

Water Quality Index and Bacteriological Composition of the Donga River in Nigeria

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ABSTRACT

Human health is of importance and getting clean drinking water has been a challenge for the third world population. River Donga serves as a water source to many households of Donga town despite its contamination. The sample collection was done in three phases from river Donga; the physical characteristics of the samples were taken to include: pH, temperature, turbidity. Bacterial cultures were carried out using MacConkey and Nutrient agar. Biochemical test which includes; catalase, indole and gram staining was done. The pH ranges from 7-8 which is neutral to slightly alkaline, temperature range of 31-32 degrees celcius, total dissolve solute ranging from 45-65 Nephelometric Turbidity Unit (NTU). The water samples show characteristics like colourless, odourless and particles present. There was significant bacteria growth on both the nutrient agar and the MacConkey agar with several colony forming units observed ranging from 1-272 units. The bacteria identified include: *Salmonella spp*, *Staphylococcus spp*, and *Escherichia coli* which some of the bacteria are gram positive while some are gram negative. This study observed the presence of pathogenic bacteria in the river Donga, which the population can be advised to use alternative water sources for domestic purposes to be able to curb public health challenges.

Keywords: River, Donga, bacteria, water, MacConkey

INTRODUCTION

Safe drinking water is crucial for human health; contaminated drinking water can cause major health problems (WHO, 2004). The availability of clean water is taken for granted by the inhabitants of industrialized nations, but the requirement to ensure the wholesome good quality of drinkable water necessitates constant monitoring from water delivery corporations, which is monitored by public health officials (Geldreich, 2010).

The public health importance of water quality cannot be overstated. Numerous infectious illnesses are disseminated by water through the faecal-oral pathway. Waterborne diseases result in the deaths of approximately 5 million children each year and afflict one-sixth of the global population (WHO, 2004). Water is essential for our survival, and its significance in daily life necessitates comprehensive microbiological and physicochemical analyses of water. Water quality has emerged as a global issue (Ibisch *et al.*, 2016).

The contamination of surface and groundwater primarily stems from the swift pace of urban development and industrial growth (Fathi *et al.*, 2022). The extensive urban expansion driven by population growth or the migration of individuals from rural to urban settings has led to a rise in domestic effluents, while industrial progress has produced a significant volume of industrial effluents. Consequently, the progressive decline in water quality can be attributed to the rise in human population and urban development (Meenar *et al.*, 2020). Contaminated water serves as a

significant medium for the transmission of diseases. In developing nations, 1.8 million individuals, predominantly children, succumb annually to water-related illnesses (WHO, 2004).

The assessment of microbiological quality in river water, in accordance with technical standards, is essential for various applications, including drinking water, irrigation, and recreational purposes. The presence of pathogenic microorganisms in a water body can indicate higher levels of faecal bacteria (Hossain *et al.*, 2019). Cholera, dysentery, typhoid fever, and hepatitis represent a few of the prevalent diseases transmitted via contaminated water sources. Contaminated water can lead to infections in the eyes, ears, nose, and throat. Indicator bacteria such as total coliforms, faecal coliforms (thermotolerant coliforms), *E. coli*, and Faecal Streptococci (intestinal enterococci) are released by humans and warm-blooded animals. These bacteria can bypass sewage treatment plants in significant quantities and can persist in the aquatic environment for a certain duration (Endo *et al.*, 2020). Faecal Coli and Faecal Streptococci serve as the most commonly utilized indicator bacteria (Hall and Hoff, 2021). The rise in bacterial pollution in the river Donga is a growing concern, attributed to the continuous discharge of organic wastes, human excreta, sewage, municipal garbage, and toxic effluents from industrial sources.

