International Journal of Chemistry and Applications.
ISSN 0974-3111 Volume 3, Number 2 (2011), pp. 131-141

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Impact Assessment of Soil Quality in Relation to Solid Waste Management in Ibadan, Nigeria

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Abstract

Solid wastes generated over most part of Ibadan City are dumped into the Ring road and Orita-Aperin dumpsites that are not properly operated as a landfill for environmental protection. Studies were carried out to assess the degree of pollution of soils around the dumpsites. Some physical and chemical parameters were used to monitor the quality of soils of the area for a period of twelve months to assess the effects of solid waste disposal on the soils around the dumpsites. The average soil characteristics for Ring Road dumpsite obtained for pH, organic carbon, organic matter, sulphate, nitrate, cadmium, copper, lead and zinc were ; 8.20, 4.00%, 6.90%, 71.00μgg^{-1} 65.00μgg^{-1}, 8.30μgg^{-1}, 225.00μgg^{-1}, 332.00μgg^{-1} and 662.00μgg^{-1} respectively. While that of Orita-Aperin dumpsite were; 7.40, 6.40%, 11.00%, 186.00μgg^{-1}, 71.00μgg^{-1}, 9.70μgg^{-1}, 289.00μgg^{-1}, 514μgg^{-1}and 838.00μgg^{-1} for pH, organic carbon, organic matter, sulphate, nitrate, cadmium, copper, lead and zinc respectively. The University botanical garden was found to contained mean values of 6.20, 2.10%, 5.30% 132.00μgg^{-1} 25.70μgg^{-1}, 0.60μgg^{-1}, 63.60μgg^{-1}, 0 2.30μgg^{-1} and 24.20μgg^{-1} for pH, organic carbon, organic matter, sulphate, nitrate, cadmium, copper, lead and zinc respectively; while the Mokola control site had mean values of 6.20, 2.10%, 5.30%, 132.00μgg^{-1}, 25.70μgg^{-1}, 0.60μgg^{-1}, 3.60μgg^{-1}, 2.30μgg^{-1} and 24.20μgg^{-1} for pH, organic carbon, organic matter, sulphate, nitrate, cadmium, copper, lead and zinc respectively . There were significant differences (α = 0.05) between the mean values of all the parameters monitored in all the study areas. The results also indicate lower values for Ring Road dumpsite compared to Orita-Aperin dumpsite. The values from the two dumpsites were found to be higher than their control sites (Mokola and Botanical garden control sites respectively).

Keywords: Impact Assessment, Soil Quality, Solid Waste, Management, Ibadan, Nigeria.

Introduction

Solid wastes have been defined as those solid materials arising from animal or human activities and discarded permanently or temporarily as wastes [1]. On the basis of sources, solid wastes have been variously classified as domestic, residential, commercial, municipal, industrial and agricultural[2,3]

Solid waste disposal is the hygienically keeping away of solid wastes from human environment so as to avoid the nuisance and public health problems associated with waste.

Proper disposal also requires that the environment should also be left aesthetically pleasing [4]. Of recent, so much solid waste is being generated that its disposal has become a major problem. Of the local budget for waste management, over 80% is said to be spent on waste collection alone, leaving only 20% for actual disposal which is most often grossly inadequate[5]. Solid waste disposal problem is mainly acute in urban areas, characterised by high concentration of people and intense competition for land for various uses. Disposal sites are thus difficult to find. Usually, existing sites get filled up rapidly without a handy arrangement for new ones. This situation leads to overflowing of such dumps, with associated un-sightedness. Ultimate solid waste disposal is carried out in the earth's mantle, either by unsanitary or engineered sanitary land filling[6].

