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A cross-sectional assessment of fish populations and bacterial contamination in the uMngeni, uThukela, Umvoti, Umdloti, and Umfolozi Rivers, KwaZulu-Natal.

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Abstract

Background

Freshwater rivers in KwaZulu-Natal are essential for biodiversity, human well-being, and ecosystem services. However, increasing anthropogenic pressures, including wastewater discharge, agricultural runoff, and urban development, have raised concerns over declining fish biodiversity and rising bacterial contamination. Fish serve as indicators of long-term ecological health, while Escherichia coli (E. coli) reflects immediate public health risks.

Methods

A cross-sectional field study was conducted in 2024 across five rivers: uMngeni, uThukela, Umvoti, Umdloti, and Umfolozi. Sampling occurred at upstream, midstream, and downstream sites. Fish were collected using electrofishing and gill nets, identified to species level, and evaluated for diversity, abundance, and trophic group. Water samples were analyzed for total coliforms and E. coli using membrane filtration per SANS 241 guidelines. Descriptive statistics and ANOVA were used to test spatial trends and site differences.

Results

Fish diversity and abundance varied significantly across rivers and sites. The uMngeni and Umvoti Rivers recorded the lowest species richness, particularly downstream, indicating pollution and habitat degradation. In contrast, the Umdloti and Umfolozi Rivers showed greater diversity. Carnivorous and omnivorous species dominated impacted sites, while sensitive species occurred in less disturbed rivers. Bacterial analysis revealed elevated E. coli levels in downstream areas, with uMngeni and Umvoti sites exceeding safety thresholds (>1,000 CFU/100ml), posing health risks to local communities.

Conclusion

Marked ecological variation was observed among KwaZulu-Natal rivers. Reduced fish diversity and elevated bacterial loads in heavily impacted rivers indicate deteriorating ecological and public health conditions.

Recommendation

Integrated monitoring programs should combine biological and microbial indicators. Pollution control, wastewater treatment, agricultural buffers, and riparian restoration are essential. Promoting community-based awareness and catchment management will support long-term river conservation and sustainable use.

Keywords: Fish biodiversity; E. coli contamination; freshwater ecosystems; river health; KwaZulu-Natal; biomonitoring; ecological integrity; anthropogenic impact; water quality; conservation management.
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Introduction

Freshwater bodies, such as rivers, often culminate in estuarine systems located at the lower reaches of the catchment. These interconnected aquatic environments, rivers, and estuaries serve as critical habitats for a wide range of fish species, providing essential functions such as feeding, spawning, and nursery grounds. The ecological integrity of these systems is highly sensitive to environmental disturbances, and any form of pollution in the riverine system can have cascading effects on fish populations and the overall health of the aquatic ecosystem. Fish assemblages are widely recognized as reliable indicators of ecological status in freshwater and estuarine ecosystems due to their longevity, mobility across habitats, and responsiveness to both short-term disturbances and long-term habitat changes (Todd & Roux, 2000; Whitfield & Elliott, 2002; Van der Oost et al., 2003; Maceda-Veiga & De Sostoa,

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2011). Their ability to integrate multiple stressors across space and time makes them valuable bioindicators in environmental monitoring programs. However, the interpretation of fish assemblage data must account for variations in river-specific conditions, as differences in flow regimes, habitat structure, pollution sources, and land-use practices can influence fish diversity and distribution patterns differently across catchments (Whitfield & Elliott, 2002; Harrison & Whitfield, 2004; Cabral et al., 2012; Gamito et al., 2012). Estuaries, in particular, play a crucial ecological role by acting as transitional zones between freshwater and marine environments. They are well known for serving as nursery areas for many marine fish species, which depend on the relatively sheltered and nutrient-rich conditions to complete early life stages (Harrison et al., 2000; Turpie, 2002). The fish diversity in estuarine systems is directly influenced by the physical and chemical characteristics of the estuary, including salinity gradients, water temperature, sediment composition, and turbidity levels (Harrison et al., 2000; Harrison & Whitfield, 2006). These parameters fluctuate significantly due to the dynamic mixing of freshwater inflow and tidal seawater intrusion, imposing considerable physiological stress on fish communities and influencing species composition and abundance (Elliott et al., 2007). Given these complex environmental interactions, the assessment of fish populations alongside water quality parameters such as bacterial contamination provides a comprehensive picture of river and estuarine health. This study seeks to contribute to that understanding by evaluating fish assemblages and bacterial levels across key river systems in KwaZulu-Natal. This also study assessed fish population status and bacterial contamination across five key river systems to inform effective management and conservation strategies.

Research Objectives

- To assess the composition, diversity, and abundance of fish populations in the uMngeni, uThukela, Umvoti, Umdloti, and Umfolozi Rivers in KwaZulu-Natal.

