LAUTECH Journal of Civil and Environmental Studies
Volume 14, March, 2025
DOI: 10.36108/laujoces/5202.41.0120

Physicochemical Properties of Natural, Processed, and Treated Leachates from Selected Dumpsites in Ogbomoso Township

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Submitted on: 23/12/2024 *Accepted on: 26/03/2025*

Abstract

As waste generation increases due to population growth and industrial expansion. A major issue arising from improper waste management is leachate, a highly contaminated liquid that seeps from waste deposits, posing severe risks to soil, groundwater, and surface water quality. This study investigates the physicochemical properties of leachates at two selected dumpsites in Ogbomoso Township. Two dumpsites, Atenda and Isale Ajuwon, were chosen to evaluate their natural, processed, and treated leachate characteristics, the parameters tested for are, pH, turbidity, conductivity, alkalinity, nitrate, nitrite, hardness, chemical and biochemical oxygen demand, sulphates, phosphate, chloride, potassium, sodium, and various heavy metals like zinc, cadmium, magnesium, iron, nickel, copper, and lead. The natural leachates were extracted from one-meter depth and analysed to determine the physicochemical properties. Leachate analysis shows significant variations in physicochemical properties, with pH values between 5.50 and 7.40 and conductivity ranging from 12.90 to 33.5µS/cm. Nitrate levels from 3.20 to 6.70 mg/L indicate potential nutrient pollution, while trace metals like lead and cadmium pose toxicity risks for soil and groundwater. The findings emphasize the importance of adopting more effective waste management strategies at both sites to curb environmental hazards and contamination, despite the relatively moderate conditions at Atenda. Enhancing leachate control and implementing proper waste-sorting practices could contribute to a more sustainable approach in these areas.

Keywords: Waste Composition, Leachate, Physicochemical Properties, Dumpsite Management, and Heavy Metals.

Introduction

Solid waste, encompassing municipal and industrial refuse, hazardous materials, agricultural refuse, construction demolition debris, and mining wastes, has escalated due to industrial and population growth, creating significant environmental and economic challenges (Abdel-Shafy and Mansour, 2018). Dumpsites, a common waste disposal method throughout history, are frequently located close to residential neighbourhoods and wetlands. The uncontrolled waste disposal in these areas results in the unregulated release of leachate (Daniel *et al.,* 2021). Leachate, which contains nitrates, ammonia, total dissolved solids (TDS), and various other pollutants, poses a significant threat to groundwater quality, accelerating metal corrosion in nearby structures, and reducing the binding strength of concrete (Rifana and Rana, 2022). With a growing global solid waste production, leachate from landfills poses severe environmental concerns, as pollutants infiltrate soil and water sources, posing long-term ecological risks (Ike *et al.,* 2018).

In response, there has been a growing emphasis on sustainable leachate treatment methods that prioritize resource recovery, environmental preservation, and eco-friendly approaches (Adeleke *et al.,* 2021). While modern landfills are designed with advanced engineering techniques to reduce waste-related impacts, leachate generation continues to pose a significant challenge in waste management. Consequently, uncontrolled leachate disposal remains prevalent in many regions, contributing to groundwater contamination. To address this issue, various treatment strategies have been implemented, generally classified into physical, chemical, and biological processes. Physical treatments such as membrane filtration and adsorption using activated carbon have been widely utilized to remove suspended solids and organic pollutants (Ahmed *et al.*, 2021).

Chemical treatments, including coagulation-flocculation, advanced oxidation processes, and chemical precipitation, have been effective in reducing heavy metals and organic compounds (Saleh *et al.*, 2022). However, these methods often generate secondary pollutants, requiring additional treatment steps. Biological treatments, including aerobic and anaerobic degradation, are commonly used due to their cost-effectiveness and sustainability in breaking down organic matter and ammonia (Ponnusami *et al.*, 2023). Despite these advances, no single treatment method is universally effective, leading to the development of hybrid systems that combine multiple techniques to achieve better pollutant removal efficiencies (Eniola *et al*., 2022).

Several studies have examined the characteristics, environmental impacts, and treatment methods for leachate, highlighting the need for continuous improvement in remediation technologies. Wang and Qiao, (2024) provided a comprehensive review of landfill leachate composition and management strategies, emphasizing the variability in pollutant concentrations based on landfill age and waste composition. More recent studies have explored advanced treatment methods, such as electrocoagulation (Das *et al.*, 2020), constructed wetlands (Shukla *et al.*, 2022), and hybrid biological-chemical approaches (Ahmed *et al.*, 2021), which have shown promising results in reducing contaminant loads.

Additionally, research by Viareco *et al.*, (2023) demonstrated the effectiveness of sequencing batch reactors (SBRs) in treating leachate with high ammonia concentrations, while Mojiri *et al.*, (2021) highlighted the role of adsorption using natural and synthetic materials in improving leachate treatment efficiency. Also, Olaiya and Ojoawo (2024) conducted a study emphasizing the significance of leachate valorization techniques, particularly the production of briquettes and bio-fertilizers, as a sustainable and efficient environmental engineering solution.

