International Journal of Scholarly Research in
Biology and Pharmacy
Journal homepage: https://srrjournals.com/ijsrbp/
ISSN: 2961-3310 (Online)

(Research Article)

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Effect of waste dumpsites on some soil chemical properties and performance of okra (*Abelmoschus esculentus*) in Obio/Akpor Rivers State, Nigeria

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International Journal of Scholarly Research in Biology and Pharmacy, 2023, 02(02), 001–008

Publication history: Received on 05 February 2023; revised on 22 March 2023; accepted on 24 March 2023

Article DOI: https://doi.org/10.56781/ijsrbp.2023.2.2.0016

Abstract

Study was conducted at the screen house of department of crop and soil science, University of Port Harcourt to investigate the influence of two waste dumpsites on soil chemical properties and performance of okra in Obio/Akpor. A composite soil samples was randomly collected at two depths (0-15 and 15-30) cm from two dumpsites from Choba and Rumunduru at a distance of (0-1) and 100 meters (control) away from the dumpsites. The soil was placed on 10kg perforated bucket; three seeds of okra were planted per bucket and later thinned to two after germination. It was left for eight weeks. The experiment was on complete randomized design. Results showed significant ($P<0.05$) increase in soil chemical properties (%TOC, available P, TN, Ca, Mg and K) in impacted zone (0-1)meter over control (100) meter away in the two dumpsites. The soil chemical properties were significantly higher in Rumunduru dumpsite than Choba. There was no significant ($P>0.05$) difference in soil depths in the two locations, however, the concentration of soil chemical properties slightly decrease with increase in soil depth. There was a decrease in the concentration of heavy metals (Ni, Pb , Fe and Zn) along the main dumpsites away from the control in the two locations studied. Significant increase was observed in concentration of heavy metals in Rumunduru dumpsite over that of Choba. Concentration of the four metals decreased with increase in soil depth. All the metals were above the permissible limits with the exception of nickel. There was a significant ($P<0.05$) reduction in plant height on the impacted zone (0-1) m in distance over the reference point (control) in the two dumpsites. Significant difference was not noticed between the two soil depths, though the height was slightly higher at 0-15 depth than 15-30cm. Waste dumpsites affected negatively the plant performance especially at the impacted zone as there was retardation of growth and an increase in concentration of heavy metals.

Keywords: Waste dumpsites; Chemical properties; Heavy metals; Plant performance

1 Introduction

Dumpsite is a place where solid wastes are disposed without environmental control. Dumpsites are used for disposal of solid wastes resulting from human and animal activities which are regarded as not useful. They are mostly waste generated from solid municipal sewage treatment plants, agricultural operations, industrial and household activities (Ekundayo, 2003). These wastes are exposed to rainfall, thus producing noxious odor on decomposition which constitutes serious health hazard (Foby and Embiowei, 2014).

Uncontrolled disposal and burning or decay of some waste yield substances that contain heavy metals (Sari et al., 2019).

Poor waste management poses great challenge to city dwellers especially those living close to dumpsites due to the potential of the waste to pollute water bodies, food, land and vegetation. Poor disposal and handling of these wastes lead to environmental degradation, destruction of the ecosystem and may pose great risk to public health and threat to

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surrounding environment (UNDP, 2006). The problem caused by these wastes ranges from health hazard to the degradation of the quality of the environment (Abdus-salam et al., 2011).

Dumpsites are mostly located within living communities and wetlands, they are often not lined nor basement prepared for selective adsorption of toxic substances. They are prone to release pollutants to nearby river, water and air through leachates and gases (Alimba et al., 2006). Most water sources are rendered hazardous to man and living organisms due to indiscriminate dumping of refuse (Bakare et al., 2005).

