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Impact of road, petrol filling station and industries on heavy metal content in nearby soil

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Abstract

The pollution of soils by heavy metals from automobile sources is a serious 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 fuel burning, wear out of tyres, leakage of oils, and corrosion of batteries and metallic parts such as radiators etc. The majority of the heavy metals are toxic to the living organisms and even those considered as essential can be toxic if present in excess. The heavy metals can impair important biochemical processes posing a threat to human health, plant growth and animal life. The distribution of these metals in the roadside soils is strongly but inversely correlated with the increase in the distance from road. Soil is the critically environmental medium, which is subject to a number of pollutants due to different human activities. The ongoing rapid economic boost has put a great burden on soil. With the increasing demand for metals during the course of industrialization and urbanization, more and more pollutants containing heavy metals has become widespread.

Keywords: pollutant, heavy metal, roadside, industry

Introduction

An increase in heavy metal deposition in agricultural soils and crops are observed due to transport of heavy vehicles, petrol filling stations, industrial activities etc. near the agricultural farm [8]. The growth of urbanized regions is occurring worldwide, and, as a result, research in the area of soil contamination by heavy metals has become increasingly important. Significantly large concentrations of toxic metals not only diminish soil quality, but also can lead to human intake. Total concentrations of metals in soils are a poor indicator of metal toxicity since metals exist in different solid-phase forms that can vary greatly in terms of their bioavailability [15-21]. Therefore, the determination of total soil metal content alone is not a good measure of bioavailability and not a very useful tool to quantify contamination and potential environmental and human health risk [21]. The biological uptake and their eco-toxicological effects on the soil biota can be better understood in terms of their chemical speciation.

The speciation of heavy metals exerts strong influences on the mobility, bioavailability and toxicity of heavy metals in contaminated soils. Among other techniques available to estimate the geochemical partitioning of heavy metals in soils, sequential extraction procedure has been widely accepted [4] and it is widely recognized as a useful tool for determination of different chemical or binding forms of heavy metal [20].

Heavy metal contamination of soil by different sources

A research work was carried by [19] to study the heavy metals pollution assessment in industrial area soil of Mysore city, Karnataka, India. In this research work it was revealed that the heavy metals concentration was at the nearby maximum level. The results shows that iron level ranges from 2.5gm/kg to 6.7gm/kg, chromium occur in range of 6.6mg/kg to 22.0mg/kg, copper varies from 6.8mg/kg to 20.3mg/kg whereas zinc found in range of 66mg/kg to 121 mg/kg and nickel was found in a range of 10mg/kg to 18.1mg/kg.

Heavy metals in soils and agricultural products near an industrial district in Dongguan City (China) and reported that except for Zn in one sample and Cd in five samples, the majority of the samples were notably enriched by heavy metals compared with background values. Among these soil samples, concentrations of Cu, Zn, Cd, and Hg in 20.6%, 8.8%, 29.4% and 38.2% soil samples, respectively, exceeded Chinese maximum allowable concentrations (MAC) for agricultural soil [13].

An attempt was made by [10] to study the heavy metal concentration in soils around oil filling and service stations in the Tamale Metropolis, Ghana. Thay found the metal concentrations ranged from 2.37 to 4.93 to 74.20 mg/kg for Pb; 3.2 to 22.68 mg/kg for Cu; 0.01 to 0.03 mg/kg for Hg; 0.12 to 6.63 mg/kg for Cd and 15.00 mg/kg for Cr. To identify possible levels of pollution from anthropogenic sources a mathematical models were employed: Index of geoaccumulation (Igeo), enrichment factors (EF), contamination factor and degree of contamination. The enrichment factor places the elements in a decreasing order of their concentration as Cd > Pb > Cr > Cu > Ni> Fe > Zn > As > Hg > Mn that agreed with others mathematical models also. Enrichment factor values of chromium (Cr), copper (Cu), lead (Pb) and manganese (Mg) was ranging from 2-5 signifying moderate enrichment. The study showed that soil contamination by the heavy metals originated from a common anthropogenic source such as the oil filling activities, brake wear, tyres wear and corroded vehicles engine materials contribute one or two correlated metals to the natural environment.

Heavy metal profile in various soil samples of Amritsar and its genotoxic potential. They observed that due to agro-climatic conditions, anthropogenic activities, presence and distribution of heavy metals is inevitable, therefore, their assimilation in soil is very likely. They reported that Fe content was the one of the predominant heavy metal in soil (2809- 5692 mg kg^{-1}) followed by Zn (73-320 mg kg^{-1}), Mn (154-194 mg kg^{-1}), Pb (7.7-118 mg kg^{-1}), Ni (9.67-24.32 mg kg^{-1}), Cu (8.4-24 mg kg^{-1}) and Cd (0.44-1.39 mg kg^{-1}). They concluded that all the samples were found to cause severe genotoxicity. Hence, it may create a health alarm to the all farmers as well as the consumers of different food crops/fruits/vegetables those are being consumed directly to meet the food needs and such studies are useful to estimate the level of metal contamination in agriculture soil to assure crop quality [6].

