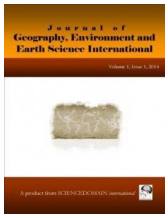

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Suspended Marine Litter in Akwa Ibom State, Nigeria: A Case Study of Cross River, QUA Iboe River and Jaja Creek

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Authors' contributions

This work was carried out in collaboration between both authors. Authors BBB and AOU designed the study, conducted the survey, performed the statistical analysis. Author AOU managed the literature searches and wrote the first draft of the manuscript. Author BBB managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

A study of Ten coastal communities along the Cross River, Qua Iboe River and Jaja Creek (all in Akwa Ibom, Nigeria) was conducted to: Identify and Geo-reference affected navigable channels in Akwa Ibom State; create a map of affected navigable channels in the state; qualitatively and quantitatively characterize floating marine debris in affected channels; Delineate the affected channels; and create awareness among coastal communities on marine litter dangers. The data for average depth revealed that the water body in Essene had the highest depth (13m) while Ufak had the least (3m); average width was highest (850m) at Akpam Nfrugam and Enitan while the least width (250m) was recorded in Ikot Ibritan; and the average flow velocity was highest (1.1 m/s) at Akpam Nfrugam and Essene, least (0.4 m/s) at Edik Ipa and Akuakpa Urang. The result of the characterization of the suspended debris showed that the debris comprised of plastic, nylon, can, foil and "others". "Others" was made up of mainly nypa palm and unidentified objects. Nylon

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recorded the highest amount, followed by plastic, can, others and foil recorded the least value across all locations. Average weight of suspended material per square kilometer ranged from the least value of 90,220 kg/km^2 at Akpam Nfrugam and the highest value of 199,820 kg/km^2 at Jaja creek. Based on 20 tons capacity estimate for dumper trucks, this study location would require between 5-10 dumper trucks to evacuate the suspended debris per square kilometers. In conclusion, navigable channels in the Akwa Ibom are faced with the recalcitrant problem of suspended debris clogging their paths making it difficult for the public to put them to good use while causing harm to aquatic life. It is a clear call for all stakeholders to be cautious of this increasing problem and device means to tackle it.

Keywords: Plastics; nylon; navigable channels; suspended debris.

1. INTRODUCTION

Oceans cover almost three quarters of the Earth's surface and comprise nine-tenths of our water resources. Water bodies are home to over 97 percent of life on our planet and constitute an essential part of our biosphere [1]. Sadly, human activities in the last 5 decades have resulted in the pollution of the ocean and the marine environment, led to over exploitation of living resources, alteration and destruction of marine habitats and influx of solid wastes such as plastics [2].

The Law of the Sea Convention by the United Nations (UNCLOS) is a legal framework dealing with all aspects of man's activities and interaction with the oceans and seas [3]. Several other International conventions and protocols are also in place to ensure the sustainable management of our ocean and marine environment. The present focus of the United Nations, national governments, private industries, non-governmental organizations calls for cooperation and provision of the tools (funds, capacity building programmes, remediate projects) that will ensure the health of our ocean and the marine environment which provides us with life [4].

Nigeria is a party to many of these international conventions and protocol. Much national and local legislation are also in place to ensure sustainable management of our ocean and marine environment. However, implementation of this legal framework is hampered by lack of human capacity, infrastructure and funds to ensure the enforcement of these legislations.

The Nigerian marine environment is presently being degraded by pollution from oil, solid waste and sewage [5]. Over exploitation of living resources has led to a constant decline in fish landings. Coastal erosion and flooding are causing widespread loss of coastal habitat and displacing people from their homes as was seen in 2012 and currently in 2018 especially in the Niger Delta. This flooding also greatly impacts on water bodies by increasing the amount of debris from land. The social, economic, and ecological problems associated with flooding are cumbersome and detrimental [6]. Nigeria owes it as duty to be active players in all global programmes that will ensure the sustainability of our ocean and marine environment as this is in the best interest of the National and International communities.

This study was conducted in Akwa Ibom State (Nigeria). This state is known for its oil and mineral deposit and a population boom from influx of people due to the high industrialisation going on in the state. Humans produce wastes which usually find its way to water bodies due to improper disposal.

1.1 Objectives

The specific objectives of the project are:

- Identify and Geo-reference affected navigable channels in Akwa Ibom State
- GIS Mapping of affected navigable channels in the states
- Qualitative and Quantitative Characterization of material in the affected channels
- Delineation of the affected channels
- Create awareness among coastal communities on the dangers of marine litter

2. MATERIALS AND METHODS

2.1 Study Area

Akwa Ibom, one of the Niger Delta states of Nigeria is the study area. Ten Communities along the Cross River, Qua Iboe River and Jaja Creek were surveyed (Figs. 1 and 2; Table 1a

and b). Typical conditions and activities in the creeks of the study locations in Akwa Ibom State are shown in Plate 1. Interactions were made during stakeholders meeting with the chairman boat association and fishers association with some community members to ascertain challenges faced by the locals in these areas and awareness created on marine litter while highlighting best practices to avoid further occurrences (Plate 2).

