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Vol: 4 & Iss: 3

Environmental Implications of Municipal Solid Waste and Leachate at the Rumuosi Active Dumpsite, Port Harcourt, River's state, Nigeria

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Citation: Ikenkwo CF, Onojake MC, Ngobiri NC. Environmental Implications of Municipal Solid Waste and Leachate at the Rumuosi Active Dumpsite, Port Harcourt, River's state, Nigeria. *J Petro Chem Eng* 2026;4(3):416-422.

Received: 05 August, 2026; **Accepted:** 24 August, 2026; **Published:** 26 August, 2026

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ABSTRACT

Open communal refuse dumps may also act as sources for production of leachate, containing dissolved salts, organic compounds and nutrients which are a danger for the receiving soil and water quality. The research characterizes municipal solid waste and leachate obtained from an active dumpsite at the Obiri-Ikwerre-Airport Road dumpsite in River state, Nigeria. Ten samples of municipal solid waste leachate were obtained from different locations covering the dumpsite. Parameters such as pH, EC, temperature, TDS, and moisture content; the concentrations of BOD, COD, NH-N and TOC were analyzed according to APHA and ASTM test procedures. Food waste and other biodegradable waste constitute a proportion of 73.8% of the municipal solid waste, consisting food waste 42.8%. Mean leachate values found were pH 7.0 ± 0.4; EC 2359.5 ± 160.4μS cm^{-1}; TDS 1565.6 ± 180.1 mgL^{-1}; BOD 398.8 ± 33.3 mgL^{-1}; COD 692.6 ± 117.5 mgL^{-1}; NH_3-N 6.5 ± 1.0 mgL^{-1} and TOC 5.8 ± 1.2 %. For screening purpose at which screening level the means of BOD and COD are higher than the NESREA guidelines by 66.5 and 23.1 percent respectively; mean NH-N was about 4.2 percent higher than the equivalent NESREA ammonium concentration guideline; All TDS samples were above the WHO taste-based category of >1200 mg L^{-1} considered unacceptable for drinking water. Comparison with WHO standard is only a pointer at the risk to ground water receivers and was nota regulated reference values for effluent discharge standards; at about 0.58 the BOD/COD ratio of roughly indicated the material to be amenable to readily biological degradation. The results indicated a high load of organic and dissolved matter to support the practice of a treatment of landfill leachates, seasonally managing environmental risks. Since the samples were considered as raw internally stored municipal solid waste leachates and not as effluent discharge from regulated point it can be concluded that these values may act in planning for an environmental management for leachate and the treatment priorities.

Keywords: Dumpsite; Environmental pollution; Leachate; Municipal solid waste; NESREA, WHO