This research focused on the relationships and variations in the physicochemical properties of natural, processed, and treated leachates, including the concentration of heavy metal ions in the two selected dumpsites.

Materials and Methods

The study area is Ogbomoso Township, encompassing the Ogbomoso North and South Local Government Areas. Ogbomoso is a major town and the second-largest urban centre in Oyo State after Ibadan, the state capital. It is located between 8˚06′70″ and 8˚06′98.7 north and between longitude 4˚14′28.2″E and 4˚14′56.9″ east. As one of the rapidly growing cities in the Southwest of Nigeria, Ogbomoso has seen substantial increases in its spatial extent and human population over time. Furthermore, the establishment of educational and other institutions in the latter half of the 20th century, particularly the inception of the Ladoke Akintola University of Technology (LAUTECH) in 1990, has significantly contributed to the spatial, social, and economic growth of Ogbomoso.

Moreover, the development accelerated in the wake of the 21st century, transforming it into a major urban centre, despite its relatively weak industrial base. This urban growth has been accompanied by a significant population increase. The population of the study area was 253,282 in 2006 (National Population Commission, 2010), and was projected to rise to 1,219,342 by 2024, based on a 3.2% annual growth rate. The population has undoubtedly continued to grow in the subsequent years. This population and urban expansion increase has been accompanied by intensified human land use activities. The study examines the Atenda and Isale Ajuwon dumpsites, as depicted in Figure 1.

Atenda, situated at approximately 8° 8' 42" N and 8° 8.3' 43" north, 4° 14' 35" and 4° 15' 36.2" east in the Ogbomoso North Local Government area, is one of the oldest waste disposal sites, posing significant environmental and health risks due to hazardous waste accumulation. Similarly, Isale Ajuwon, located between 8° 7' 6.31" and 8° 8.2' 4.1" north, and 4° 14' 30" E and 4° 15' 35.7" east within the Ogbomoso South Local Government Area, serves as a major waste disposal site, contributing to persistent waste management challenges in the region. Both sites play a crucial role in local waste disposal but also present serious environmental concerns that require urgent attention.

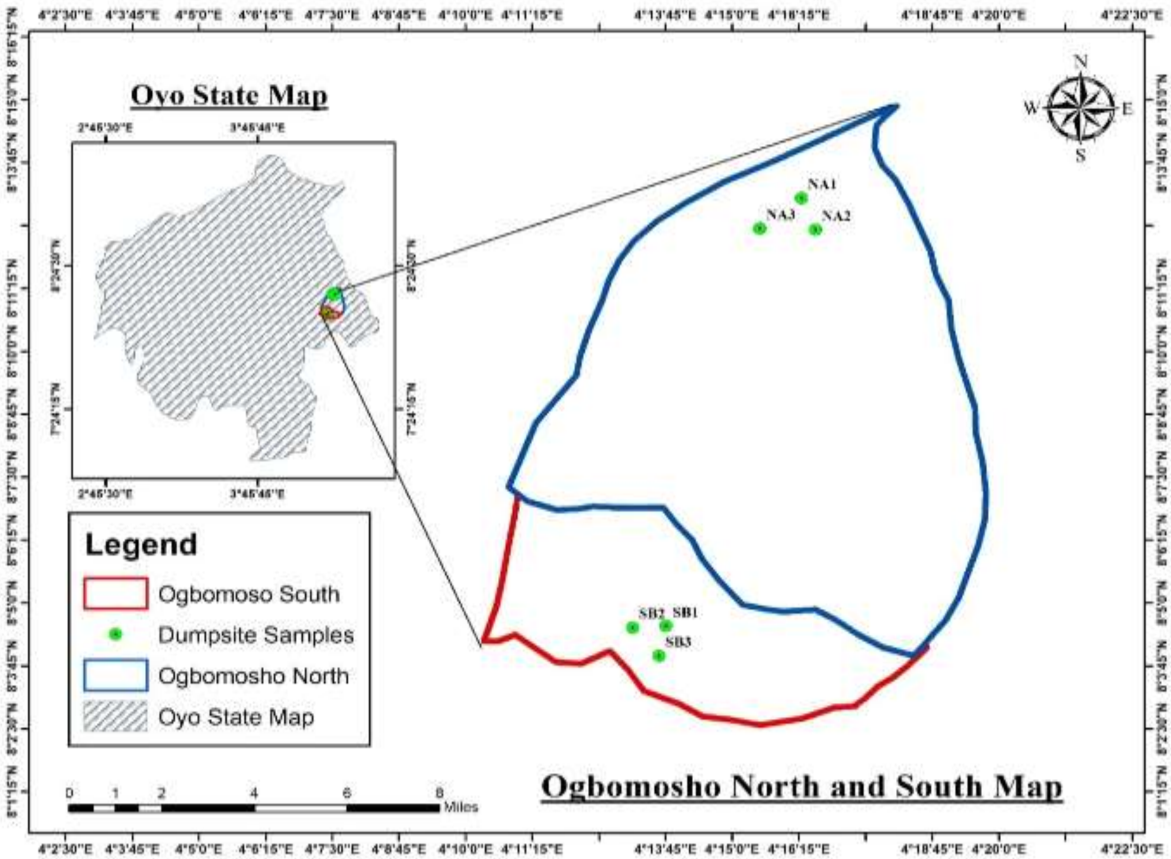

Figure 1: Digitized Map showing the sampling points of each dumpsite in Ogbomoso North and South Local Government Area.

