INVESTIGATION ON CONTAMINATION OF HEAVY METALS IN ROADSIDE SOIL AT KALI-TOLLGATE AND BAYINTNAUNG-QUARTER BETWEEN BAGO-MAWLAMYINE HIGHWAY

San San Kyu[1], Kyaw Naing[2], Win Aung[3]

Abstract

The research work intend to study the heavy metal contamination, originating from motor vehicle traffic in roadside soils near the Kali-Tollgate and Bayintnaung- Quarter on the highway road of Bago to Mawlamyine. Twenty one soil samples were collected from (Kali-Tollgate) according to the distances. Five soil samples were collected from Bayintnaung-Quarter according to the depth profile. Semi-quantitative analyses of the soil samples were done using EDXRF technique. Atomic absorption spectrophotometric method was used for the determinations of heavy metals in soil samples. Changes of concentrations of heavy metals (Pb, Zn, Cu and Cd) with distance from the highway road were studied by using single exponential decay model equation. The data were compared with maximum allowable limit of soil of highway road. The Lead content of the roadside soil range from 12.1 to 102.5 ppm, the Zinc content of the roadside soil range from 8.8 to 206.5 ppm, the copper content of the roadside soil range from 14.1 to 111.5 ppm and the cadmium content of the roadside soil range from 1.3 to 7.9 ppm according to the distance. In general heavy metal concentration decreased with increased distance from the highway road. In all soil samples measured according to the depth profile, Zn concentration was highest, whereas Cd concentration was lowest. In the depth profile of 0.5, 20- 30 cm, Pb concentration were in the range of 55.10 ppm to 20 ppm, Zn concentration were in the range of 264.20 to 56.60 ppm ,Cu concentrations were in the range of 48.0 ppm to 9.2 ppm, Cd concentrations were in the range of 2.1 ppm 1.3ppm. The maximum heavy metal concentration was observed at 0-5 cm depth and the concentration decreased with an increase. The data obtained that measured according to the distances except Cd, were within the maximum allowable limit. They slowly find entry into food chain leading to serious health hazards. Therefore, there is an urgent need for policy regulations to minimize indiscriminate disposal of oil contaminated residues, vehicular emissions, road transport and traffic emissions and the wear and tear of mechanical parts in vehicles beside.

Keywords: Highway Contamination, Heavy Metal, Bago-Mawlamyine Highway Road, Kali-Tollgate, Cadmium

Introduction

The term heavy metals, which is in common use, refers to metals with a density greater than a certain value, usually 5 gcm^{-3} or having atomic number greater than iron (atomic number 26). Heavy metal pollution in urban street dust has become a growing concern in recent years. Street dust is one major way through which heavy metals may find their way into soils and subsequently living tissues of plants and human being. In monitoring urban pollution, there is need to consider the material that cause the occurrence of pollutants. The main processes by which vehicles spread heavy metals (Pb, Zn, Cu, Cd) from roadside dust into the environment are combustion processes, the wear of cars (tires, brakes)refers to metals with a density greater than a certain brakes, engine), leaking of soil and corrosion. Lead is released in combustion of leaded petrol, zinc is derived from tire dust, copper is derived from brake abrasion and corrosion of radiators, the other heavy metals has mixed origins. Heavy metals are also released due to weathering of road surface asphalt and corrosion at crash barriers and road signs. The source 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 street dust through burning of tires and bad roads. Other sources of cadmium and zinc are found

[1] Associate professor, Department of Engineering Chemistry, Technological University (Hpa-an)
[2] Deputy Permanent Secretary
[3] Associate professor Department of Chemistry, Pakokku University

in lubricating oils as part of many activities. Environment is the basis of all forms of life. All life on earth depend on life-support systems such as pure water, fresh air and good soil (Leke, 1999). The environment impacts of toxic heavy metals are very important. This research is investigation on contamination of heavy metals in roadside soil due to the highway effects. The effect of toxic heavy are the heavy metals on roadside environment is very important to know, what metals that contained in the roadside soils, plants and how much they are contained and how much is their effects on roadside soils and plants. The aim at this research work is to study the heavy metal contamination in roadside soils near the Kali-Tollgate on the highway road of Bago to Mawlamyine.

Materials and Methods

Soil samples were collected from Kali-Tollgate and Bayintnaung- Quarter on the highway road of Bago to Mawlamyine. All the samples were dried in air to drive out moisture. Each air dried samples were sieved through a nylon sieve of 250 μm diameter. The following instruments used for the determination of heavy metals; Energy Dispersive X-ray Fluorescence Spectrometer (EDXRF- 700), Atomic Absorption Spectrophotometer (Perkin Elmer Analyst-300 AAS USA).

