DETERMINATION OF CONCENTRATION OF SOME HEAVY METALS IN ROADSIDE DUST IN DAMATURU METROPOLIS WHICH CAUSES ENVIRONMENTAL POLLUTION

P. C. VERMA

Department of Chemistry, Yobe State University, Damaturu, Nigeria
E-mail: drpcverma51@gmail.com

Abstract- Concentration of heavy metals (iron, lead, chromium and cadmium) was determined in road side dust samples. Roadside dusts were randomly collected from five roundabouts in Damaturu and digested. The digested sample solutions were analyzed using LaMotte smart spectrophotometer V2.0.11.04, 2000 model, U.S.A., for the determination of concentrations of Pb, Cd, Cr and Fe. Replicate analyses were carried out on each of the sample. Concentration of iron was found to be the highest in the samples collected, followed by cadmium, chromium, and lead in that order. Although, the main source of these heavy metals is the exhaust from motor vehicles. Other sources, such as roadside deposition of motor engine oil, battery wastes, car tires, use of metal containing pesticides to protect road side grasses, trees and flowers, the presence of iron benders, welders and electricians discharging metals with the environment and indiscriminate dumping of refuse on the roadside could also contribute significantly.

Keywords- Heavy Metals, Roadside Dust, Spectrophotometer And Damaturu.

I. INTRODUCTION

Dusts are tiny solid particles scattered or suspended in the air. The particles are “inorganic” or “organic”, depending on the source of the dust. The inorganic dusts can come from grinding metals or minerals such as rock or soil, example are silica, asbestos, and coal. The organic dusts originate from plants or animals; an example of organic dust is dust that arises from handling grain. These dusts can contain a great number of substances. Aside from vegetable or animal component, organic dusts may also contain fungi or microbes and the toxic substances given off by microbes. In some cities atmospheric dust also contains a large number of smoke particles and tarry soot particles. In an industrial city the air may contain more than 3 million particles per cu cm (more than 50 million per cu in), but above the middle of the ocean or in high mountains the count may be just a few thousand per cu cm. The size of dust particles varies from about half a micrometer to several times this size. The particles remain suspended in the air for long periods of time and may be carried great distances.

Atmospheric dust has two important physical properties: its ability to scatter light of short wavelengths and its ability to serve as nuclei for the condensation of water vapor. Mist, fog, and clouds would never occur but for the presence of dust particles in the air. The heavy concentration of dust in the air over large cities is a serious pollution problem. In places such as flour and sugar mills and coal mines a concentration of flammable particles constitutes an explosion hazard. Silica particles in dust are destructive to machinery because of their hardness; they can also be injurious when inhaled. Dust deposits and accumulates on ground surfaces, along roadsides, are called road dust, which is contaminated by heavy metals and organic matters. Anthropogenic sources of heavy metals in urban road dusts include traffic emission (vehicle exhaust particles, tire wear particles, weathered street surface particles, brake lining wear particles), industrial emission (power plants, coal combustion, metallurgical industry, auto repair shop, chemical plant, etc.), domestic emission, weathering of building and pavement surface, atmospheric deposited and so on [1-3].

Road dust does not remain deposited in place for long. It is easily re-suspended back into the atmosphere, where it contributes a significant amount of trace elements. Two main sources of road dust, and consequently of the heavy metals found therein; these are deposition of previously suspended particles (atmospheric aerosols) and displaced soil [4]. Particles of different fraction sizes have different modes of transport. Strong wind is an important factor in transport of dust particles to affect regional environment and harm human health, as well as cause significant impacts on global biogeochemical cycle. Metals are non-biodegradable and accumulative in nature [5]. The prolonged presence of the contaminants in the urban environment can significantly amplify the exposure of the urban population to metals via inhalation, ingestion, and dermal contact. These trace metals may include non-essential ones, such as Cd and Pb that can be toxic even at trace levels, and biologically essential elements, such as Cu and Zn, which might cause toxic effects at elevated concentrations.