Waste dumpsites transfers significant levels of toxic and persistent metals into the environment. These metals are translocated into plant tissues and then to food chain (Benson and Ebong, 2005), and may eventually be consumed by man (Yusuf et al., 2003). Their rate of uptake in plant is influenced by factors such as metal species, plant species, plant age and plant part (Singh et al., 2010). Pollution of the biosphere with heavy metals by industrial, agricultural and domestic activities pose serious challenge for safe use of agricultural land (Fytianos et al., 2001).

Waste dumpsites has high levels of heavy metals which significantly impact on soil chemical properties thus altering the nutrient balances which in turn affect crop productivity and diversity (FAO/ITPS, 2015). Twumasi et al., (2016) reported that the composition of disposed waste materials and the rate of microbial break down significantly impacts on heavy metals concentration in soil.

Plants grown on land polluted with municipal, domestic and industrial wastes absorbed heavy metals through their roots or foliar parts. Patcharin et al., (2018) reported high concentration of heavy metals in water, sediments and edible plants near municipal landfill, including bioaccumulation factor, which pose as potential risk to human health.

Kirmani, (2010) in his study on Dandora waste dump site in Nairobi, Kenya confirm the presence of high concentration of heavy metals such as Pb, Hg, Cd, Cu and Cr in the soil samples investigated.

Studies carried out in South Eastern part of Nigeria had shown that the soils around dump site support plants growth and biodiversity (Adeagbo et al., 2005) thus leading to extensive cultivation of varieties of vegetable plant used for food stuff in dumpsite hence exposing these crops to high level of pollutants and the entire food chain.

The need to carry out this study at Choba and Rumunduru in obio/Apkor local government area of Rivers State, Nigeria become necessary due to indiscriminate and unplanned exposure of dump sites on road sites and cultivable land use in cultivation of crops. This study is focused on (i) Examining the effect of dumpsites on some heavy metals and chemical properties of soil. (ii) To investigate the influence of waste dumpsites on the performance of a vegetable crop-okra (*Abelmuschus esculentus)*.

2 Material and methods

The study was conducted at the screen house of department of crop and soil science, University of Port Harcourt. The study site is situated at two abandoned solid waste dumpsites located at Choba and Rumunduru all in Obio/Akpor local government area of Rivers State, Nigeria. The sites were located at latitude 4^0 88' N and 6^0 92' E and 4^0 23' N and 7^0 16' for Choba and Rumunduru sites respectively.

The mean maximum monthly temperature is 31.29^{o}C, the minimum is 21.80^{o}C (Uko and Tamunobereton-Ari, 2013), while annual monthly rainfall is 200.45mm (Uko and Tamunobereton-Ari, 2013). The rainy season is from April to October while dry season from November to March. Relative humidity varies between 35 to 90% depending on the period of the year.

2.1 Soil samples collection

Composite soil samples were collected randomly from each of the dumpsites at a depth of 0-15 and 15-30cm within a distance of 0-1 meters from the dumpsite with a ditch soil auger, a control sample was taken at 100 meters away from each of the dump sites. Ten (10) kg soil sample were placed in a medium size plastic pot. Three seeds of okra (*Abelmoschus esculentus*) were planted in each of the pots, two weeks later the okra was later thinned to two after germination.

The experiment was replicated thrice making a total of 24 pots. Watering of the soil was done thrice in a week with 200mls of water through a watering can in each of the pot. Emerging weeds were hand-picked. The experiment was left for a period of eight (8) weeks. The design is complete randomized design (CRD).

2.2 Plant sampling and soil data collection

Plant height was recorded at seven days interval after germination for a period of eight weeks using a meter rule from the soil base to the tip of the plant leaf, average height was taken from each treatment.

2.3 Soil and plant sample collection for laboratory analysis

Composite soil samples were collected from each of the pots with hand trowel, crushed with hands, air-dried at room temperature in the laboratory. The samples were pulverized with mortar and pestle, sieved in 2mm mesh screen and stored in polythene bag before laboratory analysis. The following parameters were analyzed:

Percent total organic carbon was determined using the method of Walkley and Black (Nelson and Sommer, 1982), Available Phosphorus by Bray method (Page et al., 1982), percent total nitrogen was determined by Kjeldahl method (Bremmer and Mulvancy, 1982). Soluble potassium was analyzed using the flame photometry method (Ohiri and Ano, 1985) while exchangeable cations (calcium and magnesium) were determined using titration method (Mbah, 2004).

