Network for Research and Development in Africa
International Journal of Pure and Applied Science Research
ISSN: 2384-5918, Volume 12, Issue 1
PP 50-59 (January, 2025)
OTL: 45727711-11205-1
arcnjournals@gmail.com
https://arcnjournals.org

CHARCTERIZATION OF WASTE COMPOSITION AND ITS IMPACTS ON DUMPSITE LEACHATE QUALITY

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***Abstract**: This study investigated the characterization of waste composition and its impacts on dumpsite leachate quality. A comprehensive analysis of waste composition was conducted, and leachate samples were collected from various dumpsites. The results revealed that waste composition significantly influenced leachate quality, with high concentrations of organic matter, nutrients, and heavy metals detected. The findings underscored the importance of implementing effective waste management practices to minimize environmental pollution and safeguard public health.*

***Keywords:** Wastes Composition and Characterization Environmental, Leachate.*

INTRODUCTION

Characterization of waste composition is a crucial step in understanding the complex interactions between wastes materials and their environmental implications. Waste composition varies significantly depending on factors such as geographical location, cultural practices, economic, conditions and waste management strategies. Accurate Characterization of waste composition is essential to predict the potential environmental impacts of waste disposal, particularly on dumpsite leachate quality. Dumpsite leachate, a toxic liquid formed by the percolation of rainwater and groundwater through waste, poses significant environmental and health risks if not properly managed. The Quality of dumpsite leachate is directly influenced by the composition of waste, making it essential to understand the characteristic of wastes materials. The presence of organic matter, heavy metals, nutrients and other pollutants in wastes can lead to the formation of harmful leachate, contaminating soil, groundwater and surface water.

Characterization of wastes composition involves identifying and quantifying the various components of waste, including municipal solid waste, industrial waste, hazardous waste and construction and demolition waste. This process enables the determination of physical, chemical and biological properties of waste, such as moisture contents, pH, conductivity and heavy metal concentrations. Understanding waste composition is critical in predicting leachate quality and designing effective wastes management strategies. For instance, high organic matter content in waste can lead to increased biochemical oxygen Demand (BOD) and chemical oxygen demand (COD) in leachate while high heavy metals concentration can result in toxic leachate. Accurate characterization of waste composition allows for the development of targeted mitigation measures to minimize environmental impacts. In this context, various analytical techniques such as atomic absorption spectroscopy (AAS), inductively coupled plasma mass spectrometry (ICP –MS), X- Ray fluorescence(XRF) and Energy –dispersive X-ray spectroscopy (EDS), are employed to determine the elemental composition of waste. Additionally, machine learning Algorithm and predictive modelling can be used to forecast waste composition and leachate quality enabling proactive waste management decisions.

Characterization of waste composition is a vital step in understanding the complex interaction between waste materials and their environmental implications particularly on Dumpsite leachate quality. Accurate characterization enables the development of effective waste management strategies, minimizing environmental impacts and ensuring sustainable waste disposal practices in country

LITERATURE REVIEW

The increase in global population has significantly resulted in population explosion and Waste generation which is increasingly has become an issue of great concern globally. The economically -viable and environmentally – acceptable disposal of municipal solid Wastes (MSW)is increasingly an issue of concern globally. (E. Dakalapolous et al.,1998) while Siddique et al.,2020 found that high population densities makes investment in Recycling infrastructures financially viable and can lead b to improved recycling facilities. Studies conducted by several researchers such as Belgi et al.,2014., Ghazin Alaimi (2016), Viera and Mattuis (2018), Cheng et al., (2020, Magazzino and Falcone (2022) and Dasakalapoulous et al., (2019) have all demonstrated that population growth is associated with increased waste generation reflecting the influence of population growth on economic activities and Waste generation.