The solid waste management problems of Ibadan

The city of Ibadan is situated approximately on longitude 3^o 50′ E of the Greenwich Meridian and 7^o 23′ N of the equator. Disposal of solid wastes in the city has been going on at two large dumpsites, since the 1960s. One of this dumpsite is situated along the busy Ring Road. The site is located in an area of high density residential and business houses. The second dumpsite is located at Orita-Aperin, also within a high density of human settlement. Both sites believed to be far removed from human settlements at the time of selection, have since become overtaken by development. Disposal at both dumps is by open dumping with occasional burning. Land filling as claimed by the operators is not really practiced [6]. Ibadan, by its indigenous nature and culture of the inhabitants generates very large amount of waste that vary with seasonal changes. Also with two major components of old and new town, the solid wastes vary significantly in composition. The other factor that influences solid waste composition is the industries. Whereas the high density old town that is more indigenous produces waste made up of mainly agricultural produce, the low density and more cosmopolitan and newly developed areas (new town) produces waste made up primarily of food leftovers, papers, tins, metals, bottles and glass [7].

Apart from Lagos, the city of Ibadan generates the highest volumes of solid waste (in tonnes) per year in Nigeria (Lagos: 55,991; Ibadan: 55,224, in 1981), with an estimated volumes of 4,803,400 and 2,102,400 tonnes for Lagos and Ibadan respectively for the year 1991.A federal government commissioned study has traced the solid waste problem of the entire nation at that time to the oil boom earnings of the 1970s (Federal Ministry of Housing and Environment, undated). This according to the study, led to increase in the volume of industrial, economic and commercial activities with corresponding increase in the volume and complexity of waste by-products generated. The same increase in economic activities, especially in the urban centres gave rise to massive rural - urban migration, leading to a rapid rate of population growth in the cities with the resultant over stretching of public facilities with the obvious consequence of drastic decline in quality of the environment (Faniran,1994).

The climatic conditions of the city are said to have played a vital role in the protracted problem of the solid waste management [8, 9, 10]. The high rainfall and high relative humidity noted for the town, apart from encouraging rapid decomposition of the highly organic waste matter, makes handling of such waste clumsy and unhealthy. Generally, the decomposed wastes are more likely to be pathogenic and far more of a public health hazard, than when handled in an un-decomposed state. Inconsistencies and non-continuity in policy implementation and solid waste management operations from the time of Ibadan city council through various agencies charged with these responsibilities have been identified as major causes of solid waste management failure in the city and environs [11].

Conflicting recommendations by consultants such as Maclaren International Limited and Urwick, Currie and Partners and commissioned studies seem to have heightened the confusion over the entire process of solid waste management in the city. The solid waste management problems of the city do not appear to have been resolved as is the case with many other big cities of the nation, e.g. Lagos and Kano. There seem to be no improvement in the efficiency of collection either. The waste disposal practices have potential for negatively impacting on soil, surface water and air apart from constituting poor aesthetics. This present study is therefore aimed at monitoring the quality of the soil around the dumps and detailed characterization of the soil to assess the impacts of disposal activities on the soil.

Materials and methods

Study Areas

Two large dumpsites located at Ring road and Orita-Aperin in Ibadan city were considered for this study. Two control sites, Mokola and the University Botanical garden were used for comparison.

The Ring road dumpsite

The Ring road dumpsite covers an area of approximately 0.75km^2 (one kilometre along Ring road and three quarters of a kilometre along Liberty Road). The dumpsite is situated within an area of high-density residential and commercial buildings. The site is bounded in the north and eastern parts by the Elesun stream, a tributary of the larger Ogunpa River. The topography is gentle sloping with highest elevation in the southwest edge and lowest in northeast.

The Orita-Aperin dumpsite

The Orita-Aperin dumpsite has been in use longer than that of the Ring road. The dumpsite is bounded on the northeastern and southwestern parts by Orita-Aperin market and Olorunsogo-Akanran road and on the eastern fringe by Oniyere stream. The dumpsite is presently situated in the heart of a very busy commercial area of Orita-Aperin. The dump covers an area of about half a kilometre square ($0.5km^2$).

