy metals was carried out in soil especially near the roadside sites.

3.1. Sites having more than two traffic signals

Results showed a significant variation of metal concentrations in soils. The maximum and minimum concentration of heavy