Dust kicked up by vehicles traveling on roads may make up 33% of air pollution. Roadside dust consists of deposition of vehicle exhausts and industrial exhausts, tire and brake wears, dust from paved roads or potholes, and dust from construction sites. Roadside dust represents a significant source contributing to the generation and release of particulate matter into the atmosphere. Control of roadside dust is a significant challenge in urban areas, and also in other spheres with high levels of vehicular traffic upon unsealed roads such as mines and garbage dumps. The component and quantity of roadside dusts is an environmental pollution indicator in big cities as a source of outdoor air pollutant [6].

The urban environment is composed of varying concentrations of trace elements from a vast array of anthropogenic sources as well as from natural geochemical processes [7]. Road side dust particles can be grouped into: Elements geochemically associated in nature as related to the re-suspension of soil particles as their main source are building construction, renovation and weathering of building materials. Elements of anthropogenic origin, that is, traffic, petrol and diesel operated generating machines, coal combustion or domestic heating and elements related to industrial activity in an area.

Road side dust particles deposited on road, originates from the interaction of solid, liquid and gaseous materials produced from different sources [8].

1.1 Heavy Metals

The term heavy metal refers to any metallic element which is toxic and has a high density, specific gravity or atomic weight. Most heavy metals or transition metals are located in the center of the periodic table between groups II and III. Heavy metals occur naturally in the ecosystem with large variations in concentration. In modern times, anthropogenic sources of heavy metals, i.e. pollution have been introduced into the ecosystem. Environmental pollution by heavy metals may occur via various diffuse and point sources. Heavy metal scattering by traffic is an example of diffuse spread, while the emission of heavy metals by industrial establishments like metal smelters and iron works represents point sources. Traffic activities on roads can contribute to elevated levels of heavy metals in these environments through fossil fuel combustion, wear and tear of many parts of the automobile, in addition to natural sources, as they might exist in the rocks of the surrounding areas.

Heavy metals have been widely used in other research projects and therefore comparative data are readily available. Many studies have examined the contribution of individual components of the urban hydrological cycle to the transport and storage of heavy metals [9].

Heavy metals may come from many different sources in urbanized areas, including vehicle emissions, industrial discharges and other activities [10]. Atmospheric pollution is one of the major sources of heavy metal contamination. Heavy metals can accumulate in topsoil from atmospheric deposition by sedimentation, impaction and interception. Top-soils and roadside dusts in urban area are indicators of heavy metal contamination from atmospheric deposition. It has been noted that roadside soils near heavy traffic are polluted by Pb and other metals.

Heavy metal pollutant in roadside dust has become a growing concern in recent years. In Nigeria, roadside dust is one major way through which heavy metals may find their way into soils and subsequently living tissues of plants and human beings. In monitoring urban pollution, there is need to consider the materials that cause the occurrence of pollutants. Chemical and biological indicators are of interest when they provide information on the concentration and accumulation in the ecosystem.

A range of metals and chemical compounds found in roadside dust environment are harmful. Pollutants can attack specific sites or organs of the body and disease can develop as a consequence to such exposure [11-12]. Although there have been considerable number of studies on the concentration of heavy metals in roadside dust, the vast majority have been carried out in developed countries with long histories of industrialization. Very few studies have been carried out in developing countries like Nigeria. Little interest has been focused on the contamination of roadside dust by other heavy metals in Nigeria. Such data on pollutant metal concentration of roadside dust in such areas are extremely scarce.

Humans and other living organisms are exposed to a variety of heavy metals that are released into the environment. The uptake of these metals occurs through three main routes: dermal absorption, inhalation and ingestion of contaminated dusts and soils. It has been noted that children of age 1-8 are of specific concern for this pathway via their hands or mouths [13].

Most trace elements especially the heavy metals remain in the soil nearly indefinitely. These metals remain bound to organic matter unless they are remobilized mechanically as windblown dust. Human exposure to metals and their compounds in the environment is through food, drinks and water. Other forms of uptake are via skin contact [14].

