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DETERMINATION OF HEAVY METALS CONCENTRATIONS IN DUST ON ISLAMABAD HIGHWAY

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Street dust is generally composed of automobile exhaust gas originated particles and wind-transported particles. Heavy metals, such as Pb, Cu, Mn, Zn, Cd, Co and Ni are noteworthy for environmental pollution and are found in street dust. Fifteen street dust and two soil samples were collected from six different localities on Islamabad highway, which is a 25 km long road connecting Rawalpindi, a major city of Pakistan to the federal capital, Islamabad. Samples were prepared by the Leeds Public Analyst method. The samples were analyzed for Cu and Zn using AAS. Analysis was also carried out by Instrumental Neutron Activation Analysis using the sample in solid form. The initial results for a sample at Zero Point are presented in this paper. From these initial results it was found that Cu is above permissible limits.

Keywords: Air pollution, Heavy metals, Islamabad highway, Street dust, INAA, AAS

1. Introduction

Heavy metals normally have atomic weights between 63 and 201 amu and specific gravity above 5.0. Street dust makes a significant contribution to pollution in the urban environment. Street dust consists of vehicle exhaust, sinking particles in air, soil dust, house dust and particles carried by water. Such contaminants may cause Lead toxicity, asthma, greenhouse gas accumulation and obesity[1]. Many studies on street dust have paid attention to the elemental concentrations of street dust [2-6].

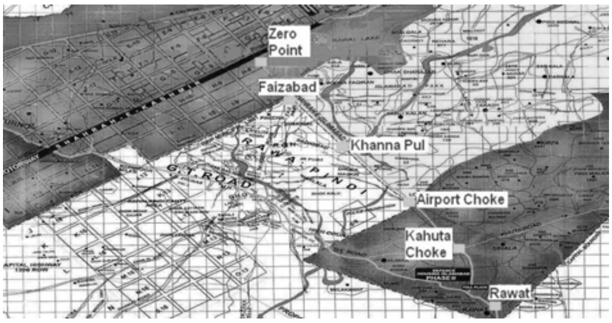

Figure 1. Sample locations on Islamabad High Way.

Out of the three materials, soil, sediment and dust, which originate primarily from the earth's crust, dust is the most pervasive and important factor affecting human health and well being. Street dust, a product of our life style, originates from interaction of solid, liquid and gaseous materials produced from different sources [7].

Urban systems are highly sophisticated and complex. Contamination with the heavy metals is of major concern because of their toxicity and threat to human life and the environment. People have tried to measure the heavy metal distribution in dust, street dust and soils separately [2]. In such studies, the source of metals in road dust normally comes out to be from non-soil derived elements namely from vehicular emissions and industrial sources [6].

The objectives of the present study were to determine the average concentrations of some heavy metals i.e. (Cd, Zn, Pb, Ni, Cu, and Co) in the street dust samples collected from six different localities on Islamabad Highway (Figure-1); to define their natural or man made activities contribution in the environment; to check whether the metals concentration is in the permissible limits for human health; and to compare the results of polluted area samples with the unpolluted samples. Permissible levels for some heavy metals are given in Table 1.

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Table. 1. Acceptable values of some heavy metals [8].

Metals	Acceptable values (mg / Kg)
Lead	100
Cadmium	3
Chromium	100
Copper	50
Nickel	50
Mercury	2
Zinc	300
Boron	25
Cobalt	50
Molybdenum	5
Selenium	3
Arsenic	20
Titanium	500
Vanadium	50
Uranium	5

2. Materials and Methods

To our knowledge, no work has been done in this area either to investigate heavy metal pollution or their fractionation. Islamabad highway is the busiest and the most heavy traffic laden roadway of Islamabad. Therefore a large number of passengers are exposed to its environment. An industrial estate is also present at different sites along this road. These include brick kilns, cement industry, pharmaceuticals and other industries as well as some green areas. Islamabad Highway is located about 20 km south of Islamabad city. This region is a rapidly developing area, and is considered a major work place.

Samples from six selected locations were collected between Zero Point to Rawat on Islamabad Highway. The locations were Zero Point, Faizabad, Khanna Bridge, Airport Chowk, Kahuta Road junction and Rawat. The sampling sites are shown in figure-1.

Large quantities of (0.5 Kg) road dust samples were collected from Islamabad Highway road side. The material was dried, ground and sieved through 0.125 mm stainless steel sieve (ASTM standard 120). These samples were used for INAA. For AAS, Leeds Public Analyst Method was used.

