Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

A CROSS-SECTIONAL STUDY ASSESSING THE IMPACT OF ILLEGAL DUMPING OF WASTE MATERIAL BY FISHERMEN AND COMMUNITIES ON RIVERINE BIODIVERSITY IN SELECTED AREAS OF THE EASTERN CAPE PROVINCE, SOUTH AFRICA.

*Sibonelo Thanda Mbanjwa**
Mangosuthu University of Technology P.O. Box 12363 Jacobs 4026 Durban, South Africa

ABSTRACT

Background
Illegal dumping of waste by fishermen and surrounding communities has emerged as a serious environmental issue in the Eastern Cape Province of South Africa, with adverse effects on riverine biodiversity. Although pollution is globally acknowledged as a threat to freshwater ecosystems, limited studies have focused specifically on how community-driven illegal dumping affects riverine environments in this region. This study aimed to assess the impact of illegal waste dumping by fishermen and local communities on riverine biodiversity in selected areas of the Eastern Cape.

Methodology
A cross-sectional mixed-methods design was adopted. Study sites were selected based on high fishing activity and visible waste accumulation. Quantitative data were obtained through biodiversity assessments using established indices, and pollution levels were measured through waste categorization and field observations. Qualitative data were collected through surveys and semi-structured interviews with 45 respondents, including 20 fishermen, 15 community residents, and 10 key stakeholders from local government and environmental organizations.

Results
The study revealed a significant negative correlation between illegal dumping and riverine biodiversity. Heavily polluted sites (pollution levels between 50%–90%) showed decreased species richness and lower organism abundance. Communities near these sites reported increased sightings of waste-related hazards, such as fish die-offs and foul odours. Socio-economic challenges such as unemployment, poor service delivery, and lack of education were identified as underlying drivers of illegal dumping. Many participants lacked awareness of environmental laws or proper disposal methods, and stakeholders cited weak municipal enforcement and insufficient infrastructure as barriers to effective waste management.

Conclusion
Illegal dumping poses a serious threat to freshwater biodiversity in the Eastern Cape. Without intervention, ongoing pollution will continue to degrade river ecosystems and threaten aquatic life.

Recommendations
Improved waste infrastructure, environmental education, and collaborative stakeholder action are urgently needed to curb pollution and support biodiversity conservation.

Keywords: *Illegal dumping, Waste Management, Riverine Biodiversity, Fishing Communities, Eastern Cape, Environmental Impact, Biodiversity Assessment, Sustainable Fishing, Pollution, Community Engagement*
Submitted: 2025-03-16 Accepted: 2025-05-22 Published: 2025-06-01

Corresponding Author: *Sibonelo Thanda Mbanjwa**
*Email:**mbanjwa.sibonelo@mut.ac.za*** ***ORCHID 0000000319417669***
Mangosuthu University of Technology P.O. Box 12363 Jacobs 4026 Durban, South Africa

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

INTRODUCTION

The Eastern Cape Province of South Africa is home to diverse riverine ecosystems, which are crucial for maintaining biodiversity, supporting local livelihoods, and fostering sustainable fisheries. However, these ecosystems are under increasing pressure from pollution, particularly due to illegal dumping of waste by fishing communities see Figure 1. The practice of illegal dumping, driven by inadequate waste management infrastructure, poverty, and limited regulatory enforcement, poses significant threats to riverine biodiversity. This growing environmental concern has been noted in various parts of the province, especially where communities rely on these ecosystems for their livelihood (Binns & Nel, 2002; McLachlan & Anderson, 2017). Research has highlighted that the degradation of riverine ecosystems has far-reaching consequences, not only for biodiversity but also for human health and the sustainability of local economies (Smith et al., 2010; Taljaard & Lamberth, 2013).

Despite these concerns, there has been limited research on the direct impact of illegal dumping by fishermen and local communities on the biodiversity of riverine systems in the Eastern Cape. Most studies have focused on broader environmental issues such as industrial pollution, water scarcity, and the effects of large-scale land use changes on aquatic ecosystems (Diedericks et al., 2012; Weston et al., 2015). However, the specific role of small-scale fishing communities in riverine waste dumping has not been adequately explored. This gap in knowledge is critical, as small-scale fisheries play an essential role in food security and poverty alleviation in rural coastal regions (Klein, 2011; Shackleton & Blair, 2017). Furthermore, the illegal dumping of waste by these communities often goes unnoticed in larger studies of pollution, leaving a critical area of environmental degradation unaddressed.

The research aims to assess the impact of illegal dumping on riverine biodiversity in selected areas of the Eastern Cape. To achieve this, a mixed-methods approach is adopted, combining both qualitative and quantitative methodologies. Qualitative data will be gathered through interviews with local fishermen and community members to understand the reasons behind illegal dumping and its perceived effects on the environment. Quantitative data will be collected through biodiversity assessments of the affected riverine areas, focusing on species diversity, abundance, and overall ecosystem health. This methodology will provide a comprehensive analysis of the environmental impacts of waste disposal practices within these communities.

Preliminary findings from this study suggest that illegal dumping significantly impacts riverine biodiversity by introducing non-biodegradable materials and toxic substances into aquatic ecosystems. Furthermore, fishing practices may be affected due to the deterioration of water quality, reduced fish populations, and the destruction of habitat for aquatic species. These findings align with broader environmental studies, which have shown that waste pollution disrupts ecological balance, particularly in freshwater and estuarine environments (Davies, 2011; Hart et al., 2014). Moreover, the study has identified that local fishing communities are often unaware of the long-term consequences of illegal waste dumping, suggesting a need for greater environmental education and waste management infrastructure.

The implications of this study are twofold. First, it highlights the need for better waste management practices and policy enforcement to mitigate the environmental damage caused by illegal dumping in rural fishing communities. Second, the study emphasizes the importance of integrating community-based environmental management strategies into conservation efforts. By providing evidence of the impacts of illegal dumping, the research aims to inform policy decisions regarding the protection of riverine biodiversity in the Eastern Cape. This approach could be applied to other coastal and riverine areas facing similar environmental challenges, promoting more sustainable fishing practices and better stewardship of natural resources (FAO, 2015; FAO & IUCN, 2020).

