International Journal of Scientific Research in Chemistry (IJSRCH) | ISSN : 2456-8457
© 2016 IJSRCH | Volume 1 | Issue 1

Spatio-Temporal Variations Of Heavy Metal Contamination in Soils in the Vicinity Of Auto Mechanic Workshop Clusters at Central Agricultural Station, Kwadaso-Ghana

Adams Sadick*[1], Gabriel Willi Quansah[1], Eric Owusu Adjei[2], Gideon Asamoah[3]

*[1]Analytical Services, Soil Research Institute, Kumasi, Ghana
[2]Directorate, Soil Research Institute, Kumasi, Ghana
[3]Soil Microbiology, Soil Research Institute, Kumasi, Ghana

ABSTRACT

A research was conducted at Auto mobile workshops in the vicinity of Central Agricultural Station to monitor the levels of heavy metals in soils in auto mechanic clusters in order to assess the pollution risk they pose to the environment and the people in the surrounding area. Four soils samples were taken from each workshop: Auto body (AB), Auto mechanic (AM), Auto electric (AE) and Auto spray (AS), making a total of 32 samples in July, 2015 and January, 2016.The soil samples were taken to Soil Research Institute's Laboratory for analysis. Lead (Pb), Iron (Fe), Copper (Cu), Cadmium (Cd), Manganese, Zinc were the heavy metals analyzed using Atomic Absorption Spectrometer (AAS). The pH of the samples was also analyzed using pH-meter. The results showed that the difference between the elements in each workshop was significant ($P<0.05$) and in order: AS>AE>AM>AB and Pb>Fe>Cu>Cd>Mn>Zn. However, there was no seasonal effect ($P>0.05$) on the elements except Pb and Cd. The pH was low in Auto electric shops and also generally low in the dry season. Similar studies on these metals at the peak of rainy season in 2016 is highly recommended to ascertain whether or not the metals actually leached down the soil to reduce their levels or concentrations increased in the dry season due to the mechanic activities.

Keywords: Heavy Metal, Soil, Concentration, Wet, Dry And Season

I. INTRODUCTION

Soils may become contaminated by the accumulation of various heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition (Wuana and Okieimen, 2011). Heavy metal is a general term used to describe a collection of metals and metalloids with an atomic density greater than 5.0 g/cm3 (Duffus, 2002). These elements occur naturally in soils and rocks at different concentrations; they are also found in ground, surface water bodies and sediments (Hutton and Symon, 1986). Unchecked industrial and human activities have contributed significantly to pollution levels of these metals, in surface and subsurface soils when compared to those contributed from geogenic or natural processes (Dasaram et al., 2011). Their pollution of the environment even at low levels and the resulting long-term cumulative health effects are among the leading health concerns all over the word (Huton and Symon, 1986). The concern is heightened by their persistence in the soil and their tendencies to bio accumulate, move along the food chain and also poison soil microorganisms (Udousoro et al., 2010).

Soil being one of the repositories for anthropogenic waste, biochemical processes can mobilize the chemical substances contained in it to pollute water supplies and impact food chains thereby causing great harm to man. The high toxic and persistent natures of heavy metals in the environment have made them priority pollutants (Abechi et. al., 2010).

Heavy metal contamination is found in different part in Kumasi mainly as a result of waste from auto mechanic workshop clusters. Auto mechanic workshops are located in areas such as suame (Magazine), Tafo, Asafo, Asuoyeboah and Kwadaso which was the study area. These places are officially allocated by Kumasi Metropolitan Assembly (KMA) for repairs and servicing of motor vehicles and other machineries.

The sources and mechanism of discharge of heavy metals into the soil and water resource of automobile mechanic site include engine oil and lubricating oil, engine and gear box recycling, battery charging, welding and soldering, automobile body work and spraying painting and combustion processes (Pam et. al., 2013). Waste originating from such activities include spent lubricants, hydraulic fluids, worn-out parts, packaging materials, metal scraps, used batteries, discarded cans and stripped oil sludge (Pam et. al.,2013). The heavy metals most frequently encountered in this waste include copper, lead, cadmium, zinc, manganese and nickel, all of which pose risks for human health and the environment. It has therefore become imperative to monitor the levels of these heavy metals in soils in auto mechanic clusters in order to assess the pollution risk they pose to the environment.