2.1. Procedure for INAA

About 200 mg road dust samples in duplicate along with control materials IAEA-Soil-7 (S-7), IAEA-Lake Sediment (SL-1) and IAEA-Marine Sediment (SD-M-2/TM) were packed in labeled polythene capsules. These were packed in polyethylene rabbits.

The sealed targets were loaded and sent for five hours irradiation in the Pakistan Atomic Research Reactor-II (PARR-II), which is a 27 kW, Miniature Neutron Source Reactor (MNSR) with a thermal neutron flux of 1×10^{12} $cm^{-2}s^{-1}$. The irradiated samples, after the desired cooling times (2 weeks), were transferred to pre-weighed fresh polyethylene capsules and counted in accordance with the optimized counting scheme (2 hours) using a high purity germanium detector (Canberra Model AL-30) hooked to PC-based Intertechnique Multichannel Analyzer (MCA). “Intergamma, version 5.03” software was used for data acquisition. The system has a resolution of 1.9 keV at 1332.5 keV peak of ^{60}Co and peak to Compton ratio of 40:1. The data files were subjected to calculations on our validated in-house computer programs. All necessary corrections (background subtraction etc) were applied and the final results obtained on dry weight basis. The dry weights were obtained by drying a sub-sample (not taken for analysis) at 105°C for 24 hours. Error propagation rules were applied at each stage of the calculation and accounted for the uncertainties in peak area and in weighing.

2.2. Procedure for AAS

2.2.1. Leeds Public Analyst Method [9]

According to Leeds Public, the samples were dried at 100 °C and sieved through a 0.125-mm (120 mesh ASTM) stainless steel sieve. One gram of the sieved sample was ashed for 30 min. at 350°C, and then refluxed for 15 min with 25 ml of 25% HNO_3. The solution was cooled, filtered and diluted to 100 ml with distilled water and analyzed by atomic absorption spectroscopy.

Varian SpectrAA 300 was used for the measurement of metals for AAS using an air/acetylene flame. The operating parameters for Cd, Co, Cu, Ni, Pb and Zn metals were set as recommended in the operation manual of the manufacturer. Solvents and chemicals were analytical reagent grade (Merck, Darmstadt, Germany). All stock solutions of the metals (1000 mg L^{-1}) were prepared from solutions provided by Fisher Scientific International Company.

The technique of flame atomic absorption spectroscopy (FAAS) requires a liquid sample to be aspirated, aerosolized, and mixed with combustible gases. During combustion, atoms of the element of interest in the sample are reduced to free, unexcited ground state atoms, which absorb light at characteristic wavelengths. The reduction of the light intensity due to absorption by the analyte can be directly related to the amount of the element in the sample. During measurement the following interference were taken in to account for a true representative reading; Chemical Interference (analyte metal forms bond with an anion which does not dissociate in flame), Spectral Interference [absorption line of matrix component (other metal) overlaps], Physical Interference [differences in viscosity or surface tension (samples/ standards)], Ionization Interference (high-temperature environment can also lead to ionization of the analyte atoms).

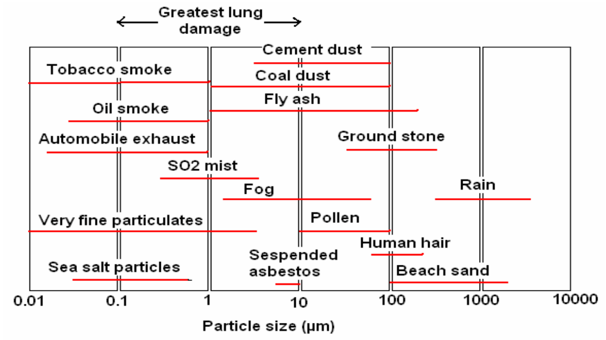

Figure 2. Particle sizes for most common species in atmosphere [9].

3. Results and Discussion

This work was carried out as part of MS Nuclear Engineering project. In this report the initial results of one sample, namely, sample-1 collected from Zero Point are presented. As the samples were passed through a mesh of 0.125 mm therefore the particle size is <125 µm. From figure-2 it can be seen that automobile exhaust, very fine particulates, cement dust and coal dust lie in this particle range.

The analysis was carried out using INAA and AAS. From Table 2 it can be seen that twenty one trace elements were determined in sample 1 using INAA. The elemental interferences for most of the elements were eliminated by variation in irradiation, cooling and counting times. Nuclear interferences were found to be negligible as the fast flux in MNSR type of reactor is very low.