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

Figure 1: The picture illustrates the impact of illegal dumping of waste material by fishermen and communities on riverine biodiversity. Source: Own creation using GIS data

Global context

On the international stage, the degradation of riverine ecosystems due to pollution is a widespread issue, particularly in developing countries. In areas where communities rely on rivers for fishing, water supply, and agricultural activities, the impacts of illegal dumping and pollution can be devastating. International environmental organizations, such as the Food and Agriculture Organization (FAO) and the International Union for Conservation of Nature (IUCN), have highlighted the need for improved waste management and sustainable fishing practices to protect these vital ecosystems. The issue of small-scale fisheries is particularly relevant internationally, as they support the livelihoods of millions of people, especially in coastal and riverine communities in Asia, Africa, and Latin America (FAO, 2015). The role of local communities in maintaining the health of riverine systems has been increasingly recognized, with efforts to promote community-based resource management as a means to improve environmental outcomes (IUCN, 2017).

Globally, riverine ecosystems are crucial for maintaining biodiversity and supporting the livelihoods of millions of people, particularly in rural areas. These ecosystems provide essential ecosystem services, such as freshwater, food, and habitat for wildlife. However, many river systems face increasing pressures from anthropogenic activities, including pollution, land-use changes, and climate change. Waste pollution, particularly from plastics and other non-biodegradable materials, has been identified as a significant threat to riverine biodiversity worldwide (UNEP, 2018). The global community, through international environmental agreements such as the Paris Agreement and the UN Sustainable Development Goals (SDGs), has recognized the importance of protecting freshwater ecosystems. Specifically, Goal 14, Life Below Water, and Goal 15, Life on Land, emphasize the need for sustainable management of natural resources and the prevention of pollution in freshwater and coastal ecosystems. However, achieving these goals remains challenging, particularly in developing countries where waste management infrastructure is often inadequate. The issue of illegal

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

waste dumping and its impact on riverine biodiversity is a global challenge that affects numerous countries, particularly those with significant coastal and riverine ecosystems that support both local populations and biodiversity. Illegal dumping often leads to the degradation of natural resources, creating lasting consequences for local communities, aquatic species, and overall environmental health. In many developing nations, small-scale fishing communities face the dual challenges of inadequate waste management systems and poor enforcement of environmental regulations, making illegal dumping a persistent issue (FAO, 2015).

Countries such as Indonesia, the Philippines, and Mexico, with comparable socio-economic conditions and geographical features to South Africa, have also been grappling with pollution-related problems in their coastal and freshwater systems. In Indonesia, for example, illegal waste dumping by fishing communities has contributed to the decline of coral reefs and fish stocks, severely affecting the livelihoods of artisanal fishers (Miller et al., 2018). In the Philippines, coastal communities have faced similar challenges, with rising plastic pollution in river systems endangering aquatic biodiversity and exacerbating poverty among small-scale fishers who depend on healthy ecosystems for survival (Garrity et al., 2015).

In Mexico, illegal dumping in the country's rivers has been a significant concern, particularly along the Gulf Coast, where industrial waste, plastic, and organic pollutants harm local marine life. The impacts of pollution are often compounded by the presence of large-scale commercial fisheries that outcompete local fishers for access to dwindling resources, thus amplifying the social and economic challenges faced by marginalized fishing communities (FAO & IUCN, 2020). In response, various initiatives, including community-based resource management programs, have been introduced to address illegal dumping and promote sustainable fishing practices in these countries (Berkes et al., 2015).

Globally, the issue of illegal dumping in aquatic environments intersects with broader challenges related to overfishing, habitat loss, and the degradation of marine ecosystems. The persistence of such pollution in riverine and coastal environments has led to increased attention from international organizations such as the United Nations Environment Programme (UNEP) and the Food and Agriculture Organization (FAO). These organizations advocate for stronger policies on waste management, community engagement, and more integrated approaches to marine conservation (FAO, 2015; UNEP, 2017). In particular, they emphasize the need for effective governance and policies that support local communities, enhance waste management infrastructure, and reduce environmental pollution to ensure that fishing and biodiversity conservation go hand in hand.

The global context of illegal dumping thus highlights a common thread: while many countries have made strides in recognizing the social, economic, and environmental value of sustainable fisheries, significant challenges remain in the practical implementation of these goals. The persistence of illegal waste dumping, particularly by small-scale fishermen, undermines both conservation efforts and the ability of local communities to sustainably manage their natural resources, calling for more collaborative and inclusive approaches to environmental governance.

National context (South Africa)

In South Africa, the issue of illegal waste dumping, particularly by small-scale fishermen and coastal communities, presents a significant challenge to both riverine biodiversity and the livelihoods of those dependent on aquatic resources. The Eastern Cape Province, known for its vast and ecologically rich river systems, is particularly affected by illegal dumping practices, which have become a major contributor to environmental degradation. Small-scale fishermen, who often rely on these rivers for sustenance and income, are faced with increasing pollution levels that undermine the health of fish populations and other aquatic species (de Villiers, 2016). Despite efforts by the South African government and local organizations to address waste management issues, illegal dumping continues to persist due to inadequate enforcement, lack of resources, and weak community engagement (Government of South Africa, 2019).

Historically, South African coastal and riverine communities have been marginalized and often excluded from formal resource management frameworks. This exclusion has led to difficulties in implementing policies that effectively address both socio-economic and environmental challenges. The country's focus on balancing environmental protection with social development has been hindered by systemic issues such as poverty, limited access to environmental education, and inadequate infrastructure in rural areas (du Plessis, 2014). These barriers make it difficult for marginalized communities to engage in sustainable waste management

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

practices and to prioritize the preservation of biodiversity in their local ecosystems.

In the Eastern Cape, illegal dumping by both local communities and commercial interests has become a pressing issue, particularly in regions with significant fishing activity. The accumulation of plastic, organic waste, and industrial pollutants in rivers has led to the degradation of aquatic habitats and a decline in fish populations. This poses a direct threat to the livelihoods of small-scale fishers who depend on these resources for food and income. Studies have shown that communities in these areas are not only struggling with environmental degradation but are also facing economic hardship due to the depletion of fish stocks caused by pollution and overfishing (Loubser et al., 2020).

