Assessments of natural radioactivity and determination of heavy metals in soil around industrial dumpsites in Sango-Ota, Ogun state, Nigeria

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ABSTRACT
The activity concentration of natural radionuclides in soil samples from industrial dumpsites in Sango-Ota were determined using gamma-ray spectrometry with NaI(Tl) detector. The mean activity concentration of $^{226}$Ra, $^{232}$Th and $^{40}$K was 3.0 ± 1.2, 33.3 ± 9.8 and 122.1 ± 20.6 Bq kg$^{-1}$, respectively. Radium equivalent activities were calculated to assess the hazards arising from the use of the soil sample in agriculture. All the calculated values were lower than the world average. The mean concentration of heavy metals in the soil samples were 33.6, 2.9, 3.8, 2.7, 48.9, 1, 5, 34.5 and 0.8 mg l$^{-1}$ for Cu, Mg, Ca, P, Fe, Pb, Zn and Cd, respectively. The concentrations of Cd, Cu and Pb were higher than the natural permissible range in soil. Therefore, the government should discourage the use of the soil around dumpsites for planting because of the presence of heavy metals in the sites.

Key words: Dumpsites, heavy metals, Ota, radiation, radionuclides

Introduction
Human beings are continuously exposed to ionizing radiation that stem from both natural and man-made sources. The principal origins of ionizing radiation exposure are natural sources. The main constituents of natural radiation are cosmic rays and gamma ray emitters in soils, building materials, water, food, and air. Natural background radiation, which is equivalent to 2.4 mSv per year, makes up approximately 80% of human exposure in a year. The spatial distribution of natural radiation is highly variable and dependent on the local geological formations. The natural radioactivity of soil samples is usually determined from the $^{226}$Ra, $^{232}$Th, and $^{40}$K contents. The study of the levels of radionuclide distribution in the environment is essential especially in providing radiological information.

Human activities generate wastes. Industrialization and population increment in most cities in Nigeria results in changing the composition and quality of waste generated as this can be seen in most cities of developing countries. Soil from waste dumpsites may contain heavy metals and naturally occurring radionuclides in significant amounts. Hazardous waste can cause and has caused pollution, damage to health and even death. The external radiation exposure pathways to the population have been extensively studied. Several studies in Nigeria have measured the activity concentration of natural radionuclides in soil to ascertain the levels of contamination. It was revealed that staple food stuffs consumed in Nigeria contain traces of radionuclide and as a result of this, refuse dumpsites were identified as a liable recipient in containment of radioactive materials as inhabitants cultivate and plant legumes, vegetables, and so on in the field around the dumpsites. The transportation of heavy metal as well as radionuclides in soil from this sites are possible via root-uptake and then to human through breathing and ingestion. Therefore, accurate measurement of elemental composition and radionuclide levels in soil sample from these dumpsites will provide information...
from which average radiation to the public from these dumpsites can be estimated. The aims of this study were to: (i) determine the activity concentrations of $^{226}$Ra, $^{232}$Th, and $^{40}$K in the representative soil samples from industrial dumpsites; (ii) to estimate the absorbed dose rates and the effective dose from the exposure to the natural radionuclides; and (iii) to determine the heavy elements contained in the representative soil samples. This study was carried out in Ota, an industrial and commercial area located between latitude 6° 41’ North and longitude 3° 14’ East [Figure 1]. Its elevation is 74.259 m above the sea level and has a large concentration of land space with land mass of about 1460 sq km and has grown into an industrial city due to the economic development planning and lobbying by the Manufacturers Association of Nigeria which led to the official designation of Ota as an industrial town. Wastes in these dumpsites were mostly generated from industries such as pharmaceuticals, medical, breweries, beverages, aluminum roofing sheet, iron, and steel companies. The infectious medical wastes as well as the industrial toxic wastes are disposed together in the dumpsites. The study area is underlain by the Precambrian basement complex of South-Western Nigeria and is at the fringes of the border between Nigeria and the Republic of Benin.

**Experimental Procedures**

**Sample collection and preparation**

Soil samples were collected from 10 industrial dumpsites in Ota. A total of 10 samples were collected from each dumpsite at a depth of about 20-30 cm at the various locations. The samples were processed following the standard procedures. Soil samples were well mixed after removing extraneous materials such as roots, pieces of stones, and gravel. Samples were weighed and then dried in an oven at 105°C overnight and reweighed to find the water content. The samples were crushed and were made to pass through a 0.2-mm sieve. Sieved samples were weighed and a mass of 200 g of each sample was placed in a plastic container. The plastic containers were hermetically sealed with adhesive tape for 30 days for secular equilibrium to take place.

