Available online at www.elixirpublishers.com (Elixir International Journal)

Applied Chemistry

Elixir Appl. Chem. 43 (2012) 6574-6576

ISSN: 2229-712X

Linear model of Cadmium content of Commercial Motor Parks in some cities in South-eastern Nigeria

Okoro I.A., Sonde C.U. and Anyim A.C.

Department of Chemistry, Michael Okpara University of Agriculture, Umudike, P. M. B. 7267, Umuahia, Abia State, Nigeria.

ARTICLE INFO

Article history:

Received: 15 December 2011;

Received in revised form:

19 January 2012;

Accepted: 31 January 2012;

Keywords

Cadmium content,
Linear model,
Permissible limits,
Analysis of variance,
Least significant difference,
Probability level,
Commercial motor parks,
South-eastern Nigeria.

ABSTRACT

Linear model of cadmium content of soil samples in five commercial motor parks in some cities in South-eastern Nigeria were studied using analysis of variance and least significant difference test. The results showed that the mean values of three out of the five samples investigated and modeled were statistically significant at 95% probability level. Three of these five samples when compared with the cadmium permissible limits of 0.01 mg/kg were statistically significant at 95% probability level using the calculated least significant difference of 0.112 mg/kg. From the results of the analyses of the study, the Cadmium content in these choice locations were greater than the permissible limit of 0.01 mg/kg for Cadmium level in the environment.

Introduction

Soil whether in the cities or rural areas represents the major sink for metals released into the environment from numerous human activities. Once in the soil, some of these metals will persist due to the immobile nature and non-biodegradability of metals. Some of these metals are highly mobile contaminating farmlands and groundwaters. The current pattern of industrial development in most less developed countries of the world has changed the natural flow of material thereby introduced new chemicals into the environment (1, 2). The rates at which the metals are released into air, soil and farmland have been on increase due to rapid growth of cities in the world. Other industrial discharges, automobile emission and the anthropogenic activities release wastes containing cadmium, lead, arsenic, chromium, nickel, among others (3, 4). These metals when presented in significant quantities in the environment cause health problems (5, 1). When these metals are presented in sufficient amount in the environment, they constitute source of pollution and pollutants. The sources of these metals are automobile exhaust emissions, industrial activities, the use of metal containing materials (6, 7). These metals in the environment are not biodegradable but are permanent additions to the environment (8, 1, and 2). They are bioaccumulative and therefore harm the environment and human health (9, 10, 11 and 12). This is the basis of this study.

The linear model was proposed and adopted for this analysis (13):

$$R = u + ai + eij \quad \ldots \quad (1)$$

Where R is the amount of cadmium in each soil sample analyzed, u is the permissible limit of cadmium in the environment, ai, is the variance associated with cadmium content of each soil sample analyzed and eij is the variance due to repeated measurements of cadmium in each soil sample analyzed.

In the use of this model for the statistical analysis of the results obtained and reported in Table 1, the following assumptions were made:

(a) if ai is zero, that is, no variation due to soil sample from particular motor park, then the results obtained for the replicate analysis of each soil sample is due entirely to the permissible limit of cadmium in soil environment (u), plus error terms associated with each soil sample analyzed, then,

$$R = u + eij \quad \ldots \quad (2)$$

Where eij is the error associated with each soil sample analyzed during the jth, repeated test measurements.

(b) If there is no variance between one test measurement and next in repeated test measurements, then eij is zero. Therefore,

$$R = u + ai \quad \ldots \quad (3)$$

Under this circumstance, as defined in equation 3, the difference between each soil sample analyzed is due to the different automobile and commercial activities in each of the motor parks studied.

The following statistical calculation formulae were used in the analysis of variance carried out using data from Table 1;

(i) Total Sum of Squares (TSS)

$$TSS = \Sigma (xi - \breve{y})^2 \quad \ldots \quad (4)$$

Where xi is repeated results for each soil sample analyzed, and $\breve{y}$ is overall mean of the five soil samples analyzed.

