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STUDIES ON PHYSICOCHEMICAL PROPERTIES AND MICROBIAL LOAD IN LEACHATES IN THE VICINITY OF OPEN WASTE DUMPSITES IN OWERRI, IMO STATE.

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Abstract

Waste generation and indiscriminate disposal is a common issue typical of most developing countries. The contamination and pollution problem associated with wastes call for intense concern by man. This study was carried out to assess the physicochemical properties and microbial load in leachates in the vicinity of open dumpsites in Owerri, Imo State. The physicochemical and microbiological analyses of collected samples were determined using well established laboratory protocols. Results obtained showed that the physicochemical properties assayed were impacted. There was a significant difference (P<0.05) between leachate samples and the control. The most dominant

Keywords: Dumpsites, Imo State, Microbial load, Pathogenic, Physicochemical

INTRODUCTION

Leachate is defined as any contaminated liquid that is generated from water percolating through a solid waste disposal site, accumulating contaminants, and moving into subsurface areas [1]. As these wastes are compacted or chemically react, bound water is released as "leachate." A second source of leachate arises from the high moisture content of certain disposed wastes [1-2]. Waste management has multifaceted and intrinsic relationship with land, air and water and associated ecosystem services and functions. There is a great impact of unsustainable activities on depletion of ecosystem integrity, with man at major risk end. Several decades ago, many developed nations raised environmental standards to reduce the contamination of land, air and water [3]. Practices such as open dumping and uncontrolled burning [4] typify main disposal strategies for developing countries like Nigeria. Though illegal, but the poor strategies persist possibly due to weak law enforcement and the needed fiscal resource constraints.

microbial isolate was *Staphyloccocus* sp., (15%) while the least isolate was *Acinetobacter* sp. (4%). For the THB and THF, the average was 3.77±1.48 and 2.61±2.06; 4.97±2.174 and 2.13±0.914 CFU/mL for Nekede area. The THB and THF average value for Orji area was 3.01±1.17 and 3.85±2.81; 2.55±1.814 and 1.79±1.884 CFU/mL respectively. It is suspected that the presence of potential pathogenic microorganisms identified in the dumpsites leachates could be a major source of public health concern. We recommend proper waste management techniques to avoid environmental contamination of the air, water, land and inhabitants where these dumpsites are situated.

This is unsustainable since such practices impact air, land and water bodies as well as the general wellbeing of host communities. It contradicts the pragmatic waste handling approach which includes segregation, storage and source processing, collection, transfer and treatment involving energy generation and final disposal exemplified in many western nations [5]. According to [1] Nigeria is home to 12% of the 50 largest dumpsites in the world. Some of the waste deposited could decompose to odorous mud made of soil, stagnant water and more. This can create complimentary conditions for vectors of diseases [6]. Decaying organic waste produce methane, a notorious greenhouse gas with adverse impact when released. However, with high proximity of dumpsites to water bodies [7-10] aquatic resources and other ecosystem services [1] could be impacted with its multiplicity on environmental receptors and media, thus eliciting danger.

As opined by [11]; the environment can be polluted by leachates from dumpsites which occur at the end of the decay of solid waste, mixed with precipitates of surface water. As a result, surface water collection system (rivers, creeks, and lakes), subsurface collection system (groundwater reservoirs) and solid system (different soil layers) become vulnerable to pollution from the dumpsite. A number of incidences have been reported in the past where leachates have contaminated the surrounding soil and polluted the underlying groundwater aquifer or nearby surface water.

Imo State does not have a well-organized waste disposal system [12]. Orji and Nekede are among the areas within Owerri where wastes are dumped by inhabitants. As a matter of fact, these waste materials are deposited in certain “open” dump sites and allowed to compile until they are taken away or incinerated. Improper disposal of untreated municipal solid waste is not only harmful to human health but also a threat to the environment [13].

Pathogenic microorganisms and harmful chemicals in solid waste can be introduced into the environment when the waste is not properly managed [14]. Waste can contaminate surface water, ground water, soil and air which pose more problems for humans, other species, and ecosystems [28].