**Activity determination**

The analysis of radionuclide concentrations was performed by gamma-ray spectrometry with sodium iodide detectors. The counting assembly was a scintillation detector and a Canberra multichannel analyzer. The detector was a 7.6 × 7.6 cm$^2$ NaI (Tl) manufactured by Bicron. A cylindrical lead shield of approximately 5 cm thickness with a fixed bottom and a movable cover shielded the detector from background radiation. The spectrometer was tested for its linearity and then calibrated for energy using gamma sources supplied by the International Atomic Energy Agency, Vienna. This was achieved by collection of spectra data from standard sources with energies in the range 0.511-2.62 MeV. The channel numbers of the photopeaks corresponding to the different gamma energies were recorded after 900s and the energy-channel linear relationship obtained is shown in Figure 2. The detection efficiency calibration of the system was carried out using a reference standard gamma source prepared by Rocketdyne Laboratories, Canoga Park, CA, USA, which is traceable to a mixed standard gamma source (ENV94084-200 g) by
Analytic Inc., Atlanta, GA, USA. The values of efficiency obtained were 0.440, 0.321, and 0.141 for $^{40}$K, $^{226}$Ra, and $^{232}$Th, respectively. The efficiency calibration curve for the NaI(Tl) detector is shown in Figure 3. The detector assembly has a resolution of $\sim$8% at 0.662 MeV of $^{137}$Cs. The reference sources have activity concentration of 479.15, 566.47, and 11.60 Bq kg$^{-1}$ for $^{40}$K, $^{226}$Ra, and $^{232}$Th, respectively. The background count was determined by counting an empty container of the same dimensions as the one containing the samples and subtracting from the gross count. The counting time was set at 36 000 s (10 h) to obtain the gamma spectrum with good statistics.

From the net area, the activity concentrations in the samples were obtained using equation (1):

$$C (\text{Bq kg}^{-1}) = kC_n$$  \hspace{1cm} (1)

where, $k = 1/\varepsilon P_\gamma M_s$

$C$ is the activity concentration of the radionuclide in the sample given in Bq kg$^{-1}$, $C_n$ is the count rate under the corresponding peak, $\varepsilon$ is the detector efficiency at the specific $\gamma$-ray energy, $P_\gamma$ is the absolute transition probability of the specific $\gamma$-ray, and $M_s$ is the mass of the sample (kg).

The detection limit (DL) of a measuring system describes its operating capability without the influence of the sample. The DL given in Bq kg$^{-1}$, which is required to estimate the minimum detectable activity in a sample, was obtained using equation (2):

$$\text{LLD} = 4.65 \times \sqrt{\frac{C_b}{tb \cdot f}}$$  \hspace{1cm} (2)

Where LLD is the Lowest limit of detect, $C_b$ is the net background count in the corresponding peak, $tb$ is the background counting time (s), and $f$ is the factor that converts cps (counts per second) to activity concentration (Bq kg$^{-1}$).

The DLs obtained were 17.3 Bq kg$^{-1}$, 4.2 Bq kg$^{-1}$, and 5.1 Bq kg$^{-1}$ for $^{40}$K, $^{226}$Ra, and $^{232}$Th, respectively. The concentration of $^{226}$Ra was determined by a 1.764 MeV gamma ray from $^{214}$Bi. The gamma-ray energy of 2.614 MeV from $^{208}$Tl was used to determine the activity concentration of $^{232}$Th and a gamma ray of 1.460 MeV from $^{40}$K was used to determine the concentration of $^{40}$K in the samples.