Control Areas

The University botanical garden represents an area of relatively undisturbed setting within a community. It is a reserved forest area within the university of Ibadan premises. Mokola control area is an area in the Sabo district of Mokola, between the stretch of the road running from Sabo to Mokola Army Barracks gate and a stream towards Sango-Dugbe road. The site is typically urban, differing from the main study areas only by the absence of large-scale solid waste disposal activities.

Geology and Hydrogeology of the study area

Ibadan city falls within the basement complex that constitutes about half of the rocks that cover the surface area of Nigeria. About the remaining half is underlain by sedimentary rocks. The rocks of the basement complex are pre-cambian in age and are composed mainly of metamorphic and igneous rocks, which are highly deformed. Field investigation has shown that the rocks are covered in most places by weathered over-burden or regoliths, with outcrops in a few places. The rocks of the basement complex have generally been grouped into three major types, namely quartzite, migmatite, banded and granite gneiss [12, 13].

The two study areas are underlain predominantly by quartzite and quartz schists, which in association with banded gneiss and amphibolite layers are said to underlie about 80% of Ibadan city [14].

Soil type

Four soil associations belonging to the major group, known as ferruginous tropical soil are said to be associated with the Ibadan basement complex [15]. Chemical characteristics of the different soil associations vary appreciably, depending on land-use, history of the profile among other reasons. They are generally known to have low nutrient- holding capacities as reflected in their low cation exchange capacities because of the presence of kaolite as the dominant clay material [13,14]. The organic matter and nutrient content of the soil also vary from place to place. Most organic matter is concentrated on the top soil, especially the upper 20cm of the profiles.

Sample Collection

The random sampling technique was employed to select samples from the two dumpsites. Each of the grids was sampled once in a month. Three samples were collected from each control site during every sampling session. Sampling points (in the dumpsites) were cleared of weeds or rubbish and a plastic scoop was used to scratch and collect loose surface (0 - 5cm) soil into clean, labeled polythene bags. Samples were air- dried in the laboratory to constant weight.

Sample Processing

Foreign or non- soil materials were removed and the soil crushed in a porcelain mortar and passed through a 2mm mesh sieve. The sieved portion was used for the determination of pH and organic carbon. Nitrate (NO_3^-); sulphate (SO_4^{2-}) and trace metals were determined on soil leachate, using sodium acetate as leaching agent.

Determination of pH

20g of air - dried sample was weighed into a 50-cm^3 beaker and 20cm^3 of distilled water was added and stirred. The water - soil mixture was allowed to stand for about 30minutes with occasional stirring, using a glass rod. The pH meter electrode was inserted into the suspension and measurement made as “pH in water”. Triplicate determinations were recorded.

Determination of Organic carbon /matter

The Walkley-Black method was adopted [16], 0.2g of air - dried soil (passed through 2mm mesh sieve) was weighed into a clean 250-cm^3 conical flask, 10cm^3 of standard $K_2Cr_2O_7$ (0.16M) solution was added and the flask swirled gently. 20cm^3 of concentrated H_2SO_4 was added rapidly from a burette and the flask was allowed to stand for between 20 - 30minutes. The contents of the flask were diluted with distilled water (200cm^3) and then titrated with standard ferrous sulphate solution (0.50M), using barium diphenylamine sulphonate as indicator. Blank titrations were similarly carried out. The organic matter was calculated by multiplying the Organic carbon by a factor of 1.72.

Determination of Nitrate and Sulphate

Extraction: - 5g of sieved soil was transferred into a screw cap plastic container. A little amount (0.25g) of activated charcoal and 20cm^3 of extracting solution (Morgan solution) were added and cap screwed in position. The plastic container was shaken on a mechanical shaker for about 30minutes. The resultant solution was filtered using a filter paper and filtrate analysed for nitrate and sulphate [17]. Nitrate was determined by Phenoldisulphonic acid method [18, 19, 20], while sulphate was determined by turbidimetric method [4].