Elemental Analysis of Soil by EDXRF Technique

EDXRF measurements were made in accordance with the procedure mentioned with the catalogue. Before measurements samples were prepared as pellets. Thus using air as reference, EDXRE spectra of the pellets were recorded.

Determination of Heavy Metal Contents in Soil by Atomic Absorption Spectrophotometric Method

A 1g of air dried roadside soil samples were accurately weighed and place in a 250 ml beaker and them treated with 10 ml aliquots of concentrated nitric acid and the mixture was heated until dry on a sand both and then cooled. This procedure was repeated with another 10 ml concentrated hydrochloric acid. The digested soil samples were then warmed in 20 ml of 2 M hydrochloric acid to rediscover the metal salts. Extracts were filtered and the volume was then adjusted to 40 ml, with deionized water. The hydrochloric acid concentrations in the solution was determined by atomic absorption spectrophotometer.

Results and Discussion

Seven soil samples from Kali-Tollgate and five soil samples from Bayintnaung-Quarter on Bago-Mawlamyiine highway road were collected according to the distances and the depth profile.

Qualitative Analysis of soil samples by EDXRF Technique

Element contents in soil samples were shown in Table 3, Fig 1, and Fig 2. All soil samples contain Si, Fe, Ca, K, Ti, Sr, Zn and Mn.

Table 1 Roadside Soil Samples from Kali Tollgate according to the Distances

Distances From Road (m)	Samples No.		
	Summer	Rainy	Winter
Edge	1	8	15
30	2	9	16
60	3	10	17
90	4	11	18
120	5	12	19
240	6	13	20
300	7	14	21

Table 2 Roadside Soil Samples from Bayintnaung-Quarter according to the Depth Profile

Depth Profile (m)	Sample No.
0 -5	22
5-10	23
10-15	24
15-20	25
20-30	26

Table 3 Elemental Contents in the Soil Samples (as determined by EDXRF)

Samples	Relative abundance (%)										
	Si	Fe	Ca	K	Zn	Pb	Cu	Ti	Sr	Zr	Mn
1	74.3	2.5	5.7	9.6	-	4.7	-	0.2	2.3	0.7	-
2	81.5	10.1	2.7	3.4	0.1	0.2	-	1.3	0.1	0.2	-
3	73.6	13.3	7.6	-	-	-	-	0.8	4.4	0.3	-
4	85.9	7.9	1.2	3.2	-	0.3	-	1.1	0.1	0.2	0.2
5	88.9	5.6	0.8	3.2	-	-	-	1.1	0.1	0.2	0.2
6	87.4	6.7	1.1	2.5	0.9	0.4	0.2	1.2	0.1	0.2	0.1
7	76.7	13.4	4.1	3.1	0.2	0.6	0.2	1.1	0.1	0.2	0.2

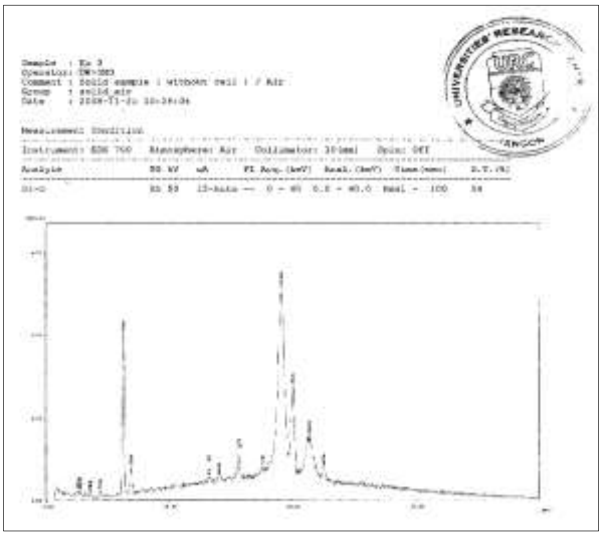

Figure 1 EDXRF spectrum for soil sample No.3

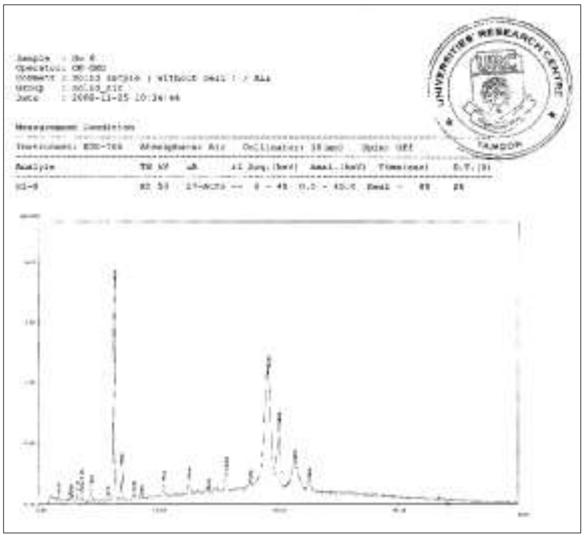

Figure 2 EDXRF spectrum for soil sampleNo.6

Determination of heavy metal (Pb, Zn, Cu, Cd) concentrations in the soil samples were determined by AAS Technique