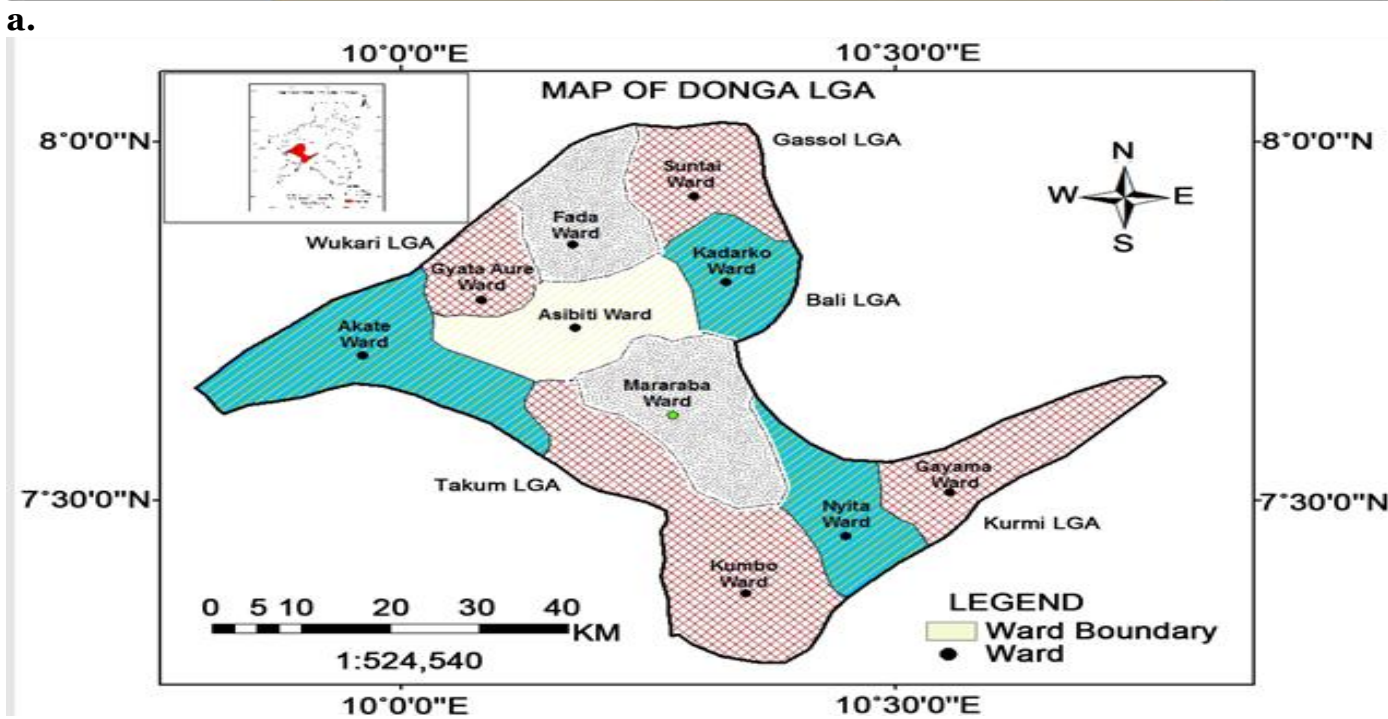
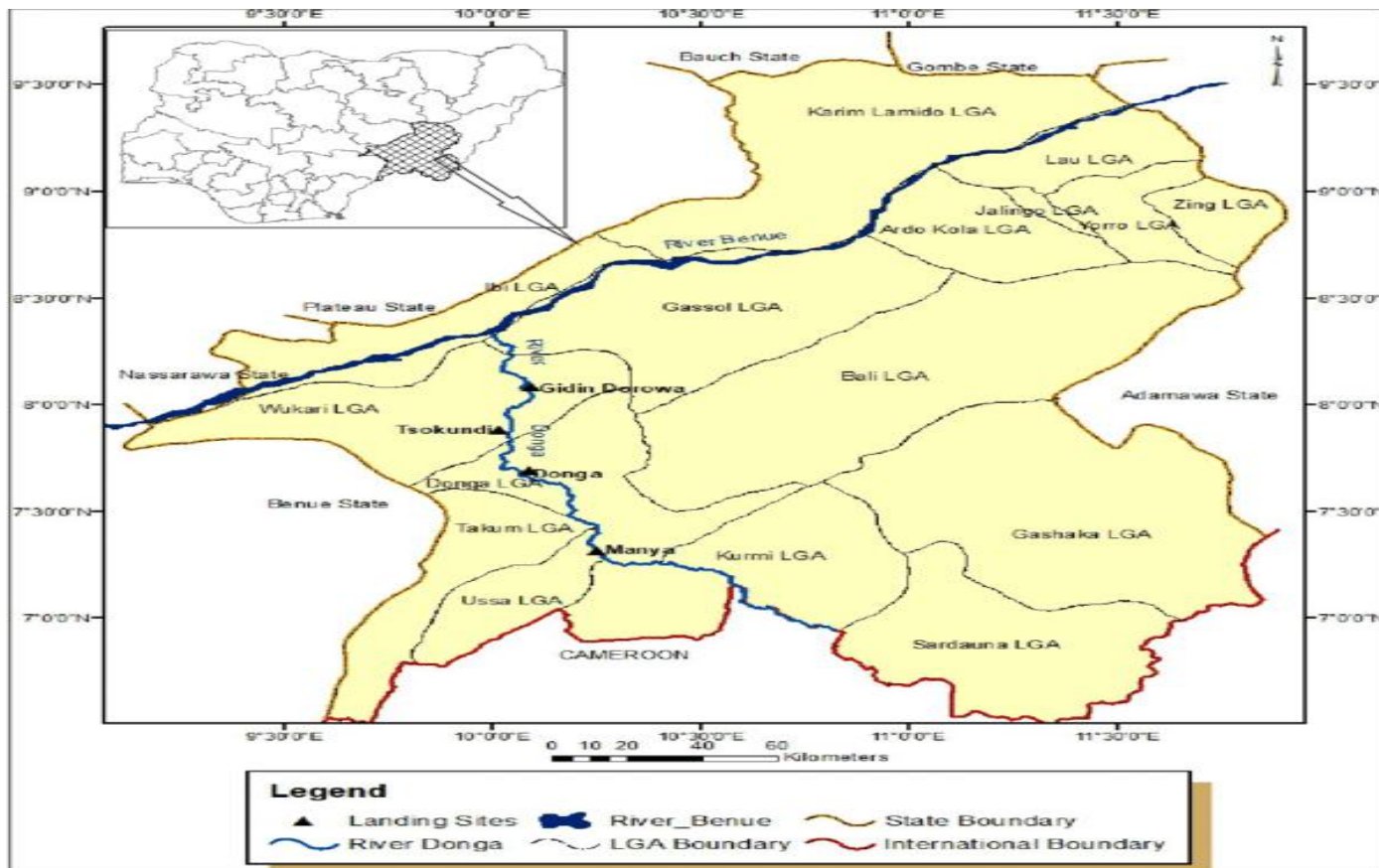
The Donga River is a river in Nigeria and Cameroon. The river arises from the Mambilla plateau in North-Eastern part of Nigeria which forms part of the international border between Nigeria and Cameroon and flows northwest to eventually merge with the river Benue. The Donga watershed is 20,000 square kilometres (7,700 sq mi) in area. At its peak, near the Benue the river delivers 1,800 cubic metres (64,000 cu ft) of water per second (Anderson *et al.*, 2008).