Natural Leachate Collection

Leachate samples were collected from three different locations at a 5m interval in each dumpsite at a depth of 1 meter, using new, pre-rinsed 2.5 litre polyethylene bottles to ensure sample integrity. Three composite samples from each dumpsite provided a comprehensive analysis of leachate properties. Samples were stored at 22°C to maintain chemical stability, preventing alterations due to acidification or microbial activity. The three samples of leachates from each dumpsite are tested in the laboratory for the physicochemical characteristics, which include pH, turbidity, conductivity, alkalinity, nitrate, nitrite, hardness, chemical and Biochemical oxygen demand, sulphates, phosphate, chloride, potassium, sodium, and various heavy metals like zinc, cadmium, magnesium, iron, nickel, copper, and lead. These parameters are crucial for evaluating the environmental and health impacts of the leachate on surrounding areas.

Preparation of Processed Leachate

Waste samples were collected from various points within the dumpsites, ensuring a representative selection of materials. The collected waste consisted of both organic and inorganic components, including food scraps, plastics, metals, glass, paper, and textiles. The 20kg of waste was gathered across different locations, reflecting the heterogeneous nature of the dumpsites. Before processing, the samples were not pre-sorted, allowing for a realistic assessment of leachate composition under typical landfill conditions. Following collection, the waste samples were carefully placed in sealed bags while adhering to strict safety protocols to maintain sample integrity. They were then transported to the Water Resources and Environmental Laboratory at Ladoke Akintola University of Technology for further analysis.

Hence, to prevent contamination and minimize the loss of volatile compounds, the samples were stored in airtight containers equipped with a tap at the bottom, facilitating the easy collection of leachate. Distilled water was added to the stored waste, and the samples were left for one week to allow for the leaching process before the processed leachate was extracted for analysis. The primary goal of this method was to determine the relationship between the natural and processed leachate in terms of their physicochemical properties. This study aimed to replicate the conditions under which leachate forms in the environment, thereby providing a controlled basis for analysis. This process was to help in gaining an understanding of how the properties of leachate evolve under different conditions, offering insights into the environmental impact of dumpsites and the effectiveness of leachate management strategies.

Leachate Coagulation Pre-treatment

The treatment of leachate utilized the coagulation method, with alum serving as the primary coagulant. Specifically, 20 g of alum was added to 7 litres of natural leachate samples collected from the dumpsites for an hour. The objective was to evaluate the effectiveness of alum in enhancing the physicochemical properties and the physical appearance of the leachate and to determine its feasibility for in-situ application at dumpsites, where rapid and cost-effective leachate treatment is essential. In this context, alum was employed to assess its Figure 2, with the clearer leachate showing after the coagulation process.

Figure 2: Comparison of leachate collected from dumpsites before and after treatment.

After the addition of alum, the treated leachate samples were characterised to assess the effectiveness of the treatment. These evaluations offered valuable insights into the efficiency of the coagulation process in leachate treatment.

Laboratory Analysis

The characterization was carried out at the Science Laboratory Technology Department at LAUTECH, Oyo State. The characterisation was carried out in line with recommended standards and procedures as outlined in Table 1.

Table 1: Physico-chemical Analysis of Natural, Processed and Treated Leachate.

Parameter	Description	Method/Standard
Appearance, Temperature	Visual assessment of leachate clarity, colour, and temperature	ASTM D1293 (2018)
Total Alkalinity	Measures buffering capacity of leachate	APHA 2320B (2017a)
Total Hardness	Reflects the presence of dissolved minerals	APHA 2340C (2017b)
Chloride	Measures chloride ions in leachate	APHA 4500-Cl- B (2017c)
Turbidity	Assesses leachate clarity or cloudiness	ISO 7027 (2016)
Total Solids, Electrical Conductivity	Quantifies dissolved/suspended solids and electrical conductivity	APHA (2017d); ASTM D1125 (2014)
pH	Measures acidity or alkalinity	ASTM D1293 (2018)
Zinc, Copper, Lead, Nickel, Iron, Sodium, Potassium, Calcium, Chromium, Manganese, Cadmium	Trace metal concentration	EPA 6010C (2007)
Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD)	Measures oxygen consumption by organisms and chemical oxidation of organic matter	APHA (2017e)

Results and Discussion

Properties of Natural Leachate

The comparative analysis of leachate parameters from Atenda and Isale Ajuwon dumpsites, alongside their respective waste compositions, reveals distinct differences in contamination levels and waste profiles. Initially, the pH levels at Isale Ajuwon, ranging from 6.20 to 7.30, and Atenda, ranging from 5.60 to 9.20, both fall within acceptable limits. This indicates that both sites maintain relatively stable acidity and alkalinity, though Atenda exhibits a wider variation, reflecting potential differences in waste decomposition processes. Regarding turbidity, Isale Ajuwon shows higher variability, ranging from 4.70 to 9.65 NTU, compared to Atenda, where samples are from 6.01 to 8.90 NTU. This higher turbidity at Isale Ajuwon suggests more suspended solids, possibly influenced by the waste composition, notably the presence of nylon and food waste, which can contribute to higher turbidity.

