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The Menace of Plastic Waste in Nigeria and its Management Techniques in the 21st Century

Imoh Ime Ekanem[1,*], Aniekan Essienubong Ikpe[1], Emem Okon Ikpe[2]

[1] Department of Mechanical Engineering, Akwa Ibom State Polytechnic, Ikot Osurua, PMB.1200, Nigeria.
imoh.ekanem@akwaibompoly.edu.ng, aniekan.ikpe@akwaibompoly.edu.ng.

[2] Department of Science Technology, Akwa Ibom State Polytechnic, Ikot Osurua, PMB. 1200, Nigeria.
emem.ikpe@akwaibompoly.edu.ng.

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Abstract

Plastic waste has become a major environmental menace in Nigeria, posing significant challenges to public health, ecosystems, and the economy. This paper examined the extent of the plastic waste problem in Nigeria and explored various management techniques that can be implemented in the 21st century to address this issue. This study employed a qualitative research approach, utilizing a literature review and case studies to analyze the menace of plastic waste in Nigeria and its management methods. The literature review involves a comprehensive analysis of existing research on plastic waste management in Nigeria, including government policies, academic studies, and reports from non-governmental organizations. Results of the study indicate that the country generates a large amount of plastic waste each year, much of which ends up in landfills, water bodies, and other natural habitats. The lack of effective waste management infrastructure and inadequate government regulations have contributed to the proliferation of plastic waste in Nigeria. However, the study also identifies several promising management methods that can be implemented to address this issue, including recycling, waste-to-energy conversion, and public awareness campaigns. The findings reveal that while some progress has been made in reducing plastic waste through recycling and waste-to-energy technologies, these methods are insufficient to address the problem effectively. The findings suggest that a combination of regulatory measures, public education, and investment in waste management infrastructure is necessary to address the plastic waste menace in the country effectively. Moreover, strategies such as Extended Producer Responsibility (EPR) and bans on single-use plastics are needed to combat plastic waste's menace practically. The study emphasized the importance of collective action and policy changes to create a more sustainable future for our planet. By implementing these strategies, Nigeria can reduce the environmental impact of plastic waste, protect public health, and promote sustainable development in the 21 century.

Keywords: Waste management, Plastic waste, Environmental impact, Public health, Recycling.

1 | Introduction

The production and consumption of plastic have skyrocketed in the past few decades, leading to a massive accumulation of plastic waste in landfills, oceans, and other natural environments. One of the main reasons for the proliferation of plastic waste is the convenience and affordability of plastic products. Plastic is

Corresponding Author: imoh.ekanem@akwaibompoly.edu.ng

lightweight, durable, and versatile, making it an attractive choice for packaging, consumer goods, and other applications [1]-[2].

However, the durability of plastic also means that it can take hundreds of years to decompose, leading to long-term pollution of the environment. According to a report by the World Economic Forum, the world produces over 300 million tons of plastic waste every year, with only a small fraction of it being recycled. Plastic waste has become a major environmental issue in Nigeria, generating significant plastic waste daily [3]-[4].

This poses a significant threat to the health of its citizens and the sustainability of its ecosystems. The rapid increase in population, urbanization, and industrialization has led to a surge in the production and consumption of plastic products, resulting in a corresponding increase in plastic waste generation [5]-[6].

Moreover, the rapid increase in plastic production and consumption in the country has led to a corresponding rise in plastic waste generation, with inadequate waste management systems exacerbating the problem. This has affected the environment, public health, and the economy. In the 21st century, Nigeria must adopt effective management techniques to address the menace of plastic waste and safeguard the environment for future generations [7].

One of the main reasons for the high generation of plastic waste in Nigeria is the widespread use of single-use plastic products such as bags, bottles, and packaging materials. These products are cheap, convenient, and readily available, making them popular consumer choices. However, their short lifespan and non-biodegradable nature mean they become waste, clogging waterways, polluting the soil, and posing a threat to wildlife. Another contributing factor to developing plastic waste in Nigeria is the lack of proper waste management infrastructure. Many cities and towns in the country lack adequate waste collection and disposal systems, leading to the indiscriminate dumping of plastic waste in open spaces, water bodies, and drainage channels [8]-[9].

This not only mars the aesthetic appeal of the environment but also creates breeding grounds for disease vectors and pollutes the air and water. Plastic waste from inland sources often finds its way into the ocean, posing a threat to marine life and ecosystems. The ingestion of plastic by marine animals can lead to entanglement, suffocation, and starvation, ultimately disrupting the delicate balance of the marine food chain. Plastic waste also has economic implications for Nigeria. The cost of cleaning up plastic waste, repairing infrastructure damaged by flooding caused by blocked drainage systems, and treating health issues related to plastic pollution all burden the economy [10].

Furthermore, the negative image created by plastic waste can deter tourists and investors, affecting the country's revenue from tourism and foreign direct investment. Plastic waste generation in Nigeria is a pressing issue requiring urgent attention and action. The government, private sector, civil society, and individuals all have a role in addressing this problem. Measures such as banning single-use plastics, promoting recycling and waste segregation, investing in waste management infrastructure, and raising public awareness about the environmental impact of plastic waste are essential steps towards mitigating the negative effects of plastic pollution in Nigeria [11]-[12]. Nigeria can obtain a cleaner, greener, healthier, and more sustainable environment by taking concerted and coordinated action on plastic waste generation.