II. METHODS AND MATERIAL

A. Location of the study area

The study area is located in Edwenase-Kwadaso, a suburb of Kumasi in the Ashanti region of Ghana (figure1). Previously, these grounds served as trial sites for agricultural research activities which have now been converted to auto mechanic workshop clusters (Sadick et al., 2015). The geographical location of Kwadaso lies within Latitude 6.42o N and Longitude 1.34o W with an altitude of 284m above mean sea level as described by Sadick et al., 2015.

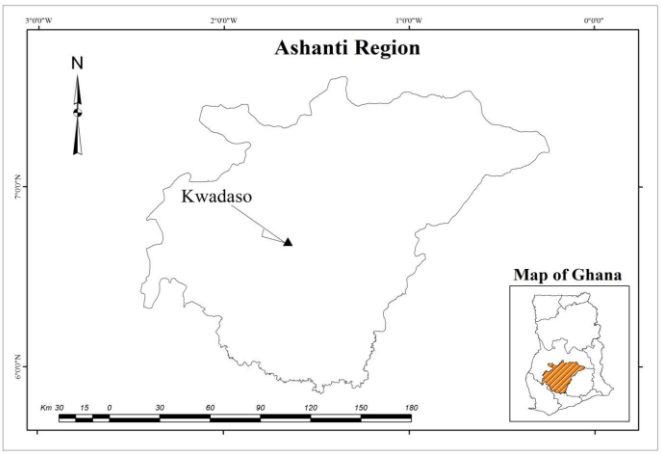

Figure 1: Location of the study area (Sadick et al., 2015)

The topography of the area is partly flat and undulating, and lies within the Tropical Rainforest Agro-ecological zone of Ghana. The soil type is made up of specifically Cutanic Lixisol (WRB, 2006). The presence of the Agricultural College and two Research Institutes in the town attracts a large population of people and presence of many automobile vehicles, which in turn gives a boost to automobile workshop activities (Sadick et al., 2015)

B. Soil sampling and treatment

Topsoils are the first locus of input of metals where they tend to accumulate on a relatively long term basis (Abenchi et al., 2010). These pollutants normally contaminate the upper layer of the soil at a depth (0 - 40) cm (Krishna and Grovil, 2007). This implies that, high concentration of these pollutants could be present at this depth if assessed (Pam et. al., 2013). Four different automobile workshops, namely auto body, auto mechanic, auto spraying and auto electrician shops were identified in the study area and soil samples were collected from these selected automobile workshops using soil auger, at the depth of 0-15cm representing the top soil. The first soil sampling was done in July, 2015 (peak of the rainy season), and the second one in January, 2016 (peak of the dry season). At each location, the soil samples were taken from four different points making a total of 32 samples (16 samples in each season). In addition to these, a control sample was collected from an undisturbed area (forest) about 100m away from the study area as described by Sadick et al., 2015. These control samples or background samples had no influence of any auto mechanic activities. The geology of the control sample area and that of the study

area are underlain by granitic rocks. The results obtained were discussed based on the control results.

The samples were placed in labeled polythene bags and transported to the CSIR-Soil Research Institute laboratory for analysis. All soil Samples were subsequently air-dried to constant weight to avoid microbial degradation (Kakulu, 1993). They were homogenized, made lump free by gently crushing repeatedly using a pulverizing machine and passed through a 2 mm plastic sieve prior to analysis.

C. Analysis of heavy metals as soil contaminant

One gram of the dried fine soil sample was weighed into an acid washed, round bottom flask containing 10 cm3 concentrated nitric acid (HNO3). The mixture was slowly evaporated over a period of one hour (1) on a hot plate. Each of the solid residues obtained was digested with a 3:1 concentrated HNO3 and HclO4 mixture for 10 minutes at room temperature before heating on a hot plate. The digested mixture was placed on a hot plate and heated occasionally to ensure a steady temperature of 150°C over 5 hours until the fumes of HClO4 were completely evaporated (Jacob et al., 2009). The mixture was allowed to cool to room temperature and then filtered using Whitman No.1 filter paper into a 50 cm3 volumetric flask and made up to the standard mark with deionized water after rinsing the reacting vessels, to recover any residual metal. The filtrate was then stored in pre-cleaned polyethylene storage bottles ready for analysis. Heavy metal concentrations were determined using an Atomic Absorption Spectrophotometer (AAS) at the CSIR-Soil Research Institute, Ghana. The settings of the instrument and operational conditions were in accordance with the manufacturer's specifications.