Moreover, conductivity levels at Isale Ajuwon are relatively low, ranging from 13.10 to 13.90 µS/cm, while Atenda shows significantly higher values, spanning from 13.50 to 49.60 µS/cm. The elevated conductivity at Atenda likely reflects an increased ionic presence, possibly due to higher concentrations of food waste and other organic materials that enhance ionic strength. Alkalinity measurements also differ, with Isale Ajuwon ranging from 220.00 to 272.00 mg/L and Atenda presenting considerably higher values between 488.00 and 608.00 mg/L. This discrepancy could be attributed to Atenda's greater organic content, which contributes to higher bicarbonate and carbonate levels. Both sites exhibit low nitrate and nitrite concentrations, with Isale Ajuwon recording 0.20 to 0.76 mg/L for nitrate and 0.02 to 0.32 mg/L for nitrite, and Atenda showing 0.22 to 0.28 mg/L nitrate and consistently low nitrite levels, indicating similar nitrogenous pollution despite differing waste compositions.

Furthermore, hardness levels are slightly higher at Atenda, ranging from 6.20 to 7.30 mg/L, compared to Isale Ajuwon, where values range from 3.30 to 4.20 mg/L. The difference may be linked to the diverse waste types, with Atenda's higher proportion of metal-containing waste potentially contributing to increased hardness. On the other hand, COD levels at Isale Ajuwon are significantly higher, ranging from 204.00 to 356.00 mg/L, compared to Atenda, where values range from 64.00 to 444.00 mg/L. The high COD at Isale Ajuwon, particularly in samples B1 and B2, suggests a higher organic load, potentially from the diverse waste types including food waste and textiles. Moreover, BOD levels are also higher at Atenda, ranging from 27.40 to 40.60 mg/L, compared to Isale Ajuwon, where values range from 8.30 to 25.60 mg/L. The elevated BOD at Atenda could be due to the higher proportion of biodegradable organic waste, such as food waste.

In addition, SO_4^{2-} concentrations are notably higher at Atenda, ranging from 0.30 to 14.40 mg/L, compared to Isale Ajuwon, where values range from 0.10 to 0.20 mg/L. This suggests that Atenda leachate contains higher sulphate levels, potentially from waste materials like food waste and textiles. Furthermore, PO_4^{3-} levels are exceedingly high at both sites, with Isale Ajuwon ranging from 16.00 to 648.00 mg/L and Atenda from 704.00 to 880.00 mg/L. The extreme phosphate concentrations, particularly at Atenda, can be attributed to the high organic waste content, which often increases phosphorus levels. Additionally, chloride levels are higher at Atenda, ranging from 215.00 to 297.00 mg/L, compared to Isale Ajuwon, where values range from 102.00 to 167.60 mg/L. This increase may be related to the higher proportion of food waste and other chloride-containing materials at Atenda.

Moreover, potassium and sodium levels at both sites are relatively similar, with Isale Ajuwon showing potassium values between 2.90 and 3.80 mg/L and sodium values from 0.93 to 3.50 mg/L. Atenda has slightly lower potassium, ranging from 2.81 to 3.66 mg/L, and lower sodium, ranging from 0.85 to 2.42 mg/L. These values suggest that the potassium and sodium concentrations are consistent with the waste types at both sites. Zinc levels are slightly higher at Atenda, ranging from 0.15 to 1.84 mg/L, compared to Isale Ajuwon, where values range from 0.19 to 0.75 mg/L, likely due to the presence of metals in the waste. In contrast, cadmium levels are consistent at both sites, with Isale Ajuwon and Atenda showing values between 0.04 and 0.05 mg/L. Both sites exhibit cadmium levels slightly above the standard, reflecting potential contamination from various waste sources.

Magnesium levels are lower at Atenda, ranging from 0.30 to 1.08 mg/L, compared to Isale Ajuwon's 1.13 to 1.18 mg/L, likely reflecting differences in mineral content from the waste. Manganese concentrations are similar at both sites, between 0.01 and 0.03 mg/L, suggesting minimal contamination concerns. Iron is notably higher at Atenda, ranging from 0.25 to 2.17 mg/L versus 0.10 to 0.49 mg/L at Isale Ajuwon, potentially due to more metal-containing waste. Nickel levels remain low and similar across sites, at 0.00 to 0.03 mg/L. Copper levels are also higher at Atenda, between 1.35 and 2.55 mg/L, compared to Isale Ajuwon's range of 0.96 to 2.74 mg/L, likely from increased metallic waste. Atenda's density of 3.17kg/m^3 suggests more consistent waste accumulation. This aligns with Taghipour *et al.*, (2016), who observed seasonal waste variation, especially in urban versus low-income areas, where recyclable and organic waste levels fluctuated.