Waste characterization is therefore an essential aspects of proper waste management strategies. Most of the wastes characterization studies done are primarily consists of segregation and categorization of wastes components, screening wastes based on size to obtain the coarse and fine particles

Waste characterization refers to the processes of identifying and quantifying the physical, chemical and biological properties of wastes materials. Its involves analysing the waste composition to determine its potential environmental impact and develop effective waste management strategies

Dumpsites are significant source of environmental pollution with leachate being a major concern. Waste characterization is crucial for the understanding of waste compositions and its potential impacts on leachate quality

Organic matters such as food waste, yard trimming., paper and Cardboard played a significant role in waste composition and characterization. According to several authors, food wastes constitute about 20 –to-30% 0f Municipal solid wastes(MSW) globally which can be argued as its only feasible in the developed economy unlike in Nigeria. Food wastes are as a result of economic prosperity and cultural affiliations as some culture do not believe in food waste as every single component of food waste are use or reuse for animal feeding or Agricultural manure in some part of Nigeria .According to Kaza et al., 2018 in his work stated that there is observed high organic content ,moisture and nutrients in food wastes which makes it suitable for composting and anaerobic digestion as also stated by Li et al.,2020.Both assertion are in conformity with the studies undertaken in Nigeria and with the present study. Yard trimming was reported to constitute 10 -20% of MSW in the United states while much less was observed in Nigeria and other developing economy which can be attributed to the socio-economic status of the people (US EPA,2020).Accordingly ,a mere 4-6% of yard trimming wastes was reported for Nigeria .A study undertaken by Goldstein et al, 2020 indicated that high organic matter contents of yard trimming has made it a suitable product for composting ,though it was rarely practised in Developing Economy like in Nigeria.

Paper and Cardboard materials are also prominent constituents of municipal solid as observed by Kaza et al., 2018 and Abdullahi et al.,2019., paper and cardboard constitute 20 -30% of municipal solid wastes globally. Several similar researches have clearly demonstrated the high cellulose and hemicellulose content which has made it a suitable material for Recycling, Composting and Energy productions (Muitrileri et al.,2020. Kaza et al., 2018). emphasised the need for accurate waste characterization which will aid in development of a robust and effective waste management strategies while Liu et al., (2020) proper the potential of food waste for possible valorisation through anaerobic digestion and composting whereas Goldstein (2019) explored the benefits of yard trimming composting for soil amendment and Carbon Sequestrations. Plastics was reported to be in the range of approximately 10 -20% 0of municipal solid globally and the prominent components of or types are PET, HDPE, PVC, LDPE and PP as reported by Hopewell et al.,2009). The implications of the presence of plastics in MSW ranges from its non-biodegradability which contributes to marine pollution and micro plastics (law et al., 2020) and its global recycling rates is 8 -9% globally as reported by Geyer et al., 2017).

Significant percentage of metals are normally found in municipal solid wastes(MSW) and are usually in the range of 5 -10% depending on the sites location and economic prosperity of the area(EPA ,2020).Typical metal constituents includes Aluminium(Al),Copper (Cu),Steel ,Tin and others (Bekkali et al., 2020). The known implications of metals are recyclable, Energy –intensive production ,toxic leaching among others as observed by Kumar et al.,2020.it has been reported by several authors that the recyclable rates of metal components in MSW ranges from 50 -90% depending on the metal type (Bekkiali.,2020).Glass also constitute approximately 5-10 % of MSW as reported by Kaza et al.,) The different varieties of glass that are commonly found in MSW includes Soda –lime, Boron silicates, and Lead –crystals (Gendebien et al., 2019).Significant percentage of glass found in MSW are recyclable up to 30-50% globally (Geyer et al., 2017).Ceramic and other related items are also found in municipal solid wastes amounting to 1 -5 % of MSW(EPA.,2020).The commonly found type includes Earth ware, Stoneware and Proclaim (Chen et al.,2020).Ceramic are non-toxic ,non-recyclable and are normally dispose at landfill/Dumpsites. The nutrients contents in wastes incudes organic wastes(food waste, yard trimming) which may be rich in Nitrogen(N),Phosphorous(P),Potassium (K) and Carbon (c) according to research conducted by Li et al.,2020) while inorganic waste includes sewage sludge and industrial wastes which are proven to contain heavy metals(HMs) ,Micronutrients and Macronutrients (Kumar et al.,2020) .it was also observed in many similar work that Biomass waste which includes Agricultural waste, Biodegradable plastics) are generally known to be rich in Carbon(

C),Nitrogen (N) and Phosphorous (P) which assertion was equally supported by Mutiara et al., 2020).