Donga River water is likely to get contaminated at some point as a result of human activities such as washing, defecating, and swimming. These activities are potential sources of pathogenic organisms. When water or rivers become polluted, they are no longer suitable for human eating or other household purposes. As a result, polluted rivers pose a variety of health risks. The study's goal is to evaluate the bacteria in the Donga River water in order to discover and isolate pathogenic germs.

MATERIALS AND METHOD

Study Area

Donga is situated at a latitude of 7°43'N from the equator and a longitude of 10°E from the meridian, encompassing a land area of roughly 58 square kilometers. The area is situated in southern Taraba, bordered to the Northeast by Kurmi Local Government Area, to the Northwest by Bali Local Government, to the Southwest by Wukari Local Government Area, and to the Southeast by Takum Local Government Area. Donga comprises ten political wards: Fada, GyataAure, Gindin Dutse, Mararaba, Kadarko, Akate, Suntai, Asibity, Gayama, and Nyita Ward (figure 1).



b. **Figure 1. a.** Map of Taraba state, showing River Donga, **b.** Map of Donga local government area showing the various wards (Okoli *et al.*, 2021).

Sample Collection

The collection occurred three times daily:

Initial phase: The initial collection occurred at location 1 (characterized by minimal human activities) between 5-6am, prior to the onset of human activities, and location 2 (noted for significant human activities). The bottles were designated as A1 and A2 to represent low and high levels of human activities, respectively.

Second stage: The collection occurred between 12-2pm during regular activities, from point 1 (characterized by low human activities) and point 2 (characterized by high human activities). The bottles were designated as B1 and B2, corresponding to low and high levels of human activities, respectively.

Third stage: The collection occurred between 5-6pm in the evening, a time when human activities had diminished, also considering point 1 (characterized by low human activities) and point 2 (noted for high human activities). The bottles were designated as C1 and C2 to indicate low and high levels of human activities, respectively.

