

INVESTIGATING MICROBIAL LOADING ALONG THE FLOODPLAIN OF RIVER BENUE AT YOLA, NIGERIA

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ABSTRACT

Microbial loading is a challenge in seasonal variations of Total coliform count (TCC), Faecal coliform count (FCC) and Escherichia coliform (E.coli) in surface water along the River Benue floodplain Yola. The microbial loadings were determined using Membrane Filtration (MF) medium, m-ColiBlue24 Broth. Analytical findings revealed that the water was polluted with FCC and E.coli which were more during the rainy season than the dry season. It was also discovered that the pH of the water in the rainy season was (3.9), soil (4.6), while in the dry season water the pH of water was (5.3), soil (6.9) which showed that the floodplain was more acidic in the rainy than dry season. This affirmed that humid environment favour pathogen survival, dry environment facilitates pathogen die-off. Acidic environments (soil/water) favour longer survival of pathogens while alkaline environments were associated with rapid die-off. The leafy vegetable also accumulated these microbes in the study area. This implies that long consumption of leafy vegetable from this area most especially in the dry season especially vegetables that can be eaten raw is unsafe. Statistically it was also proven that there is significant difference in the bacterial accumulation in soil and crops grown in the dry and rainy season in the study area. Regular monitoring and further research is recommended to prevent build up of microbes in food chain.

Keywords: Floodplain, microbial, Benue river, Loadings, coliform

1 INTRODUCTION

Pathogenic microorganisms associated with irrigation water include bacteria, viruses and parasites (protozoa and helminthes). This research focused on pathogenic bacteria loadings in River Benue floodplain at Yola which supplies most vegetables and fresh fruits used by the people. However, the presence of other disease causing microbes in water is unhealthy and even life threatening. For example, bacteria that live in the intestinal tracts of humans and other warm blooded animals, such as Escherichia coli, salmonella, shigella and vibrio, can contaminate water if faeces enter the water [1]. The use of untreated groundwater was responsible for more than one-third of the waterborne disease outbreaks. The major sources of pathogens are wastewater effluents, residual sludge from waste treatment plants, septic tank effluents and floodplains where contaminated water is being used. The major contributors to the contamination of subsurface environments are household chemicals (nitrate, heavy metals, and organic toxicants), pathogenic microorganisms and parasitic cysts. The quality of water, whether used for domestic purposes, food production or recreational purposes has an important impact on health as reported by World Health Organization [2]. The fate of pathogenic microorganisms in soils and aquifer material is primarily governed by their transport and persistence in these environments. The survival and transport of pathogens in soils and aquifers are controlled by four major factors: climate (e.g. temperature, rainfall), type of soil or aquifer material

(texture, pH, water holding capacity, cation exchange capacity), properties of pore fluids (e.g. chemistry, saturation), and type of pathogen [2]. Bacterial transport through absorption fields of septic tanks is controlled by soil porosity and the degree of saturation with water. Under saturated conditions bacteria may be transported over much greater distances than under unsaturated conditions. Studies have shown that pathogen transport through soil is promoted by heavy rainfall, and bacterial contamination of wells was found to coincide with periods of heavy rainfall. Rainfall generally lowers the ionic strength of the pore fluid and thus promotes bacterial transport through soils. Laboratory experiments with sludge-soil mixtures challenged with bacterial indicators, total coli-forms (TC) and faecal coli-form (FC), have shown that only heavy rainfall (12.3 cm/day) promotes significant downward transport of the bacteria to the bottom of the 8 inch-deep column. Bacteria are a type of living organisms of biological cells, few micrometers in length having a number of shapes ranging from spheres to rods and spirals. They were among the first life forms to appear on earth, and are present in most habitats. They inhabit soil, water, hot springs, radioactive waste and the deep portions of Earth crust. Their loading in the subsurface is more complex than is the case for abiotic colloids. A floodplain is a flat area covered with very rich fertile alluvium soils mostly along river banks containing fine sediments deposited by flood waters. This makes floodplains a good place for agriculture. A build-up of alluvium on the banks of a river can create levees, which raise the river bank. In Adamawa State, such alluvial formations are found along River Benue floodplains, where most of the farmers practice irrigation during the dry season period [3]. Bacteria are found almost everywhere in the environment including soil, water, plants, animals and humans; hence there is a need to undertake this research to monitor their loading areas so as to remediate them by planting remediating plants. River Benue is one of the major Rivers in Nigeria. The river passes through many states in Nigeria (Adamawa, Taraba, Nassarawa, Benue and Kogi). River Benue is the largest tributary of River Niger. Over the years the river is being silted thereby creating more floodplains and the floodplain of Yola is one of such. With the increase of the floodplain land use, anthropogenic activities have increased with people parking sand, practicing irrigation, and building residential houses along it. Wastewater from Jimeta metropolis into this floodplain aids movement or loading of bacteria in water and soil; River Benue being main source of water recharge especially during dry season and the same water is being used for irrigation activities poses health risks to the growing population. Large population depends on this river and the floodplain for source of living. Therefore there is also a need to bring out the microbial health risks posed by bacterial loading along the flood plain where farming activities take place during rainy and dry seasons along the floodplain. Sewage discharges are also received in this area along with rampant dumpsites and indiscriminate open defecations happening in the area which can trigger out breaks of waterborne diseases. Therefore, to investigate microbial loadings so as to reduce health risk is very important especially along the Benue floodplain which is the immediate environment close to it.