Introduction

Increasing size and complexity of municipal solid waste City size leads to increased volume and complexity of municipal solid waste. Global waste generation is likely to rise given current rates of population growth, urbanization and consumption; at the same time collection and environmentally managed treatment continue to be spread very unevenly across the globe. In many low- to middle-income countries it is common still for material to be disposed of at open or poorly managed dumpsites due to low site capital costs and inability to receive mixed waste streams for significant pre-treatment[1-3]. Air quality problems result from emission of smoke, odours, vectors, litter and gases. Water bodies receive leachate with dissolved organic constituents, ammonia, chloride, salts, metals and often xenobiotic constituents and it may travel far from waste origin. Composition of landfill leachate leachate will vary greatly according to waste composition, waste age, climate conditions, hydrology, method of disposal. Young, rapidly degrading waste will typically yield leachate characterized by high concentrations of biodegradable organic matter whereas aging leachate will contain more refractory organic matter such as humics, together with nitrogen[4-7]. It is not practical to assign specific concentrations of single parameter for determining pollution of landfill waste; thus, some commonly accepted indicators such as pH, E.C., TDS, BOD_5/COD ratio, ammonium, and TOC are generally interpreted collectively[8-10]. BOD_5 is a measures the volume of dissolved oxygen required to reduce the chemical and/or biochemical oxygen demand of a substance under defined conditions. It's value is 5 days in the case the ratio 5-day incubation time period. A substance that measures the potential of a sample to consume dissolved oxygen when put in a solution to support aquatic life, COD tests reflect overall total capacity to react with substances in presence of the oxidant that will remove and that have an easily reducible compounds as defined by the level; TCD - total concentration dissolved substance and thus has relation to the salinity and pollution parameters like pH value. ED dissolved concentrations of mineral atoms. ED also reflects concentration of salts; Ammonium occurs during putrefaction process which takes place from proteins and organic acids. The pH value of a solution is a numerical representation of what the effective hydrogen ion concentration in solutions; and is important for the solubility and chemical form of organic compounds. Uncontrolled leachates infiltrating soil, water table, and nearest surface-waters can then have impacts upon ecosystems or human health. The risk assessment depends on landfill characteristics and on many other parameters including permeability of layers beneath the site, soil and rock cover; precipitation; hydrological circumstances; and depth to surface water sources; not to mention also the number and kind of people exposed and their location to the landfill. However given all these elements, it may be stated, when global studies considering risk assessment from landfill as a source of pollution in relation to groundwater and surface waters, that it is one of the potential global causes for the pollution of these waters[7,11,12]. Nigeria and open dumping The challenges of waste collection, segregation, proper engineered disposal and law enforcement continue to hamper effective municipal waste management in Nigeria. Despite a growing body of research into waste at open dumpsites showing evidence of elevated organic loads and their potential impact on nearby water resources, investigations remain spread out and do not usually address seasonality or quality assurance systematically. Due to its high rainfall and the potential for increased leachate generation and mobility, the urban agglomeration of Port Harcourt is a high-interest candidate for studies on landfill leaching. With a significant proportion of mixed waste generated in Nigeria dumped without the controlled systems of sanitary landfills such as that found at the open Obiri-Ikwerre-Airport Road dumpsite, a specific physicochemical characterization of waste and leachate from a local dumpsite is required to inform policy. Appropriate environmental standards exist at the Nigerian and international levels, but their application must consider the specific aim of each standard. The Nigerian National Environmental (Surface and Groundwater Quality Control) Regulations propose criteria on leachate discharged directly from landfills that could be used to define limits on effluent quality and, if a leachate pollutes groundwaters, water quality targets for irrigation and potable reuse[13]. WHO has guideline values for TDS for drinking water purposes rather than a landfill or effluent discharge limit[14]. The NESREA standards were applied to provide context on the severity of the raw leachate in relation to national discharge limits, and the WHO guideline was used only to highlight a potential threat posed by groundwater and surface-water impacts if raw leachate eventually impacts. Because the samples analysed consisted of raw leachate samples extracted from pools on a dumpsite site, not from a designated point discharge into the environment or from a supervised process under strict permits, no actual violations of the cited national standards nor significant off-site environmental contamination can be concluded. A quantitative site-specific data base regarding the specific characteristics of raw MSW at Rumuosi dumpsite was collected including; physico-chemical characteristics of MSW and MSW leachate; and a baseline physico-chemical baseline analysis to establish possible impacts on the groundwater quality at Rumuosi dumpsite was then made in comparisons with the respective Nigerian, WHO and European environmental benchmark values.

This paper presents these specific findings with emphasis on the physico-chemical profile of the dumpsite samples for an environmental assessment purpose. However, there is lack of data including groundwater samples for a thorough environmental investigation.

Materials and Methods

Study area

The Obiri-Ikwerre-Airport Road dumpsite situated at Rumuosi in Ikwerre Local Government Area of Rivers State of Nigeria, approximately at 4°51′39.6″ N and 6°56′41.2″ E. This site accepts mixed domestic, local market, commercial, and institutional waste from the metropolitan region of Port Harcourt. Port Harcourt's location is in a humid tropical zone, characterised by a relatively warm mean annual temperature and annual precipitation totalling around 2,400mm per year with an intensive wet season. This abundance of moisture combined with continuous inputs of waste leads to significant activity related to biodegradation and leachate generation **(Figures 1 and 2)**.