Solid waste management poses significant challenges in urban centres, with waste disposal at dumpsites generating leachates that contaminate nearby land and water resources. Developing countries like Nigeria struggle to address these issues due to the high costs involved. Among the various solutions, the aquatic plant Ipomoea aquatica Forsk has been found to reduce various organic and toxic pollutants to acceptable levels. This plant, Indigenous to tropical climates and tolerant to toxic chemicals, offers a phytoremediation technique that can be combined with other physicochemical methods to maintain environmental safety (Aluko *et al.*, 2003).

Properties such as pH, turbidity, alkalinity, and COD show significant differences between leachate samples from Atenda and Isale Ajuwon, reflecting varying contamination levels and environmental impact from the respective sites as shown in Table 2.

Table 2: Properties of Natural Leachate Collected in the Study Areas.

Parameters	Atenda			Isale Ajuwon		
	Sample A1	Sample A2	Sample A3	Sample B1	Sample B2	Sample B3
pH	7.50	9.20	5.60	6.20	6.70	7.30
Turbidity (NTU)	6.01	7.00	8.90	6.00	9.65	4.70
Conductivity (µS/cm)	13.50	37.40	49.60	13.90	13.10	13.30
Alkanility (mg/L)	584.00	608.00	488.00	220.00	250.00	272.00
Nitrate (NO_3^{2-}) mg/L)	0.26	0.28	0.22	0.32	0.76	0.20
Nitrite (NO_2^{2-}) (mg/L)	0.11	0.11	0.11	0.12	0.32	0.02
Hardness (mg/L)	6.20	7.30	6.60	4.20	3.70	3.30
COD (mg/L)	444.00	84.00	64.00	356.00	264.00	204.00
BOD (mg/L)	27.40	40.60	30.20	18.10	25.60	8.30
SO_4^{2-} (mg/L)	0.50	14.40	0.30	0.20	0.10	0.20
PO_4 (mg/L)	704.00	880.00	704.00	648.00	648.00	16.00
Chloride (Cl) (mg/L)	218.60	297.00	215.00	167.60	102.00	105.70
Potassium (K) (mg/L)	2.81	3.66	3.64	2.90	3.36	3.80
Sodium (Na) (mg/L)	1.11	2.42	0.85	0.93	1.39	3.50
Zinc (Zn) (mg/L)	0.25	1.84	0.15	0.28	0.75	0.19
Cadmium (Cd) (mg/L)	0.05	0.04	0.05	0.04	0.04	0.04
Magnesium (Mg) (mg/L)	0.30	0.98	1.08	1.18	1.18	1.13
Manganese (Mn) (mg/L)	0.00	0.03	0.03	0.03	0.03	0.01
Iron (Fe) (mg/L)	0.36	2.17	0.25	0.16	0.49	0.10
Nickel (Ni) (mg/L)	0.02	0.01	0.03	0.00	0.01	0.03
Copper (Cu) (mg/L)	2.33	2.55	1.35	1.06	2.74	0.96
Lead (Pb) (mg/L)	2.71	1.76	0.79	1.71	1.52	0.89

Properties of Processed and Treated Leachate

The analysis of leachate from Dumpsite A (Atenda) and Dumpsite B (Isale Ajuwon) reveals crucial insights regarding the impacts of leachate production and subsequent treatment on water quality parameters. The initial pH levels of the Natural leachate from both sites were similar, with Isale Ajuwon measuring 7.2 and Atenda measuring 7.3, indicating that the leachate production process, which utilizes distilled water, tends to maintain a neutral pH. This observation aligns with Saikia *et al.*, (2018), who noted that leachate from sites using distilled water exhibited stable pH levels, reflecting minimal acidification despite varying waste compositions. However, after the alum coagulation treatment, a noteworthy contrast emerged: Isale Ajuwon's pH slightly increased to 7.4, whereas Atenda's leachate exhibited a drop to 5.5. This significant reduction in pH at Atenda highlights the coagulation process's pronounced effect on acidity, which could adversely impact the leachate's suitability for agricultural applications.

Additionally, in examining turbidity, the Natural leachate from both sites recorded low levels of 1 NTU, suggesting minimal particulate matter presence from the leaching process with distilled water. Post-coagulation, Isale Ajuwon's turbidity increased to 6 NTU, while Atenda's turbidity reduced to 5 NTU. This rise in turbidity for Isale Ajuwon underscores the effectiveness of alum in suspending particulates during treatment, supporting findings by Iwuozor (2019), which indicate that alum treatment can sometimes lead to increased turbidity due to the aggregation of suspended particles. In contrast, the lower turbidity at Atenda suggests a more efficient removal of particulates, enhancing the quality of the treated water for reuse in construction or irrigation.

Moreover, conductivity measurements revealed that Isale Ajuwon's Natural leachate had higher conductivity at 25.3 µS/cm compared to Atenda's 12.9 µS/cm, indicative of a greater concentration of dissolved ions. Following coagulation, conductivity levels remained stable for both sites, suggesting that the coagulation process does not significantly alter ion concentration. This stability aligns with the observations of Saleem and Bachmann (2019), who noted that coagulation processes often maintain conductivity levels, which is essential for assessing the suitability of treated water for various applications. The consistent conductivity values suggest that while the treatment effectively reduces suspended solids, it does not substantially affect dissolved ion concentrations critical for various uses.