1.0 IMPLICATIONS IN WASTE COMPOSITION AND CHARACTERIZATION

- Nutrients recovery essential for sustainable waste management, reducing wastes volume and producing valuable fertilizers (Kaza et al., 2018)
- Environmental implications: Excessive nutrients in waste can lead to water pollution, soil degradation and climate change (Law et al., 2020)
- Waste –to – Energy: Nutrient – rich waste can produce bioenergy reducing greenhouse gas emissions(GHE) (Goldstein et al., 2019)

1.1 Waste composition components

- Organic matter: food waste, yards trimming, paper, cardboard etc.
- Inorganic matter: plastics, metals, glass, ceramics etc.
- Nutrients: Nitrogen, phosphorous, potassium etc.
- Heavy metals: Lead, mercury, cadmium
- Hazardous waste: Batteries, Electronics, Chemical etc.

1.2 Importance of waste characterization and characterization

- Environmental impacts: Waste composition affects Leachate quality, gas production and soil pollution
- Waste management strategies: Waste characterization informs decisions on waste treatment, disposal and recycling
- Resources recovery: Waste compositions determines potential for Energy recovery, composting and recycling

1.3 WASTE CHARACTERIZATION METHODS

There are various methods widely used to conduct waste characterization which includes: -

- Elemental Analysis (EA)
- Inductively Coupled Plasma Mass Spectrometry (ICP –MS)
- X- ray Fluorescence (XRF)
- Themogravimetric Analysis (TGA)

Elemental Analysis is a crucial method for waste characterization providing valuable information on the composition and properties of waste materials. There are several methods of conducting Elemental Analysis which includes: -

- Atomic Absorption Spectroscopy (AAS) (1)
- Inductively Coupled Plasma Mass Spectrometry (ICP –MS)
- X-Ray fluorescent (XRF)
- Neutron – Activation Analysis (NAAA)
- Energy - Dispersive X – Ray Spectroscopy) (EDS)

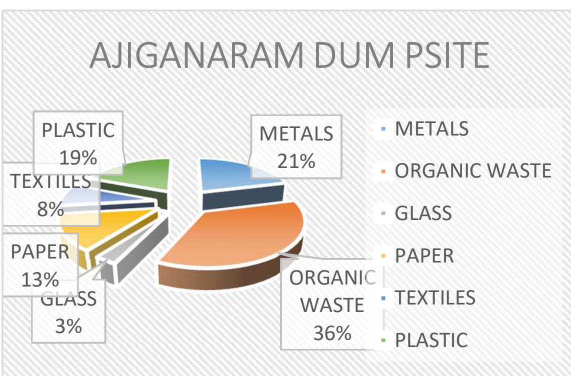
Table 1.0 shows the common methods of waste characterization and compositions

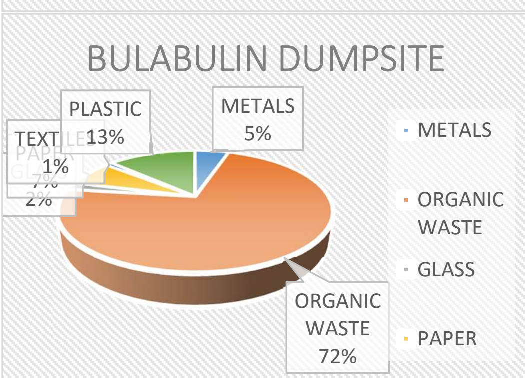
S/N	METHODS	APPLICATION
1	Atomic Absorption Spectroscopy (AAS)	Heavy metal Analysis in waste
2	Inductively coupled plasma mass spectrometry (ICP –MS)	Determination of Nutrients contents in Organic waste
3	X- Ray Fluorescence (XRF)	Determination of Nutrient Contents in organic waste
4	Neutron Activation Analysis	Analysis of Ash composition from waste incineration
5	Energy –Dispersive X-Ray Spectroscopy (EDS)	Identification of toxic elements in E-wastes

