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Article

Assessment of Determinant Sources of Plastics and Microplastics Pollution in Inland Waterways Navigation in Lower River Niger

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Abstract: This study was aimed at assessing the impact of plastics and micro plastics pollution in Nigerian inland waterways operations. The main aim of this study is to provide a baseline assessment of plastic pollution in the River Niger, along with recommendations for further research. Using a survey and appropriate data analysis tools, the study investigated the determinant sources of plastic pollution in the River Niger, as well as the most significant impact and preferred means of plastic pollution and regulation. The main findings indicate that disposal of plastics is the determinant source of plastics and micro plastics in the River Niger. The most significant impact of plastic pollution was identified as reduction in the accessibility of certain areas of the river. Behavioral instrument is indicated to be the most preferred means of plastic pollution control and regulation. Hence, there is an urgent need for improved awareness among local communities. This can be achieved through education programs, which will help to reduce the use of single-use plastics while also reducing littering in these areas. The paper also recommends that more

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research be conducted on how these pollutants affect human health and ecosystems.

Keywords: Marine pollution, micro plastic-pollution, sources, inland-navigation, lower-Niger.

1. Introduction

Marine pollution is the accumulation of contaminants in water bodies and the coastal environment such that they pollutants develops harmful effects on aquatic and coastal life and hinder the optimum performance of the marine and coastal ecosystem. It can result from a variety of sources, including sewage, industrial effluents, and other pollutant sources and types. The problem has been a concern for many years; however, it has become more noticeable in recent decades as technological advances have expanded the amount of shipping activity at sea. The International Maritime Organization (IMO) estimates that at least 20% of all marine pollution comes from ships [1]. This includes oil spills and other forms of marine wastes. According to the IMO, most marine pollution from plastics occurs in developing countries like Nigeria, China, India, Indonesia and Bangladesh. Marine pollution occurs when contaminants are discharged into the ocean or other bodies of water. These pollutants may be intentionally introduced through dumping or accidental spills during transport. One of such pollutants is plastics. Plastic pollution has become a major issue in marine environments.

There are several ways that plastic pollution affects marine animals. First, it can block their digestive tracts, causing them to starve. Second, it can cause internal injuries due to blockage of blood flow or other organs of absorption [2]. This means that they may die from infections or septicemia (blood poisoning). Third, plastic contamination can lead to anoxia (oxygen starvation) as it prevents marine animals from breathing through their gills. Marine animals also ingest plastics through their diet; this includes fish that eat other fish with bits of plastic in them and sea birds that eat fish caught with plastic in their stomachs. In addition, some species such as seals have been observed swallowing plastic bags whole without digesting them first because they think they are jellyfishes. This can result in starvation or death and can also affect their ability to reproduce. Plastic pollution can affect the health and reproduction of marine animals, and it can also disrupt the food chain by contaminating organisms at the top of the chain [3].

In the past few years, there has been a lot of research done on the effects of plastic pollution in marine animals, with most studies showing that the rate of

plastic pollution is increasing rapidly. For example, a Study by reference [4]. Identified that more than 80% of all seabirds in the world have ingested plastics at some point in their lifetime and that between 5-20% of all sea mammals are suffering from entanglement with plastic debris.

Plastic pollution is caused by human activities, including littering, shipping, and manufacturing. Plastic is often used as packaging material, which means that it ends up in the environment when it is discarded or recycled. When plastic waste ends up in the ocean, it can take hundreds of years to break down into smaller pieces and biodegrade. This means that even if we stopped using plastics today, they would still be there for centuries to come. Other sources of maritime pollution include untreated waste water discharges from treatment plants; leaking cargo tanks; and oil leaks from pipelines or tankers.

Issues regarding environmental pollution, environmental sustainability and climate changes have ranked the top of global concerns. The effect of plastics in marine bodies has significant effect on the environment. Plastics are very versatile materials and have different applications. From domestic to industrial activities, one can see how much plastics are relied on to carry out several functions. In our homes we use plastics as furniture's and utensils. Several products are packaged using plastics or materials derived from plastics. Plastics are durable materials because they are corrosion-free and are more resistant to weathering [5]. These properties make them suitable for several applications thus making them a very important material. However, these same properties make them a threat to the environment. When plastics are disposed into the environment, they do not decompose easily. Studies have shown that plastics take at least 20 years to decompose and can take as long as 500 years to decompose. Plastic bags can decompose in 20 years while other plastics such as diapers, plastic cups and plastic water bottles can take up to 450 years to decompose [6;7]. They accumulate and remain in circulation in the environment. Furthermore, when these plastics eventually decompose, they release methane gas which is a harmful greenhouse gas.