Table 2. Concentration of different elements measured by INAA for zero point sample.

Element	Concentration (ppm)	S.D	Relative standard deviation (%)
Nd	36.97	2.57	6.95
Yb	2.16	0.37	17.13
Lu	0.31	0.07	22.58
Eu	0.73	0.098	13.42
Ce	61.07	2.62	4.29
Sn	13.69	3.42	24.98
Hf	6.87	0.55	8.01
Th	11.12	0.75	6.74
Cr	85.94	8.35	9.72
Sr	423.33	----	20.5
Zr	185.07	----	67.5
Mo	0.64	0.05	7.81
Cs	2.60	0.03	1.15
Sc	8.53	0.65	7.62
Rb	56.56	0.93	1.64
Fe	2.65 (%)	0.02	0.75
Zn	136.38	0.45	0.33
Co	8.79	0.43	4.89
Tb	0.54	0.10	18.52
Ta	0.73	0.26	35.62
Sb	1.83	0.46	25.14

The results shown in Table 2 clearly indicate that this area is heavily contaminated with heavy metals which can become suspended after the passage of speedy vehicles. Moreover the suspended matter containing heavy metals can be ingested by humans [10]. Closer inspection of the results shows that the RSD values for some elements, i.e. Yb, Sn and Lu are very high. The reason behind this is that standards (IAEA-SL1, IAEA-S7 and IAEA- SD-M-2/TM) were used for quantification and their concentrations for these elements have been cited with high uncertainties by the IAEA [11-13]. The RSDs for Sr and Zr are very high as the concentrations cited for these elements in the IAEA certificates are information values which are not as reliable as certified values.

Some elements such as Cd, Cu, Ni, Pb etc cannot be determined using INAA. These were studied using AAS. Figures 3 and 4 show the calibration plot for Zn and Cu which are the elements determined so far in this sample.

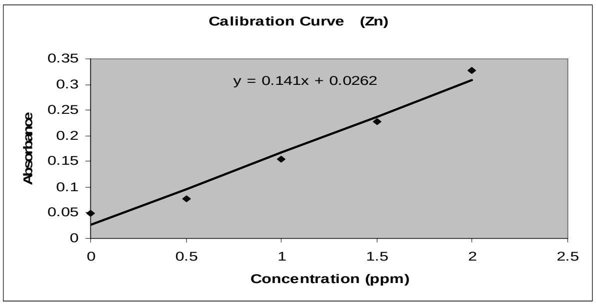

Figure 3. Calibration curve for Zn.

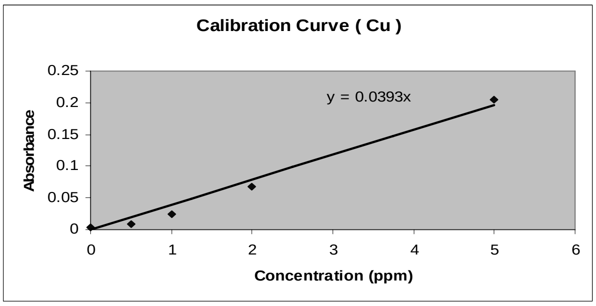

Figure 4. Calibration curve for copper.

In the sample studied, concentration of Zn as measured by AAS is 133 ppm, which is comparable with the results of INAA for the same sample i.e. 136 ppm (Table II). Concentration of Cu which has only been determined using AAS in the same sample is found to be 60 ppm. When we compare the results of Zn, Mo, Co and Cu, with the data for permissible levels given in table I we find that Zn, Co, Mo concentration is within limits, while the Cu concentration is high. Therefore it may be hazardous to human health. The initial results show that both INAA and AAS provide useful information regarding the composition of road dust. Therefore the results of the remaining 14 road dust and 2 clean soil samples should provide information regarding the pollution status of the area surrounding Islamabad Highway.

4. Conclusions

In this work the initial results for road dust collected at a site at Zero Point are presented. Twenty one elements were determined using INAA while Cu and Zn were determined by AAS. The results for Zn obtained by both techniques were found to be comparable. The concentration of Cu was found to be slightly above the permissible levels.

The results for remaining sites are required in order to determine whether concentrations of these elements vary for each location and the possible reasons for such variations. Moreover the study of road side soil pollution must be carried on periodic basis and the policies and the National Environmental Quality Standards (NEQS) is based on such solid grounds. Vehicles with catalytic converters must be encouraged and the vehicles and industries whose emissions exceed the NEQS must be brought to justice at the soonest.

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