Some key observations from the study for each community are outlined below:

Nwaniba: A collection of dispersed fishers can be seen around the water way with non-biodegradable wastes and other bio-degradable wastes. Lots of vegetative cover can be seen with massive tree lumbering. A small hub of commercial activities can be also seen at the jetty. Small scattered fishing pods can also be seen in the water which looks black in colour which comprises of wooden houses. A few block houses can be seen along the water ways above the water. Le Meridian golf club and hotel is situated in this area.

Ufak Effiong: A collection of dispersed fishers can be seen around the water way with non-biodegradable wastes and other bio-degradable wastes. Lots of vegetative cover can be seen with massive tree lumbering. Small scattered fishing pods can also be seen in the water which looks black in colour which comprises of wooden houses above the water.

Edik Ikpa: A collection of dispersed fishers can be seen around the water way with non-biodegradable wastes and other bio-degradable wastes. Lots of vegetative cover can be seen with massive tree lumbering. Small scattered fishing pods can also be seen in the water which looks black in colour which comprises of wooden houses. A few block houses can be seen along the river bank above the water.

Akpam Nfrugam: A collection of dispersed fishers can be seen around the water way with non-biodegradable wastes and other bio-degradable wastes. Lots of vegetative cover can be seen with massive tree lumbering. Small scattered fishing pods can also be seen in the water which looks black in colour which comprises of wooden houses above the water.

Usu Urang: A collection of dispersed fishers can be seen around the water way with non-biodegradable wastes and other bio-degradable wastes. Lots of vegetative cover can be seen with massive tree lumbering. Small scattered fishing pods can also be seen in the water which looks black in colour which comprises of wooden houses above the water. Massive dead trees can be seen aggregated at a point in this area, blocking off almost the entire width of the river.

Badek Eman: A collection of dispersed fishers can be seen around the water way with non-biodegradable wastes and other bio-degradable wastes. Lots of vegetative cover can be seen with massive tree lumbering. Small scattered fishing pods can also be seen in the water which looks black in colour which comprises of wooden houses above the water.

Akwuakpa Uruang: A collection of dispersed fishers can be seen around the water way with non-biodegradable wastes and other bio-degradable wastes. Lots of vegetative cover can be seen with massive tree lumbering. Small scattered fishing pods can also be seen in the water which looks black in colour which comprises of wooden houses suspended above the water.

Essene: A jetty can be seen in this zone where massive ships come to fill their tanks with aluminum ore from the ALCON Company. A floating massive petroleum product retailing station can also be seen in this area. A hub of commercial activities can be seen at the jetty region. Massive vegetative cover can be seen on the other side of the creek with heavy military presence. Seeds from the nypa palm (*Nypa fruitican*) and its twigs can be seen at some locations within the creek.

2.2 Depth Measurement

The depth of the rivers was measured using a type H1-ITL depth resounding water gun (Plate 3) and supported with a gravity corer (Plate 3).

2.3 Velocity Measurement

Andrea recording current meter (RCM 9) with Acoustic Doppler current sensor 3620 was used in water current measurements (Plate 3). The current meter is self-recording and intended to be moored to measure and record the vector-averaged velocity and direction of the tidal current. The instrument features a newly developed RCM Doppler current sensor.