Each sample was promptly transported to the laboratory upon collection. 10 ml of distilled water was carefully pipetted into each of the tubes. The process was subsequently halted using cotton wool and foil paper, with the 1ml pipette facilitating the transfer into the test tubes. The sample obtained from the river underwent incubation at 37°C for a duration of 24 hours.

Preparation of media culture

Preparation of MacConkey Agar

MacConkey agar was prepared by suspending about 50g of dehydrated powder in 1 liter of distilled water, heat to boiling to dissolve, autoclave at 121°C for 15 minutes, then cool to 45-50°C before pouring into sterile Petri dishes (MacConkey, 1905).

Preparation of Nutrient Agar

Nutrient agar was prepared by dissolving 28g of powder in 1 liter of distilled water, heating to dissolve, sterilizing in an autoclave (121°C, 15 min), cooling to about 50°C, and pouring into sterile Petri dishes under aseptic conditions (Wehr & Frank, 2004).

Physico-chemical Analysis of Samples Collected

Immediately after collection of samples, odour was recorded using the human senses. pH was determine using suntex (TS-2 pH meter). Turbidity was determined with turbidity secchi disc/tube. Chloride, Nitrate and bacteriological evaluation were done using standard methods for the examination of water and waste water as described by Hossain *et al.*, (2019).

Test for pH

A 40 ml volume of each sample was poured into a beaker, the pH meter probe was immersed in the beaker containing the sample, the device was activated, and the measurement was observed and documented under standard calibration (BenChioma *et al.*, 2015).

Test for Temperature and Turbidity

The water temperature was measured by submerging the thermometer two-thirds beneath the surface. The measurement was conducted in a centrally flowing location.

The thermometer was calibrated to the water temperature for a minimum of one minute before being swiftly removed from the water. This test was done using the secchi disc/tube.

Bacteriological Analysis

The bacteriological properties were assessed according to the methodology outlined by Bezeraj *et al.*, (2025). Nutrient agar (NA) and MacConkey agar (MA) were employed to identify heterotrophic bacteria, Salmonella, Shigella, and Vibrio cholerae, respectively. All plates were incubated at 35°C for 24 hours. Presumptive colonies were validated using gram staining and biochemical assays, with each plate assigned a positive or negative score. Isolates were validated via routine biochemical tests, SCA (2009).

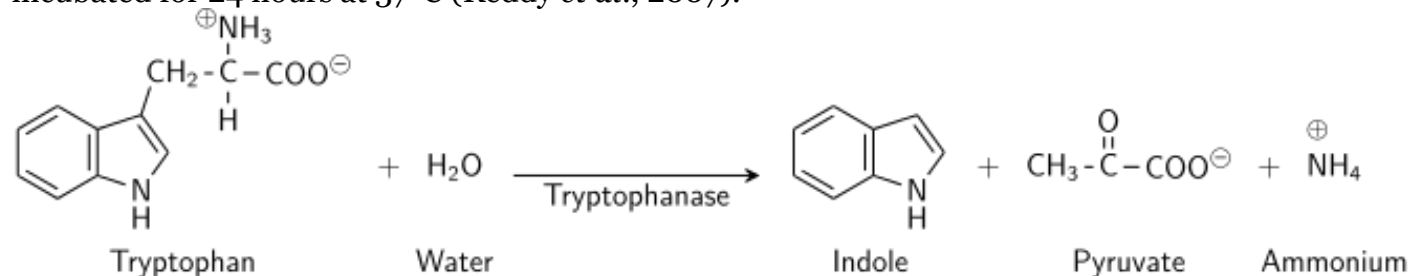
Biochemical Test

Catalase Test

A sterile wire loop was utilized to transfer a little quantity of colony growth onto the surface of a clean, dry slide. A drop of hydrogen peroxide solution was subsequently poured onto the slide and monitor for quick effervescence (Okoye *et al.*, 2024).

Indole test

This test identifies bacteria that produce the enzyme tryptophanase by breaking down tryptophan into indole. Sterilized wire loop was used to isolate a colony from a purified sub-culture, which was then inoculated into bijoux bottles. Bijou bottle carrying 3 cc of sterile peptone solution. The small vial was ignited, sterilized, securely sealed with a screw top, and appropriately labelled. It was incubated for 24 hours at 37°C (Reddy *et al.*, 2007).



