Original article

Helminths and heavy metals in soils from a dumpsite in Ibadan city, Nigeria

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Keywords

Helminths • Heavy metals • Soil • Dumpsite • Ibadan city

Summary

Waste generation is inevitable because humans continue to generate waste due to increase in population, urbanization and advancement in technology. This generation of waste is of public health concern especially when the waste materials are deposited on dumpsites. This study assessed the helminths and heavy metal content of Awotan dumpsite in Ibadan city. Surface soils (0-15cm depth) of the dumpsite were randomly sampled at different dumpsite areas with the aid of a quadrat. Helminth content was determined using the zinc floatation method and the heavy metal concentrations of the soil were determined using Atomic Absorption Spectrophotometry (AAS). Some physicochemical properties of the soil were also determined. Results showed that the dumpsite soil was slightly alkaline with an average pH of 8.1 ± 0.2 while the overall mean electrical conductivity, temperature, moisture content and height above sea level were 545.9 ± 235.3µS/cm, 32.6 ± 2.2°C, 17.2 ± 4.8 % and 236±4.6 m respectively. The overall prevalence of soil helminths was 10.4% with Ascaris lumbricoides being more prevalent (8.8%). The heavy metal concentration of the soil followed the trend Pb (709.7± 1574.9mg/g) > Cu (316 ± 227.1mg/g) > Cr (48.8 ± 17.7mg/g) > Cd (9.7 ± 10.9mg/g). There was a low overall prevalence of soil helminths. However, the heavy metal concentrations exceeded USEPA permissible limits providing a possible source for underground water contamination in residential areas around the dumpsite. Human settlements close to the dumpsite should be discouraged by the government.

Introduction

Soil is a highly dynamic, ecologically complex and diverse living entity that is formed as a result of various biological and climatological interactions with the earth's bedrock [1]. Soil pollution is a phenomenon characterized by the loss of the structural and biological properties of the soil layers as a result of numerous human and natural factors [2]. Human activities that cause pollution include increased urbanization, disposal of untreated waste, indiscriminate use of agrochemicals, unscientific mining, dumping of industrial waste, accidental pollution and leakages, inadequate treatment and safety management of chemicals and toxic waste. As urbanization increases and human population grows, there is a need to manage the waste produced from human activities and this has led to the creation of dumpsites.

Dumpsites are waste depositing land (soil) areas where uncontrolled waste disposal activities occur in such a way that the environment is not protected from the detrimental effect that arises from these activities [3]. The ecological balance of any ecosystem gets affected due to the widespread contamination of the soil [2].

Accumulation of heavy metals can degrade soil quality, reduce crop yield and the quality of agricultural products, and thus negatively impact the health of humans, animals and the ecosystem [4]. Small life forms may consume harmful chemicals, accumulate and pass them up the food chain to larger animals leading to morbidity and an increased mortality rates of organisms. Human exposure to pollution is believed to be more intense now than any other time in human existence [5, 6].

Municipal and industrial solid wastes contain a variety of potentially significant chemical constituents and pathogenic organisms that could negatively affect public health, air, soil and groundwater qualities [7]. Some contaminants are carcinogens while others for example DDT are known to be toxic to humans and can also alter chromosomes. Others such as PCBs cause liver and nerve damage, skin eruptions, vomiting, fever, diarrhoea, and fetal abnormalities [8].

Over the last three decades there has been increasing global concern over the public health impacts attributed to environmental pollution [9]. The pathogenic organisms that can be found in solid waste include parasitic nematodes, protozoa and other microorganisms [10]. Parasitic nematodes represent a serious threat to humans, animals and plants. The parasitic nematodes whose infective stages can embryonate in the soil are soil transmitted helminths (STHs) [1]. Soil-transmitted helminths can cause a range of symptoms including intestinal manifestations (diarrhoea and abdominal pain), general malaise and weakness, impaired cognitive and physical development, and chronic intestinal blood loss which can lead to anaemia. Helminth infection is a major cause of disease burden among children in developing countries especially in sub-Saharan Africa [11]. This study was carried out to assess the helminths and heavy metals in soils from a dumpsite in Ibadan city.

