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Research Article

Accumulation of Heavy Metals (Pb, Cu and Zn) at Road Side Soil from Kontagora-Mokwa Road, Niger State, Nigeria

Mohammed U.M.[1]*, Fanika S[1]., Mustapha S.[2], Taofeek A.[1]

[1]Department of Chemistry, Federal College of Education, P. M. B. 39 Kontagora, Niger state, Nigeria
[2]Department of Chemistry, Federal University of Technology, P.M.B. 36, Minna, Niger State, Nigeria

Abstract Soil Samples collected along the left and right sides of Kontagora – Mokwa road were analyzed for lead, copper and zinc with Atomic Absorption Spectrophotometer (AAS). The mean levels of both sides of the studied highway road ranged from 22.5 ± 24.82, 77.5 ± 31.91, 10.75 ± 10.99, 31.00 ± 17.73, 12.75 ± 7.44 and 263.75 ± 349.29 for lead (Pb), copper (Cu) and zinc (Zn) respectively. These results revealed that studied soils are contaminated since the values obtained are higher than the typical natural concentrations of 20 and 15 µg/g for the heavy metals and this called for concern as these metals can accumulate to pollute the environment.

Keywords Pollution, heavy metals, Kontagora/Mokwa, concentration

1. Introduction

Ecosystem like garden, a farm, a forest and regional watershed, soils are known for their importance in providing habitat for a myriad of living organisms of unimaginable numbers and diversity. The characteristics of soil determine the nature of the vegetation present and indirectly the number and types of animals including man that the vegetation can support [1]. Although the role of soil in the ecosystem and its utilization for food production, housing, transportation and engineering construction has exposed it to a myriad of contaminations. Decomposition of fossil fuels, smelting, grazing, electroplating and other processing techniques serve as sources of contaminations that accumulate in the soil [2]. The presence of these pollutants such as toxic elements in road deposit plays an important role in dictating urban storm water quality [3].

Potential toxic elements contribution to the environment from urbanization is mainly from automobiles. The extensive uses of automobiles and heavy vehicle traffic on our roads have contributed to heavy metal loads [4]. Anthropogenic sources such as lubricating oil from engines, vehicle emission, wears of engine parts and industrial processes are pathways through which heavy metals enter into the soil [5]. Particulates from automobiles have been identified as the main source of deposit of heavy metals accumulation on a surface in municipal areas [6]. Heavy metal contamination in the soils is a major concern because of their toxicity and threat to human life and the environment. Heavy metals like arsenic (As), cadmium (Cd) and lead (Pb) have been reported to be toxic at low concentrations in human biochemistry and physiology [7-8]. High concentrations of Pb from motor vehicles that operate with leaded gasoline affect the diversity and biological species in the soil community [9]. They enter the body system through food, air and water and bioaccumulate over a period of time [10-11]. Exposures to these heavy metals cause damage of the nervous system, brain, mal-function in children and carcinogenic effects [12].

Soils serve as a reservoir and a source for metal pollutants which after temporary storage can release them into the environment by changes in environmental conditions [13]. The consequence of agricultural soils pollution is as a result of accumulation of heavy metals in the tissues of plants from polluted waters [14-15]. The effect of heavy metal contaminations is more worrisome in the developing countries where research efforts towards monitoring the environment have not been given enough and desired attention. Lack of environmental regulations has caused increase in occurrence of metal contamination resulting from rapid growth in population, increased urbanization and industrial activities, exploration and exploitation of natural resources. Hence, the need for this study is to investigate the level of contamination by lead (Pb), copper (Cu) and zinc (Zn) of soil along Kontagora–Mokwa highway and to assess if their levels are sufficient to pollute the soil since the road is a major link between North and Southern parts of Nigeria and traffic volume is very high.

2. Sampling

The soil samples were collected along Kontagora–Mokwa expressway. Areas with obvious signs of disturbance, such as animal burrowing, engine oil spillage and landfills were avoided. Sampling spots were cleared of debris before actual sampling started [16]. 500 g each of composite soil samples were collected within a distance of 4 kilometers from the edge of the main road at each location. All soils collected were sampled at the surface (0 to 10 cm depth) using a hand-driven stainless steel auger. The soil samples were labeled and stored on polyethylene bags and taken to the laboratory for analysis [17].