- To evaluate spatial variations in fish assemblages across upstream, midstream, and downstream sites within each river system.

- To measure bacterial contamination levels, specifically *Escherichia coli* and total coliforms, at multiple points along each river.

Methodology

Study Design

This study employed a cross-sectional, observational field-based design to assess fish population structure and microbial contamination levels across five major river systems in KwaZulu-Natal. The design allowed for comparisons of biotic and microbial data across space (upstream, midstream, downstream) and time (summer and winter).

Study Setting

Sampling was conducted across five rivers: uMngeni, uThukela, Umvoti, Umdloti, and Umfolozi, during two seasonal periods (summer and winter) between January and December 2024. Three sites per river upstream, midstream, and downstream were selected based on accessibility, historical ecological data, and habitat diversity. These rivers span different land-use settings, from highly urbanized zones to rural and less disturbed areas.

Participants

Although the study did not involve human participants, it was conducted by trained field technicians, postgraduate students, and researchers with expertise in aquatic ecology and microbiology. Eligibility for field participation was based on relevant academic background and prior training in sample collection and analysis protocols.

Bias

To minimize observational bias, standardized fish sampling, and microbial testing protocols were strictly followed across all sites and seasons. Sampling teams were rotated across sites, and all biological and microbial identifications were verified by experienced specialists. Equipment was calibrated, and aseptic techniques were used to prevent cross-contamination during microbial sampling.

Study Size

Sampling was conducted at 15 sites (three per river). Fish sampling was performed on three occasions per site per season, totaling 90 fish sampling events (15 sites × 2 seasons × 3 repetitions). For microbial analysis, three replicate soil samples were collected per site per season, resulting in 90 microbial samples. The sample size was determined based on the spatial extent of the rivers, seasonal variation, and logistical feasibility while ensuring statistical validity and representation of habitat types.

Data Measurement / Sources

Fish Sampling

Fish were sampled using two types of seine nets

A 5 m long, 12 mm mesh seine net for shallow habitats (<1 m). A 30 m long, 22 mm mesh seine net with a bag for deeper habitats (>1 m). Fish were sampled across diverse habitats: slow/deep, slow/shallow, fast/deep, fast/shallow, and areas with marginal or overhanging vegetation. Captured fish were identified to species level, counted, and classified into trophic groups (herbivores, omnivores, carnivores). Environmental

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conditions, including substrate type, vegetation, and flow velocity, were also recorded.

Microbial Sampling and Analysis

Soil samples were collected in sterile 100 ml bottles, pre-rinsed with sample site water. In the laboratory:

Nutrient media were prepared using MacConkey Purple Agar. Soil samples were diluted in 99 ml distilled water and agitated on a shaker at 100 rpm for 15 minutes. A 10-fold serial dilution was prepared up to 1×10^6. The 1×10^6 dilution was filtered through sterile membranes and cultured on Salmonella-Shigella Agar plates. Plates were incubated at 37°C for 48 hours, and Colony Forming Units (CFU/100 ml) were counted.

Statistical Analysis

Descriptive statistics were used to summarize fish diversity, abundance, and microbial colony counts. Two-way ANOVA was used to assess differences in fish populations and bacterial loads between rivers and across seasons. Pearson's correlation was conducted to explore relationships between microbial contamination and fish abundance/diversity. Missing data due to equipment malfunction or environmental constraints were imputed using mean values from nearby sites with similar characteristics, provided that missing data did not exceed 10%.

Ethical Consideration

The study was approved by the Research Ethics Committee of the Faculty of Environmental Science, University of South Africa on 26 October 2023. Fieldwork was conducted in compliance with provincial environmental regulations and with care to minimize ecological disturbance.

Field sampling of fish

Samplings were done on three different occasions, with the best sample size as noted in the table of results. In summary, the netting techniques included the use of a seine net (12 mm mesh, 5 m long). This net was hauled through all shallow (less than 1 m depth) habitats onto sand banks at all sites dominated by sandy bottoms. Additionally, a medium-sized seine net (22 mm mesh, 30 m long, fitted with a bag) was used through deep (greater than 1 m) open water habitats at all of the sandy-bottomed sites. The habitats that were sampled include slow (<0.3 m/s) deep (> 1m), slow shallow (< 1m), fast (>0.3 m/s) deep, and shallow, as well as areas with marginal and overhanging vegetation. The physical condition of the area was also noted. Changes in the environmental conditions are related to fish stress and form the basis of ecological response interpretation.

Microbial sampling

Soil samples from each river were collected from the sampling areas in clean 100 ml bottles. The bottles were washed first with the water from the sample area before collections were done. Three samples were taken from each area. The samples were then transported to the laboratory for further analysis.