**Elemental analysis procedure**

The main material used in the determination of the elemental composition of the samples is the Flame Atomic Absorption Spectrophotometer model S4 series, Model (GBC 906) (USA). Soil samples are digested. A total of 1 g of fine particles of dried soil samples from dumpsites was weighed into a 100 mL digestion tube. Each of the tubes was labeled to avoid mix-up. A total of 5 mL each of nitric acid and hydrogen peroxide were added, while SO4 was added in small amount and the mixture was thoroughly stirred until white fumes evolved. The process continued until the solution is clear. The solution was decanted and diluted with deionized water up to 100 mL before being filtered. The procedure was repeated for all the samples. Before metal concentrations were determined, standard solutions were prepared in each case and were used to eliminate sample standard matrix indifferences. The instrument was calibrated for all the measurement carried out using deionized and standard solutions; these standard solutions are different for different elements. The concentration of the samples were obtained from the readings of Atomic Absorption Spectrophotometer (AAS) in equation (3)

$$\text{Concentration of sample} = \frac{\text{AAS reading} \times 100}{\text{Weight of sample}}$$  \hspace{1cm} (3)

**Results and Discussions**

Figure 4 shows the portion of the x-ray spectrum of sample 2 from site S4. The $^{226}$Ra, $^{232}$Th, and $^{40}$K activity concentrations measured in soil samples from 10 industrial dumpsites in Ota are shown in Table 1. The activity concentrations of $^{232}$Th and $^{40}$K in soil samples ranged from 16.1 ± 2.4-49.2 ± 5.2 Bq kg$^{-1}$ and 88.8 ± 13.4-161.7 ± 16.1 Bq kg$^{-1}$ with mean values 33.3 ± 9.8 and 122.1 ± 20.6 Bq kg$^{-1}$, respectively. All the values of $^{226}$Ra measured in the samples were below the

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**Figure 2:** Graph of the energy-channel dependence

**Figure 3:** The efficiency calibration curve for the NaI(Tl) detector
DL. From the data obtained, it is clear that the activity concentration of 40K in all the samples were higher than the activity concentration of 226Ra and 232Th. The mean value of the activities concentrations of 226Ra, 232Th, and 40K were found to be lower than the world average of 35, 30, and 400 Bqkg\(^{-1}\), respectively.\(^{[2]}\)

The absorbed dose rate, radium equivalent, internal hazard index, and annual effective dose calculated from the activity concentrations of the natural radionuclides in soil samples were presented in Table 2.

### Absorbed Dose Rate

The total absorbed dose rate in air (nGy h\(^{-1}\)) at 1 m above the ground due to the activity concentration of 226Ra, 232Th, and 40K was calculated using the formula.\(^{[2]}\) We assumed here that the contribution from other naturally occurring radionuclides and cosmic radiation at the locations were insignificant.

\[
D(nGy h^{-1}) = 0.446\Delta_{Ra} + 0.662\Delta_{Th} + 0.048\Delta_{K} \quad \text{....(4)}
\]

Where D is the dose rate (nGy h\(^{-1}\)) at 1 m above the ground due to 226Ra, 232Th, and 40K in the soil sample. \(\Delta_{Ra}, \Delta_{Th},\) and \(\Delta_{K}\) are the activity concentrations of 226Ra, 232Th, and 40K in Bqkg\(^{-1}\), respectively. The value of LLD (4.2 Bqkg\(^{-1}\)) was used in the calculation of ARa since all the values obtained for 226Ra in this study were below the DL.

The absorbed dose rate calculated for this study ranged from 16.53-42.21 nGy h\(^{-1}\) with a mean value of <29.79 nGy h\(^{-1}\). The highest value in this study is lower than the world average of 51 nGy h\(^{-1}\).\(^{[2]}\)

### Radium Equivalent Activity and Internal Hazard Index

It is important to assess the gamma radiation hazards to human associated with the use of the soil from the site for filling or for use in construction. Radium equivalent activity (\(Raeq\)) was calculated in this study because it gives a single index to describe the gamma output from different mixture of radium, thorium, and potassium in the samples. The Raeq was calculated using equation described by.\(^{[18,19]}\)

\[
Raeq = \frac{1.43A_{Th} + 0.077A_{K}}{1.85} \quad \text{....(5)}
\]

where \(A_{Ra}, A_{Th},\) and \(A_{K}\) are the activity concentrations in Bqkg\(^{-1}\) of 226Ra, 232Th, and 40K respectively.