In a bid to understand and solve the problem of environmental pollution, several researches have been conducted to determine the cause, effect and solutions to environmental pollution. Researchers have identified about10 Rivers around the world that contributes to 90% of the total plastics found in the oceans. Interestingly, River Niger was listed as one of such rivers whose high plastic waste content has contributed to the global issue of marine pollution. River Niger is a major river in Africa as it runs through five African countries before dumping its content in the Atlantic Ocean. River Niger flows across one of Nigeria's biggest commercial cities, like Onitsha, Lokoja, etc. Such towns are known for high production and use of one-time plastic packaging such as nylon

bags and sachet from packaged water. These plastics eventually end up in the water as a result of poor disposal and lack of recycling facilities [4].
Since creeks flow into rivers and rivers into seas and ocean, it is becoming increasingly apparent that this global problem of plastic pollution needs to be tackled from the grassroots. Hence, this study seeks to assess grassroots causes of plastic pollution and most effective approaches toward eradicating the menace of plastic pollution in the Lower River Niger area

2. Aims and Objectives of the Study

The aim of this research is to assess the determinant sources of plastics and micro plastics on Nigerian inland waterways operations and determine the preference scores for the instruments for combating the menace of plastic pollution in the lower River Niger.
Other specific objectives include;
i. To identify the determinant sources of plastic pollution in Nigeria inland Waterways
ii. To rank the determinant sources of micro-plastic pollution in the Inland water regions in increasing order of impact.
iii. To determine the preference scores for price-based instruments, rights-based instruments, regulation, and behavioural instruments for controlling micro-plastic pollution in Inland waterways in Nigeria
iv. To rank the effects of plastic and micro plastic pollution on inland water navigation through the River Niger.

3. Brief Review of Literature

Reference [1] defines pollution satisfaction as “the introduction by man into the environment of substances or energy liable to cause hazards to human health, harm to living resources and ecological systems, damage to structure or amenity or interference with legitimate uses of the environment”. Studies by [4] and [8] went on to explain the determinant of pollution specifically stating that non-production activities can also be a major contributing factor to the issue of pollution. In his study, he carried out several experiments to determine how materials cause pollution and what activities contribute the most. This is what he termed ‘Long-run determinant of pollution’. The above-mentioned studies are still relevant in today’s world and to this research. Pollution is also a social phenomenon that affects populations in a negative way. For example, air pollution can affect people's health and even increase the risk of death for those who breathe in toxic fumes.
Reference [8] identified about four main types of pollution. They include marine/water pollution, air pollution, land pollution, noise pollution and others.
(a) marine/Water Pollution: Water pollution refers to any substance that enters into our waterways through runoff or seepage from urban areas or agricultural

uses such as livestock feedlots (which are often near rivers). Examples include chemicals used in agriculture such as pesticides or fertilizers that get into lakes and streams; petroleum products such as gasoline slick on top of water bodies; garbage dumped into water bodies[8].

Marine pollution specifically is the pollution of water bodies and its surrounding environment arising from maritime operations from vessels and other land-based activities of humans that pollute the marine and coastal ecosystem. The term "maritime pollution" has also been used in some cases to refer specifically to the environmental degradation caused by shipping traffic on oceans or seas rather than just coastal areas [9]. The International Maritime Organization has estimated that over 40% of maritime pollution comes from ships, and it is expected to increase as shipping increases. Marine pollution can come from many sources: ships themselves (e.g., hull fouling), ballast water exchange between ships and the sea floor, fuel spills at sea, oil leaks from ships, cargo handling practices on land that may contribute to marine pollution by transporting contaminated materials offshore or into ports, increased use of diesel engines in shipping due to emissions regulations worldwide, etc[8].

