COMPARATIVE PHYSICOCHEMICAL CHARACTERISTICS AND PHYTOASSESSMENT OF DUMPSITE SOILS ON THE MAIN CAMPUS OF THE UNIVERSITY OF BENIN, NIGERIA

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Abstract

As human population increases, the generated waste also tend to increase. This could be as a result of improved technology and urbanization. The waste produced by humans are either biodegradable or non-biodegradable waste. The implication for the use of biodegradable waste for compost cannot be overemphasized as this would tremendously improve the yield of farm produce. This research was carried out within the vicinity of the University of Benin, Benin City. Four strategic dumpsites were located using the global positioning satellite (GPS), and a control that had no record of waste dumpsite or industrial activity was also located. In this study, the sampled soils from the waste dumpsites and control were assessed for some heavy metals. Some essential elements that were required for plant growth were also assessed using standard procedures. The result showed increase in plant growth *viability in Vigna unguiculata grown on the soil from the waste dump sites compared to the control. However, heavy metal concentrations of the soil from the waste dumpsites were significantly higher compared to the control. In this research, it was also shown that chromium exceeded the benchmark of USEPA for phytotoxicity.*

Keywords: Heavy metals, waste dumpsites, biodegradable waste, non-biodegradable waste.

In recent times, the amount of solid wastes generated has increased tremendously. In Nigeria, the rate of increase cannot be overrated due to the increase in population growth, urbanization and industrialization. There is a significant difference between the quantity of solid waste generated during the pre- independence era and post- independence era. This observation could be accrued to the technological advancement the country has achieved over the past years and industrialization in all sectors of the economy. Despite the fact that this improvement was an economic advantage to the country, it has constituted a major challenge causing various environmental problems, such as reduction in environmental sustainability, pollution of the soil and posing health risks to humans. Soil pollution primarily affects the yield of cultivated plants, depending on the type of waste that the soil is primarily exposed to.

Solid waste could be biodegradable and non-biodegradable waste. Biodegradable waste are easily decomposed by biological activities, particularly with the use of microorganisms; examples include paper, organic and food waste. On the other hand, non-biodegradable waste are not easily broken down and decomposed by biological activity; examples include plastics, bottles, wrappings of all kinds and metals. The present study aims at investigating physicochemical characteristics of the various waste from dumpsites on the main campus of the University of Benin, as well as to determine how soils from dumpsite impacted on seedling development of cowpea (*Vigna unguiculata* var. Ife Brown).

Methodology

The waste dumpsites were selected within the environs of the University of Benin, Benin City. The university has a university rank enrolment range of 40,000-44,999 students annually. A number of five (5) active dumpsites were selected, identified and described in the study. Specific sites chosen for the study within the UNIBEN Campus includes; Control (CTRL), Life Sciences Complex (LC), Physical Sciences Complex (PC), Basement Complex (BC), Art Complex (AC), Photographs of the sampled sites were also taken alongside with the GPS locations. The control site was the Botanical Garden of the Department of Plant Biology and Biotechnology (PPB) which had no record of waste dump or any form of industrial activity. Soils were collected from within each sampled area and used for the phytoassessment study of viable seeds of cowpea. The plants were observed for any possible growth changes for a period of seven weeks. Soil samples were analyzed for pH and Electrical Conductivity (Nelson & Sommers, 1982 & Davey and Conyers, 1988), and selected heavy metal content (Iron, Manganese, Nickel, Zinc, Copper, Chromium, Cadmium, and Lead) and some essential elements according to the methods of SSSA (1971) and AOAC (2005). Data from the laboratory analyses were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS 20.0). The descriptive statistics as well as ANOVA were conducted. The US EPA standards were used to compare for statutory levels of metals in soil.

Results

A look at the contemporary environmental degradation in Nigeria, reveals that it would be possible to predict the state of the environment in the next 27 years. This is the time estimated for the Nigerian human population to be twice over in size using the double time calculation (Globalize Interactive World Map, 2005). This is the time it will take Nigeria to reach its carrying capacity and this will place a huge burden on the environment if no technology is put in place to deal with environmental issues. The environment is already being depleted, showing that the population is impacting negatively on it. In the learning institute of the great university of Benin, Benin City the display of environmental non-challant attitude of the residence community poses a negative threat to the future of a sustainable environment. The plates below shows the sampled dump sites in strategic locations within the university environs. The dumpsites were unseemly, unattractive and placed on the bare ground exposed to resident members within the university.