Soil nutrient and heavy metal concentrations in agricultural land of Zirani industrial area (Dhaka) and reported that Cu and Pb concentration were relatively higher than their recommended value in soil. The abundance order of heavy metal content in soil samples were Pb>Cu>Zn>Cd which indicated that the concentration of these heavy metals were harmful for the environment and human life [17].

Heavy metal pollution of the soils around the mining area near Shamlugh town and related risks to human health were assessed. The investigations showed that the soils were polluted with heavy metals that can be ranked by anthropogenic pollution degree as follows: Cu>Pb>As>Co>Ni>Zn. The main sources of the anthropogenic metal pollution of the soils were the copper mining area near Shamlugh town, the Chochkan tailings storage facility and the trucks transferring ore from the mining area. Copper pollution degree in some observation sites was unallowable for agricultural production. The total non-carcinogenic chronic hazard index (THI) values in some places, including observation sites in Shamlugh town, were above the safe level (THI<1) for children living in this territory. Although the highest heavy metal enrichment degree in the soils was registered in case of copper, however, the highest health risks to humans especially children were posed by cobalt which is explained by the fact that heavy metals have different toxicity levels and penetration characteristics [12].

Heavy metal concentrations in soils adjoining some refined petroleum products facilities in Ado-Ekiti, Nigeria reported the sequence of heavy metal contamination in the samples in the order: mechanical workshops (1356±356 µg/g) > generator houses (1241.3±121.8 µg/g) > petrol filling stations (1147.3±66.4 µg/g). He further observed that the average concentrations of individual metals ranged from 1.2 to377.7 ug/g in all the soil samples. He concluded that stringent measure be taken by the environmental protection agency in the state to regulate the activities of individual/organizations handling refined petroleum products in the city. Hao and Jiang (2015) while analyzing the heavy metal concentrations in soils and plants in Rongxi Manganese Mine of Chongqing, Southwest of China, showed that the total Mn, Cd, Cu, Pb and Zn concentrations were up to 48,383, 3.91, 79.97, 80.68 and 131.23 mg kg^{-1} respectively, indicating that the mine soils were polluted by these five metals [11].

A study involved a laboratory based analysis of soil samples collected in the neighbourhood of five fuel filling stations systematically selected during the study. Two local government areas were randomly selected for the study, they were split into five natural clusters and soil samples were purposively collected from the neighbourhood of one fueling station per cluster. Topsoil (0-15cm deep) and subsoil (15-30cm deep) samples were collected at 5m, 10m, and 20m intervals away from the fuel filling stations. Samples were analyzed for benzene, toluene, ethyl-benzene, xylene, lead, and chromium using standard methods. Results were compared with Canadian and United Kingdom standards. Results were analyzed using descriptive statistics and were compared with the Canadian (monocyclic aromatic hydrocarbon) soil quality guideline limit for human health and the UK heavy metal guideline limit for soil in residential areas. Apart from xylene, the mean concentration of benzene, toluene, and ethyl-benzene were approximately 600 times higher than the Canadian limit both for topsoil and subsoil. Fortunately, mean concentrations of lead and chromium in all soil samples were insignificant compared with the UK limit. The study showed that there is contamination of the soil in the study area with some monocyclic aromatic hydrocarbons namely benzene, toluene, and ethyl-benzene while there are no potential threats with regards to heavy metal contamination [10].

In a study on physico-chemical properties and heavy metal contents of soils and *kharif* crops of Punjab (India) [5] reported that the contents of heavy metals (Cr, Cu, Cd, Co and Pb) analyzed in soil samples were below the maximum permissible limits, but Cr, Cd and Pb contents were above maximum permissible limits in sugarcane and sorghum.

The heavy metal contamination long a major highway bisecting the panda's habitat and analyzed that the potential ecological risk index of this area was very high degree of ecological hazards due to serious Cd contamination. And, the hazard quotient indicated that Cd, Pb, and Mn especially Cd could pose the health risk to giant pandas. Multivariate analyses demonstrated that the highway was the main source of Cd, Pb, and Zn and also put some influence on Mn. The study has confirmed that traffic does contaminate roadside soils and poses a potential threat to the health of pandas. This should not be ignored when the conservation and management of pandas is considered [22].

The soils *and leaves of Eucalyptus camaldulensis* in different areas at Baghdad were investigated. The results showed a significant difference in the concentrations between soil and plant part. Heavy metal contents in the soil and plant leaves were found in the following manner: lead > nickel > cadmium. The soil from Al-Záfaranya had the higher concentration of lead and cadmium. While, Jisr Diyala soil sample was higher in nickel. According to Eu Standards, concentration of Pb and Cd were found above the acceptable limits in the soil sample. While the concentration of Ni were within the recommended limit [1].