(ii) Between Samples Sum of Squares (BSS)

$$BSS = \Sigma (\breve{Y}-\breve{y})^2 ni \quad \ldots \quad (5)$$

Where $\breve{Y}$ is the mean of cadmium in each soil sample analyzed, and $\breve{y}$ is overall mean of cadmium from five soil samples; n is the number of repetitions carried out at ith times

(iii) Within Sample Sum of Square (WSS)

$$WSS = \Sigma (xi - \breve{Y})^2 \quad \ldots \quad (6)$$

$$WSS = TSS - BSS$$

Tele: +2348037564050
E-mail addresses: xtopheraries@yahoo.co.uk

(iv) Between Sample Mean Square (BSMS):

$BSMS = \Sigma (\bar{Y} - \bar{y})^2 ni / r - 1$ … (7)

Whereas the number of samples analyzed, r = 5, r - 1, the degree of freedom.

Within Sample Mean Square (WSMS):

$WSMS = (xi - \bar{y})^2 / n (r - 1)$ … (8)

Where n is the number of replicate measurements, and r is the number of samples analyzed, n = 4, r = 5.

If ai > eij, the F- test was used to determine the significance of variations between the five samples analyzed.

F- test = Between Sample Mean Square / Within Sample Mean Square … (9)

If $F^4\ 16_{cal} > F^4\ 16$ at 5%, then the least significant difference test (LDS), is carried out, thus $LSD = t_\alpha \sqrt{2ems/n}$… (10)

Where t_α is the student's distribution at the appropriate degree of freedom, ems, is the error mean square equal to the within sample mean square (WSMS). These equations were used in obtaining the values reported in Table 2. The calculated least significant difference (LSD) at five percent probability level which was 0.112 was used for ranking and comparison for individual mean of cadmium in the five soil samples studied.

Five cities were selected for this study from South-eastern Nigeria. These include Aba, Okigwe, Owerri and Umuahia.

They represent two commercial centres and two administrative capital cities in the South-eastern geo-political zone of Nigeria. Cities in the world suffer from environmental pollution due to undesirable level of heavy metals. Such metals include; cadmium, lead, arsenic, air pollution and noise pollution (13, 14). Therefore to monitor city pollution, there is the need to indicate material occurrence; soil samples (top soils 2 - 5cm) contain heavy metals such as cadmium, lead, zinc and arsenic among others at a level that makes for a reliable analysis (15). Again, the study samples can be collected without disturbing the ecosystem. This makes large for scale and repeated sampling possible (16). In this study therefore, we report the cadmium concentrations in five different commercial motor park soil samples in each of the four selected cities in the South-eastern Nigeria namely; Aba, Okigwe, Owerri and Umuahia respectively.

Materials and Methods

Sample collection: Soil samples were collected from five different commercial motor parks in each of the cities of Aba, Okigwe, Owerri and Umuahia respectively. A composite sample of each soil samples was randomly collected at four different points in each of the sampling location and was stored in a labeled plastic bag until, required for analysis (17, 18). All chemicals used are of the analytical grade reagents from the British drug house.

Sample preparation: Each of the composite soil samples was oven dried at 100 - 105^0C until a constant weight was achieved. Each of the dried soil samples was passed through a 2 mm nylon sieve to obtain a fine powder. The fine soil sample of each of the five different soil samples was stored in a labeled polythene container until required for analysis.