Thus, the aim of this study is to evaluate the physicochemical and microbial load of surface soils collected in the vicinity of these makeshift open waste dumpsites located within Owerri, Imo State. The data obtained in this study can help to prioritize sustainable waste management practices in the State and also reduce the potential risks associated with these landfills in the environment.

Materials and methods

Study Area

The study was carried out in pre-selected open dumpsites located in Owerri, [Nekede and Orji open dumpsites], Imo State. The constituents of the wastes included: paper, wood, plastic paper bags, straws, buckets, tin cans, sacks, clothes, glass bottles, cotton wool, food wastes, leaves, fruit wastes, medicine bottles, foams, ashes, water sachets, dry leaves, card board and human excreta (urine and faeces).

Sample collection

Leachate samples were collected along the dumpsite axis at different periods at a depth sufficient enough to bring out the leachates during the rainy season (July, 2023) from randomly selected leachate drains at the two sites in well labeled three different clean bottles that were rinsed with the leachates prior to sample collection for determination of the physicochemical properties. The samples were corked under immediately after collection and subsequently transported to the laboratory for microbiological analysis [15].

Physicochemical analyses

The physicochemical parameters of leachate samples were determined using Association of Official Analytical Chemists method [25]. The pH of the soil was determined using the Jenway pH meter (3015 model).

Microbiological Analyses

The total heterotrophic bacterial count was performed in duplicates on dried nutrient agar plates and incubated at 30°C for 24 h [16-17]. At the end of the incubation period, isolation for pure culture was carried out. Acidified potato dextrose agar plates containing streptomycin (1 mg/100 ml) were used to obtain fungal isolates as described by Harley and Prescott. The plates were incubated at 30°C and observed after 48 h for yeasts and 96 h for mould, thereafter, isolation of pure isolates was done in line with the method of [11].

Identification and Characterization of isolates

The pure bacterial strains were identified on the basis of their morphological and biochemical tests with descriptive identification schemes as described by [18] and [19]. The pure cultures of the bacterial isolates were subjected to various morphological and biochemical characterization tests such as color, shape, elevation, consistency, margin, catalase test, MRVP (Methyl Red-Voges Proskauer test), fermentation of sugars, kovacs citrate, indole, hydrolysis of starch and sensitivity tests [20]. In order to determine the identity of bacteria isolates, results were compared with standard references of Bergey's Manual of Determinative Bacteriology [21].

Statistical analysis

Results were subjected to statistical analysis employing the student t-test at 95% probability levels using SPSS (VERSION 20.0) statistical package.

Results and Discussion

The physicochemical parameters of the soil sample from Nekede and Orji areas dumpsites is displayed in Table 1. Results obtained showed that the concentration of EC ranged from 103.10±5.48 to 128.88±19.09 µS/cm. These values were lower than those earlier reported by [22] who reported values from 164.00 to 540.00 µS/cm; but in same range with the findings of [1] who reported 77.22 ± 6.14 to 259.67 ± 64.34 µS/cm respectively. The EC values were significantly higher at the dumpsite sites than those of the control site. The high EC values obtained in this study is an indication that the soil samples have a high concentration of soluble salts which is a good indicator of plant growth [10]. The pH value ranged from 5.45±2.10 to 6.78±1.00 indicating a general acidic soil medium. The mean pH values of the soils from most of the locations were significantly higher than that of the control soil. According to earlier reports, this could be attributed to liming materials and the activities of some microorganism in the solid wastes [23]. pH among variables such as soil structure, the organic matter quantity and the cation exchange potential of the soil could control the circulation and enrichment of heavy metals in soil [8]. The percentage of TOC and TOM obtained for the respective soils ranged from 3.92±1.80 to 9.50±3.00 and 2.16±1.89 to 5.18±1.90. These percentages were higher than those of [40] who reported 0.028-0.409 and 0.048-0.707%. The carbon content and organic matter in the various dumpsite soils were significantly higher than those of the control soil samples respectively. The higher percentage of the concentration of organic matter in the examined soils could be attributed to the presence of organic waste residues which add more organic matter when decomposed. The elevated amount of organic carbon in the vicinity of dumpsites could be suggestive of possible degradation or the presence of degradable and compostable wastes [21].