However, over a period of time, adverse toxic effects may occur as a result of long-term low-level exposure [14]. Motivations for controlling heavy metal concentrations in gas streams are diverse. Some of them are dangerous to health or to the environment (e.g. Hg, Cd, As, Pb, Cr), some may cause corrosion (e.g. Zn, Pb), some are harmful in other ways (e.g. Arsenic may pollute catalysts). Within the European community the elements of highest concern are As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sn, and Tl, the emissions of which are regulated in waste incinerators. Some of these elements are actually necessary for humans in minute amounts (Co, Cu, Cr, Mn, Ni) while others are carcinogenic or toxic, affecting, among others, the central nervous system (Mn, Hg, Pb, As), the kidneys or liver (Hg, Pb, Cd, Cu) or skin, bones, or teeth (Ni, Cd, Cu, Cr) [8;15-16]. Heavy metal pollution can arise from many sources but most commonly arises from the purification of metals, e.g., the smelting of copper and the preparation of nuclear fuels. Electroplating is the primary source of chromium and cadmium through precipitation of their compounds or by ion exchange into soils and mud's, can be localize and lay dormant. Unlike organic pollutants, heavy metals do not decay and thus pose a different kind of challenge for remediation. As an indicator of environmental pollution, the following metals were chosen for analysis: cadmium (Cd), chromium (Cr), Iron (Fe), and lead (Pb). Wood (1974) indicated that these metals have known pollutant properties, are toxic and readily available to the environment.

1.2. Toxic effects of Heavy Metals

Many heavy metals act as biological poisons even at parts of per billion (ppb) levels. The toxic elements accumulated in organic matter in soils are taken up by growing plants. The metals are not toxic as the condensed free elements but are dangerous in the forms of cations and when bonded to short chains of carbon atoms. Many metals with important commercial uses are toxic and hence undesirable for indiscriminate release into the environment.

The uncontrolled input of heavy metals in soils is undesirable because once accumulated into the soil, the metals are generally very difficult to remove. Subsequent problems may be toxicity to the plant growing on the contaminated soils and uptake by the plants resulting in high metal levels in plant tissues. Generally, at the biochemical levels, the toxic effect caused by excess concentrations of heavy metals include competition for sites with essential metabolites, replacement of essential ions, reactions with SH groups, damage to cell membranes and reactions with the phosphate groups.

1.3 Statement of the Problem

The heavy concentration of dust in the air over large cities is a serious pollution problem in places such as flour and sugar mills and coal mines, a concentration of flammable particles constitutes an explosion hazard. Silica particles in dust are destructives to machinery because of their hardness and they can also be injurious when inhaled.

Control of roadside dust is a significant challenge in urban areas, and also in other spheres with high levels of vehicular traffic upon unsealed roads such as mines and garbage dumps. This therefore gives us compelling need to investigate the effect of heavy metals in roadside dust in Damaturu, Yobe state.

1.4 Aim and Objectives of the Study

The aim of this project is to determine the presence and concentration of heavy metals in road side dust in Damaturu, Yobe State. The specific objectives are as follows:

- To evaluate the characteristics of the contents of four metals; Cd, Pb, Cr, and Fe.
- To provide the scientific basis for the composition of road dust as indicator for the influence of urban traffics, residential and commercial activities on the metal content.
- To evaluate the status of heavy metals pollution and quantify the overall potential ecological risk of observed metals in road dust due to different activities along major Roundabouts in Damaturu metropolitans' area which include Potiskum Roundabout (PKRM), Maiduguri Roundabout (MR), Gujba Roundabout(GJBR), Gashua Roundabout(GSHR), and Center Roundabout(CR).
- To investigate the effect of traffic densities on heavy metal accumulation in roadside dust.

1.5 Significance of the Study

The study of the concentration of the heavy metals on roadside dust in Damaturu is of great significance considering that it is a linear settlement where most of the settlement and activities is carried out along the major roads. For this and several reasons, roadside dust issues now occupy a centre stage on academic discourse and other public arena, both at the 2nation and international level. More over the findings will also be beneficial for policy makers because it will provide them with improved capacity to deal with issues of toxic effect of heavy metals in roadside dust.

1.6 Scope of the Study

The main content of the project is analyzing the concentration of heavy metals in roadside dust. However this study would be limited to the Damaturu, Yobe State. The Damaturu was chosen as the case study or study area because of the nature of the settlement in the area which is a linear settlement where most activities are carried out by the roadsides.