2.1. Sample Preparation

The size of each large clod was first reduced and the sample was spread on a tray in a layer not thicker than 15 mm. Thereafter, the various samples were placed in a drying oven at a temperature of 50°C. They were left in the oven for 24 hours to remove the moisture in the samples. Each over dried sample was crushed into particles and passed through a 2 mm sieve (EPA method 3052). However before crushing commenced, stones, fragments of glass and other noticeable impurities were removed by hand. 1.0 g of each soil sample was accurately weighed and treated with 16 cm^3 of high purity of concentrated nitric acid and 4 cm^3 of perchloric acid. The mixture was allowed to stand for 10 minutes. The mixture was heated for 1 hour and allowed to cool and the digest was filtered into 50 cm^3 volumetric flask, made up to the mark with distil water and stored in plastic rubbers for analysis with Perkin Elmer 3300 Atomic absorption spectroscopy.

3. Results and Discussion

3.1. Results

Table 1: Concentration (µg/g dry weight) of Pb, Cu and Zn in Roadside Topsoil from Kontagora to Mokwa

Sampling points	Distance from kontagora	Pb		Cu		Zn	
		left	Right	left	Right	left	Right
1	4	25	55	7.5	18.5	25.5	52.5
2	8	35	45	22	11.5	37.5	14
3	12	45	50	6	16	79	21
4	16	15	60	15.5	14	30	26.5
5	20	25	60	18.5	43.5	31	50
6	24	5	40	3	18.5	61.5	18
7	28	30	55	8.5	16	27	23.5
8	32	25	60	13	21	30.5	84.5
9	36	20	65	11.5	18	49	20
10	40	25	75	7.5	39.5	17.5	51
11	44	30	60	8	16	15	9.5
12	48	40	65	8.5	19	36.5	42.5
13	52	40	60	7.5	16	18	7.5
14	56	40	65	11	19.5	20	14
15	60	35	80	8.5	19.5	20.5	26
16	64	45	70	12	17.5	12.5	21.5

17	68	45	80	9.5	36	28	64.5
18	72	35	80	27	22	52	26.5
19	76	40	80	11.5	20.5	22.5	13
20	80	55	100	14.5	22	51.5	47

Table 2: Mean Concentration (µg/g dry weight) of Pb, Cu and Zn for both sides of the studied highway

Sampling points	Pb	Cu	Zn
1	40.0 ± 21.27	13.00 ± 7.80	39.00 ± 19.14
2	40.0 ±7.09	16.75 ± 7.44	25.75 ± 16.66
3	47.5 ± 3.54	11.00 ± 7.09	50.00 ± 41.13
4	37.5 ± 31.91	14.75 ± 1.06	28.25 ± 2.48
5	42.5 ± 24.82	31.00 ± 17.73	180.00 ± 184.39
6	22.5 ± 24.82	10.75 ± 10.99	39.75 ± 43.50
7	42.5 ± 17.73	12.25 ± 5.31	25.25 ± 2.48
8	42.5 ± 24.82	17.25 ± 6.02	57.50 ± 38.29
9	42.5 ± 31.91	14.75 ± 4.60	34.50 ± 20.56
10	50.0 ± 35.46	23.50 ± 22.69	263.75 ± 34.29
11	45.0 ± 21.27	12.00 ± 5.67	13.75 ± 6.02
12	52.5 ±17.73	13.75 ± 7.44	39.50 ± 4.25
13	50.0 ± 14.18	11.75 ± 6.02	12.75 ± 7.44
14	52.5 ± 17.73	15.25 ± 6.02	17.00 ± 4.25
15	57.5 ± 31.91	14.00 ± 7.80	23.25 ± 3.90
16	57.5 ± 17.73	14.75 ± 3.90	17.00 ± 6.38
17	62.5 ± 24.82	22.75 ± 18.79	46.25 ± 25.88
18	57.5 ± 31.91	24.50 ± 3.54	39.25 ± 18.08
19	60.0 ± 28.36	16.00 ± 6.38	17.75 ± 6.73
20	77.5 ± 31.91	18.25 ± 5.31	49.25 ± 3.19

3.2. Discussion of Results

A distance of 4 km was allowed from Kontagora before first sample was collected, 2 km to Mokwa for the collection of the last sample and 2 m away from the roadsides in order to eliminate effects of municipal contaminations such as waste, industrial and commercial activities. The total concentration of the lead, copper and zinc obtained from the soil samples at the forty sites are presented in Table 1.

The highest lead content was 100 µg/g, although increase in lead concentration in roadside soil is not particularly surprising as it has been reported that lead contents of soils increases remarkably as one approaches a highway with volume of traffic [18]. The high concentrations of lead observed could be attributed to lead particle from gasoline combustion of vehicles that settles on roadside soils. However, the levels obtained from this study are particularly high enough to be toxic to plants including plant grazing animals and humans through food chain.

The highest level of copper was 43.50 µg/g. This may be ascribed to fungicides, insecticides, fertilizers and manures applied to farmlands along the roadside studied [18]. The pattern observed for zinc was similar to that observed for lead. This is not surprising as zinc is used in agrochemical and as an additive in lubricating oils.