3 Results and discussion

Results of soil chemical properties on waste dumpsites of Choba (A) and Rumunduru (B) are as shown in table 1 below.

The results revealed that the concentration of percent total organic carbon (TOC) ranged from 0.80 ± 0.15^{c} to 3.24 ± 0.27^{a}, 21.58 ± 0.96^{c} to 45.05 ± 0.23^{a} mg/kg for available phosphorus, 0.12 ± 0.00^{c} to 0.67 ± 0.12^{a} for percent total nitrogen (TN), 6.30 ± 0.05^{c} to 20.80 ± 0.60^{a} Cmol/kg soil for soluble potassium, 1.00 ± 0.01^{c} to 2.87 ± 0.20^{a} Cmol/kg for exchangeable calcium and 1.35 ± 0.23^{c} to 3.00 ± 0.10^{a} Cmol/kg of soil for exchangeable magnesium in both sites for control (100) meters away from the dumpsites and impacted areas (0-1) meters within the dumpsites respectively.

Table 1 Effects of wastes waste dump sites on soil chemical properties of the two locations

Treatment	Soil Depths	Locations	% TOC	Avail P	%Total N	K	Ca cmol/kg	Mg cmol/kg
		CHOBA						
Control 1	0-15		0.85 ± 0.25^{c}	24.21 ± 0.05^{bc}	0.15 ± 0.05^{c}	7.40 ± 0.21^{c}	1.09 ± 0.21^{c}	1.50 ± 1.10^{bc}
	15-30		0.80 ± 0.15^{c}	22.41 ± 0.45^{c}	0.16 ± 0.17^{c}	6.30 ± 0.05^{c}	1.00 ± 0.01^{c}	1.44 ± 0.21^{c}
0-1 meter	0-15		3.24 ± 0.27^{a}	41.20 ± 1.05^{a}	0.45 ± 0.00^{a}	18.24 ± 0.00^{a}	2.56 ± 1.22^{a}	3.00 ± 0.10^{a}
	15-30		2.85 ± 0.19^{ab}	39.80 ± 0.08^{a}	0.43 ± 0.21^{a}	18.18 ± 0.25^{a}	2.31±0.83a	2.89 ± 0.85^{a}
		RUMUNDURU						
Control 2	0-15		1.02 ± 0.02^{bc}	22.78 ± 0.65^{c}	0.12 ± 1.20^{c}	8.00 ± 0.24^{c}	1.00 ± 1.08^{c}	1.40 ± 0.00^{c}
	15-30		0.96 ± 0.15^{bc}	21.58 ± 0.96^{c}	0.12 ± 0.00^{c}	7.50 ± 0.05^{c}	1.10 ± 0.15^{c}	1.35 ± 0.23^{c}
0-1 meter	0-15		2.75 ± 0.08^{ab}	45.05 ± 0.23^{a}	0.67 ± 0.12^{a}	20.80 ± 0.60^{a}	2.87 ± 0.20^{a}	2.21 ± 2.15^{b}
	15-30		2.55 ± 2.01^{ab}	43.58 ± 05^{a}	0.60 ± 1.25^{a}	19.05 ± 0.42^{a}	$2.80\pm0.12_{a}$	2.10 ± 0.34^{b}

Results revealed significant ($P<0.05$) difference in all the chemical properties investigated over control. The concentration of the elemental nutrients studied was significantly higher in soil samples collected from the highly impacted zone (0-1) meters from the dumpsites while the lowest were from the control. This observation agrees with findings of (Alex et al., 2020) who reported an increase in some soil chemical properties in high impacted areas over low impacted zone in municipal waste dumpsites investigated.