The heavy metal contents in soil measured in summer season at Kali-Tollgate according to the distances were shown in table 4. The decrease of elemental concentrations with distance from the highway would indicate aerial deposition of metal particulates in the roadside environment from extraneous sources.

Table 4 Heavy Metal Contents in Soil Measured in Summer Season at Kali-Tollgate according to the Distances

Samples	Distances from road (m)	Pb(ppm)	Zn(ppm)	Cu(ppm)	Cd(ppm)
1	Edge	102.5	206.5	111.5	7.9
2	30	91.6	107.4	100.4	3.8
3	60	87.9	103.9	66.2	3.7
4	90	66.3	77.8	45.0	3.6
5	120	64.2	72.5	43.2	3.5
6	240	45.2	14.1	21.5	3.4
7	300	12.1	8.8	14.1	1.3
	Maximum Allowable Limit	100	300	100	5

According to table, concentrations of all metals decreased with an increased in distance from the Bago-Mawlamyine highway road at Kali-Tollgate. Pb concentrations were in the range of 102.5 ppm at edge to 12.1ppm (300 m distance). Zn concentrations were in the ange of 206.5 ppm at edge to 8.8 ppm (300 m distance).Cu concentrations were in the range of 111.5 ppm at edge to 14.1 ppm (300 m distance).Cd concentrations were in the range of 7.9 ppm at edge to 1.3 ppm (300 m distance).

$$Y = ae^{-bx}$$ (sigma plot, 2004)

Where x = concentration of the studied metal

Y = the distance from the highway road

a,b = parameters of the exponential equation

(Sigma plot, 2004)

By using Microsoft excel, changes of the concentrations of heavy metals (Pb, Zn, Cu and Cd) with distance from roadside were plotted as single exponential decay model equation. The plot of Pb contents measured at Kali Tollgate in summer season was shown in Figure 3. The plot of Zn contents measured at Kali Tollgate in summer season was shown in Figure 4. The plot of Cu contents measured at Kali Tollgate in summer season was shown in Figure 5. The plot of Cd contents measured at Kali Tollgate in summer season was shown in Figure 6. From these Figures, the values of R^2 are equal one. So, decrease of metal concentrations from highway road were considered as single exponential decay model equation.

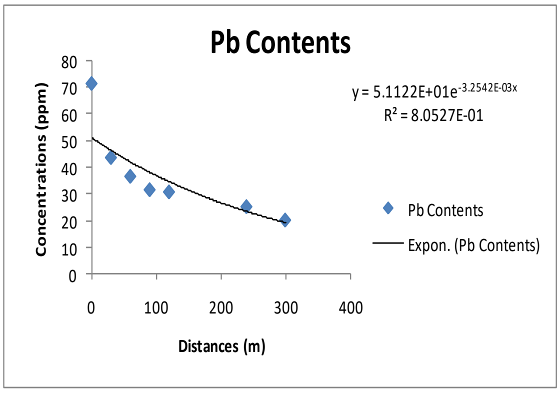

Figure 3 Plot of Pb contents as a function of distance from highway road at Kali- Tollgate in summer season

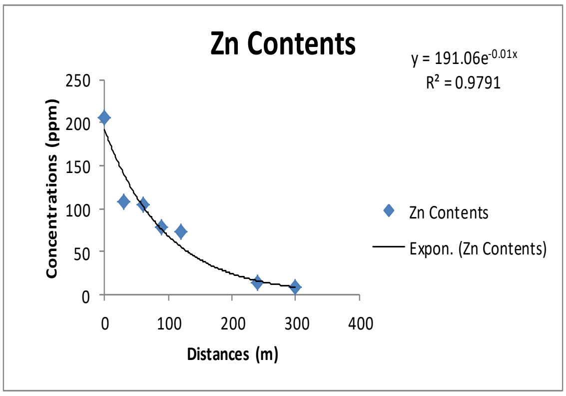

Figure 4 Plot of Zn ontents as a function of distance from highway road at Kali-Tollgate in summer season