Sample analysis: 1000 mg of each of dried soil samples was weighed out into a labeled conical flask (250 ml) in a fume chamber using the following extract. 25 ml of concentrated trioxonitrate (v) acid was measured out and added into the flask-containing the sample then 2 ml of concentrated tetraoxosulphate (VI) acid was also measured out and added into the flask-containing sample. The solution mixture of each of the soil samples was heated at 85^0C until there was the appearance of dense white fume. Deionised water 40 ml was added and heating continued for one hour (16). The digested soil sample was each allowed to cool then filtered through an acid-washed No. 40 Whatman filter paper into a labeled 100ml flask. Each filterate was made up to mark with deionised water. The concentration of cadmium in each of the digested soil samples was measured using atomic absorption spectrophotometer model 969 Unicam instruments (18, 19). A standard solution of cadmium was prepared using trioxonitrate (v) acid solution (20). Standard solution of cadmium was matrix matched to each soil sample digest. The AAS instrument used air-acetylene flame equipped with single hollow cathode lamp for cadmium ion with a maximum wavelength of 228.8 nm. The AAS was equipped with deuterium (D_2) background correction device. The air-acetylene fuel ratio was used and the optical filter width slit was adjusted automatically. The results obtained thereof was modeled using the linear model and analysis of variance equations 1 - 10.

Results and Discussion

The results of cadmium content of soil samples collected from five different commercial motor parks in the four selected cities in south-eastern Nigeria and analysis of variance carried out on the results using the linear model are presented below in Tables 1 and 2 respectively.

Since ai = eij + 5eij = 0.02489 + 5 (0.02489) = 0.14934

Therefore ai > eij, 0.14934 > 0.02489, then F-test was carried out according to the equation 9: $F^4\ 16 = 97.7153 / 0.02489 = 3684.825$.

$F^4\ 16$ from the table at 5% probability level = 3.01.

Since $F^4\ 16$ calculated > $F^4\ 16$ from the standard table, then the least significant difference (LSD) value was calculated according to equation 10 at 5% probability level as equal to 0.112.

Aba Park in Umuahia was the highest while cadmium content of soil sample collected in Aba Main Park in Aba gave the least value. The wide marginal value in the cadmium content of soil sample from the Aba park in Umuahia compared to the other four sampling site may be attributed to the closeness of dumping site and local refuse burning site to this motor park. This is coupled to other cadmium generating activities within the park such as metal fabrication, motor mechanics, and battery charging among others.

From Table 2, the calculated analysis of variance values were presented. Values from this Table 2 were used in the calculation of the least significant difference as 0.112. The comparison of the mean value of each soil samples (not shown) showed that the mean of cadmium content in the soil sample from Umuahia and Owerri motor parks respectively was statistically significant while the other three were not. The same trend was observed when the mean value of cadmium content of each soil sample was compared with the permissible limit of Cadmium level in the environment which is 0.010 mg/kg.

Conclusion & Recommendation

From the results of the analyses of the study, the Cadmium content in these choice locations were greater than the permissible limit of 0.01 mg/kg for Cadmium level in the environment. It is therefore important to pay attention to commercial motor parks and the activities going on there as possible source of metal pollution in the environment. The various law enforcement agents like the State Environmental Protection Agency, the Sanitation Officials etc. should also brace up to the enormous challenge of the threat posed by

pollution especially from heavy metal discharges in these motor parks. This will be enhanced by ensuring adequate, proper and prompt disposal and treatment of waste substances in their various site locations.

References

1.A. A. Abia and J.C. Igwe (2005). Sorption kinetics and intraparticulate diffusivity of Cd, Pb and Zn on maize cobs. Afr. J. Biotechnology. 4 (6): 506 - 512.

2.A. J. M. Baker, R. D. Reeves and S. A. M. Hagar (1994). Heavy metal accumulation and
tolerance in a British population of metllophytes. J & C press ltd, new phytol 127: 61 - 68.

3.E. Berman (1980). Toxic metal hazard and their analysis. Heyden publishers ltd India, pp. 48 - 101.

4.B. L. Carson, H. V. Ellis and J. I. McCann (1986). Toxicology and biological monitoring of metal ion in human. Lewis publishers, Chelsea Michigan US, pp. 65 - 297.

5.R. A. EI-aziz and B. I. Chaney (1991). Metal tolerance of rhizobiun metlotisolate from heavy metal contaminated soil. Soil. Biochem. 23: 795 - 807.

6.F. E. EI-nady and M. M. Atta (1996). Toxicity and bioaccumulation of metals in some marine biota from Egyptain coastal waters. J. Environ. Sci. Health. A-31 (7): 1529-1545.