It is estimated that over 3 million tons of trash are dumped into the ocean each year. This can be anything from plastic bags to oil and other chemicals. Maritime pollution is a problem because it impacts many different species including fish, birds, dolphins, whales and seals. The damage that this pollution does to these animals causes them to become sick or die. This can lead to an extinction of some species if we do not take action soon. Maritime pollution can cause significant damage to marine life and ecosystems, as well as human health. The effects of maritime pollution include damage to ecosystems and marine habitats, loss of biodiversity, increased risk of disease transmission and other human health concerns, and economic costs.

In the views of [10], plastics are synthetic substance composed of hydrocarbons that can be molded into solid objects of nearly any form and size. Crude oil is cracked to produce petrochemicals that are used to make polymers. Plastics like polyethylene and polypropylene (PP) are made from olefins, whereas polystyrene (PS) and polyamide (PA) are made from aromatic hydrocarbons (nylon). In factories, these pre-production materials are heated, extruded, or blow molded into form. Plastic pollution involves the build-up of plastic items and particles (for example, plastic bottles, bags, and beads) in the Earth's ecosystem (marine ecosystem) that has a negative impact on animals, wildlife habitat, and people.

Micro plastics are tiny pieces of plastic that have been broken down into smaller pieces by physical action or chemical treatment. Once at sea, sunlight, wind, and wave action break down plastic waste into small particles, often less than one-fifth of an inch across. These micro plastics are spread throughout the water

column and have been found in every corner of the globe, from Mount Everest, the highest peak, to the Mariana Trench, the deepest trough. Micro plastics are a major part of the issue. In 2014, an estimated 15 to 51 trillion micro plastic particles were floating in the world's oceans, weighing between 93,000 and 236,000 tonnes.

The United Nations estimates that there are approximately 8 million tonnes of plastic in our oceans by weight. This impacts marine life in many ways and can have serious consequences for human health as well. Plastic waste has been found in many places around the world, including the Arctic Ocean, the South Pacific Ocean and remote areas of Antarctica. These areas are important for conserving biodiversity and supporting sustainable marine economies.

Plastic pollution affects marine life in several ways. First, it can be ingested when marine animals mistake it for food. Second, it can cause harm when ingested or when it enters the bloodstream through ingestion or direct contact with skin or mucous membranes. Third, it can become toxic to marine life when they accidentally ingest plastic items or absorb toxins from these items through their skin or other tissues. Fourth, plastics may also affect marine life directly by causing the deterioration of their habitat due to their ability to attract microorganisms that attach themselves to them and break down into smaller pieces which then become trapped near the surface of the water where they accumulate until they eventually sink to the bottom where they will remain for decades before breaking down further into smaller pieces again over time until eventually becoming sediment which eventually becomes part of the ocean floor itself where it will remain forever unless disturbed through conscious effort by humans [11; 12].

Nigeria is no exception when it comes to plastic pollution. Reference [13] gave insight to the plastic pollution situation in Nigeria. According to [13], plastics were widely used in Nigeria in the second part of the 20th century for packaging. At the time, there were only approximately 50 recognized plastics producers in the nation. However, as its popularity expanded, people started to accept plastics, and plastic manufacturing grew to over 3,000 registered firms in Nigeria by the turn of the century. Nigeria is now Africa's largest importer of plastics and plastic raw materials. Hanafi (2018) estimates that Nigeria produces up to 100,000 Tonnes of plastic yearly. In another study, reference [14] notes that Nigeria produces up to 2.5 million Tonnes of plastic garbage every year.

Inland waterways in Nigeria total more than 10,000 kilometers in length. This water resource consists of rivers, streams, lagoons, and lakes, as well as intra-coastal water, which receives its water from two major rivers, the Niger and the Benue, which meet in Lokoja, in Kogi State, and flow into the Atlantic Ocean. Despite the fact that the River Niger is the longest, its tributary, the

Benue River, is the most frequently used waterway, especially by larger vessels. The Benue River is particularly important for commercial activities in the Delta area of Cross River and all the way along the coast to the Lagos lagoon. As of 2010, Nigeria was generally believed to have spilled up to 0.34 million tonnes of plastic garbage into the ocean, placing it in ninth place on the global scale of pollution of marine habitats [15].

Bad waste management practices and behaviors encourage the indiscriminate dumping of plastic waste, which in turn contributes to the escalation of plastic pollution in Nigeria. Inadequate public awareness of the environmental and potential health dangers of plastic pollution, inadequate funding for waste management and recycling infrastructure, an unskilled/inadequate waste collection workforce, and a failure to collect litter on time are all factors that could contribute to the problem's spread.