The levels of copper and zinc in soils are fairly critical for healthy plant growth as both elements are known to activate certain enzymatic systems in plants [18]. The concentration levels of lead and zinc in the roadside soil can be attributed primarily to pollution originating from automobile related emissions and contaminations. The concentration level of copper may be from varied sources of which pesticides contamination seems to be the principal source. With the correlation established between soil zinc and plant zinc [19], soil lead and plant lead [18] and the fact that cultivated and grazing lands are located along the roadside, the possible uptake of these metals by crops and consequently adverse effects on the crops themselves and on livestock and human diet should be of concern.

The mean and standard deviations of elemental contents (Table 2) along Kontagora-Mokwa road soils were compared with other reported values and that the concentration distributions of trace elements are different from that of major elements in soils hence geometric means of trace metal contents are reported in most of the recent literatures [20]. Total metal concentrations along Kontagora–Mokwa highway surface soils were generally higher than those in U.S and Florida agricultural soils [20]. The Kontagora-Mokwa road sides copper levels range from 10.57 to 31.00 µg/g. Compared to a previous study, the mean values of Cu are less than 61.00 µg/g reported in literature [21]. Only zinc had mean value close to the contents of U.S agricultural soils. The obtained results were also compared with typical levels of World soils and the zinc average content was close to it. Specifically, high metal concentrations of Cu and Zn in Kontagora–Mokwa highway soils could be ascribed to application of fertilizer, pesticides and sewage sludge to forest soils than to agricultural soils [20].

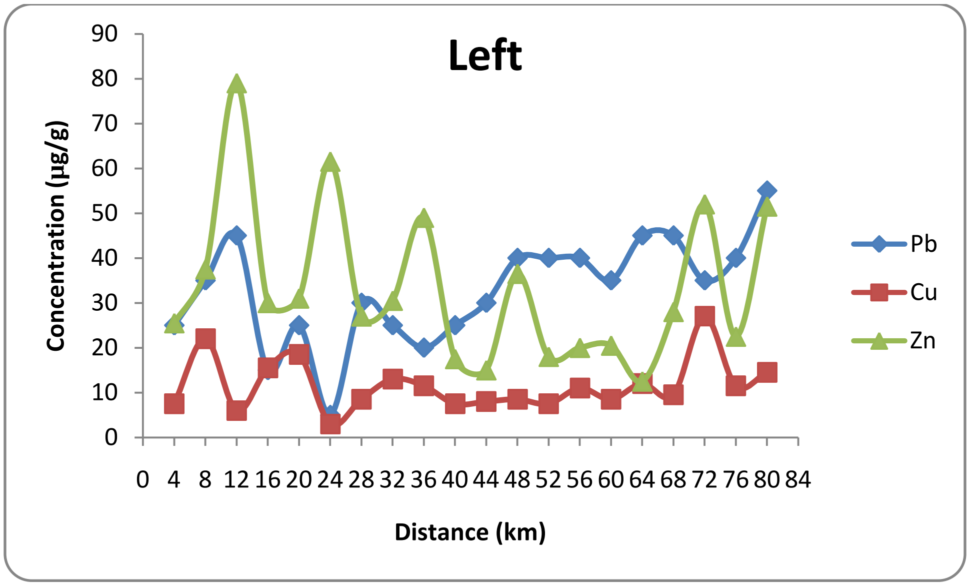

Figure 1: Concentrations of Pb, Cu and Zn across the sampling points (left)