D. Statistical analysis

In this context, the analysis for the interpretation of the data gives a clear understanding of the variations of the heavy metals with respect to concentration of the study area. For data processing six variates, Fe, Cu, Zn, Mn, Pb and Cd were subjected to statistical analysis using Genstat 12th edition to analyze seasonal and locational variations of heavy metals with respect to concentration. According to this package if P-value is less than 0.05, there is significant difference and vice-versa.

III. RESULTS AND DISCUSSION

Analysis of soil samples selected at the peak of wet and dry seasons at each of the auto workshops are presented in the tables and figures below. Tables 1 and 2 show concentrations of the elements at selected auto body (AB), auto mechanic (AM), auto electric (AE) and auto spray (AS) workshops at the peak of the rainy and dry seasons, table 3 indicates statistical analysis of the concentrations of the element in each of the locations and figures 2,3 and 4 also show the comparisons of the levels of concentrations in each season and location. The pH of the soil samples ranged between 4.44 and 6.45 in the rainy season and 4.00 and 6.78 in the dry season with average values of 5.70 and 5.38. This indicated that the study area was virtually acidic in both season but highest in the dry season (Table 1-2). Therefore there was a definite movement of cations from the surface to the underlying soil layer especially during the rainy season (Gambrell, 1994). The pH was actually considered in this research because it influences the interactions and dynamics of metals in the soil matrix (Aloysius et al., 2013). The acidic level in the soil is higher in auto electric workshop than all the other shops. This could be attributed to the disposal or spillage of spent H2SO4 contained in the batteries. These auto electricians mostly repair auto mobile batteries and replace the acid in the batteries with fresh one before charging.

A. Heavy Metal Contaminations and Variations

Many studies have shown that heavy metal contaminations are higher in urban areas than rural areas, due to anthropogenic activities of urban settlements such as industrial activities, sewage from domestic activities etc. (Adelekan and Alawode, 2011).

Generally, the elements were higher in concentrations in rainy and dry seasons as compared to control results (Table 1-2), and the concentration of the elements were in order: Pb>Fe>Cu>Cd>Mn>Zn (Figure 2). There were significant difference ($P<0.05$) in concentration among the location of the elements (Table 3). Lead (Pb) and Iron (Fe) have the highest concentrations in all the auto shops and Zn is the lowest (Figure 4). Pb concentration was high at the auto electric shops (Figure 4), this could be due to the auto mobile emissions and expired motor batteries in the area (Aloysius et al., 2013).

There were no seasonal effect on the concentration of all the elements (P>0.05), except Pb and Cd which showed seasonal effects on concentrations (P<0.05) (Table 3). The concentration of Pb and Cd in the areas studied could come from lubricating oils, vehicle wheel, leaded gasoline and metal alloys used to harden engine parts (Dabkowska -Naskret, 2004). There were also seasonal variations of the concentrations of the elements in the study area. The concentrations were high in the dry season than rainy season (Figure 3). This could be explained from the fact that in the dry season, evaporation is very high, exposing most of the elements from the top of profile. In the rainy season there was a definite movement of cations from the surface to the underlying soil layer especially during the rainy season (Gambrell, 1994).

TABLE I
CONCENTRATIONS OF HEAVY METALS (PPM) IN THE SOILS IN AUTO MECHANIC WORKSHOP CLUSTERS IN THE RAINY SEASON

Location	Fe	Cu	Zn	Mn
	ppm			
AB1	43.88	11.64	1.88	6.27
AB 2	90.56	7.89	2.91	4.84
AB3	80.11	15.32	1.65	5.28
AB4	50.05	12.98	1.89	4.99
AM1	112.84	22.59	2.46	10.29
AM 2	59.96	20.36	2.93	18.49
AM3	94.00	21.36	2.33	13.20
AM4	65.34	25.54	1.99	14.62
AE1	129.83	12.30	1.43	3.80
AE 2	120.38	33.06	2.84	10.36
AE3	115.23	20.13	1.89	11.31
AE4	120.33	23.14	2.02	12.01
AS1	264.09	49.03	33.38	32.53
AS 2	125.34	26.91	33.00	19.97
AS3	198.23	31.09	2.33	10.23
AS4	188.99	38.99	2.85	11.20
BS	36.89	12.33	1.90	4.80
Mean	116.20	23.27	6.11	11.84