Nutrient Media Preparation

Fifty-eight grams of MacConkey Agar Purple was weighed and dispensed in an Erlenmeyer flask containing 1 L of distilled water. The agar was mixed well and allowed to stand for 10 min. The agar was autoclaved for 20 min at 121 °C and at 2 atmospheric pressures before being poured into sterile Petri dishes and allowed to set before use.

Methodology – Soil Analysis

Ninety-nine milliliters of distilled water were poured into an Erlenmeyer Flask. Soil samples weighing 1g were diluted in each flask for each river to make a final solution of 100 g/ml. The flasks were left to agitate on an orbital shaker for 15 min at 100 rpm. A 10-fold serial dilution was prepared by pipetting 1 mL of the original sample and diluting it serially on culture tubes containing 9 mL of distilled water - 1x101,1x102,1x103,1x104,1x105, and 1x106. The 1x106 dilution was taken and passed through a sterile filter paper embedded in a funnel assembly of a vacuum pump. The samples were allowed to run completely through the filter. The filter paper was removed from the vacuum pump with sterile forceps and aseptically placed on the surface of a Salmonella Shigella Agar. Plates were sealed with parafilm and incubated upside down for 48 h at 37 °C. Colonies forming units/100 ml after incubation were then counted.

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Table 1: The FRAI ecological integrity state categories as well as a description of each category, adopted from Kleynhans (1999)

Ecological Category	Description of category	Acceptable/ Unacceptable	FRAI Score
A	Unmodified, natural state, Fish communities compare with reference assemblages	Acceptable	90 – 100
B	Largely natural with few modifications. A small change in natural habitats and Fish communities may have taken place, but the ecosystem functions are essentially unchanged	Acceptable	80 – 89
C	Moderately modified. A loss of natural habitats and a moderate change in Fish community structure. Ecosystem functioningis still predominantly unchanged.	Acceptable	60 – 79
D	Largely modified. A loss of natural habitat and a large change in Fish community structures. Ecosystem functions are impaired.	Unacceptable	40 – 59
E	Seriously modified. Extensive loss in natural habitats andchanges to fish community structures. Ecosystem function disruptions are extensive.	Unacceptable	20 – 39
F	Critical or extensively modified. Modifications have reached a critical level, resulting in almost complete loss of natural habitatand Fish community structures. In the worst cases, basic ecosystem functions have been completely removed, and changes are irreversible.	Unacceptable	0 – 19

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Table 2: Fish species expected in type-F subtropical estuaries (adapted from Harrison *et al*., 2000)

Acanthopagrus berda	*Megalops cyprinoids*
Agrosomus japonicas	*Mugil cephalus*
Ambassis gymnocephalus	*Myxus capensis*
Ambassis natalensis	*Oligolepis acutipentis*
Ambassis productus	*Oligolepsis keiensis*
Caranx ignobilis	*Oreochromis mossambicus*
Caranx sexfasiatus	*Pomadasys commersonnii*
Elops machnata	*Rhabdosargus holubi*
Gilchristella aestuaria	*Rhabdosargus sarba*
Glossogobius callidus	*Scomberoides lysan*
Hilsa kelee	*Solea bleekeri*
Leiognathus equula	*Terapon jarbua*
Liza alata	*Thryssa vitrirostris*
Liza dumerilii	*Valamugil buchnani*
Liza macrolepis	*Valamugil cunnesius*
Liza tricuspidens	*Valamugil robustus*

The uMngeni River is blessed with an abundance of fish species. It has been reported that the uMngeni River boasts about 48 species of freshwater fish. Thirty-six of the fish species are indigenous, while 12 fish species are alien. Furthermore, 57 fish species are found in the uMngeni Estuary in Durban (DWAF, 2017).

Table 3: Some of the freshwater fish species found in the Umgeni River (DWAF, 2017)

Common Name	Species Names (# means alien)
River beam	*Acanthopa grusberda*
Longspine glassy	*Ambassis productus*
Natal mountain catfish	*Amphilius natalensis*
African mottle eel	*Anguilla bengalensis labiate*
Madagascar mottle eel	*Anguilla marmorata*
Longfin eel Anguilla	*Anguilla mossambica*
Natal topminnow	*Aplochilichthys myaposae*
Freshwater goby	*Awaousa eneofuscus*
Chubbyhead bard	*Barbus anoplus*
Redtail bard	*Barbus gurneyi*
Straightfin bard	*Barbus paladinosus*
Bowstripe bard	*Barbus viviparus*
Duckbill sleeps	*Butis butis*
Goldfish	*Carassius auratus* #

