



Assessment of Physicochemical Properties of Wastewater in Alkalawa, Ajiya, Doubeli, Jambutu and Rumde at Yola North, Adamawa State, Nigeria

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ABSTRACT: Poor wastewater management is a major environmental and public health challenge facing many urban slums in developing countries. However, comprehensive studies examining the challenges and risks are lacking, limiting risk mitigation efforts. Hence, the objective of this paper was to assess physicochemical properties of Alkalawa, Ajiya, Doubeli, Jambutu and Rumde in Yola North, Adamawa State, Nigeria using appropriate standard procedures. Data obtained reveals that the levels of the selected physicochemical properties in the wastewater samples were pH: (5.46-7.92): 6.87 ± 0.71 ; EC (0.35-0.95): 0.62 ± 0.16 ; DO (4.94-10.80): 8.34 ± 1.86 ; and ALK: (0.83-1.4): 1.07 ± 0.21 respectively. For the month of December, the mean value for pH was recorded as (6.894), electrical conductivity was (0.582), dissolve oxygen was (7.912) and the mean value for alkalinity was (1.118). The mean summary was (6.87333) standard deviation (0.706667), min (5.46) max (7.92). For the month of January, mean value for pH was (6.615), electrical conductivity was (0.628), dissolve oxygen was (8.348) and the mean value for alkalinity was (0.986). The mean summary was (8.34333) standard deviation (1.86333), min (0.35) max (0.9466). For the month of February, mean value for pH was (6.825), electrical conductivity was (0.686), dissolve oxygen was (7.99) and the mean value for alkalinity was (1.216). The mean summary was (1.07333) standard deviation (0.206667) min (0.83) max (0.146). This study aimed to assess wastewater management practices and quantify associated health risks in some areas in Yola, Nigeria. The results show that the physicochemical properties across the three months are not significantly different ($P > 0.05$) while those across the different sites are not significantly different ($P > 0.05$).

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Wastewater is a complex mix of organic matter, nutrients, chemicals, pathogens and heavy metals (Monney *et al.*, 2013). If untreated, it can contaminate soil and water resources, increase health risks and impair overall ecological balance (Mahmood and Maqbool, 2006; Paillard *et al.*, 2005). Most developing world cities currently lack sewage infrastructure due to rapid expansion outpacing utility provision. As a result, untreated wastewater is often discharged directly into the environment or re-used

for agriculture without proper treatment, posing risks to human and ecological health (Qadir *et al.*, 1997). The world is faced with problems related to the management of wastewater. This is due to extensive industrialization, increasing population density and high urbanized societies (EPA, 1993). The effluents generated from domestic and industrial activities constitute the major sources of the natural water pollution load. This is a great burden in terms of wastewater management and can consequently lead

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to a point-source pollution problem, which not only increases treatment cost considerably, but also introduces a wide range of chemical pollutants and microbial contaminants to water sources (Eikelboom and Draaijer, 1999). If wastewater is not properly managed it could become a point source of pollution which could be hazardous to the human health and the environment. The environmental impact of wastewater degradation may result in physical changes to receiving waters, increased level of dissolved oxygen, bioaccumulation in aquatic life, release of toxic substances and increased ground water quality (Mahmood and Maqbool, 2006). Diseases caused by bacteria, viruses and protozoa are the most common health hazards associated with untreated wastewater. Many microbial pathogens in wastewater can cause chronic diseases with long-term effects such as degenerative heart disease and stomach ulcer (Paillard *et al.*, 2005). Wastewater also consists of vast quantities of bacteria, most of which are harmless to man. However, pathogenic forms that cause diseases such as typhoid, dysentery and other intestinal disorder may be present in the wastewater (Okereke *et al.*, 2016). Even though wastewater and its nutrient contents can be used for crop production, thus providing significant benefits to the farming communities and society in general, its use could however also impose negative impacts on communities and on ecosystems. The use of wastewater containing toxic wastes coupled with the lack of adequate finances for treatment is likely to cause an increase in the incidence of water borne diseases as well as more rapid environmental degradation. Although the harmful effects of using contaminated wastewater effluents could go undetected for several years, it however adversely affects groundwater quality when nutrients leach down the soil into the groundwater system (Mahmood and Maqbool, 2006). Near surface aquifers in intensely irrigated areas using wastewater can indeed become polluted, thus reducing the aquifer portability. The concept of environmentalism is now widely held as the newly emerging social paradigm; its future is becoming deeply held in terms of the global need for pure drinking water. Particularly, wastewater has reformed physicochemical properties containing a complex mixture of chemicals and organisms released from sewage outlets, with the “butterfly” theory of chaos; as a result, it is a haven for a gamut/ spectrum of infecting microbes, thereby rendering the water inappropriate for human use. Despite being released from treatment facilities with some carefully designed and engineered networks of ponds, wastewater is the stream of spent water that is released from residences, industries, enterprises,

