Physicochemical assessment of soils from selected metal scrap dumpsites in Anambra State, Nigeria.

Abstract

Soils for agricultural activities are prone to pollution due to the influence of climate change, globalization and industrialization. Soil samples used in this research were collected from two different metal scrap dumpsites while the controls were taken500meters away from sampling sites allin Anambra state, Nigeria. The physico-chemical parameters analyzed were pH, electrical conductivity, total organic carbon (TOC), moisture content, nitrate, phosphate and heavy metals. The heavy metal concentrations were determined using Varian AA240 model ofatomic absorption spectrophotometer (AAS). The results obtained were compared with World Health Organization(WHO) standards to ascertain their possible implications.Although most of the analysed physicochemical parameters of the soils are favourable for agricultural activities, however the concentrations of some toxic heavy metals are significantly higher than WHO permissible limit and therefore posing severe threat to the ecosystem.

Key words: soil, metal scrap dumpsites, pollution,heavy metals, AAS, WHO.

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Introduction

Soils for agricultural activities are exposed to pollution due to the influence of climate change, globalization and industrialization [1].With rapid urbanization and industrialization, the environment is severely contaminated by heavy metals and their rates of transfer in the soil, water and air have continued to increase till date[2].Crude oil which contains both inorganic and organic compounds is known to cause environmental pollution through its exploration, production, transportation and oil spillage activities. Soil contamination with high concentration of pollutants may affect the microorganisms living in the soil [3].

Soil is a major component of agricultural food production and soil serves as the source and/ or sink for toxic substances [4].

One of the major challenges confronting Nigeria as a country is solid waste management [5]. Municipal solid wastes are routinely deposited on the roads, drains, water bodies and

uninhibited lands. Metal scrap is one of the municipal solid wastes (MSW), which have monetary value in Nigeria [6]. The scrapyards are haphazardly sited in rural and urban centres in Nigeria where all kinds of scraps from abandoned automobiles, machineries and electrical appliances are disassembled[7]. Many of these scrap materials contain contaminants such as heavy metals, polycyclic aromatic hydrocarbon and other toxic substances that adversely affect the ecosystem [8]. Human beings may be exposed to these toxic substances through inhalation, ingestion or dermal contact [9]. Heavy metals present in solid municipal wastes via interaction with soil components, bio-accumulate and persist in soil and consequently go into the food chain and consumed by man [10].

The increased level of metals that accumulate in the soil and affect nearby ecosystems primarily originates from anthropogenic activities such as discharge of industrial and domestic wastes, mining, smelting operations and vehicular emission [11]. Weathering of the natural rock is another known source of heavy metal pollution in soils. However, input of metals from human sources in soils is higher than the input from natural sources [12].

Heavy metals are released into the environment from metal smelting and refining industries, scrap metals, plastic and rubber industries, various consumer products and from burning of waste containing these elements. The metals volatilize on burning and is released into the air. These volatilized metals become mobile and travel long distances to deposit on the soil, vegetation and water depending on their density [13]. The deposited metals are non-degradable and persistent in the environment and pose severe poisoning on humans through inhalation, ingestion and skin absorption. Acute exposure to these toxic metals leads to nausea, anorexia, vomiting, gastrointestinal abnormalities, dermatitis and many fatalities. The contamination of the ecosystem by heavy metals is a serious problem in the society because the environment is a direct receptacle for waste products generated in the space within the environment [14]. Meanwhile, zinc and copper are some essential nutrients to humans and animals for biochemical activities [15].Waste from municipal dumpsites bear soils that are satisfactorily rich in organic matter that would be acceptable for surface feeder plants[16]. It was reported that open dump sites perform a twofold purposes of a safe disposal of waste and simultaneously improve chemical properties of soils that constitute productive agricultural fields [13].

Nigeria has a comparatively very poor waste management approach[17]. Indiscriminate waste dumps and scrap dumpsites occupy almost every vacant plot of land especially along major roads and streets. It is suspected that these activities contaminate and degrade the soil by causing substantial alteration of the physical and chemical composition of the soil hence compromise efficient and quality plant growth.

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Thus, the inadequate waste management approach has the potential of increasing soil metal concentration in and around Anaocha and Njikoka major scrap dumpsites. The mobility of heavy metals, bioavailability and related bio-toxicity to organisms depend on their specific chemical forms or ways of binding and the total metal concentration obtained after strong acid digestion.

Presently, there is no information regarding the assessment of inorganic and organic compounds in soil around the metal dumpsites in the studied areas. It is hoped that the present study would produce a new framework for assessment of environmental risks associated with metal scrap dumpsite activities. Therefore, this study seeks to assess the physicochemical properties andheavy metals (Cd, Co, Fe, Mn, Pb and Zn) in the vicinity of open waste dumpsite at Adazi-ani (Anaocha) and Abagana (Njikoka) areas in Anambra state, Nigeria. Assessment of these soils followed a thorough soil chemistry as well as comprehensive laboratory work to fully comprehend the extent of contamination of the environment and the potential risk to the ecosystem.

Materials and Methods

Description of Study Area

Adazi-ani is a community in Anaocha local government area while Oyeagu is situated at Abagana, in Njikoka local government area, both in Anambra state, Nigeria. They are in between Awka and Nnewi metropolis.