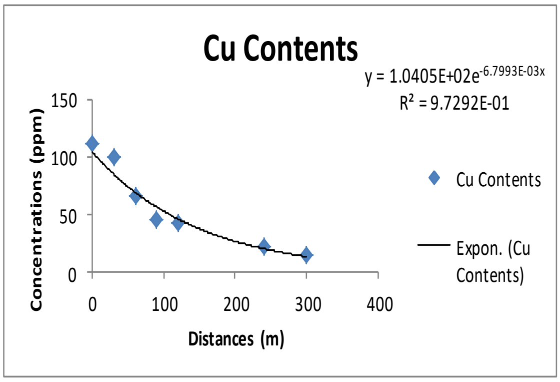

Figure 5 Plot of Cu contents as a function of distance from highway road at Kali-Tollgate in summer season

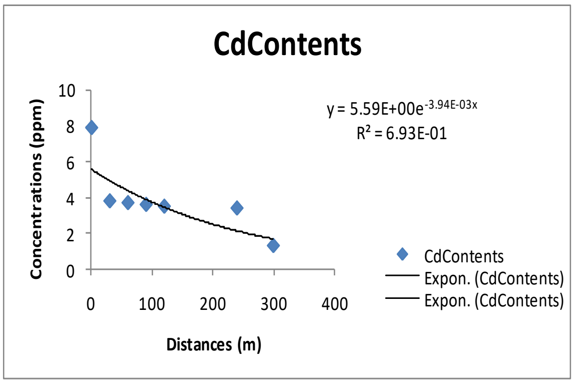

Figure 6 Plot of Cd contents as a function of distance from highway road at Kali-Tollgate in summer season

The heavy metal contents in soil measured in rainy season at Kali-Tollgate according to the distances were shown in Table 5. According to table, concentrations of all metals decreased with an increased in distance from the Bago-Mawlamyine highway road at Kali-Tollgate because the rainfalls washed out the heavy metals in soil and carried away or permeate into the soil. Pb concentrations were in the range of 60.3 ppm at edge to 2.1 ppm (300 m distance). Zn concentrations were in the range of 158.4 ppm at edge to 4.1 ppm (300 m distance).Cu concentrations were in the range of 55.7 ppm at edge to 2.6 ppm (300 m distance).Cd concentrations were in the range of 6.1 ppm at edge to 0.5 ppm (300 m distance). The plot of Pb contents measured at Kali Tollgate in rainy season was shown in Figure 7. The plot of Zn contents measured at Kali Tollgate in rainy season was shown in Figure 8. The plot of Cu contents measured at Kali Tollgate in rainy season was shown in Figure 9. The plot of Cd contents measured at Kali Tollgate in rainy season was shown in Figure 10. Their respective exponential equation was shown in the figures.

The heavy metal contents in soil measured in winter season at Kali-Tollgate according to the distances were shown in table 6. The contaminated dust particles were carried away by the wind. The father from the edge of the road were lower the concentration of heavy metals. According to table, concentrations of all metals decreased with an increased in distance from the Bago-Mawlamyine highway road at Kali-Tollgate. Pb concentrations were in the range of 71.4 ppm at edge to 6.5 ppm (300 m distance). Zn concentrations were in the range of 173.2 ppm at edge to 5.9 ppm (300 m distance).Cu concentrations were in the range of 120.4 ppm at edge to 5.3 ppm (300 m distance).Cd concentrations were in the range of 6.8 ppm at edge to

0.9 ppm (300 m distance). Decreased of metal concentrations from highway road was considered as single exponential decay model equation. The plot of Pb contents measured at Kali Tollgate in winter season was shown in Figure 11. The plot of Zn contents measured at Kali Tollgate in winter season was shown in Figure 12. The plot of Cu contents measured at Kali Tollgate in winter season was shown in Figure 13. The plot of Cd contents measured at Kali Tollgate in winter season was shown in Figure 14. Their respective exponential equations was shown in the figures.

Table 5 Heavy Metal Contents in Soil Measured at Kali Tollgate in Rainy Season according to the Distances

Samples	Distances from road (m)	Pb(ppm)	Zn(ppm)	Cu(ppm)	Cd(ppm)
8	Edge	60.3	158.4	55.7	6.1
9	30	54.6	80.1	48.0	5.2
10	60	52.5	62.5	47.6	4.8
11	90	48.1	60.5	41.1	4.5
12	120	40.3	58.1	31.1	4.1
13	240	20.8	12.3	10.0	3.8
14	300	2.1	4.1	2.6	0.5
Maximum Allowable Limit		100	300	100	5