Determination of Heavy metals

Soil samples were leached with a solution of sodium acetate (Morgan solution) (Black, 1965) and heavy metal content of leachate determined using atomic absorption spectrophotometer (AAS) model 210VGP Bulk Scientific.

Sample preparation for heavy metals

Non-concentrated 50cm^3 aliquot of samples were transferred into a beaker and 5cm^3 of concentrated HCl and 3cm^3 of concentrated HNO_3 were added and samples heated on a boiling water bath until the volume was reduced to about 15cm^3. Samples were allowed to cool, filtered into 50cm^3 standard volumetric flasks with thorough rinsing of the beakers. The solutions were made up to the mark with distilled deionised water.

Measurement

The AAS was operated in the air- acetylene flame mode and the hallow cathode lamps were operated at the following wave lengths (in nm) Cd 228.2; Cu 324.7; Pb 283.3; Zn 213.9 according the manufacturer's instruction. Blank readings were subtracted from those of the standards before calibration curves were prepared from where concentrations were estimated.

Results and discussion

Results of pH from the Ring Road and Orita-Aperin dumpsites sites study areas was found to be higher (8.20 and 7.50) respectively, that is, less acidic than those of soil samples from Botanical garden and Mokola control areas which in both cases was found to be 6.20. The results indicate that the soil of Ring Road dumpsite is slightly alkaline (Tables 1, 2, 3 and 4). The high pH values of the Ring Road soil is as a result of active anaerobic condition of the dump due to the presence of large amounts of un-decomposed waste matter, the decomposition process of which is under limited amount of oxygen. Such a situation enhances increase pH [7]. The situation observed at Orita-Aperin dumpsite is similar (i.e pH 7.40), but with less active anaerobic activities going on at the dumpsite, since the waste is almost completely decomposed. pH of the soil is, therefore, lower than that of the Ring Road dump soil and is near neutral. The mean pH levels of the two dump areas were significantly different (at α= 0.05). This difference is traceable to the ages of the two dumps, which differ significantly.

Soils of Mokola and University botanical garden control areas had mean pH values of 6.20 and 7.20 respectively. Soils of humid regions, such as Nigeria's are known to have a pH of between 5.0 to 7.0 depending on the buffering effects on either side of the scale by a number of substances such as hydroxyaluminium ions, carbon dioxide, carbonate ions and certain exchange reactions[21]. The mean pH values of Mokola control area were significantly different at $\alpha = 0.05$ using Duncan's Multiple Range Test from that of Botanical garden control area. The difference between the two controls areas may be probably due to the different characteristics of the areas. A comparison of mean pH values of the two dumpsites with those of the control areas also shows a significantly different at $\alpha = 0.05$, suggesting that waste disposal activities may have been responsible for the difference.

Organic carbon and organic matter content of the Orita-Aperin dumpsites was found to be higher (6.40% and 11.50 respectively) than that of the Ring Road dumpsites with (4.00% and 6.90% for organic carbon and organic matter respectively). Generally, the values of the two dumpsites were observed to be higher than samples from the control sites with 2.10% and 5.30% for organic carbon/matter content respectively (Tables 1, 2, 3 and 4). This is expected in view of the presence of large amounts of organic matter content of wastes in the dumps. Soils of Botanical garden were slightly richer in organic carbon/organic matter than those of Mokola control area. This may be explained on the fact that soils of Botanical garden are usually covered with grasses and leaf litter which continually die and decay to fix more organic carbon/organic matter into the soil. This is contrary to the nearly bare soils of most parts of Mokola. Organic carbon has strong affinity for heavy metal ions or cations in general, as a result of the presence of such functional groups like alcohols, carboxylic acids or carbonyls with which the metals form stable complexes.

