

Analysis of cadmium and lead using atomic absorption spectrophotometer in roadside soils of Jimma town

Abstract

Cadmium and lead are pollutants of great concern to human health. The analysis of Cadmium and lead content in our environment is crucial for policy makers to make decisions concerning the environment and to secure the wellbeing of the inhabitants. In this study lead and cadmium in roadside soil was analyzed. The soil sample was collected at the distance of 18m, 20m, 25m, 26m and from the roadside. The collected sample was digested on hot plate. The concentration of lead and cadmium was measured by flame atomic absorption spectroscopy (FAAS). Lead concentrations in soil samples varied from 36.47 to 43.42mgkg⁻¹. Lead analyses showed that there was a considerable contamination in soil affected from traffic intensity. Cadmium and lead were determined using AAS in the surface layer (0.0-5.0cm) of soils, situated in areas under different impact of traffic contamination. The Concentration cadmium in soil samples lies between 0.505mg/kg to 1.745mg/kg. The obtained results of Cadmium and lead concentration in the soil around Jimma, Ethiopia; 1.745mg/kg and 43.42mg/kg respectively, were compared with WHO and EPA. The maximum contaminate level according to WHO, for lead and cadmium in soil is 100 and 3.00mg/Kg respectively and appropriate recommendation and conclusion was forwarded. From this site the concentration of lead is higher than cadmium. The average lead and cadmium concentration in soil samples from the four sites of Jimma were all found to be below the maximum tolerable limit according to WHO standards.

Keywords: atomic absorption, lead, cadmium, soil samples, traffic contamination

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Introduction

Anthropogenic sources of heavy metals such as industrial wastes, automobile emissions, mining activity and application of chemical fertilizers, have led to their accumulation in soils. Heavy metals levels in soil are increasing also due to disposal of domestic sewage sludge on agricultural areas. Elevated cadmium and lead levels in soil may result in increased uptake by plants. This is the principal process by which heavy metals enter the food chain.¹⁻²

Lead and cadmium level in soil tend to be higher in cities, near road ways and around industrial sources that use or release lead and cadmium. Soils whether in urban or agricultural area, represent a major sink for metals released in to the environment from a variety of anthropogenic sources. Once in soil some of these materials will be persistent because of their fairly immobile nature.³

According to the kind of vehicle in traffic; the quality of heavy metals varies in street dust. The use of leaded Gasoline gives a boost to the importance of lead level especially in street dust even at the start of 21st century. Air Pollution has long been recognized as lethal form of pollution, much of the problems of societal concern today are the heavy metals associated with air pollution.⁴

Many researches on analysis of lead and cadmium were done most of them mainly to wards determination of lead and cadmium in roadside soil. However there is no more consideration about health effect of lead and cadmium in society.

The result of the analysis of cadmium and lead in the soil of a given

area is very crucial for comparison with WHO's permissible limit and take corrective measures for the wellbeing of inhabitants. This study may be serve as an important tool for policy makers to make decisions concerning the environment and to secure the wellbeing of the community or promoting health care services by minimize the level of cadmium and lead in the soil.

Material and methods

Sampling sites

The soil samples were collected from four different sites of Jimma town, Oromia regional state, south western Ethiopia in December 2018. The soil samples were kept in polythene bags and labeled to avoid a mix up of the different soil samples. They finally were brought to the laboratory.

Soil sample collection

Soil samples was collected from four different site Mercato, Koch, Jimma hospital and Yetebaberut of the sample collect different distances from the road side to a depth of 0.0-5.0cm using a soil auger. The soil samples were keeping in a polythene bags and labeled to avoid a mix up of the different soil samples. Then it was bright to the laboratory and keeps in the air dried place prior to analysis for lead and cadmium.

Soil sample preparation

Unwanted materials such as stones, leaves and debris was remove from the soil samples by hand picking and dried on an air dried oven.

