



## Prevalence of Enteric (*Escherichia coli*) and Physico-chemical properties of River Sediments in Lapai, Niger State

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### ABSTRACT

The isolation and characterization of *Escherichia coli* associated with river sediments in Lapai Local Government area Niger State were assessed. Three sediments samples from rivers (Ndakotsu = NR, Yoruba = YR, and waterboard = WB) were collected from different locations labeled SD1 (10cm), SD2 (20cm) and SD3 (30cm) depth, and analyzed bacteriologically using standard methods. Results showed that more than 80% of sediments examined were contaminated with *E. coli* and this bacterium was identified based on its morphological, physiological and biochemical characteristics. Total heterotrophic bacteria count from river sediment samples showed that NR (6.14 – 6.32 log<sub>10</sub> cfu/ml) had the highest heterotrophic bacterial load, followed by the YR (5.59 – 6.00 log<sub>10</sub> cfu/ml) and the least was the WB (5.75 – 5.96 log<sub>10</sub> cfu/ml). The total *E. coli* load from river sediment showed that WB (4.80 – 4.40 log<sub>10</sub> cfu/ml) had the highest *E. coli* load, followed by the YR (4.48 – 3.90 log<sub>10</sub> cfu/ml) and NR sediments had no *E. coli* isolated from it. Total enteric organism load from river sediments showed that WB (5.22 – 4.98 log<sub>10</sub> cfu/ml) had the highest enteric load followed by YR (5.20 – 4.67 log<sub>10</sub> cfu/ml) and the least was NR (4.90 – 4.84 log<sub>10</sub> cfu/ml). Statistical analyses of the data showed that depth (10–30 cm) of the sediments had no significant impact on the prevalence and population of *E. coli* profile. Considering the pathogenic nature of the isolates and data profile observed in this study, it is concluded that all the assessed water bodies were unfit for domestic purpose; hence require treatment prior usage.

**Keywords:** *E. coli*, pathogenic, coliform, river sediments.

### INTRODUCTION

River is part of the hydrological cycle, which is usually a natural flowing water course, usually fresh water, flowing towards an ocean, sea, lake or another river. In some cases, a river flows into the ground and become dry at the end of its course without reaching another body of water. Water generally collects in a river from precipitation through a drainage basin from surface run off and other sources such as groundwater recharge, springs and the release of stored water in natural ice and snow packs (e.g. from glaciers) (Albrecht, 2003).

A river begins at a source (or several sources and ends at a mouth), flowing to a path called a course. The water in a river is usually confined to a channel, made up of a stream bed between banks. In large rivers, there is also a wider flood plain shaped by flood-waters over topping the channel. Rivers in the immediate environments is also ecosystems and natural life habitats. It form part of the food chain from vegetative material through invertebrate up to vertebrate

animals, including humankind and microbes. Rivers are indeed complex life support system, the sustainability of which depends on rather delicate balances being maintained. (Kluth, 1990).

various types which will be named and examples given. Their termination can be in the form of estuaries, simple river mouths, open or closed due to sand bars, or complex delta formations. The ingress of salinity into river mouths is one important complicating factor, so is the contribution of sediment by the river to the termination area. These factors will affect uses such as navigation, fisheries, water supply and irrigation (Sharp, 2000).

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Rise and fall in rivers, streams and lakes according to the amount of runoff occurring from the surrounding land, this is how rivers initially become contaminated. Some potential sources for contamination are leaking septic tanks, sewage overflow, and run off concentrations of microbes in the water. After the water is contaminated, microbes begin to settle in the sediment where they can impact water quality at a later time if and when sediments are disrupted. *Escherichia coli* is a bacterium that is commonly used as an indicator of sewage contamination and water.

*Escherichia coli* is one subgroup of fecal coliform bacteria even within this species, there are numerous different strains, some of which can be harmful. However, the release of these naturally-recurring organisms into the environment is generally not a cause for alarm but, other disease causing bacteria, which can include some pathogenic strain of *E. coli* or viruses may also present in these wastes and pose a health threat.

Bacteria in water can originate from the intestinal tracts of both humans and other warm-blooded animals such as pets, livestock and wildlife. Human sources include failing septic tanks, leaking sewer lines, waste water treatment plants combined sewer overflow (CSOs) boat discharges, summing “accidents” and urban storm water runoff. In urban water sheds, fecal indicator bacteria are significantly correlated with human density ((Nobel *et al.*, 2003).