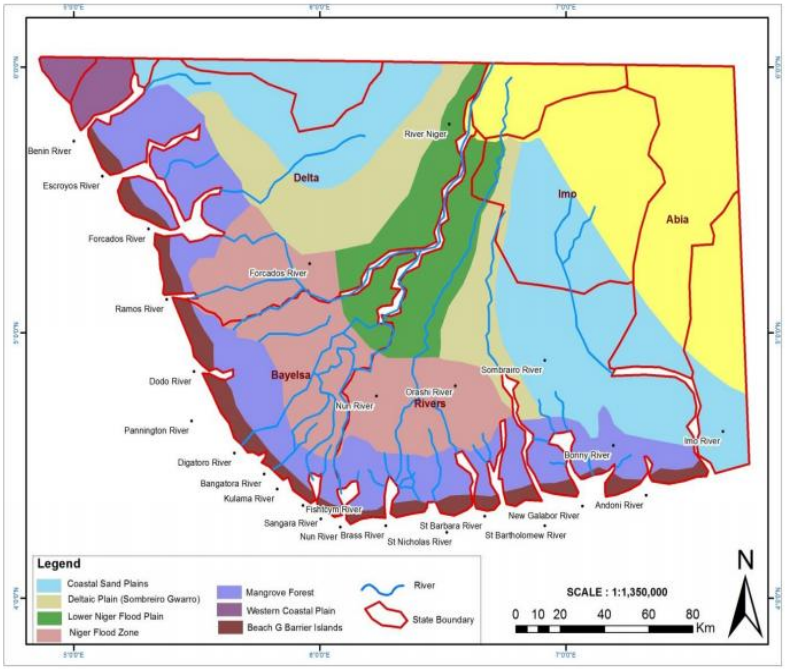

Fig. 1. Map of Niger Delta showing major rivers and the wetland watershed
Source: Google, 2018

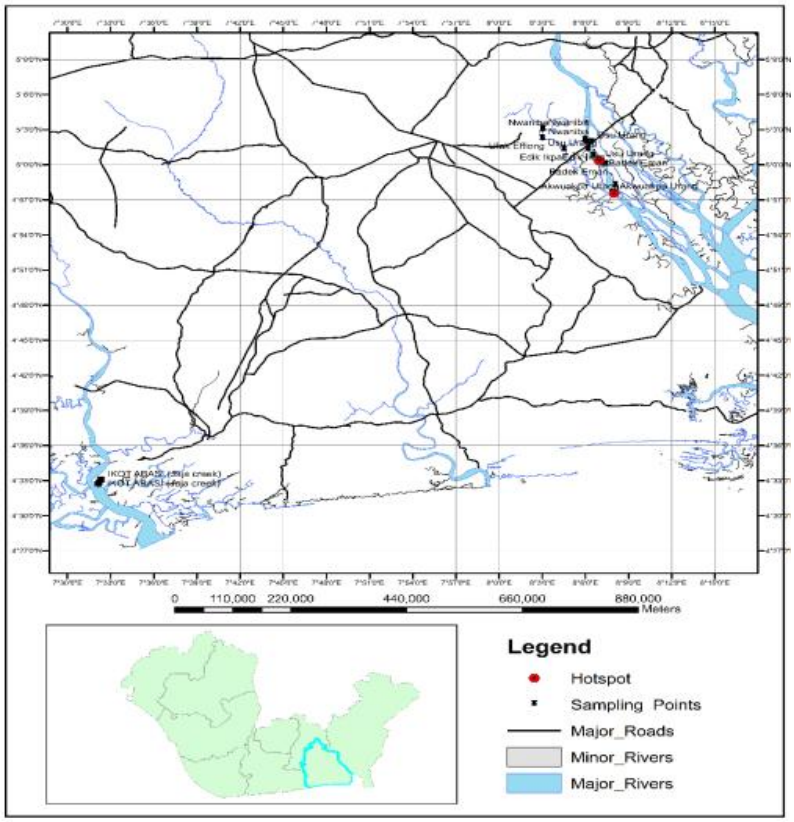

Fig. 2. Map of study area showing channels surveyed in Akwa Ibom State
Source: Fieldwork, 2016