2 | Causes of Plastic Wastes in Nigeria

Plastic waste has become a major environmental issue in Nigeria, generating large amounts of plastic waste daily. This waste poses a significant threat to the environment, as it can take hundreds of years to decompose and can harm wildlife and ecosystems [13]. To effectively address this issue, it is essential to understand the sources of plastic waste in Nigeria. One of the leading causes of plastic waste in Nigeria is the lack of proper waste management infrastructure. For example, the country generates a large amount of plastic waste due to the widespread use of plastic products in various sectors such as packaging, agriculture, and construction. The

lack of proper waste management infrastructure exacerbates the problem of accumulating plastic waste in landfills, water bodies and streets [14]-[15].

Many communities in Nigeria do not have access to formal waste collection services, leading to the improper disposal of plastic waste. This can result in plastic waste being dumped in open spaces, rivers, and other natural areas, where it can accumulate and cause environmental harm [16]-[17].

Furthermore, the nature of plastic waste in Nigeria is diverse, with a wide range of discarded plastic products (see *Fig. 1*). Single-use plastics such as bags, bottles and packaging materials are commonly found in the waste stream, contributing to the problem of plastic pollution. Another cause of plastic waste in Nigeria is the widespread use of single-use plastics. Items such as plastic bags, bottles, and packaging are commonly used in Nigeria but are often disposed of improperly. This can lead to large amounts of plastic waste entering the environment, which can take years to break down and harm wildlife and ecosystems [18].

Nigeria's rapid urbanization and population growth have also contributed to the increase in plastic waste generation. As more people move to urban areas and adopt modern lifestyles, the demand for plastic products has increased, generating higher levels of plastic waste [19].

Fig. 1. Diverse nature of plastic wastes.

3 | Classification of Plastic-based Wastes

Plastic materials have become integral to our daily lives, with various applications in various sectors. The Resin Identification Code (RIC) is a system used to classify different types of plastic based on their chemical composition. There are seven main types of plastic waste identified by the RIC, ranging from 1 to 7, each with unique properties and characteristics. These include the following:

I. Type 1 plastic, known as PolyEthylene Terephthalate (PET), is commonly used to produce beverage bottles and food containers. It is lightweight, transparent, and has good barrier properties against moisture and gases. However, it is unsuitable for high-temperature applications as it can deform and release harmful chemicals. [20]-[21].

II. Type 2 plastic, or High-Density PolyEthylene (HDPE), is a versatile material used to produce milk jugs, detergent bottles, and plastic bags. It is strong, durable, and chemical-resistant, making it ideal for packaging applications. However, it is not easily recyclable and can release harmful chemicals when exposed to heat [22].

III. Type 3 plastic, PolyVinyl Chloride (PVC), is widely used in construction, healthcare, and automotive industries. It is flexible, durable, and resistant to chemicals, making it suitable for a wide range of applications. However, it contains harmful additives such as phthalates and can release toxic fumes when burned. [23]-[24].

IV. Type 4 plastic, or Low-Density PolyEthylene (LDPE), is a flexible material for producing plastic bags, shrink wraps, and squeeze bottles. It is lightweight, moisture-resistant, and recyclable, making it a popular choice for packaging applications. However, it is not suitable for high-temperature applications as it can melt and release harmful chemicals [25]-[26].

V. Type 5 plastic, or PolyPropylene (PP), is versatile for producing food containers, yogurt cups, and bottle caps. It is lightweight, heat-resistant, and recyclable, making it ideal for food packaging applications. However, it is not easily biodegradable and can release harmful chemicals when heat exposure [27]-[28].

VI. Type 6 plastic, or PolyStyrene (PS), is a rigid material used to produce disposable cups, food containers, and packaging materials. It is lightweight, insulating, and cost-effective, making it a popular choice for food service applications. However, it is not easily recyclable and can release harmful chemicals when exposed to heat. [29]-[30].

VII. Type 7 plastic, or other, is a catch-all category that includes various types of plastic, such as PolyCarbonate (PC) and bioplastics. These materials produce water bottles, baby bottles, and medical devices. They have unique properties such as transparency, durability, and biodegradability, making them suitable for various applications. However, some types of type 7 plastic, such as PC, contain harmful chemicals such as BisPhenol A (BPA), which can leach into food and beverages [31]-[32].

The seven main types of plastic identified by the RIC each have unique properties and characteristics. While plastic materials have revolutionized various industries and improved our quality of life, it is crucial to be aware of the potential environmental and health impacts associated with their use. By understanding the properties of different types of plastic and making informed choices, we can minimize the negative impacts of plastic pollution and work towards a more sustainable future.

4 | Effects of Non-decomposable Nature of Plastic Wastes

Plastic materials take hundreds of years to decompose, leading to long-term pollution of the environment. This persistence threatens wildlife, as animals often mistake plastic debris for food, leading to ingestion and entanglement [33]-[34]. Plastic's non-decomposable nature or inability to break down naturally in the environment has significantly impacted soil and land quality. One of the critical effects of non-decomposable plastic waste on soil and land is soil contamination. When improperly disposed of plastic waste, it can leach harmful chemicals and toxins into the soil, contaminating the land and affecting plant growth. This can seriously affect agriculture and food production, as contaminated soil may not be suitable for growing crops [35]-[36].