Sampling design and waste characterization

A total of ten samples each of MSW (S1 to S10) and landfill leachate (L1 to L10) were collected from several regions of the active dumpsite area to represent spatial variation. Leachate was obtained from active accumulation points in clean, labelled polyethylene terephthalate containers. Containers were conditioned with the sample before final collection. pH and temperature were measured promptly, while samples for the remaining analyses were preserved in insulated containers and transported to the laboratory. Waste samples were obtained from different positions and depths in the waste mass using shovels, spades and hand trowels, thereby including recently deposited and partly degraded material. Sampling bags and containers were labelled with permanent waterproof identifiers. For compositional analysis, all selected waste was placed on a clean tarpaulin; it was then dissected and sorted into categories such as food, paper & cardboard, yard & garden waste, wood, textiles, plastics, metals, glass, and 'others. All component fractions were then individually weighed using a portable digital scale and their mass percentages calculated relative to the total mass of the sorted waste samples based on the ASTM D5231-92(2016) principles. Biodegradable waste included food waste, paper waste, yard & garden waste, wood waste and textiles. Non-biodegradable components include plastics, metal, glass, and 'others', were considered non-biodegradable for this study.

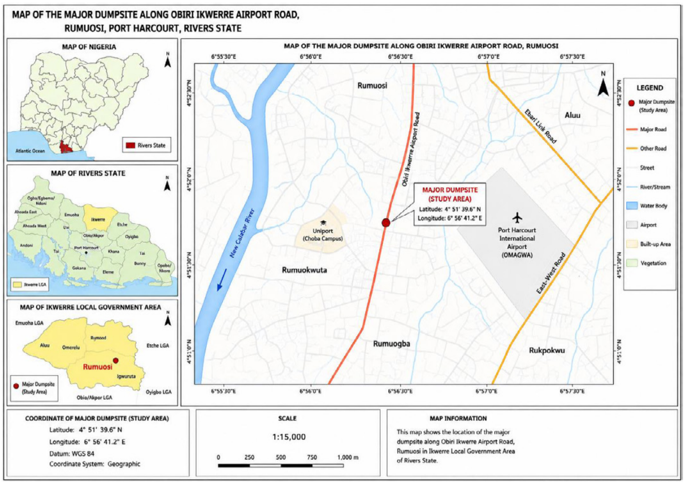

Figure 1: Location of the Obiri-Ikwerre-Airport Road (Rumuosi) active dumpsite, Rivers State, Nigeria.

Figure 2: Active waste mass at the Rumuosi dumpsite during fieldwork (photographed 31 January 2026).

Analytical procedures

pH, temperature and electrical conductivity: The pH value was determined using an electrometric method ASTM D1293B. A pH meter was calibrated by the pH of standard Buffers 4.0,7.0,10.0 to obtain the results presented in section A1 &A2. A 3 electrode was then flushed by and between sample to obtained stable reading. A digital calibrated thermometers was used together to measure. The procedure was followed as directed in protocol (en 1568H) as an electrical conductivity measurement A APHA 2510 an electrical and conductivity meter was calibrated with potassium chloride Standards. The measurement was to µS cm^{-1}.

Total dissolved solids and moisture content: The TDS was analyzed gravimetrically by following APHA 2540C procedures. A 10g (Solid waste) or 10ml (Leachate) of the filtered sample was evaporate in a dish, dried in oven at 180 ^{0}C, cooled and weighed. With help of desiccator the residue was calculate in mg/l; Moisture of the solid was measured following APHA 2540B procedures. A 10g was homogenized then placed at 105 degree centigrade until to get the constant value and weighed in a dish with the support of the desiccator. TDS was calculated from the dried residue and moisture from the loss in mass.