Animal sources of fecal coliform bacteria include manure spread on land, livestock in runoff or in streams improperly disposed farm animal wastes, pel wastes (Dogs, Cats), Wildlife (Deer, Raccons etc) and birds (Geese, Pigeon, Duck, Gulls etc). Thus, this study was designed to assess the prevalence of *E. coli* and physicochemical properties of Lapai river sediments.

## METHODOLOGY

### Study Area

The water samples that were collected from Lapai River at different locations were shown the calibrated map (Fig. 1).

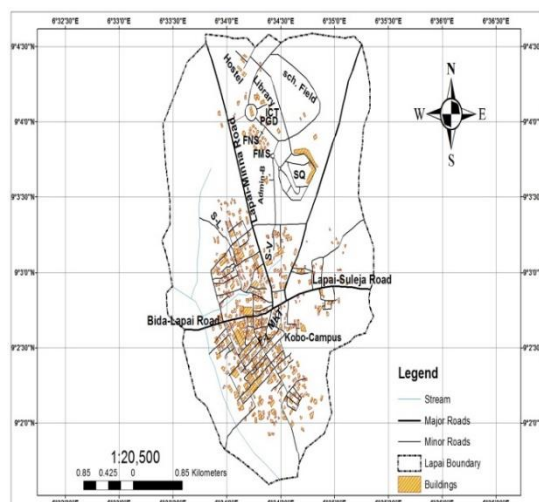


Fig. 1: The Geographical map of Lapai Showing the Sampling site

### Sample Collection

This study consists of three sediments samples from rivers of different locations: Ndakotsu River (NR), Water board (WB) and Yoruba River (YR) and three depth of sediments were collected from each river and designated as SD1(10cm), SD2 (20cm and SD3(30cm). The samples were collected with nitric acid pre-rinsed container for chemical analysis and sterile glass container for microbial assay. Triplicate sampling were done for each site and results expressed as mean with standard deviation.

### Bacterial Isolation from River Samples

Nutrient Agar, Eosine Methylene Blue Agar (EMB), Macconkey Agar, Triple Sugar Iron Agar, and Simmons Citrate were prepared according to manufacturer’s instructions, sterilizer at 121<sup>0</sup>C for 15 minutes. Bacterial species from river samples pour plated on the media after serial dilution to the 5<sup>th</sup> index. Plates were incubated at 37 °C for 24 - 48 hrs (Cowan and steel 2004). Colonie s were counted and expressed as cfu/ml. Isolates were characterized by morphology and biochemical properties.

### Physicochemical Assay

Selected physicochemical parameters (pH and Temperature) were assessed on-site using portable digital device (Jenway3510, Camlab,UK). The probes of the instruments were dipped into sample for 2-3mins and stable triplicate readings were taken and expressed as mean and standard deviation values.

**RESULTS**

Isolated and characterized *E. coli* were prevalent in WB and YR at 32.33% each while none was isolated from NR (fig. 2).

Total *E. coli* load was higher in WB (4.40– 4.54 log<sub>10</sub> cfu/ml) than in YR (3.90 – 4.38 log<sub>10</sub> cfu/ml), no count was recorded for NR (Fig. 3). There was an observable declining trend on the total enteric loads of WB (4.26 – 5.22 log<sub>10</sub> cfu/ml) and YR (4.67 – 5.22 log<sub>10</sub> cfu/ml) river sediments.

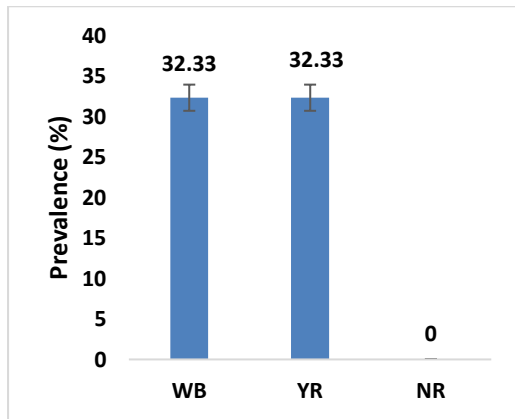


Fig. 2: Prevalence of *E. coli* in River Sediments  
YR= Yoruba river, WB = Water board, NR = Ndako-etsu river

However, sediments of NR (4.08 – 4.90 log<sub>10</sub> cfu/ml) had no trendy correlation to the depth sediment (fig. 4). Similarly, There was an observable declining trend on the total heterotrophic bacteria loads of NR (6.14 – 6.32 log<sub>10</sub> cfu/ml) and YR (5.59 – 6.0 log<sub>10</sub> cfu/ml) river sediments. However, WB (5.83 – 5.96 log<sub>10</sub> cfu/ml) sediments of had no trendy correlation to the depth sediment (fig. 5).