In addition, plastic waste can also block the flow of water and nutrients in the soil, further impacting plant growth and soil quality. Another significant impact of non-decomposable plastic waste on soil and land is the physical degradation of the environment. Plastic waste can accumulate in the soil, forming a layer of non-biodegradable material that prevents the natural decomposition of organic matter [37]. This can lead to soil compaction, reduced water infiltration, and decreased soil fertility. In addition, plastic waste can also disrupt the habitat of soil-dwelling organisms, such as earthworms and microorganisms, which play a crucial role in maintaining soil health and fertility.

Furthermore, non-decomposable plastic waste in soil and land can also have long-term consequences for human health. As plastic waste breaks down into smaller particles, known as microplastics, it can be ingested by soil organisms and eventually enter the food chain [38]-[39]. This can lead to the accumulation of harmful chemicals in our food, posing a risk to human health. In addition, microplastics can also contaminate groundwater and surface water sources, further exacerbating the problem of plastic pollution. The non-decomposability of plastic waste has significant effects and impacts on soil and land quality. Urgent action is needed to address this issue and prevent further damage to the environment [40]-[41]. By taking proactive measures to address this issue, the deteriorating condition of our environment due to plastic waste can be salvaged, thus ensuring a sustainable future for generations to come.

5 | Impact of Plastic Wastes on Water Bodies

The proliferation of plastic products and the improper disposal of plastic waste have led to widespread pollution of rivers, lakes, and oceans. This has the following consequences on aquatic ecosystems:

I. One of the primary effects of plastic waste on water bodies is the physical harm it causes marine life. Animals like fish, seabirds, and marine mammals can become entangled in plastic debris or mistake it for food (see *Fig. 2*). This can lead to injury, suffocation, and death. Ingestion of plastic can also block the digestive tracts of animals, causing starvation and other health problems. Plastic waste in water bodies can disrupt the natural balance of ecosystems, leading to declines in biodiversity and overall ecosystem health [42]-[43].

Fig. 2. Illustration of fishes entangled in plastic waste or mistaken for food.

II. In addition to the physical harm caused by plastic waste, there are also chemical and toxicological impacts to consider. Plastics are made from various chemicals, many known to be harmful to aquatic organisms. When plastic debris breaks down in water bodies, it can release these chemicals into the environment, contaminating the water and posing a threat to the health of aquatic life. Furthermore, plastics can absorb and concentrate pollutants from the surrounding environment, such as pesticides and heavy metals. This can result in transferring these harmful substances up the food chain, ultimately affecting human health through consuming contaminated seafood [44]-[45].

III. The accumulation of plastic waste in water bodies also has economic implications. Coastal communities that rely on fishing and tourism can suffer from plastic pollution, as it can deter visitors and damage local economies. The costs of cleaning up plastic waste from water bodies can also substantially burden governments and taxpayers [46]-[47].

The effects of plastic waste on water bodies are far-reaching and multifaceted. Action must be taken to reduce the amount of plastic entering our waterways and to clean up existing pollution. This will require individual behaviour change, industry innovation, and government regulation. By addressing the issue of plastic waste in water bodies, we can protect aquatic ecosystems, wildlife, and human health for generations to come.

6 | Impact of Plastic Wastes on Wildlife

One of the most significant impacts of plastic waste on the environment is its effect on wildlife. The proliferation of plastic products and the improper disposal of these materials have led to a significant increase in plastic pollution in our oceans, rivers, and forests. This has profoundly impacted wildlife, causing harm to a wide range of species and disrupting entire ecosystems [48]. Countless marine animals, birds, and other wildlife are harmed or killed each year due to ingestion of plastic debris. This can lead to internal injuries, starvation, and even death.

Additionally, animals can become entangled in plastic waste, leading to suffocation, drowning, or other fatal consequences. One of the most visible effects of plastic waste on wildlife is animals' ingestion of plastic materials. Marine animals, in particular, are at risk of ingesting plastic debris, mistaking it for food. This can lead to serious health problems, including blockages in the digestive system, malnutrition, and even death. Studies have shown that over half of all sea turtles worldwide have ingested plastic debris, with devastating consequences for their health and survival [49].

Plastic waste also poses a threat to wildlife through entanglement. Animals such as birds, seals, and sea turtles can become trapped in discarded fishing nets, plastic bags, and other debris, leading to injuries, suffocation, and death. The impact of entanglement on wildlife populations can be significant, with some species facing

the risk of extinction due to the prevalence of plastic waste in their habitats. In addition to direct harm to individual animals, plastic waste can have broader impacts on wildlife populations and ecosystems [50].

Plastic pollution can alter habitats, disrupt food chains, and introduce toxic chemicals into the environment, posing a threat to the health and stability of entire ecosystems. The accumulation of plastic waste in natural environments can also lead to the spread of invasive species, further disrupting native wildlife populations. The effects of plastic waste on wildlife are profound and far-reaching, posing a severe threat to the health and survival of many species. We must address this issue and protect our natural world from the harmful impacts of plastic pollution. By working together to reduce plastic waste and promote sustainable practices, we can help to ensure a healthier and more resilient environment for wildlife and future generations [51].

7 | Impact of Plastic Wastes on Ecosystems

Plastic waste can have devastating, devastating, devastating effects on the health of ecosystems. As plastic breaks down into smaller pieces, known as microplastics, it can contaminate soil, water, and air. These microplastics can be ingested by plants and animals, leading to a range of health issues and disrupting the natural balance of ecosystems. In addition, plastic waste can leach harmful chemicals into the environment, further compromising the health of ecosystems [1].