2 MATERIALS AND METHODS

2.1 The Study Area

The study area is River Benue floodplain of Yola, the immediate environment before the Jimeta Bridge by the left hand while coming out of Jimeta main town along bye-pass road popularly known as Goruba irrigation area down to Lake Geriyo irrigation project in Jambutu area. Jimeta-Yola lies on an elevation range of 400 to 700 m above the sea level (MSL). 400 to 550 m elevation occupies an area of 141,889 hectares and was considered as a floodplain [4]. Jimeta and Yola are gap towns which are situated at a point where the Benue River carves its valley through the eastern highlands. The study area falls within the Benue trough which is generally a low lying flat terrain of 183.3-200 meters above sea level with gentle undulation and hill ranges punctuating the extensive flat floodplain at various locations notably across the river from Jimeta eastward [5]. Alluvial formations are found along River Benue floodplain, where most of the farmers practice irrigation during dry season period. Alluvial soil is typically a variety of materials, including fine particles of silt and clay and larger particles of sand and gravel. The study area is characterized by broadly flat topography with gentle undulations and hill ranges largely drained by the Benue River (Figure 1). The river alluvium belongs to the quaternary age and is found along the main course of the Benue river and extends

towards the north east and southern parts of the study area underlined by the AlbianBirma Sandstone being the oldest formation in the Upper Benue trough overlying the basemen complex [6].

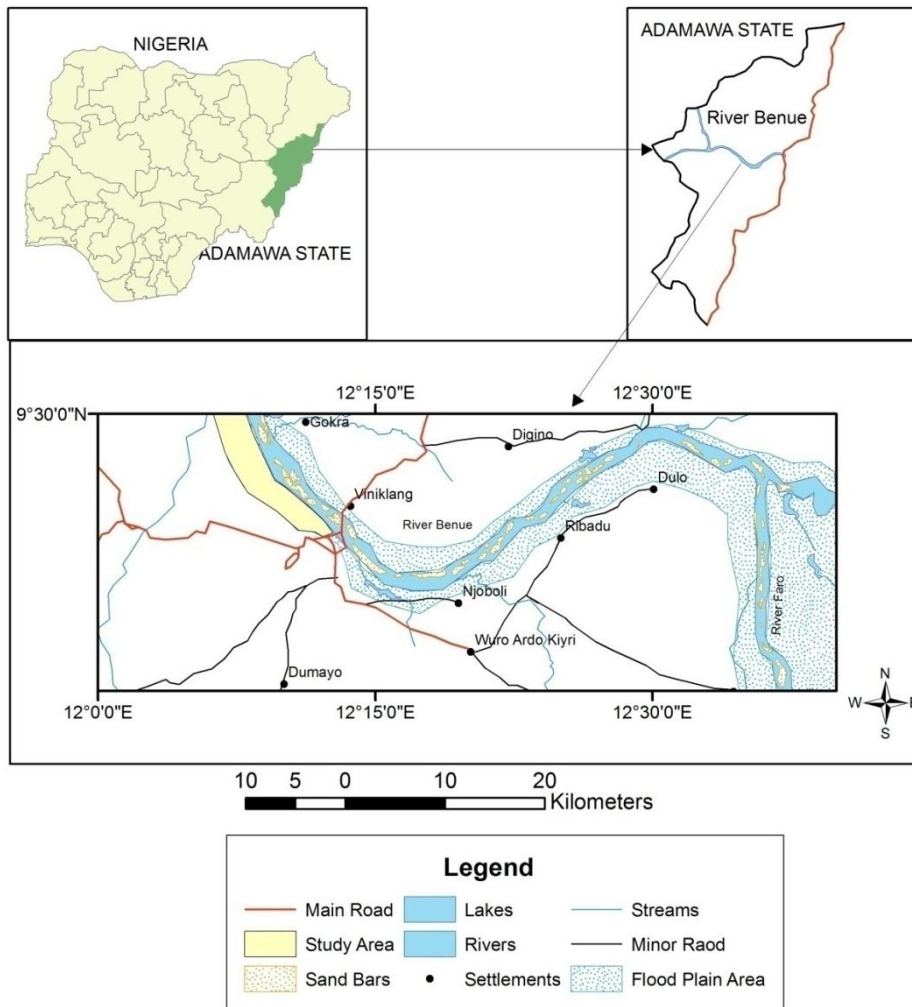


Figure 1. Map of Upper River Benue Showing Study Area

2.2 Materials and Chemicals

The following materials and equipment were used during the research: Dilution tubes, 10, 1.0 and 0.1 ml pipettes, Water samples, Incubator, Lactose broth tubes, EMB agar plates, Nutrient agar slants, Soil samples, Hydrochloric acid, Atomic Absorption Spectrophotometer (AAS VGB210 model), Sieves, Polythene bags, Plastic buckets and Soil Augers.