7.M. Faisal and S. Hassamias (2004). Adsorption processes for water treatment. Butter-wood
publishers, Boston USA, pp. 106 - 113.

8.S. Gang and S. Weisxing (1998). Sunflower as adsorbents for the removal of metal ions from wastewater. Ind. Eng. Chem. 37: 1324 - 1328.

9.J. I. Gardean-Torresedy and J. M. Salvador (1996a). Copper adsorption by etherified and
unesterified fraction of sphagnum peat moss and its different humic substances. J. Hazard. Mater. 48: 191 - 206.

10. J. I. Gardean-Torresedy, K. J. Tiemann, J. H. Gonzalez, J. A. Henning and M. S Towsend
(1996b). Ability of silica immobilized medicago sativa (alfa-alfa) to remove cadmium, chromium, lead and zinc ions from aqueous solution. J. Hazard. Mater. 49: 205 - 226.

11.F. Honma and H. Hirata (1978). A noticeable increase in Cd absorption by Zn deficient rice plant. Soil Sci. plant nutria, 24: 295 - 297.

12.M. Horsfall and A. I. Spiff (2004). Studies on the effect of p^H on the sorption of Pb^{2+} and Cd^{2+} from aqueous solution by Caladium bicolor (wild cocoyam) biomass. Electronic J. Biotechnology (online), 15 December vol. 7, No. 3, 1 - 11.

13.I. A. Okoro (2003). Comparative Analysis of adsorption models of oil cleaning cellulose Materials. PhD thesis. Federal University of Technology Owerri Imo State, Nigeria (Unpublished), pp. 130 - 136.

14.M. A. Correa and S. E. Bailer (1992). Chelators and heavy metal intoxication, basic and
chemical pharmacology. Lange medical publishers, California, USA, pp. 744 - 745.

15J. T. Ayodele and M. B. Abubakar (1988). Trace element contamination of rain water in the semi-arid region of Kano, Nigeria. Man and health. 9: 174 - 176.

16. U. M. Gaya and J. T. Ayodele (1994). Determination of lead in street dust to index street pollution in Kano municipal. Spectrum J. (1): 192 - 193.

17.E. Berman (1980). Toxic metal hazard and their analysis. Heyden, pp. 48 – 101.

18.R. A. Chanley (1980). Health risk associated with toxic metals in municipal sludge, health risk of land application. Ann. arbor Science Publishers, pp. 59 - 83.

19.A. Ahmed and J. T. Ayodele (1996). Monitoring air pollution in Kano by chemical analysis of Scot pine (Pinus syslvestris) needle for heavy metals. J. Chemical Society of Nigeria, 21: 80 - 84.

20.S. E. Allen (1989). Chemical analysis of ecological materials. 2nd edition, Blackwell Scientific Publishers, Oxford, London, pp. 101 - 114.

Table 1: Cadmium Content of the Soil Samples

Number of runs	Cadmium Content of Aba Park Umuahia (mg/kg)	Cadmium Content of Abia Line Park Owerri (mg/kg)	Cadmium Content of Imo Transport Ltd Owerri (mg/kg)	Cadmium Content of New Umuahia Park Okigwe (mg/kg)	Cadmium Content of Aba Main Park Aba (mg/kg)
1	10.830	0.162	0.132	0.101	0.086
2	10.850	0.166	0.130	0.104	0.084
3	10.820	0.160	0.131	0.100	0.085
4	10.810	0.161	0.135	0.102	0.089
Total	43.310	0.649	0.528	0.407	0.344
Mean	10.828	0.162	0.132	0.1020	0.086

Table 2: Calculated Analysis of Variance Values

Source of Variation	Sum of Square	Degree of Freedom	Mean Square (MS)	Parameters estimated by MS
Between sample	366.86117	4	97.71530	eij + 5eij = ai
Within sample	0.39819	16	0.02489	
Total	367.25936	20	18.36297	