The values obtained in the samples were presented in Table 2 column 3. Raeq in the dumpsites varies between 34.06 and 87.01 Bqkg\(^{-1}\) with a mean of <61.02 Bqkg\(^{-1}\). The radiation hazard due to internal exposure from radon and its short-lived decay products to the respiratory organs can be estimated using the following formula:

\[
H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_{K}}{4810} \leq 1 \quad \text{....(6)}
\]

Where \(H_{in}\) is the interhazard index and \(A_{Ra}, A_{Th},\) and \(A_{K}\) are the activity concentrations in Bqkg\(^{-1}\) of 226Ra, 232Th, and 40K respectively.

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**Table 1: Activity concentration of 226Ra, 232Th, and 40K (Bqkg\(^{-1}\)) in the dumpsites**

| Dumpsites | 226Ra | 232Th | 40K  |
|-----------|-------|-------|------|
| S1        | BDL   | 16.1±2.4 | 88.8±13.4 |
| S2        | BDL   | 34.2±1.2 | 104.3±12.2 |
| S3        | BDL   | 28.2±5.0 | 110.6±18.0 |
| S4        | BDL   | 28.1±6.2 | 107.3±10.1 |
| S5        | BDL   | 29.6±5.8 | 107.0±18.0 |
| S6        | BDL   | 47.0±12.0 | 111.6±11.0 |
| S7        | BDL   | 36.1±8.1 | 133.1±28.1 |
| S8        | BDL   | 33.4±7.2 | 152.4±18.6 |
| S9        | BDL   | 31.1±6.3 | 144.1±17.2 |
| S10       | BDL   | 49.2±5.2 | 161.7±16.1 |
| Mean      | BDL   | 33.3±9.8 | 122.1±20.6 |

BDL: Below detection limit

**Table 2: The absorbed dose rate, internal hazard index, radium equivalent, and annual effective dose estimated in the dumpsites**

| Dumpsites | Absorbed dose rate (D) (nGy h\(^{-1}\)) | Internal hazard index (\(H_i\)) | Radium equivalent dose (\(Ra_{eq}\)) (Bqkg\(^{-1}\)) | Annual effective dose (E) (μSv h\(^{-1}\)) |
|-----------|--------------------------------------|-------------------------------|---------------------------------|---------------------------------|
| S1        | 16.86                                | 0.10                          | 34.06                           | 20.68                           |
| S2        | 29.52                                | 0.18                          | 61.13                           | 36.20                           |
| S3        | 25.85                                | 0.15                          | 53.04                           | 31.70                           |
| S4        | 25.63                                | 0.15                          | 52.65                           | 31.43                           |
| S5        | 26.61                                | 0.16                          | 54.78                           | 32.03                           |
| S6        | 38.34                                | 0.23                          | 80.00                           | 47.02                           |
| S7        | 32.20                                | 0.19                          | 66.07                           | 39.49                           |
| S8        | 31.30                                | 0.18                          | 63.70                           | 38.38                           |
| S9        | 29.38                                | 0.17                          | 59.77                           | 36.03                           |
| S10       | 42.21                                | 0.25                          | 87.01                           | 51.77                           |
| Mean      | 29.79                                | 0.18                          | 61.02                           | 36.47                           |
The internal hazard index ranged from 0.1-0.25 with a mean of <0.18 which is less than 1 as desirable.

The results obtained in this study compared well with the similar investigation carried out in Botswana. [20] The mean absorbed dose rate in this study (29.79 nGy h⁻¹) is lower than the results obtained in Lagos [21] (56.40 nGy h⁻¹) and in Portharcourt [22] (38.17 nGy h⁻¹), Nigeria. The activity concentrations and the absorbed dose rate obtained in this study when compared with other studies from normal living areas in Abeokuta [9] (43, 84 and 329 Bq kg⁻¹), 88 nGy h⁻¹), Ibadan [23] (26, 54 and 619 Bq kg⁻¹; 69 nGy h⁻¹) for ²³⁸U, ²²⁶Th, ⁴⁰K and absorbed dose rate, respectively and Lagos [10] (absorbed dose rate = 41 nGy h⁻¹), south-western Nigeria were found to be lower. All the results obtained in this study are lower than the world average given by United Nations Scientific Committee on the Effect of Atomic Radiation, 2000.