2.3 Experimental Design

The research design adopted is an experimental design, whereby soil and water samples were collected within the study area mapped out. Purposive sampling technique was adopted because the sampling sites were purposively for this research. The control was the standard by [7] for microbial water and soil quality. The parameters were *E. coli* and faecal coliform for water samples because *E. coli* was considered to be the best of coliform bacteria that is best indicator of faecal pollution and the possible presence of pathogen.

2.4 Sampling procedure

Determination of Physicochemical properties of soil: The soil pH was determined with digital electrometric pH meter well calibrated using buffers pH 4.0, 7.0 and 10.0 and the electrode immersed in 1:1 soil/water solution by weight. Organic matter was determined using the chromic acid oxidation

method [8]. The textural class of the soil was determined using [9] Soil Textural Triangle. Determination of microbial water quality: Water samples were collected along a section of the River Benue floodplain (from the Jimeta Bridge, Goruba irrigation area down to Geriyo junction which involved a field study distance of two kilometers. The water sample was collected from the surface water used for irrigation supplement during the wet season (July-August, 2020) and the dry season (February-March, 2021). Membrane Filtration method was used to investigate the microbial loadings (E.coli, faecal coliform count (FCC) and Total coliform count (TCC) were investigated in the water samples collected in the identified 8 major drains discharging wastewater and other effluents from the city into the floodplain and was being used for irrigation in the dry season and as supplement in the rainy season.

2.5 Statistical Analysis

The data obtained from the field were analyzed using Microsoft Excel (T-test) which allowed determination of differences between samples whether they were simply due to random error (sampling errors) or whether there were systematic treatment effects that causes the mean in one sample to differ from the mean of another. The mean values from the data obtained were then used to compare the results with other approved standards of [10].

3 RESULTS AND DISCUSSION

3.1. Microbial loadings count laboratory results

The results of microbial loadings can be observed from Tables 1 and 2 for the wet and dry seasons. The study revealed that the values of coliform counts in cfu/100mL for wet season and dry seasons were 1046(TCC), 460 (FCC), 199 (E_{coli}) and 353 (TCC), 179 (FCC), 72 (E_{coli}) respectively. All the mean values of TCC, FCC and Ecoli showed significant presence of microbial loadings into the floodplain especially Ecoli whose presence was used as an indicator for the presence of pathogens (bacteria causing diseases [11]). In a similar study, [12] revealed that humid environment favour pathogen survival, dry environment facilitates pathogen die-offs. Rainfall can result in splashing of contaminated soils on crops that could be the reason why the result of this study showed higher microbial loadings during the wet season than the dry season as indicated in Tables 1 and 2. This implies that Ecoli is highly abundant in wastewater; easily detected and considered the best indicator for faecal contamination. Lower pH that is acidic environment favours longer survival of pathogens while alkaline environment are associated with more rapid die offs since this study detected the mean value of pH of the water in the wet season to be 3.9 while in the dry season was 5.3. The soil was also more acidic in the wet season with pH 4.6 compared with dry season with pH of 6.9 shown in Table 3.

Table 1. Microbial Loadings Count in Wet/Rainy Season

Sample	pH	TCC	FCC	Ecoli
D1	3.6	1068	427	85
D2	4	950	380	157
D3	4.2	980	392	169
D4	3.8	1210	484	245
D5	3.6	1115	502	200
D6	3.7	1050	420	235
D7	4	998	397	198
D8	4	1010	455	205
D9	4.2	1025	553	226
D10	3.8	1065	585	274
Mean	3.9	1046	460	199

TCC is Total coliform count in (cfu/100 mL); FCC is Faecal coliform count; E.coli in (cfu/100 mL); D is Drainage.