Soil sampling and analysis

Total of eight(8) soil samples were used in this study. Soil samples used in this research were collected with a soil auger at 0-15cm depth and 15-30 cm depth from the metal scrap dumpsites and controls collected 500m away from sampling sites. After pH and moisture content determination, the soil samples were air dried, crushed and passed through a 2mm sieveprior to other analysis. The samples were digested using aqua regia method and finally analysed using Varian AA240 atomic absorption spectrometer(AAS) at Spring Board Research Laboratories, Awka, Anambra state, Nigeria. The data obtained were compared with WHO permissible limits.

Results and Discussion

Table 1. Results of physicochemical parameters of the soil.

Sample	pH	Conductivity	Moist cont	TOC	Salinity	Nitrate	Phosphate
AD0	8.23	-54	3.5	14.585±0.120	0.208±0.012	6.625±0.176	2.325±0.0

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AD15	8.30	-57	2.5	26.520±0.254	0.289±0.050	6.458±0.028	3.281±0.768
AC0	8.43	-43	3	14.315±0.120	0.869±0.820	4.552±0.368	2.294±0.043
AC15	7.78	-8	2	9.390±0.537	0.406±0.038	8.437±0.206	3.075±0.937
OD0	8.07	-42	1	23.660±0.438	0.605±0.063	5.865±0.603	2.381±0.061
OD15	8.48	6.7	52	28.455±0.247	0.242±0.271	5.448±0.574	2.056±0.062
OC0	8.53	-57	4.5	14.075±0.063	0.361±0.050	6.146±0.323	2.306±0.132
OC15	8.42	-62	2.5	9.390±0.537	0.451±0.024	6.510±0.043	2.913±0.777

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Table 2. concentrations(mg/kg) of metals from all depths(cm) and locations

Samples ID	Lead	Cadmium	Zinc	Manganese	Cobalt	Iron
AD0-15cm	0.1035±0.0176	0.1545±0.0360	1.9400±0.0056	0.0210±0.0141	0.0065±0.0063	8.1580±9.4214
AD15-30cm	0.0575±0.0120	0.0620±0.0141	1.842± 0.0070	0.0075±0.0007	0.0055±0.0077	1.1510±0.0353
AC0-15cm	0.3690±0.1329	0.4135±0.0770	1.5170±0.1583	0.0135±0.0007	0.0110±0.0042	0.1920±0.0989
AC15-30cm	0.0130±0.0127	0.0270±0.0014	0.3015±0.0106	0.0045±0.0063	0.006±0.0084	0.3205±0.0106
OD0-	0.0285±0.003	0.0155±0.002	1.4800±0.016	0.0110±0.007	0.0140±0.002	0.7475±0.044

15cm	5	1	9	0	8	5
OD15-30cm	0.0465±0.0091	0.0215±0.0007	1.8430±0.0084	0.0090±0.0028	0.0000	1.1095±0.0643
OC0-15cm	0.0105±0.0035	0.0200±0.0042	0.1010±0.1159	0.0100±0.0028	0.0000	0.2440±0.0042
OC15-30cm	0.0080±0.0098	0.0120±0.0014	0.1495±0.0007	0.0075±0.0035	0.0060±0000	0.2950±0.0169

AD0 and D15 =Adazi-ani dumpsite 0-15cm and15-30 cm respectively, AC0andC15=Adazi-ani control 0-15cm and15-30 cm respectively, OD0 and D15= Oyeagu dumpsite0-15cm and 15-30cm respectively, OC0 and C15 =Oyeagu control 0-15cm and 15-30cm respectively, TOC=total organic carbon.

According to **Table 1**, the results showed that the pH values of the soils are alkaline except for AC15 which has a neutral value of 7.78. The pH values obtained in this study is higher than the prescribed limits of 6.5-7.5 [18].Plants may not thrive in acidic (low pH) soils. Salinity values of the analysed soils were within the limit. Salts reduce the soils water holding capacity. A soil that is salty can be wet and yet lack water for plant growth. This is because salts have a strong attraction for water molecules that the roots cannot overcome it. The salt content of a soil can be estimated from the electrical conductivity of the soil measured in a saturated soil paste [19].Moisture content of all the soil samples were within the range of 2-4% but OD015 significantly have 52%. Higher moisture content of 20-40% shows poor soil aeration.It was observed that the dumpsite recorded the highest value (28.455) while the least value (9.390) occurred in a control sample. The organic carbon content (TOC) of the soils were greater than 0.7% and thus revealed that the soil would be fertile for agriculture in case if the scrap activities discontinued [20]. The nitrate and phosphate content of the soils were higher than the values obtained in the literature [18].

From **Table 2**, the heavy metal analysis revealed that AD0, AD15,OD0, OD15,OC15 have higher concentration of lead, AC15 has the value(0.008mg/kg) which is lower than WHO recommended limit while OC0 and AC15 values are within WHO permissible limit of (0.01mg/kg). The average values of Cd in all the soil samples exceeded 0.003mg/kg recommended by world health organization standard for agricultural soils[21, 22]. The mean concentrations of zinc, manganese and cobalt in all samples were found to be withinthe WHO permissible limit. The concentration of iron in all the soil samples were within the threshold except for AD0 whose value (8.1580mg/kg) is far above the WHO permissible limit [24].

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Conclusion

Although most of the analysed physicochemical parameters of the soils are favourable for agricultural activities, however the concentrations of some toxic heavy metals are significantly higher than WHO permissible limit and therefore posing severe threat to the ecosystem.

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