commercial activities and hospitals (Kumari *et al.*, 2023). Clean water is a basic necessity for human health and the bandwagon of economic activities linked to industry, agriculture and animal husbandry; thus, the sanitization of wastewater remains essential (Ghosh *et al.*, 2022). The prevention of pollution of water sources and protection of public health by safeguarding water supplies against the spread of diseases, are the two fundamental reasons for treating wastewater. This is accomplished by removing substances that have a high demand for oxygen from the system through the metabolic reactions of microorganisms, the separation and settling of solids to create an acceptable quality of wastewater effluents and the collection and recycling of microorganisms back into the system, or removal of excess microorganisms from the system (Akpoy and Muchie, 2011). The notorious Makoko slum in Lagos, Nigeria is home to over 250, 000 people (Irin, 2015). The situation of sanitation is very poor and this is common to all slums as the facilities are either lacking or they are inadequate for the heavy population of residents in such neighbourhoods. The fact that such large proportions of urban residents’ dwell in slums summarizes a critical factor that cannot be ignored when designing sustainable growth in cities: the vast majority of the hundreds of millions of migrants leaving behind their rural livelihoods in hopes of success in the city end up becoming part of the lowest socio-economic group - the urban poor. Wastewater is sometimes referred to as ‘reused water’, ‘recycled water’ and ‘reclaimed water’. In general, wastewater can be defined as the by-product of many uses of water. For USA EPA, wastewater is “water that has been used and contains dissolved or suspended waste materials”. Taking into account that 80% of water consumption leads to wastewater generation (Qadir *et al.*, 1997), treated municipal wastewater can be a significant source of irrigation water. In addition, urban expansion and increasing population and industrial use have led to remarkable production of wastewater and growing water scarcity for agricultural use. In a wider perspective, Corcoran *et al.* (2010b) define wastewater as “a combination of one or more of: domestic effluent consisting of blackwater (excreta, urine and faecal sludge) and greywater (kitchen and bathing wastewater); water from commercial establishments and institutions, including hospitals; industrial effluent, stormwater and other urban run-off; agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter”. Given its broader and more inclusive character, these definitions remain the most answered in the reports of many international and UN organizations. The effective management of any wastewater flow requires an accurate knowledge of

its characteristics. These characteristics, according to Burks and Minnis (Burks and Minnis, 1994), are necessary to facilitate the effective design of wastewater treatment and disposal system and also to enable the development and application of water conservation and waste load reduction strategies. The quality of wastewater may be defined by its physical, chemical and biological characteristics. Physical parameters include: temperature, pH, electrical conductivity, colour, odour and turbidity. Insoluble contents such as oil and grease, solids (suspended or dissolved) and inorganic fractions also fall into this category (Burks and Minnis, 1994). Chemical parameters associated with the organic content of domestic wastewater include Chemical Oxygen Demand (COD), Biological Oxygen Demand, Total Organic Carbon (TOC) and Total Oxygen Demand (TOD). Inorganic chemical parameter includes: alkalinity, salinity, hardness, acidity as well as concentrations of cations such as Manganese, Iron and anions such as sulfates, chlorides, nitrates and phosphates. Bacteriological parameters include faecal coliforms, coliforms, algae, protozoas, specific pathogens and viruses (Ezugwu and Osarumwense, 2022). Management of wastewater involves identifying the source and type of wastewater, ways in which it can be harnessed for potential reuse and ways in which the potential risk posed by wastewater

can be eliminated or reduced. Major challenges faced by wastewater management include infrastructure, pollution of water bodies and choice of appropriate technology, sludge production and reuse. Hence, the objective of this paper was to assess physicochemical properties of wastewater in Alkalawa, Ajiya, Doubeli, Jambutu and Rumde at Yola North, Adamawa State, Nigeria