The mean nitrate and sulphate values for Ring road was found to be 65.00 and 171.00 respectively, while the values for Orita-Aperin were 72.00 and 185.00 respectively. It was observed that soils of these sites were higher in nitrate and sulphate levels than those from the control areas. Sulphate levels were higher than those of nitrate in both soils of Ring road and Orita-Aperin sites. Also, mean nitrate and sulphate levels of the soils of Mokola control area were closer in value to those of Ring road and Orita-Aperin than that of the Botanical garden. This confirms the fact that Mokola site and the dumpsites have more common characteristics than with the Botanical garden area. Mokola control area and the study areas are subject to quite a number of identical human activities that tend to influence the quality of soil than does the Botanical garden, which is essentially rural. Such activities or processes include fossil fuel combustion, fallout from vehicular exhaust and atmospheric deposition on the land /soil. The main difference between Ring road and Orita-Aperin on one hand and Mokola on the other, however, is the absence of large-scale waste disposal activities in Mokola. The soils of the Botanical garden are relatively free from human activities that tend to enhance the amount of different pollutants such as nitrate, sulphate and trace metals among others. This control is, therefore, generally lower in the levels of all the parameters determined.

The trace metal levels in the soils of Ring Road indicate cadmium, copper, lead and zinc to be 8.40μgg^{-1}, 226.00μgg^{-1}, 332.00μgg^{-1} and 662.00μgg^{-1}, while that of Orita- Aperin soil was found to be 9.70μgg^{-1}, 276.00μgg^{-1}, 514.00μgg^{-1} and 838.00μgg^{-1} for cadmium, copper, lead and zinc. The results indicate that the levels of traced metals to be much higher than those of the control soils. Copper, lead and zinc were high in amount (Tables 1, 2, 3, 4) but reasonably comparable between the two dumpsites. High levels of Cu and Zn in soils of Ring Road and Orita-Aperin dumps could be traced to a number of sources, which include atmospheric pollution from vehicular exhaust emissions, disposal of solid waste, application of inorganic fertilizers, disposal of all kinds of domestic waste as well as fallouts of metallurgical industries and smelting and fabrication of non-ferrous metals. Corrosion of brass and other copper containing metals disposed of in the dump appear to be the major source of copper in the dumpsites soils.

High levels of zinc may be traceable to the large amount of zinc-coated sheets, generally uses as roofing material in the country. Ibadan city is made up of large number of houses with rusty zinc-sheet roofs that are leached by rainfall into the soils and water sources. A large amount of such galvanized scraps also find their way into the dumps, thereby increasing the amount of zinc in the dump soils beyond the levels found in the control areas (Table 3).

The mean cadmium amounting to 8.30μgg^{-1} and 9.70μgg^{-1} for Ring road and Orita-Aperin sites respectively were found to be low, though these were found to be relatively higher compared to the controls sites with values of 0.60μgg^{-1} and 0.57.00μgg^{-1} for Botanical garden and Mokola respectively. Whereas there was no significant different (at $\alpha = 0.05$) in mean values of cadmium between the two control areas, there was re in the cases of Cu, Pb and Zn. The usual low level of cadmium in nature as compared to larger concentrations of zinc, lead, and some other metals is reflected in the soils of all the areas. Cadmium is found in low amounts in rock, coal, and petroleum. Its other major sources, though very low compared to other metals include industrial operations and leachate from waste dumps and landfills. It is, therefore, quite in order to have found Cd in small amounts in soils of both the dumpsites and control areas as compared to Zn, Cu and Pb. As a result of the high degree of toxicity of Cd, however, even low levels of Cd is treated with all the seriousness it deserves.

A number of countries including Canada and Japan have soil quality criteria against which metal levels in soils can be assessed for the protection of the environment and human health. Nigeria is yet to have such criteria. Soil metal levels in this study area, when compared with Canadian and Japanese criteria are higher than the highest Canadian lowest level of Cd (1.40μgg^{-1}) for residential and the highest level of Cu (91.00$\mu gg^{-1}$for industrial sources, while the commercial level of Pb is 260μgg^{-1}. The level of Zn from industrial from sites had been found to be 60μgg^{-1} [22]. Average levels of all the metals in soils of the control areas were, however, lower than the lowest (residential) Canadian limit.

