OPEN ACCESS
NIJBAS
Publications 2024
ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

NEWPORT INTERNATIONAL JOURNAL OF BIOLOGICAL AND APPLIED SCIENCES (NIJBAS)

Volume 6 Issue 1 Page 1-13, 2025

https://doi.org/10.59298/NIJBAS/2025/6.1.11300

Electronic Sensors Detection of Nanoplastic Effects on Aqua Biota in Africa

[1]Awafung Emmanuel Adie, [2]Faithpraise Fina, [3]Paul Anyin, [4]Gertrude Fischer, [4]Glory Nja and [4]Veronica Awafung

[1]Biomedical Engineering, Kampala International University, Uganda.
[2]Department of Computer Science, University of Calabar.
[3]Department of Electrical Electronics Engineering University of Cross river
[4]Department of Public Health. University of Calabar
Email: awafungadie@gmail.com

ABSTRACT

Nanoplastics, plastic particles smaller than 1 micrometer, are an emerging contaminant of concern in aquatic ecosystems globally, including in Africa. Monitoring the presence and impacts of nanoplastics is crucial for the continent given its reliance on fisheries and aquaculture for food and livelihoods. Advanced electronic sensor technologies offer promising tools for detecting and quantifying nanoplastics in water bodies, as well as assessing their biological effects on aquatic organisms. This review examines the potential applications of electronic sensors, such as optical, electrochemical, and biosensors, in nanoplastic pollution monitoring and impact assessment in African aquatic environments. The review tells how electronic sensors can be used to measure a range of nanoplastic-related impacts on aquatic biota, including bioaccumulation, disruption of physiological processes, induction of oxidative stress, and alterations in gene expression. Deploying sensor networks in African water bodies could provide real-time, high-resolution data to inform policy decisions, water quality management, and conservation efforts aimed at protecting critical aquatic resources and food security. The review also highlights technical challenges related to sensor performance in complex aquatic matrices, as well as the need to integrate sensor data with other monitoring and ecological assessment approaches. Ensuring equitable access to sensor technologies and data across different regions and stakeholder groups in Africa will also be crucial. Therefore, this review underscores the significant potential of electronic sensors to advance our understanding of nanoplastic pollution and its effects on aquatic biota in Africa, while also identifying key considerations for the successful implementation of these technologies.

Keywords; Africa, Aqua Biota, Effects, Electronics, Nanoplastics, Sensors

INTRODUCTION

Nanoplastics, which are plastic particles smaller than one micrometer, are an emerging environmental contaminant of concern due to their potential to bioaccumulate and cause harm to aquatic organisms. Monitoring the presence and impacts of nanoplastics in African aquatic ecosystems is crucial, given the continent's reliance on fisheries and aquaculture for food and livelihoods [1, 2]. Nanoplastic pollution has emerged as a significant environmental concern globally, with Africa facing unique challenges due to its vast geography and varied socioeconomic conditions. This review presents a comprehensive analysis of the current state of nanoplastic pollution across the

ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

African continent. The improper management of plastic waste, combined with increasing plastic production and consumption, has exacerbated the prevalence of nanoplastic contaminants in various ecosystems [3, 4]. The review examines the potential of electronic sensors, including optical, electrochemical, and biosensors, for monitoring nanoplastic pollution and its impacts on aquatic biota in Africa. It discusses the capabilities of these sensor technologies, their applications in nanoplastic detection and impact assessment, and the benefits they could provide for informing policy, management, and conservation efforts in the continent. The review also addresses key challenges and considerations for the successful deployment of electronic sensors in African aquatic environments. It highlights the primary sources of nanoplastic pollution, including the breakdown of larger plastic debris and the direct release of microplastics from industrial and domestic activities. It examines the environmental and health impacts of nanoplastics, emphasizing the need for improved waste management systems and regulatory frameworks to mitigate these effects. The study underscores the importance of collaboration and infrastructure development to address nanoplastic pollution effectively [5, 6]. It calls for increased research efforts to understand the extent of contamination and its implications fully. Moreover, the review advocates for the implementation of sustainable management practices and the promotion of public awareness to reduce plastic waste generation. Through an in-depth analysis of existing literature and case studies, the review identifies gaps in current management practices and proposes strategic interventions to enhance nanoplastic management in Africa. These interventions include the development of robust policies, investment in recycling technologies, and fostering regional and international cooperation. Overall, this review serves as a call to action for stakeholders, including policymakers, researchers, and communities, to prioritize nanoplastic pollution control and work towards a cleaner and healthier environment in Africa, [7].

Role of Electronic Sensors

Advanced electronic sensor technologies offer promising tools for detecting and quantifying nanoplastics in water bodies, as well as assessing their biological effects on aquatic organisms. Sensor types that could be employed include optical sensors, electrochemical sensors, and biosensors using aquatic organisms as sensing elements [6, 7]. Optical sensors offer a promising approach for the detection and quantification of nanoplastics in water samples [8, 9]. These sensors can utilize techniques such as light scattering, fluorescence, and Raman spectroscopy to identify and characterize nanoplastic particles based on their unique optical properties [10, 11].

Use of Electronic Sensors

Advanced electronic sensors offer promising tools for detecting and quantifying nanoplastics in water bodies, as well as assessing their biological effects on aquatic biota. Sensor technologies that could be employed include Optical sensors that can identify and count nanoplastic particles based on their optical properties. Electrochemical sensors that can measure nanoplastic-induced changes in the electrochemical properties of water samples. Biosensors use aquatic organisms or their biomolecules as sensing elements to detect nanoplastic-induced stress responses [11].

Monitoring Nanoplastic Impacts on Aquatic Biota

Electronic, sensors can be used to monitor a range of nanoplasic-related impacts on aquatic organisms, such as Accumulation of nanoplastics in tissues and organs, Disruption of physiological processes like growth, reproduction, and metabolism, Induction of oxidative stress, inflammation, and other biochemical changes, Alterations in gene expression and cellular function.