(a)

(b)

(c)

(d)

Plate 1: Dumpsite at (a) Art complex (b) Life Sciences complex (c) June 12 complex (d) Physical sciences

Table 1 below shows the description of the sampled dumpsites within the University of Benin, Benin City. The control site had no record of waste dumpsite or industrial activities. The most prominent waste seen in all the dumpsites sampled were paper sheets, followed by plastics which includes bottles, disposable plates, polyethylene packaging materials and emptied sachet water. The dumpsites also contained other forms of degradable waste. However, it was observed that metallic waste were scantily present in all the sampled sites investigated.

Table 1: Description of sample sites and composition of waste by space occupied

Designations	**Description**	**GPS**	**Composition of waste by space**
Control (CTRL)	PBB Dept. botanical garden soil	6^o23'53"N 5^o36'54.1E	No waste, just a botanical garden
Life Sciences complex (LC)	Dumpsite meant for the shopping complex. Used by shop owners as well as contract cleaners who clean the Facility Offices	6^o23'51.2"N 5^o36'55.4"E	Metals (-); Plastics (+++) Paper (+++++) Food waste (+++) Other degradables (+)
Physical Sciences complex (PC)	Dumpsite meant for the shopping complex. Used by shop owners as well as contract cleaners who clean the Facility Offices	6^o23'57.9"N 5^o36'59.0"E	Metals (++); Plastics (+++) Paper (+++++) Food waste (+++) Other degradables (++)
Basement	Dumpsite meant for the shopping	6^o23'47.7"N	Metals (+); Plastics (++++)

complex (BC)	complex. Used by shop owners. Sometimes accessed by cleaners from the Library Complex	5^{o}36'54.7"E	Paper (++++) Food waste (+++) Other degradables (++)
Art complex (AC)	Dumpsite meant for the shopping complex. Used by shop owners, as well as cleaners of Faculties of Law, Agric, Art, Mgt Sci., as well as the nearby Halls of residence	6^{o}24'11.4"N 5^{o}37'22.4"E	Metals (+); Plastics (++) Paper (++++) Food waste (++++) Other degradables (+++)
June 12 complex (JC)	Dumpsite accessed by occupiers of June 12 complex as well as the nearby Halls of residence	6^{o}23'55.7"N 5^{o}37'15.1"E	Metals (+); Plastics (+) Paper (+++++) Food waste (+++) Other degradables (+)

Scale of occurrence; “+” that it is scanty and “+++++” that it is the most prominent waste in the dumpsite; - none

Table 2 below shows the physicochemical conditions of the soil samples collected from the sampled sites. The soil samples collected from the Life Sciences complex had a pH of 5.76 compared to 5.78 in Physical Sciences complex and 5.74 at the control sites. The pH values were non-significant (p= 0.917). The electric conductivity (EC) significantly varied from site to site. The result showed that in the soil sampled from waste dumpsite at the Physical Science Complex, had an electric conductivity of 144 uS/cm, however this varied greatly from 113 uS/cm in Basement Complex and 57 µS/cm in the control site. The sulphate levels of the soil were significantly high at the sampled waste dumpsites, with values ranging from 13.27-36.29 mg/kg in all the sites when compared to 9.87 mg/kg in the control site. Reportedly Base Complex had the highest sulphate levels in the soil (36.29 mg/kg). Results shows that there is significant reduction in Ammonium nitrogen levels in the control soil (6.31mg/kg) and the sample collected from the Life sciences complex (1.78 mg/kg). However, significant increase was reported in Basement Complex (20.6 mg/kg) and Physical Sciences Complex (28.8 mg/kg). High levels of heavy metal concentrations of Zinc, Copper, Chromium, Lead, Manganese, Iron and Nickel was observed in significant amounts in the waste dumpsites compared to the control site. Though the levels was all within the ecological screening benchmarks as provided by the USEPA except Chromium that exceeded the benchmark.