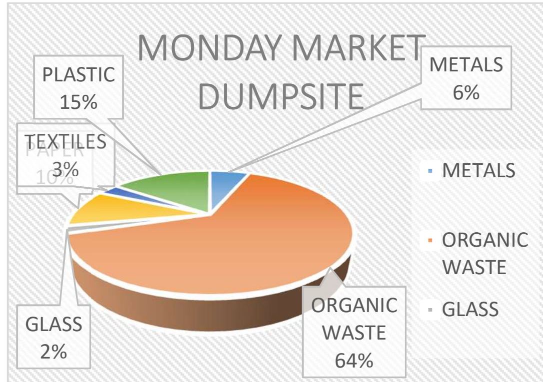
Previous studies have shown that waste composition plays a critical role in determining leachate quality (Kumar et al.,2017., Singh et al.,2020). Organic matter, nutrients and heavy metals are significant contributors to leachate pollution (Liu etal.,2019).

- Waste characterization: waste samples were collected and analysed for composition including organic matter

Wastes characterization and composition fractions in five (5) major open dumpsite in Maiduguri







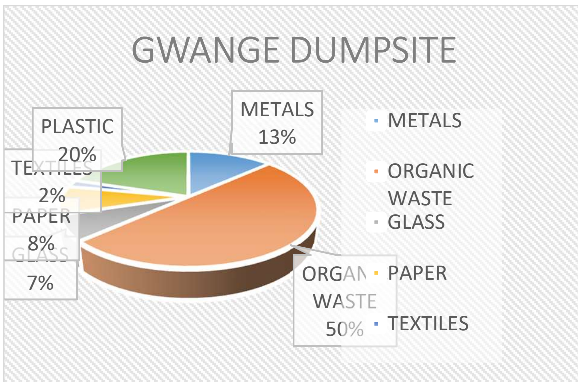


Figure 3 shows the waste composition fraction of some selected Dumpsites in Maiduguri metropolis.

Solid waste compositions vary substantially with socio-economic conditions, locations, season, waste collection and disposal methods, sampling and sorting procedure and many other factors (El-Fadel et al.,1997). Solid waste characterization was carried out for the fresh and old municipal solid wastes to know the basic compositions of solid wastes which are dumped in the various dumpsites in the metropolis.
The solid waste generation rate of the various dumpsites in the metropolis sites are largely due to the rapid population growth, economic development in the country and increased consumption of packaged foods and other products coupled with the insurgency which has made all the rural dwellers to migrate to the metropolis as the only safe haven for them. It was observed that the percentage of paper textiles, plastic and metals are in the range of 2 to 13 %.,1 to 8%,5 to 20%and 5 to 23% while others constitute 1.6% respectively. Organic wastes are relatively high.

1.4 SELECTION CRETERIA FOR EVALUATION

The prevalence of open dumping is an issue of great concern to both government and environmentally conscious individual. The uncontrolled proliferation of open waste dumpsite is not only an eyesore, but it has greatly impacted negatively on the environment thereby increasing the rate of groundwater and surface water contaminations in addition to the presence of methane gases in it vicinity resulting in fire burning and smoke around the areas. There were reported concerns of groundwater contamination near dumpsites across the

globe and most of such arises from old landfill. Dumpsites impact is as a result of leachate e getting in contact with the groundwater in the shallow aquifers at its vicinity.
The sampled sites are a geographically covered representative of the whole area, presents less operational constraints and accessibility to the sites whereas other established criteria such as sample size, population size, sampling error, sampling bias, sampling frame and cost and time were all considered as criteria in selecting the sample. These stated parameters are the principal consideration in selecting the five dumpsites under considerations for the study.
The five dumpsites in the metropolis has age considerably and no any meaningful efforts are being made by concerned authority to mitigate its proliferation The five selected dumpsites are in the middle of the metropolis with a population worthy of consideration by any standards. These considerations necessitated the need to evaluate the potential impacts of such dumpsites on the environment and the groundwater. They are representative of the other dumpsites in the metropolis.
Sampling criteria helps in defining the boundaries and scope of our study and explains the relationship between the sample and the population or the phenomenon of interest while sampling sites are specific locations identified for the study.