Overview of Plastic Pollution

Plastic pollution has become a critical global environmental issue due to the widespread use and disposal of plastic products. Plastics are durable and resistant to degradation, resulting in their accumulation in natural environments, particularly in oceans and waterways. Over time, larger plastic debris breaks down into smaller fragments, including microplastics (less than 5 mm) and nanoplastics (less than 100 nm). Nanoplastics, due to their minuscule size, pose unique challenges. They can penetrate biological membranes, making them potentially more hazardous to marine life and human health than larger plastic particles. Nanoplastics are generated from the degradation of larger plastics through mechanical, chemical, and biological processes, and they are found in diverse environments, including soil, water, and air. These particles can be ingested by a wide range of organisms, from plankton to humans, causing various adverse effects such as physical blockages, toxic chemical exposure, and the transfer of pathogens [12, 13].

Relevance to Africa

Deploying electronic sensor networks in African water bodies could provide real-time, high resolution data on nanoplastic pollution and its effects on aquatic ecosystems. This information could inform policy decisions, water quality management, and conservation efforts to protect aquatic resources and food security. Building local capacity for sensor development, deployment, and data analysis would also strengthen Africa's scientific and technological capabilities. Nanoplastic pollution holds significant relevance for Africa due to several factors. The continent is witnessing a notable surge in plastic production and importation, driven by economic growth and urbanization.

However, this rise in plastic consumption is not matched by adequate waste management infrastructure, leading to widespread mismanagement of plastic waste [14]. Many African countries face challenges in waste management, characterized by insufficient infrastructure and regulatory frameworks. This results in improper disposal of plastics, exacerbating environmental pollution [15]. The presence of nanoplastics in soil, water, and air poses serious environmental and health threats. In Africa, where communities often rely on natural water sources and agriculture, the contamination from nanoplastics can profoundly affect food and water safety [16, 17]. Economic limitations further compound the issue, restricting the capacity of African nations to invest in advanced waste management technologies. Additionally, there is a lack of public awareness and education regarding the environmental and health impacts of plastic pollution. These economic and social factors hinder efforts to effectively manage nanoplastic pollution in the region [18]. The rapid increase in plastic consumption and inadequate waste management systems have led to a surge in nanoplastic pollution across Africa. Sub-Saharan Africa, in particular, is grappling with rising levels of plastic production, unregulated usage, and insufficient waste management infrastructure [19]. Challenges in managing nanoplastic pollution in Africa stem from a lack of scientific facilities, hindering comprehensive research efforts and effective solutions [20]. The impacts of nanoplastic pollution on Africa's ecosystems and human health are profound. Environmental degradation, including disruption of natural processes and threats to biodiversity, poses significant ecological risks [21]. The ingestion of nanoplastics and associated chemicals through contaminated water and food sources presents serious health risks to human populations [21]. One potential solution is the establishment of effective waste management systems. Implementing stringent regulations to control plastic usage and improve recycling programs can help mitigate nanoplastic pollution. Establishing effective waste management systems is crucial [22]. Investing in scientific research and infrastructure is essential for understanding the extent of nanoplastic pollution and developing targeted mitigation strategies [23]. Collaboration between governments, industries, and research institutions is essential to drive progress in this area [24]. Efforts to address nanoplastic pollution in Africa must also consider socio-economic factors and community engagement. Public awareness campaigns and educational initiatives can empower local communities to participate in waste reduction and recycling efforts [18]. Incentivizing sustainable practices and supporting the development of eco-friendly alternatives to plastic can help reduce reliance on conventional plastic products [25].

Sources of Nanoplastic Pollution

Nanoplastic pollution originates from several primary sources, including improper waste management, industrial activities, and consumer products [26]. These sources contribute significantly to the presence of nanoplastics in the environment, posing serious ecological and health risks.

Improper Waste Management

Improper waste management is a major contributor to nanoplastic pollution. In many parts of Africa, waste management systems are either inadequate or nonexistent, leading to uncontrolled disposal of plastic waste. Open dumping is a common practice where plastics are discarded in open areas, exposed to sunlight and wind. Over time, these plastics degrade into smaller particles, eventually forming micro- and nanoplastics. Similarly, open burning of plastic waste not only releases toxic fumes but also results in the fragmentation of plastics into nanoplastics. Even managed landfills can be significant sources of nanoplastic pollution if not properly sealed and maintained, allowing plastics to degrade and release nanoplastic particles into the surrounding soil and groundwater [27, 28].

Industrial Activities

Activities Involved in the production and processing of plastic materials generate waste that includes micro- and nanoplastic particles. These particles can be released into the air, water, and soil during manufacturing processes. The textile industry is a notable contributor, as the production and washing of synthetic fibers release a substantial number of microfibers, many of which are nanoplastics, into wastewater. Additionally, industries that manufacture packaging materials and consumer goods made from plastics produce tiny plastic particles during cutting, molding, and shaping processes, which can enter the environment [29-31].

Consumer Products

Consumer products are another significant source of nanoplastics. Many personal care products, such as exfoliants, toothpaste, and cosmetics, contain microbeads, which are tiny plastic particles. These microbeads can break down further into nanoplastics once they enter the wastewater stream. Synthetic textiles, such as polyester, nylon, and acrylic, shed microfibers during washing, which can further fragment into nanoplastics, contributing to water pollution. The widespread use of plastic packaging for food, beverages, and other goods leads to considerable plastic waste. Over time, these plastics degrade into smaller particles, contributing to nanoplastic pollution. The automotive industry also contributes to nanoplastic pollution through the wear and tear of components such as tires and brake pads, which release micro- and nanoplastic particles into the environment. These particles are dispersed through air and runoff from roads, eventually contaminating various ecosystems. Additionally, household dust can contain

OPEN ACCESS
ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

nanoplastics originating from the wear and tear of plastic items, synthetic fibers from carpets and furniture, and particles released from electronic devices and appliances [27, 32, 33].