Identification Method

Gram Staining

The glass slide is cleared by rapidly passing the smeared slip over a flame, followed by covering the smear with crystal violet for 30 to 60 seconds, rinsing with water, then flooding with Lugol's iodine for 20 to 60 seconds. The smear would be quickly cleaned, decolorized with 95% ethanol for 20 seconds, and subsequently counterstained with safranin for 30 seconds. The slide will be desiccated and analyzed using an oil immersion (x100) objective lens under a light microscope to identify gram-positive and gram-negative organisms (Ciaccio and Ruhe, 1973).

RESULTS

Table 1: Physical Parameter of Sample Collected from Different Locations of the River Donga

	Colour	Odour	pH	Temp. (°C)	NTU (CM)	Particle
A1 L.A Morning	colourless	Odour	7.68	32.8°C	50.00	Absent

A1 L.A afternoon	colourless	Odour	7.00	32.1°C	49.00	Absent
A1 L.A evening	colourless	Odourless	8.00	32.0°C	50.00	Present
A2 H.A morning	colourless	Odour	7.00	32.1°C	56.00	Present
A2 H.A afternoon	colourless	Odourless	7.25	32.1°C	52.00	Present
A2 H.A evening	colourless	Odour	7.62	32.1°C	55.00	Absent
B1 L.A morning	colourless	Odour	7.59	32.2°C	45.00	Absent
B1 L.A afternoon	colourless	Odour	7.00	32.0°C	50.00	Absent
B1 L.A evening	colourless	Odourless	7.00	32.0°C	47.00	Absent
B2 H.A morning	colourless	Odour	7.00	32.2°C	56.00	Present
B2 H.A afternoon	colourless	Odour	7.00	32.0°C	65.00	Present
B2 H.A evening	colourless	Odour	7.42	32.2°C	54.00	Present
C1 L.A morning	colourless	Odourless	7.59	32.2°C	45.00	Absent
C1 L.A afternoon	colourless	Odourless	7.00	32.1°C	53.00	Present
C1 L.A evening	colourless	Odourless	7.30	32.0°C	52.00	Absent
C2 H.A morning	colourless	Odourless	7.00	32.1°C	49.00	Present
C2 H.A afternoon	colourless	Odourless	7.00	32.1°C	65.00	Present
C2 H.A evening	colourless	Odourless	7.00	32.2°C	51.00	Present

Table 2: Isolated Bacteria on MacConkey Agar

Water Sample	Organism suspected	Colonies forming unit	Colour	Shape	Gram reaction
A1 L.A Morning	<i>Salmonella typhimurium</i>	272	Pale pink	Rod	-
A1 L.A afternoon	<i>Salmonella typhimurium</i>	54	Pale pink	Rod	-
A1 L.A evening	<i>Salmonella typhimurium</i>	32	Red /pink	Rod	-
A2 H.A morning	<i>Salmonella typhimurium</i>	25	Pale pink	Rod	-
A2 H.A afternoon	<i>Staphylococcus aureus</i>	32	Red/ pink	Spherical	+
A2 H.A evening	<i>Salmonella typhimurium</i>	15	Pale pink	Rod	+
B1 L.A morning	<i>Salmonella typhimurium</i>	13	Pale pink	Rod	+
B1 L.A afternoon	<i>Escherichia coli</i>	18	Pale pink	Rod	-
B1 L.A evening	<i>Salmonella typhimurium</i>	120	Pale pink	Rod	+
B2 H.A morning	<i>Salmonella typhimurium</i>	39	Pale pink	Rod	+
B2 H.A afternoon	<i>Salmonella typhimurium</i>	29	Pale pink	Rod	+
B2 H.A evening	<i>Salmonella typhimurium</i>	5	Pale pink	Rod	+
C1 L.A morning	<i>Escherichia coli</i>	41	Red/ pink	Rod	-
C1 L.A afternoon	<i>Salmonella typhimurium</i>	23	Pale pink	Rod	+
C1 L.A evening	<i>Staphylococcus aureus</i>	38	Pale pink	Spherical	+
C2 H.A morning	<i>Escherichia coli</i>	9	Red/ pink	Rod	-
C2 H.A afternoon	<i>Escherichia coli</i>	11	Red/ pink	Rod	-
C2 H.A evening	<i>Staphylococcus aureus</i>	17	Pale pink	spherical	+