The dried soil samples were then powder in to finer particles using a laboratory mortar and pestle and sieve to homogenize the sample. The powdered soil samples were farther dry using an air dried oven for 8hours at 105°C.⁵

Experimental procedure

To make lead and cadmium analyses first each soil sample was homogenized and dry at 105°C. After that 1.0g of the sieved sample was placed in 300ml beaker and boiled at 230°C with 15ml of nitric acid (HNO₃,69%) and 25ml of perchloric acid (HClO₄,58%). After completely turned to ash, the digested solution was filtered and made the volume up to 50ml in a volumetric flask. The metal concentrations were determined by atomic absorption spectrophotometer.^{5,6}

Statistical analysis

Statistical analysis was performed using SPSS 18.0 (SPSS Inc. Chicago, IL, USA) software. One-way ANOVA was used. P-Values less than 0.05 were considered significant.

Results

The analysis of soil samples for lead content by flame atomic absorption spectrophotometer The analysis showed the presence of lead in all the four soil samples collected from different sites at varying concentrations ranging from 36.47±0.000243 to 43.42±0.000029mg/kg (Table 1 & Figure 1).

Table 1 Lead standard solution

No	Name	Abs	SD	RSD	con (mg/L)
1	Cal – zero	0.000003	0.000013	380.9	0
2	Cal – std1	0.000057	0.000067	117.1	0.001
3	Cal – std2	0.004414	0.000004	0.092	0.5
4	Cal – std3	0.008724	0.00092	1.056	1
5	Cal – std4	0.02308	0.000009	0.394	2.5

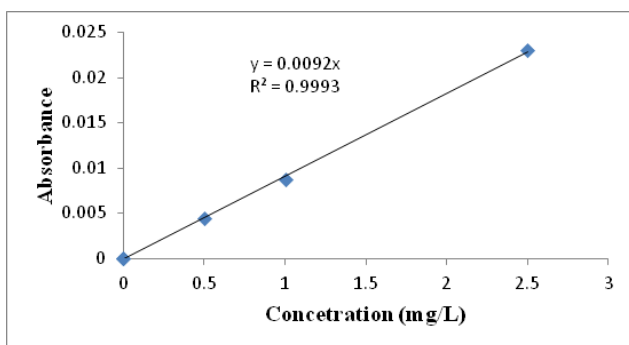


Figure 1 Calibration curve for lead standard solution.

The analysis of soil samples for Cadmium content by flame atomic absorption spectrophotometer. The analysis showed the presence of cadmium in all the four soil samples collected from different sites at varying concentrations ranging from 0.505±0.000257 to 1.745±0.000706 mg/kg (Table 2,3 & Figure 2).

Table 2 Cadmium standard solution

No	Name	Abs	SD	RSD	Cons(mg/L)
1	Cal-Zero	0.00247	0.001466	59.35	0
2	Cal-std1	0.01456	0.000409	2.812	0.05
3	Cal-std2	0.008796	0.000073	0.084	0.5
4	Cal-std3	0.1726	0.000174	0.068	1
5	Cal-std4	0.3283	0.005955	0.053	2
6	Cal-std5	0.635	0.000888	0.938	5

Table 3 Concentration levels of lead and cadmium in different places of Jimma town

Sample sites	Average lead concentrations in (mg/kg)	Average cadmium level in (mg/kg)
Merkato (bus station)	36.47±0.000243	0.815±0.001082
Yetebaberut (around Garage)	43.42±0.000029	0.89±0.00137
Kochi (Bajaj tera)	40.97±0.000168	1.745±0.000706
Jimma Hospital	39.17±0.000796	0.505±0.000257

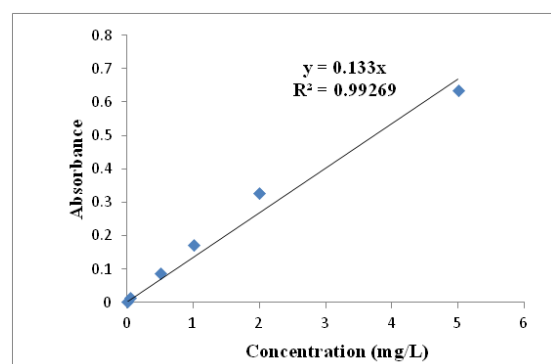


Figure 2 Calibration curve for cadmium standard solution.

Comparison of heavy metal in roadside soil samples Ethiopia (Jimma) with other countries.

The result obtains from the analysis of different soil sample by using Atomic spectroscopy (AAS). The method was summarized in the Table 3 above. The heavy metal concentration were determine the analysis of lead and cadmium were not done before in Jimma town (Table 4).