Furthermore, the governance of South Africa's marine and riverine resources, under the Department of Environmental Affairs and Tourism (DEAT), has been criticized for its top-down approach, which often excludes local communities from decision-making processes. This has led to a lack of ownership and responsibility for waste management and environmental conservation, especially in rural areas where community members feel disconnected from formal environmental policies (Pinnock, 2013). However, there has been increasing recognition of the need for co-management approaches that include local stakeholders in the governance of natural resources to ensure sustainable outcomes and foster a sense of responsibility for environmental stewardship (de Villiers, 2016; du Plessis, 2014).

The South African government has made strides to address these issues through various legislative frameworks, including the National Environmental Management Act (NEMA) and the Integrated Coastal Management Act (ICMA), which aim to enhance environmental protection and promote sustainable resource use. However, the challenge remains in effectively enforcing these laws in rural and underserved areas, where illegal dumping and pollution continue to exacerbate the vulnerability of riverine biodiversity (National Department of Environmental Affairs, 2017). There is a pressing need for more effective collaboration between government agencies, local communities, and NGOs to tackle illegal waste dumping and promote sustainable practices that protect both the environment and the livelihoods of vulnerable populations.

In South Africa, riverine ecosystems are vital to the economy, biodiversity, and the livelihoods of rural communities. The country has a rich diversity of river systems, including the Orange River, the Limpopo River, and the Eastern Cape's numerous estuaries and rivers. However, pollution, including illegal dumping, has become a critical issue in many of these river systems. In particular, the Eastern Cape faces significant environmental challenges due to waste pollution, driven by poverty, inadequate waste management services, and limited regulatory enforcement (McLachlan & Anderson, 2017). The South African government has recognized these challenges and has implemented various policies to address environmental degradation, such as the National Environmental Management Act (NEMA) and the National Waste Management Strategy. Despite these efforts, enforcement of waste management policies in rural and coastal areas remains a significant challenge, particularly in informal settlements and fishing communities. The Department of Environmental Affairs has also called for improved community participation in environmental management to curb pollution and enhance sustainability.

Provincial context (Eastern Cape)

The Eastern Cape Province of South Africa is characterized by a vast and ecologically diverse landscape, including extensive river systems, wetlands, and a long coastline that supports various marine and freshwater species. The province is home to numerous small-scale fishing communities that depend on these natural resources for their livelihoods. However, illegal dumping of waste by both local communities and outsiders has emerged as a significant environmental threat to riverine biodiversity, particularly in areas where fishing and other resource-based activities are prevalent. These issues are particularly visible in areas such as the Kei River, the Buffalo River, and the Fish River, which have historically been vital sources of food and income for local communities (Snyders, 2018).

Illegal dumping of waste, including plastics, organic materials, and hazardous substances, has become a prevalent practice in both rural and urban areas of the Eastern Cape, exacerbating environmental degradation. The accumulation of waste in these river systems contributes to the pollution of aquatic habitats, which in turn affects the health of fish populations and other aquatic organisms. For the small-scale fishing communities that rely on these rivers for sustenance, this pollution directly threatens their food security and income, as fish stocks are depleted, and water quality deteriorates (Matsebe & Loubser, 2020). Furthermore, the

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

presence of hazardous waste in rivers, including heavy metals and industrial chemicals, poses a long-term threat to both human health and biodiversity (Nhamo et al., 2016).

The Eastern Cape's fishing communities face particular challenges in addressing illegal waste dumping due to socio-economic factors such as poverty, limited education on environmental management, and insufficient access to waste disposal infrastructure. Many of these communities are rural and have limited access to formal waste management services, which results in improper waste disposal practices. In some cases, these communities lack awareness about the environmental consequences of illegal dumping and may prioritize short-term economic needs over long-term environmental sustainability (Snyders, 2018). As a result, rivers become depositories for waste, which further exacerbates the ecological degradation and impacts the resilience of local communities to environmental change.

Moreover, the provincial government has struggled to implement effective waste management policies in these areas due to resource constraints, inadequate enforcement, and limited community engagement. While the Eastern Cape provincial government has introduced some initiatives aimed at improving waste management and environmental protection, including community-based waste management programs and awareness campaigns, the success of these initiatives has been limited by poor infrastructure, a lack of funding, and inconsistent enforcement of regulations (Matsebe & Loubser, 2020). This highlights the need for more comprehensive and localized interventions that integrate environmental education, better waste management practices, and community involvement in resource conservation.

There is also a growing recognition of the need for co-management approaches that involve local communities in the management of riverine ecosystems and waste management efforts. The inclusion of local stakeholders in decision-making processes has the potential to improve the effectiveness of conservation efforts and foster a sense of shared responsibility for the protection of natural resources (de Villiers, 2016). These approaches can also help to bridge the gap between government policies and the realities faced by local communities, ensuring that waste management strategies are both feasible and culturally appropriate.

The illegal dumping of waste in river systems poses significant challenges to the health of aquatic ecosystems in the Eastern Cape. Addressing this issue requires a multi-faceted approach that involves improving waste management infrastructure, raising environmental awareness, and fostering community engagement. By prioritizing the involvement of local fishing communities in resource governance and waste management, it is possible to mitigate the negative impacts of illegal dumping and promote the long-term sustainability of both riverine biodiversity and the livelihoods of those dependent on these resources.

The Eastern Cape Province in South Africa is home to a unique range of riverine ecosystems, including the Kei River, the Gqunube River, and the Fish River. These river systems are essential for local biodiversity, as well as the socio-economic development of the region. Fishing, agriculture, and tourism are key sectors that rely on the health of these ecosystems. However, the province has been facing increasing pressure from pollution, including illegal waste dumping by local fishing communities (Binns & Nel, 2002). Many communities in the Eastern Cape, especially in rural coastal areas, face challenges related to poverty, lack of access to waste management infrastructure, and limited awareness of environmental issues. As a result, illegal dumping of waste into riverine systems has become a common practice, contributing to the degradation of these vital ecosystems. This environmental concern is particularly prominent in areas where communities rely on fishing for their livelihoods, as the declining health of riverine ecosystems threatens both biodiversity and the availability of fish stocks (Taljaard & Lamberth, 2013).