Materials and methods

Study area

This study was conducted in Awotan Solid Waste Dumpsite (ASWD) (Fig. 1) located within 07’27.719’ – 07’27.811’ North and 003’51.003’ – 003’50.999’ East, Ibadan, Oyo State. ASWD has been active since 1998, receiving 36000 tonnes of municipal wastes in an area of 14 hectares [3]. Residential buildings, markets, block industries, schools and churches are located within thirty meters radius of the dumpsite.

Soil sampling and preparation

The study area was divided into five sampling sites (A-E) and a total of twenty five samples were collected from each site. Soil sample (60g) was collected at each sampling point with the aid of a 0.25 m^2 quadrat thrown at random and with a soil auger at depth 0-15cm. The temperature of the soils was measured in-situ. Samples were collected in labelled airtight polythene bags and immediately transported to the laboratory for analysis. Sampling was done in the first three weeks of November, 2015.
Soil samples from the field were analysed for moisture content. Soils to be checked for helminths were kept moist in polythene bags pending time of checking and the remaining soils were transferred into a plastic tray for air drying; large clods of soil were broken to speed up drying. The soil was passed through 2mm sieve to remove stones and other unwanted materials, crushed and ground into fine powder using mortar and pestle and then analyzed for pH, conductivity and heavy metals.
Activities in each sampling site within the study area were observed. Site A had sorted and burnt waste materials while newly brought-in wastes were dumped in site B. Site C was the sorting region where the scavengers stored the recyclable materials such as plastic bottles, iron rods, aluminium cans and many more, site D was covered with wastes deposited for a long time while site E was a newly opened section for dumping activities (Plates A-E).

Laboratory Analysis

Physico-chemical parameters of soil

The pH of soil was measured in the supernant suspension of 1:2.5 soils: liquid mixture with the aid of a hand held pH meter [12] while soil electrical conductivity and in-situ temperature measurements were done according to established methods [13]. The height of the area above the sea level was measured using a GPS Garmin etrex 30 model. Moisture content was measured before air drying the soil samples and estimated in percentage. Ten grams of soil sample was transferred into a previously weighed tin plate, followed by the weighing of both the tin and