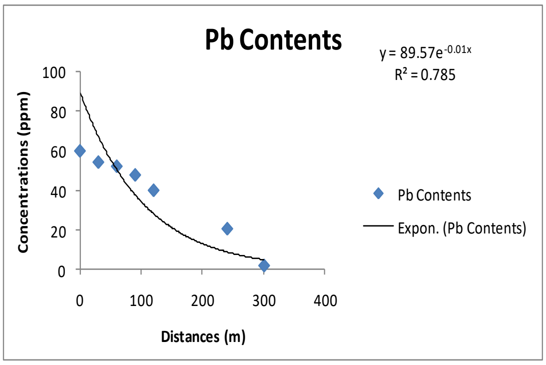

Figure 7 Plot of Pb contents as a function of distance from highway road at Kali- Tollgate in rainy season

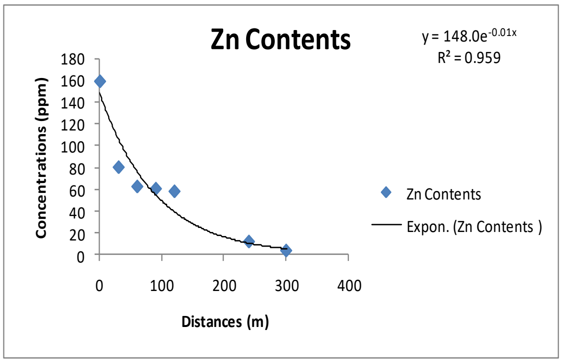

Figure 8 Plot of Zn contents as a function of distance from highway road at Kali- Tollgate in rainy season

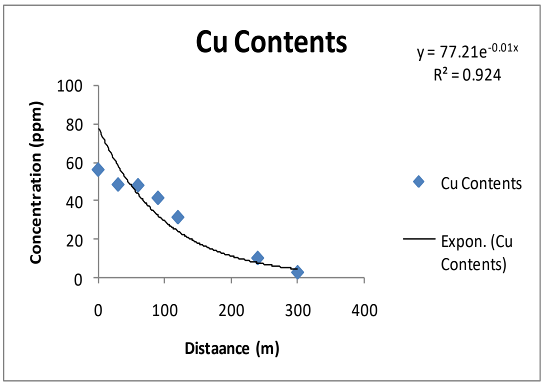

Figure 9 Plot of Cu contents as a function of distance from highway road at Kali- Tollgate in rainy season

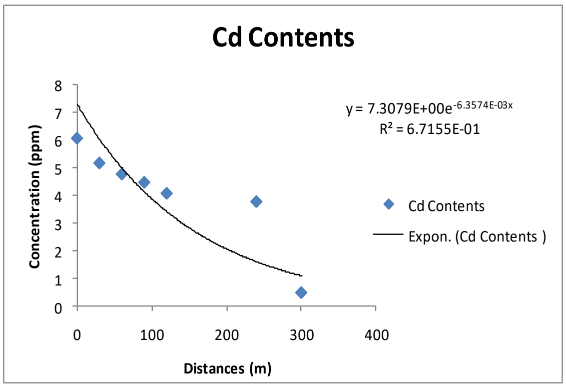

Figure 10 Plot of Cd contents as a function of distance from highway road at Kali- Tollgate in rainy season

Table 6 Heavy Metal Contents in Soil Measured at Kali Tollgate in Winter Season according to the Distances

Samples	Distances from road (m)	Pb(ppm)	Zn(ppm)	Cu(ppm)	Cd(ppm)
15	Edge	71.4	173.2	120.4	6.8
16	30	43.8	159.8	102.6	6.3
17	60	36.8	142.4	92.8	5.2
18	90	31.8	138.5	16.3	4.8
19	120	31.0	94.8	5.7	4.0
20	240	20.5	70.2	5.6	3.6
21	300	6.5	5.9	5.3	0.9
Maximum Allowable Limit		100	300	100	5

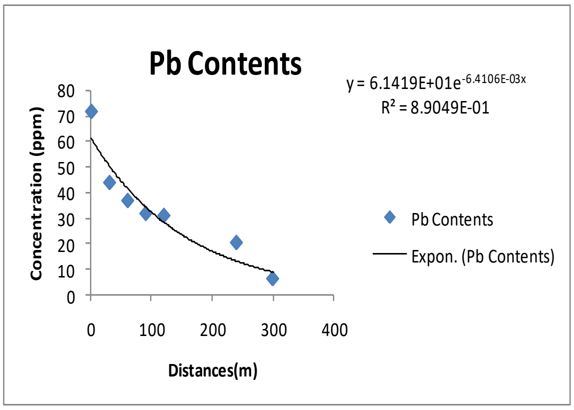

Figure 11 Plot of Pb contents as a function of distance from highway road at Kali-Tollgate in winter season