TABLE II
CONCENTRATIONS OF HEAVY METALS (ppm) IN THE SOILS IN AUTO MECHANIC WORKSHOP CLUSTERS IN THE RAINY SEASON (CONTINUATION)

Location	pb	Cd	pH
	ppm		
AB1	223.53	12.90	6.30
AB 2	225.96	13.50	6.40
AB3	205.21	10.00	6.38
AB4	210.32	10.98	6.45
AM1	250.00	14.00	5.80
AM 2	260.43	17.80	5.64
AM3	233.11	15.00	5.99
AM4	220.98	12.56	6.01
AE1	270.00	12.30	4.50
AE 2	265.33	10.22	4.30
AE3	245.11	11.09	4.99
AE4	247.98	9.99	4.44
AS1	235.03	11.01	5.99
AS 2	230.10	10.90	6.23
AS3	252.33	12.31	5.75
AS4	230.70	9.78	6.00
BS	9.22	7.01	6.50
Mean	237.88	12.15	5.70

TABLE III
CONCENTRATIONS OF HEAVY METALS (ppm) IN THE SOILS IN AUTO MECHANIC WORKSHOP CLUSTERS IN THE DRY SEASON

Location	Fe	Cu	Zn	Mn
	ppm			
AB1	50.10	15.60	2.01	6.29
AB 2	93.59	10.89	2.91	4.84

AB3	91.16	15.32	1.69	5.33
AB4	58.12	20.11	2.58	5.01
AM1	112.84	22.99	2.48	10.29
AM 2	65.01	29.36	3.09	18.59
AM3	95.00	25.11	2.88	13.20
AM4	76.00	30.10	2.00	16.60
AE1	140.00	19.20	1.59	3.89
AE 2	124.38	40.06	2.88	10.39
AE3	120.29	20.13	2.00	12.38
AE4	129.33	26.19	3.80	12.00
AS1	264.09	55.12	20.33	35.99
AS 2	139.34	30.14	35.00	24.97
AS3	210.10	31.13	2.35	12.24
AS4	190.00	45.99	2.89	16.23
BS	35.99	12.69	2.03	4.35
Mean	122.46	27.34	5.69	13.02

TABLE IV
CONCENTRATIONS OF HEAVY METALS (ppm) IN THE SOILS IN AUTO MECHANIC WORKSHOP CLUSTERS IN THE DRY SEASON (CONTINUATION)

Location	pb	Cd	pH
AB1	250.53	12.99	6.78
AB 2	245.96	13.57	6.01
AB3	220.29	11.00	6.20
AB4	240.30	15.12	5.60
AM1	260.98	14.78	5.40
AM 2	260.99	21.81	5.01
AM3	255.12	16.00	5.23
AM4	240.00	13.50	5.40
AE1	285.00	12.30	4.10
AE 2	279.99	14.22	4.25
AE3	260.11	15.09	4.00
AE4	260.99	9.99	4.23
AS1	235.03	15.01	6.01
AS 2	230.10	12.00	5.99
AS3	256.99	12.30	5.85
AS4	236.79	10.78	5.99
BS	9.64	7.50	6.40
Mean	251.20	13.78	5.38

AB: Auto body, AM: Auto mechanic, AE: Auto electric, AS: Auto spray and BS: Background sample or Control

TABLE V
DATA ANALYSIS BASED ON LOCATION AND SEASONAL VARIATIONS

Location				**Season**		
Heavy Metals	P-value	Analysis		Heavy Metals	P-value	Analysis
Fe	0.001	Significant		Fe	0.582	Insignificant
Cu	0.001	Significant		Cu	0.137	Insignificant
Zn	0.004	Significant		Zn	0.889	Insignificant
Mn	0.001	Significant		Mn	0.574	Insignificant
Pb	0.001	Significant		Pb	0.006	Significant
Cd	0.003	Significant		Cd	0.036	Significant