Reference [16] in their research titled; Plastic debris in rivers, aims to offer an overview of riverine plastic debris studies to date and identify future research directions provided a short overview of plastics, as well as information on the kinds of polymers that are often found in rivers and the dangers they represent to aquatic ecosystems. They provided an overview of the monitoring efforts being undertaken to describe riverine plastic movement, as well as samples of typical values from throughout the globe. Finally, they provided a forecast for riverine plastic research in the future.

Studies by [13] examined the issue of plastic pollution in Nigeria from the standpoint of environmental security. The study emphasizes that, due to Nigeria's large population of over 200 million people and the nation's inadequate waste management system, the country is burdened with a massive amount of trash, including plastics and other biodegradable and non-biodegradable waste materials. Consequently, as a technique for tackling Nigeria's plastic pollution problem, this article recommends plastic pyrolysis as a proven method of reducing the threat of plastic wastes while converting such waste into a sustainable source of energy and economic growth. It is the purpose of this article to analyse the potential difficulties and possibilities related with plastic pyrolysis in Nigeria. To understand the magnitude of the effects of plastic pollution in Nigerian inland waters and the world in general, the existing statistical information has to be analysed and considered. In this section, journals and publications with the aim of providing statistical data concerning plastic pollution will be analysed. Methods of data gathering, and analysis methods are taken note off and results discussed.

Reference [17] stipulated that more than 5 trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea, provides the estimate of the total number of plastic particles and their weight floating in the world's oceans from 24 expeditions (2007–2013).

Reference [5] in their research paper 'Plastic wastes: environmental hazard and instrument for wealth creation in Nigeria', did justice to this segment as they aimed to identify effective techniques for recycling plastic garbage in Nigeria as a tool for diversification and implementation. According to the article the three main established ways of effective waste management are: Recycling, Reducing and Reusing.

From the foregoing, it is observed that issue of plastic pollution in Nigerian inland waterways is a growing concern. However, available empirical studies have not yet been done to ascertain the determinant sources of plastic and micro plastic pollution in Nigeria Inland Waterways and the most preferred strategies for combating the menace in Nigeria. This the gap which this study is cast to bridge.

4. Methodology

The study used a survey method in which primary data was sourced from sampled population living around the River Niger using questionnaire as survey instrument. The research areas of this study include the bank of River Niger at Onitsha, Anambra state, Nigeria. The Niger River flows from its source in central Chad through Mali, Niger, Nigeria and Benin to its mouth on the Gulf of Guinea. Its basin covers about 2 million square kilometers and is home to over 100 million people.

The study used random sampling techniques in which the questionnaires were randomly distributed to the sampled population to elicit responses in line with the objectives of the study. The sample size was determined using the Taro Yamane formula for known population since the population of the City of Onitsha living by the River bank is already known.

The study used the Arithmetic mean statistical tool to analyze the data obtained from the survey. Basically, arithmetic mean is calculated by adding up all the numbers in the data set and then dividing that sum by the number of numbers in the set.

5. Results and Discussion of Findings

Table1: Major Determinants Sources of Plastic Pollution in Inland Waterways in Nigeria

S/N	Production	Consumption	Disposal
1	4.00	5.00	4.00
2	2.00	1.00	3.00
3	4.00	5.00	4.00
4	5.00	4.00	4.00
5	4.00	5.00	4.00
6	4.00	4.00	5.00
7	4.00	5.00	4.00

8	4.00	4.00	5.00
9	5.00	4.00	4.00
10	2.00	3.00	1.00
11	4.00	5.00	4.00
12	5.00	4.00	3.00
13	5.00	4.00	4.00
14	5.00	4.00	4.00
15	5.00	4.00	4.00
16	1.00	2.00	3.00
17	4.00	4.00	4.00
18	1.00	3.00	2.00
19	4.00	5.00	5.00
20	5.00	4.00	4.00

Table 2: Extraction Method: Principal Component Analysis.

