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Bacteriological Quality, Indicator Organisms and Antimicrobial Resistance Profiles of Okwe and Imo Rivers Used for Domestic Water Supply in Imo State, Nigeria

Aleru-Obogai, Constancy Prisca*, Giami Lynda Kadi and Mbata Christian Alfred

Department of Medical Microbiology, Faculty of Medical Laboratory Science, Rivers State University, Nigeria

**Corresponding author*

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A B S T R A C T

Surface water sources remain a primary domestic water supply in many rural communities in Nigeria. However, microbiological contamination of untreated river water poses substantial public health risks, particularly in settings with inadequate sanitation infrastructure. This study evaluated the bacteriological quality and antimicrobial resistance patterns of bacterial isolates from Okwe and Imo Rivers in Imo State, Nigeria. A descriptive cross-sectional study was conducted between July and September 2020. Forty water samples (20 per river) were collected aseptically from multiple sites. Heterotrophic plate counts (HPC) were determined using the pour plate method. Total coliform count (TCC) and total *Escherichia coli* count (TEC) were assessed using the Most Probable Number (MPN) technique. Isolates were identified by Gram staining and standard biochemical tests according to Cheesbrough (2006). Antimicrobial susceptibility testing was performed using the disc diffusion method. All samples demonstrated bacterial contamination. HPC values exceeded recommended limits for potable water in multiple sampling sites. Total coliforms and *E. coli* were detected in both rivers, indicating faecal contamination. Predominant isolates included *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella* spp., *Pseudomonas aeruginosa*, *Proteus* spp., *Salmonella* spp., and *Shigella* spp. Several Gram-negative isolates demonstrated resistance to commonly used antibiotics, including Septrin and Amoxicillin. Okwe and Imo Rivers are microbiologically unsafe for direct human consumption. The detection of faecal indicator organisms and antibiotic-resistant bacteria highlights a significant public health concern. Immediate water treatment interventions and improved sanitation infrastructure are recommended.

Introduction

Access to microbiologically safe drinking water remains a critical determinant of public health. Despite global progress in water safety, surface water sources continue to serve as primary drinking water supplies in many low-resource settings [Citation required]. In Nigeria, particularly in rural communities, rivers frequently

function as domestic water sources without prior treatment.

Waterborne diseases remain a leading cause of morbidity in developing countries (WHO, 2006; WHO, 2008). Pathogenic bacteria transmitted through contaminated water include *Vibrio cholerae*, *Salmonella enterica*, *Shigella* spp., and pathogenic *Escherichia coli* strains (Seas *et al.,* 2000; Cabral, 2010).

The presence of faecal indicator organisms, particularly *E. coli*, signifies recent faecal contamination and possible pathogen transmission.

Anthropogenic activities such as open defecation, agricultural runoff, refuse disposal, and untreated sewage discharge significantly contribute to microbial loading of surface waters (Adelegan, 2004; Adebowale *et al.,* 2008; Oparaocha *et al.,* 2010).

Within Imo State, Okwe and Imo Rivers serve as essential water sources; however, their bacteriological status remains insufficiently characterised.

Additionally, environmental waters increasingly act as reservoirs of antimicrobial-resistant bacteria, posing an emerging global health threat.

Research Gap

Although studies have assessed water quality in selected Nigerian rivers (Nnaji *et al.,* 2010), there is limited recent bacteriological data on Okwe and Imo Rivers, particularly incorporating antimicrobial susceptibility profiling.

The main aim of this study includes, evaluating the bacteriological quality and antimicrobial resistance patterns of bacterial isolates from Okwe and Imo Rivers in Imo State, Nigeria.

Materials and Methods

Study Design and Reporting Framework

This descriptive cross-sectional study was conducted between July and September 2020. Reporting aligns with STROBE recommendations for observational environmental studies.

Study Area

Okwe River is located in Onuimo Local Government Area within the Imo River basin. Imo River flows through multiple communities in Imo State, supporting domestic and agricultural activities (SJMLS, 2017).