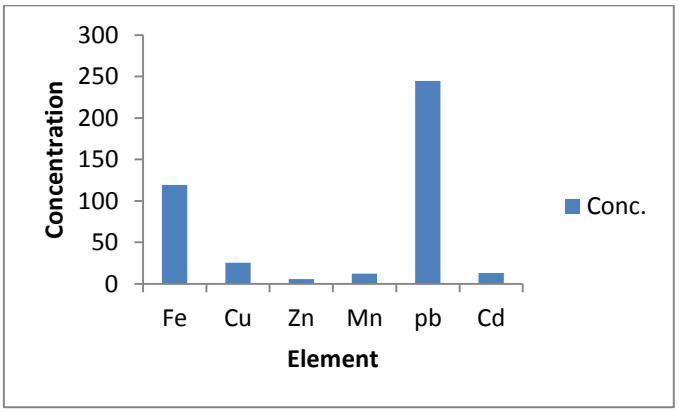

Figure 2: Average concentration of elements in the study area (wet/dry)

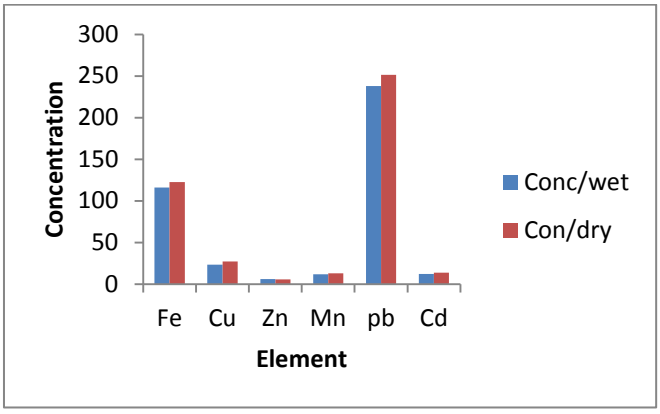

Figure 3: Concentrations of elements in wet and dry season

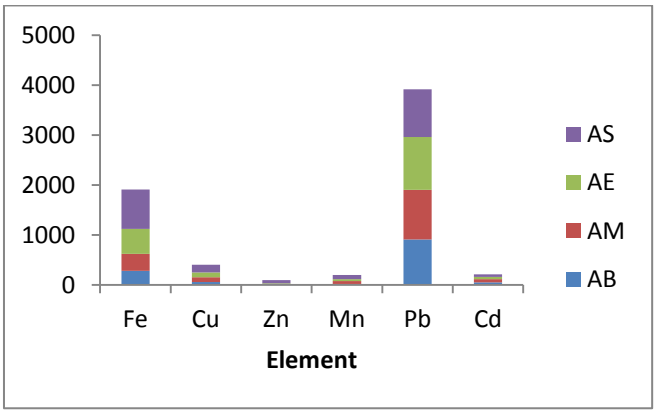

Figure 4. Average concentration of elements in each location

IV.CONCLUSION

The research at the auto mechanic workshop clusters showed that the study area moderately acidic, with high concentration of elements in dry season. The difference in concentrations of element in each shop is significant; however there was no seasonal effect on the concentrations except Pb and Cd. On the basis of the background results, it can be concluded that the study area is polluted.

V. REFERENCES

[1]. Abechi E.S., Okunola O. J., Zubairu S. M .J., Usman A. A., And.Apene E. 2010. Evaluation of Heavy metals in roadside soils of major streets in Jos Metropolis, Nigeria. Journal of Environmental chemistry and Ecotoxicology, 2010, 2(6): 98 – 102.

[2]. Aloysius A. P., Rufus S. and John O. O. 2013. Evaluation of heavy metals in soil around auto mechanic workshops clusters in Gboko and Makurdi central Nigeria. Journal of Environmental Chemistry and Ecotoxicology. 5(11), 298-306. DOI:10.5897/JECE2013.0295

[3]. Adepoju M. O., Adekoya J. A. 2008. Distribution and assessment of heavy metals in sediments of the river orle, south-western Nigeria. J. Sustainable Dev. Environ. Protection 2(1):78-97.

[4]. Akoto O., Ephraim J. H., Darko G. 2008. Heavy metals pollution in surface soils in the vicinity of abandoned railway servicing workshop in Kumasi, Ghana. Int. J. Environ. Res. 2(4):359 - 364.

[5]. Dabkowska-Naskret H. 2004. The mobility of heavy metals in urban soils used for food production in Poland. Land contamination and reclamation,12(3): 205-212.