Table 2: Physicochemical result of the soil sample

	LC	BC	AC	PC	JC	CTL	***p-values***	ESVm	ESVp
pH	5.76^{a}	5.21^{a}	5.31^{a}	5.78^{a}	5.44^{a}	5.74^{a}	***0.917***	NA	NA
EC (uS/cm)	89^{b}	113^{a}	95^{ab}	144^{a}	61^{b}	57^{b}	***0.024***	NA	NA
Cl (mg/kg)	19.58^{ab}	22.66^{ab}	20.9^{ab}	31.68^{a}	11.68^{ab}	6.93^{b}	***0.092***	NA	NA
Sulphate (mg/kg)	22.25^{ab}	25.75^{ab}	23.75^{ab}	36.29^{a}	13.27^{b}	9.87^{b}	***0.046***	NA	NA
Nitrate (mg/kg)	17.8^{a}	20.6^{a}	19.94^{a}	28.88^{a}	10.61	9.34^{a}	***0.812***	NA	NA

Phosphate (mg/kg)	12.46^{ab}	14.42^{ab}	13.3^{ab}	20.16^{a}	7.43^{b}	4.41^{b}	***0.035***	NA	NA
Ammonium nitrogen (mg/kg)	1.78^{c}	20.6^{ab}	19.57^{ab}	28.8^{a}	10.61^{bc}	6.31^{c}	***0.005***	NA	NA
Calcium (mg/kg)	6.23^{a}	7.21^{a}	6.65^{ab}	10.08^{a}	3.71^{b}	2.2^{b}	***0.041***	10000	40
Magnesium (mg/kg)	14.24^{a}	16.48^{a}	15.2^{a}	23.04^{a}	11.49^{a}	10.04^{a}	***0.952***	NA	NA
Sodium (mg/kg)	22.34^{b}	25.85^{ab}	23.85^{ab}	36.14^{a}	13.32^{bc}	4.27^{c}	***0.102***	NA	NA
Potassium (mg/kg)	32.93^{abc}	38.11^{ab}	35.15^{ab}	53.28^{a}	19.64^{b}	11.65^{c}	***0.156***	NA	NA
Zinc (mg/kg)	1.42^{a}	1.65^{a}	1.52^{a}	2.3^{a}	0.85^{a}	0.5^{a}	***0.678***	100	50
Copper (mg/kg)	3.56^{a}	4.12^{a}	3.8^{a}	5.76^{a}	2.12^{a}	0.68^{a}	***0.719***	100	100
Chromium, Cr^{6+} (mg/kg)	8.19^{bc}	9.48^{ab}	8.74^{bc}	13.25^{a}	4.88^{cd}	0.9^{e}	***0.002***	10	1
Lead (mg/kg)	2.67^{a}	3.09^{a}	2.85^{a}	4.32^{a}	1.59^{a}	0.94^{a}	***0.831***	900	50
Manganese (mg/kg)	3.2^{a}	3.71^{a}	3.42^{a}	5.18^{a}	1.91^{a}	0.61^{a}	***0.980***	100	50
Iron (mg/kg)	40.05^{ab}	46.35^{ab}	42.75^{ab}	64.8^{a}	23.88^{bc}	7.65^{c}	***0.126***	200	NA
Nickel (mg/kg)	5.34^{abc}	6.18^{a}	5.87^{abc}	8.64^{a}	3.18^{bc}	1.89^{c}	***0.042***	90	30
Moisture (%)	10.65^{a}	13.06^{a}	9.54^{a}	13.85^{a}	10.72^{a}	13.02^{a}	***0.976***	NA	NA
Organic carbon (%)	0.48^{a}	0.54^{a}	1.74^{a}	0.66^{a}	0.92^{a}	0.24^{a}	***0.819***	NA	NA
Organic matter (%)	0.83^{a}	0.93^{a}	2.99^{a}	1.14^{a}	1.58^{a}	0.41^{a}	***0.901***	NA	NA
Total nitrogen (%)	0.15^{a}	0.21^{a}	0.19^{a}	0.23^{a}	0.11^{a}	0.03^{b}	***<0.001***	NA	NA

Means on the same row with similar alphabets do not differ from one another. NA not available. ESVm ecological screening value for toxicity to soil microorganisms; ESVp phytotoxicity benchmark (Efroymson et al., 1997a,b). Dumpsites originally meant for shopping complexes at LC Life Sciences, BC Basement, AC Faculty of Art, PC Physical Sciences, and JC June 12. CTL is the botanical garden of PBB Dept.