Table 1.0 Average monthly characteristics of Soils of Ring Road dumpsites between Nov. 2005 and Oct. 2006

Month	pH	Organic Carbon(%)	Organic Matter(%)	SO_4^{2-} (µg/g)	NO_3^- (µg/g)	Cd (µg/g)	Cu(µg/g)	Pb(µg/g)	Zn(µg/g)
Nov/Dec	8.00±0.57	4.00±1.40	6.90±2.40	800.00 ±7.20	71.00±1.40	7.70±3.50	234.00±6.50	272.00±8.70	601.00±1.20
Jan.	8.10±0.60	3.40±2.00	5.90±3.40	174.00±5.50	73.30±2.40	8.00±4.30	215.00±8.20	275.00±1.27	645.00±7.30
Feb.	8.40±0.50	4.30±1.90	7.40±3.30	171.00±7.20	65.00±1.61	9.10±5.30	239.00±7.80	510.00±1.31	661.00±8.00
March	8.30±0.40	3.96±1.80	6.80±3.00	169.00±3.90	66.00±4.20	9.10±4.40	199.00±8.40	354.00±1.16	684.00±1.30
April	8.10±0.30	4.60±1.80	7.90±5.00	1.73.00±8.40	56.30±1.02	10.10±4.90	206.00±4.20	310.00±1.05	701.00±1.00
May	8.30±0.50	3.90±1.80	6.90±3.00	167.00±8.50	64.90±1.73	8.40±3.90	276.00±9.00	384.00±1.42	659.00±1.10
June	8.20±0.30	3.00±1.90	5.20±3.30	165.00±5.90	71.30±1.78	8.20±3.60	239.00±3.80	366.00±1.39	651.00±1.40
July	8.10±0.30	4.30±1.50	7.30±2.60	159.00±4.60	61.50±2.28	8.10±2.80	243.00±1.53	318.00±9.90	635.00±1.20
Aug.t	8.30±0.50	4.10±1.50	7.20±2.40	176.00±1.09	62.00±1.97	7.30±5.00	182.00±7.90	374.00±1.23	695.00±1.20
Sept.	8.20±0.50	4.30±2.10	7.40±3.60	167.00±4.80	57.70±2.05	7.70±3.40	256.00±8.60	281.00±1.41	661.00±1.30
Oct.	8.40±0.50	4.10±1.80	7.10±3.10	184.00±1.02	65.00±2.25	8.100±3.50	199.00±6.60	362.00±1.25	682.00±9.80
Mean	8.20±0.10	4.00±0.50	6.90±1.00	171.30±7.10	65.00±5.40	8.40±0.50	226.00±2.80	332.00±4.20	662.00±2.80

Table 2: Average Characteristics of Soils of Orita-Aperin dumpsite between Nov . 2005 and Oct. 2006