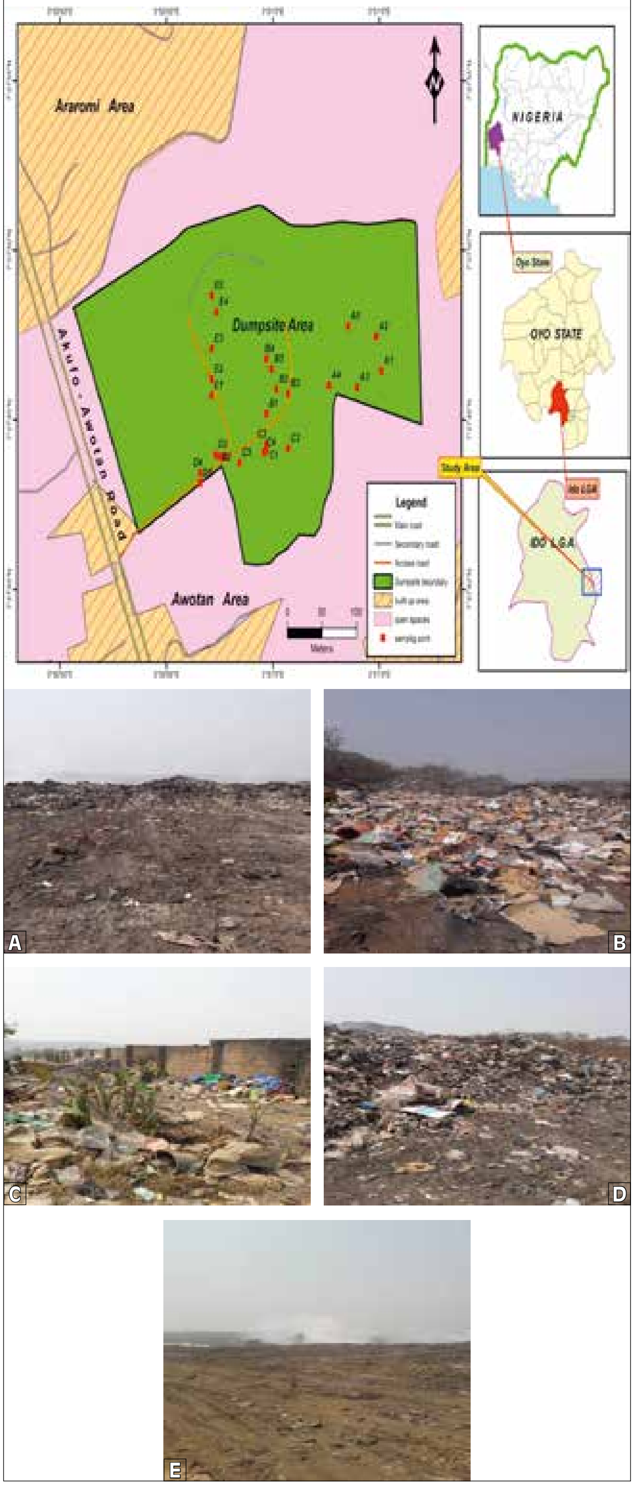

Fig. 1. Map of the study Area.

A. Repository of sorted and burnt materials
B. Repository for newly collected waste
C. Sorting areas for storing recyclable materials
D. Repository for long-term deposited waste materials
E. Newly opened area for dumping activities

Tab. I. Physicochemical parameters of soil samples from Awotan dumpsite.

Area/parameter	pH	EC (μS/cm)	Temp.(°C)	MC (%)	Height above sea level (m)
A	8.0 ± 1.8	724.2 ± 226.4	29.9 ± 1.3	24.6±4.5	232.8 ± 3.2
B	8.2 ± 0.3	680.4 ± 208.9	31.5 ± 1.0	18.3±2.8	240.2 ± 4.2
C	8.2 ± 0.2	600.7 ± 245.2	33.0 ± 1.1	15.6±2.1	238.2 ± 1.9
D	8.0 ± 0.2	396.9 ± 125.5	35.6 ± 1.7	13.3±1.8	231.8 ± 3.0
E	8.1 ± 0.1	327.1 ± 87.2	33.0 ± 1.1	14.0±1.0	236.8 ± 4.9
f- value	0.93	4.31	13.79	14.12	5.00
P-value	0.47	0.01	0.00	0.00	0.01
Overall mean	8.1 ± 0.2	545.9 ± 235.3	32.6 ± 2.2	17.2±4.8	236 ± 4.6

Keys: A-E are the subsampling areas; EC: Soil Electrical conductivity; Temp: Soil temperature; MC: Soil moisture content

soil sample (A gram). It was then dried in an oven until constant weight was obtained. This was then cooled in a desiccator and weighed (B gram) again [12]. The percentage soil moisture content was calculated using the formula,

$$\text{Moisturecontent }\% = \frac{\mathbf{A - B}}{\mathbf{B - tin}} \times 100$$

Total heavy metal contents were determined by acid digestion using aqua regia solution (Nitric acid and Hydrochloric acid in ratio 3:1). Three millilitres of distilled water was added to one gram of finely ground soil sample in a 250 mL conical flask. Freshly prepared aqua regia made from 15mL of HNO_3, 3 mL of HCl and 1mL of perchloric acid was added to the sample and the conical flask was then covered with a watch glass. The mixture was heated on a hot plate in a fume cupboard until brown fumes disappeared. The mixture was then removed from the hot plate, allowed to cool and was filtered through a Whatman No. 42 filter paper into a 50 mL standard volumetric flask. The volume was made up to mark by adding de-ionized water to get a meniscus. The concentrations of Pb, Cd, Cr, and Cu were determined on the Atomic Absorption Spectrophotometer (AAS) (Bulk Scientific Model GVP 210).
Dilution Factor (DF):

$$DF = \frac{C + B}{B}$$

C = Aliquot , B = Diluent
The measured concentrations of the metal were multiplied with the dilution factor to get the actual metal concentration.