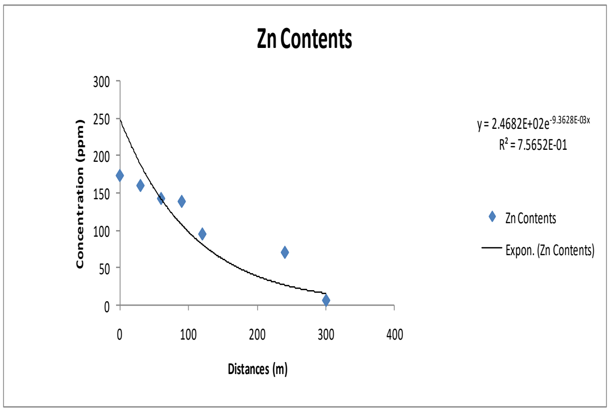

Figure 12 Plot of Zn contents as a function of distance from highway road at Kali-Tollgate in winter season

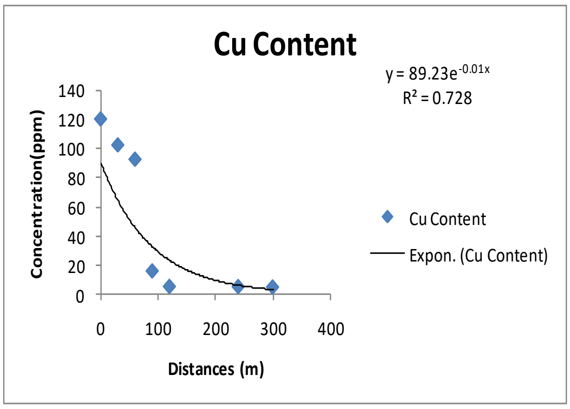

Figure 13 Plot of Pb contents as a function of distance from highway road at Kali-Tollgate in winter season

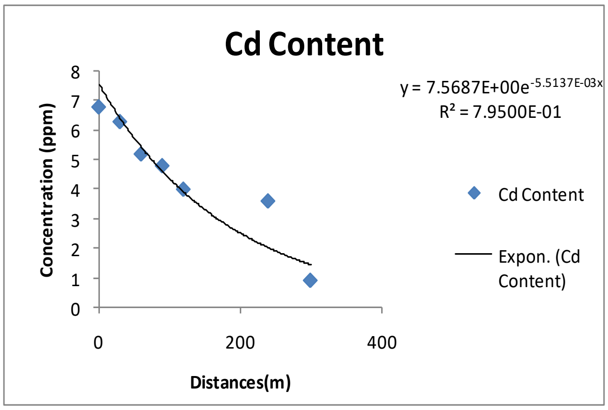

Figure 14 Plot of Cu contents as a function of distance from highway road at Kali-Tollgate in winter season

Table 7 The Regression Equation for the Heavy Metals Contents with Respect to Distance (X) from the Highway Road

No.	Metals	Kali -Tollgate	
		Regression Equation	R^2
1	Pb (Summer)	$Y=1.1827E+02e^{-6.1035E-03x}$	8.4599E-01
2	Zn (Summer)	$Y=191.0e^{-0.01x}$	0.979
3	Cu (Summer)	$Y=1.0405E+02e^{-6.7993E-03x}$	9.7292E-01
4	Cd (Summer)	$Y =5.59E+00\ e^{-3.94E-03x}$	6.93E-01
5	Pb (Rainy)	$Y=89.57e^{-0.01x}$	0.785
6	Zn (Rainy)	$Y=148.0e^{-0.01x}$	0.959
7	Cu (Rainy)	$Y=77.21e^{-0.01x}$	0.924
8	Cd (Rainy)	$Y=7.3079E+00\ e^{-6.3574E-03x}$	6.7155E-01
9	Pb (Winter)	$Y=6.1419E+01e^{-6.4106E-03x}$	8.9049E-01
10	Zn (Winter)	$Y=2.4682E+02e^{-9.3628E-03x}$	7.5652E-01
11	Cu (Winter)	$Y=89.23e^{-0.01x}$	0.728
12	Cd (Winter)	$Y=7.5687E+00e^{-5.5137E-03x}$	7.9500E-01

Heavy Metal Concentrations Changes with the Depth Profile

Changes of heavy metal contents with the depth profile at Bayintnaung-Quarter at the edge of Bago Mawlamyine highway road was shown in Table 8.