**Elemental composition of the soil samples**

The concentrations of iron (Fe), copper (Cu), magnesium (Mg), calcium (Ca), phosphorus (P), lead (Pb), zinc (Zn), and cadmium (Cd) in soil samples from the 10 dumps survey were presented in Table 3. The mean concentrations of Fe, Zn, Mg are 33.6, 48.9 and 34.5 mg l⁻¹, respectively. These values are within the natural range of these metals in soil which is 15-250, 0.05-1.5, and 5.0-175, respectively. [24] The mean concentrations of Cu and Cd are 33.6 and 0.8 mg l⁻¹, respectively in the soil sample. These values are higher than their natural range in the soil which is 0.035-0.400 and 0.01-0.7 mg L⁻¹, respectively. [25] Pb was detected in only three of the 10 dumps sites and was higher in 2 of the dumps sites. Calcium and phosphorous were also detected in the soil samples and the concentration of the two were below the natural range in the soil. Calcium had the highest value of concentration in parts per million out of the eight elements detected in the soil samples. This may be due to the primary and secondary mineral components in the soil of the area, which is essential for many plants functions. Calcium has not been considered as a major pollutant in the environment compared with other elements.

**Conclusion**

The radionuclide content and heavy metal concentration of soil samples from 10 dumpsites in Ota Industrial city has been measured using gamma-ray spectrometry with NaI (TI) and flame atomic absorption spectrophotometer. The average outdoor gamma radiation dose values obtained due to the activity concentrations of the radionuclides in the samples from these dumpsites are lower when compared with the results obtained for normal living areas in the same region. [9,10,23] However, no matter how small radiation exposure could be, it has effect on human being and exposure to this radiation must be reduced. The results of heavy metal concentrations in the soil showed the presence of heavy metals with cadmium and copper having concentrations above their natural range in the soil. At lower concentrations, these metals may be beneficial to the ecosystem but they are regarded to be toxic at higher concentrations. However, heavy metal are potentially toxic with prolonged exposure. [3] Therefore, it is imperative to monitor their accumulation in soil samples before inhabitants can cultivate the land around the dumps sites for agricultural purposes to prevent the transportation of these metals into human system. The government should discourage the use of the soil/fields around these dumpsites for agricultural purposes because of the presence of heavy metals in the sites at present.

**Table 3: Concentrations (mg l⁻¹) of heavy elements in the soil samples from the dumpsites**

| Dumpsites | Cu  | Mg  | Ca  | Pb | Fe  | Pb  | Zn | Cd  |
|-----------|-----|-----|-----|----|-----|-----|----|-----|
| S1        | 21.5| 4.0 | 2.7 | 2.6| 31.0| 0.1 | 15.4| 0.3 |
| S2        | 21.5| 3.0 | 2.1 | 2.1| 37.0| 0.4 | 40.0| 0.6 |
| S3        | 40.5| 3.5 | 5.0 | 2.6| 74.5| ND  | 78.3| 1.8 |
| S4        | 40.0| 1.5 | 3.1 | 3.5| 47.5| 5.0 | 19.1| 1.8 |
| S5        | 51.1| 2.5 | 3.1 | 2.8| 65.5| ND  | 23.7| 0.3 |
| S6        | 20.0| 2.5 | 10.0| 2.3| 16.0| ND  | 40.8| 0.6 |
| S7        | 36.0| 3.0 | 3.0 | 2.3| 47.5| ND  | 21.4| 0.9 |
| S8        | 40.0| 2.5 | 2.1 | 3.3| 31.0| ND  | 27.0| 0.4 |
| S9        | 46.5| 2.5 | 2.0 | 2.5| 76.5| ND  | 38.8| 0.7 |
| S10       | 18.5| 3.5 | 4.6 | 2.7| 62.5| ND  | 34.3| 0.2 |
| Mean      | 33.6| 2.9 | 3.8 | 2.7| 48.9| ND  | 34.5| 0.8 |