Biochemical and chemical oxygen demand: Samples were analyzed for BOD5 using the APHA 5210B dilution method. An aliquot of the solid waste extract and/or leachate was prepared with 10g (Solid waste) or 10ml (Leachate), diluted in water, and microbial seed. The initial dissolved oxygen (DO) concentration was determined, after which the samples were then incubated in the dark at 20^{0}C for 5 days. A five-day incubated DO concentration for each bottle was also then determined. The DO consumed per sample, when corrected by the dilution factor, provided BOD_5 (mg O_2 L^{-1}). BOD_5 was calculated from oxygen depletion after applying the dilution factor. COD was measured using the APHA 5220B closed-reflux titrimetric method. Samples were digested with potassium dichromate in sulphuric acid in the presence of silver sulphate catalyst; mercuric sulphate was used for chloride interference control. Following approximately two hours of reflux, residual dichromate was titrated with ferrous ammonium sulphate using ferroin indicator. Results were expressed as mg O2 L^{-1}.

Ammonia nitrogen and total organic carbon: Ammonia nitrogen was determined by the APHA 4500-NH_3 B distillation procedure. The sample was rendered alkaline to convert ammonium to ammonia, distilled, captured in boric acid solution and quantified by titration. TOC was measured following APHA 5310C. Samples were acidified to remove inorganic carbon and the remaining carbon was oxidised at high temperature in an oxygen-rich environment; the evolved carbon dioxide was measured by infrared detection and reported as TOC.

Data analysis

Mean (S.D.) values from ten readings were determined for each parameter. Mean BOD/COD were derived from mean concentrations as an initial estimate of the biodegradability of the leachate. The leachate values were compared to the standards of Schedule, National Environmental (Surface and Groundwater Quality Control) Regulations 2011(NESREA) which specify the standards for effluent discharge, irrigation, and recycling in Nigeria (NESREA, 2011) and the WHO TDS categories of acceptability for drinking-water (WHO, 2003). The results for pH, BOD, and COD were directly compared to the relevant NESREA standards. The NESREA ammonium standard (2.0 mg L as NH) was converted to an approximation of 1.55 mg N L and then compared with other reported results in terms of NH-N. WHO/TDS categories were used solely as an illustration of a drinking-water perspective. In the absence of relevant limits and ambient base levels, ECs TOCs and temperature values were given a qualitative assessment. Fold exceedance was calculated by dividing each mean concentration by the corresponding benchmark. The comparison was treated as screening evidence rather than a formal compliance determination because the sampled liquid was raw leachate within the dumpsite and no regulated final discharge point, receiving-water baseline or dilution condition was established.

Results

Waste composition

73.8% of waste stream consisted of biodegradable materials with 42.8% of this being food waste, 15.2% was plastics and 12.6% was paper and cardboard. Yard waste, textiles and wood represent an additional 18.4% of the material. Overall, there is a large portion of quickly and moderately degrading organic matter and a plastic content which potentially affects permeability, infiltration and long-term stability **(Tables 1 and 2)**.

Table 1: Municipal solid waste composition at the Rumuosi active dumpsite.

Waste component	Composition (%)	Environmental relevance
Food waste	42.8	Organic substrate
Paper/cardboard	12.6	Organic substrate
Yard/garden waste	8.4	Organic substrate
Wood	4.7	Organic substrate
Textiles	5.3	Organic substrate
Plastics	15.2	Persistent/inert fraction
Metals	4.1	Persistent/inert fraction
Glass	3.5	Persistent/inert fraction
Other materials	3.4	Persistent/inert fraction

Table 2: Physicochemical characteristics of Municipal solid waste composition at the Rumuosi active dumpsite.