II. DETAILS EXPERIMENTAL

Apparatus: **(**LaMotte smart Spectrophotometer .V2.0.11.04, 2000 model. U. S. A).

Reagents: **(**all reagents were of analytical grade and used without further purification), Nitric acid HNO_3 (density 1.42g/cm^3, % purity 72%, molar Weight 63.01g/mol)

Sampling Map

Damaturu town is located in the $11^0 44^1$ North and longitude $11^0 56^1$ east. It covers a total land area of about 2366 square kilometers and according to the 2006 census, it is estimated that the population of Damaturu stood at 44286 and a population density of 18.72 per square kilometer.

Damaturu is located in semi-arid region of Nigeria with tropical climate. The climate is characterized by short wet season (June – August), and long dry season (October – May), with high temperature of about 39^0C – 45^0C throughout the year. Annual rainfall is usually low, with an average of 500 – 1000mm, while evapo-transperation is high.

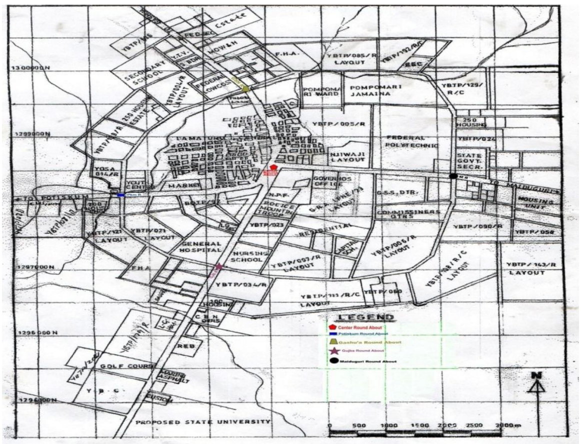

Fig. 1: Map of investigation areas in Damaturu city.

2.1 Sampling Technique

Some major roads in Damaturu were used for the collection of samples for heavy metal analysis seen in the Fig. 1 above. The dust samples were collected from five different roundabouts within Damaturu. Roadside dust samples were as discussed above. Roadside dust samples were sampled using brush and plastic scoop to collect the settled dust along the road. Samples were collected in the month of May, 2013 to avoid rain-washing out the heavy metals. During this period the largest difference of heavy metal concentration in roadside dust may occur.

2.2 Sample Preparation

Dust samples were collected and transferred to clean polyethylene bags. They were labeled immediately at the point of collection for proper identification. All the samples were dried at 100 – 110 ^{0}C to drive out moisture. On cooling each sample was sieved through a nylon sieve of 250 μm diameter.

2.3 Method

All experiments were performed with analytical reagent grade chemicals. The digestion of the dust samples was done using 1:1 ratio distilled water to trioxonitrate (v) acid [17]. A portion of 1g of each of oven dried dust samples were weighed and transferred into 250 ml beaker. The samples were heated to boil for 30 minutes and were acid washed to pass through (whatman 540) and then filtered into 100 ml volumetric flask and were made up to the mark with distilled water. Calibration standards were prepared from the stock solution by dilution and were matrix matched with the acid concentration of the digested samples. The digested samples were then analyzed for heavy metal using LaMotte Smart Spectrophotometer.V2.0.11.04, 2000 model. U.S.A.

2.3.1 Determination of Chromium

A sample tube was cleansed with sample water and filled to 10ml line with the sample. It was inserted into the sample chamber of the spectrophotometer and scan blanked. The sample was removed then a 0.1g spoon was used to add a chromium reagent powder. The sample tube was capped and shaken until the powder dissolved. The sample was allowed to stand for 3 minutes for full color development. The sample was filtered using a filter paper into a clean tube and mixed, then inserted into the sample chamber and was scanned. Result was recorded in mg/l.