TABLE 3: Isolated Bacteria on Nutrient Agar

Water Sample	Organism suspected	Colonie forming unit	Colour	Shape	Gram reaction
A1 L.A Morning	<i>Salmonella typhimurium</i>	7	Gray	Rod	-
A1 L.A afternoon	<i>Salmonella typhimurium</i>	3	Cream	Rod	-
A1 L.A evening	<i>Salmonella typhimurium</i>	6	Red /pink	Rod	-
A2 H.A morning	<i>Salmonella typhimurium</i>	2	Pale pink	Rod	-
A2 H.A afternoon	<i>Staphylococcus aureus</i>	4	Red/ pink	Spherical	+
A2 H.A evening	<i>Salmonella typhimurium</i>	1	Pale pink	Rod	+
B1 L.A morning	<i>Salmonella typhimurium</i>	11	Pale pink	Rod	+
B1 L.A afternoon	<i>Escherichia coli</i>	6	Pale pink	Rod	-
B1 L.A evening	<i>Salmonella typhimurium</i>	1	Pale pink	Rod	+
B2 H.A morning	<i>Salmonella typhimurium</i>	1	Pale pink	Rod	+
B2 H.A afternoon	<i>Salmonella typhimurium</i>	9	Pale pink	Rod	+
B2 H.A evening	<i>Salmonella typhimurium</i>	1	Pale pink	Rod	+
C1 L.A morning	<i>Escherichia coli</i>	1	Red/ pink	Rod	-
C1 L.A afternoon	<i>Salmonella typhimurium</i>	1	Pale pink	Rod	+
C1 L.A evening	<i>Staphylococcus aureus</i>	15	Pale pink	Spherical	+
C2 H.A morning	<i>Escherichia coli</i>	3	Red/ pink	Rod	-
C2 H.A afternoon	<i>Escherichia coli</i>	2	Red/ pink	Rod	-
C2 H.A evening	<i>Staphylococcus aureus</i>	1	Pale pink	spherical	+

Table 4: Biochemical Test

Water Sample	Catalase Test	Indole Test	Gram Reaction	Organism Suspected
A1 L.A Morning	+ ve	+ ve	_ ve	<i>Escherichia coli</i>
A1 L.A afternoon 1	+	_	+ve	<i>Streptococcus aureus</i>
A1 L.A afternoon 2	_	+	+ ve	<i>Streptococcus aureus</i>
A1 L.A evening	+	_	+ ve	<i>Streptococcus aureus</i>
A2 H.A morning 1	_	_	+ ve	<i>Streptococcus aureus</i>
A2 H.A morning 2	+	_	+ ve	<i>Streptococcus aureus</i>
A2 H.A afternoon 1	_	+ ve	+ ve	<i>Streptococcus aureus</i>
A2 H.A afternoon 2	+	+	+ ve	<i>Streptococcus aureus</i>
A2 H.A evening	+	+	+ ve	<i>Streptococcus aureus</i>
B1 L.A morning	_	+	+ ve	<i>Salmonella typhimurium</i>
B1 L.A afternoon 1	_	_	_ ve	<i>Escherichia coli</i>
B1 L.A afternoon 2	+	_	+ ve	<i>Salmonella typhimurium</i>
B1 L.A evening	+	+	+ ve	<i>Salmonella typhimurium</i>
B2 H.A morning 1	+	+	+ ve	<i>Salmonella typhimurium</i>
B2 H.A morning 2	+	+	+ ve	<i>Salmonella typhimurium</i>
B2 H.A afternoon	_	_	_ ve	<i>Escherichia coli</i>
B2 H.A evening	_	+	+ ve	<i>Salmonella typhimurium</i>
C1 L.A morning 1	+	+	+ ve	<i>Staphylococcus aureus</i>
C1 L.A morning 2	+	+	_ ve	<i>Escherichia coli</i>
C1 L.A morning 3	_	+	_ ve	<i>Escherichia coli</i>
C1 L.A afternoon	+ ve	+ ve	+ ve	<i>Staphylococcus aureus</i>
C1 L.A evening	_ ve	_ ve	_ ve	<i>Escherichia coli</i>
C2 H.A morning 1	+	_	+ ve	<i>Streptococcus aureus</i>
C2 H.A morning 2	_	+	+ ve	<i>Streptococcus aureus</i>
C2 H.A afternoon 1	_	_	+ ve	<i>Streptococcus aureus</i>
C2 H.A afternoon 2	+	+	+ ve	<i>Streptococcus aureus</i>
C2 H.A afternoon 2	_	_	+ ve	<i>Streptococcus aureus</i>
C2 H.A evening	_	_	+ ve	<i>Streptococcus aureus</i>