Parameter	Minimum	Maximum	Mean ± SD
pH	6.2	7.4	6.8 ± 0.4
Temperature (°C)	32	46	38.8 ± 4.9
EC (µS/cm)	320.3	450.5	385.3 ± 51.8
TDS (mg/L)	224.2	398.2	310.2 ± 57.2
Moisture (%)	8	10	8.8 ± 0.9
BOD_5 (mg/L)	31.3	44.6	37.7 ± 4.4
COD (mg/L)	100.9	129.5	115.0 ± 10.5
NH_3-N (mg/L)	8.4	14.8	12.2 ± 1.8
TOC (%)	15.2	21.7	18.2 ± 2.2

Summary statistics for municipal solid-waste samples (n = 10).

The MSW pH ranged from 6.2 to 7.4, with a mean of 6.8. The MSW in these conditions would be weakly acidic to neutral. The mean temperature in these waste samples was 38.8 ^{0}C, with some samples above 40 ^{0}C.

This suggests vigorous chemical and biological action in the fresh or partially-decayed refuse.

The average TOC concentration (18.2 %) confirms the significant organic fraction. The mean moisture was 8.8% of the MSW from samples; because representative bulk moisture content of the MSW typically decreased in sampling and preparation, this does not reflect the water content in situ **(Table 3)**.

Table 3: Physicochemical characteristics of leachate

Parameter	Minimum	Maximum	Mean ± SD
pH	6.5	7.8	7.0 ± 0.4
Temperature (°C)	29	43	35.9 ± 5.3
EC (µS/cm)	2035	2601	2359.5 ± 160.4
TDS (mg/L)	1276.6	1787.1	1565.6 ± 180.1
BOD_5 (mg/L)	339.5	452.5	398.8 ± 33.3
COD (mg/L)	538.5	845.6	692.6 ± 117.5
NH_3-N (mg/L)	5.2	8	6.5 ± 1.0
TOC (%)	3.3	7	5.8 ± 1.2

Summary statistics for leachate samples (n = 10).

Leachate came out close to neutral in pH value (the mean pH was 7.0) and 2359.5 S cm^{-1} and 1565.6 mg L $^{-1}$ of mean EC and TDS, respectively; both values proved that dissolved organic matter in a considerable amount of volume existed, in general of total dissolved ions with different sizes; and then, BOD_5 values ranged from 339.5–452.5 mg L^{-1} (mean: 398.8 mg L $^{-1}$), COD ranges from 538.5–845.6 mg L^{-1} (mean: 692.6 mg L $^{-1}$),the ratio of mean BOD5/mean COD of leachate shows 0.58 means most portion of oxygen demand material is biodegradation **(Figure 1)**; ammonia nitrogen in leachate ranges from 5.2–8.0 mg L^{-1} (mean: 6.5 mg L $^{-1}$) and TC ranges from 2 to 14.1 % (mean: 5.8%).

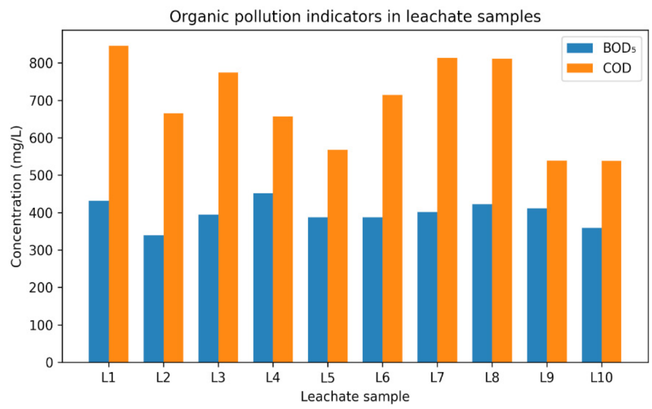

Figure 3: BOD5 and COD concentrations in individual leachate samples.