2.3.2 Determination of Lead

A universal sample tube was rinsed with 10ml of sample water and scan blanked then it was removed.5ml of sample was removed using a syringe and was discarded. 5ml of the sample in the tube was transferred into the tube. A 5ml buffered ammonium chloride was added to fill the 10ml line of the tube; the sample was swirled to mix. 3 drops of 10% sodium cyanide was added, sample was swirled to mix again. A 0.5ml pipette was used to add 0.5ml PAR indicator then swirled again. Another 0.5ml pipette was used to add 0.5ml stabilizing agent. The sample was capped and mixed then inserted into the sample chamber and scanned and the result was recorded as reading A. Sample was removed from the sample chamber, 3 drops of DDC reagent was added. The sample was capped and swirled then subjected for analysis. The result was recorded as reading B.

mg/l lead = reading A – reading B

2.3.3 Determination of Cadmium

A universal sample tube was rinsed with 10ml of sample water and scan blanked in the spectrophotometer at the cadmium test menu. Sample tube was removed and 0.1ml pipette was used to add 0.5ml buffered ammonia reagent. The sample was swirled to mix 2 drops of 10% sodium citrate was added and swirled to mix again followed by the addition of 0.5ml PAN indicator using a 0.5ml pipette. Another 0.5ml pipette was used to add 0.5ml stabilizing reagent. The sample was then mixed by shaking then immediately inserted into the sample chamber for scanning and the result recorded in mg/l.

2.3.4 Determination of Iron

A sample was rinsed using the sample water then it was scanned blank at the iron test menu. Sample was removed and a 0.5ml of iron reagent was added to the sample using a 0.5ml pipette. The sample was capped and mixed a 0.1g iron (II) powder was added. Sample was capped and swirled then shake vigorously for 3 minutes for maximum color development. Sample was immediately inserted into the sample chamber and scanned. The result was recorded in mg/l.

III. RESULTS AND DISCUSSION

3.1. Results:

We have used the LaMotte Smart Spectrophotometer V2.0.11.04, 2000 model (U.S.A.) for determination of concentration of heavy metals in roadside dust. The observed concentration at Center roundabout (CR), Gashua roundabout (GSHR), Gujba roundabout

(GJBR), Maiduguri roundabout (MR) and Potiskum roundabout (PKMR) in Damaturu region is given in Table 1.

Table 1: Heavy metal concentration (in mg/l unit) in roadside dust samples at five different roundabouts in Damaturu metropolis.

S. No.	Sample	Pb	Cr	Cd	Fe
1	CR	-1.20	0.07	0.44	12.90
2	GSHR	-0.80	0.02	0.21	1.93
3	GJBR	-1.70	0.27	0.91	10.01
4	MR	-0.30	0.39	0.93	19.70
5	PKMR	+0.50	0.15	0.71	16.00

Table 2: The comparison of observed concentration (in mg/l unit) with the WHO (2004) standard for twenty four hours.

Elements	WHO (2004) Standard	Damaturu Roundabout and their location
Cadmium	2.0	3.2
Chromium	1.5	0.9
Iron	4.0	14.83
Lead	0.5	-3.5

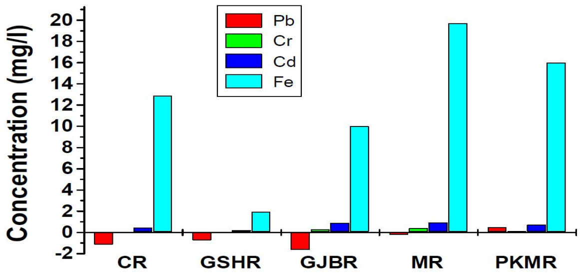

Fig. 2: Concentration of the metals in the roadside dust samples for Pb, Cr, Cd and Fe at five different places at Center roundabout (CR), Gashua roundabout (GSHR), Gujba roundabout (GJBR), Maiduguri roundabout (MR) and Potiskum roundabout (PKMR) in Damaturu region.