Furthermore, alkalinity levels were also evaluated, revealing that Isale Ajuwon had higher initial alkalinity at 624 mg/L compared to Atenda's 536 mg/L. After treatment, alkalinity decreased to 288 mg/L for Isale Ajuwon but increased to 520 mg/L for Atenda. The increase in Atenda's alkalinity post-treatment indicates a greater buffering capacity, which could enhance soil stability in agricultural settings. This finding contrasts with the research by Ishaq *et al.*, (2022), which reported decreases in alkalinity across multiple treatment methods, indicating potential variations in treatment efficiency depending on the specific site conditions and leachate composition.

In addition, nitrate and nitrite concentrations showed similarities at both sites, with nitrate levels at 0.18 mg/L at Isale Ajuwon and 0.16 mg/L at Atenda, and nitrite levels at 0.05 mg/L. Following coagulation, nitrate levels significantly increased to 0.26 mg/L in Isale Ajuwon and 4.4 mg/L in Atenda, with nitrite levels rising to 0.03 mg/L and 1.6 mg/L, respectively. The elevated nitrate and nitrite concentrations in Atenda suggest a reduced effectiveness of the coagulation process in removing these contaminants.

Consequently, hardness levels were notably higher in Isale Ajuwon at 8.4 mg/L compared to Atenda at 6 mg/L before treatment. After coagulation, hardness measurements dropped to 3.2 mg/L for Isale Ajuwon and increased to 4.9 mg/L for Atenda. This increase in Atenda's hardness suggests a higher concentration of calcium and magnesium ions in the original leachate, which could affect the suitability of the treated water for irrigation purposes. This is in line with the findings of Zhang *et al.*, (2023), which highlighted the impacts of hardness on soil health and plant growth, underscoring the importance of considering hardness levels when assessing leachate for reuse.

In addition, Chemical Oxygen Demand (COD) measurements indicated significantly higher values at Atenda at 424 mg/L compared to Isale Ajuwon at 288 mg/L, suggesting a greater presence of organic materials. Following treatment, COD levels decreased to 80 mg/L for Isale Ajuwon and 200 mg/L for Atenda, indicating the effective removal of organic pollutants. However, the elevated COD level in Atenda implies that additional treatment may be necessary for safe reuse. Additionally, the analysis of Biochemical Oxygen Demand (BOD) levels revealed that Isale Ajuwon's Natural leachate had a higher BOD at 68.2 mg/L than Atenda at 27.4 mg/L. Post-coagulation BOD levels were recorded at 48.6 mg/L for Isale Ajuwon and 44.8 mg/L for Atenda, indicating a reduction in biodegradable organic matter but still retaining significant levels of organic contaminants in Isale Ajuwon's leachate.

Moreover, sulphate concentrations were found to be higher in Atenda at 14.6 mg/L compared to Isale Ajuwon at 9.9 mg/L before treatment. Post-coagulation, sulphate levels decreased to 7.7 mg/L in Atenda while increasing to 20.6 mg/L in Isale Ajuwon. This disparity suggests that alum treatment impacts sulfate levels differently at each site, which could have implications for usability in various applications. Similar observations were reported by Ishaq *et al.*, (2022), indicating that sulfate removal can vary significantly based on the specific characteristics of leachate and treatment methods employed. Lastly, phosphate levels were higher in Isale Ajuwon at 224 mg/L compared to Atenda at 136 mg/L in the Natural leachate. Following coagulation, phosphate concentrations were recorded at 156 mg/L for Isale Ajuwon and 160 mg/L for Atenda. These elevated phosphate concentrations could contribute to eutrophication if the treated leachate is used for agricultural purposes.

Furthermore, this finding is consistent with the study by Mmonwuba *et al.*, (2023), which raised concerns about the potential for treated leachate to contribute to nutrient loading in agricultural soils, necessitating careful management practices. Finally, chloride levels were higher at Atenda at 315.9 mg/L compared to Isale Ajuwon at 247.9 mg/L, with post-treatment chloride measurements at 144 mg/L for Isale Ajuwon and

203.9 mg/L for Atenda. The increase in chloride levels at Atenda after treatment could adversely affect soil salinity, thereby limiting its suitability for agricultural reuse. This observation is in line with research by Salami and Susu, (2019), which emphasized the need to monitor chloride concentrations in treated leachate to avoid detrimental impacts on soil health and plant growth.

Table 3 shows the detailed properties of processed and treated leachate from each study area. In summary, significant differences exist in parameters such as pH, turbidity, conductivity, alkalinity, nitrate levels, COD, and BOD between processed and treated leachate samples from both dumpsites, reflecting varying levels of contamination and treatment effectiveness. Comparatively, alum coagulation also improves the leachate quality, especially in removing the foul odour and the thick dark colour, making it suitable for reuse in agriculture and construction. However, it requires careful management to meet safety standards, highlighting the need for further treatment in some cases.

Table 3: Properties of Processed and Treated Leachate from Each Study Area.