MATERIALS AND METHODS

Study Area: The area of the study was in Yola North local government area. Yola North is one of the 21 local government areas in Adamawa State. It lies between latitude 09°13'N and 09°20'N and longitude 12°20'E and 12°30'E (Figure 3.1). Yola North has 11 wards namely: Alkalawa, Ajiya, Doubeli, Gwadabawa, Jambutu, Karewa, Limawa, Nassarawo, Rumde and Yelwa Wards. Yola North is served by the port of Jimeta (5.5 miles [9km] north-northwest) on the Benue River, about 500 miles (800km) above its confluence with the Niger and by an airfield. Yola has a road connection with Numan, Jalingo, Ganye, Fufore and Jimeta (Mayomi *et al.*, 2013). Yola North has an area of 714.8km, a population density of 393.7/km and an estimated population of 281, 435 (Sahabo and Mohammed, 2016)

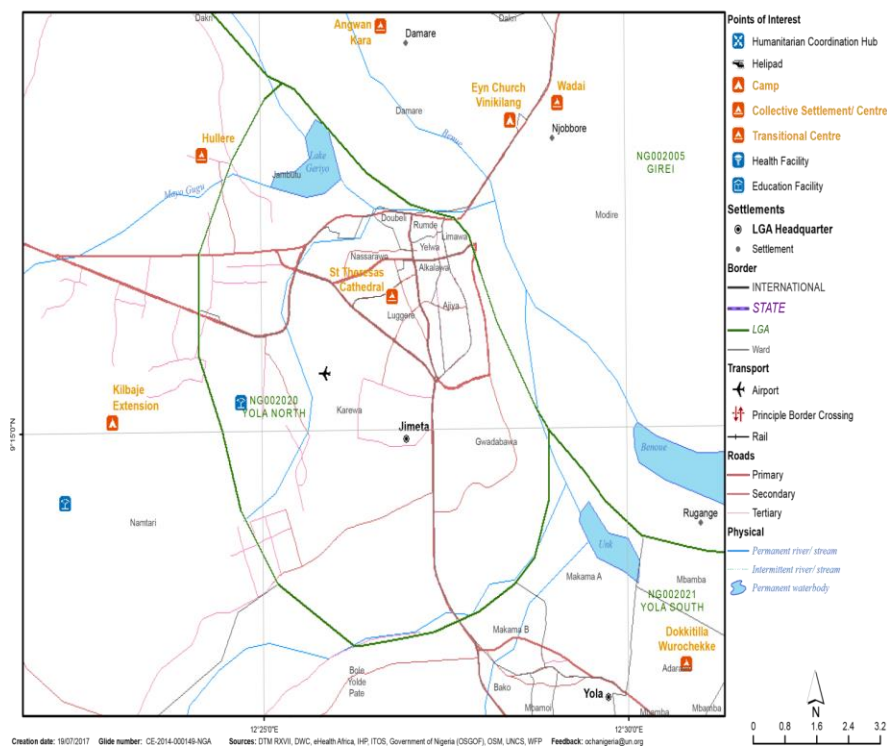


Fig 1: Map of Yola North showing the various wards (OCHA, 2017)

Method of data collection: Wastewater samples were collected from different sources; stagnant water pools, car wash drainage, laundry areas, drainages, wastewater from washing dishes from the study area. Samples were collected in sterile 250ml plastic bottles in triplicates following specific guidelines to avoid contamination and the sample collected for each location was immediately labelled. After sample collection, the wastewater samples were preserved and transported to the laboratory for analysis following safety guidelines to avoid contamination.