3.2. Discussion

Table 1 presents the concentrations of some heavy metal pollutants determined in the roadside dust samples in Damaturu in May 2013. Table 2 show the comparison of the result obtained with the WHO. Fe had the highest concentration followed by Cd, Cr, and Pb in the five different sampling areas (Fig 2). The high concentration of iron in the roadside dust samples may be attributed to metal construction works, iron bending and welding of metals, which is a common practice along the roadside in Maiduguri roundabout, Potiskum roundabout, and Gujba roundabout . Virtually in every mechanical workshop there are various sections that deal with either filing of metals, welding of these metals and pave lings of vehicle bodies. Iron fillings from this metal works, exhaust emissions from vehicles, oil spillage of gasoline, diesel, engine oil and lubricating oils.

Coated metals have all collectively contributed to the high concentration of the elements Fe, Pb, Cr, and Cd. Studies have shown that, stainless steel and alloy steel contain Fe, Cr, and Pb or Cu and that exhaust emission from both gasoline and diesel fueled vehicles contain variable quantities of these elements (Chong, 1986). The sources of cadmium in the urban areas are much less well defined than those of lead, but metal plating and tire enforced with metals were considered the likely common anthropogenic sources of cadmium in roadside dust through burning of tires and bad roads. Other sources of cadmium are found in lubricating oils as part of many additives. It was reported that the cadmium level in car tires is in the range of 20 to 90 (g/g) as associated Cd contaminations in the process of vulcanization (Yu et al., 2003). The uses of cadmium-plated and galvanized equipment in food processing, cadmium-containing enamel and pottery glazes, and cadmium base pigments or stabilizer in plastics may also be significance sources of food contaminations. Statistically Cr shows no significant difference in almost all the studied areas. This indicates that the level of Cr in Damaturu originates from common source. The most probable source of such contamination is the chromites particulate matter emitted from electroplating and degeneration of alloy, which settles along the roadsides as dust. Lead though in a high concentration but not commonly found in many of the sampled areas which are because most of the lead present as pollutant in the road side dust is gotten from the incomplete combustion of petroleum products such as gasoline, petrol and lubricants. Other sources of lead contamination could be from paints, pesticides, gasoline additives, lead pipes and other materials.

Statistical analysis showed significant differences between the elements as indicated in Table 1. This suggests that, the indicated heavy metal pollutants in roadside dust of Damaturu did not originate from common anthropogenic sources with probably automobile and the welding of metals as the major sources.

The health implication of this ugly trend is quite obvious. This dust with its high heavy metal contents has a high vulnerability of causing cough in both children and adults during inhalation. Inhalation of high chromium containing dust may lead to toxic effects in the gastrointestinal tract and may damage kidneys (IPCS). Also, high levels of chromium can cause spinal/joints degeneration, depressed immune system and lymphatic swelling. It has been observed that inhalation of some mineral particles can produce diseases in persons working in quarry sites, mines and welders. These mainly affect the lungs and the major pathogenic effect is the formation of fibrotic tissues in the lungs. The degree of incapacitation or loss of operational capacity of the lungs is dependent on the amount and type of mineral dust inhaled. This response of lungs to mineral dust with the attendant formation of fibrotic tissue is commonly referred to as pneumonomosis. Chromium and its compounds are known to cause cancer of the lungs, nasal cavity and Para nasal sinus and suspected to cause cancer of the stomach and larynx (ATSDR, 2000). Apart from these direct effects of the dust on man, its effects are also felt indirectly. It settles on dried foodstuff such as rice, groundnut, maize, yam flour and dried cassava when the moisture contents of these foods are still high, the dust dissolves in this moisture and become absorbed and thereby contaminate the foodstuff. Dust also settles on building, walls, roofs, windowpanes and doors causing mechanical abrasion and aesthetic blight.

CONCLUTIONS

The result clearly indicated the concentration of Cd, and Fe, in road side dust within Damaturu is above the WHO standard [18].While that of Cr, and Pb is below the WHO [18].

The WHO acceptable of human cadmium in ambient air is 2.0 mg/l for twenty- four hours. It was observed in this study that the mean concentration of cadmium for twenty four hours during the period of study is 3.2 mg/l (Table 2), which is above the acceptable level. Hence, the environment is concerned polluted with cadmium. In human, long-term exposure to cadmium is associated with renal dysfunction [18]. Some sources of cadmium in the environment are: batteries, inorganic fertilizers produced from phosphate over which constitute a major source of diffuse cadmium pollution. Severe damage to the lungs may occur though breathing high levels of cadmium and condition compounds are known human carcinogens (ATSDR, 2000).