The provincial government has acknowledged the issue of waste pollution and has implemented several initiatives aimed at improving waste management practices, such as the Eastern Cape Waste Management Strategy. However, enforcement remains a challenge, and the role of local communities in mitigating pollution is critical. Local fishing communities are often unaware of the long-term ecological consequences of their actions, making it essential to integrate education and capacity-building programs into policy and management strategies. The global, national, and provincial contexts all highlight the importance of protecting riverine ecosystems from pollution, particularly in rural and coastal communities. The Eastern Cape, as a critical area for biodiversity and the livelihoods of fishing communities, faces significant environmental challenges related to illegal waste dumping. These challenges are not unique to South Africa but are part of a broader global issue of riverine ecosystem degradation. Addressing these issues requires a multi-

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

level approach, including policy enforcement, community engagement, and improved waste management infrastructure, in line with international environmental goals and national strategies.

Background information

The pollution of riverine and coastal ecosystems, particularly through illegal dumping, has emerged as a pressing global challenge with profound implications for biodiversity, human health, and sustainable livelihoods. In South Africa, the Eastern Cape Province boasts an array of vital river systems that support diverse aquatic species and underpin the livelihoods of local communities. However, these ecosystems are increasingly at risk from pollution, much of which stems from the illegal disposal of waste by local populations, including small-scale fishing communities. Unlike general waste pollution, illegal dumping presents unique and often overlooked challenges, introducing hazardous substances such as non-biodegradable plastics, chemicals, and organic debris into sensitive aquatic environments (McLachlan & Anderson, 2017). This unchecked pollution not only compromises water quality but also dismantles the integrity of aquatic habitats and jeopardizes biodiversity (Davies, 2011; Hart et al., 2014).

Despite the urgent nature of this issue, much of the existing research in South Africa has historically concentrated on the impacts of industrial pollution and large-scale land-use changes on freshwater and marine ecosystems. This focus leaves a significant gap in understanding the contributions of small-scale fishing communities to environmental degradation (Smith et al., 2010). This oversight is particularly troubling, as these communities are pivotal to the Eastern Cape's economy and food security (Klein, 2011). Living on the margins of poverty, many of these communities lack access to adequate waste management infrastructure, leaving illegal dumping as a pragmatic albeit harmful alternative (Shackleton & Blair, 2017). Government initiatives aimed at addressing waste management challenges have had limited success due to insufficient enforcement mechanisms and a lack of environmental education at the community level (Binns & Nel, 2002).

Research has consistently shown that waste pollution poses a direct and severe threat to aquatic ecosystems. Pollutants disrupt ecological balance by reducing species diversity, altering the composition of aquatic communities, and impairing the productivity of these ecosystems (Weston et al., 2015). In the Eastern Cape, these impacts are particularly acute, with declining fish stocks and habitat destruction threatening not only local biodiversity but also the livelihoods of fishing communities. Overfishing, compounded by pollution, has led to a precarious state for several fish species, with some at risk of extinction (Taljaard & Lamberth, 2013). Polluted waters further degrade the economic prospects of local fishermen by reducing the availability and quality of fish stocks, thereby undermining food security and economic resilience (Diedericks et al., 2012; McLachlan & Anderson, 2017).

Globally, nations like Indonesia, Mexico, and the Philippines face similar challenges, as small-scale fishers contend with the twin pressures of environmental degradation and resource depletion. Illegal dumping in these regions has led to widespread damage to aquatic ecosystems, diminishing the viability of fisheries and exacerbating poverty in rural communities (FAO, 2015; FAO & IUCN, 2020). While regulatory frameworks in these countries aim to mitigate waste pollution, enforcement remains a persistent challenge, particularly in underserved areas where waste management infrastructure is absent and community awareness is low (Smith et al., 2010; Shackleton & Blair, 2017). These shared struggles underscore the global nature of the problem and highlight the urgent need for targeted, localized interventions that align with broader international conservation goals.

The Eastern Cape's predicament is emblematic of a broader issue that demands greater research attention. The limited exploration of how illegal dumping by small-scale fishing communities specifically affects biodiversity represents a critical knowledge gap. Small-scale fisheries are not only essential to local economies but also to maintaining ecological balance in riverine systems. Without a deeper understanding of the drivers, impacts, and potential solutions to this form of pollution, policy interventions risk being insufficient or misaligned with community realities.

Addressing illegal dumping in riverine ecosystems requires a dual focus: the implementation of effective waste management policies and the empowerment of local communities through education and sustainable practices. Research that centres on the intersection of human activity, ecological health, and community livelihoods is vital for crafting actionable solutions. This endeavour is not only essential for preserving biodiversity but also for safeguarding the socio-economic futures of fishing

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

communities in the Eastern Cape and similar regions worldwide.

Research questions

What measures can be implemented to reduce illegal dumping and mitigate its impact on riverine biodiversity in the Eastern Cape?

RESEARCH METHODOLOGY

Study Design

This study employed a cross-sectional mixed-methods design, integrating both quantitative and qualitative approaches to assess the environmental impact of illegal dumping on riverine biodiversity and to explore community behaviours and awareness related to waste disposal.

This research employed a mixed-methods approach to assess the impact of illegal dumping on riverine biodiversity in selected areas of the Eastern Cape Province, South Africa. The methodology involved both qualitative and quantitative data collection techniques to ensure a comprehensive understanding of the issue.

Study Area Selection

The research focused on selected riverine and coastal zones in the Eastern Cape Province, which were identified based on their susceptibility to illegal waste dumping and their importance for local fisheries. Areas were chosen based on reports of illegal dumping activities, proximity to fishing communities, and the availability of biodiversity data.

Qualitative Data Collection

Semi-structured interviews were conducted with local fishermen, community members, and key stakeholders from local government and environmental organizations. These interviews aimed to gather insights into the causes of illegal dumping, the types of waste involved, and the perceived environmental and socio-economic impacts. The interviews also explored community attitudes toward waste management practices and the effectiveness of existing regulations. A total of 30 interviews were conducted, ensuring a diverse representation of stakeholders.

Quantitative Data Collection

The study also involved the collection of quantitative data through field surveys and water quality assessments. Surveys were conducted at designated dumping sites to document the types and volumes of waste materials present in the river systems. The waste types were categorized into plastic, fishing-related materials, glass, metal, and other household waste. In addition, water samples were taken from the rivers at regular intervals to assess the quality of the water. Parameters such as pH, dissolved oxygen, turbidity, and nutrient levels were measured to determine the impact of waste dumping on water quality. Fish populations were also surveyed using standardized fish sampling techniques, including electrofishing and netting, to evaluate the biodiversity of the river systems.