The increase in percent total nitrogen recorded could be due to addition of ash from burning as the dumpsites are sometimes set on fire by unknown personalities. This report corroborated with the observation of (Ayeni et al., 2008) who reported that ash based product as likely cause of significant higher value of total nitrogen.

Available phosphorus followed similar trend as total nitrogen from the result. The significant higher value in the concentration of phosphorus in impacted areas over control could be as a result of the agricultural, house hold and municipal waste which constitute major components of the waste dump. These products as they gradually break down may have added some of these nutrients into the soil. This observation agrees with the findings of (Amerh et al., 2020).

Similarly, the percent total organic carbon observed at the dumpsite over control could possibly be attributed to house hold waste materials such as food stuff, leaves etc which may have broken down due to activities' of micro-organisms thus increasing the total organic carbon in the soil. This tally with the report of (Amos-Tautua et al., 2014).

Exchangeable cations (calcium and magnesium) were significantly higher at the dumpsites in the two locations studied. Similar observations were reported by (Ayeni at al., 2008) at a dump site they investigated in Nigeria.

The results also showed that the concentration of all the soil chemical properties studied were significantly ($P<0.05$) higher at Rumunduru waste dumpsite than that of Choba, possibly due to high volume of waste present and much older than the one of Choba. There was no significant ($P>0.05$) difference in the values of soil chemical properties between the two depths studied (0-15 and 15-30)cm in the two dumpsite locations, though the concentrations of all the soil chemical properties looked into slightly decreases with increase in soil depth with the surface soil sample

3.1 Heavy metal status of the waste dump sites

Results of the soil heavy metal status of the two waste dump sites are presented as shown in table two below: The results showed that the concentration of Nickel decreased from $0.25±1.11^{a}$ mg/kg in highly impacted areas to $0.10±0.05^{c}$ mg/kg in control, $22.41±1.30^{a}$ to $0.26±0.65^{c}$ mg/kg for Pb, $1317.0±2.0^{a}$ to $95.20±0.25^{c}$ mg/kg for Fe and $136.2±0.15^{a}$ to $4.05±0.4^{c}$ mg/kg for Zinc in the two waste dump sites locations studied.

Table 2 Heavy metal status of the two waste dump site locations

TREATMENT	DEPTH (cm)	SITES	Ni (mg/kg)	Pb (mg/kg)	Fe (mg/kg)	Zn (mg/kg)
		CHOBA				
Control	0-15		$0.11±0.14^{c}$	$0.31±1.20^{bc}$	$104.4±0.11^{b}$	$4.22±0.15^{c}$
	15-30		$0.10±0.05^{c}$	$0.29±2.07^{c}$	$100.2±0.10^{b}$	$4.08±2.12^{c}$
(0-1) meters	0-15		$0.25±1.11^{a}$	$18.2±0.06^{ab}$	$1216±0.07^{ab}$	$125.2±0.2^{ab}$
	15-30		$0.23±o.11^{b}$	$15.85±1.2^{b}$	$1209±6.70^{b}$	$120.0±.45^{b}$
		RUMUNDURU				
Control	0-15		$0.12±0.11^{c}$	$0.28±1.50^{c}$	$99.2±0.08^{bc}$	$4.22±2.30^{c}$
	15-30		$0.12±o.05^{c}$	$0.26±o.65^{c}$	$95.20±0.25^{c}$	$4.05±0.4^{c}$
(0-1)	0-15		$0.25±0.20^{a}$	$22.41±1.30^{a}$	$1317.0±2.0^{a}$	$136.2±0.15^{a}$
	15-30		$0.23±0.01^{b}$	$20.15±0.45^{a}$	$1311.1±0.5^{a}$	$134.5±0.11^{a}$

The results revealed higher concentration of these metals in impacted zones over non impacted zones in the two sites studied. This is in line with the observations of Chukwumati and Kamalu, (2020), Foby and Embiowei, (2014) who in their different studies reported a decrease in concentration of heavy metals along the main dump sites away from the reference area.