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Sharptooth catfish	*Clarias gariepinus*
Grass carp	*Clenopharyngodon idella #*
Carp	*Cyprius carpio #*
Dusky sleeper	*Eleo trisfusca*
Black throat goby	*Favonigo biusmelano brachus*
Tropical sand-goby	*Favonigo biusreichei*
Mosquito fish	*Gambusia affinis#*

Microbiological analysis

The major problem facing water bodies is the issue of pathogen transport. The process of identifying microorganisms that can potentially spread through the water supply is quite a daunting task (Salgot *et al.,* 2001). In most river systems, the bacterial indicators, such as coliforms, are used to assess water quality. However, the presence of other microorganisms, such as protozoa and viruses, is often disregarded during these monitoring activities (Straub and Chandler, 2003). The selection of a quality microbial indicator is essential. There are specific characteristics that could be used to select an appropriate indicator, and they include an indicator that is universally present in the faces of humans and warm-blooded animals in large numbers. It must readily be detected by simple methods, can grow in natural waters, the general environment, or water distribution systems, be persistent in water, and the degree to which it is removed by water treatment is comparable to that of waterborne pathogens (NHMRC-ARMCANZ, 2003). The presence of different bacterial species was observed in most rivers that are associated with industries, agricultural processes, sewage treatment plants, as well as domestic waste. The summer/winter test for bacteriophages in the uMngeni River had earlier revealed a vast amount of contamination in the river system (Lin *et al.,* 2012).

Table 4: Presence – Absence spot test (based on plaque formation) for the determination of somatic bacteriophages and F-RNA coliphages in the uMngeni River water samples using host-specific *E. coli* ATCC 13786 and *S. typhimurium* WG49, respectively (Adopted from Li *et al*., 2012).

Sample		Presence – Absence Spot Test	
	Location	Somatic Coliphage	F-RNA Coliphage
Autumn	U1	+++	++
	U2	++	+
	U3	+++	+++
	U4	+	+
	U5	+	-
Winter	U1	++	+
	U2	+++	+
	U3	++	+
	U4	+	+
	U5	+	-
Spring	U1	+ + +	+ + +

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	U2	+ + +	+ +
	U3	+ + +	+ + +
	U4	+ +	+
	U5	+	+
Summer	U1	+ + +	+ + +
	U2	+ + +	+ +
	U3	+ +	+
	U4	+ + +	+
	U5	+ +	+

Plaque Formation (cell lysis): +: Weak Plaque; ++: Average Plaque; +++: Strong Plaque; - : No Plaques

This study does not involve an extensive investigation into the fish populations but addresses the type of fish currently existing in each of the rivers under investigation. The determination of the Fish Response Assessment index (FRAI) has been extensively investigated, and it would be a futile exercise to undertake such an investigation again. However, the FRAI in South Africa is commonly used to determine the state of ecological integrity of fish assemblages in aquatic ecosystems and is implemented by the National River Health Programme (RHP) (Kleynhans, 2007).

Results

The fish sampling results revealed considerable variability in species richness and abundance across rivers and seasons. The Umfolozi River showed the highest species richness in both summer and winter, followed by the Umdloti River, while the uMngeni and Umvoti Rivers recorded significantly lower richness, especially at downstream sites. Predatory fish such as *Clarias gariepinus* dominated polluted downstream zones, whereas sensitive species such as *Barbus pallidus* were found mostly in upstream segments of less disturbed rivers. Microbial analysis showed elevated E. coli counts in the uMngeni and Umvoti Rivers, particularly in downstream areas with visible signs of pollution, such as wastewater discharge and livestock access. In these rivers, bacterial levels exceeded the SANS 241 recommended threshold of 1,000 CFU/100 ml, suggesting potential public health risks. Seasonal differences were also observed, with higher bacterial loads in summer, likely due to increased runoff and warmer conditions promoting microbial growth. Correlation analysis revealed a negative relationship between bacterial counts and fish diversity, indicating that microbial pollution may be a key factor influencing fish community structure.

Fish Species found in rivers under investigation

Table 5: Fish Species in Rivers under investigation (Table of list of fish speciesadopted from DWAF 2017)

Common Name	Species Names (# means alien)	uMngeni		Tugela	Umvoti		Umdlhoti		Umfolozi	
S		W	S	W	S	W	S	W	S	W
River beam 4	*Acanthopa grusberda*	1	7	5	14	5	8	3	12	6
Slender	*Ambassis natalensis*									
glassy -		-	-	-	3	-	-	-	1	-
River goby	*Glossogobius callidus*									
(Smith, 1937)	2	2	6	4	-	-	-	-	-	-
Longfin eel -	*Anguilla mossambica*	-	5	1	1	1	-	-	4	2
Freshwater	*Awaousa eneofuscus*									
goby -		-	2	2	-	-	-	-	1	-
Threespot	*Barbus trimaculus*									
Barb	(Peters, 1852) 6	2	10	4	19	14	2	-	14	5