[6]. Dasaram B., Satyanarayanan M., Sudarshan V., Keshav K. A. 2010. Assessment of soil contamination in Patancheru industrial area, Hyderabad, Andhra Pradesh, India. Res. J. Environ. Earth Sci. 3: 214-220.

[7]. Duffus J. H. 2002. "Heavy Metals-A Meaningless Term". Pure and Applied Chemistry 74:793 -807.

[8]. Fagbote E. O., Olanipekun E. O. 2010. Evaluation of the status of Heavy Metal pollution of soil and plant (Chromolaena Odorata) of Agbadu Bitumen Deport Area, Nigeria. American - Eurasian J. Sci. Res. 5(4):241- 248.

[9]. Hakanson L. 1980. An ecological risk index for aquatic pollution control. A sediment logical approach. Water Reps. 14:975-1001.

[10]. Hutton M., Symon C. 1986. The Quantities of Cadmium, Lead, Mercury and arsenic entering the UK. Environment from human activities. Science of the Total Environment, 57:129 - 150.

[11]. Gambrell RP (1994). Trace and Toxic Metals in Wet lands -A Review. J. Environ. Qual. 23:883 – 891

[12]. Ibitoye A. A. 2006. Laboratory Manual on Basic Soil analysis. 2nd edition. Foladave Nig. ltd. Pp. 32 - 36.

[13]. Jacob J. O., Paiko T. B., Yusuph B. M., Falowo F. O. 2009. Lead, copper and zinc accumulation in soils and vegetables of urban farms in Minna, Nigeria. Int. J. Chem. Sci. 2(2):2006 - 3350.

[14]. Kakulu S. E. 1993. Biological monitoring of atmospheric trace metal deposition in North Eastern Nigeria. Environmental Monitoring and Assessment, 28:137 - 143.

[15]. Krishna A. K., Govil P. K. 2007.Soil contamination due to heavy metals from an industrial area of Surat, Gujarat, Western India. Environ Monit Assess. 124:263-275.

[16]. Laurent P. R. O., Jean P. T. 2011. Heavy metals in soil on spoil heap of an abandoned lead ore treatment plant, S.E Congo-Brazzaville. Afri. J. Environ. Sci. Technol. 5(2):89 - 97.
[17]. Muller G. 1969. Index of geo-accumulation in sediments of the Rhine River. Geo. J. 2(3):108-118.
[18]. Nwachukwu M. A., Feng H, Alinnor J. 2011. Trace metal Deposition in soil from Auto-mechanic village to urban residential areas in Owerri, Nigeria. Proc. Environ. Sci. 4: 310-322.
[19]. Oguntimehin I., Ipinmoroti K. O. 2008. Profile of heavy metals from automobile workshops in Akure, Nigeria. J. Eviron. Sci. Technol. 1(7):19 - 26.
[20]. Pam A. A., Sha'ato R., And Offem J. O. 2013. Evaluation of heavy metals in soils around auto mechanic workshop clusters in Gboko and Makurdi, Central Nigeria. Journal of Environmental chemistry and ecotoxicology. Vol. 5(11), pp. 298-306. www.academicjournals.org/JECE
[21]. Puyate Y.T, Rim-Rukeh A, Awatefe J. K. 2007. Metal pollution assessment and particle size distribution of bottom sediment of Orogundo River, Agbor, Delta State, Nigeria. J. Appl. Sci. Res. 3(12):2056 - 2061.
[22]. Sadick A., Amfo-Otu R., Acquah J. S., Nketia K. A., Asamoah E., Adjei E. O. 2015. Assessment of Heavy Metal Contamination in Soils around Auto Mechanic Workshop Clusters in Central Agricultural Station, Kumasi-Ghana. Applied Research Journal, 2015, 1(2): 12-19
[23]. Udousoro Ii, Umoren I. U., Asuquo E. O. 2010. Survey of some heavy metal concentrations in selected soils in South Eastern parts of Nigeria. World J. Appl. Sci. Technol. 2(2):139 - 14.
[24]. Victor A. A., Akinlolu F. A., Cheo E. S. 2006. Heavy metal concentrations and distribution in surface soils of Bassa industrial zone1, Douala, Cameroon. The Arab. J. Sci. Eng. 31(2A):147-158.