Screening comparison with Nigerian and international benchmarks

The standards-based comparison was restricted to leachate because the MSW results were generated from solid-waste samples or extracts and do not represent a regulated liquid discharge or receiving-water matrix. As summarized in Table 4, all leachate pH values fell within the NESREA range. In contrast, every BOD_5 and COD result exceeded the corresponding NESREA discharge value. Mean NH_3-N also exceeded the nitrogen-equivalent NESREA ammonium value, while all TDS samples were above the WHO taste-based category of >1200 mg L^{-1} considered unacceptable for drinking water. No directly comparable generic benchmark was available in the selected standards for EC, TOC or leachate temperature, so these parameters were interpreted in terms of environmental significance rather than formal compliance **(Table 4)**.

Table 4: Screening comparison of Rumuosi leachate with Nigerian and international environmental benchmarks.

Parameter	Rumuosi leachate	Benchmarks	Screening interpretation
pH	6.5–7.8; 7.0 ± 0.4	NESREA: 6.5–8.5	All samples were within the NESREA pH range.
BOD_5 (mg L^{-1})	339.5–452.5; 398.8 ± 33.3	NESREA: 6	The mean was 66.5 times the NESREA value, and all samples exceeded the national discharge criterion.
COD (mg L-^{1})	538.5–845.6; 692.6 ± 117.5	NESREA: 30	The mean was 23.1 times the NESREA value, and all samples exceeded the national discharge criterion.
NH-N (mg N L^{-1})	5.2–8.0; 6.5 ± 1.0	NESREA: 2 mg L^{-1} as NH^{4+} (≈1.55 mg N L-^{1})	Mean NH_3-N was about 4.2 times the nitrogen-equivalent NESREA value.
TDS (mg L^{-1})	1276.6–1787.1; 1565.6 ± 180.1	WHO: no health-based limit; <1000 mg L^{-1} is generally acceptable, while >1200 mg L^{-1} is rated unacceptable for drinking-water taste	All samples exceeded 1200 mg L^{-1}. This is a receptor-screening comparison, not an effluent-compliance test.

Note: Values in the NESREA standards pertain to National Standards for the Discharges of Effluents into Rivers or other Surface Waters, for IRRIGATION AND RE-USE WATERS, as appropriate; WHO classes were in the context of Drinking Water Acceptability. Hence, they are to be taken as a preliminary comparative approach to evaluating likely treatment need/receptor risk, as it cannot serve as a legally binding analysis for raw internal landfill leachate.

Discussion

Waste composition and decomposition potential

The predominance of food and other bio-degradable waste, as commonly seen in most of the organic-rich domestic refuse from many developing countries, which high consumption for fresh food and recovers metals and some plastic materials after/before deposition. The highest content of organic elements in the MSWs increases acid genesis for producing soluble intermediate, Leachate BODs and Leachate gas production. High degree of organic-waste, such as food waste undergoes faster hydrolysis process as it contributes to the high Acidogenic load as paper, woody materials and clothing materials undergo slower anaerobic digestion process as the contaminant and gas generation rate would be of sustained nature. Therefore, the composition of waste leads for concurrent active Leachate generation process and Methanogenic activity development conditions, with a reasonable concentration of degradable materials[1,10].

pH and temperature as indicators of waste state

Both MSW and leachate exhibited near neutral pH values indicating that an early, intensely acid hydrolytic stage was not the predominant phase within the sampled areas. Neutralisation processes can occur via depletion of volatile fatty acids with methane production or carbonate, ash and soil provided buffered conditions. Even so the range still implies spatial variations, to be expected in a modern working site with refuse of a range of ages. The solid samples' temperature of between 32-46 ^{0}C falls at the high and warm mesophilic range at which active biodegradation processes would occur. Elevated temperatures, above ambient would be produced from microbial activity, or from heating from above and solar radiation heating of open sites of an incomplete site. In that gaseous concentrations or temperature profiling were not produced within a closed area temperatures cannot be used as a proxy for levels of CH_4 output.