Data Analysis

The qualitative data obtained from interviews were analysed using thematic analysis to identify common themes related to the causes, effects, and community perceptions of illegal dumping. This allowed for a deeper understanding of the socio-economic factors contributing to waste disposal behaviours. The quantitative data from the field surveys and water quality assessments were analysed statistically to identify correlations between illegal dumping sites, water quality degradation, and the health of aquatic biodiversity. Descriptive statistics were used to summarize the frequency and types of waste materials. In contrast, inferential statistics, including regression analysis, were applied to assess the relationship between waste levels and changes in biodiversity indicators.

Participants

Participants were selected using purposive sampling based on their proximity to the affected river systems and their involvement in fishing or community leadership. Eligible participants included adult community members (≥18 years old), active fishermen, and officials or stakeholders from local government and environmental organizations operating within the study areas. Participants were required to have lived or worked in the area for at least one year.

Survey Sites with Designated Dumping Hotspots

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

Surveys were conducted near riverside dumping zones at the following sites:

- Mthatha River – Norwood Extension Site
- Kei River – Butterworth Rural Edge
- Buffalo River – Duncan Village Informal Settlement
- Kowie River – Ndlambe District fishing zone

Bias

To reduce selection bias, efforts were made to include a diverse group of participants from multiple communities and stakeholder groups. Interviews were conducted by trained fieldworkers in the local language to minimize language-related misunderstandings. Researcher triangulation was employed to reduce interpretation bias in qualitative data analysis.

Study Size

A total of 45 participants took part in the qualitative component:

- 20 local fishermen
- 15 community residents
- 10 stakeholders from local government and environmental organizations Sampling continued until data saturation was achieved.

Ethical Considerations

The study received ethical approval from the University of South Africa Research Ethics Committee on 15 February 2024. All participants gave informed consent before data collection, and anonymity was maintained throughout the research process.

RESULTS AND FINDINGS

Participant Flow and Eligibility

- 50 individuals were approached for participation.
- 45 were examined for eligibility based on the inclusion criteria.
- 40 were confirmed eligible (meeting criteria of being ≥18 years, living/working in the area for≥1 year).
- 30 participants consented, completed interviews, and were included in the final analysis.
- No follow-up was required as data were collected in a single round of interviews and surveys.

Demographic characteristics of respondents (n=30)

Gender

- 18 males
- 12 females

Age range (23–65 years)

- 23–35 years: 9 participants
- 36–50 years: 13 participants
- 51–65 years: 8 participants

Roles

- Fishermen: 12
- Community members: 10
- Government and NGO stakeholders: 8

Education level

- No formal education: 5
- Primary education: 10
- Secondary education: 11
- Tertiary education: 4

Employment status

- Unemployed: 18
- Employed (formal/informal): 12

Qualitative Findings

Participants in this study consistently perceived illegal dumping as a serious threat to their local rivers, highlighting several key environmental and socio-economic impacts. Many residents reported visible water contamination, describing river water as "no longer usable for bathing or cooking." Fishermen noted a significant decline in aquatic life, with one stating that "fewer fish are caught now compared to five years ago," attributing this directly to waste accumulation in river systems. In

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

addition to biodiversity loss, communities also pointed to foul odors and an increase in disease vectors, such as mosquitoes and rodents, linked to decomposing waste piles. Rivers were often described as "dirty" and "no longer beautiful," indicating a loss of both ecological and cultural value. The socio-economic consequences of illegal dumping were also evident. Fishermen reported reduced catches and increased travel distances in search of viable fishing grounds, leading to diminished income and food insecurity. Communities expressed concern over health issues, particularly skin rashes, stomach illnesses, and infections in children, believed to result from contact with polluted water. Local stakeholders further noted that pollution undermines tourism potential and poses a threat to emerging ecotourism initiatives, thereby affecting the broader local economy.

In terms of community attitudes, many participants demonstrated low awareness of environmental regulations and policies. One fisherman remarked, "We never hear about the rules. No one talks about them." Skepticism toward local authorities was widespread, with frequent criticism directed at the municipality for failing to provide adequate waste bins or maintain regular collection services. Despite this frustration, most residents expressed a willingness to adopt responsible waste practices, provided they were supported through education, improved infrastructure, or incentives. Participants identified a range of causes behind illegal dumping, including a lack of municipal waste services, long distances to official dumping sites, poverty, informal housing, and limited environmental education. Many believed there were few consequences for illegal dumping, with one respondent noting, "No one comes to check." The types of waste observed in the affected areas included household materials such as plastics, glass, food waste, and disposable nappies, as well as fishing-related waste like nylon lines, bait containers, hooks, and polystyrene boxes.

Construction rubble, broken appliances, and agricultural waste (e.g., pesticide containers and animal remains) were also prevalent. Ecological assessments conducted at four major river systems further confirmed the impact of illegal dumping on biodiversity. The Mthatha River was heavily polluted, with only two fish species, *Tilapia sparrmanii* and *Clarias gariepinus*, found in low abundance. In the Buffalo River, four fish species were identified, but signs of physiological stress, such as discoloration and lesions, were common. The Kei River showed severe macroinvertebrate loss, with only pollution-tolerant species like chironomids present. Although the Kowie River exhibited comparatively better biodiversity, sensitive species such as *Labeobarbus aeneus* were still in decline. Across these rivers, fish kills, water discoloration, and the spread of invasive vegetation such as *water hyacinth* were frequently observed in the most polluted sections.

Quantitative Data on Waste Types and Volumes (from Field Surveys)

At each designated dumping site, field surveys involved stratified transect sampling (100m river stretches). The most common waste materials and average quantities recorded were:

Table 1: Most common waste materials and average quantities

Waste Type	Average Volume per 100m stretch
Plastic bottles and wrappers	420 items / 35 kg
Glass and cans	160 items / 48 kg
Disposable diapers	85 items / 21 kg
Fishing gear (lines, bait boxes)	190 items / 28 kg
Household organic waste	60 kg (estimated from 3 dumps)
Construction rubble	95 kg (estimated bulk weight)

Figure 2, titled Conceptual Representation of Pollution Levels in Riverine Ecosystems, illustrates pollution levels across five rivers, with River C exhibiting the highest pollution (90%), followed by River A (80%) and River E (70%), indicating severe contamination. River B (65%) shows moderate pollution, while River D (50%) has the lowest level, suggesting better waste management or lower human impact. The variation in pollution levels highlights the need for targeted interventions, such as improved waste management strategies and stricter environmental policies, to mitigate pollution and protect riverine biodiversity.