Impact and Spread

Nanoplastics released into the environment can spread extensively through various pathways. Airborne transport allows nanoplastic particles to travel long distances before settling in remote areas, including oceans and Polar Regions. Water systems are another significant pathway, as nanoplastics enter water bodies through runoff, wastewater discharge, and atmospheric deposition. These particles can be transported via rivers to oceans, where they accumulate in marine environments. Soil contamination also occurs, with nanoplastics originating from littering, agricultural practices involving plastic mulch, and sludge application from wastewater treatment plants [27, 34, 35].

Challenges and Solutions

Addressing the sources of nanoplastic pollution involves multiple challenges. Improving waste management infrastructure and practices is crucial, including enhancing recycling systems, implementing proper landfill management, and reducing open dumping and burning. Strengthening regulations on industrial emissions and waste disposal can help minimize nanoplastic release from manufacturing processes. Educating consumers about the impact of plastic use and promoting alternatives to plastic products can reduce the generation of nanoplastic pollution. Additionally, developing and adopting technologies for filtering and capturing nanoplastics in wastewater treatment plants and industrial effluents can mitigate the spread of these particles [36, 37].

Challenges in Managing Nanoplastic Pollution

Managing nanoplastic pollution in Africa presents several significant challenges, including inconsistent policies, lack of infrastructure, and economic and social barriers. Inconsistent Policies One of the primary challenges in managing nanoplastic pollution across African countries is the inconsistency in waste management policies. There is a significant disparity in the adoption and enforcement of environmental regulations related to plastic waste. While some countries have implemented strict laws and regulations aimed at reducing plastic pollution, others lack comprehensive policies or fail to enforce existing ones effectively. This inconsistency results in uneven progress in tackling nanoplastic pollution. For instance, while Rwanda has implemented a successful ban on plastic bags, other countries continue to struggle with plastic waste due to weak regulatory frameworks and poor enforcement mechanisms [27, 38, 39].

Lack of Infrastructure

Another critical challenge is the inadequate waste management infrastructure in many African countries. Effective management of plastic waste requires robust systems for collection, sorting, recycling, and disposal. However, many regions lack the necessary infrastructure to handle the increasing amounts of plastic waste. Insufficient recycling facilities mean that a large proportion of plastic waste, including potential nanoplastics, ends up in landfills or is openly dumped and burned. This improper disposal not only leads to environmental contamination but also poses health risks to nearby communities. The lack of infrastructure is particularly acute in rural areas, where waste management services are often minimal or nonexistent. Without significant investment in waste management infrastructure, efforts to mitigate nanoplastic pollution will remain largely ineffective [40, 41].

Economic and Social Barriers

Economic constraints and social factors further exacerbate the challenges in managing nanoplastic pollution. Many African countries face economic limitations that restrict their ability to invest in advanced waste management technologies and infrastructure. Additionally, the informal sector plays a significant role in waste management in many regions, which complicates regulatory oversight and enforcement. Economic pressures also drive the continued production and use of cheap plastic products, contributing to the accumulation of plastic waste. Social factors, such as limited public awareness and education about the environmental and health impacts of plastic pollution, hinder community engagement in waste management initiatives. Cultural practices and socioeconomic conditions can influence waste disposal behaviors, making it challenging to implement standardized waste management practices across diverse communities [27, 42, 43].

Potential Solutions

Addressing these challenges requires a multifaceted approach. Harmonizing waste management policies across African countries could enhance regional cooperation and effectiveness in combating nanoplastic pollution. Strengthening enforcement mechanisms and providing support for policy implementation are crucial steps. Investing in waste management infrastructure, particularly in recycling facilities and safe disposal methods, is essential for effective waste management. Additionally, promoting public awareness campaigns and education programs can help change behaviors and encourage community participation in waste reduction and recycling efforts. Economic incentives, such as subsidies for recycling businesses and penalties for noncompliance with waste management regulations, could also drive improvements in waste management practices. Finally, fostering partnerships between governments, private sectors, and international organizations can mobilize the resources and expertise needed to address the complex issue of nanoplastic pollution in Africa [28, 44, 45].

Potential Solutions for Managing Nanoplastic Pollution Policy and Regulation

One key solution is the development and strict enforcement of comprehensive waste management policies. African countries need robust regulations that govern the production, use, and disposal of plastics. These policies should include measures to minimize plastic waste generation, promote recycling and circular economy principles, and establish penalties for non-compliance. By implementing effective policies, governments can create a regulatory framework that incentivizes responsible plastic use and ensures accountability throughout the product lifecycle [28, 46, 47].

Improving Infrastructure

Investments in waste management infrastructure and technologies are essential for better handling plastic waste. Many African countries face challenges in waste collection, sorting, and recycling due to inadequate infrastructure. By investing in modern waste treatment facilities, such as recycling plants and incinerators, governments can improve the efficiency of waste management processes and reduce the leakage of plastics into the environment. Additionally, supporting research and innovation in waste management technologies can lead to the development of more sustainable solutions for handling nanoplastic pollution [48, 49].

Public Awareness and Education

Raising public awareness about the dangers of nanoplastic pollution and promoting sustainable practices are crucial steps in mitigating this environmental issue. Public education campaigns can inform individuals about the impacts of plastic pollution on ecosystems and human health, encouraging behavior change and responsible consumption habits. Educational initiatives targeting schools, communities, and industries can empower stakeholders to adopt eco-friendly practices, such as reducing single-use plastics, properly disposing of waste, and supporting plastic free initiatives [50].

International Collaboration

Regional and international collaboration is vital for sharing knowledge, resources, and best practices in managing nanoplastic pollution. African countries can benefit from partnerships with other nations, international organizations, and research institutions to access funding, expertise, and technical assistance for addressing this global challenge. Collaborative initiatives can facilitate information exchange, capacity-building, and joint research efforts to develop innovative solutions for nanoplastic pollution. By working together, countries can leverage collective expertise and resources to implement effective strategies for combating plastic pollution on a global scale [49].