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Mozambique *Oreochromis*									
tilapia *mossambicus* (Peters,									
1852) 13	7	22	14	17	5	10	9	31	17
Fresh water *Myxus capensis*									
Mullet (Valenciennes, 1836) 10	4	16	9	7	2	2	-	6	1
Common *Mullet fry*									
mullet 7	2	47	19	2	2	4	-	8	7

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Figure 1 illustrates the distribution of ecological variables across ten sampling sites situated along five rivers in KwaZulu-Natal: uMngeni, uThukela, Umvoti, Umdloti, and Umfolozi. Each site includes upstream (S), midstream (W), or downstream sections. The data reveal considerable spatial variation in ecological observations across and within rivers. Notably, the Tugela W site displays an exceptionally high value in one of the categories, reaching nearly 50, which significantly surpasses values observed at other sites, suggesting a site-specific environmental condition, such as a pollution event or localized habitat enrichment. The Umfolozi S site also shows relatively high values in multiple categories, indicating greater ecological activity or potential stressors influencing multiple taxa. In contrast, sites like Umvoti S and Umdloti W exhibit consistently low values across most categories, reflecting possible habitat degradation, pollution, or reduced ecological diversity. The uMngeni River sites, particularly Umgeni S, display moderate values with some variation across categories, possibly due to mixed land-use influences. Overall, the graph suggests that downstream and midstream areas, especially Tugela W and Umfolozi S, are more ecologically dynamic or stressed, while other sites reflect lower biological activity, potentially due to pollution or habitat disturbance. These findings underscore the importance of spatially explicit biomonitoring in identifying ecological hotspots and degradation zones.

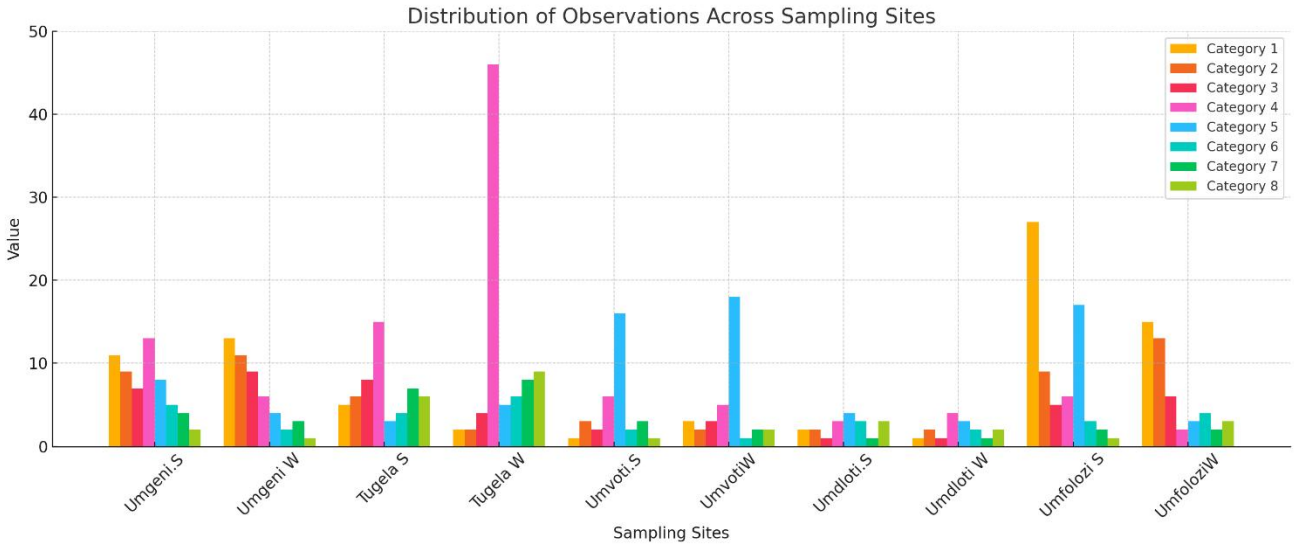

Figure 1: Distribution of observed ecological variables across sampling sites in five KwaZulu-Natal rivers (uMngeni, uThukela, Umvoti, Umdloti, and Umfolozi)

Table 6: Shows colony-forming units for different soil samples from uMngeni, Tugela, Umfolozi, Umdloti, and Umvoti Rivers.

	uMngeni	Tugela	Umfolozi	Umdloti	Umvoti
Umgeni ($1x10^6$)	cfu/100ml	cfu/100ml	cfu/100ml	cfu/100ml	cfu/100ml
Sample 1 Salmonella Shigella (SS) Agar	4	19	6	9	11
Sample 2 MacConkey Agar Purple	10	11	8	23	8
Sample 3 Nutrient Agar	89	48	26	67	78

Soil sample analysis

An investigation of the fish community structure of various estuaries indicated that each estuary has a specific community of fish species (Harrison *et al*., 2000). Research by Allanson and Baird (1999) indicated that information on the larval biology and ecology of most fish taxa is generally lacking.