	Initial Eigenvalues	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1(Production)	0.443	74.186	74.186	2.226	74.186	74.186
2(Consumption)	2.226	14.762	88.948			
3 (Disposal)	0.332	11.052	100.000			

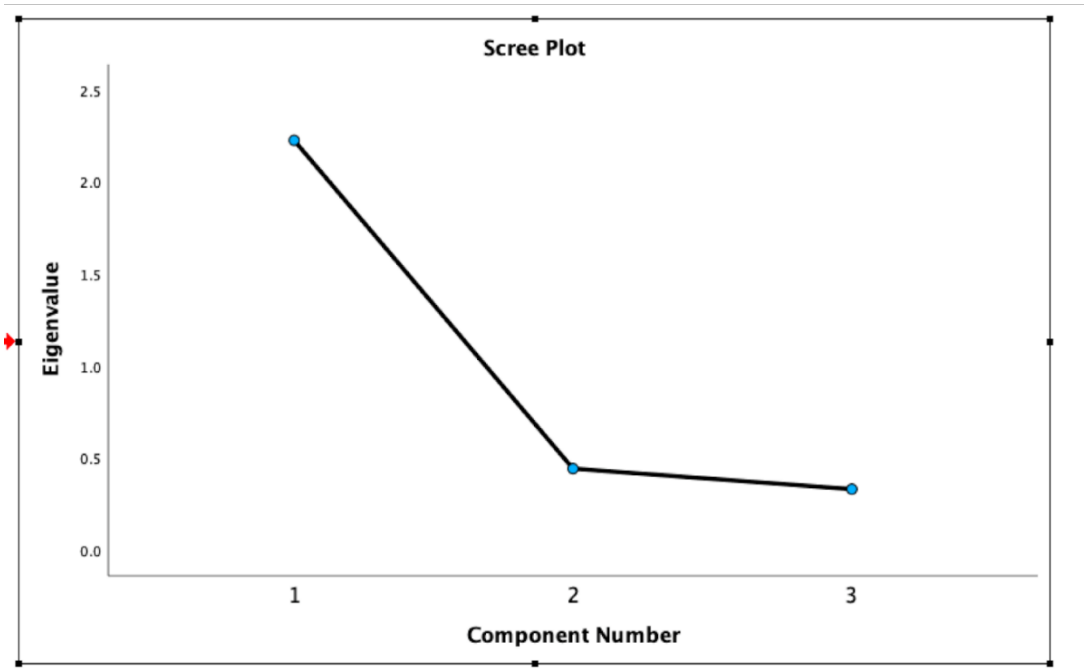
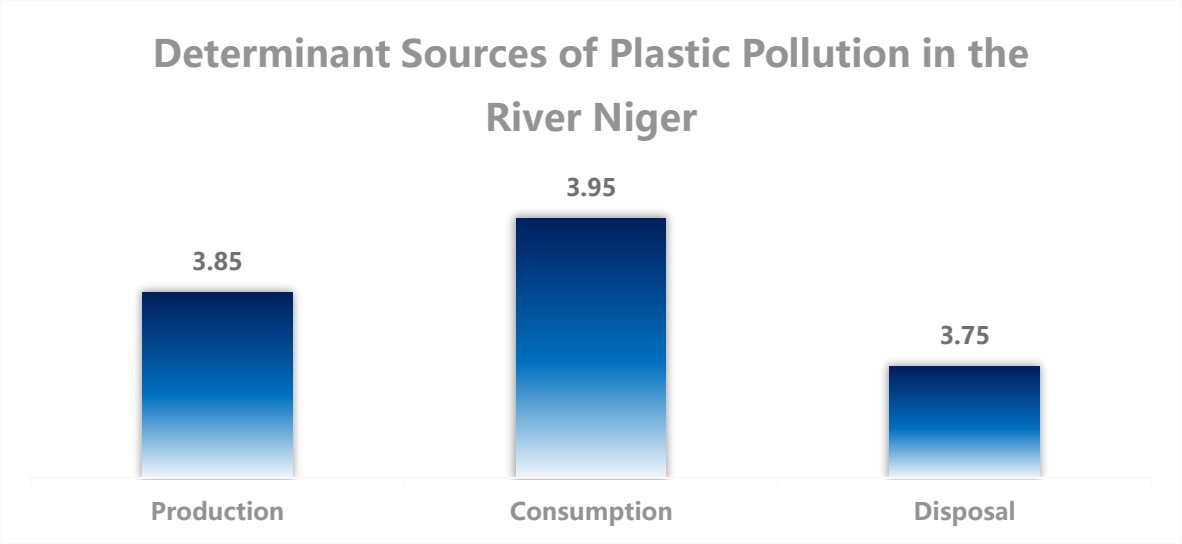