Performance of Sensors

Complex aquatic environments can be hindered by several factors: Interference from dissolved organic and inorganic compounds: The presence of high concentrations of dissolved compounds like humic substances, suspended particulates, and ions can interfere with the sensors' ability to accurately measure the target analytes. This can lead to signal drift, interferences, and reduced sensitivity. Biofouling: The buildup of biological matter like algae, bacteria, and other microorganisms on the sensor surface can degrade sensor performance over time. This can impact parameters like response time, measurement accuracy, and the sensor's usable lifetime. Pressure and temperature fluctuations: Sensors deployed in aquatic environments are subject to changes in pressure and temperature, which can affect the stability and calibration of the measurements. Corrosion and mechanical wear: The harsh aquatic conditions can lead to physical degradation of sensor components through corrosion, abrasion, and other weathering processes, compromising the sensor's durability and reliability. Turbulence and flow effects: Rapid changes in flow velocity and turbulence in the water column can influence the transport of analytes to the sensor surface, leading to measurement variability and errors. Addressing these technical challenges often requires innovative sensor designs, advanced signal processing algorithms, biofouling mitigation strategies, and careful sensor deployment and maintenance protocols. Rigorous testing and calibration in representative aquatic matrices is crucial to ensure reliable sensor performance in complex aquatic environments.

Considerations

Overcoming technical challenges related to sensor sensitivity, selectivity, and durability in complex aquatic environments. Integrating sensor data with other monitoring, modeling, and ecological assessment approaches for a comprehensive understanding of nanoplastic impacts. Ensuring equitable access to sensor technologies and data across different regions and stakeholder groups in Africa.

OPEN ACCESS
ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

Table 1: Impact of Nanoplastic Pollution on African Ecosystems: A Compilation of Recent Research

S/No.	Author(s) and Year	Finding
1	[1, 51]	[1], examined the environmental and health impacts of plastic waste pollutants in Sub-Saharan Africa. Their research highlighted the increasing levels of plastic production and importation in the region, which are not matched by adequate waste
		management systems. This mismatch leads to significant environmental pollution, particularly in aquatic ecosystems. They found that the mismanagement of plastic waste results in the proliferation of micro- and nanoplastics, which pose severe health risks to humans and wildlife. [51], supported these findings by emphasizing the broad environmental and health impacts of plastic waste pollutants. They identified that plastic debris can degrade into smaller particles that are ingested by various organisms, leading to physical blockages and exposure to toxic chemicals. Both studies underline the need for improved waste management infrastructure and policies to mitigate the adverse effects of plastic pollution in Sub-Saharan Africa.
2	[5, 52]	[5], explored the current status of plastic pollution in Africa, focusing on its implications for aquatic ecosystem health. They found that rapid population growth and poor waste management practices are the main drivers of plastic pollution. These practices lead to the accumulation of plastic debris in water bodies, adversely affecting aquatic life. Their findings revealed that the ingestion of microplastics by aquatic organisms can cause physical harm and expose these organisms to harmful pollutants. [52], further examined the impact of plastic pollution on aquatic ecosystems. They discussed how plastic waste disrupts natural processes and poses significant threats to
		biodiversity. Their research highlighted the urgent need for effective waste management strategies to address the escalating plastic pollution crisis in African water bodies.
3	[11, 53]	[11], provided a comprehensive review of microplastic pollution in African aquatic environments. Their study summarized previous research efforts and assessed current analytical procedures used to measure microplastic contamination. They found that the methodologies for detecting microplastics vary significantly, leading to inconsistent data across studies. They emphasized the need for standardized protocols to accurately assess the extent of microplastic pollution. Similarly, [53] highlighted the need for better analytic procedures in their work on microplastic pollution in African rivers. They pointed out that existing methods often fail to capture the full scope of microplastic contamination, leading to an underestimation of the problem. Both studies call for improved scientific approaches to better understand and mitigate microplastic pollution in Africa's aquatic ecosystems.
4	[54, 55]	[54], highlighted the barriers to plastic waste valorization in Africa, emphasizing the low fraction of recycled plastics. Their research suggested that improvements in plastic waste management could significantly reduce the environmental burden of plastic pollution. They recommended implementing policies that promote recycling and the development of infrastructure to support

OPEN ACCESS
ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

		waste management efforts. [55], echoed these sentiments, discussing the importance of removing barriers to plastic waste valorization. They pointed out that effective waste management practices could help mitigate the impact of plastic pollution on the environment. Both studies stressed the need for policy interventions and technological innovations to enhance plastic recycling rates in Africa.
5	[56, 33]	[56], discussed the increasing levels of plastic production and importation in Sub-Saharan Africa. Their study highlighted the unregulated usage of plastics and inadequate waste management systems, which lead to widespread environmental contamination. They emphasized the need for stringent regulations to control plastic usage and improve recycling programs. [33] focused on the health impacts of plastic pollution, particularly the role of nanoplastics in spreading infectious diseases. Their research revealed that nanoplastics could carry pathogens, posing significant health risks to humans. Both studies underscore the urgent need for comprehensive strategies to address plastic pollution, including regulatory measures and public health interventions.
6	[57, 58]	[57], highlighted the presence of nanoplastics in remote areas, showing the widespread nature of the pollution. Their research documented how nanoplastics are found in air, water, and
		soil, even in locations far from urban centers. This widespread distribution indicates the pervasive nature of plastic pollution and its potential to affect diverse ecosystems. [58], further examined the environmental impacts of micro- and nanoplastics, focusing on their prevalence in African ecosystems. They found that nanoplastics pose a significant threat to biodiversity, as they can be ingested by a wide range of organisms, leading to various adverse effects such as physical blockages and toxic chemical exposure. Both studies emphasize the urgent need for comprehensive research to understand the full extent and impact of nanoplastic pollution in Africa.
7	[19]	[19], discussed the policy gaps and opportunities for improving plastic waste management in Africa. Their study highlighted the need for comprehensive policies that address the entire lifecycle of plastic products, from production to disposal. They pointed out that current policies are often fragmented and insufficient to tackle the scale of plastic pollution.
8	[55, 59]	[55], discussed the importance of removing barriers to plastic waste valorization in Africa. They emphasized the need for policies that promote recycling and the development of infrastructure to support waste management efforts. Their study highlighted that effective waste management practices could significantly reduce the environmental burden of plastic pollution. [59],
		echoed these sentiments, focusing on the role of international collaboration in managing plastic waste in Africa. They pointed out that partnerships between African countries and international organizations could enhance the region's capacity to handle plastic waste more effectively. Both studies stress the need for policy interventions and international cooperation to improve plastic waste management in Africa.