One of the most visible impacts of plastic waste on the ecosystem is its effect on wildlife. Marine animals, in particular, risk ingesting or becoming entangled in plastic debris, leading to injury or death. Studies reveal that over 800 species worldwide are affected by plastic waste, with seabirds, sea turtles (see *Fig. 3*), and marine mammals being among the most vulnerable [52]-[53]. In addition to direct harm to wildlife, plastic waste indirectly affects ecosystems. As plastic debris breaks down into smaller particles, known as microplastics, it can enter the food chain and accumulate in the tissues of organisms. This can have negative consequences for the health of both wildlife and humans, as these microplastics can contain harmful chemicals and toxins.

Furthermore, plastic waste can also impact water quality and ecosystem function [54]-[55]. When plastic debris enters water bodies, it can leach chemicals and pollutants into the water, affecting the health of aquatic organisms and disrupting the balance of ecosystems. In addition, plastic waste can clog waterways and drainage systems, leading to flooding and other environmental problems. The impacts of plastic waste on the ecosystem are significant and wide-ranging, posing a threat to biodiversity, water quality, and human health. We must address this issue and reduce our reliance on plastic to protect ecosystems and preserve the health of our planet [56]-[57].

Fig. 3. Sea turtles, among other aquatic animals, affected by plastic waste.

8 | Impacts of Plastic Wastes on Drainage Systems

In recent times, the performance of drainage systems has been dramatically affected by plastic waste, which has become a primary environmental concern. The accumulation of plastic waste in drainage systems can lead to a range of negative effects, including blockages, flooding, and pollution [17]. One of the primary effects of

plastic waste on drainage systems is blockages. When plastic waste is improperly disposed of, it can clog drains and pipes, preventing the flow of water and leading to blockages (see *Fig. 4*). This can result in localized flooding, as water cannot drain properly. In extreme cases, blockages caused by plastic waste can lead to widespread flooding, causing damage to infrastructure and posing a risk to public safety [58]-[59].

In addition to blockages, plastic waste in drainage systems can also contribute to pollution. As plastic waste breaks down over time, it releases harmful chemicals and toxins into the water, contaminating the environment and posing a threat to aquatic life. Plastic waste can also act as a magnet for other pollutants, such as oil and grease, further exacerbating the problem of water pollution.Furthermore, plastic waste in drainage systems can long-term impact the environment [60].

As plastic waste accumulates in waterways, it can disrupt ecosystems and harm wildlife. Marine animals, in particular, are at risk of ingesting plastic waste, mistaking it for food. This can lead to serious health problems and even death for these animals, further contributing to the decline of already vulnerable species. Urgent action is needed to address this issue and prevent further environmental damage. Drainage systems can be protected by reducing plastic waste and ensuring sustainable disposal practices. Governments, businesses, and individuals must work together to tackle this problem and safeguard the health of our planet for future generations [61].

Fig. 4. Impacts of plastic wastes on drainage systems.

9 | Economic Impact of Plastic Wastes

The accumulation of plastic waste in the environment also has economic implications. Tourism, fishing, and other industries that rely on healthy ecosystems can suffer from plastic pollution. In addition, the cost of cleaning up plastic waste and mitigating its impacts can be significant, burdening governments, businesses, and communities. One of the primary economic effects of plastic waste is the cost of clean-up and disposal [62]. Studies have indicated that the annual cost of plastic pollution to the global economy per annum is estimated to be around $13 billion. This includes expenses related to waste collection, recycling, and landfill management. These costs are ultimately borne by taxpayers and businesses, leading to a drain on financial resources that could be better utilized elsewhere.

Furthermore, plastic waste has a negative impact on industries such as tourism and fishing. Beaches and oceans littered with plastic debris deter tourists and harm marine life, affecting the livelihoods of fishermen and coastal communities. Studies have also shown that the fishing industry could lose up to $1.5 billion annually due to ocean plastic pollution [63]. In addition, plastic waste in the environment can lead to a decline in property values and a decrease in tourism revenue. Studies have shown that homes near polluted beaches or areas with high levels of plastic waste tend to have lower property values than those in cleaner areas [9]. This can ripple effect on local economies, as businesses reliant on tourism may suffer from reduced foot traffic and revenue. We must reduce our plastic use, properly dispose of waste, and work towards a more sustainable future for our planet. The economic effects of plastic waste can be mitigated only through collective effort and commitment.

10 | Impacts of Plastic Wastes on Human Health and Wellness

The proliferation of plastic products in our daily lives has led to a widespread accumulation of plastic waste in landfills, oceans, and other natural environments. This has resulted in various negative effects on human health, including exposure to harmful chemicals and toxins and physical and psychological impacts (see *Fig. 5*). One of the critical effects of plastic waste on human health is the leaching of harmful chemicals from plastic products. Many plastics contain chemicals such as BPA and phthalates, which have been linked to various health problems, including hormonal imbalances, reproductive issues, and even cancer [64]. When plastic waste breaks down in the environment, these chemicals can leach into the soil and water, contaminating food sources and drinking water supplies. In addition to chemical exposure, plastic waste can physically impact human health. Plastic debris in the environment can pose a choking hazard to wildlife and humans, leading to respiratory and other health problems. Ingestion of plastic particles by marine animals can also transfer toxins up the food chain, ultimately affecting human health [65].