RESULTS AND DISCUSSIONS

Physicochemical Properties of Wastewater: Table 1.0 shows the physicochemical properties of wastewater samples collected from 5 different locations within the study area over a period of three months. The pH values of the wastewater samples varied across locations and months. pH values ranged from 5.65 to 7.59. The highest pH was recorded at Jambutu (7.59) while Rumde (6.90), Ajiya (6.76) and Alkalawa (6.69) were slightly acidic. Doubeli measured 6.53. January exhibited a decrease in mean pH to 6.55 ± 0.80 , with a wider range of 5.53 to 7.92. Rumde recorded the highest pH (7.21), a significant increase from December. Ajiya (6.89), Jambutu (6.71) and Doubeli (6.56) were close to neutral and Alkalawa (5.82) showed more acidic conditions. February showed an increase in mean pH to 7.20 ± 0.57 , ranging from 5.65 to 8.04. Ajiya recorded the highest pH (7.54). Doubeli (7.32) and Jambutu (7.28) were also on the alkaline side. Rumde (6.66) was close to neutral. Alkalawa showed the most acidic conditions this month (5.65). The electrical conductivity showed notable variations across locations and months. In December, the EC values ranged from 0.57 to 0.82 mS/cm. The highest EC was recorded at Doubeli (0.82 mS/cm) followed by Alkalawa. 0.71 mS/cm. Jambutu, 0.58 mS/cm. Rumde measured 0.42 mS/cm, while Ajiya (0.38 mS/cm). January exhibited a slight increase in mean EC to 0.62 ± 0.15 mS/cm, with a range of 0.57 to 0.72 mS/cm. Alkalawa recorded the highest EC (0.72 mS/cm), followed by Jambutu (0.71 mS/cm). Ajiya and Doubeli had similar values of 0.59 and 0.56 mS/cm respectively. Rumde maintained its EC at 0.56 mS/cm. February showed a slight increase in mean EC to 0.64 ± 0.11 mS/cm, ranging from 0.57 to 0.81 mS/cm. Jambutu and Rumde shared the highest EC (0.81 mS/cm), followed Ajiya 0.65 mS/cm. Alkalawa decreased to 0.59 mS/cm and Doubeli recorded 0.57 mS/cm. The dissolved oxygen levels in the wastewater samples varied widely across locations and months. In December, DO values ranged from 5.52 to 9.29 mg/L. The highest DO concentration was recorded at Alkalawa (9.29 mg/L), followed by Doubeli (7.98

mg/L). Jambutu showed a value of 7.69 mg/L. Ajiya measured 7.49 mg/L. Rumde had a reading of 7.11 mg/L. January exhibited an increase in mean DO to 8.95 ± 2.55 mg/L, with a wider range of 5.52 to 12.23 mg/L. Jambutu recorded the highest DO (12.23 mg/L), closely followed by Alkalawa (12.01 mg/L). Rumde measured 6.51 mg/L. Ajiya decreased to 6.14 mg/L. Doubeli recorded the lowest DO value this month at 4.85 mg/L respectively. February showed a slight decrease in mean DO to 8.21 ± 1.87 mg/L, ranging from 5.52 to 11.44 mg/L. Jambutu maintained the highest DO (11.44 mg/L), Doubeli recorded a value of 8.37 mg/L. Alkalawa decreased to 7.89 mg/L. Rumde measured 6.73 mg/L, Ajiya slightly decreased to 5.52 mg/L. The alkalinity values of the wastewater samples showed less variation compared to other parameters. In December, alkalinity values ranged from 0.94 to 1.52 mg/L, with a mean of 1.11 ± 0.20 mg/L. The highest alkalinity was recorded at Alkalawa (1.52 mg/L), followed by Ajiya (1.32 mg/L), Doubeli (1.07 mg/L). Rumde had a value of 1.01 mg/L. Jambutu (0.98 mg/L) showed the lowest alkalinity level for this month. January exhibited a slight decrease in mean alkalinity to 1.01 ± 0.23 mg/L, with a range of 0.94 to 1.25 mg/L. Alkalawa recorded the highest alkalinity (1.25 mg/L), followed by Jambutu (1.23 mg/L). Doubeli recorded 0.99 mg/L. Rumde and Ajiya all showed the lowest values this month at 0.74 and 0.72 mg/L respectively. February showed a slight increase in mean alkalinity to 1.10 ± 0.19 mg/L, ranging from 0.94 to 1.53 mg/L. Jambutu recorded the highest alkalinity (1.53 mg/L), followed by Doubeli (1.32 mg/L). Rumde measured 1.13 mg/L, while Alkalawa showed 1.14 mg/L. Ajiya showed a value of 0.94 mg/L. The parameters are significantly different across the group ($P < 0.05$). Physicochemical properties collected across the three months are not significantly different ($P > 0.05$) while physico chemical properties across the different sites are not significantly different ($P > 0.05$)

Physicochemical Properties of Water Samples: The physicochemical properties of water samples, including pH, electrical conductivity (EC), dissolved oxygen (DO) and alkalinity, are crucial indicators of water quality and potential environmental impacts (Rahman *et al.*, 2021). The observed variations in these parameters across sites and months highlight the complex nature of water quality dynamics in the study area. The wastewater samples exhibited a wider range of pH values, from acidic (5.20) to alkaline (8.04) conditions. This variability can be attributed to various factors, including the nature of industrial and domestic effluents, as well as biological and chemical processes occurring in the wastewater (Iloms *et al.*, 2020). Extreme pH values, either too acidic or too

alkaline, can have detrimental effects on aquatic life and can also impact the efficacy of wastewater treatment processes (Boyd *et al.*, 2016). Electrical conductivity (EC) which is a measure of the dissolved ionic content, showed notable variations across locations and months for the wastewater samples. High EC values can indicate the presence of dissolved salts, minerals, or contaminants, which may pose risks to aquatic ecosystems and human health