1.5 SAMPLING LOCATIONS

The sampled location includes the Ajiganaran dumpsites located at latitude 11^{o} 4'9 52 34'' and Longitude 13^{o} 09' 26 27'' and is in the center of the metropolis located strategically behind a Mega filling station and opposite the new maximum security prison and the state low cost while Bulabulun dumpsite is located at latitude 11^{o} 49' 52 34 ''and longitude 13^{o} 09' 26 27'' and is located near a slaughter slab with abundant scavengers and blacksmith engaged in menial jobs with some livelihood depending on scavenging on the dumpsite .The .Bulumkutu dumpsite is a dumpsite located at latitude 11^{o} 48' 30 34'' and longitude 13^{o} 24' 20 14'' and is located right in the middle of the neighborhood and surrounded by a public school and other human settlements.it has a population of nearly a million inhabitant and majority are relatively downtrodden and their main source of water supply is from shallow wells spread across the neighborhood. Whereas the Gwange dumpsite is located at latitude 11^{o} 49' 52 34'' and longitude 13^{o} 09 '26 27'' and is located near a seasonal river which flows near it while Monday market dumpsite is located at latitude 11^{o} 49’ 55 58'' and longitude 13 ^{o}09' 14 51’ and is located near the Monday market and surrounded by vegetable markets and horse’s riders for years besides being in closed proximity to the river Ngadda.

TABLE 2.0: SAMPLING LOCATIONS AND CODES

DUMPSITE	CODE	LATITUDE	LONGITITUDE
AJIGANARAN(AJD)	AJD -001	11^{o} 49' 52 3''4	13^{o} 09' 26 27''
BULABULIN(BLBD)	BLBD-002	11^{o} 49' 52 34''	13^{o} 09' 26 27''
BULUMKUTU(BKLM)	BLKM-003	11^{o} 48' 30 34''	13 ^{o}24' 20 14 ''
GWANGE(GWGD)	GWGD-004	11^{o} 49' 52 34''	13^{o} 09' 26 27 ''
MONDAY MARKET(MMD)	MMD-0005	11^{o} 49' 55 58''	13^{o} 09' 14 51''

1.6 LEACHATE COLLECTIONS AND SAMPLING

Leachate samples were collected from the five (5) designated point namely at 5,10,15,20 and 25m of sampling points which are non-engineered, with no sanitary facilities open dump site heaps that have no bottom liner or leachate collection system or equipment.

Leachate sampling: Leachate samples were collected from the five dumpsites and analyse for physiochemical parameters including PH Conductivity and heavy metals.

CONCLUSIONS

In conclusion, this study underscores the critical importance of characterizing waste composition to predict and mitigate the environmental impacts of dumpsites leachate. The comprehensive analysis of waste composition employing advanced analytical techniques and predictive modelling, provides valuable insight into the complex interactions between waste materials and their environmental implications. The finding of the study highlights the significance of:

- Accurate waste characterization to inform effective waste management strategies
- Understanding the physical, chemical and biological properties of waste to predict leachate quality
- Identifying key pollutants and their sources to develop target mitigation measures
- Employing advanced analytical techniques such as AAS, ICP –MS, XRF and EDS for elemental analysis
- Leveraging machine learning algorithms and predictive modelling for waste composition forecasting

The study highlights the significance of waste characterization in understanding leachate quality. Effective waste management practices including Segregation, Composting and recycling can minimize environmental pollution.

RECENT ADVANCE

- Potable XRF Analysers for on – site waste Analyser
- Machine learning Algorithms for predictive modelling of Waste composition
- Integration of multiple analytical techniques for comprehensive waste characterization

REFERENCE

Bear, J. (1972). Dynamics of fluids in porous medium. Dover Publications.