Figure 1 shows a cluster analysis that attempts to associate the various sample locations with respect to their physical chemical attributes. Results showed that samples from June 12 Complex was most likely associated with the control, whereas, Physical Science Complex was a complete stand alone, an indication of its highest level when compared to the others.

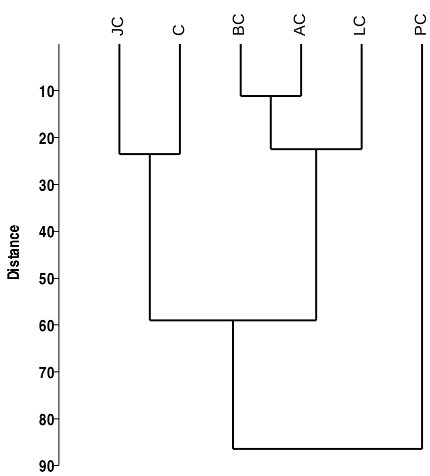

Figure 1: Dendrogram from Cluster analyses by Ward's Method associating the sample locations together

A correspondence analysis was also made to associate the physicochemical parameters with the various dumpsites (Figure 2). The results showed close association between moisture content and the control, perhaps an indication of the fact that moisture content was better in the control compared to the other dumpsites.

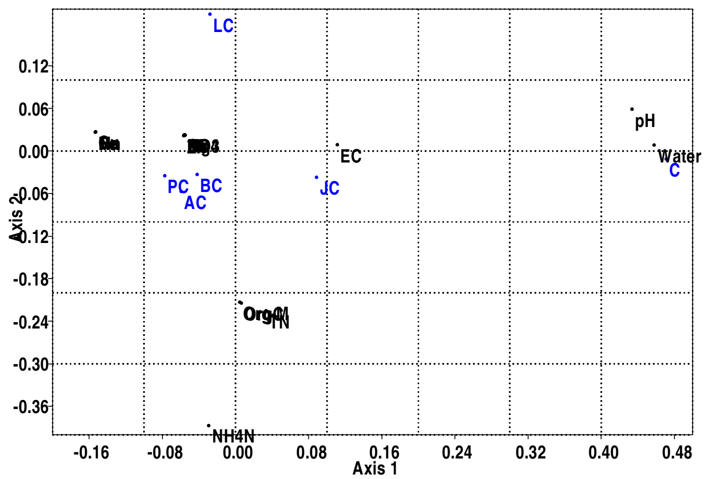

Figure 2: Correspondence analysis showing association between sample locations and the physicochemical parameters determined in the study

Plant growth parameters recorded at the sixth week was an attestation of phytoassessment of the various soils sample from the waste dumpsites (Table 3). The results showed that the number of leaves per plant was significantly higher in June 12 Complex (14) compared to the control (3). Similarly, there was significant increase in stem girth in June 12 Complex (2.3 cm) as well as in Physical Complex and Life Science Complex (1.37cm) compared to the control (0.5 cm). The leaf area in the plants exposed to the waste dumpsite soils was significantly larger compared to the control (p= 0.005). In terms of number of nodules per plant, there was a significant increase in nodulation in plants exposed to dumpsite soils in June Complex, Physical Science Complex, Life Science Complex and Basement Complex compared to the control. For example, in June Complex soil samples, nodulation in *Vigna sp*. were up to thirty (30) nodules per plant compared to five (5) recorded in the control. However, there was significant differences with respect to nodulation index.