A research work was conducted to study heavy metal contamination in roadside soils of northern England [3]. All soil samples showed that there was a significant decrease in the roadside soils with we move away from the side of the road. The highest concentrations of heavy were detected in the samples collected from the border zone of road and there was a trend of gradual decrease in the heavy metal contents with the increasing distance from the paved roads [14].

Heavy metal concentrations of Pb, Cd, Zn, Cu, Ni and Cr in soil solutions from three different distances (2.5, 5 and 10 m) from the side of the highway and took three soil depths (10, 30, and 50 cm). The results show that heavy metal concentrations were up to 20 times increased compared to the geochemical background levels and a reference site of 800-m distance from the roadside [14].

A study was conducted by [16] to check the levels of lead, cadmium, and nickel in roadside vegetables and soils along a major highway in Ghazipur, Bangladesh. Soil and plants samples were collected at distances of 0, 50, 100, and 1000 m (meter) from the edge of road. The concentrations of nickel (Ni) and lead (Pb) in vegetables and soils (bottle gourd and pumpkin) decreased with distance from the road, indicating their relation to traffic emissions. On the other hand concentration of cadmium (Cd) was independent to distance from road.

A study on total metal content in this study, the ranges and mean concentrations (μg/g) of metals in the soil samples were 4.00-4.80 (4.37±0.27), 1.07-1.85 (1.51±0.26), 41.40-68.13 (58.00±7.13),200.67-295.33 (260.00±32.30), 14.00-19.83 (17.13±1.94), 216.00-276.67 (242.67±18.29) and 100.33-162.33 (134.75±21.93) for Cd, Co, Cu, Mn, Ni, Pb and Zn respectively. The concentration of Pb was the highest. The degree of contamination by each metal was estimated by the enrichment factors. The enrichment factors obtained for Cd, Co, Cu, Mn, Ni, Pb and Zn in fuel filling stations were 15.46, 1.87, 3.20, 1.80, 1.96, 73.74 and 13.43, respectively. The inter-element correlation was found among metals in the soils of fuel filling stations using Pearson's correlation co-efficient. There were positive correlations among the metals determined. Metals such as Pb, Cd, and Zn shows high degree of contamination, while Co, Cu, Mn and Ni shows low degree of contamination in the study sites [7].

The concentrations of all the metals in the four sampling sites decreased exponentially with distance from the edge of the road and dropped to the minimum levels at about 60 meters [2]. The affinity and exponentially decreasing concentration with distance from the edge of the road suggest that automobiles are a major source of these metals in the roadside soils. Use of leaded gasoline and tire erosion gives a boost to this claim [18].

The study reported by [10] to assess soil contamination with mono-cyclic aromatic hydrocarbons and heavy metals in residential areas situated close to (1-20m range) fuel filling stations in Ibadan metropolis, Nigeria. The study involved a laboratory based analysis of soil samples collected in the neighbourhood of five fuel filling stations systematically selected during the study. Two local government areas were randomly selected for the study, they were split into five natural clusters and soil samples were purposively collected from the neighbourhood of one fuelling station per cluster. Topsoil (0-15cm deep) and subsoil (15-30cm deep) samples were collected at 5m, 10m, and 20m intervals away from the fuel filling stations. Samples were analyzed for benzene, toluene, ethyl-benzene, xylene, lead, and chromium using standard methods. Results were compared with Canadian and United Kingdom standards. Results were analyzed using descriptive statistics and were compared with the Canadian (monocyclic aromatic hydrocarbon) soil quality guideline limit for human health and the UK heavy metal guideline limit for soil in residential areas. Apart from xylene, the mean concentration of benzene, toluene, and ethyl-benzene were approximately 600 times higher than the Canadian limit both for topsoil and subsoil. Fortunately, mean concentrations of lead and chromium in all soil samples were insignificant compared with the UK limit. The study showed that there is contamination of the soil in the study area with some monocyclic aromatic hydrocarbons namely benzene, toluene, and ethyl-benzene while there are no potential threats with regards to heavy metal contamination.

The general decrease in concentrations of metals with distance from the highway indicates their relation to traffic. Higher concentrations of metals have been observed in soil samples near to the highway (0-5 m) than in soil samples from sites a little farther away (5-10 m, 10-15 m). These indicate that the deposition of heavy metal is maily aerial deposition [9].

Toxic metals derived from road abrasion, vehicle emission, and the wear of vehicle parts could be transported to roadside soils via spray, surface water runoff, or wind dispersal which decrease as the distance from the road increase. Concentrations of all metals except as exceeded background levels, and concentrations of Cu, Zn, Mn, Pb, and Cd decreased significantly with increasing distance from the highway. Geo-accumulation index indicated that topsoil next to the highway was moderately contaminated with Pb and Zn, whereas topsoil up to 300 m away from the highway was extremely contaminated with Cd [22].

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