Dissolved solids and ionic pollution potential

The salinity of the leachates was about six times the average MSW extract, and about five times for TDS. This indicates salts and other decomposition products became concentrated by water percolating through the MSW. A high ionic strength is undesirable from a soil impacts point of view (destroying soil structure) on plants and on groundwater quality if it migrates to the domestic supply. Leachet data for global landfills suggest a range of concentrations for chloride, sulphate, sodium, potassium, calcium and many other ions. EC/TDS levels are considered useful as they are relatively low cost to monitor for site screening, although they don't provide information on chemical toxicity or composition. In an enhanced assessment project, chloride and alkalinity measurements, with key major ions and a range of metals analysis, would offer much more interpretation guidance and also data for site transport models.

Organic loading and biodegradability

The BOD5 and COD levels in the leachate represent a significant load of organics. BOD_5/COD ratio of 0.58 falls within the range normally found in easily biodegradable leachate and suggests that a large percentage of the organic matter is treatable by biological means. However, interpretation must be made cautiously because factors such as waste age, dilution by rainwater, analytical matrix influences and spatially mixing affect both measurements. Younger and intermediate-aged leachates can have BOD5/COD ratios that are high, whereas older stabilized leachates are dominated by recalcitrant humic/fulvic matter and thus have lower BOD5/COD ratios[4,6,9]. Along with near neutral pH values and active waste generation, the ratio is indicative of a mixed-age, biologically active dumpsite rather than a fully aged landfill.

Ammonia and carbon indicators

Ammonia arises from the decomposition of proteins and other nitrogen containing organics and is expected to be retained due to poor removal under anaerobic landfill environments. Measured values are lower than values reported for some high-strength landfill leachates but indicative of nitrogen mineralization processes, differences between solid extracts and leachate may be attributed to dilution, volatilisation, microbial assimilation or uneven waste composition on a micro scale. TOC within the solid sample confirms the carbon pool for continued decomposition and TOC in the leachate reflects dissolved and suspended carbon mobile due to percolation. More comprehensive monitoring of dissolved organic carbon, total nitrogen, nitrate, nitrite and alkalinity would establish a full picture of carbon and nitrogen transformations in the landfill environment.

Comparison environmental benchmarks

Comparison with the standard provides a better understanding of the treatment needs of the raw leachate as represented by the raw value data. It was found that the pH of the leachate collected was in the range 6.5 to 7.8 and hence falls within the range for NESREA limits 6.5-8.5[13]. In the sample obtained acidity or alkalinity seemed not to be a major problem at that instant but appropriate pH doesn't imply that the leachate is environmentally sound due to high organic content, nitrogen compounds and dissolved solids. Organic pollution indicators have the largest proportion of disagreement with the standard chosen. BOD had a mean concentration of 398.8 mg L about 66.5 times the limit of 6 mg L for NESREA whereas COD had a mean concentration of 692.6 mg L about 23.1 times the limit of 30 mg L for NESREA. It was also noted that even the least value from all BOD and COD readings exceeded the limits in NESREA, which indicates that the problem of high organic loading was prevalent all along the various sampling points. If such leachate is discharged into a surface water body without being properly treated, the microbial and chemical oxidation may deplete oxygen supply, lead to the formation of anaerobic condition, odors and degradation of the habitat. It was noted that the ratio of BOD to COD was about 0.58 which implies that a large portion of the organic load is biodegradable and hence it is feasible to treat with aerobic processes followed by a polishing process in order to improve residual COD and dissolved salts.