Furthermore, the presence of plastic waste in the environment can have psychological impacts on human well-being. The sight of littered beaches, streets, and parks can contribute to feelings of stress, anxiety, and depression, as well as a sense of helplessness in the face of environmental degradation. This can have a negative impact on mental health and overall quality of life. From chemical exposure to physical harm and psychological impacts, plastic waste in the environment severely threatens human well-being. Proper action must be taken to reduce plastic waste and mitigate its harmful effects on our health and the environment [66].

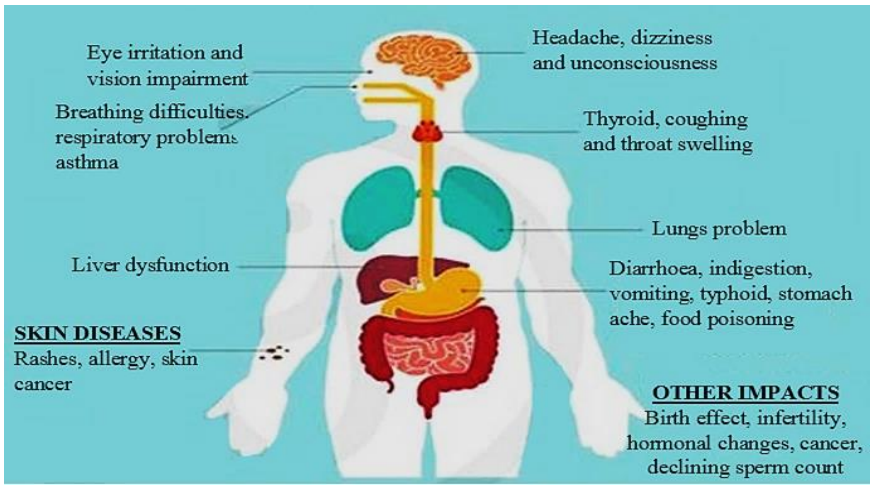

Fig. 5. Impacts of plastic wastes on human health and wellness.

11 | Effects of Plastic Wastes on Animals

The key impacts of plastic waste on animals are numerous and severe, ranging from ingestion and entanglement to habitat destruction and disruption of ecosystems. One of the most significant effects of plastic waste on animals is ingestion. Many animals mistake plastic items for food, leading to ingestion and subsequent health problems. For example, sea turtles often mistake plastic bags for jellyfish, a staple in their diet, leading to blockages in their digestive systems and eventual death. Similarly, seabirds ingest small plastic particles, which can accumulate in their stomachs and cause starvation and malnutrition [67]. Entanglement is another significant impact of plastic waste on animals. Discarded fishing nets, plastic rings and other debris can entangle animals such as seals, dolphins, and seabirds, leading to injuries, suffocation, and death. This not only affects individual animals but also disrupts entire populations and ecosystems. Plastic waste also destroys habitat, smothering coral reefs, suffocating mangroves, and clogging waterways. This disrupts the natural habitats of many animals, leading to displacement, reduced breeding success, and increased vulnerability to predators.

Furthermore, plastic waste can have long-term effects on ecosystems by altering nutrient cycles, contaminating water sources, and introducing harmful chemicals into the environment (see *Fig. 6*) [68]-[69]. This can have cascading effects on the food chain, affecting animals that directly interact with plastic waste and those higher up in the food chain. Therefore, we must take action to reduce plastic waste and mitigate its impacts on animals to protect biodiversity and ensure the health of our planet.

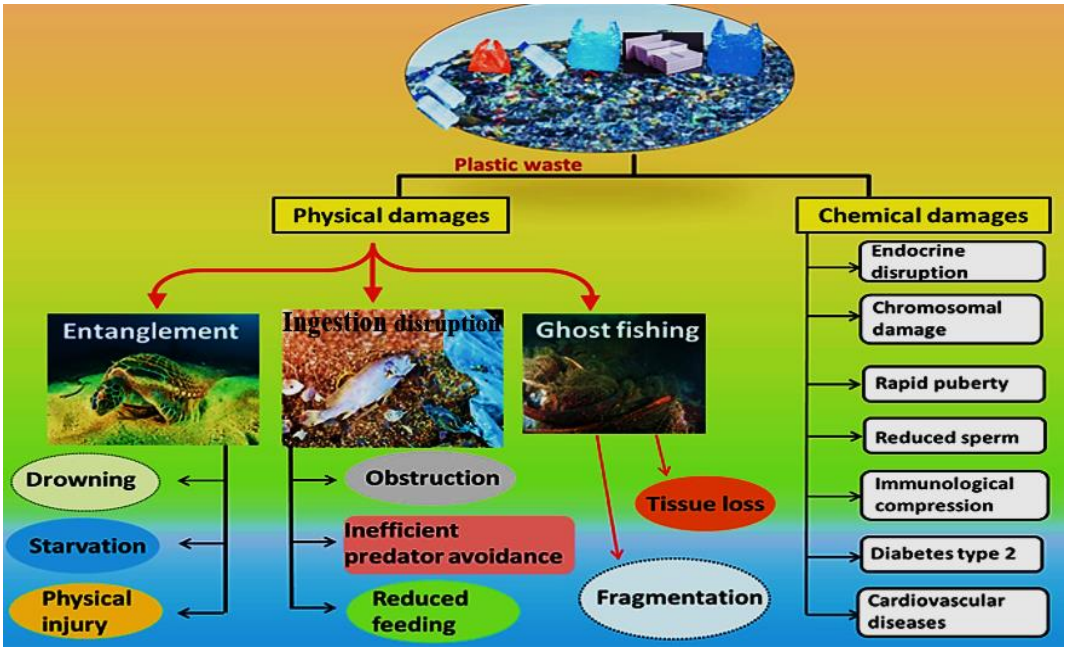

Fig. 6. Effects of plastic waste on animals.