According to Turpie (2002), the lower reaches of a river system, especially the estuaries, are not only well known in terms of their biodiversity due to their migratory ability. Hence, the river system, especially the estuarine areas, is used as a transit to the sea and, at most, a nursery for many fish species. Harrison *et al*. (2000) also indicated that the fish species occurring in the lower reaches of the rivers, especially estuaries, have an ability to adapt to variations in salinity, temperature, and pH. The environmental variation is due to the mixing of marine water with fresh water during the tidal changes, which brings about abrupt changes in salinity, temperature, dissolved oxygen, and turbidity, which place considerable physiological demands on the fishes that occupy these systems (Harrison and Whitfield, 2006a). Estuaries

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provide nursery areas for marine fish species. Approximately 40% of the fish species occurring in estuaries are marine species that occupy the estuary for nursery sites or intermittent foraging areas during high tides. It is known that the estuaries and/or lower reaches of the river system have a fluctuation in salinity levels due to the changes in the ocean tides. Species occurring in these areas need to become tolerant to these salinity changes (Harrison *et al*., 2000). There is a major need for responses by river management authorities to report on the status of rivers according to their environmental changes. This would bring about awareness and the need to improve ecosystem resources and feed into the policies of the management plans of river ecosystems (Whitfield and Elliot 2002, Harrison and Whitfield 2004).

The investigation of the five rivers showed some common species that occur in all the rivers in KwaZulu-Natal. These species could be used as indicator species of river health. A decline in any of these species should be an alarm, as it would indicate some sort of disturbance to the river system. In total, 9 fish species were netted in all five rivers under investigation. The most predominant species were *Acanthopa grusberda* (River bream), *Oreochromis mossambicus* (Mozambique tilapia) and *Myxus capensis* (Fresh water mullet). Most of the species were found to be under overhanging vegetation as well as within the reeds that occupy the river system in certain areas. All soil samples tested positive for *Salmonella* and *Shigella*. They were lactose-non-fermenters because they were mostly transparent and colorless. Some colonies produced black-centered colonies, which means they can produce H2S. MacConkey Agar showed both lactose-fermenting and lactose-non-fermenting organisms. The colonies formed were a combination of brown to red, whilst some were colorless. Possible colonies detected were Gram-negative. *Escherichia coli* was characterized by red colonies, and *Salmonella enterica* appeared as colorless colonies. Nutrient Agar produced colorless colonies from all the soil samples assayed, and it was the only medium that produced colonies that were consistently over 20 CFU/100 mL from all soil samples. Nutrient agar is a non-selective and non-deferential agar allowing the growth of all organisms present on the samples. The microbial analysis indicated pollution due to the various activities occurring at the upper reaches of the river system. Industrial, agricultural, and domestic uses are the key contributors to this pollution. It is suggested that control measures should be put in place to eliminate this problem.

Discussion

This study assessed fish population dynamics and bacterial contamination across five major rivers in KwaZulu-Natal: the Umfolozi, Umdloti, uMngeni, Umvoti, and Thukela Rivers. The results revealed significant spatial variability in both fish assemblages and microbial loads. Rivers with lower anthropogenic influence, particularly the Umfolozi and Umdloti, exhibited greater fish species richness and abundance. In contrast, the uMngeni and Umvoti Rivers, especially at downstream sites near urban and agricultural zones, showed reduced fish diversity, higher dominance of hardy, pollution-tolerant species, and elevated microbial contamination, including *Escherichia coli* and total coliforms that exceeded SANS 241 (2015) thresholds for safe water use. The observed patterns highlight a strong spatial gradient in riverine ecological health, with less-disturbed sites supporting more diverse and balanced fish populations. These findings align with the hypothesis that fish community structure can serve as a sensitive bioindicator of river health (Maceda-Veiga & De Sostoa, 2011; Harrison & Whitfield, 2004). While no statistical correlation was presented between fish metrics and microbial levels, the co-occurrence of low fish diversity and high bacterial contamination in urban-impacted sites (particularly in the uMngeni and Umvoti Rivers) suggests potential interactive stressors affecting aquatic biota.