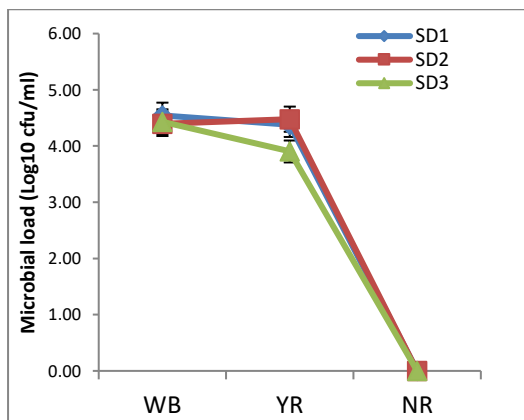


Fig. 3: Total *E. coli* load from River Sediments  
YR= Yoruba river, WB = Water board, NR = Ndako-etsu river  
SD1=(10cm), SD2 =(20cm) SD3 =(30cm)

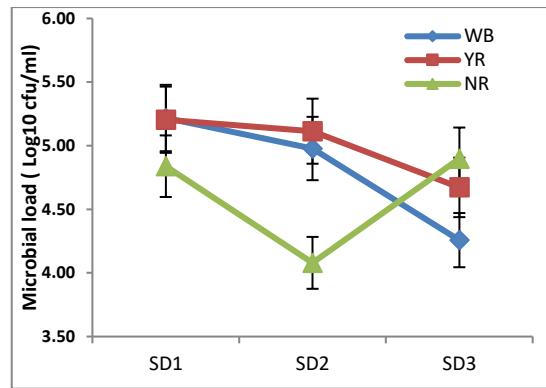


Fig. 4: Total Enteric Organism Load of River Sediments  
YR= Yoruba river, WB = Water board, NR = Ndako-etsu river  
SD1=(10cm), SD2 =(20cm) SD3 =(30cm)

Trendy pattern were observed in the physicochemical properties of sampled river sediments’ depth. Temperature (25.5 – 28.0°C) of river sediments were correlatively stable with the depth when compared to the pH that ranged within 3.35 – 4.15 (fig. 6).

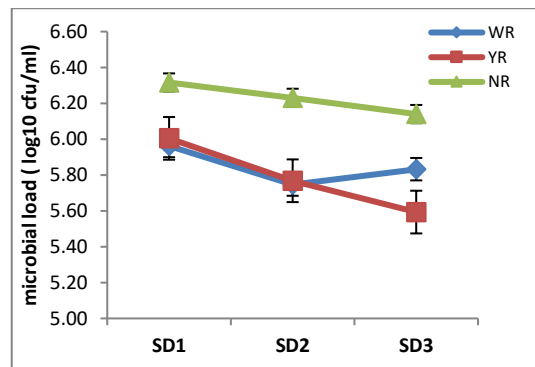


Fig. 5: Total Heterotrophic Bacteria Count of River Sediment  
YR= Yoruba river, WB = Water board, NR = Ndako-etsu river  
SD1=(10cm), SD2 =(20cm) SD3 =(30cm)

**DISCUSSION**

The study shows a comparative nature of the bacterium isolates obtained from different sediment sources. The total plate counts observed in sediment samples from river indicated the presence of high organic matter and related nutrient sources. The primary sources of bacterial contamination might include sewage treatment facilities, natural soil/plant bacteria and improper management activities of the inhabitants like fecal dropping and refuse dump.

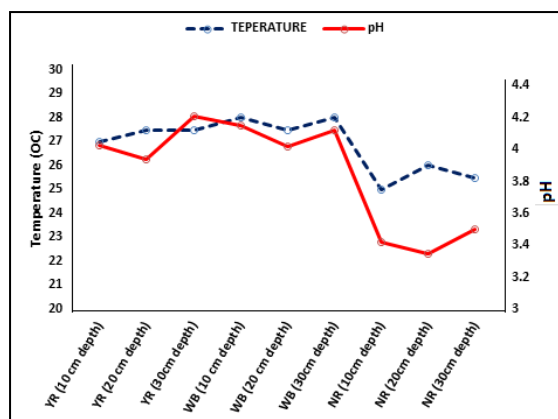


Fig. 6: Physicochemical properties of Lapai River Sediments

YR= Yoruba river, WB = Water board, NR = Ndako-etsu river

The sediment samples from the river water also had high number of coliform. Sediments from the river may have no undesirable change. However, it is unfortunate that the pathogens found in these soils can be harmful, thereby causing severe illnesses. Various human activities around the river could contaminate the water the high coliform count obtained in the sediment samples may an indication that the water sources were faecally contaminated (EPA 2002).