The amount of NH-N in the leachate was about 4.2 times more than the NESREA limits for ammonium which was found after converting to nitrogen basis. The NESREA limit for ammonium is 2.0 mg L as NH which is approximately equivalent to 1.55 mg L as N. Since nitrate, nitrite and organic N in the leachate have not been measured, the total N loading at this site can't be determined but ammonia also has environmental consequences in increasing oxygen demand, nutrient enrichment and toxicity depending on pH, temperature and receiving water. For the purpose of comparison of TDS, the WHO threshold for non-acceptable drinking water quality based on taste is greater than 1200 mg L[14]. Every reading for TDS is above this limit, but it is not a discharge limit but gives the sense that possible undesirable influence on potential groundwater source for drinking water is likely if the leachate reaches it. Although these high values are also supported by high EC, it is impossible to establish what dissolved components were responsible without analysis of chloride, sulphate, Na, K, and other major ions.

Temperature, EC and TOC are impossible to compare using one threshold concentration derived from any of the accepted standards. An appropriate comparison would involve baseline receiving water temperatures for Temperature or compare EC and TOC values to those of specific inorganic and organic constituents. The comparison with standards should therefore be treated as a deviation from screening, or discharge, levels rather than evidence that the site's disposal permit has been violated. Regulatory comparisons need a final discharge point, flow rates and dilution capacities, relevant permit conditions, sampling over a season, and comparison to receiving surface and groundwater receptors for an accurate environmental assessment. Even with these limitations, the uniform high levels of BOD, COD, ammonia and TDS provide compelling justification for leachate collection, treatment, and monitoring.

Environmental significance and management response

While these results prove that the landfill has some pollution potential, they do not show that ground-water and surface-water has already been polluted. Monitoring off-site impacts typically requires background and down-gradient monitoring wells, and surface water sampling, complemented by hydrogeology details, and ideally, seasonal data. A working lined or partially unlined landfill with a high concentration of leachate EC, TDS, BOD5 and COD should, however, be proactively managed with controls, including: diversion of storm water flows away from the body of refuse, managed discharge of Leachate Management Systems, routine checking of spill routes, limiting public access, placing progressive cover and undertaking provision of treatment appropriate to the leachate Strength, flow, seasonality and seasonability[12,15].The site also needs to be incorporated into an effective ambient monitoring programme for leachate collected from wet and dry weather, for ground-water and local surface water quality, and for soil analyses. Recommended water quality analytes should also include alkalinity, Chloride, Sulphate, Phosphate, Nitrate and Nitrite, Total Kjeldahl Nitrogen (TKN), chosen Metals, Indicators of Microbial Contamination and Screening for Organic Micro-Contaminants where available[7,11,16-19].

Conclusion

The Rumuosi active dumpsite has organic-rich waste input and the output shows high dissolved solids and organic loading. In total, sorted biodegradable waste was 73.8%, out of which food waste was 42.8%. The leachate showed near-neutral pH, with average EC (2359.5 $\mu S\ cm^{-1}$), TDS (1565.6 mg L^{-1}), BOD (398.8 mg L^{-1}), COD (692.6 mg L^{-1}) and NH4-N (6.5 mg N L^{-1}). Mean BOD_5, COD and NH_3-N were 66.5, 23.1 and approximately 4.2 times the relevant NESREA values, respectively. The total dissolved solids (TDS) in all samples were higher than the WHO taste-based category of > 1200 mg L-1 for unaccepted drinking water; pH was within NESREA. The mean BOD/COD ratio of about 0.58 suggests that the leachate was fairly biodegradable and that biological treatment could serve as the central process for treatment followed by tertiary polishing to address remaining organic matter and dissolved salts. Given the results, storm water control, leachate interception and storage/treatment, as well as monitoring of surface and groundwater and soil during both wet and dry seasons are justified. Since samples are internal raw leachate, not from a permitted outfall, the observed values show an indicator of pollution and need for treatment, not of off-site contamination or of non-compliance with NESREA, by themselves.

Acknowledgements

The author sincerely appreciates Mr. Kenneth Okeozo for his assistance during the sample collection and preparation process. The authors further acknowledges the researchers and authors whose published works provided useful knowledge, methods and supporting literature for this study.

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