Parameter	**Processed Leachate**		**Treated Leachate**		**WHO (2017)**
	(Dumpsite A - Atenda)	**(Dumpsite B - Isale Ajuwon)**	**(Dumpsite A - Atenda)**	**((Dumpsite B - Isale Ajuwon)**	
pH	7.3	7.2	5.5	7.4	6.0 – 9.0
Turbidity (NTU)	6	5	5.2	6	≤ 5.0
Conductivity (μS/cm)	12.9	25.3	13.8	13.3	1000
Alkalinity (mg/L)	536	624	520	288	500
Nitrate (NO_3^{2-}) (mg/L)	0.16	0.18	4.4	0.26	50
Nitrite (NO_2^{2-}) (mg/L)	0.05	0.05	1.6	0.03	1
Hardness (mg/L)	6	8.4	4.9	3.2	500
COD (mg/L)	424	288	200	80	≤ 250
BOD (mg/L)	27.4	68.2	44.8	48.6	≤ 50
SO_4^{2-} (mg/L)	14.6	9.9	7.7	20.6	250
PO_4^{3-} (mg/L)	136	224	160	156	5
Chloride (Cl^-) (mg/L)	315.9	247.9	203.9	144	250
Potassium (K) (mg/L)	3.03	3.35	3.02	2.7	-
Sodium (Na) (mg/L)	1.71	1.94	1.7	1.46	200
Zinc (Zn) (mg/L)	1.51	0.45	0.11	0.12	2
Cadmium (Cd) (mg/L)	0.02	0	0.03	0.02	0.01
Magnesium (Mg) (mg/L)	1.72	1.22	1.23	1.23	150
Manganese (Mn) (mg/L)	0.15	0.39	1.32	0.04	0.5
Iron (Fe) (mg/L)	1.64	0.21	0.12	0.62	1
Nickel (Ni) (mg/L)	0.01	0.02	0.02	0	0.05
Copper (Cu) (mg/L)	0.09	0.08	0.02	0.06	0.5
Lead (Pb) (mg/L)	0.05	0.05	0.04	0.03	0.01

Conclusion

This research compares the key differences between the Atenda and Isale Ajuwon dumpsites regarding leachate quality. Some of the points deduced are:

i. Isale Ajuwon has lower pH, turbidity, and metal concentrations in its leachate, while Atenda presents elevated conductivity, alkalinity, and organic pollutants.

ii. Although alum coagulation enhances leachate quality for agricultural applications, some parameters, including BOD, COD, and certain ions, remain high.

iii. These findings emphasize the need for site-specific waste management strategies and the need for controlled release of dumpsite leachate into the environment to address distinct negative environmental impacts.

References

Abdel-Shafy, H. I., and Mansour, M. S. (2018). Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian journal of petroleum*, *27*(4), 1275-1290.

Adeleke, O., Akinlabi, S. A., Jen, T. C., and Dunmade, I. (2021). Sustainable utilization of energy from waste: A review of potentials and challenges of Waste-to-energy in South Africa. *International Journal of Green Energy*, *18*(14), 1550-1564.

Ahmed, S. F., Mofijur, M., Nuzhat, S., Chowdhury, A. T., Rafa, N., Uddin, M. A., and Show, P. L. (2021). Recent developments in physical, biological, chemical, and hybrid treatment techniques for removing emerging contaminants from wastewater. *Journal of hazardous materials*, *416*, 125912.

Aluko, O. O., Sridhar, M. K., and Oluwande, P. A. (2003). Characterization of leachates from a municipal solid waste landfill site in Ibadan, Nigeria. *Journal of Environmental Health Research*, *2*(1), 32-37.

APHA, AWWA, and WEF. (2017a). *Standard methods for the examination of water and wastewater* (23rd Ed.). American Public Health Association. Method 2320 B: Alkalinity by titration.

APHA, AWWA, and WEF. (2017b). *Standard methods for the examination of water and wastewater* (23rd Ed.). American Public Health Association. Method 2340 C: Hardness by EDTA titration.

APHA, AWWA, and WEF. (2017c). *Standard methods for the examination of water and wastewater* (23rd Ed.). American Public Health Association. Method 4500-Cl^- B: Argentometric method.

APHA, AWWA, and WEF. (2017d). *Standard methods for the examination of water and wastewater* (23rd Ed.). American Public Health Association. Method 2540 B: Total solids dried at 103-105°C.

APHA, AWWA, and WEF. (2017e). *Standard methods for the examination of water and wastewater* (23rd Ed.). American Public Health Association. Method 5210 B: 5-day BOD test.

ASTM D1125. (2014). *Standard test methods for electrical conductivity and resistivity of water*. ASTM International. https://www.astm.org/d1125-14.html

ASTM D1293. (2018). *Standard test methods for pH of water*. ASTM International. https://www.astm.org/d1293-18.html

Daniel, A. N., Ekeleme, I. K., Onuigbo, C. M., Ikpeazu, V. O., and Obiekezie, S. O. (2021). Review on effect of dumpsite leachate to the environmental and public health implications. *GSC Advanced Research and Reviews*, *7*(2), 051-060.

Das, P. P., Sharma, M., and Purkait, M. K. (2022). Recent progress on electrocoagulation process for wastewater treatment: A review. *Separation and Purification Technology*, *292*, 121058.