12 | Impacts of Plastic Wastes on Soil and Plants

Plastic waste has become a primary environmental concern in recent years, significantly impacting soil and land. The key effects of plastic waste on soil and land include soil contamination, reduced soil fertility, and harm to wildlife and ecosystems. One of the primary impacts of plastic waste on soil is contamination. Plastic waste in the environment can also have a range of negative impacts on plant growth and agricultural productivity. This has substantial detrimental effects on plants and the agricultural sector being increasingly recognized. One critical effect of plastic waste on plants is physical damage. Plastic debris can smother plants, blocking sunlight and inhibiting photosynthesis. This can lead to stunted growth and reduced crop yields. In addition, plastic waste can also leach harmful chemicals into the soil, which plants can take up and affect their growth (see *Fig. 7*) and development [70]-[71].

Furthermore, plastic waste can also serve as a breeding ground for pests and pathogens, further damaging plants and reducing agricultural productivity. In addition, plastic waste can clog irrigation systems and drainage channels, leading to waterlogging and soil erosion, which can have a negative impact on plant growth. Policymakers, industry stakeholders, and the general public must reduce the amount of plastic waste generated and properly manage and dispose of existing plastic waste [72]. By doing so, we can help protect plants and ensure the sustainability of agriculture for future generations. When improperly disposed of plastic waste, it can leach harmful chemicals into the soil, contaminating the land and potentially affecting plant growth [73]. These chemicals can also seep into groundwater, further polluting the environment.

Additionally, plastic waste can physically degrade soil structure, reducing its fertility and ability to support plant growth. Plastic waste in soil can prevent water and nutrients from reaching plant roots, leading to stunted growth and decreased crop yields. This can have profound implications for agriculture and food security. Furthermore, plastic waste can harm wildlife and ecosystems that rely on healthy soil and land. Animals may ingest plastic waste, mistaking it for food, leading to internal injuries and even death. Plastic waste can also entangle wildlife, causing physical harm and hindering their ability to move and feed. The impacts of plastic waste on soil and land are significant. We must reduce plastic waste and adequately manage its disposal to protect our soil, land, and the environment [74]. By implementing sustainable waste management practices and promoting recycling and reuse, we can mitigate the harmful effects of plastic waste on soil and land.

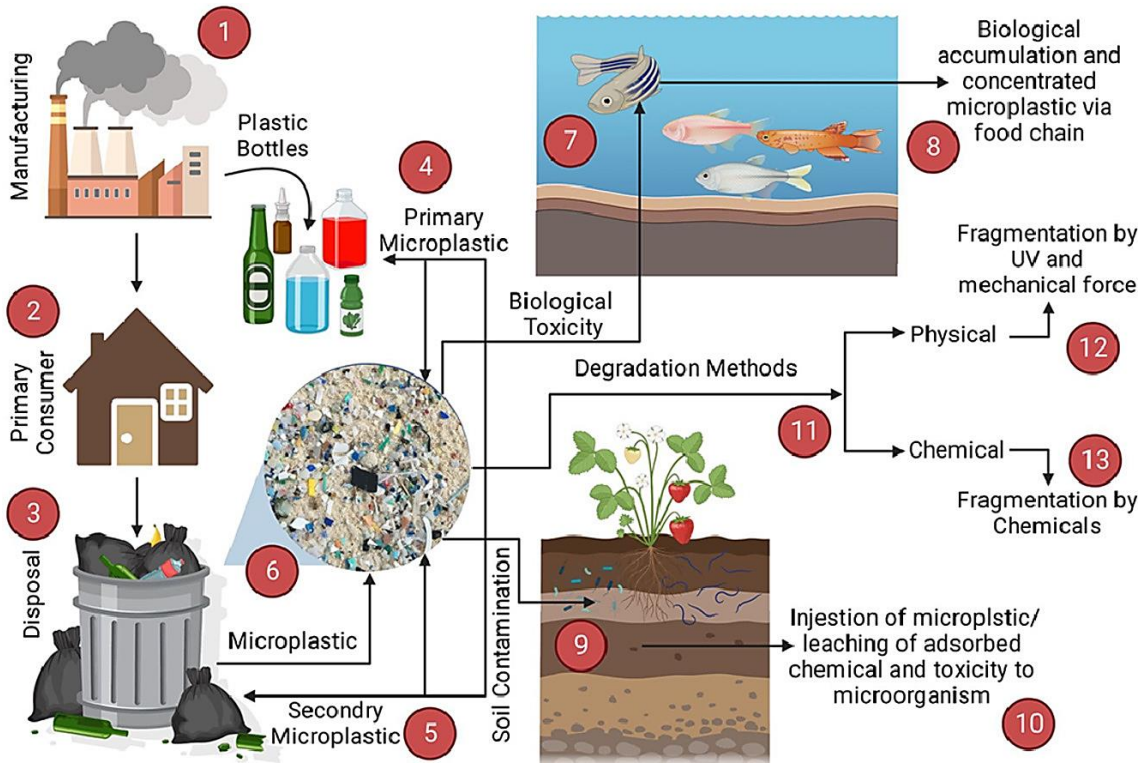

Fig. 7: Impacts of plastic wastes on soil and plant growth.