At Nekede dump site; the phosphate value varied 33.10±11.01 - 46.50±6.09 mg/kg, Nitrate, 8.30±4.01- 10.70±5.09 mg/kg and Sulphate, 12.10±6.03 - 20.70±13.10 mg/kg, compared to Orji dump site with Phosphate 44.00±11.7- 90.01±9.44 mg/kg, Nitrate, 10.80±5.50 - 20.00±8.03c mg/kg and Sulphate, 17.00±5.81 - 40.55±10.33 mg/kg. In both dumpsites, the Phosphate, Nitrate and Sulphate levels were significantly ($P < 0.05$) higher in the soils from the different sampled locations compared to the control sites. This corroborates the findings of [22].

The mean values of the nutrient content of the soil, phosphate, nitrate and sulphate followed the trend Phosphate >Sulphate> Nitrate. The active dumpsite contained more nutrients than the control. This could be an indication of dumpsite aided contamination [19]. Application of fertilizers for soil enhancement for farming purposes could exceed the absorption capacity of the crops on the farm and accumulate in the soil. Hence there is possibility of leaching as soluble phosphate, as well as nitrate into the surface and groundwater where they could pollute surface and groundwater aquifers [1]; Nitrate (NO^3) compound is important for fertilizing plants, but a dangerous contaminant of groundwater. Phosphate is one of the key nutrients found in fertilizers and also necessary for plant growth [26]. Discharge of substances containing nitrate or phosphate into aquatic ecosystem could induce eutrophication, which is an excess enrichment of a body of water with mineral and nutrients, causing extreme increase of plants and algae [4]. This could deplete available oxygen in the aquatic ecosystem [1] with consequent adverse impact on the aquatic ecosystem such as creation of 'dead zone'. Hence oxygen available to the organism is highly reduced and may cause death. With increased nitrate load in a biological system, there could be biotransformation which may cause the formation of metabolites such as nitrosamine resulting to carcinogenesis, teratogenesis and juvenile methaemoglobinaemia [27]. In school children, their thyroid gland state as regards size and functionality have been reported as adversely affected by nitrate contaminated drinking water [14].

Table 1: Mean Physicochemical features of leachate samples from Orji and Nekede dumpsite

LOCATIONS	ORJI AREA			NEKEDE AREA		
	OSS1	OSS2	OSSC	NSS1	NSS2	NSSC
PARAMETERS						
EC (MS/CM)	113.10±5.48^{a}	137.47±9.02^{ab}	91.01±28.91^{c}	116.90±11.09^{ab}	128.88±19.09^{b}	77.95±6.91^{cb}
PH	5.86±1.06^{a}	5.73±1.01^{a}	4.17±1.10^{b}	6.78±1.00^{a}	5.45±2.10^{ab}	4.11±2.40^{b}

TOC (%)	7.30±2.03^{a}	3.92±1.80^{b}	0.70±0.12^{c}	9.50±3.00^{d}	5.40±2.10^{ab}	1.52±0.30^{c}
TOM (%)	5.18±1.90^{a}	4.31±1.20^{b}	1.69±0.36^{c}	2.16±1.89^{ac}	3.52±2.15^{b}	1.10±0.41^{c}
PHOSPHATE (MG/KG)	46.50±6.09^{a}	45.04±7.21^{b}	33.10±11.01^{a}	90.01±9.44^{c}	60.20±7.20^{d}	44.00±11.7^{a}
NITRATE (MG/KG)	10.70±5.09^{a}	8.30±4.01^{a}	9.10±5.01^{a}	20.00±8.03^{c}	17.55±11.29^{b}	10.80±5.50^{a}
SULPHATE (MG/KG)	20.70±13.10^{c}	12.70±6.01^{a}	12.10±6.03^{a}	40.55±10.33^{c}	35.01±14.88^{c}	17.00±5.81^{b}
CALCIUM (MG/KG)	35.160±11.2^{a}	36.580±15.33^{a}	37.620±11.9^{a}	43.800±20.04^{b}	40.90±17.08^{b}	44.560±19.02^{b}
SODIUM (MG/KG)	12.770±8.22^{b}	9.650±11.60^{a}	8.720±3.91^{a}	10.500±5.02^{a}	11.17±6.90^{b}	13.018±6.91^{b}
POTASSIUM (MG/KG)	17.860±6.10^{c}	15.040±3.09^{c}	10.340±5.01^{a}	16.040±3.09^{c}	17.380±5.12^{c}	12.140±4.99^{a}
MAGNESIUM (MG/KG)	1.940±0.88^{a}	1.520±1.00^{a}	0.660±0.01^{a}	32.600±11.59^{b}	35.580±12.10^{b}	43.640±14.80^{a}