Table 8 Changes of Heavy Metal Contents in Soil Samples with Depth Profile at Bayintnaung-Quarter

Samples	Depth profile(cm)	Pb(ppm)	Zn(ppm)	Cu(ppm)	Cd(ppm)
22	0-5	55.10	264.20	48.00	2.10
23	5-10	54.90	229.50	31.40	1.90
24	10-15	53.30	175.40	27.20	1.70
25	15-20	22.90	144.20	10.60	1.70
26	20-30	20.00	56.60	9.20	1.30

From this table, in all soil samples, Zn concentrations were highest whereas Cd concentrations were lowest. In the depth profile of 0 - 5 cm and 20-30 cm, Pb concentrations were in the range of, 55.10 ppm to 20 ppm ,Zn concentration were in the range of 264.2 ppm to 56.60 ppm ,Cu concentrations were in the range of 48.0 to 9.2 ppm, Cd concentrations were in the range of 2.1 to 1.3 ppm . The maximum heavy metal concentrations were observed at 0-5 cm depth and the concentration decreased with an increase in depth.

The histogram of changes of Pb contents with depth Bayitnaung-Quarter was shown in Figure 15. The histogram of changes of Zn contents with depth Bayitnaung-Quarter was hown in Figure 16. The histogram of changes of Cu contents with depth Bayitnaung-Quarter was shown in Figure 17. The histogram of changes of Cd contents with depth Bayitnaung-Quarter was shown in Figure 18.