Helminth analysis

The soil samples were checked for helminth using the Zinc Sulphate centrifugal floatation method. Five grams (5g) of the soil sample was measured and mixed thoroughly with distilled water. The suspension was filtered to remove coarse particles while the filtrate was centrifuged at 1500 rpm for 5 minutes and the supernant was decanted. Finally the sediment was mixed with 15mL saturated Zinc Sulphate solution in a centrifuge tube filled to the brim and allowed to stand for a few minutes with cover slip superimposed on the tube. The sample was centrifuged at 2500 rpm for 5mins then the cover slip was lifted onto a microscope glass slide and examined for the presence of parasite eggs and larvae under X 40 objective lens [14].

Statistical analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 20. Quantitative data were summarized using mean, median and standard deviation. Inferential statistics were performed using ANOVA and chi-square at $P < 0.05$.

Results

Physicochemical properties of soils from Awotan dumpsite

Table I shows the physicochemical properties of soils from Awotan dumpsite. The values of pH of the areas were A (8.00 ± 1.80), B (8.20 ± 0.30), C (8.20 ± 0.20), D (8.01 ± 0.16) and E (8.10 ± 0.10). The soils' electrical conductivity (μS/cm) and temperature (°C) ranged from 327.14 ± 87.23 to 724.23 ± 226.37and 29.88 ± 1.34 to 35.56 ± 1.69 respectively. The soil moisture content (%) for the areas were A 24.56 ± 4.53, B 18.34 ± 2.76, C 15.62 ± 2.07, D 13.34 ± 1.81, E 14.02 ± 1.04 while the heights above sea level(m) were A (232.80 ± 3.19), B (240.20 ± 4.21), C (238.20 ±1.92), D (231.80 ± 2.95) and E (236.80 ± 4.87)

Prevalence of helminths in soils in Awotan dumpsite

The distribution and prevalence of helminths in soil samples from Awotan dumpsite is shown in Table II. The total number of soil samples examined within the dumpsite was 125 (100%), out of which 13 (10.4%) were positive for soil helminths. The prevalence of helminths in Areas A, B, C, D, E were 6 (24.0%), 0 (0%), 2 (8.0%), 3 (12.0%), 2 (8.0%), 3 (12.0%) respectively. The prevalence of *Ascaris lumbricoides* (Fig. 2) in areas A, D and E were 6 (24.0%), 3 (12.0%) and 2 (8.0%) respectively but was below detection limits in areas B and C while *Strongyloides stercoralis* (Fig. 3) was only found in area C 2(8.0%).

Tab. II. Distribution and prevalence of helminths in soil samples within Awotan dumpsite.

Area	Number examined	Helminth type (%)		Number infected (%)	Number uninfected (%)
		Ascaris lumbricoides	Strongyloides stercoralis		
A	25	6 (24.0)	0 (0.0)	6 (24.0)	19 (76.0)
B	25	0 (0.0)	0 (0.0)	0 (0)	25 (100)
C	25	0 (0.0)	2 (8.0)	2 (8.0)	23 (92.0)
D	25	3 (12.0)	0 (0.0)	3 (12.0)	22 (88.0)
E	25	2 (8.0)	0 (0.0)	2 (8.0)	23 (92.0)
Total	125	11 (8.8)	2 (1.6)	13 (10.4)	112 (89.6)

$\chi^2_{(8)} = 20.13; p = .01$

Heavy metal content of soils within Awotan dumpsite

The concentration of heavy metals in soils within Awotan dumpsite is shown in Table III. Concentrations of Cu, Cr, Cd and Pb respectively were A (342.2 ± 177.55, 49.69 ± 7.80, 14.69 ± 11.77, 421.38 ± 182.41), B (322.99 ± 90.51, 42.26 ± 21.69, 14.37 ± 18.26, 663.49 ± 375.64), C (18 441 ± 130.81,57.34 ±16.72,3.49 ± 3.48,1779.39 ± 3557 .45), D (459.09 ± 401.31, 55.63 ± 19.68, 9.36 ± 9.02, 488.04 ± 332.9) and E (271.34 ± 20.24, 39.12 ± 19.19, 6.38 ± 5.3, 796.17 ± 115.88).