Eniola, J. O., Kumar, R., Barakat, M. A., and Rashid, J. (2022). A review on conventional and advanced hybrid technologies for pharmaceutical wastewater treatment. *Journal of Cleaner Production*, *356*, 131826.

EPA Method 6010C. (2007). *Inductively coupled plasma-atomic emission spectrometry*. U.S. Environmental Protection Agency.

Ike, C. C., Ezeibe, C. C., Anijiofor, S. C., and Daud, N. N. (2018). Solid waste management in Nigeria: problems, prospects, and policies. *The Journal of Solid Waste Technology and Management*, *44*(2), 163-172.

Ishaq, A., Said, M. I. M., Azman, S., Abdulwahab, M. F., and Alfa, M. I. (2022). Impact, mitigation strategies, and future possibilities of Nigerian municipal solid waste leachate management practices: a review. *Nigerian Journal of Technological Development*, *19*(3), 181-194.

ISO 7027. (2016). *Water quality — Determination of turbidity*. International Organization for Standardization. https://www.iso.org/standard/62801.html

Iwuozor, K. O. (2019). Prospects andchallenges of using the coagulation-flocculation method in the treatment of effluents. *Advanced Journal of Chemistry-Section A*, *2*(2), 105-127.

Mmonwuba, N. C., Francis, O. O., Somtochukwu, O., Chinweike, M. P., Ezenwafor, K., and Ifunanya, G. E. (2023). Effects of Solid Wastes (Leachates) on the Quality of Underground Water. *Journal of Engineering Research and Reports*, *24*(3), 20-31.

Mojiri, A., Zhou, J. L., Ratnaweera, H., Ohashi, A., Ozaki, N., Kindaichi, T., and Asakura, H. (2021). Treatment of landfill leachate with different techniques: an overview. *Water Reuse*, *11*(1), 66-96.

National Population Commission (NPC) (2010) Federal Republic of Nigeria (2006) Population and Housing Census. Priority Table Volume IV, Population Distribution by Age and Sex. National Population Commission (NPC), Abuja.

Olaiya, S. A., and Ojoawo, S. O. (2024). Biological Valorization of Dumpsite Leachates in Ogbomoso, Nigeria: Biogas, Briquettes, and Biofertilizers. *Adeleke University Journal of Engineering and Technology*, *7*(2), 158-168.

Ponnusami, A. B., Sinha, S., Ashokan, H., Paul, M. V., Hariharan, S. P., Arun, J. and Pugazhendhi, A. (2023). Advanced oxidation process (AOP) combined biological process for wastewater treatment: A review on advancements, feasibility and practicability of combined techniques. *Environmental research*, *237*, 116944.

Rifana, F., and Rana, R. M. (2022). Treatment of landfill leachate using algae. *International Research Journal of Engineering and Technology (IRJET)*, 9(6), 1407.

Saikia, N., Borah, R. R., Konwar, K., and Vandecastelee, C. (2018). pH-dependent leachings of some trace metals and metalloid species from lead smelter slag and their fate in natural geochemical environment. *Groundwater for Sustainable Development*, *7*, 348- 358.

Salami, L., and Susu, A. A. (2019). A comprehensive study of leachate characteristics from three soluos dumpsites in Igando Area of Lagos State, Nigeria. *Greener Journal of Environmental Management and Public Safety*, *8*(1), 1-14.

Saleem, M., and Bachmann, R. T. (2019). A contemporary review on plant-based coagulants for applications in water treatment. *Journal of Industrial and Engineering Chemistry*, *72*, 281297.

Saleh, T. A., Mustaqeem, M., and Khaled, M. (2022). Water treatment technologies in removing heavy metal ions from wastewater: A review. *Environmental Nanotechnology, Monitoring and Management*, *17*, 100617.

Shukla, A., Parde, D., Gupta, V., Vijay, R., and Kumar, R. (2022). A review on effective design processes of constructed wetlands. *International Journal of Environmental Science and Technology*, *19*(12), 12749-12774.

Taghipour, H., Amjad, Z., Aslani, H., Armanfar, F., and Dehghanzadeh, R. (2016). Characterizing and quantifying solid waste of rural communities. *Journal of Material Cycles and Waste Management*, *18*, 790-797.

Viareco, H., Adriansyah, E., and Sufra, R. (2023). Potential Sequencing Batch Reactor in Leachate Treatment for Organic and Nitrogen Removal Efficiency. *Journal of Environmental Health*, *15*(2).

Wang, J., and Qiao, Z. (2024). A comprehensive review of landfill leachate treatment technologies. *Frontiers in Environmental Science*, *12*, 1439128.

World Health Organization (WHO). (2017). *Guidelines for the safe use of wastewater, excreta, and greywater: Volume 4 – Excreta and greywater use in agriculture*. World Health Organization.

Zhang, P., Yang, M., Lan, J., Huang, Y., Zhang, J., Huang, S., and Ru, J. (2023). Water quality degradation due to heavy metal contamination: Health impacts and eco-friendly approaches for heavy metal remediation. *Toxics*, *11*(10), 828.