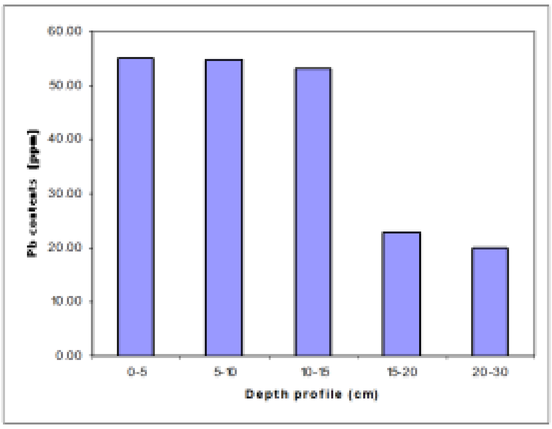

Figure 15 Changes of Pb contents with Depth profile at Bayintnaung Quarter

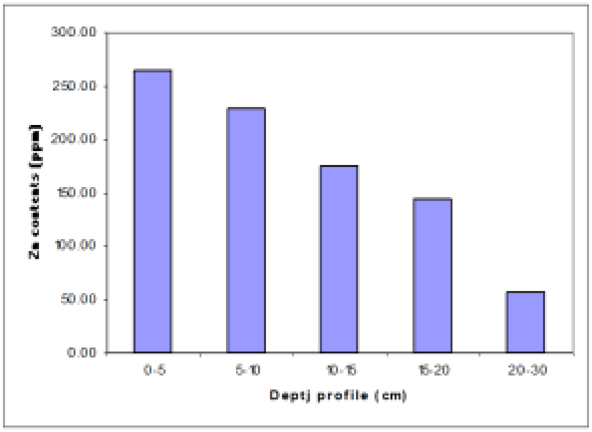

Figure 16 Changes of Zn contents with depth profile at Bayintnaung Quarter

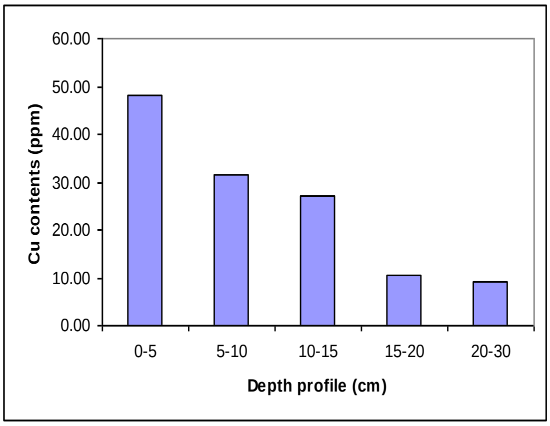

Figure 17 Changes of Cu contents with depth profile at Bayintnaung-Quarter

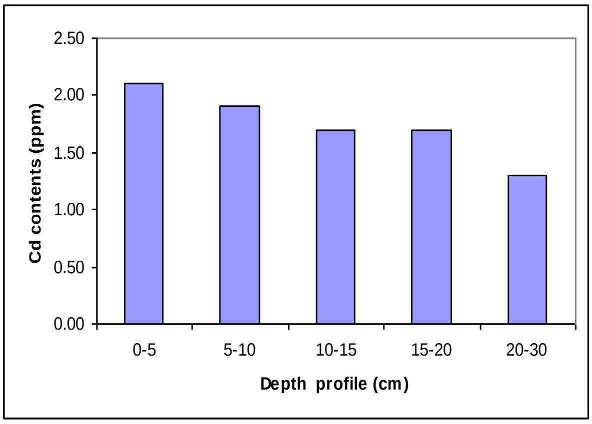

Figure 18 Changes of Cd contents with depth profile at Bayintnaung Quarter

Conclusion

The research work intends to study the heavy metal contamination, originating from motor vehicle traffic in roadside soils near the Kali-Tollgate on the high way road of Bago to Mawlamyine. From this research, all soil samples contain Si, Fe, Cd, K, Ti, Sr, Zn and Mn. The Lead content of the roadside soil range from 12.1 to 102.5 ppm in summer, 2.1 to 60.3 ppm in rainy, 6.5 to 71.4 ppm in winter season at Kali-Tollgate according to the distance. The Zinc content of the roadside soil range from 8.8 to 206.5 ppm in summer, 4.1 to 158.4 ppm in rainy, 5.9 to 173.2 ppm in winter season at Kali-Tollgate according to the distance. The copper content of the roadside soil range from 14.1 to 111.5 ppm in summer, 10.0 to 55.7 ppm in rainy, 5.3 to 120.4 ppm in winter season at Kali-Tollgate according to the distance. Cadmium content of the roadside soil range from 1.3 to 7.9 ppm in summer, 0.5 to 6.1 ppm in rainy, 0.9 to 6.8 ppm in winter season at Kali-Tollgate according to the distance.

In all soil samples measured according to the depth profile, Zn concentration was highest, whereas Cd concentration was lowest. In the depth profile of 20 to 30 cm to 0.5 cm. Pb concentration were in the range of,20 ppm to55.10 ppm ,Zn concentration were in the range of 56.60 to 264.20 ,Cu concentrations were in the range of 9.2 to'48.0 ppm, Cd concentrations were in the range of 1.30 to2.1 ppm.. The maximum heavy metal concentrations were observed at 0-5 cm depth and the concentration decreased with an increase in depth.

The data obtained that measured according to the distances except Cd, were within the maximum allowable limit. Cd concentration was higher than that of maximum allowable limit. So, the resultant Cd contamination might be due to different sources as well as their sinks in the soil profile. The findings of present study would be helpful for understanding soil contamination in the surface soil near national highway influenced by road transportation. If the heavy metals leak into adjacent agricultural fields. They slowly find entry into food chain leading to serious health hazards. Therefore, there is an urgent need for policy regulations to minimize indiscriminate disposal of oil contaminated residues, vehicular emissions, road transport and traffic emissions and the wear and tear of mechanical parts in vehicles beside urban highways.

Acknowledgments

The author would like to express their profound gratitude to the Department of Higher Education, Ministry of Education, Yangon, Myanmar for permitting this grant to carry out the research programme and thanks are extended to Myanmar Academy of Arts and Science, Yangon. And also thanks to Dr.Kyaw Naing, Deputy Permanent Secretary and Dr. Win Aung, Associate professor, Department of Chemistry, Pakokku University for their kind encouragement.

References

Ales, A.P. and Nina Zupancic, N.Z., (2009), "Heavy Metal Contamination of Roadside Soil along Ljubljana-Obrezja Highway", *RMZ-Materials and Geoenvironment*, 52, 403-418

Ayodele, J.T., (1998), "Chromium, Zinc and Manganese in Kano Municipality Street Dust", *Chem,Soc.Nig*, 23,24-31

Alistair, D. and Willam H.G., (2006), "Heavy metal contamination of Roadside Soils of Northern England". Northern England",*Soil and Water Research Journal*, 1,158-163

Chong C. (1986), "Determination of Silver, Bismuth, Cadmium, Copper, Iron, Nickel and Zinc in Lead and Tin Base Solder and White Metal Bearing Alloys by Atomic Absorption Spectrophotometer," *Talanta*, 33,91- 94

Jaradat, Q.M.(1999),"Contamination of Roadside Soil, plants and Air with Heavy metals in Jordan" Jordan, A Comparative Study*", Turk J. Chem*, 23, 313-318

Kabata, A. (1986), "*Trace Elements in Soils and Plants*", Boca Raton press, 313-318

Leke, T.T., (1999), "*Environmental Health*", Adeka Press and Publishing Co. ltd, Markudi., 16-24

Pendias K.A., and Pendias, H., (1992), "*Trace Elemens in Soil and Plants",* 2nd Edition, Boca Raton: CRC Press, Florida, U.S.A. 305-313

Van Bohemen, H.D. and Van De Laak, W.H.J., (2003), "The Influence of Road. Infrastructure and Traffic on Soil, Water, and Air Quality", *Environmental Management*, 31, 50-68