DISCUSSION

The upper reaches of streams and rivers in uplands and mountainous areas are characterized by factors such as shallow water, low temperature, fast flow, high saturation with oxygen, exposed rocks and a relatively large splash zone. The River Donga has such characteristics (Table 1) which is typical of fresh water bodies of being colourless at all the sample locations, and time. Though slight turbidity was observed. In some sample locations, odour was perceived, which could be due to the waste dumped into the water bodies and decaying organic matter. pH is nearly neutral with slight fluctuations at some sites which could be as a result of the dissolved solutes. The temperature is almost at the body's physiological temperature of 37 degrees centigrade, which could be due to the warm and cold currents. These near perfect physiological conditions could account for the fauna and flora of flowing (lentic) systems which is characterized by significant species diversity (Moiseenko, 2009).

There were growths observed (Table 2), organisms isolated include; *Salmonella typhimurium*, *Staphylococcus aureus*, *Escherichia coli* which is an indication of microbial communities in terrestrial fresh water which are diverse and dynamic in composition due to different environmental factors (Ibekwe *et al.*, 2016). The different microorganism (bacteria) suspected in these water samples is as a result of the free-flowing nature, and human activity on the river which supports microbial growth. The bacteria were either gram positive or gram negative (Table 3). Biochemical test confirmed the presence of the various microorganisms (Table 4), after been sub-cultured (Frank-Ogu *et al.*, 2023) which include *Salmonella spp.*, *Escherichia coli*, *Staphylococcus aureus*.

CONCLUSION

The findings from the results shows that River Donga has a lot of commensal and pathogenic bacteria, which can affect human health. This is why effort should be made to avoid contamination or be affected by this pathogenic organism. It also shows that various microbes (bacteria) have different degree of affinity for different substrates e.g. the greater number shown by *streptococci faecalis*, *salmonella spp* and *chostridium perfringens*. These bacteria colonies are high in areas of high human activities which favours their survival. The pathogenic organisms appear most in the afternoon when the river is busy. People who use the water for drinking and other domestic purpose are advised to fetch in the morning before the level of microbial contamination increases during the day. Appropriate measures should be made and adopted by the community that are making use of this river to avoid contamination of the river, particularly dumping of refuse, defaecating and channeling of sewage into the river body.

CONFLICT OF INTEREST

The authors declare there is no conflict of interest

REFERENCES

- Andersen, I., & Golitzen, K. G. (Eds.). (2005). *The Niger river basin: A vision for sustainable management*. World Bank Publications.
- Andrew, C., Aremu, M. O., Oko, O. J. and Shenge, G. A. (2017). Seasonal Analysis of Water Quality In Two Settlements Of Wukari Local Government Area, Taraba State, Nigeia. *FUW Trends in Science & Technology Journal*, 02: 613 – 617.