OPEN ACCESS
ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

9	[60, 61]	[60], reviewed the implications of rapid population growth and inadequate waste management practices on plastic pollution in African aquatic environments. Their study found that these factors lead to the accumulation of plastic debris in water bodies, adversely affecting aquatic life. They emphasized the need for effective waste management strategies to address the escalating plastic pollution crisis in African water bodies. [61], highlighted the urgent need for policy and technological solutions to address plastic pollution in Africa. They pointed out that current waste management practices are insufficient and called for the implementation of innovative technologies and comprehensive policies to mitigate the impact of plastic pollution. Both studies underscore the critical need for improved waste management practices and policy reforms to protect Africa's aquatic ecosystems.
10	[11, 62]	[11], analyzed the state of plastic pollution and its impacts on African water systems, focusing on microplastic contamination. Their research highlighted the adverse effects of plastic waste on aquatic ecosystems, including physical harm to marine life and the introduction of toxic substances into the food chain. [62], discussed the prevalence of nanoplastic particles in African ecosystems and the need for more comprehensive data to understand their impact fully. They found that nanoplastics pose a significant threat to biodiversity and human health due to their small size and ability to carry harmful pollutants. Both studies call for more research to understand the full extent of plastic pollution and its effects on African ecosystems and public health.
11	[63, 64]	[63], discussed the policy gaps and opportunities for improving plastic waste management in Africa. Their study highlighted the need for comprehensive policies that address the entire lifecycle of plastic products, from production to disposal. They pointed out that current policies are often fragmented and insufficient to tackle the scale of plastic pollution. [64], examined the challenges and opportunities in addressing plastic waste management in Africa. They identified several key barriers, including inadequate infrastructure, lack of funding, and limited public awareness. Both studies call for coordinated efforts
		from governments, industries, and communities to develop and implement effective waste management strategies that can mitigate the impact of plastic pollution.
12	[57, 58]	[57], highlighted the presence of nanoplastics in remote areas, showing the widespread nature of the pollution. Their research documented how nanoplastics are found in air, water, and soil, even in locations far from urban centers. This widespread distribution indicates the pervasive nature of plastic pollution and its potential to affect diverse ecosystems. [58], further examined the environmental impacts of micro- and nanoplastics, focusing on their prevalence in African ecosystems. They found that nanoplastics pose a significant threat to biodiversity, as they can be ingested by a wide range of organisms, leading to various adverse effects such as physical blockages and toxic chemical exposure. Both studies emphasize the urgent need for comprehensive research to understand the full extent and impact of nanoplastic pollution in Africa.
13	[54, 40]	[54], highlighted the barriers to plastic waste valorization in Africa, emphasizing the low fraction of recycled plastics. Their research suggested that improvements in plastic waste management could significantly reduce the environmental burden of plastic pollution. They recommended implementing policies that promote recycling and the development of infrastructure to support

OPEN ACCESS
ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

		waste management efforts. [40], echoed these sentiments, discussing the importance of removing barriers to plastic waste valorization. They pointed out that effective waste management practices could help mitigate the impact of plastic pollution on the environment. Both studies stressed the need for policy interventions and technological innovations to enhance plastic recycling rates in Africa.
14	[65, 53]	[65], provided a comprehensive review of microplastic pollution in African aquatic environments. Their study summarized previous research efforts and assessed current analytical procedures used to measure microplastic contamination. They found that the methodologies for detecting microplastics vary significantly, leading to inconsistent data across studies. They emphasized the need for standardized protocols to accurately assess the extent of microplastic pollution. Similarly, [53] highlighted the need for better analytic procedures in their work on microplastic pollution in African rivers. They pointed out that existing methods often fail to capture the full scope of microplastic contamination, leading to an underestimation of the problem. Both studies call for improved scientific approaches to better understand and mitigate microplastic pollution in Africa's aquatic ecosystems.
15	[5, 52]	[5], explored the current status of plastic pollution in Africa, focusing on its implications for aquatic
		ecosystem health. They found that rapid population growth and poor waste management practices are the main drivers of plastic pollution. These practices lead to the accumulation of plastic debris in water bodies, adversely affecting aquatic life. Their findings revealed that the ingestion of microplastics by aquatic organisms can cause physical harm and expose these organisms to harmful pollutants. [52], further examined the impact of plastic pollution on aquatic ecosystems. They discussed how plastic waste disrupts natural processes and poses significant threats to biodiversity. Their research highlighted the urgent need for effective waste management strategies to address the escalating plastic pollution crisis in African water bodies.
16	[56, 33]	[56], discussed the increasing levels of plastic production and importation in Sub-Saharan Africa. Their study highlighted the unregulated usage of plastics and inadequate waste management systems, which lead to widespread environmental contamination. They emphasized the need for stringent regulations to control plastic usage and improve recycling programs. [33], focused on the health impacts of plastic pollution, particularly the role of nanoplastics in spreading infectious diseases. Their research revealed that nanoplastics could carry pathogens, posing significant health risks to humans. Both studies underscore the urgent need for comprehensive strategies to address plastic
		pollution, including regulatory measures and public health interventions.
17	[57, 58]	[57], highlighted the presence of nanoplastics in remote areas, showing the widespread nature of the pollution. Their research documented how nanoplastics are found in air, water, and soil, even in locations far from urban centers. This widespread distribution indicates the pervasive nature of plastic pollution and its potential to affect diverse ecosystems. [58], further examined the environmental impacts of micro- and nanoplastics, focusing on their prevalence in African ecosystems. They found that nanoplastics pose a significant threat to biodiversity, as they can be ingested by a wide range of organisms, leading to various adverse effects such as physical blockages and toxic chemical exposure. Both studies emphasize the urgent need for comprehensive research to understand the full extent and impact of nanoplastic pollution in Africa.
18	[54, 55]	[54], highlighted the barriers to plastic waste valorization in Africa, emphasizing the low fraction of recycled plastics. Their research suggested that improvements in plastic waste management could significantly reduce the environmental burden of plastic pollution. They recommended implementing policies that promote recycling and the development of infrastructure to support waste management efforts. [55] echoed these