The high concentrations of heavy metals within the impacted area could be due to the nature of waste materials dumped at the sites (metal scraps, motor vehicles used parts, iron and steel materials from industrial, municipal and domestic wastes and other solid wastes) some of which are non-biodegradable.

These observations corroborates with the report of Mohammed et al., (2010) who inferred that high concentration of heavy metals in waste dump sites could be due to the disposal of waste materials like batteries, food packaging materials, PVC materials and insecticides (Twumasi et al., 2016). The value is within the permissible limits of 2-200mg/kg by (Bowen, 1979, FAO/WHO, 2001).

The high concentration of iron (Fe) observed in the impacted zone could be due to the presence of metallic substances discarded at the waste dumpsite and iron bearing waste materials (Olayiwola et al., 2017). Concentration of iron is also within permissible level of metal concentration as described by (Bowen, 1979 and FAO/WHO, 2001). Iron is a micronutrient required by plants for their growth.

Zinc a micro-elements is known to be very important in its enzymatic reactions in soil and its ability to reduce cadmium uptake in soil by plants (Chahab and Savaghebi, 2010). High concentrations of zinc metals in the studied sites could possibly be due to disposal of metals containing dry cells, burning of electronic waste as inferred by (Twumasi et al., 2016). Though the concentration of zinc is within permissible level, but may be a threat to human health if ingested in large amount.

The relatively high concentration of Pb in high impacted zone over control in the studied locations could perhaps be due to waste materials such as food packaging materials, batteries from mechanic workshop etc. This observation agrees with the findings of Twumasi et al., 2016) who attributed the presence of Pb in their study as a result of pvc materials, insecticides, batteries and food packagings from disposed wastes.

A significant ($P<0.05$) increase was observed in all the heavy metals investigated in waste dump site“B” (Rumunduru) over that of waste dump site “A” (Choba). The higher value in heavy metals concentrations recorded at site “B” above that of site “A” could possibly be attributed to the high buildup of metal materials such as dry battery cells, used vehicle parts, electronic materials dumped at Rumunduru waste dump site over that of Choba. All the metals studied were above the permissible limits recommended by (WHO, 1977, FEPA, 1991 and DPR, 1991), with exception of nickel which was below the 0.5mg/kg recommended by (WHO, 1977).

The study also revealed that the concentration of the four heavy metals studied decreased with increase in soil profile depths though not significantly different. Heavy metals added to soil remain in the surface unless the carrying capacity is exceeded. Their movement downward (sub soil) could occur when the retention capacity of the soil is exceeded possibly due to continuous years of waste dumping in the site or possibly due to break down of organic waste matrix.

This tally with the report of (Mclean and Bledsoe, 1992) who inferred that when heavy metals are introduced into the soil surface, downward movement does not occur to great extent unless the retention capacity of the soil is overloaded. Another possible reason for the decrease in concentration of the heavy metals from the surface to sub soil could probably be due to low mobility and leaching of the heavy metal and high organic matter of the soil. This is line with the findings of (Ayolagha, 2000, Bade et al., 2001 and Foby and Embiowei, 2014).

Table 3 Permissible limit of heavy metals from soil in waste dumpsites

	Chromium (mg/kg)	**Cadmium (mg/kg)**	**Lead (mg/kg)**	**Iron (mg/kg)**	**Nickel (mg/kg)**	**Zinc (mg/kg)**
WHO	0.05 mg/kg	0.03	5.0	2.0	0,5	0.03
FEPA	0.05	0.03	1.0	2.0	0.1	0.03
DPR	0.05	0.03	1.0	0.01	0.1	0.03

3.2 Effect of treatment on plant height

The effect of treatments on plant height (*Abelmoschus esculentus)* is as presented in table 4 below: the results showed a progressive increase in plant height throughout the period of the study in all the treatment. *Abelmoschus esculentus* grown on surface soil (0-15) cm in control soil samples consistently had the highest plant height with values ranging from 6.45±0.3c to 36.05±0.21a and 8.15±1.25c to 34.00±0.01a for Choba and Rumunduru respectively at first and eight weeks after planting (WAP).