Month	pH	Organic Carbon(%)	Organic Matter(%)	SO_4^{2-} (µg/g)	NO_3^- (µg/g)	Cd(µg/g)	Cu(µg/g)	Pb(µg/g)	Zn (µg/g)
Nov/Dec.	7.40±0.00	6.20±2.00	10.40±3.90	166.00±4.70	65.50±1.77	9.6±3.80	291.00±1.00	498.00±1.60	852.00±1.30
Jan.	7.40±0.40	6.90±2.40	11.50±4.10	203.00±136	71.00±2.04	8.80±2.90	287.00±8.80	517.00±1.70	824.00±1.20
Feb.	7.50±0.40	6.10±2.10	10.60±3.50	185.00±4.60	69.20±1.79	8.80±3.00	292.00±8.20	526.00±1.60	864.00±1.00
Mar.	7.50±0.30	6.20±2.60	10.70±4.50	185.00±3.30	77.70±1.87	9.10±5.00	280.00±9.20	527.00±1.80	848.00±9.10
Apr.	7.40±0.30	6.20±1.70	10.70±2.90	191.00±2.90	68.60±1.59	10.30±4.70	189.00±1.00	490.00±1.70	833.00±1.70
May	7.50±0.20	6.30±2.20	10.90±3,90	169.00±2.80	72.40±1.65	9.90±4.10	292.00±9.40	544.00±1.70	833.00±9.40
June	7.40±0.30	6.70±0.24	11.60±4.20	191.00±5.90	64.90±1.83	9.90±4.30	263.00±7.30	506.00±1.60	833.00±9.00
July	7.50±0.40	6.20±2.50	10.80±4.00	170.00±3.90	732.00±161	11.50±5.90	283.00±8.00	505.00±1.60	837.00±1.20
Aug.	7.60±0.40	6.30±2.50	10.90±4.10	187.00±3.90	689.00±4.20	9.80±5.00	300.00±8.20	517.00±1.20	851.00±1.20
Sept.	7.40±0.30	6.10±2.50	10.60±4.50	200.00±4.70	732.00±1.54	9.00±4.60	286.00±6.20	506.00±1.70	820.00±1.00
Oct.	7.30±0.30	7.00±2.40	12.10±4.10	185.00±2.30	720.00±2.15	9.90±9.00	296.00±9.00	522.00±1.72	836.00±1.70
Mean	7.50±0.01	6.40±1.60	11.50±1.80	186.00±1.27	709.00±3.90	9.70±0.80	276.00±9.06	514.00±1.50	838.00±1.00

Table 3: Average Characteristics of Soils of University Botanical Garden between Nov. 2005 and Oct. 2006

Month	pH	Organic Carbon(%)	Organic Matter(%)	SO_4^{2-} (µg/g)	NO_3^- (µg/g)	Cd(µg/g)	Cu(µg/g)	Pb(µg/g)	Zn (µg/g)
Nov/Dec.	6.30±0.30	2.70±0.40	4.60±0.80	147.00±4.90	41.20±0.60	0.57±0.60	4.61±1.20	2.65±2.60	26.58±2.60
Jan.	6.30±0.60	3.20±1.40	5.60±2.40	118.00±4.00	43.30±1.57	0.47±0.50	3.57±1.60	3.85±1.00	22.38±1.65
Feb.	5.80±0.80	2.50±1.10	4.30±2.00	143.00±2.60	46.30±1.00	0.38±0.50	0.64±0.60	2.95±3.20	24.57±1.55
Mar.	6.20±0.50	4.40±1.30	7.50±2.20	156.00±5.30	67.10±2.70	0.98±0.30	2.77±2.60	1.57±1.60	14.59±5.40
Apr.	6.00±0.60	2.80±0.30	4.80±0.60	107.00±6.10	56.30±6.90	1.13±0.30	4.16±3.40	2.11±1.70	28.48±6.30
May	6.20±0.10	2,70±1.40	4.70±2.30	118.00±4.90	71.80±1.16	0.41±0.40	3.30±4.24	2.94±1.10	19.98±8.20
June	6.40±0.50	2.80±2.30	4.90±3.90	109.00±6.60	48.90±1.94	0.58±0.40	3.07±1.00	2.15±1.20	27.22±1.00
July	5.70 ±0.70	3.60±1.10	6.20±2.00	162.00±4.90	43.70±1.77	0.63±0.40	3.65±2.70	1.39±1.60	23.52±7.00
Aug.	6.60±0.60	2.70±1.50	4.70±2.60	135.00±2.80	47.80±5.10	0.74±0.60	3.71±1.20	2.66±0.10	22.57±1.40
Sept.	6.20±0.40	2.70±1.20	4.70±2.10	123.00±1.60	61.10±2.35	0.44±0.40	4.61±1.00	2.16±1.40	24.46±3.60
Oct.	6.00±0.40	2.60±1.00	6.20±1.70	135.00±2.90	52.20±6.40	0.31±0.20	5.48±1.50	0.83±0.20	31.47±1.25
Mean	6.20±0.30	2.10±0.60	5.30±1.00	132.00±1.60	25.70±1.02	0.60±0.26	3.60±1.50	2.30±0.80	24.20±4.30