13 | Impacts of Plastic Waste on Public Health

One of the most direct effects of plastic waste on public health is the contamination of water sources. Plastic waste often ends up in rivers, lakes, and oceans, breaking into smaller particles known as microplastics. Marine life can ingest these microplastics and eventually enter the human food chain, posing a risk to human health [75]. Studies have shown that microplastics can contain harmful chemicals and toxins, adversely affecting human health, including hormonal disruptions and reproductive issues. In addition to water contamination, plastic waste also contributes to air pollution. When plastic waste is burned in open dumps or incinerators, it releases toxic chemicals and greenhouse gases into the atmosphere, negatively impacting respiratory health and exacerbating existing health conditions such as asthma and lung disease [56].

Furthermore, environmental plastic waste can impact public health psychologically and socially. The sight of littered streets and beaches can contribute to feelings of stress and anxiety and negatively impact community well-being. In addition, the presence of plastic waste in the environment can lead to apathy and helplessness among individuals, as they may feel overwhelmed by the scale of the problem and unsure how to address it. From water contamination and air pollution to psychological and social impacts, plastic waste seriously threatens human health. Adequate actions must be taken to reduce plastic waste and mitigate its impacts on public health through recycling, waste reduction, and sustainable consumption practices [76]-[77].

By addressing the issue of plastic waste, public health can be protected, and a healthier environment can be created for a more sustainable future.

14 | Preventive Measures to Minimize the Effects of Plastic Waste

Plastic waste has recently become a primary environmental concern, with millions of tons of plastic entering our oceans and landfills yearly. The negative impact of plastic waste on the environment, wildlife, and human health is well-documented, making it imperative for the following management measures to eradicate or minimize its effects.

I. One of the most effective ways to tackle the issue of plastic waste is by reducing the use of single-use plastics. Single-use plastics, such as plastic bags, straws, and water bottles, significantly contribute to plastic pollution. By banning these items and opting for reusable alternatives, a significant reduction in plastic waste entering the environment can be achieved. For example, countries like Canada and the European Union have implemented bans on certain single-use plastics to curb plastic pollution. [78]-[79].

II. Another important preventive measure is recycling. Recycling programs encourage individuals and businesses to properly dispose of their plastic waste by recycling it instead of sending it to landfills or incinerators. Recycling allows us to give a second life to plastic materials, reducing the need for new plastic production and ultimately decreasing the amount of plastic waste in our environment [80]. Furthermore, the implementation of Extended Producer Responsibility (EPR) programs, which hold manufacturers accountable for the disposal of their products at the end of their life cycle, can also go a long way in reducing the amount of plastic waste disposal. By shifting the responsibility of waste management onto producers, governments can incentivize them to design more sustainable products and packaging. Individuals, businesses, and governments must prioritize recycling efforts and invest in infrastructure that supports a circular economy [81]-[82].

III. Implement policies to promote the use of alternative materials for plastic. Biodegradable and compostable materials offer a more sustainable alternative to traditional plastics, as they break down more quickly in the environment. By incentivizing the use of these materials through policies such as tax incentives or subsidies, governments can reduce the reliance on plastic and promote a more circular economy [83]-[84].

IV. Another method for managing plastic waste is incineration. Incineration involves burning plastic waste at high temperatures to generate energy. While incineration can help to reduce the volume of plastic waste and generate electricity, it also produces harmful emissions and ash that must be appropriately disposed of. Additionally, incineration may not be a sustainable long-term solution for managing plastic waste, as it does not address the root cause of the problem [85]-[86].

V. Another preventive measure to consider is the implementation of EPR programs. EPR programs require manufacturers to take responsibility for the entire lifecycle of their products, including proper disposal and recycling. By holding manufacturers accountable for the waste generated by their products, EPR programs can incentivize them to design more sustainable and recyclable products, thereby reducing the amount of plastic waste generated [87]-[88].

VI. One such measure is the promotion of reuse programs, which encourage individuals and businesses to reduce their consumption of single-use plastics instead of reusable alternatives. Reuse programs are highly effective in reducing plastic waste and promoting sustainable practices. By encouraging individuals to use reusable bags, bottl es, and containers, these programs help minimize the amount of plastic waste in our environment. In addition, reuse programs can also help reduce the demand for new plastic products, thereby decreasing the amount of plastic produced in the first place. One of the critical benefits of reuse programs is that they are relatively easy to implement and can be tailored to suit the needs of different communities and organizations. For example, businesses can incentivize customers who bring their reusable bags or containers, while local governments can fund community-wide reuse initiatives. Promoting reuse programs at both the individual and institutional levels can develop a sustainability culture that will help reduce plastic waste and protect the environment [89]-[90].

VII. There has been increasing interest in promoting the use of biodegradable alternatives to control the effects of plastic waste. These alternatives are classified as biodegradable and compostable plastics, which can be easily broken down by bacteria and other organisms, making them a more sustainable option for packaging and other products. Biodegradable plastics can break down into natural components over time, reducing plastic waste in our environment. These plastics are typically made from plant-based materials such as corn or sugarcane, which are biodegradable and can be composted. Biodegradable plastics offer a sustainable alternative to traditional plastics, as they do not contribute to the accumulation of plastic waste in our environment. Compostable plastics are another biodegradable alternative that can help control plastic waste. These plastics are designed to break down into compost when exposed to the right conditions, such as heat and moisture. Compostable plastics are typically made from plant-based materials and are biodegradable, making them more environmentally friendly than traditional plastics [84], [88].