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

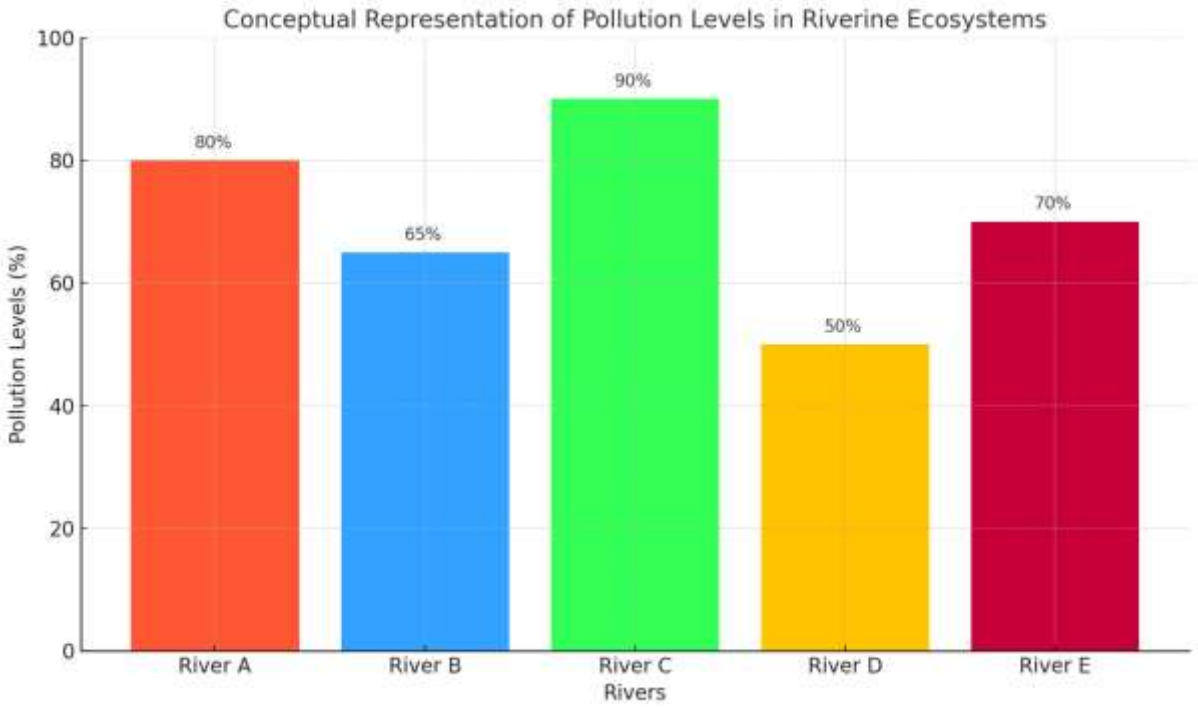

Figure 2: The graph represents a conceptual representation of pollution levels in riverine ecosystems

DISCUSSION

This study aimed to assess the impact of illegal dumping of waste materials by fishermen and local communities on riverine biodiversity in selected areas of the Eastern Cape Province, South Africa. The findings confirmed the prevalence of illegal dumping in riverine systems and revealed its detrimental effects on aquatic biodiversity and socio-economic conditions within local communities. A key finding was the high volume of waste, particularly plastics, discarded fishing gear, and household waste, accumulating in rivers with limited or no formal waste disposal infrastructure. This aligns with the observations of Weideman et al. (2020), who noted that inadequate municipal services in rural and peri-urban South Africa contribute to increased instances of environmental dumping. In the current study, areas with higher waste accumulation exhibited significantly reduced species richness and abundance, indicating a clear negative impact on aquatic biodiversity. This is consistent with findings by Gall and Thompson (2015) and Windsor et al. (2019), who reported that plastic pollution and microplastic ingestion severely affect aquatic species' health and survival rates.

Fish populations in polluted rivers exhibited signs of physiological stress and reproductive anomalies, likely due to toxin bioaccumulation and habitat degradation. This finding supports the work of Naidoo et al. (2011), who documented abnormal growth and reduced reproductive success in fish exposed to polluted South African waterways. The decline in macroinvertebrate diversity further indicates that illegal dumping alters the ecological structure of river systems, as observed by Dallas and Day (2004) in their freshwater biomonitoring studies. On the socio-economic front, interviews revealed that illegal dumping practices are often driven by poverty, unemployment, and a lack of affordable waste management alternatives. Fishermen and community members admitted to engaging in dumping due to the absence of nearby disposal sites and weak enforcement mechanisms. This finding mirrors Moses et al. (2018), who emphasized the link between socio-economic hardship and environmentally harmful behaviours in informal settlements.

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

Importantly, the study found that affected communities had limited awareness of environmental legislation and policies. This lack of awareness, combined with insufficient regulatory enforcement, perpetuates a cycle of ecological degradation. Similar conclusions were drawn by Khoza et al. (2022), who highlighted poor policy implementation as a barrier to effective environmental governance in rural South Africa. Despite these challenges, there was strong interest among participants in community-based waste management solutions. Many expressed willingness to participate in environmental education programs and proposed community-led waste collection initiatives. This reflects the participatory approach advocated by Le Maitre et al. (2009) and UNEP (2016), who argue that community engagement is essential for successful conservation and waste management interventions. The findings of this study not only demonstrate the ecological harm caused by illegal dumping but also reveal the complex socio-economic realities that underlie these behaviours. The results underscore the need for integrated, community-driven waste management strategies supported by effective policy enforcement and environmental education.