OPEN ACCESS
ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

		sentiments, discussing the importance of removing barriers to plastic waste valorization. They pointed out that effective waste management practices could help mitigate the impact of plastic pollution on the environment. Both studies stressed the need for policy interventions and technological innovations to enhance plastic recycling rates in Africa.
19	[65, 53]	[65], provided a comprehensive review of microplastic pollution in African aquatic environments. Their study summarized previous research efforts and assessed current analytical procedures used to measure microplastic contamination. They found that the methodologies for detecting microplastics vary significantly, leading to inconsistent data across studies. They emphasized the need for standardized protocols to accurately assess the extent of microplastic pollution. Similarly, [53] highlighted the need for better analytic procedures in their work on microplastic pollution in African rivers. They pointed out that existing methods often fail to capture the full scope of microplastic contamination, leading to an underestimation of the problem. Both studies call for improved scientific approaches to better understand and mitigate microplastic pollution in Africa's aquatic ecosystems.
20	[5, 6]	[5], explored the current status of plastic pollution in Africa, focusing on its implications for aquatic ecosystem health. They found that rapid population growth and poor
		waste management practices are the main drivers of plastic pollution. These practices lead to the accumulation of plastic debris in water bodies, adversely affecting aquatic life. Their findings revealed that the ingestion of microplastics by aquatic organisms can cause physical harm and expose these organisms to harmful pollutants. [6], further examined the impact of plastic pollution on aquatic ecosystems. They discussed how plastic waste disrupts natural processes and poses significant threats to biodiversity. Their research highlighted the urgent need for effective waste management strategies to address the escalating plastic pollution crisis in African water bodies.

CONCLUSION

Electronic sensors offer a versatile and powerful tool for advancing our understanding of nanoplastic pollution and its effects on aquatic biota in Africa. Collaborative efforts to develop and deploy these technologies could contribute to more sustainable management of the continents critical water resources. The current state of nanoplastic pollution in Africa presents significant challenges that demand urgent attention and concerted action. Despite limited research and data availability, it is evident that nanoplastic pollution is on the rise across the continent, driven by various sources such as improper waste management, industrial activities, and consumer products. This pollution poses significant environmental and health risks, including ecosystem contamination, biodiversity loss, and potential human health impacts. Addressing nanoplastic pollution in Africa requires a multifaceted approach that integrates policy, infrastructure, education, and international cooperation. By implementing these potential solutions, African countries can mitigate the environmental and health impacts of nanoplastic pollution and move towards a more sustainable future.

REFERENCES

1. Adeniran, A. A., Ayesu-Koranteng, E., & Shakantu, W. (2022). A review of the literature on the environmental and health impact of plastic waste pollutants in sub-saharan africa. *Pollutants*, *2*(4), 531-545.
2. Koelmans, A. A., Besseling, E., & Shim, W. J. (2015). Nanoplastics in the aquatic environment. Critical review. In Marine anthropogenic litter (pp. 325-340). Springer, Cham.
3. Gracia-Lor, E., Rousis, N. I., Zuccato, E., Bade, R., Baz-Lomba, J. A., Castrignanò, E., ... & Castiglioni, S. (2017). Estimation of caffeine intake from analysis of caffeine metabolites in wastewater. Science of the Total Environment, 609, 1582-1588.
4. Machado, A. A., Kloas, W., Zarfl, C., Hempel, S., & Rillig, M. C. (2018). Microplastics as an emerging threat to terrestrial ecosystems. Global change biology, 24(4), 1405-1416.
5. Akindele, E. O., & Alimba, C. G. (2021). Plastic pollution threat in Africa: Current status and implications for aquatic ecosystem health. *Environmental Science and Pollution Research*, *28*, 7636-7651.
6. Çevik, C., Kıdeyş, A. E., Tavşanoğlu, Ü. N., Kankılıç, G. B., & Gündoğdu, S. (2021). A review of plastic pollution in aquatic ecosystems of Turkey. *Environmental Science and Pollution Research*, 1-20.