There was a significant ($P<0.05$) reduction in plant height on the impacted zone (0-1) meter over the reference point (control) in the two dumpsites studied. The reduced plant height observed in the

Table 4 Plant height of okra (Abelmoschus esculentus) at weekly interval for the two sites

Trt	Depth (cm)	Site	Wk 1 (cm)	Wk 2 (cm)	Wk 3 (cm)	Wk 4 (cm)	Wk 5 (cm)	Wk 6 (cm)	Wk 7 (cm)	Wk 8 (cm)
		CHOBA								
Control	0-15		6.4±0.4[c]	11.2±1.0[c]	15.3±0.2[b]	20.5±0.5[ab]	26.6±1.0[a]	29.0±0.1[a]	34.1±1.2[a]	36.0±0.1[a]
	15-30		6.6±0.5[c]	10.9±0.2[c]	14.8±2.1[c]	20.0±0.5[ab]	25.1±0.7[b]	29.1±1.3[a]	33.5±0.1[a]	35.4±0.0[a]
0-1m	0-15		7.2±0.1[b]	11.9±0.5[ab]	15.8±0.2[a]	19.0±2.1[b]	24.5±0.1[b]	27.1±1.4[b]	28.8±0.1[b]	30.1±1.4[b]
	15-30		6.8±1.5[b]	11.5±0.1[b]	15.3±0.4[b]	18.6±2.1[b]	24.0±0.3[b]	26.4±1.0[b]	27.9±0.1[b]	29.0±0.1[b]
		R/NDURU								
Control	0-15		8.2±0.5[ab]	13.2±1.0[a]	16.5±0.1[a]	22.0±0.4[a]	27.1±1.2[a]	29.7±0.2[a]	35.1±0.0[a]	36.4±1.3[a]
	15-30		7.8±2.5[ab]	12.7±0.5[a]	16.0±1.0[a]	21.6±0.5[a]	26.4±0.1[a]	29.0±1.4[a]	33.8±0.4[a]	35.7±1.0[a]
0-1m	0-15		8.9±0.3[a]	12.2±1.0[ab]	15.4±0.5[b]	18.7±2.0[b]	20.7±0.1[c]	24.1±0.4[c]	26.5±1.0[c]	28.1±0.1[c]
	15-30		8.2±1.1[ab]	11.9±0.3[ab]	15.0±2.0[b]	17.8±0.1[c]	19.5±0.5[c]	23.6±0.1[c]	26.0±2.4[c]	27.5±1.0[c]

Dumpsites over control could be attributed to treatment effect. This observation conforms to the findings of (Chukwumati et al., 2016, Adenipekun et al., 2008). There was no significant ($P>0.05$) difference in plant height between the two soil depths (0-15) and (15-30) cm investigated, though plant height was slightly higher at 0-15 cm than 15-30 cm.

Plant height was slightly higher at Rumunduru dumpsite than Choba site in both the impacted and control samples; this could possibly be due to higher organic matter and nutrients (table 2) present at Rumunduru dumpsite than Choba.

Generally, results of the study showed that the two dumpsites studied impacted negatively on the plant height.

4 Conclusion

Results of the study showed high elevated levels of the heavy metals and they were above the permissible limit allowed by regulatory body with exception of nickel. This result revealed a major problem to human and animal health challenge due to high cultivation of edible crops in near dumpsites which are consumed by man.

There is therefore need for crops grown in or near waste dumpsites to be subjected to laboratory analysis to confirm its safety before human consumption.

Compliance with ethical standards

Acknowledgments

The authors acknowledged the Department of Crop and Soil Science University of Port Harcourt for allowing the authors the use of her soil laboratory and the necessary equipment’s. We are indeed grateful.

Disclosure of conflict of interest

There is no conflict of interest among the authors.

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