Values are Mean ± SD of three replicates. Different superscripts in the same column indicate significant differences at $p < 0.05$ according to Duncan Multiple Range Test (DMRT).

Table 2 displays the microbial status of soil around the Nekede and Orji Area dumpsites. Results obtained showed that there are detectable amount of microbial activates in the soil of both dumpsites. As displayed Table 2, a THB bioload average of 3.77±1.48^{4} and 2.61±2.06^{4} CFU/mL for Orji Area and 3.01±1.17 and 3.85±2.81 CFU/mL for Nekede Area respectively were recorded. The bacterial counts in soils from the dumpsites were significantly higher than those of the control soil (2.91±0.51^{4}).

For the THF, the average was 4.97±2.17^{5} and 2.13±0.91^{5} CFU/mL for Nekede Area. THF average value for Orji Area was 2.55±1.81^{4} and 1.79±1.88^{4} CFU/mL, with corresponding 2.10±0.41^{4} value for control area.

Table 2: Average Total Bacterial and Fungal Counts of the Leachate samples from the study areas

	NEKEDE AREA			ORJI AREA		
	NKSS 1	NKSS 2	NKSSC	OSS1	OSS2	OSSC
PARAMETER						
THB($\times10^5$CFU/G)	3.77±1.48	2.61±2.06	1.33±0.49	3.01±1.17	3.85±2.81	3.36±1.43
THF($\times10^5$CFU/G)	4.97±2.17	2.13±0.91	1.85±3.30	2.55±1.81	1.79±1.88	2.51±1.06
CONTROL	**1.41±0.51**			**1.18±0.41**		

Values are Mean ± SD of three replicates. Different superscript in the same column indicates significant differences at $p < 0.05$ according to Duncan Multiple Range Test (DMRT). THB and THF Total Bacterial and Fungal counts.

The isolation and identification of microbial activates such as *Acinetobacter* sp., *Pseudomonas* sp., *Micrococcus* sp. *Bacillus* sp., *Klebsiella* sp., *Enterobacter* sp. *Aspergillus* sp., *Penicillium* sp., *Mucor* sp. and *Fusarium* sp. in the two dumpsite soils corroborate the report by [20] who isolated similar microorganisms from a municipal waste dumpsite in Benin City. All the microbial isolates identified from the soil samples have been previously reported to be associated with waste biodegradation [28]. There were noteworthy variations in the Percentage frequency of occurrence of the microbial isolates for the two dumpsites as shown in Figure 3. The percentage frequency of the bacterial isolates from the two waste dumpsite soils fluctuated as follows: *Klebsiella* sp. (13%), *Staphylococcus* sp. (14%), *Pseudomonas* sp. (10%), *Bacillus* sp. (8%), *Micrococcus* sp. (5%), *Acinetobactor* sp. (3%), *Enterobacter* sp. (10%), while fungi species encountered were: *Pennicilium* sp. (12%), *Fusarium* sp. (7%), *Aspergilus niger* (5%), and *Mucor* sp. (13%) respectively. This is in line with the report of [29] who identified similar microbes at Orji and Naze Dumpsite in Owerri Imo State. The observation in this study was also in line with that of [414] who identified the presence of *Bacillus* and *Staphyloccocus* from a waste dumpsite a waste dumpsite located at Eagle Island, River State. A study by [30] also recorded similar observation at Electronic Waste Dumpsite in Port Harcourt Metropolis, River state. Most of the bacterial species encountered at the dumpsites have been implicated as opportunistic human pathogens [22]. As reported by [17], though positive species such as Staphylococcus aureus have high pathogenic effect but in recent times Staphylococcus epidermidis has emerged as a nosocomial pathogen in individuals with compromised immune system.