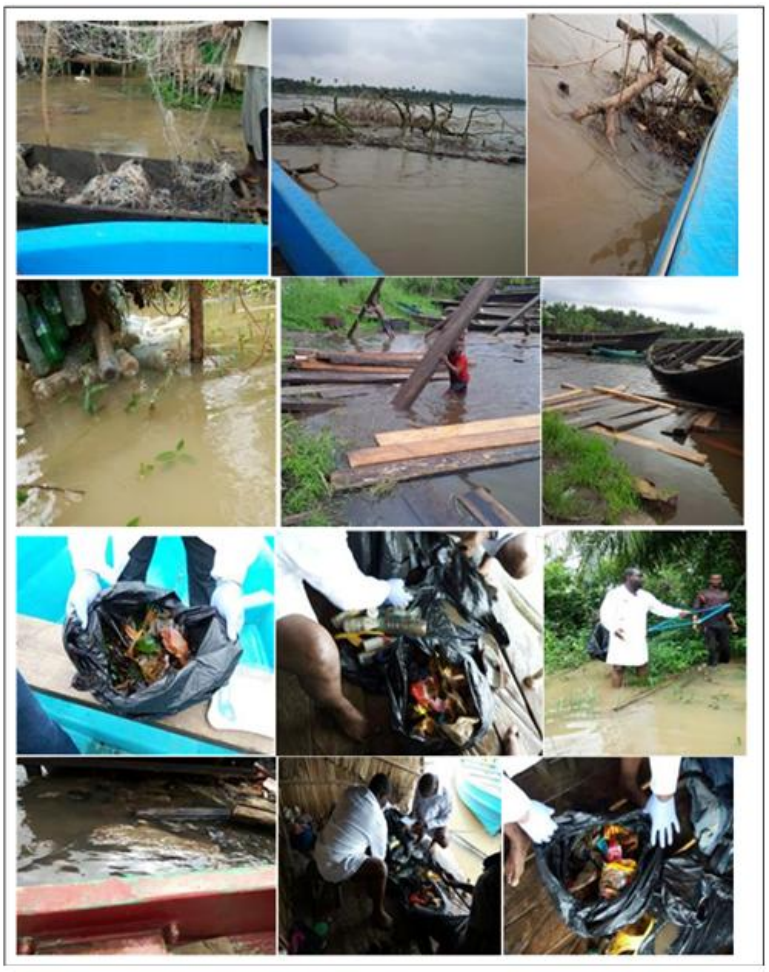

Plate 1. Typical Scenario along creeks in Akwa Ibom
Source: Fieldwork, 2016

Plate 2. Some Stakeholders meeting (both on land and on water) in Akwa Ibom State
Source: Fieldwork, 2016

Table 1a. GPS Coordinates of Visited locations in Akwa Ibom State

	1. Cross River	
	Latitude	**Longitude**
Ufak/Nwaniba	005° 03' 00" N	008° 03' 02" E
	005° 03' 01" N	008° 03' 03" E
	005° 03' 03" N	008° 03' 03" E
Ufak Effiong	005° 02' 13.35" N	008° 3' 6.113" E
	005° 01' 143.902" N	008° 4' 54.732" E
Edik Ikpa	005° 01' 16" N	008° 04' 31" E
	005° 01' 17" N	008° 04' 31" E

Table 1b. GPS Coordinates of Visited locations in Akwa Ibom State

	2. Mmo iyang creek (Qua Iboe River)	
	Latitude	**Longitude**
Akpam Nfrugam	005° 02' 06" N	008° 5' 58" E
	005° 01' 55" N	008° 6' 03" E
	005° 01' 53" N	008° 6' 04" E
Usu Urang	005° 01' 16" N	008° 06' 11" E
	005° 01' 55" N	008° 06' 26" E
Enitan	005° 00' 44" N	008° 06' 33" E
	005° 00' 21" N	008° 06' 58" E
Badek Eman	005° 00' 01" N	008° 07' 26" E
	005° 00' 01" N	008° 07' 13" E
Akwuakpa Urang	004° 58' 13" N	008° 08' 05" E
	004° 57' 33" N	008° 07' 50" E
	004° 57' 33" N	008° 07' 59" E
	3. IKOT ABASI (Jaja creek)	
Essene	4°32'36.94"N	7°32'11.53"E
	4°32'36.94"N	7°32'3.56"E
	4°32'36.94"N	7°32'5.27"E
	4°32'36.94"N	7°32'11.53"E
	4°32'44.00"N	7°32'12.23"E
Ikot Ibritan	4°32'47.04"N	7°32'13.19"E
	4°32'54.28"N	7°32'15.75"E
	4°32'57.40"N	7°32'21.12"E
	4°32'57.40"N	7°32'24.31"E

2.4 Width Measurement

The width of the rivers was measured using a tape.

2.5 Quantitative Assessment of Material Type

A quadrat technique was used to assess the amount of material. Quadrat sizes of 50 cm^2 and 1 m^2 (Plate 3) were deployed at random severally within defined area. Material found within a quadrat is collected and weighed in kilogram.

2.6 Qualitative Assessment of Material Type

Material collected from the quadrat are spread on a 1meter nylon and sorted out into its constituents according to ASTM D5231 – 92 [7] standard procedure (Plate 3).

2.7 Data Analysis and Report

Data collected was managed using statistical quantities and presented in tables and graphs. The minimum statistical treatment of a data set should include mean, standard deviation and standard error of the mean (SEM) which was employed in the present study.

3. RESULTS AND DISCUSSION

3.1 Depth, Width and Velocity of the Studied River Channels in Akwa Ibom State

Table 2 contains the data for the depth, width and velocity of the river channels. The average depth data revealed that the water body in Essene had the highest depth (13 m) while Ufak had the least (3m). This depth observed in Essene creek is a natural phenomenon (its proximity to the Atlantic ocean) which has made it a jetty for large ships to pass through to patronize the aluminum mining company there as was observed during the field trip [8].