Correlation matrix of soil parameters

Table IV shows the correlation matrix of soil parameters at the dumpsite. A significant ($p < 0.05$) negative correlation was observed between temperature and electrical conductivity (r = -0.4), height and copper (r = -0.5) and temperature and moisture content (r = -0.7), (p = 0.01) while a significant positive correlation was observed between cadmium and copper (r = 0.4)

Fig. 2. Egg of *Ascaris lumbricoides.*

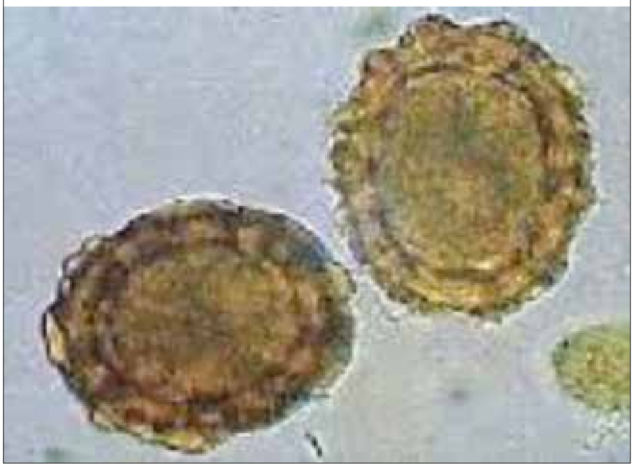

Fig. 3. Larva of *Strongyloides stercoralis.*

Discussion

The pH of the soil determines the viability of parasites in the soil because acidic pH inhibits the normal development of parasite infective stages while an alkaline pH level support the development of infective stages of parasites [15]. The range of pH from 8.0 to 8.2 observed showed that the study site was moderately alkaline. This finding is consistent with the study by Thomas et al. [16], where the mean dumpsite soil pH value was 8.0 but not in accordance with findings of Badmus et al. [17], who recorded acidic pH within the range of 5.45 – 6.45 at the Aba-Eku dumpsite area. The high average soil temperature (32.6ºC) recorded in this study might be due to low

Tab. III. Variations of heavy metal concentrations within Awotan dumpsite.

Heavy metals (mg/g)	Sampling areas (mean± SD)							Overall mean	USEPA permissible limits
	A	B	C	D	E	F	P		
Cu	342.2 ± 177.6	323.0 ± 90.5	18441± 130.8	459.09 ± 401.3	271.3 ± 20.2	0.98	0.44	316.01 ± 227.11	4.3
Cr	49.69 ± 7.80	42.26 ± 21.69	57.34 ± 16.72	55.63 ± 19.68	39.12 ± 19.19	1.02	0.42	48.81 ± 17.74	0.05
Cd	14.69 ± 11.77	14.37 ± 18.26	3.49 ± 3.48	9.36 ± 9.02	6.38 ± 5.31	1.01	0.42	9.65 ± 10.91	.07
Pb	421.38 ± 182.41	663.49 ± 375.64	1779.39 ± 3557.45	488.04 ± 332.90	196.17 ± 1115.88	0.74	0.57	709.69 ± 1574.91	0.4

Tab. IV. Correlation matrix of soil parameters.