The microorganisms found in these dumpsites get their nutritional requirement from the wastes, hence the high bacterial growth profile in the waste dumpsites [19]. The microbial isolates identified from the soil samples have been reported to be associated with waste and waste bio-degradation [23]. Also, *Aspergillus, Fusarium, Mucor, Penicillium, Rhizopus* have also been implicated in waste bio-degradation [17]. This should be the case in this study which further suggests the participation of these bacteria and fungi in waste bio-degradation.

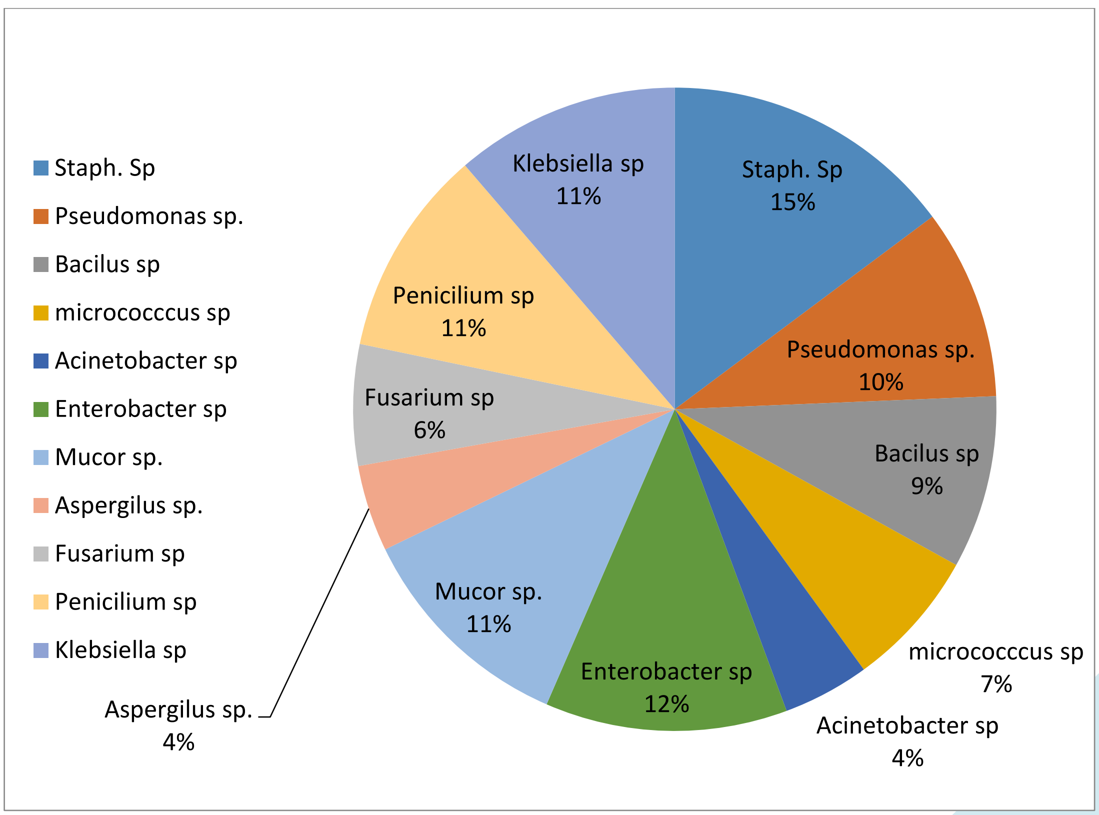

Figure 3: Percentage frequency of occurrence of the microbial isolates from the dump sites

Conclusion

This study was to assess the physicochemical and microbial load in leachate around Nekede and Orji open Waste Dumpsites in Owerri, South-Eastern Nigeria. This study revealed the presence of high microbial load which could be associated with the increased nitrate, phosphate, and organic matter levels established in the examined dumpsite leachates. These waste sites could be a potential source of infections to the inhabitants living around the open waste dumpsites which in turn could lead to public health problem arising from spread of communicable diseases carried by potential pathogenic bacteria and fungi occurring in the waste dumpsite soils. We recommend continuous monitoring at major dumpsites within the city to forestall environmental pollution.

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