Sample Collection

Forty water samples (20 per river) were collected from spatially distributed sampling points. Samples were collected in sterile 750 mL containers at midstream depth and transported under cold chain conditions for immediate analysis.

Microbiological Analysis

Heterotrophic Plate Count

Ten-fold serial dilutions were performed. Aliquots were plated using the pour plate technique on Nutrient Agar and incubated at 37°C for 24–48 hours (Cheesbrough, 2006). Counts were expressed as CFU/mL.

Total Coliform and *E. coli* Enumeration

The Most Probable Number (MPN) method using MacConkey broth was employed. Confirmatory testing utilised Eosin Methylene Blue agar. MPN values were interpreted per standard probability tables (Cheesbrough, 2006).

Bacterial Identification

Isolates were characterised by Gram staining and biochemical testing (Catalase, Coagulase, Citrate, Indole).

Antimicrobial Susceptibility Testing

Disc diffusion testing was performed on Iso-sense agar. Zones of inhibition were measured in millimetres. Interpretation followed standard laboratory guidance (Cheesbrough, 2006; Hegstad *et al.,* 2014).

Statistical Analysis

Data were analysed using Microsoft Excel. Results were expressed as means and standard deviations.

Results and Discussion

All 40 samples showed detectable bacterial growth.

Bacterial Isolates

Both rivers yielded multiple potential pathogens. *E. coli* was isolated in the majority of samples from both rivers. *Shigella* spp. were detected exclusively in Imo River samples.

Bacterial Counts

HPC values ranged from 1.0 to 9.2 CFU/mL (as recorded). Total coliform and total *E. coli* counts were detected in all samples, indicating faecal contamination.

All recorded HPC values exceeded the recommended limit of 1.0×10^2 CFU/mL for potable water (EPA, 2002).

Antimicrobial Resistance Patterns

Gram-negative isolates exhibited resistance to Septrin across all species tested. Reduced susceptibility to Amoxicillin and Augmentin was observed. Ciprofloxacin and Pefloxacin demonstrated higher activity against several isolates.

Gram-positive isolates (*Staphylococcus aureus*) showed resistance to Septrin and Zinnacef but moderate susceptibility to Ciprofloxacin.

This study demonstrates widespread bacterial contamination of Okwe and Imo Rivers. The detection of *E. coli* in all samples strongly indicates recent faecal contamination (George *et al.,* 2001; Cabral, 2010).

HPC values exceeding recommended potable standards suggest high organic loading and nutrient enrichment, potentially attributable to anthropogenic discharge (Adebowale *et al.,* 2008; Oparaocha *et al.,* 2010).

The isolation of *Salmonella* and *Shigella* spp. represents a direct public health concern due to their low infectious dose and documented waterborne transmission (Seas *et al.,* 2000; Scheutz *et al.,* 2015).

Of particular significance is the detection of antimicrobial resistance among environmental isolates. Surface waters may serve as reservoirs and transmission pathways for resistant organisms [Citation required]. Resistance to commonly accessible antibiotics such as Septrin and Amoxicillin may reflect widespread community antibiotic usage [Citation required].

Public Health Implications

Communities consuming untreated water from these rivers face increased risk of diarrhoeal disease, enteric fever, and other gastrointestinal infections.

Study Limitations

- Absence of molecular confirmation of isolates
- No seasonal comparison
- Limited statistical modelling
- No physicochemical parameter analysis

Future Directions

- Molecular characterisation of resistance genes
- Longitudinal seasonal monitoring
- Risk assessment modelling
- Integration with community health surveillance data

In conclusion, Okwe and Imo Rivers are microbiologically unsafe for direct human consumption. The presence of faecal indicator organisms and antibiotic-resistant bacteria underscores significant public health risk. Immediate implementation of water treatment strategies and sanitation improvements is essential.

Author Contributions

Aleru-Obogai: Investigation, formal analysis, writing—original draft. Constancy Prisca: Validation, methodology, writing—reviewing. Giami Lynda Kadi:—Formal analysis, writing—review and editing. Mbata Chris Alfred: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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