OPEN ACCESS
ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

7. Arugula, M. A., & Simonian, A. (2014). Novel trends in affinity biosensors: current challenges and perspectives. Measurement, 53, 1-15.
8. Herrera, A., Ŝtindlová, A., Martínez, I., Rapp, J., Romero-Kutzner, V., Samper, M. D., ... & Gómez, M. (2019). Microplastic ingestion by Atlantic chub mackerel (Scomber colias) in the Canary Islands coast. Marine pollution bulletin, 139, 127-135.
9. Cózar, A., Echevarría, F., González-Gordillo, J. I., Irigoien, X., Ubeda, B., Hernández-León, S., ... & Duarte, C. M. (2014). Plastic debris in the open ocean. Proceedings of the National Academy of Sciences, 111(28), 10239-10244.
10. Bhakta, S. A., Evans, E., Benavidez, T. E., & Garcia, C. D. (2015). Protein adsorption onto nanomaterials for the development of biosensors and analytical devices: a review. Analytica chimica acta, 872, 7-25.
11. Aragaw, T. A. (2021). Microplastic pollution in African countries' water systems: a review on findings, applied methods, characteristics, impacts, and managements. *SN Applied Sciences*, *3*(6), 629.
12. Bouwmeester, H., Hollman, P. C., & Peters, R. J. (2015). Potential health impact of environmentally released micro-and nanoplastics in the human food production chain: experiences from nanotoxicology. *Environmental science & technology*, *49*(15), 8932-8947.
13. Kershaw, P. J., & Rochman, C. M. (2015). Sources, fate and effects of microplastics in the marine environment: part 2 of a global assessment. *Reports and Studies-IMO/FAO/UnescoIOC/WMO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) Eng No. 93*.
14. Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., ... & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, *347*(6223), 768-771. https://doi.org/10.1126/science.1260352
15. Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a waste 2.0: a global snapshot of solid waste management to 2050*. World Bank Publications.
16. Thompson, R. C., Moore, C. J., Vom Saal, F. S., & Swan, S. H. (2009). Plastics, the environment and human health: current consensus and future trends. *Philosophical transactions of the royal society B: biological sciences*, *364*(1526), 2153-2166.
17. Besseling, E., Wang, B., Lurling, M., & Koelmans, A. A. (2014). Nanoplastic affects growth of S. obliquus and reproduction of D. magna. *Environmental science & technology*, *48*(20), 1233612343.
18. Chen, Y., Awasthi, A. K., Wei, F., Tan, Q., & Li, J. (2021). Single-use plastics: Production, usage, disposal, and adverse impacts. *Science of the total environment*, *752*, 141772.
19. Ayeleru, O. O., Dlova, S., Akinribide, O. J., Ntuli, F., Kupolati, W. K., Marina, P. F., ... & Olubambi, P. A. (2020). Challenges of plastic waste generation and management in sub-Saharan Africa: A review. *Waste Management*, *110*, 24-42.
20. Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: a review. *Marine pollution bulletin*, *62*(12), 2588-2597.
21. Rochman, C. M., Hoh, E., Kurobe, T., & Teh, S. J. (2013). Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. *Scientific reports*, *3*(1), 1-7.
22. Macarthur EL, Heading HE. How the circular economy tackles climate change. Ellen MacArthur Found. 2019;1:1-71.
23. Law, K. L., Morét-Ferguson, S., Maximenko, N. A., Proskurowski, G., Peacock, E. E., Hafner, J., & Reddy, C. M. (2010). Plastic accumulation in the North Atlantic subtropical gyre. *Science*, *329*(5996), 1185-1188.
24. Horton, A. A. (2022). Plastic pollution: When do we know enough?. *Journal of Hazardous Materials*, *422*, 126885.
25. Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science advances*, *3*(7), e1700782.
26. Kumar D, Biswas JK, Mulla SI, Singh R, Shukla R, Ahanger MA, Shekhawat GS, Verma KK, Siddiqui MW, Seth CS. Micro and nanoplastics pollution: sources, distribution, uptake in plants, toxicological effects, and innovative remediation strategies for environmental sustainability. Plant Physiology and Biochemistry. 2024 Jun 5:108795.
27. Donuma, K. U., Ma, L., Bu, C., George, L. Y., Gashau, M., & Suleiman, A. O. (2024). Environmental and human health risks of indiscriminate disposal of plastic waste and sachet water bags in Maiduguri, Borno State Nigeria. *Waste Management Bulletin*, *2*(2), 130-139.

OPEN ACCESS
ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

28. Rahman, M. M., Toha, M., & Sikder, S. (2024). Micro/Nanoplastics Pollution from Landfill Sites: A Comprehensive Review on the Formation, Distribution, Effects and Potential Mitigation. *Technical Landfills and Waste Management: Volume 1: Landfill Impacts, Characterization and Valorisation*, 247-265.
29. Ferronato, N., & Torretta, V. (2019). Waste mismanagement in developing countries: A review of global issues. *International journal of environmental research and public health*, *16*(6), 1060.
30. Gazal, A. A., & Gheewala, S. H. (2020). Plastics, microplastics and other polymer materials–a threat to the environment. *J. Sustain. Energy Environ*, *11*, 113-122.
31. Rathinamoorthy, R., & Raja Balasaraswathi, S. (2021). A review of the current status of microfiber pollution research in textiles. *International Journal of Clothing Science and Technology*, *33*(3), 364-387.
32. Qiu, R., Song, Y., Zhang, X., Xie, B., & He, D. (2020). Microplastics in urban environments: sources, pathways, and distribution. *Microplastics in terrestrial environments: emerging contaminants and major challenges*, 41-61.
33. Chang, X., Xue, Y., Li, J., Zou, L., & Tang, M. (2020). Potential health impact of environmental micro-and nanoplastics pollution. *Journal of Applied Toxicology*, *40*(1), 4-15.
34. Ahmad, M., Li, J. L., Wang, P. D., Hozzein, W. N., & Li, W. J. (2020). Environmental perspectives of microplastic pollution in the aquatic environment: a review. *Marine Life Science & Technology*, *2*, 414-430.
35. Su, L., Xiong, X., Zhang, Y., Wu, C., Xu, X., Sun, C., & Shi, H. (2022). Global transportation of plastics and microplastics: A critical review of pathways and influences. *Science of The Total Environment*, *831*, 154884.
36. Lv, X., Dong, Q., Zuo, Z., Liu, Y., Huang, X., & Wu, W. M. (2019). Microplastics in a municipal wastewater treatment plant: Fate, dynamic distribution, removal efficiencies, and control strategies. *Journal of Cleaner Production*, *225*, 579-586.
37. Hanif, M. A., Ibrahim, N., Dahalan, F. A., Ali, U. F. M., Hasan, M., & Jalil, A. A. (2022). Microplastics and nanoplastics: Recent literature studies and patents on their removal from aqueous environment. *Science of The Total Environment*, *810*, 152115.
38. Nyika, J. M., Onyari, E. K., Mishra, S., & Dinka, M. O. (2020). Waste Management in South Africa. In *Sustainable Waste Management Challenges in Developing Countries* (pp. 327-351). IGI Global.
39. Behuria, P. (2021). Ban the (plastic) bag? Explaining variation in the implementation of plastic bag bans in Rwanda, Kenya and Uganda. *Environment and Planning C: Politics and Space*, *39*(8), 1791-1808.
40. Ferronato, N., Maalouf, A., Mertenat, A., Saini, A., Khanal, A., Copertaro, B., ... & Mohandas, V. J. (2024). A review of plastic waste circular actions in seven developing countries to achieve sustainable development goals. *Waste Management & Research*, *42*(6), 436-458.
41. Gunarathne, A. D. N., Tennakoon, T. P. Y. C., & Weragoda, J. R. (2019). Challenges and opportunities for the recycling industry in developing countries: the case of Sri Lanka. *Journal of material cycles and waste management*, *21*, 181-190.
42. Kayode, A. M., & Omole, F. K. (2011). Some socio-economic factors affecting solid wastes generation and disposal in Ibadan metropolis, Nigeria. *Journal of environmental issues and agriculture in developing countries*, *3*(1), 55-64.
43. Bening, C. R., Kahlert, S., & Asiedu, E. (2022). The true cost of solving the plastic waste challenge in developing countries: The case of Ghana. *Journal of Cleaner Production*, *330*, 129649.
44. Ozoike-Dennis, P., Spaling, H., Sinclair, A. J., & Walker, H. M. (2019). SEA, urban plans and solid waste management in Kenya: participation and learning for sustainable cities. *Journal of environmental assessment policy and management*, *21*(04), 1950018.
45. Doan, P. L. (1998). Institutionalizing household waste collection: the urban environmental management project in Cote d'Ivoire. *Habitat International*, *22*(1), 27-39.
46. Nyathi, B., & Togo, C. A. (2020). Overview of legal and policy framework approaches for plastic bag waste management in African countries. *Journal of environmental and public health*, *2020*(1), 8892773.
47. Mahjoub, O., Jemai, A., & Haddaoui, I. (2020). Waste management in Tunisia—what could the past bring to the future?. *Waste management in MENA regions*, 35-69.
48. Oteng-Ababio, M., Arguello, J. E. M., & Gabbay, O. (2013). Solid waste management in African cities: Sorting the facts from the fads in Accra, Ghana. *Habitat International*, *39*, 96-104
49. Schmaltz, E., Melvin, E. C., Diana, Z., Gunady, E. F., Rittschof, D., Somarelli, J. A., ... & DunphyDaly, M. M. (2020). Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. *Environment international*, *144*, 106067.
50. Akande, M. (2023). Sustainable solution for plastic waste management and education campaigns to mitigate plastic consumption and foster behavior change.