The highest average width (850m) of this study was in Akpam Nfrugam and Enitan while the least width (250m) was recorded in Ikot Ibriton. The lowest average width of this study is higher than the average width (190m) recorded by Udo-Akuaibit, [9], who studied the entrance of Qua Iboe River. This increase in width may be linked to bank erosion which has become intensified with human activities [10].

The average velocity of all studied creeks revealed that those at Akpam Nfrugam and Essene had the highest flow velocity (1.1 m/s) while the least flow velocity (0.4 m/s) was recorded in Edik Ipa and Akuakpa Urang. The pattern of flow velocity recorded in this study agrees with studies by Antia et al. [11] who recorded flow velocities ranging from 0.22 – 0.33m/s and 1.13 – 1.60m/s during high and low tide respectively in Qua Iboe and Calabar river.

Plate 3. Instrument used during field survey

3.2 Characterization of Suspended Debris in the Studied River Channels in Akwa Ibom State

The result of the characterization of the suspended debris in creeks in Akwa Ibom State is presented in Figs. 3 – 8 and Table 3. The categories of debris comprised plastic, nylon, can, foil and others. Others was made up of mainly nypa palm and unidentified objects. Nylon recorded the highest amount in composition followed by plastic, can, others and foil recorded the least value across all locations Fig. 3. Average weight of suspended material per square meter and per square kilometer is presented in Table 3. It ranged from the least value of 4,511 kg/m^2 at Akpam Nfrugam to the highest value of 9,991 kg/m^2 at Jaja creek. This translates to a least value of 90,220 kg/km^2 at Akpam Nfrugam and the highest value of 199,820 kg/km^2 at Jaja creek. Based on 20 tons capacity estimate for dumper trucks, this study location would require between 5-10 dumper trucks to evacuate the suspended debris per square kilometers Table 3.

The quality and severity of the distribution of suspended debris in Akwa Ibom State is presented in Figs. 3-8. Plastic ranged from 1000 kg/m^2 to 1,400 kg/m^2 at hotspots such as Jaja, Usu Urang, Akuakpa Urang creeks Figs. 3 and 5. The category 'others' ranged from 312 kg/m^2 to 567 kg/m^2 Fig. 6 and the hotspots were at Ediki Ikpa and Ufak Effiong. Nylon ranged from 2,850 kg/m^2 to 3,419 kg/m^2 and its hotspots were at Usu Urang, Akuakpa Urang and Ediki Ikpa Fig. 7. Foil material ranged from 2 kg/m^2 to 5 kg/m^2 and recorded its hotspots at Usu Urang, Akuakpa Urang, Ediki Ikpa and Ufak Effiong Fig. 7. The distribution of can material ranged from over 250 kg/m^2 to 440 kg/m^2 with hotspots in ikot Ibriton, Jaja, Ediki Ikpa and Ufak Effiong creeks Fig. 8.