Table 2. Microbial Loadings Count in Dry Season in cfu/100 mL

Sample	pH	TCC	FCC	Ecoli
D1	4.7	305	135	45
D2	4.8	250	160	58
D3	5.2	265	168	61
D4	5.8	408	200	92
D5	5.5	390	182	78
D6	5.9	387	179	66
D7	6	295	170	64
D8	4.9	390	175	69
D9	5	425	220	98
D10	5.2	410	205	85
Mean	5.3	353	179	72

TCC is Total coliform count in (cfu/100 ml); FCC is (cfu/100ml) Faecal coliform count in (cfu/100ml); E.coli (cfu/100ml); D is Drainage. Table 3 showed the microbial loadings T-test for the dry and wet season. The P-value (0.3137891) was higher than the level of significance (P=0.05). This implies that there was no significance difference in the microbial loadings in the wet and dry seasons which does not agree with [13].

Table 3. T-test for Microbial Loading
t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	Variable 2
	427.225	152.325
Variance	205082.469	23016.82
Observations	4	4
Hypothesized Mean Difference	0	
Df	4	
t Stat	1.15117875	
P(T<=t) one-tail	0.15689457	
t Critical one-tail	2.13184678	
P(T<=t) two-tail	0.3137891	
	2.7764451	

4 CONCLUSIONS

It can be concluded that the mean values of coliform counts cfu/100 ml for wet season and dry season were 1046 (TCC), 460 (FCC), 199 (E_{coli}) and 353 (TCC), 179 (FCC), 72 (E_{coli}) respectively. All the mean values of TCC, FCC and Ecoli showed significant presence of microbial loadings into the floodplain especially Ecoli whose presence was used as an indicator for the presence of pathogens such as bacteria causing disease agents. Physiochemical properties of soils investigated at River Benue floodplain during wet and dry seasons indicated that the pH of the soil ranged from 4.7-4.9 with a mean of 4.6; and 6.7-7.3 with a mean of 6.9 for wet and dry seasons respectively. The soil in the floodplain, the study area was more acidic in the wet season than in the dry season. The mean percentages of organic content matter of the soils were 2.4% and 4.5% for the dry and wet seasons. Based on the above classification, soils of the study area fall under moderate organic matter content. The study also revealed that the textural class of the soil was sandy clay loam (SCL) with the wet season having slightly higher percentage of sand.

REFERENCES

1. Ashbolt, N.J., Grabow, W.O.K. and Snozzi, M. (2001). Indicators of microbial water quality, Water Quality Guidelines, Standards and Health: Assessment of risk and risk management for water related infectious diseases. *World Health Organization*, pp. 291-292.
2. Bitton, G. and Harvey, R.W. (1992). Transport of pathogens through soils. In Mitchell, R., ed., *Environmental Microbiology: New York, Wiley-Liss*, pp.103-124.
3. Burmamu, B.R. (2019). Modeling of pollutants movement from decayed vegetables. *Global Journal of Environment*, vol. 6, no. 4, pp. 101-111.
4. FAO/WHO (2015). Food and Agriculture Organization of the United Nations/ World Health Organization. Microbiological hazards in fresh leafy vegetables and herbs. *Meeting Report of Microbiological Risk Assessment Series, Rome*, no. 14, pp. 1-151.
5. Tammi, H. and Oliver, K. (2018). Assessment of Channel Sedimentation of Selected Reach River Benue in Yola. *Journal of Environmental Sciences, Toxicology, and Food Technology*, vol. 12, Issue 9, pp. 9-27.
6. Isa, M.Z. and Musa, A.A. (2014). Delineation of Built-up Areas liable to Flood in Yola, Adamawa State, Nigeria Using Remote Sensing and Geographic Information System Technologies. *FUTY Journal of Environment*, vol. 8, no. 1, pp. 7-9.
7. Sjolander, I. (2012). Modeling the decay of E-coli and Ascarissuum in wastewater irrigated vegetables: implications for microbial health risk reduction. *2nd edition, Washington D.C.*, pp. 238-239.
8. Ishaku, J.M. (2011). Assessment of groundwater quality index for Jimeta-Yola area, North eastern Nigeria. *Journal of Geology and Mining Research*, vol. 3, no. 9, pp. 219-231.
9. United States Department of Agriculture/Food Safety and Inspection Service (USDA/FSIS) (2015). Microbial Risk Assessment Guideline. *Pathogenic Organisms with Focus on Food and Water.FSIS Publication No.USDA/FSIS/2015*, pp. 20-22.
10. United States Environmental Protection Agency (2012). A review of the Reference Dose and Reference Concentrations Processes U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC, EPA/630/P-02/002f, 2002, pp. 51-53.
11. World Health Organization (2016). Quantitative Microbial Risk Assessment. Application for Water Safety Management. *Document Services Geneva Switzerland*, pp. 45-55.
12. World Health Organization (2015). Preventing Diarrhoea Through Better Water, Sanitation And Hygiene. Exposures and Impacts in Low-and Middle-Income Countries. *Geneva Switzerland*, pp. 21-30.
13. World Health Organization (2013). World Health Drinking Water Quality Standards and Update. *Geneva Switzerland*, pp. 134-136.