Microbial contamination in these rivers is likely driven by untreated wastewater discharges, stormwater runoff, and agricultural practices. These anthropogenic inputs contribute not only to bacterial proliferation but also to nutrient loading, which can cause eutrophication, habitat degradation, and hypoxic conditions, factors detrimental to sensitive fish species. Seasonal variation was also evident, with summer months showing increased bacterial loads and slight declines in fish richness. This can be attributed to elevated runoff due to summer rainfall, increased agricultural activity, and higher water temperatures that favor bacterial growth but may stress certain fish species. Similar seasonal patterns have been reported by Turpie (2002), who notes that hydrological fluctuations and temperature shifts influence both microbial dynamics and fish community structure in South African rivers. The integration of fish and microbial indicators offers a robust framework for assessing ecological integrity. The spatial heterogeneity documented in this study underscores the need for site-specific interventions aimed at reducing pollution inputs and protecting aquatic biodiversity in KwaZulu-Natal's River systems.

Generalizability

The findings are most applicable to river systems in KwaZulu-Natal with similar hydrological, climatic, and land-use profiles. The methodology and insights can inform broader water resource management efforts across South African river-estuary systems, though caution should be taken when applying results to catchments with markedly different geomorphology, hydrology, or pollution profiles. Nonetheless, the study framework combining biotic and microbial indicators can be adapted for national aquatic ecosystem monitoring programs.

Conclusion

This study demonstrated that fish assemblage structure and bacterial contamination levels vary considerably across the uMngeni, uThukela, Umvoti, Umdloti, and Umfolozi Rivers. Heavily impacted rivers showed signs of ecological stress, evident in low fish species richness and elevated *E. coli* concentrations, particularly in downstream areas. In contrast, less disturbed systems supported more diverse and balanced fish communities and recorded lower microbial contamination.

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These findings highlight the value of integrated bioassessment in informing catchment management, conservation planning, and public health protection.

Limitations

This study was cross-sectional and limited to two seasonal periods (summer and winter of 2024), which did not capture interannual variability or episodic pollution events. Fish sampling was constrained by habitat accessibility, which resulted in the likely underestimation of cryptic or nocturnal species. The microbial analysis was restricted to *E. coli* and total coliforms, thereby excluding other potentially harmful pathogens or chemical contaminants that could further impact river health. Furthermore, although patterns were observed between fish diversity and microbial contamination, causal relationships could not be established due to the complex, multifactorial nature of aquatic ecosystem dynamics.

Recommendations

To safeguard the ecological integrity of river systems, it is essential to implement integrated monitoring programs that involve routine fish population surveys and microbial water quality testing, particularly in ecologically vulnerable stretches. Government and conservation agencies should lead these initiatives to ensure consistency and data reliability. Pollution control and wastewater management must also be prioritized, with targeted interventions aimed at reducing pollutant inputs from urban, industrial, and agricultural sources. This includes upgrading wastewater treatment facilities and establishing vegetated buffer zones to filter runoff before it enters waterways. Riparian zone rehabilitation through the restoration of degraded riverbanks with native vegetation is another critical strategy, as it enhances water quality, stabilizes habitats, and supports fish biodiversity. Equally important is the role of community awareness and stewardship. Intensified environmental education campaigns can foster a sense of responsibility among local populations, encouraging active participation in river conservation and safe sanitation practices. Finally, monitoring programs should be seasonally adaptive, incorporating both summer and winter assessments to detect temporal changes and enable early responses to pollution spikes, thus enhancing the resilience of freshwater ecosystems.

List of Abbreviations

FRAI - Fish Response Assessment Index
RHP - River Health Programme

Biography

Dr. Sibonelo Thanda Mbanjwa is a dedicated lecturer in the Department of Nature Conservation at Mangosuthu University of Technology (MUT), South Africa. He holds a Ph.D. in Environmental Science and specializes in biodiversity conservation, sustainable development, and environmental education. Dr. Mbanjwa is deeply committed to community engagement, student mentorship, and the integration of indigenous knowledge systems into conservation practices. His work bridges academia and practical application, empowering students and communities through innovative teaching, research, and outreach initiatives.

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Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

I, the author, contributed to the study's conception and design. Material preparation, data collection, and research were performed by Mbanjwa S.T. The first draft was written by Mbanjwa S.T.

Data Availability

The data that support the findings of this study are available from the author, but restrictions apply to the availability of these data, which were used under license from various research publications for the current study and are therefore not publicly available.