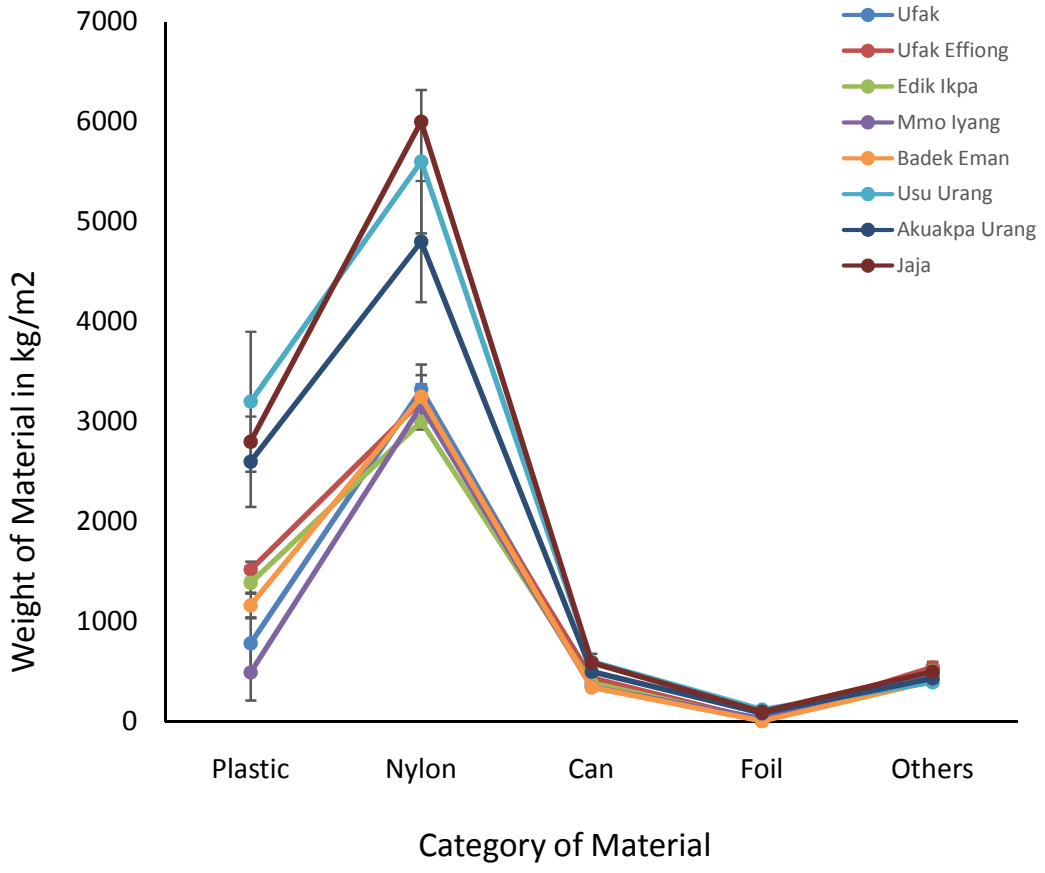

Fig. 3. Mean composition of material at different sampling locations in Akwa Ibom State (SEM =n=30)

The data on suspended debris agrees with studies by King et al. [12] who studied Qua Iboe River and recorded that plastics (foil, nylon, straw, PET bottles etc) were the most diverse and constituted 63.70% of the entire debris found. Other studies across the continent are also in sync with this finding where plastics account for majority of suspended marine debris [13,14,15,16,17,18,19,20].

Table 2. Average depth, width and speed of rivers at study locations in Akwa Ibom State

Location	Average Depth (m)	Average Velocity (m/s)	Average Width (m)
Ufak/Nwaniba	3	0.5	800
Ufak Effiong	5	0.6	500
Edik Ikpa	6	0.4	650
Akpam Nfrugam	4	1.1	850
Usu Urang	5	0.5	500
Badek Eman	5	0.6	580
Akuakpa Urang	5	0.4	600
Ikot Ibriton	4	0.5	250
Enitan	6	0.8	850
Essene	13	1.1	450

Source: Fieldwork, 2016

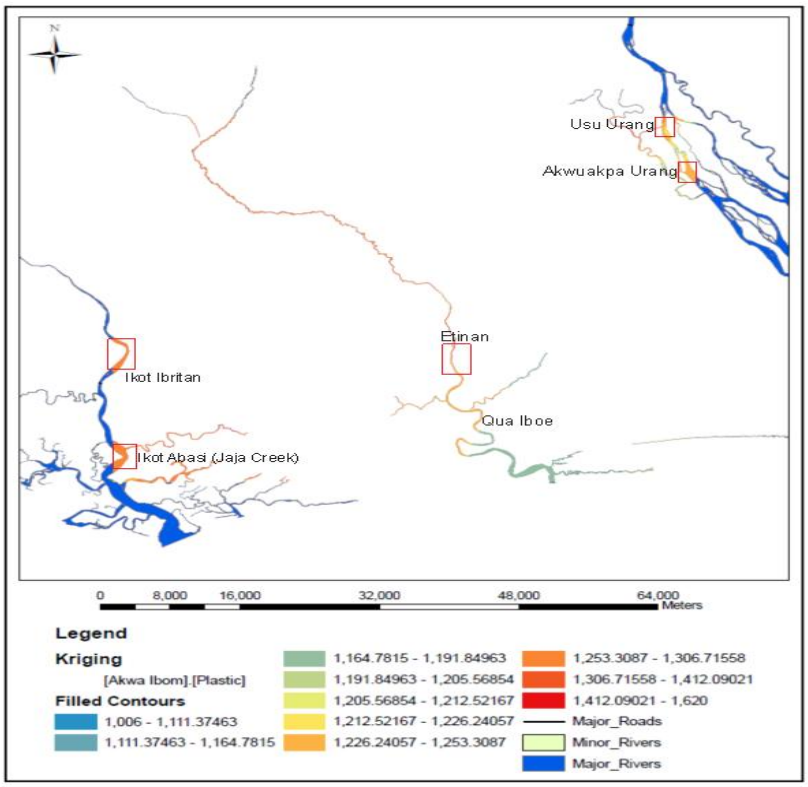

Fig. 4. Interpolated map showing the severity of plastic distribution at study locations in Akwa Ibom State