GENERALIZABILITY

The findings of this study offer valuable insights into the environmental and socio-economic impacts of illegal waste dumping on riverine biodiversity within the Eastern Cape Province of South Africa. While the results are context-specific, they may be cautiously generalised to other rural and peri-urban regions in South Africa and similar Global South settings that experience poor waste management infrastructure, socio-economic marginalization, and weak environmental regulation. The combination of ecological assessments and community perspectives provides a holistic understanding that could inform riverine conservation and waste policy frameworks in comparable contexts. However, generalizability is limited by the purposive sampling approach and the relatively small sample size of qualitative participants. Additionally, the rivers selected for study were chosen based on known pollution hotspots and fishing activity, which may not fully represent less-affected or better-managed areas. As such, the findings may not capture the full variability of riverine conditions or community behaviours across the entire province or country. Nonetheless, the methodological approach, integrating biodiversity assessments with social data, enhances the applicability of the study design to other regions facing similar challenges. Future research involving broader geographic sampling, longitudinal data collection, and quantitative modelling of waste flows would further strengthen the generalizability and policy relevance of these findings.

CONCLUSION

Illegal waste dumping by fishermen and local communities poses a significant environmental challenge in the Eastern Cape, particularly in riverine and coastal zones. The study found widespread waste disposal activities concentrated in key river catchment areas, often linked to fishing practices. Fishermen commonly discard fishing nets, lines, and plastic packaging alongside general household and industrial waste. Plastic waste was identified as the most prevalent pollutant, followed by fishing-related debris, glass bottles, and hazardous materials such as oil and chemicals. The persistence of non-biodegradable waste in river systems presents severe ecological risks, leading to long-term environmental degradation. The research revealed a strong negative correlation between illegal dumping and riverine biodiversity. Plastic waste obstructs waterways, reduces oxygen levels, and disrupts aquatic ecosystems, resulting in fish mortality, reproductive failures, and food chain disturbances. Chemical pollutants further degrade water quality, altering pH levels, increasing nutrient loading, and exacerbating eutrophication. These environmental stressors contribute to the decline of key fish species, threatening local fisheries and the sustainability of aquatic resources.

Socio-economic factors such as poverty, inadequate waste management infrastructure, and limited environmental awareness were identified as primary drivers of illegal dumping. Many communities lack access to proper waste disposal facilities, and the high cost of waste removal services discourages responsible waste management. Weak enforcement of environmental regulations further perpetuates the problem. While some community members recognize the environmental risks, active participation in conservation efforts remains low due to insufficient education and engagement programs. To mitigate these challenges, the study recommends improving waste management infrastructure, increasing access to legal disposal options, and enforcing stricter environmental regulations. Community education programs are essential to raising awareness of the ecological consequences of illegal dumping and promoting sustainable waste practices. Stronger collaboration between local governments, environmental NGOs, and fishing communities is crucial in developing integrated waste management strategies.

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

This study underscores the urgent need for multi-stakeholder collaboration, involving government agencies, local communities, environmental organizations, and academic institutions. Solutions should include the establishment of accessible waste disposal facilities, community-driven education initiatives, and enhanced enforcement mechanisms. By adopting a holistic and inclusive approach, it is possible to mitigate illegal dumping, conserve biodiversity, and support sustainable livelihoods. This research contributes to the broader discourse on environmental management, highlighting the importance of balancing ecological conservation with socio-economic development while providing a framework for addressing similar challenges in other regions.

RECOMMENDATIONS

The study findings emphasize the need for comprehensive and targeted interventions to address the impact of illegal dumping on riverine biodiversity in the Eastern Cape Province. Strengthening waste management infrastructure is critical, including the establishment of accessible and adequately resourced waste disposal facilities and regular waste collection services to reduce reliance on illegal dumping. Community awareness and education must be prioritized through targeted environmental programs highlighting the ecological and socio-economic consequences of illegal dumping. Community-led campaigns should foster a sense of environmental stewardship and promote proper waste disposal practices. Policy implementation and enforcement require significant enhancement, particularly by strengthening existing environmental legislation to deter illegal dumping activities. Training and deploying environmental compliance officers can improve monitoring and ensure adherence to policies.

Local knowledge and community participation should be integrated into waste management strategies to ensure culturally relevant and context-specific solutions. Community-based environmental programs can empower residents to actively participate in conservation efforts. Addressing the socio-economic drivers of illegal dumping is crucial. Poverty alleviation initiatives and alternative livelihoods for marginalized communities should be developed to reduce economic pressures that contribute to unsustainable practices. Additionally, ongoing monitoring and research are essential to assess the effectiveness of interventions and the health of riverine ecosystems. Long-term monitoring programs and interdisciplinary research can provide innovative approaches to waste management and biodiversity conservation. Multi-stakeholder collaboration must be fostered to create holistic and sustainable waste management strategies. Partnerships between government, non-governmental organizations, academic institutions, and local communities can leverage resources and expertise for impactful solutions. By implementing these recommendations, policymakers can mitigate the detrimental impacts of illegal dumping, preserve riverine ecosystems, and improve the quality of life for communities in the Eastern Cape Province. These measures also provide a framework for addressing similar challenges in other regions, contributing to global environmental conservation and sustainable development efforts.

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.

ACKNOWLEDGEMENTS

I acknowledge the moral support and encouragement from the Deans and HOD of the Department of Nature Conservation, Faculty of Natural Science, Mangosuthu University of Technology.

FUNDING

This work was not supported by any grant. The author did not receive research support from any company. The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

COMPETING INTERESTS

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

AUTHOR CONTRIBUTIONS

I, the author, contributed to the study conception and design. Material preparation, data collection, and research