According to Oso and Fagade (2002), presence of coliform especially *Escherichia coli* in river sediments, simply indicated the possible presence of bacteria, pathogens and was in agreement with the work. The outcome of this study supports the fact that high heterotrophic counts in river sediment samples reflect high coliform counts and the presence of faecal coliform.

Despite the improving water quality of Lapai River, *E. coli* is widely distributed, detected in both water and sediment at every sampling site and within every individual sediment sample analyzed (Figure 2,3.4 and 5). These data suggest that sediment in the Lapai rivers act as a significant reservoir for *E. coli*, as has been found in other similar systems (Anderson *et al.*, 2005; Boehm *et al.* 2005; Bonilla *et al.*, 2007). The correlated abundances of *E. coli* in sediment samples provides added confidence in the use of each indicator and would indicate that *E. coli* share a common delivery mechanism (Nobel *et al.*, 2003), consistent with sewage as a source for *E. coli* to the Lapai river sediment.

Given the correlations of *E. coli* to other known pathogens (Walters *et al.* 2007), recreator illness (Haile *et al.*, 1999), and antibiotic resistant bacteria (Young *et al.*, 2013) from prior studies, the current *E. coli* results are also strong evidence that other microbial agents of concern, beyond the *E. coli* themselves, are likely to be widely distributed in Lapai river sediment. Recreators could be exposed to sewage-associated pathogens residing in sediment through activities along the shoreline, for example wading (Phillip *et al.*, 2009), when sediment is directly contacted, but also through other activities when sediment becomes resuspended into the water column. Boat traffic (Pettibone *et al.*, 1996), wave-shore interactions (LeFevre and Lewis 2003), high flow conditions in rivers and estuaries (Jamieson *et al.*, 2005; Wilkinson *et al.*, 2006), and even high winds (Roslev *et al.* 2008) can cause sediment re-suspension events that may negatively impact water quality.

Sediment Persistence Experiments and Molecular Identification of *E. coli* in Lapai river sediments from this study were found to persist for more than five weeks at detectable levels (Figure 5) above shows a similar time scale found in some other aquatic systems (Haller *et al.*, 2009). Extended persistence is not only expected in sediments, but there is also some evidence that particle-associated microbes in the water column may persist for longer periods than free-living (Fries *et al.*, 2008). This may be significant in the Hudson, where a high percentage of FIB are found to be particle associated (Suter *et al.*, 2011). A recent review (Jamieson *et al.*, 2005) of water quality modeling studies identified gaps in the understanding of Faecal indicator bacteria (FIB) and enteric ecological behavior within the environment as a significant obstacle to the generation of improved prediction systems. Variable persistence in high versus low nutrient environments, the significance of particle attachment for transport, and interactions between sediment and water column associated microbes are all important areas of continued research toward the goal of next generation water quality models (US-EPA 2007; Surbeck 2009; Kim *et al.*, 2010).

Finally, the molecular genetic characterization of *E. coli* isolates suggest that the vast majority (96%) of isolates obtained using cultivation based approaches were *E. coli*. This finding is

significant because it supports the use of cultivation-based approaches to quantify FIB in estuarine sediments and it confirms the long persistence of FIB in estuarine sediment, as suggested by cultivation based approaches.