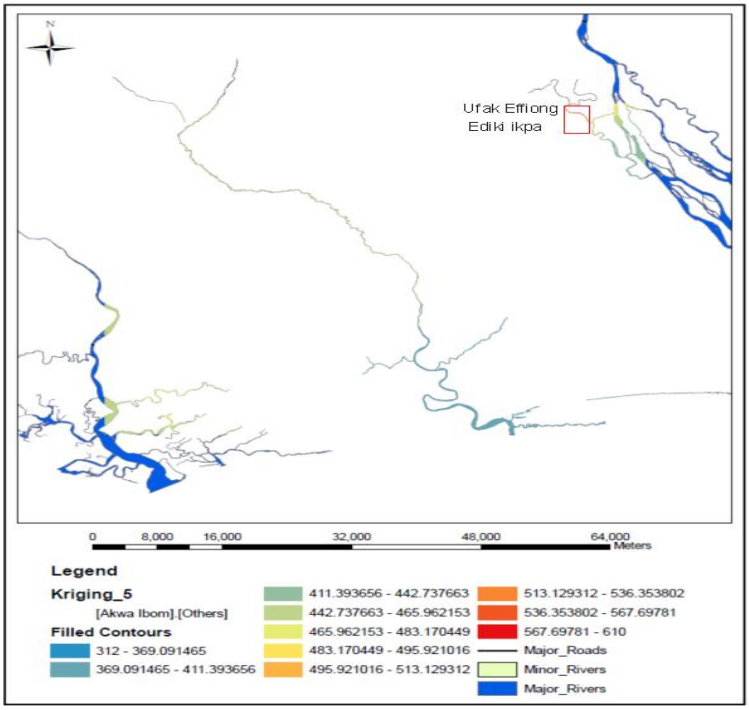

Fig. 5. Interpolated map showing the distribution and severity of the category 'others' at study locations in Akwa Ibom State

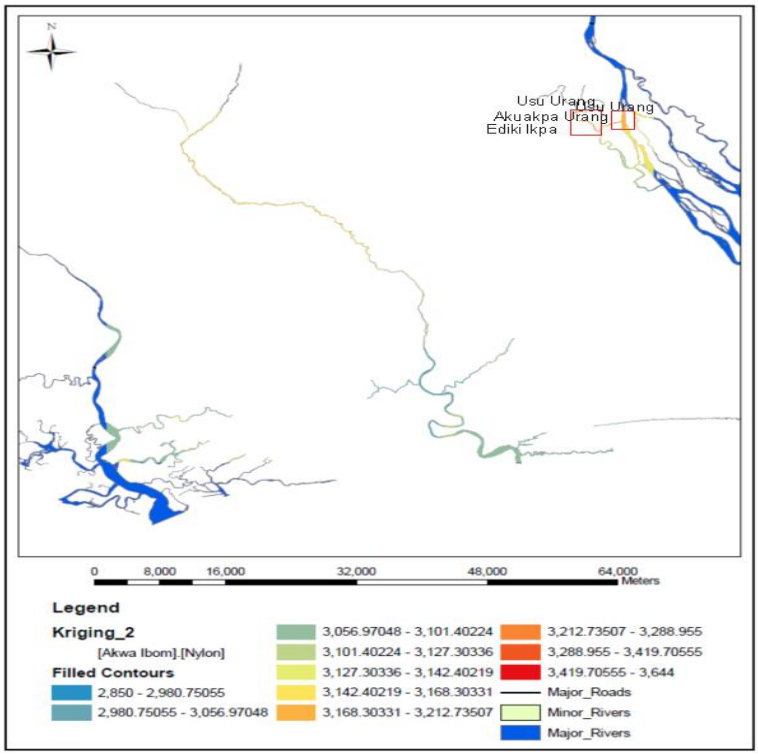

Fig. 6. Interpolated map showing the severity of nylon distribution at study locations in Akwa Ibom State