Table 3: Plant growth parameters recorded at the 6th week after sowing

Soils	No. of leaves	No. of pry root	Plant height (cm)	Stem girth (cm)	Leaf area (cm²)	No of leaf branche	No. of nodules per	Nodulation efficien

		branches				s	plant	cy/ index
AC	$5.33^{ab}\pm0.33$	$11.7^{a}\pm1.76$	$56.4^{ab}\pm17$	$1.2^{ab}\pm0.12$	$32.6^{ab}\pm6.84$	$5.67^{a}\pm0.33$	$5.67^{c}\pm1.76$	$0.09^{a}\pm0.07$
JC	$14^{bc}\pm3.06$	$15^{a}\pm2.08$	1.78E2±30.5	$2.3^{c}\pm0.06$	$69.3^{b}\pm12.8$	$14.7^{c}\pm2.33$	$29.7^{b}\pm8.76$	$0.15^{a}\pm0.05$
PC	$6^{ab}\pm0.58$	$16^{a}\pm0$	$60.7^{ab}\pm17.1$	$1.37^{b}\pm0.09$	$23.6^{a}\pm1.66$	$7.33^{ab}\pm0.88$	$17^{ab}\pm3.51$	$0.11^{a}\pm0.03$
LC	$9^{abc}\pm3.61$	$8^{a}\pm2.31$	$32.5^{ab}\pm17.7$	$1.37^{b}\pm0.09$	$21.8^{a}\pm11.5$	$5.33^{a}\pm1.86$	$10.7^{ab}\pm8.29$	$0.06^{a}\pm0.05$
BC	$18.3^{c}\pm5.04$	$14.3^{a}\pm5.46$	$93.2^{b}\pm19.7$	$1.73^{bc}\pm0.19$	$48.1^{ab}\pm10.4$	$11.7^{bc}\pm1.33$	$24^{ab}\pm9.54$	$0.17^{a}\pm0.01$
CTRL	$3.33^{a}\pm3.33$	$5.33^{a}\pm5.33$	$15.6^{a}\pm15.6$	$0.5^{a}\pm0.5$	$18^{a}\pm18$	$3^{a}\pm3$	$5^{c}\pm5$	$0.05^{a}\pm0.05$
p-value	**0.04**	**0.252**	**0.001**	**0.003**	**0.005**	**0.007**	**0.124**	**0.439**

Means on the same column with similar alphabets do not differ from one another. Dumpsites originally meant for shopping complexes at LC Life Sciences, BC Basement, AC Faculty of Art, PC Physical Sciences, and JC June 12. CTL is the botanical garden of PBB Dept.

Discussion

Research has shown that decomposed soil encourages phyto-enhancement in crops (Yu, Murphy, and Lin, 2003). The food remains and all other inorganic matter would eventually decompose to increase the available nutrients in the soil. This is majorly possible with the action of aerobic and anaerobic microbial organism in the soil. Warm temperature and oxygen also propagates decomposition of waste matter. Therefore, this research showed that *Vigna unguiculata* was generally more viable in growth on soils from the sampled waste dumpsites compared to the control. Improved plant development on the dumpsite soils may be accrued to enhanced plant nutrients (nitrogen, magnesium, manganese and potassium) in the dumpsite soils compared to the control soil. This is an evidence of soil enrichment by the predominant biodegradables. This agrees with the research of Pheby, Grey, Giusti & Saffron (2002).

However, it is also pertinent to consider the high level of heavy metal concentrations in the sampled soil compared to the control, this poses a great treat to human population. Most vegetables and edible mushrooms grow in and around these waste dumpsites which serve as a source of food to the resident community. Similarly, research carried out by Ikhajiagbe & Anoliefo, (2012); Anolifo, (2016); Chukwu, Anoliefo, & Ikhajiagbe, (2017), has shown that some plants have the ability to bio-accumulate heavy metals in plants and as such has been used successfully for bioremediation. Researchers have shown that the bioaccumulation of heavy metals in plants and biomangnifications in humans has intrinsic long lasting implications on human health, and this could result in accelerated rates of bronchitis and reduced lung function, advanced rates of respiratory symptoms, cancer and would eventually reduce the lifespan of man (WHO, 2000).

Conclusions

The geometric increase in the human population and rising urbanisation has significantly increased the production of waste.

Recommendations

In order to achieve a futuristic sustainable environment a deliberate, conscious, proper waste management has to be enforced. The non-biodegradable waste products should be distinctively separated and implied for recycling. While the biodegradable waste could be maximally transformed into compost for improved crop yield. Thereby achieving waste to wealth in a diminishing economy.

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