	Cu	Cr	Cd	Pb	pH	EC	Temperature	Heights	MC
Cu	1								
Cr	-.252	1							
Cd	.428*	.108	1						
Pb	-.153	.482*	-.037	1					
pH	-.315	.175	.239	-.064	1				
EC	.024	-.122	.081	.050	.137	1			
Temperature	.234	.010	-.181	-.124	.079	-.407*	1		
Heights	-.459*	.209	-.119	.189	.379	-.179	-.093	1	
MC	.175	-.140	.262	-.127	-.070	.708**	-.689**	-.207	1

*. Correlation is significant at the 0.05 level (2-tailed).**. Correlation is significant at the 0.01 level (2-tailed).

moisture content ($r = -0.69$, $p < 0.05$) and the season of the year during which the study was carried out.

The mean electrical conductivity (EC) of the dumpsite soil (545.9µS/cm) was low when compared with the findings of Badmus et al. [17] who recorded 6280µS/cm from a study at Aba-Eku landfill Ibadan. The season of the year and moisture content of the soil determines the EC of the soil because salt moves in water therefore the presence of these ions in a moisture filled soil will increase the EC [17]. This can be supported by the result of the present study that showed a positive association ($r = 0.71$, $p < 0.05$) between EC and moisture content of dumpsite soil. The low level of soil moisture content (17.2%) observed may also be attributed to season of the year and high overall mean height (235.9 m) of the dumpsite above sea level.

The low overall prevalence of soil helminths (10.4%) recorded at the study area can be adduced to high temperature (32.6°C) and low moisture content (17.2%) as lower moisture content and higher temperature lead to faster inactivation process of soil helminth eggs [18-21]. High overall heavy metal content of the dumpsite soil might also contribute to the overall low prevalence of helminth parasite, although the association between soil heavy metal concentration and helminth parasite intensity was not investigated in the study.

The higher prevalence of *Ascaris lumbricoides* (8.8%) than *Strongyloides stercoralis* (1.6%) observed in this study can be corroborated by the findings of [22] where the percentage occurrence of *Ascaris lumbricoides* was (8.0%) and *Strongyloides stercoralis* was (5.7%). This might be due to the fact that eggs of *Ascaris lumbricoides* can withstand extreme environmental conditions because of the presence of the ascaroside layer [22].

Heavy metals are metallic elements that have their specific gravity above $5g/cm^3$ [23] and are available in both natural and polluted environments. Heavy metals deposited do not disintegrate over a long time, thereby leading to health problems such as vomiting, abnormalities, nausea and gastrointestinal disorder. Some are known to be carcinogenic, mutagenic while others are known to cause brain disorders.

The findings of this study showed that the heavy metal content of the dumpsite followed the trend Pb > Cu > Cr > Cd which agrees with the work of Thomas et al. [16] who discovered the level of Pb (580.6 mg/kg) to be highest, followed by Cu (471 mg/kg), Cr (136 mg/kg) and Cd (16.8 mg/kg) from selected dumpsite soils in Ibadan metropolis.

The overall higher concentrations of Pb, Cu, Cr and Cd above USEPA limits might be due to the deposition of different forms of wastes like tyres, lubricant oil, old paint, pesticides, cans, tin, aluminum, plastics, glass bottles, old batteries, automobile parts, electronic waste and scraps of metals at the dumpsite over time.

Conclusions and recommendation

This study was carried out to investigate the helminths and heavy metals in soils from Awotan dumpsite, Ibadan. The overall prevalence of soil helminths was found to be low at the dumpsite. However, the heavy metal contents were dangerously higher than USEPA permissible limits, a possible source of underground water pollution which can cause harmful health effect to the population exposed to the environment.

Phytoextracting plants can be used to take up the heavy metals in soil. This will reduce the risk of the metals leaching into underground water. Scavengers and dumpsite workers should be encouraged to use personal protective gears at the site to reduce the risk of helminth infestation and exposure to heavy metals. Citing of residential buildings and social amenities close to dumpsites should be discouraged as dumpsites often have a high elevation due to accumulated refuse and this can support the movement of pollutants to residential areas with short and long term health effects.

Acknowledgements

The authors have no conflicts of interest.

Authors' contributions

OM designed and supervised the study. AA carried out field study. OM and AA analysed and interpreted data. Both authors read and approved the final manuscript.

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