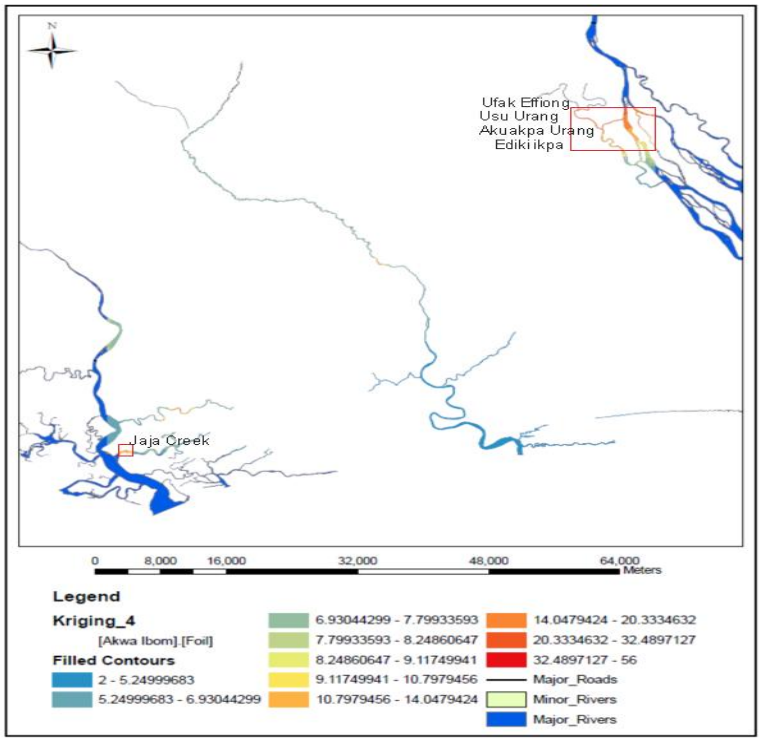

Fig. 7. Interpolated map showing the severity of foil distribution at study locations in Akwa Ibom State

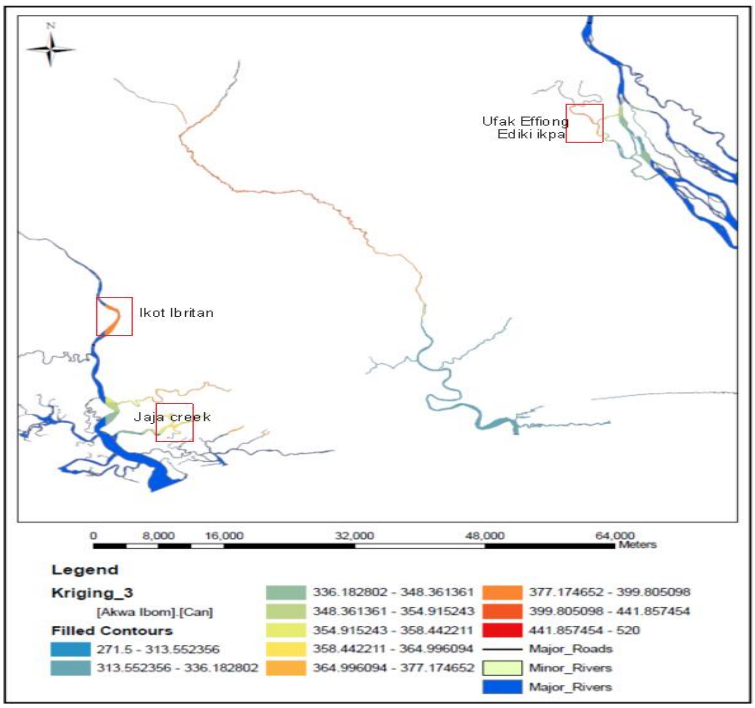

Fig. 8. Interpolated map showing the severity of can distribution at study locations in Akwa Ibom State

Table 3. Average Weight of Material per unit Area at study Locations in Akwa Ibom State

Location/Creek	Average Weight of Material (kg/m^2)	Average Weight of Material (kg/km^2)	No of Dumper Trucks
Ufak/Nwaniba	5033	100660.00	5
Ufak Effiong	5718	114360.00	6
Edik Ikpa	5287	105750.00	6
Akpam Nfrugam/Mmo Iyang	4511	90220.00	5
Usu Urang	9914	198280.00	10
Badek Eman	5166	103320.00	6
Akuakpa Urang	8420	168400.00	7
Enitan	6350	127000.00	7
Ikot Ibritan	5620	112400.00	6
Essene (Jaja)	9991	199820.00	10

4. CONCLUSION

Navigable channels in the Niger Delta are faced with the recalcitrant problem of suspended debris clogging their paths making it difficult for the public to put them to proper use. According to the stakeholders, several accidents and mishaps have occurred as a result of this avoidable menace. Apart from obstruction, reduction in aesthetic value, materials such as plastics and nylon do not biodegrade quickly, but steadily leach their toxic components into the water consumed by the people and aquatic life forms [15,17,21,18,22,23].

This huge menace by marine debris is a worldwide problem as can be seen by the 2018 World Environmental Day Theme. It is a clear call for all stakeholders to be cautious of this increasing problem and device means to tackle it.

5. RECOMMENDATION

Based on the finding of this study, it is recommended that:

- Massive awareness campaign should be embarked on before, during and after the removal of the suspended debris from navigable waterways.
- Efforts should be made to at least sort the materials into their various components.
- Plastics, cans and nylons can be recycled into useful products such as dustbin bags and even shopping bags.

COMPETING INTERESTS

Authors have declared that no competing interests exist

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