Table 4 Comparison of heavy metal in roadside soil samples Ethiopia (Jimma) with other country

Country	Lead (mg/kg)	Cadmium (mg/kg)	Reference
Turkey	45	0.527	⁵
Northern England	1.198.0	3.8	¹⁴
Ethiopia (Jimma)	43.42	1.745	Present study
European Highway E30	155.75	0.909	¹⁵

Discussion

As shown on the above table (Table 1) the soil taken from Yetebaberut (garage area) recorded as the highest lead content with concentration of $43.42 \pm 0.000029 \text{ mg/kg}$ followed by Koch (bajajtera) with a level $40.97 \pm 0.000627 \text{ mg/kg}$, Hospital area with level $39.17 \pm 0.000721 \text{ mg/kg}$ and Merkato with the level 36.47 ± 0.000243 which was taken from different site. No elevated level of lead in soil (greater than 50 mg/kg) was detected in all four sites investigated. Soil lead concentration in all sites was found to be within the estimated natural concentration range of 35 to 50 mg/kg .^{7,8} However, soil samples of Merkato, garage and Koch (bajajtera) that were taken from vehicular and gasoline area contain by far large concentration of lead when compared with non-gasoline area of Hospital area. Due to high construction expiation around in hospital area high concentration lead than in Merkato.

This is primarily due to vehicular emissions and partly igneous activity. In contrast, soil samples of Merkato contain in low concentration. Because this site was remote from vehicular, gasoline and other causes.

As shown on the above table (Table 2) the soil taken from Koche (bajajtera) recorded as the highest cadmium content with concentration of $1.745 \pm 0.000706 \text{ mg/kg}$ followed by Yetebaberut (around Garage) with a level $0.89 \pm 0.00137 \text{ mg/kg}$, Merkato (around bus station) with level $0.815 \pm 0.001082 \text{ mg/kg}$ and with the level which was taken $0.505 \pm 0.000257 \text{ mg/kg}$ from different site. No elevated level of cadmium in soil (greater than 5 mg/kg) was detected in all four sites investigated. Soil cadmium concentration in all sites was found to be within the estimated natural concentration range of 0.5 to 2 mg/kg . However, soil samples of Merkato, garage and Koch (bajajtera) that were taken from vehicular and gasoline area contain by far large concentration of cadmium when compared with non-gasoline area of Hospital area. Due to high construction expiation around in hospital area low concentration cadmium than in kochi. Because this site was remote from vehicular, gasoline and other causes. In contrast, soil samples of Kochi contain in high concentration. This is primarily due to vehicular emissions and partly igneous activity. Nonetheless, the average lead and cadmium concentration in soil samples from the four sites studied were all found to be below the maximum tolerable limit according to world health organization (WHO) standards.⁹⁻¹²

The result of this study provides answers to our testable hypotheses and the finding suggests that the level of cadmium and lead is below the maximum tolerable/permissible limit of WHO. But, certain precautionary measures must be conducted in order to prevent possible ingestion of soil containing lead and cadmium. To the best of my knowledge this study is the first in the given area and size of the samples.

Conclusion

As the study result indicated there is no sampling sites recorded a lead and cadmium concentration beyond the world health organization (WHO) permissible limit of 100 and 3.12 mg/kg respectively.^{11,13-15} An average soil lead and cadmium concentration in these studied sites was in the estimated natural concentration 35 mg/Kg to 50 mg/Kg and 0.5 mg/Kg to 5 mg/Kg . However, the concentration of such a heavy metal in these sampling sites were below the world health organization permissible limit the soil sample taken from sampling site of roadside exposed to gasoline and vehicular emission shows a considerable difference in concentration of lead and cadmium in relative to the soil of non-gasoline area. This shows that the level of lead and cadmium in these sites were primarily due to vehicular emission and goals line effluent. In this study the concentration of lead is higher than cadmium in the roadside soil in Jimma south west Ethiopia.

Generally for this study the concentration of lead and cadmium in around Garage area and bajajtera soil in Jimma town is almost very slightly affect human and animal health. Even if the result is below the limit, certain precautionary measures must be conducted in order to prevent possible ingestion of soil containing lead and cadmium. Finally, we recommend further study on this area by increasing the sample size to make it more representative.

Acknowledgments

None.

Conflicts of interest

The author declares that there is no conflict of interest.

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