(Singh *et al.*, 2020). The observed EC levels in some locations, warrant further investigation into the sources of ionic contaminants and their potential impact on water quality and aquatic life. The electrical conductivity of the water samples was within the range of 0.31mS/cm to 1.08mS/cm within the range set by the WHO which is <400 and Murtala *et al* found similar result.

Table 1. Physicochemical properties of wastewater samples from Yola North and Yola South.

		Alkalawa	Ajiya	Doubeli	Jambutu	Rumde	WHO limit
Ph	Dec	6.69	6.76	6.53	7.59	6.90	6.5 - 8.5
	Jan	5.82	6.89	6.56	6.71	7.21	6.5 - 8.5
	Feb	5.65	7.54	7.32	7.28	6.66	6.5 - 8.5
EC (mS/cm)	Dec	0.71	0.38	0.82	0.58	0.42	<400
	Jan	0.72	0.59	0.56	0.71	0.56	<400
	Feb	0.59	0.65	0.57	0.81	0.81	<400
DO (mg/L)	Dec	9.29	7.49	7.98	7.69	7.11	>5
	Jan	12.01	6.14	4.85	12.23	6.51	>5
	Feb	7.89	5.52	8.37	11.44	6.73	>5
AL (mg/L)	Dec	1.52	1.32	1.07	0.98	1.05	0.5–24.5
	Jan	1.25	0.72	0.99	1.23	0.74	0.5–24.5
	Feb	1.14	0.94	1.32	1.53	1.13	0.5–24.5

EC= Electrical conductivity; DO= Electrical conductivity; DO= Dissolved oxygen; AL= Alkalinity; WHO= World Health Organization; For Parameter $f(3,105)=381.69; P=0.000; P<0.05$; For Month $f(2,105) = 1.01; P=0.367; P>0.05$; For the Location $f(9,105)=1.52; P=0.152; P>0.05$

Dissolved oxygen (DO) levels are crucial for sustaining aquatic life and facilitating biological processes in water bodies (Singh *et al.*, 2020). The wide range of DO values observed in the wastewater samples could be attributed to the varying levels of organic matter, temperature and biological activity in the water bodies receiving the wastewater. Low DO levels, as observed in some locations (Ajiya, 4.85 mg/L), can lead to eutrophication and the depletion of aquatic ecosystems. Maintaining adequate DO levels in wastewater is essential to support aerobic biological treatment processes and ensure the survival of aquatic organisms in receiving water bodies (Hanjaniamin *et al.*, 2023). Alkalinity, which reflects the buffering capacity of water, exhibited relatively consistent values across locations and months, indicating a stable buffering system in the study area. However, it is essential to consider the potential impacts of alkalinity on water treatment processes and the solubility of certain contaminants. High alkalinity levels can interfere with coagulation and disinfection processes in water treatment, while low alkalinity can lead to corrosion in distribution systems (Zhang *et al.*, 2021). This is consistent with the findings of Eric and Catherine, 1997. The observed variations in physicochemical properties highlight the need for regular monitoring and site-specific water quality assessments to ensure effective water resource management and environmental protection in the study area. Maintaining appropriate

pH, EC, DO and alkalinity levels is essential for supporting aquatic life, ensuring the efficiency of water treatment processes and mitigating potential adverse impacts on human health and the environment (Kulabako *et al.*, 2010; Singh *et al.*, 2020).

Conclusion: This comprehensive study has shed light on the pressing issues of wastewater management challenges in the study area. The prevalent inadequate waste disposal practices and lack of awareness regarding the effects of wastewater worsen these concerns. Urgent interventions, including effective waste management strategies, pollution control measures, remediation efforts, public education campaigns and infrastructure improvements, are crucial to mitigate these risks and protect public health and the environment. Collaborative efforts involving government agencies, non-governmental organizations and local communities are vital to develop and implement sustainable solutions to these pressing challenges.

Declaration of Conflict of Interest: The authors declare that no known conflict of interest or personal relationships that could have influence the work reported in this paper

Data availability statement: data are available upon request from the first author or the corresponding author

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