- Ben Chioma, A. E., Jack, A. S., & Philipokere, G. K. (2015). A comparative study on the measurement of pH of water, using pH metre and water testing kit [test tube method] in port harcourt. *International Journal of Applied Chemistry*, 1(3), 1-5.
- Bezeraj, E., Debrie, S., Arraez, F. J., Reyes, P., Van Steenberge, P. H., D'hooge, D. R., & Edeleva, M. (2025). State-of-the-art of industrial PET mechanical recycling: technologies, impact of contamination and guidelines for decision-making. *RSC Sustainability*, 3(5), 1996-2047.
- Ciaccio, L. L., & RUHE, R. (1973). Water and water pollution handbook. *Soil Science*, 116(6), 453-454.
- Endo, A., Yamada, M., Miyashita, Y., Sugimoto, R., Ishii, A., Nishijima, J., ... & Qi, J. (2020). Dynamics of water–energy–food nexus methodology, methods, and tools. *Current Opinion in Environmental Science & Health*, 13, 46-60.
- Fathi, P., Ebrahimi Dorche, E., Zare Shahraki, M., Stribling, J., Beyraghdar Kashkooli, O., Esmaeili Ofogh, A., & Bruder, A. (2022). Revised Iranian Water Quality Index (RIWQI): a tool for the assessment and management of water quality in Iran. *Environmental Monitoring and Assessment*, 194(7), 504.
- Food and Agriculture Organization (FAO) (2002): *Chemical analysis manual for food and water*. 5th Ed. FAO ROME 1: 20-26.
- Frank-Ogu, N., Ogbulie, J. N., Okorundu, S. I., & Akujobi, C. (2023). Assessment of physiochemical properties and bacteriological diversity of Otamiri river in Owerri eastern Nigeria. *World J. Adv. Res. Rev*, 18(03), 430-445.
- Geldreich, E. E. (1990). Microbiological quality of source waters for water supply. In *Drinking water microbiology: Progress and recent developments*, New York, NY: Springer New York. pp. 3-31.
- Hall, C., & Hoff, W. D. (2021). *Water transport in brick, stone and concrete*. CRC Press.
- Hossain, M. B., Islam, M. N., Alam, M. S., & Hossen, M. Z. (2019). Industrialisation scenario at Sreepur of Gazipur, Bangladesh and physico-chemical properties of wastewater discharged from industries. *Asian J Environ Ecol*, 9(4), 1-14.
- Ibekwe, A. M., Ma, J., & Murinda, S. E. (2016). Bacterial community composition and structure in an Urban River impacted by different pollutant sources. *Science of the Total Environment*, 566, 1176-1185.
- Ibisch, R. B., Leidel, M., Niemann, S., Hornidge, A. K., & Goedert, R. (2016). Capacity development for integrated water resources management: lessons learned from applied research projects. In *Integrated water resources management: concept, research and implementation* (pp. 335-373). Cham: Springer International Publishing.
- MacConkey, A. (1905). Lactose-fermenting bacteria in faeces. *Epidemiology & Infection*, 5(3), 333-379.
- Meenar, M., Howell, J. P., Moulton, D., & Walsh, S. (2020). Green stormwater infrastructure planning in urban landscapes: Understanding context, appearance, meaning, and perception. *Land*, 9(12), 534.
- Moiseenko, T. I. (2009). Biological properties of freshwater bodies. *Types and Properties of Water-Volume II*, 80.
- Odeyemi, D. F., Ogunniran, A. O., Omode, T. S., Ayeni, I. E., & Fagbure, A. F. (2024). Assessment of water quality from selected borehole locations in Ado Ekiti, Ekiti State, Southwest Nigeria. *World Journal of Advanced Research and Reviews*, 21(2), 1161-1170.
- Okoli, E. C., Olawale, O., Abah, M., Emmanuel, O. P., Bando, D. C., & Shenia, Z. H. (2021). Ecological risk assessment of pesticide residues in fish samples from river

- donga in Donga, Taraba state, nigeria. *International Journal of Biochemistry, Bioinformatics and Biotechnology Studies*, 6(2), 1-8.
- Okoye, E. C. S., Egudu, N. A., Dibua, N. A., & Okoye, L. C. (2024). Seasonal variation and antibiotic susceptibility patterns of bacteriological parameters in groundwater sources in Oyi LGA, Anambra State, Nigeria. *Journal of Advances in Microbiology*, 24(5), 40-55.
- Oluyemi, E. A., Adekunle, A. S., Adenuga, A. A. and Makinde, W. O. (2010). Physico-chemical properties and Heavy Metal content of water sources in Ife North Local Government Area of Osun State, Nigeria. *African Journal of Environmental Science and Technology*, 4(10): 691-697.
- Oyatayo, K. , Songu, G. , Adi, T. , Jidauna, G. and Ndabula, C. (2016) Assessment of People's Awareness and Perception of Flooding in Donga Town, Taraba State, Nigeria. *Journal of Geoscience and Environment Protection*, 4, 54-62. doi: [10.4236/gep.2016.45006](https://doi.org/10.4236/gep.2016.45006).
- Reddy, C. A., Beveridge, T. J., Breznak, J. A., & Marzluf, G. (Eds.). (2007). Methods for general and molecular microbiology. *American Society for Microbiology Press*. 7th Ed. Pp 365
- Shittu, O. B., Olaitan, J. O. and Amusa, T. S. (2008). Physico-Chemical and Bacteriological Analyses of Water Used for Drinking and Swimming Purposes in Abeokuta, Nigeria. *African Journal of Biomedical Research*, 11, (1119 – 5096): 285 – 290.
- Standing Committee of Analysts (2009). The microbiology of drinking water. Part 1- Water quality and public health methods for the examination of waters and associated materials. Environment Agency. <http://www.environmentagency.gov.uk/commondata/105385/>
- Wehr, H. M., & Frank, J. F. (Eds.). (2004). Standard methods for the examination of dairy products. *American Public Health Association*, 5th Ed. Pp 276
- World Health Organization. (2004). *Guidelines for drinking-water quality* (Vol. 1). World health organization.