VIII. The production and consumption of plastic products and the affordability of plastic products have increased exponentially, leading to their widespread use and disposal and resulting in massive amounts of plastic waste entering our oceans and landfills. By promoting reasonable consumption patterns, individuals can reduce their reliance on single-use plastics and make more sustainable choices in their daily lives. One way to promote reasonable consumption patterns is through education and awareness campaigns. Individuals can make more informed choices about their consumption habits by creating awareness about the environmental impacts of plastic pollution and the benefits of reducing plastic consumption. Schools, businesses, and community organizations can be crucial in educating the public about reducing plastic waste and promoting sustainable alternatives [91]-[92].

IX. Education and awareness play a crucial role in preventing plastic waste. Educating the public about plastic waste's environmental impact and promoting sustainable practices can encourage individuals to make more conscious choices and reduce their plastic consumption. Additionally, raising awareness about the importance of proper waste management and the benefits of recycling can help shift societal attitudes towards a more sustainable future [93]-[94].

X. It is essential to implement adequate waste collection infrastructure to control the effects of plastic waste. One of the critical reasons why waste collection infrastructure is essential in controlling the effects of plastic waste is that it helps prevent plastic from entering the environment. Improper disposal of plastic waste, such as littering or illegal dumping, can result in plastic debris ending up in rivers, oceans, and other natural habitats. Waste collection infrastructure also has economic advantages. Properly managing plastic waste through proper collection methods such as buyback can create new job opportunities and stimulate economic growth in the waste management sector. Furthermore, reducing plastic waste in the environment can lead to cost savings for local governments and businesses by minimizing the need for clean-up efforts and environmental remediation [95]-[96].

Effective plastic waste management is essential for protecting the environment and human health. Recycling, incineration, and composting are just a few of the methods that can be used to manage plastic waste. However, it is essential to consider these methods' environmental impact, cost, and feasibility when implementing plastic waste management strategies. Ultimately, a combination of these methods, public education, and policy initiatives are needed to manage plastic waste and create a more sustainable future effectively.

15 | Conclusion

The menace of plastic waste in Nigeria is a pressing issue that requires immediate attention and effective management techniques in the 21st century. This study has highlighted the detrimental effects of plastic waste on the country's environment, public health, and socio-economic development. The increasing production and improper disposal of plastic waste have led to pollution of land, water bodies, and air, posing severe threats to biodiversity and human well-being. Various management techniques have been proposed to address Nigeria's plastic waste challenge. These include waste reduction, recycling, reuse, and proper disposal practices. However, inadequate infrastructure, lack of awareness, and limited resources have hindered the implementation of these techniques.

The government, private sector, civil society, and individuals must collaborate and take proactive measures to manage plastic waste in the country effectively. Plastic waste management in Nigeria requires a multifaceted approach that integrates environmental, social, and economic considerations. By implementing sustainable waste management practices and promoting a culture of responsible consumption and disposal, Nigeria can mitigate the adverse effects of plastic waste and move towards a cleaner and healthier environment in the 21st century. It is time for concerted action and collective responsibility to tackle the menace of plastic waste and ensure a sustainable future for all. In light of the aforementioned points, the following recommendations are suggested for the challenges caused by plastic waste in Nigeria:

I. There is a need for policy interventions, capacity building, research, and public education to promote sustainable waste management practices in Nigeria. Adopting innovative technologies, circular economy principles, and EPR can also contribute to reducing the generation and impact of plastic waste in the country. All stakeholders must play their part in addressing the menace of plastic waste and safeguarding the environment for future generations.

II. There is a need for strict enforcement of existing environmental laws and regulations related to plastic waste management. The government should ensure that industries and individuals comply with waste disposal guidelines and take responsibility for their plastic waste. Penalties should be imposed on those who violate these regulations to deter further pollution.

III. Public awareness campaigns should be intensified to educate the population on the dangers of plastic waste and the importance of proper disposal. Community engagement and involvement in waste management initiatives can help foster a culture of environmental responsibility and sustainability. Schools, media, and local organizations can be crucial in spreading awareness and promoting eco-friendly practices.

IV. Investment in recycling infrastructure and technology is essential to manage plastic waste in Nigeria effectively. The government should collaborate with private sector partners to establish recycling facilities and promote the recycling of plastic materials. This will reduce the amount of plastic waste in landfills and create economic opportunities for local communities.

V. Promoting alternative packaging materials and sustainable practices can help reduce the reliance on single-use plastics. Businesses and consumers should be encouraged to adopt eco-friendly alternatives such as biodegradable packaging, reusable bags, and compostable materials. This shift towards sustainable practices can significantly reduce plastic waste generation and mitigate its environmental impact.

The menace of plastic waste in Nigeria requires a multifaceted approach that involves government intervention, public participation, and technological innovation. By implementing the aforementioned recommendations based on the findings from this study, Nigeria can effectively manage its plastic waste in the 21st century and safeguard the environment for future generations. Immediate action must address this pressing issue and ensure a healthier future.

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