References

1. Allanson, B.R. & Baird, D. (eds.), 1999. Estuaries of South Africa. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511525490 PMCid: PMC1734375
2. Barbour, M.T., Gerritsen, J., Snyder, B.D. & Stribling, J.B., 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish. 2nd ed. Washington, D.C.: U.S. Environmental Protection Agency.
3. Cabral, H.N., Vasconcelos, R.P., Vinagre, C., França, S., Fonseca, V., Maia, A., Reis-Santos, P., Lopes, M., Ruano, M., Campos, J., Freitas, V., Santos, P.T., Costa, M.J. & Gordo, L.S., 2012. Ecological traits of fish assemblages from different estuarine systems in Portugal. Marine Ecology Progress Series, 448, pp.221-234.
4. Department of Water Affairs and Forestry (DWAF), 2017. River EcoClassification: Manual for EcoStatus Determination

(Version 2). Pretoria: DWAF / Water Research Commission.
5. Department of Water and Sanitation (DWS), 2017. Water Quality Standards Handbook: Chapter 3: Water Quality Guidelines. Pretoria: DWS.
6. Elliott, M., Whitfield, A.K., Potter, I.C., Blaber, S.J.M., Cyrus, D.P., Nordlie, F.G. & Harrison, T.D., 2007. The guild approach to categorizing estuarine fish assemblages: a global review. Fish and Fisheries, 8(3), pp.241-268. https://doi.org/10.1111/j.1467-2679.2007.00253.x
7. Gamito, R., Cabral, H.N., Costa, M.J., Jorge, I. & Erzini, K., 2012. Functional diversity of fish communities in estuaries of the Iberian Peninsula. Estuarine, Coastal and Shelf Science, 110, pp.43-53.
8. Harrison, T.D., Cooper, J.A.G. & Ramm, A.E., 2000. State of South African estuaries: Geomorphology, ichthyofauna, water quality and aesthetics. State of the Environment Series. Pretoria: Department of Environmental Affairs and Tourism.
9. Harrison, T.D. & Whitfield, A.K., 2004. A multi-metric fish index to assess the environmental condition of estuaries. Journal of Fish Biology, 65(3), pp.683-710. https://doi.org/10.1111/j.0022-1112.2004.00477.x
10. Harrison, T.D. & Whitfield, A.K., 2006. Temperature and salinity as primary determinants influencing the biogeography of fishes in South African estuaries. Estuarine, Coastal and Shelf Science, 66(2), pp.335-345. https://doi.org/10.1016/j.ecss.2005.09.010
11. Kleynhans, C.J., 1999. Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (Version 2). Pretoria: Water Research Commission.
12. Kleynhans, C.J., 2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (Version 2). Pretoria: Joint Water Research Commission & Department of Water Affairs and Forestry.
13. Lin, Y., Wang, D., Xu, D., Chen, J. & Wang, H., 2012. Assessment of river water quality using fuzzy synthetic evaluation. Procedia Environmental Sciences, 13, pp.1601-1612.
14. Maceda-Veiga, A. & De Sostoa, A., 2011. Observational evidence of the sensitivity of some fish species to environmental stressors in Mediterranean rivers. Ecological Indicators, 11(2), pp.311-317. https://doi.org/10.1016/j.ecolind.2010.05.009
15. Meador, M.R., McIntyre, J.P. & Pollock, K.H., 1993. Assessing the effectiveness of electrofishing and rotenone for sampling fish assemblages in a small southeastern stream. North American Journal of Fisheries Management, 13(4), pp.686-697.
16. National Health and Medical Research Council (NHMRC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), 2003. Australian Drinking Water Guidelines. Canberra: NHMRC and ARMCANZ.
17. Straub, T.M. & Chandler, D.P., 2003. Towards a unified system for detecting waterborne pathogens. Journal of Microbiological Methods, 53(2), pp.185-197. https://doi.org/10.1016/S0167-7012(03)00023-X PMid:12654490
18. Todd, C. & Roux, D., 2000. Design of an aquatic biomonitoring programme, using the South African River Health Programme as a case study. In: 1st WARFSA/Water Net Symposium: Sustainable Use of Water Resources, Maputo, 1-2 November 2000.
19. Turpie, J.K., 2002. The valuation of riparian fisheries in southern Africa. African Journal of Aquatic Science, 27(1), pp.59-70.
20. Van der Oost, R., Beyer, J. & Vermeulen, N.P.E., 2003. Fish bioaccumulation and biomarkers in environmental risk assessment: a review. Environmental Toxicology and Pharmacology, 13(2), pp.57-149. https://doi.org/10.1016/S1382-6689(02)00126-6 PMid:21782649
21. Whitfield, A.K. & Elliott, M., 2002. Fishes as indicators of environmental and ecological changes within estuaries: a review of progress and some suggestions for the future. Journal of Fish Biology, 61(sA), pp.229-250. https://doi.org/10.1111/j.1095-8649.2002.tb01773.x
22. World Health Organ ization (WHO), 1990. Guidelines for Drinking-water Quality. Geneva: World Health Organization

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