## REFERENCES

- Albrecht, A. (2003). "Validating riverine transport and speciation models using nuclear reactor-derived radiocobalt". *Journal of Environmental Radioactivity* 66 (3): 295-307.
- Ambroggi, R.P. (1966). Water under the Sahara, *Scientific American*, volume 214, No.5.pp.21-29
- Anderson, K.L., Whitlock, J.E. and Harwood. V.J.(2005).Persistence and differential survival of fecal indicator bacteria in subtropical waters and sediments. *Applied and Environmental microbiology* 71: 3041-3048.
- Cowan, ST; Steel, KJ (2004). Manual for the Identification of Medical Bacteria (3rd ed.). *Cambridge University Press*. London. 331pp
- Haller, L., E. Amedegnato, J. Pote, and Wildi, W. (2009). Influence of freshwater sediment characteristics on persistence of fecal indicator bacteria. *Water, Air and Soil Pollution* 203:217-227. 75:30-38.
- Jamieson R.C., Joy, D.M. Lee, H. Kostaschuk, R. and Gordon, R.J. (2005). Resuspension of sediment-associated *Escherichia coli* in a natural stream. *Journal of Environmental Quality* 34:581-589.
- Kluth D.J. (1990). "The great manmade River project". Proc. 6th international conference on pressure Surges, British Hydromechanics *Research Association*. Chapter ix; pp 121-128. Bedford U.K: BHRA
- Boehm, A.B., D.P. Keymer, and G.G. Shellenbarger.( 2005). An analytical model of enterococci inactivation, grazing, and transport in the surf zone of a marine beach. *Water Research* 39:3565-3578.
- Bonilla, T.D., Nowolski, K. Cuvelier, M. Hartz, M. Green, N. Esiobu, D.S. McCorquodale, J.M. Fries J.S., Characklis, G.W. and Noble, R.T. (2008). Sediment-water exchange of *Vibrio* sp. and fecal indicator bacteria: Implications for persistence and transport in the Neuse River Estuary, North Carolina, USA. *Water Research* 42:941-950.
- Kim J.-W., Pachepsky, Y.A. Shelton, D.R. and Coppock, C. (2010). Effect of treumbed bacteria release on *E. coli* concentrations: Monitoring and modeling with the modified SWAT. *Ecological Modeling* 221:1592-1604.
- LeFevre, N.M., and Lewis.G.D. (2003). The role of resuspension in Enterococci distribution in water at an urban beach. *Water Science and Technology* 47:205-210.
- Haile, R.W., J.S. Witte, M. Gold, R.Cressey, C. McGee, R.C. Millikan, A. Glasser, N. Harawa, C. Ervin,P. Harmon, J. Harper, J. Dermand, J. Alamillo, K. Barrett, M. Nides, and Wang, G. (1999). The health effects of swimming in ocean water contaminated by storm drain runoff. *Epidemiology* 10:355–363. II-19
- Sharp B. (2000). Personal communication, Burnell Research Laboratory, Don caster, Victoria, Australia "E. coli food poisoning." About. N.P., n.d. web.13 Dec.2014.
- Liu, L., . Phanikumar, M.S. Molloy, S.L. Whitman, R.L D.A. Shivley, M.B. Nevers, D.J. Schwab, and Rose. J.B. (2006). Modeling the transport and inactivation of *E. coli* and Enterococci in the near-shore region of Lake Michigan. *Environmental Science and Technology* 40:5022-5028.
- Nobel, R.T., Moore, D.F. Leecaster, M.K. McGee, C.D. and Weisberg. S.B. (2003). Comparison of total coliform, fecal coliform, and Enterococcus bacterial indicator response for ocean recreational water quality testing. *Water Research* 37:1637 – 1643.
- Walters S.P., Gannon,V.P. and Field. K.G. (2007). Detection of Bacteroidales fecal indicators and the zoonotic pathogens *E. coli* 0157:H7, *Salmonella*, and *Campylobacter* in river water. *Environmental Science and Technology* 41:1856- 1862.

- Suter, E., Juhl, A.R. and O'Mullan. G.D. (2011). Particle association of Enterococcus and total bacteria in the lower Hudson River Estuary, USA. *Journal of Water Resource and Protection*. 3:715-725.
- Pettibone, G.W., Irvine, K.N. and Monahan, K.M. (1996). Impact of ship passage on bacteria levels and suspended sediment characteristics in the Buffalo River, New York. *Water Research* 30:2517-2521.
- Roslev, P., Bastholm S., and Iversen, N. (2008). Relationship between fecal indicators in sediment and recreational waters in a Danish estuary. *Water, Air, and Soil Pollution* 194:13-21.
- Surbeck, C.Q. (2009). Factors influencing the challenges of modeling and treating fecal indicator bacteria in surface waters. *Ecohydrology* 2:399-403.
- Wilkinson J., D. Kay, M. Wyer, and Jenkins A. (2006). Processes driving the episodic flux of faecal indicator organisms in streams impacting on recreational and shellfish harvesting waters. *Water Research* 40:153-161.
- Osho A. And Fagade O.E, (2000), Occurrence of coliform and fecal coliform and fecal Streptococcus Ago-Iwoye well fall, *Nigeria Journal of Science* 34(1):323-329.
- Phillip, D.A., Antoine, P. V. Cooper, L.Francis, Mangal, E. Seepersad, N. R. `Ragoo, S. Ramsaran, I.Singh, and Ramsabhag. A. (2009). Impact of recreation on recreational water quality of a small tropical stream. *Journal of Environmental Monitoring* 11: 1192-1198.
- United State. Environmental Protection Agency. (2004). Method 1600: *Enterococci* in water by membrane filtration using membrane-*Enterococcus* Indoxyl- B –D Glucoside Agar(mEI). EPA-821-R-06-009