The WHO acceptable level for iron in ambient air is 4 mg/l for twenty four hours. It was observed that the mean concentration of iron for twenty four hours during the period of study is 14.83 mg/l (see Table 2), which is above the acceptable level. The study area is polluted with iron.

ACKNOWLEDGMENT

I am thankful to Professor Musa Alabe, Vice Chancellor, Yobe State University, Damaturu, Yobe State, Nigeria for encouragement and financial support.

REFERENCES

[1] X. Lu et al. "Contamination assessment of copper, lead, zinc, manganese and nickel in street dust of Baoji", NW China. J. Hazard Matter Vol. 161, pp1058–1062, 2009.

[2] B. Wei et al., "Determination of heavy metal concentrations in street dusts in Istanbul E-5 highway", Environ. Intern. Vol. 29, pp979–985, 2003.

[3] B. Wei et al. "Contamination levels assessment of potential toxic metals in road dust deposited in different types of urban environment", Environ. Earth Sci., vol. 61, pp 1187– 1196, 2010.

[4] G. Eason et al. "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions", Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955.

[5] J. Clerk Maxwell, "A Treatise on Electricity and Magnetism", 3rd ed., vol. 2. Oxford: Clarendon, pp.68–73, 1892.

[6] N. Sezgin et al. "Determination of Heavy Metal Concentrations in Street Dusts in Istanbul E-5 highway", Environ Int. vol. 29(7), pp 979- 985, 2004.

[7] A. A. Shakourn and N. M. El- Table, "Heavy Metals in Atmospheric Particulate in the Industrial Area. North Cairo, Egypt", Air Pollution Department. National Research Centre. Ducky Cairo, Egypt, 1995.

[8] A. D. K. Banerjee, "Heavy Metal Levels and Solid Phase Speciation in Street Dust of Delhi, India", Environmental Pollution, vol. 123, pp95-105, 2003.

[9] R. S. Hamilton et al. "Level and Physico-Chemical", 1984.

[10] R. M. Harrison et al., "Chemical Associations of Lead, Cabonium, Copper and Zinc in Street Dust and Roadside Soils", Environmental Science and Technology, vol. 15(11), pp 1376-83, 1981.

[11] A. Archer and R. S. Barratt, " Lead in the Environment: Monitoring for Lead" Sci.Total Environ vol. 96, pp173-176, 1976.

[12] J. T. Ayodele and U. M. Gaya, "Chromium, Manganese and Zinc in Kano Municipality Street Dust", J. Chem. Soc. Nigeria vol. 23, pp24-31, 1998.

[13] J. Walt et al., "Physical Evidence Suggesting the Transfer of Soil Pb into Young Children via Hand-to-Mouth Activity", Appl. Geochemist, vol. 2, pp 269-272, 1993.

[14] U. Ewers, "Standards, Guidelines and Legislative Regulations Concerning Metals and their Compounds in Merian E. (Ed) Metals and their Compounds in the Environment VCH", Verlags Gesell's chaftmb H, Wembheim, New York, pp687-750, 1991.

[15] S. Charles worth, et al., "A Comparative Study of Heavy Metal Concentration and Distribution in Deposited Street Dusts in a Large and a Small Urban Area: Birmingham and Coventry, West Midlands, UK", Environment International, Vol.29, No.5, pp563-573, 2003.

[16] X. L. Lu et al.,"Multivariate Statistical Analysis of Heavy Metals in Street Dust of Baoji, NW China", Journal of Hazardous Materials, Vol. 173, No.7, pp744-749, 2010.

[17] I. N. Ward et al., "Heavy Metal Pollution from Automotive Emission and its Effect on Roadside Soils and Pastures in New Zealand", Environ. Sci. Technol. Vol. 1, pp917-20, 1977.

[18] WHO, "Air Quality Guidelines for Europe", 2nd Ed. Copehagen, World Health Organization, Regional Office for Europe, 2000 (WHO) regional publications, European series No.91, 2004.

★★★