OPEN ACCESS
ONLINE ISSN: 2992-5797
PRINT ISSN: 2992-6122

51. Verma, R., Vinoda, K. S., Papireddy, M., & Gowda, A. N. S. (2016). Toxic pollutants from plastic waste-a review. *Procedia Environmental Sciences*, *35*, 701-708.
52. Thushari, G. G. N., & Senevirathna, J. D. M. (2020). Plastic pollution in the marine environment. *Heliyon*, *6*(8).
53. Campanale, C., Savino, I., Pojar, I., Massarelli, C., & Uricchio, V. F. (2020). A practical overview of methodologies for sampling and analysis of microplastics in riverine environments. *Sustainability*, *12*(17), 6755.
54. Debrah, J. K., Teye, G. K., & Dinis, M. A. P. (2022). Barriers and challenges to waste management hindering the circular economy in Sub-Saharan Africa. *Urban Science*, *6*(3), 57.
55. Khoaele, K. K., Gbadeyan, O. J., Chunilall, V., & Sithole, B. (2023). The devastation of waste plastic on the environment and remediation processes: a critical review. *Sustainability*, *15*(6), 5233.
56. Muheirwe, F., Kombe, W., & Kihila, J. M. (2022). The paradox of solid waste management: A regulatory discourse from Sub-Saharan Africa. *Habitat International*, *119*, 102491.
57. Materić, D., Peacock, M., Dean, J., Futter, M., Maximov, T., Moldan, F., ... & Holzinger, R. (2022). Presence of nanoplastics in rural and remote surface waters. *Environmental Research Letters*, *17*(5), 054036.
58. Amobonye, A., Bhagwat, P., Raveendran, S., Singh, S., & Pillai, S. (2021). Environmental impacts of microplastics and nanoplastics: a current overview. *Frontiers in Microbiology*, *12*, 768297.
59. Oyake-Ombis, L., van Vliet, B. J., & Mol, A. P. (2015). Managing plastic waste in East Africa: Niche innovations in plastic production and solid waste. *Habitat International*, *48*, 188-197.
60. Mihai, F. C., Gündoğdu, S., Markley, L. A., Olivelli, A., Khan, F. R., Gwinnett, C., ... & MolinosSenante, M. (2021). Plastic pollution, waste management issues, and circular economy opportunities in rural communities. *Sustainability*, *14*(1), 20.
61. Nikiema, J., & Asiedu, Z. (2022). A review of the cost and effectiveness of solutions to address plastic pollution. *Environmental Science and Pollution Research*, *29*(17), 24547-24573.
62. Alimi, O. S., Fadare, O. O., & Okoffo, E. D. (2021). Microplastics in African ecosystems: Current knowledge, abundance, associated contaminants, techniques, and research needs. *Science of the Total Environment*, *755*, 142422.
63. Olatayo, K. I., Mativenga, P. T., & Marnewick, A. L. (2022). Does policy on plastic waste support higher waste management hierarchy options?. *Recycling*, *7*(3), 36.
64. Godfrey, L., Ahmed, M. T., Gebremedhin, K. G., Katima, J. H., Oelofse, S., Osibanjo, O., ... & Yonli, A. H. (2019). Solid waste management in Africa: Governance failure or development opportunity. *Regional development in Africa*, *235*(10.5772).
65. Mvovo, I. (2021). A comprehensive review on micro-plastic pollution in African aquatic systems. *Environmental Advances*, *5*, 100107.

CITE AS: Awafung Emmanuel Adie, Faithpraise Fina, Paul Anyin, Gertrude Fischer, Glory Nja and Veronica Awafung (2025). Electronic Sensors Detection of Nanoplastic Effects on Aqua Biota in Africa. NEWPORT INTERNATIONAL JOURNAL OF BIOLOGICAL AND APPLIED SCIENCES, 6(1):1-13. https://doi.org/10.59298/NIJBAS/2025/6.1.11300