ND: Not detected

**References**

1. International Atomic Energy Agency. Radiation Safety. Regulation for the safe transport of radioactive material. IAEA Division of Public Information, IAEA-00725 IAEA/P/IA7E; 1996.
2. United Nations Scientific Committee on the Effect of Atomic Radiation, UNSCEAR, Sources and effects of ionizing radiation (without scientific annexes); 2000. p. 6.
3. Alamaer AS. Assessment of human exposures to natural sources of radiation in soil of Riyadh, Saudi Arabia. Turk J Environ Sci 2008;32:229-34.
4. United Nations Industrial Development Organization, (UNIDO). Industrial Environmental Policy and Strategy for Ethiopia, 2001. Vol. 2. Addis Ababa: EPA/UNIDO.
5. Faweya EB, Babalola IA. Radiological safety assessment and occurrence of heavy metals in soil from designated waste dumpsites used for building and composting in southwestern Nigeria. Arab J Sci Eng 2010;35:219-25.
6. Ramli AA, Hussein AW, Wood AK. Environmental 238U and 232Th concentration measurements in an area of high level natural background radiation at Palong, Johor, Malaysia. J Environ Radioact 2005;80:287-304.
7. Jibiri NN, Adeyewo GO. Radionuclide contents and physico-chemical characterization of solid waste and effluent samples of some selected industries in the city of Lagos, Nigeria. Radioprotection 2008;43:203-12.
8. Oresegun MO, Babalola IA. Occupational radiation exposure associated with milling of Th-U rich Sn ore in Nigeria. Health Phys 1990;58:215-5.
9. Obed RI, Farai IP, Jibiri NN. Population dose distribution due to soil radioactivity concentration levels in 18 cities across in Nigeria. J Radiol Prot 2005;25:305-12.
10. Jibiri NN, Farai IP. Assessment of dose rate and collective effective dose equivalent due to terrestrial gamma radiation in the city of Lagos, Nigeria. Radiat Prot Dosimetry 1998;76:191-4.
11. Jibiri NN, Esen NU. Radionuclide contents and radiological risk to the population due to raw materials and soil samples from the mining sites of quality ceramic and pottery industries in Akwa Ibom, Nigeria. Radioprotection 2011;46:75-87.
12. Farai IP, Obed RI, Jibiri NN. Soil radioactivity and incidence of cancer in Nigeria. J Environ Radioact 2006;90:29-36.
13. Ademola JA, Farai IP. Gamma activity and radiation dose in concrete building blocks used for construction of dwellings in Jos, Nigeria. Radiat Prot Dosimetry 2006;121:395-8.
14. Ademola AK, Obed RI. Gamma radioactivity levels and their corresponding external exposure of soil samples from Tantalite mining areas in Oke-Ogun, South-Western Nigeria. Radioprotection 2012;47:23-252.
15. EML Procedure Manual. In: Volchok, Herbert L, de Planque, Gail, editors. 26th ed. New York: US Department of Energy, Environmental Measurement Laboratory; 1983.
16. Atomic Energy Regulatory Board. Accreditation of laboratories for measurement of radionuclide content in commodities. Mumbai: Atomic Energy Regulatory Board; 2003.
17. Veiga R, Sanches N, Anjos RM, Macario K, Bastos J, Iguateny M, et al. Measurement of natural radioactivity in Brazilian Beach sands. Radiat Meas 2006;41:189-96.
18. Berekta J, Mathew PJ. Natural radioactivity in Australian building materials, industrial waste and by-products. Health Phys 1985;48:57-59.
19. Yang YX, Wu XM, Jiang ZY, Wang WX, Lu JG, Lin J, et al. Radioactivity concentration in soil of the Xinzhuan Granite area, China. Appl Radiat Isot 2005;63:255-9.
20. Murty VR, Karanakara N. Natural radioactivity in the soil samples of Botswana. Radiat Meas 2008;43:1541-5.
21. Oladapo OO, Oni EA, Olawoyin AA, Akande OO, Tijani SA. Assessment of natural radionuclide level in wasteland soil around Oluoson dumpsite Lagos, Nigeria. J Appl Phys 2012;2:38-43.
22. Awirii GO, Nte FU, Olarewaju AI. Determination of radionuclide concentration of landfill at Elioatu, Portharcourt, River State. Scientia Africana 2001;10:46-57.
23. Ajayi OS, Ikukunle SB. Radioactivity of surface soil from Oyo state, South-Western Nigeria. Int J Radiat Res 2013;11:271-8.
24. Okeyode IC, Rufai AA. Determination of elemental composition of soil samples from some selected dumpsites in Abeokuta, Ogun State, Nigeria, using Atomic Absorption Spectrophotometer. Int J Basic Appl Sci 2001;2:55-70.
25. Parth V, Murthy NN, Saxena PR. Assessment of heavy metal contamination in soil around hazardous waste disposal sites in Hyderabad city (India): Natural and anthropogenic implications. J Environ Res Manage 2011;2:27-34.

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