Figure1: Factor Analysis Scree Plot

A scree plot visualizes the Eigenvalues (quality scores) we just saw. Again, we see that the first component have Eigenvalues over 1. We consider this a

"strong factor". After that, component 2 and 3 has Eigenvalues that drops off dramatically. The sharp drop between components 1-2 strongly suggests that one factor underlie our questions. Thus far, we concluded that the eigenvector or component 1 (production of plastics) is our first principal component. The result shows that the production source has a mean score of 3.8500 while the consumption source has a mean score of 3.9500, disposal has a mean score of

3.7500. This implies that the consumption level with a mean score of 3.95 and Eigen value of 2.226 is the most major determinant source of plastic pollutants into waterways in Nigeria. This is followed by the production source of plastic with mean score of 3.85 and Eigen value of 0.442. Disposal level with a mean score of 3.750 and Eigen value of 0.332 is not a major source of plastic pollutants into waterways in the River Niger area of Onitsha, Nigeria. The figure-1 below shows the ranking of the major sourcing of plastic pollution into the River Nigeria in Onitsha Nigeria.



Source: Prepared by Author. Figure-2: Ranking the determinant sources of plastics into waterways

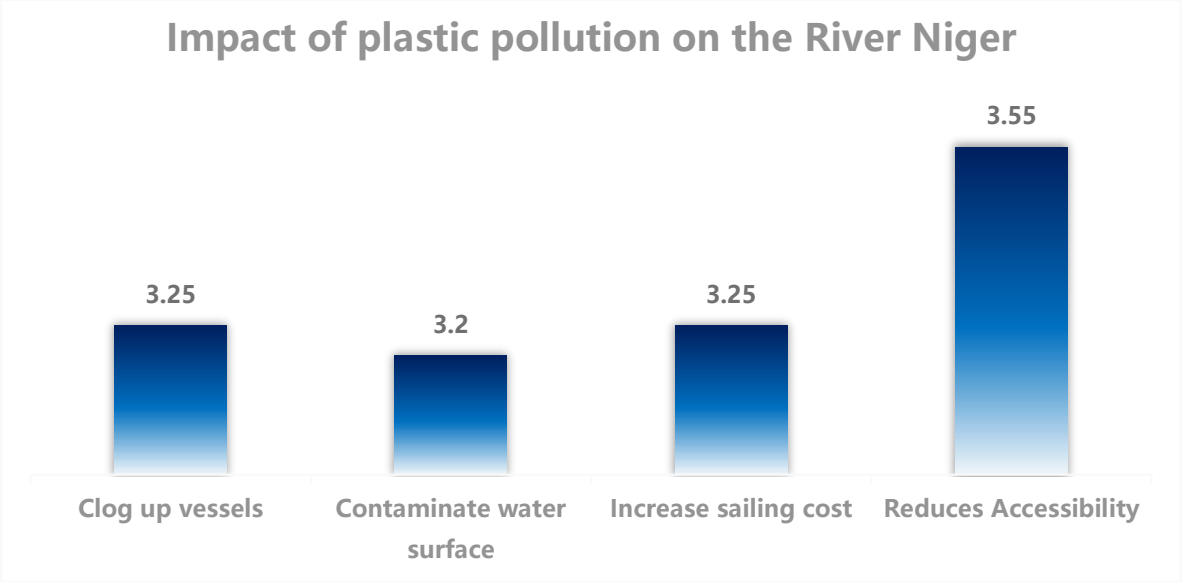


Figure 3. Ranking the Impacts of Plastic Pollution on Navigation in the River Nigeria

The figure-3 above indicates that the survey reveal that the most effect of plastic pollution on navigation and maritime operations in the River Nigeria is that it hinders the accessibility of inland vessels into the inland water routes. Reduction of accessibility has a mean score of 3.55. This is followed by increased sailing cost through the route which has a mean score of 3.26. Since delays occasioned by the preponderance of plastic debris and blockade on the inland water routes induces fuel and time wastages which when quantified in monetary terms leads to increased sailing cost through the waterways. The result also indicates that plastics clogging to the inland vessels navigating through the waterways have a mean score of 3.25. The implication is that the clogging to the propellers of inland vessels can result to marine accidents and disruption of the transport operations. Lastly, contamination of water surface has a mean score of 3.20 and is the least effect plastic pollution on navigation through the inland waterways identified by the respondents.