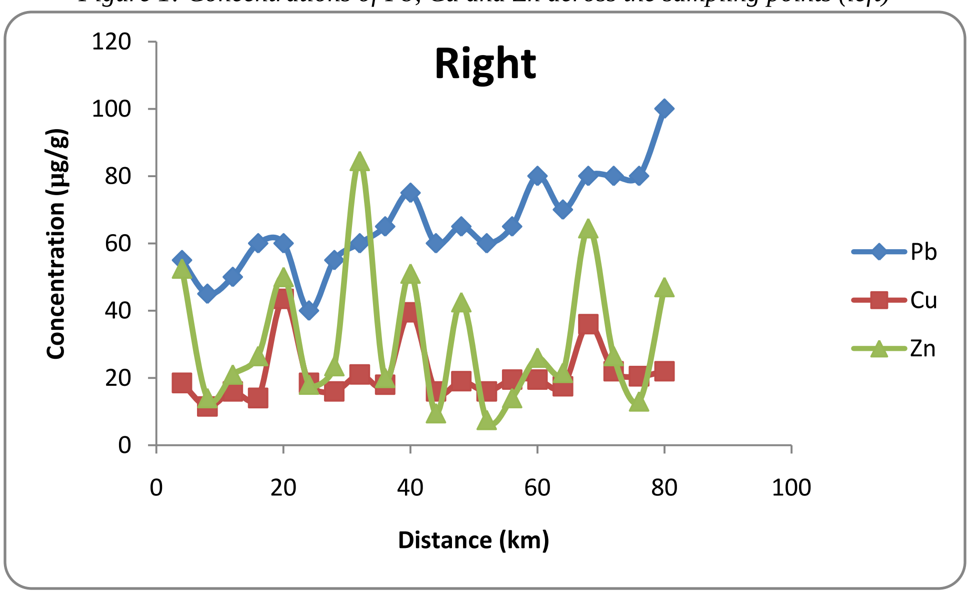

Figure 2: Concentrations of Pb, Cu and Zn across the sampling points (right)

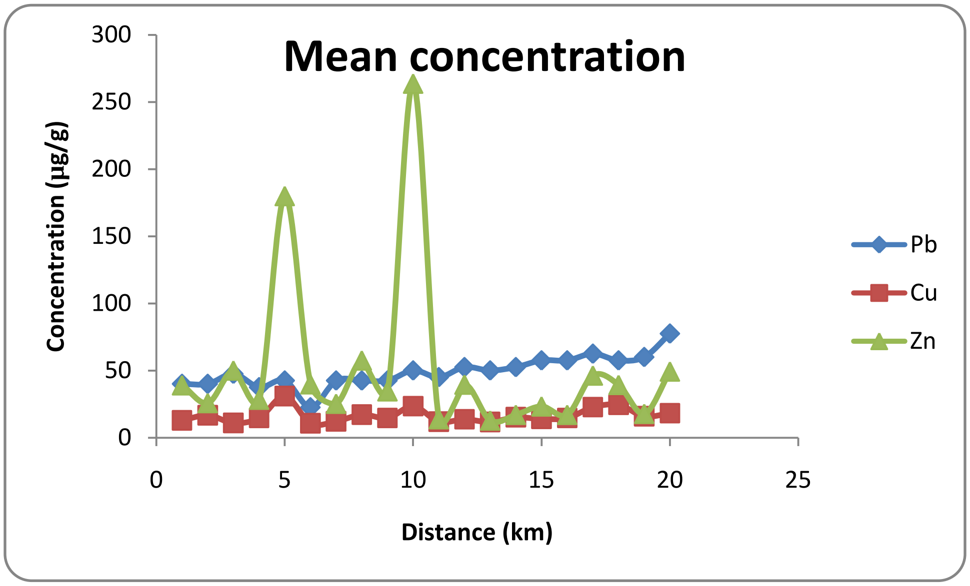

Figure 3: Concentrations of Pb, Cu and Zn across the sampling points (left and right)

Table 3: Correlation analysis among metals (Pb, Cu and Zn) in Roadside (left) Topsoil from Kontagora to Mokwa

	Pb	**Cu**	**Zn**
Pb	1		
Cu	0.122	1	
Zn	-0.059	0.073	1

Table 4: Correlation analysis among metals (Pb, Cu and Zn) in Roadside (right) Topsoil from Kontagora to Mokwa

	Pb	**Cu**	**Zn**
Pb	1		
Cu	0.345	1	
Zn	0.244	0.566**	1

** Correlation is significant at 0.01

Table 5: Correlation analysis among metals (Pb, Cu and Zn) in Roadsides (left and right) Topsoil from Kontagora to Mokwa

	Pb	**Cu**	**Zn**
Pb	1		
Cu	0.247	1	
Zn	-0.048	0.666**	1

** Correlation is significant at 0.01

Correlation calculations, among concentrations of the heavy metals in topsoil are shown in Table 3, 4 and 5. Positive and negative correlation were observed between metals, negative correlation between Pb and Zn indicate that other sources other than automobile emission could contribute to concentration of these metals in the soils. Significant positive correlations between Cu: Pb and Zn could indicate contamination of the soils by automobile emissions.

4. Conclusions

Soil samples collected along a heavy traffic Kontagora – Mokwa highway was found to contain lead, copper and zinc. However, the general trend is that of a fluctuating variation in the concentration of the metal analyzed along the highway and on either side of the road. Although, automobile related activities and fertilizer application could be identified as sources of contamination, other sources cannot be entirely ruled out. The levels of the metal at some sites are high enough to be of concern to plants and animals. Hence, accumulation of the metal in the soil and transfer to plants growing along the roadsides could lead to accumulation of Pb in the tissues of organisms that feed on the plant. Therefore, a serious attention is needed in order to avoid lead poisoning in the area.

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