Charrerjee, A., Singh S., and Kumar, V., (2018). Neutron activation analysis of Hazardous waste from industry al processes. Journal of Radio analytical and Nuclear Chemistry, Vol.316, issue .2 Pg. .533 -539

Chen, X., Geng, Z. and Zhou. (2020) Comprehensive Characterization of municipal solid wastes(MSW) Using Multiple Analytical techniques. Journal of Cleaner Production .287, [120644].

Environmental Protection Agency(EPA) (2002): Natural Attenuation of Contaminants in soil and Groundwater.US Environmental Protection Agency.

European Commission (2020), Nutrients recovery from Waste Water

Fetter, C.W. (2001). Contaminant Hydrology. Pretence Hall.

Huang j., kauhi E. (2019) Heavy metal pollution from waste disposal and its Environmental impact. Journal of Environmental Management,241:328 -336

Khan, M.A., Alamn, M,.and Kumar, N. (2021). Environmental impacts of solid wastes Disposal. A journal of Environmental Management261.

Khan, M.A., Alan, M., and Kumar, N (2020): Lead Contamination in Soil and Water: Sources, effects and remediation techniques. Journal of Environmental Chemical Engineering 8(4).103945

Kumar, A., Singh, R., Kumar, N.N., and Kumar., (2020). Determination of Heavy metals in wastewater using atomic absorption Spectroscopy. Journal of Environmental Sciences and Health.Vol.55, pg 347 -355

Kumar, V, Kumar and Chaudhary, R. (2019). Impact of Dumpsite leachate in Groundwater Quality. A review journal of Environmental Sciences and Health. Part nC,31.1 -23

Kumar, V., Kumar, N., and Chaudhary, R. et al (2018) Lead contamination in soil and Groundwater. A review journal of Environmental sciences and Health. Part C,36,1 -1`

Li, J., Zhang, H., and Li, J., (2019): Analysis of toxic Elements in Electronic Wastes Using inductively coupled plasma mass spectrometry (ICP –MS). Journal of Hazardous materials.Vol.368, Pg.597 -604

Li, S(2020).Numerical Simulation of Contaminant Transport in Water Using Advection –Dispersion Equation .Journal of Contaminant Hydrology.233,103 -6371

Liu, J. Cheju., L and hum (2019) Heavy metals pollution in soil and water in a solid wastes Disposal area. Environmental sciences and pollution Rehear ch.2(15

Sharma, S, Tiwan, S., and Gupta, N., et al., (2019). chromium Contamination in soil and water. A review of source. effects and remediation Techniques. Journal of Environmental Chemical Engineering .7(3)

Singh, J., Kumar, A., and Singh, R., (2019): Characterization of municipal solid waste(MSW) Using X –Ray fluorescence (XRF) and Principal Components Analysis (PCA). Journal of Waste Management.Vol.87 Pg. 351 0359

Singh, R., Singh, P., Kumar, V. and Kumar, N. (2018). Zinc Concentration in soil and water. A review of source, effects and remediation techniques. Journal of Environmental Sciences and Health. Part B, 53,147-155

Thakur, P., Kumar, N., and Thakur, A. (2020). Portable X- Ray fluorescence (XRF) Analyser for on –site Analysis of Heavy metals in soil. Environmental Monitoring and Assessment ,192(4), [247] US EPA (2020), Sustainable materials management :2019 Data Highlights

Wang, J., Li, M., and Chen, L., (2020). Predictive modelling of waste composition Using machine learning algorithm. Waste management 105,53 -62.

WHO (2019). Guidelines for assessment and Management of Hazardous wastes.

World Health Organisation (2018). Waste and Human Health. Evidences and needs., World health organisation.

Zhang, Y., Li, Y., and Wang, Y., (2019). Energy - dispersive X-Ray Spectroscopy for Analysis of construction and demolition wastes Journal of Building Engineering.Vol.24(.102744)

Zheng. (2018).MT3DMS, A modular Three –Dimensional multi-species Transport models for simulation of Advection, Dispersion and Chemical reactions of Contaminants in groundwater System. PA reports.