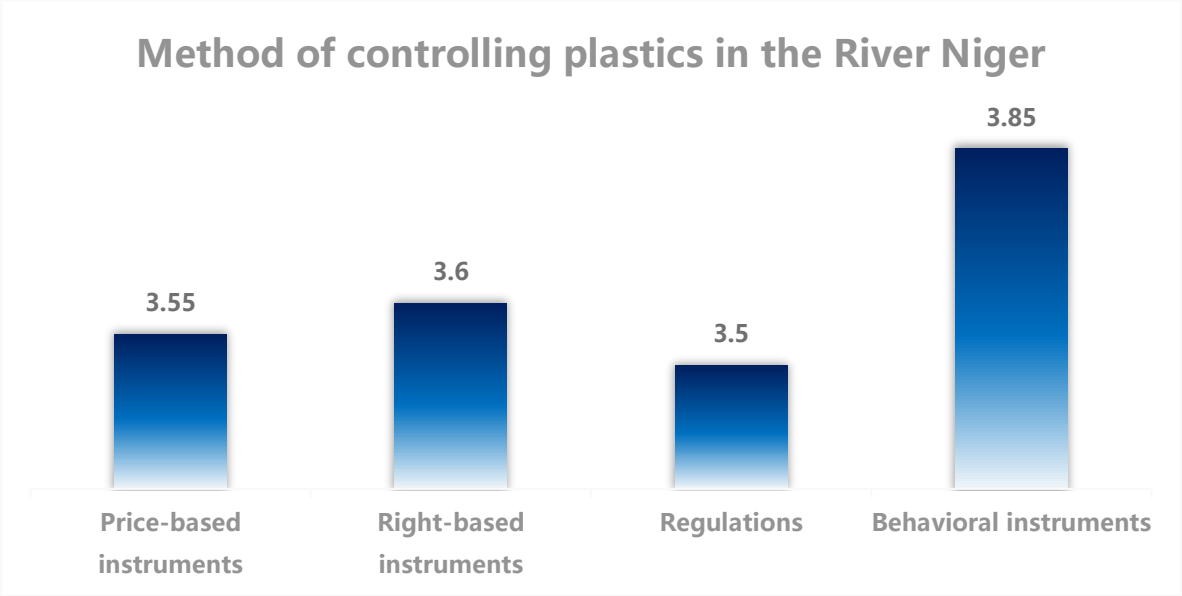


Figure 4. Ranking the Most Preferred Strategy/Method of Plastic Pollution Control

Figure-3 shows the ranking of the preference of strategies for controlling plastics and micro-plastic pollution in Inland waterways in Nigeria which include: price-based instruments, rights-based instruments, regulation, and behavioural instruments. From our study, most participants prefer the use of behavioural instruments e.g educational campaigns, information dissemination on the menace of plastic pollution, the effects and control measures, as the most

preferred of plastic pollution control. It has the highest preference score (mean score) of 3.85. This is followed by rights-based instruments with a mean preference score of 3.6 and price-based instruments with a mean preference score of 3.55.

6. Conclusions

Plastic pollution in Nigeria Inland Waterways is an immense and growing problem that has significant ecological, economic, and health implications for the nation. This research has also shown that plastic pollution in the Nigerian Inland Waterways can significantly affect maritime operations. There are many sources of plastic pollution in the country namely production, consumption and disposal. The Nigeria's existing waste management infrastructure is not adequate to manage or prevent this pervasive form of pollution. In light of these issues, it is important that both the government and industry take proactive steps to reduce plastic pollution through strong legislation, improved waste management practices, and reduction in production levels while also raising public awareness and promoting alternatives to single-use plastics.
From this study, behavioral instruments appear to be a promising tool for controlling plastic pollution. Awareness campaigns and educational programs targeting both youth and adults can help in changing attitudes towards the use and disposal of plastics while providing incentive activities intended to promote pro-environmental behavior.

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