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

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. Binns, T. & Nel, E., 2002. The challenges of sustainable development: Policy, strategies, and community engagement in the Eastern Cape, South Africa. Development Southern Africa, 19(3), pp.543-567.
2. Dallas, H.F. & Day, J.A., 2004. The effect of water quality variables on aquatic ecosystems: A review. Water Research Commission Report, No. TT 224/04. Available at: https://www.wrc.org.za/wp-content/uploads/mdocs/TT-224-04.pdf.
3. Davies, B., 2011. Pollution in freshwater ecosystems: Sources, impact, and management strategies. Water Resources Management, 25(9), pp.2285-2303.
4. de Villiers, A., 2016. The impact of pollution on fish biodiversity in South Africa's coastal rivers. South African Journal of Marine Science, 38(3), pp.433-442.
5. Diedericks, M., McLachlan, A. & Lee, M., 2012. Freshwater management in South Africa: The effect of human activity on river ecosystems. Environmental Management, 50(6), pp.1234-1247.
6. du Plessis, A., 2014. Environmental governance in South Africa: A focus on waste management. Environmental Development, 11, pp.47-55.
7. FAO, 2015. The State of World Fisheries and Aquaculture 2015. Rome: Food and Agriculture Organization of the United Nations.
8. FAO & IUCN, 2020. Promoting sustainable fisheries management in coastal regions. Rome: FAO & IUCN.
9. Gall, S.C. & Thompson, R.C., 2015. The impact of debris on marine life. Marine Pollution Bulletin, 92(1-2), pp.170-179. https://doi.org/10.1016/j.marpolbul.2014.12.041 PMid:25680883
10. Garrity, S., Savoy, H. & Moraga, J., 2015. Pollution, overfishing, and small-scale fisheries in the Philippines. Marine Policy, 58, pp.122-131.
11. Government of South Africa, 2019. National Environmental Management Act (NEMA) Report. Pretoria: Department of Environmental Affairs and Tourism.
12. Hart, T., Strydom, W. & Clark, B., 2014. Impacts of anthropogenic activities on estuarine environments in the Western Cape. Estuarine, Coastal and Shelf Science, 147, pp.245-256.
13. Hoornweg, D. & Bhada-Tata, P., 2012. What a waste: A global review of solid waste management. Washington, DC: World Bank. Available at: https://doi.org/10.1596/17388 PMid:22324502
14. Khoza, S. & Biyase, M., 2022. The symmetric and asymmetric effect of financial development on ecological footprint in South Africa: ARDL and NARDL approach. Frontiers in Environmental Science, 10, 1347977. https://doi.org/10.3389/fenvs.2024.1347977.
15. Klein, M., 2011. Sustainable livelihoods and fisheries in South Africa: A case study of the Eastern Cape. Ecological Economics, 70(4), pp.703-711.
16. Le Maitre, D.C., O'Farrell, P.J. & Reyers, B., 2009. Ecosystem services in South Africa: A review. South African Journal of Science, 105(9-10), pp.409-420. https://doi.org/10.4102/sajs.v105i9/10.132
17. Loubser, M., Jones, P. & Fourie, T., 2020. The socio-economic impact of pollution on small-scale fishing communities in the Eastern Cape. African Journal of Environmental Science and Technology, 14(6), pp.219-231.
18. McLachlan, A. & Anderson, P., 2017. Waste management and pollution control in coastal and riverine ecosystems. Environmental Pollution, 235, pp.1011-1019.
19. Miller, K., Gustafsson, M. & López, A., 2018. The impacts of coastal pollution and illegal dumping on artisanal fisheries in Indonesia. Environmental Conservation, 45(3), pp.285-295.
20. Moses, M. & Simatele, D., 2018. Illegal dumping of solid waste in urban areas: A case study of Johannesburg, South Africa. South African Geographical Journal, 100(3), pp.367-384.
21. Naidoo, T., Glassom, D. & Smit, A.J., 2011. Plastic pollution in five urban estuaries of KwaZulu-Natal, South Africa. Marine Pollution Bulletin, 62(12), pp.2589-2594.
22. National Department of Environmental Affairs, 2017. Integrated Coastal Management Act (ICMA). Pretoria: Government of South Africa.
23. OECD, 2004. Environmental indicators: Development, measurement, and use. Paris: OECD. Available at: https://www.oecd.org.
24. Pinnock, D., 2013. A review of coastal resource management policies in South Africa. Journal of Coastal Research, 29(3), pp.713-721.
25. Pretorius, J.C. et al., 2023. Spatial variability of microbial richness and diversity and relationships with soil organic carbon in agricultural soils. Unpublished. Available at: https://abdn.elsevierpure.com/ (Accessed: 12 January 2025).

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1634
Original Article

26. Resnik, D.B., 2020. What is ethics in research & why is it important? National Institute of Environmental Health Sciences. Available at: https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm.
27. Shackleton, C. & Blair, A., 2017. Small-scale fisheries and poverty alleviation in rural South Africa. African Journal of Aquatic Science, 42(1), pp.49-59.
28. Smith, R., Green, J. & Ellis, P., 2010. Marine pollution and its effect on South African estuaries. Marine Pollution Bulletin, 60(9), pp.1440-1446.
29. Taljaard, S. & Lamberth, S., 2013. Impacts of human activity on the biodiversity of the Eastern Cape's River systems. South African Journal of Aquatic Sciences, 39(3), pp.147-156.
30. UNEP, 2016. Marine plastic debris and microplastics: Global lessons and research to inspire action and guide policy change. Nairobi: United Nations Environment Programme. Available at: https://www.unep.org.
31. UNEP, 2017. Marine Pollution and Coastal Ecosystems. Nairobi: United Nations Environment Programme.
32. UNEP-WCMC, 2020. Protected planet report 2020. Cambridge: UNEP-WCMC and IUCN. Available at: https://www.protectedplanet.net.
33. Varol, T. & Sgn, J., 2020. Integrating uncertain prior knowledge regarding ecological preferences into multi-species distribution models: Effects of model complexity on predictive performance. Unpublished. Available at: https://www.researchgate.net/.
34. Weideman, E.A., Perold, V., Ryan, P.G. & Cowie, R.J., 2020. Quantifying changes in litter loads in urban stormwater run-off from Cape Town, South Africa, over the last two decades. Science of The Total Environment, 724, 138310. https://doi.org/10.1016/j.scitotenv.2020.138310 PMid:32268294
35. Windsor, F.M., Tilley, R.M., Tyler, C.R. & Ormerod, S.J., 2019. Microplastic ingestion by riverine macroinvertebrates. Science of the Total Environment, 646, pp.68-74. https://doi.org/10.1016/j.scitotenv.2018.07.271 PMid:30048870
36. Yin, R.K., 2018. Case study research and applications: Design and methods. 6th ed. Thousand Oaks, CA: SAGE Publications.

PUBLISHER DETAILS

Student's Journal of Health Research (SJHR)
(ISSN 2709-9997) Online
(ISSN 3006-1059) Print
Category: Non-Governmental & Non-profit Organization
Email: studentsjournal2020@gmail.com
WhatsApp: +256 775 434 261
Location: Scholar's Summit Nakigalala, P. O. Box 701432, Entebbe Uganda, East Africa