Table 4: Average Characteristics of Soils of Mokola Area of Ibadan between Nov. 2005 and Oct. 2006

Month	pH	Organic Carbon(%)	Organic Matter(%)	SO_4^{2-} (µg/g)	NO_3^- (µg/g)	Cd(µg/g)	Cu(µg/g)	Pb(µg/g)	Zn (µg/g)
Nov/Dec.	6.30±0.30	2.70±0.40	4.60±0.50	147.00±4.90	41.20±9.50	0.57±0.80	4.61±1.20	2.65±2.30	26.58±5.60
Jan.	6.30±0.60	3.20±1.40	5.60±2.40	118.00±4.00	43.30±1.57	0.47±0.50	3.57±1.80	3.85±1.00	22.38±1.65
Feb.	5.80±0.50	2.50±1.10	4.30±2.00	143.00±2.80	46.30±1.00	0.38±0.50	0.64±0.80	2.95±3.20	24.57±1.35
Mar.	6.20±0.50	4.40±7.50	7.50±2.20	156.00±5.30	67.10±2.70	0.98±0.50	2.77±2.60	1.57±1.80	14.59±5.40
Apr.	6.00±0.60	2.80±0.50	4.80±0.60	156.00±5.30	67.10±2.70	0.98±0.50	2.77±2.60	1.57±1.80	14.59±5.40
May.	6.20±0.10	2.70±1.40	4.70±2.50	118.00±4.90	71.80±1.16	0.41±0.40	3.30±4.24	2.94±1.10	19.98±8.20
June	6.40±0.50	2.80±2.30	4.90±3.90	109.00±6.60	48.90±1.94	0.58±0.40	3.07±1.00	2.15±1.20	27.22±1.00
July	5.70±0.70	3.60±1.10	4.90±3.90	109.00±6.60	48.90±19.9	0.58±0.40	3.07±1.00	2.15±1.20	27.22±1.00
Aug.	6.60±0.60	2.70±1.50	4.70±2.60	135.00±2.60	47.80±5.10	0.74±0.60	3.71±1.20	2.66±0.10	22.57±1.40
Sept.	6.20±0.40	2.70±2.10	4.70±2.10	123.00±1.80	61.10±2.35	0.44±0.40	4.61±1.00	2.16±1.40	24.46±3.60
Oct.	6.00±0.40	2.60±1.00	6.20±1.70	135.00±2.90	52.20±6.40	0.31±0.20	5.48±1.50	0.83±0.20	31.57±1.25
Mean	6.20±0.30	2.10±0.60	5.30±1.00	132.00±1.80	25.70±1.02	0.60±0.26	3.60±1.30	2.30±0.80	24.20±4.50

There seems to be no maximum permissible levels of some of these substances and pollutants, such as sulphate, nitrate and heavy metals in urban soils. The establishment of such threshold levels is essential in order to know precisely when safety limits are exceeded

Conclusion

The soils of the Ring Road and Orita-Aperin dumpsites have higher levels of most of the parameters determined (organic carbon/matter, sulphate-sulphur, nitrate-nitrogen, Cd, Cu, Pb and Zn) than those of Mokola and Botanical garden control areas. Ring Road dump soil was slightly alkaline with a pH of 8.20, while Orita-Aperin was 7.40 that is, about neutral.

Apart from mean organic carbon/matter content of dump soils being higher than those of the two control areas, soils of the Botanical garden were richer in organic carbon/organic matter than those of Mokola control area. Cd concentration was the lowest, followed by Pb and Cu. Zn was the most abundant of the four metals. There were significant differences ($\alpha = 0.05$) between the mean levels of all the parameters among all the study areas.

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