Suspended Marine Litter in New Calabar/Bonny Estuary System and Amadi Creek, Rivers State, Nigeria

Arinze O. Uche[2,3]* Babatunde, Bolaji B[1,2,3]

[1]Animal and Environmental Biology Department, Faculty of Science, University of Port Harcourt, Port Harcourt, Nigeria

[2]National Coordination Centre, IAEA Technical Cooperation Projects – Nigeria, University of Port Harcourt, Port Harcourt, Nigeria

[3]Earthpro Unique Integrated Limited, D-Line, Port Harcourt, Nigeria

.

ABSTRACT

A study of Nine coastal communities along the New Calabar/Bonny Estuary and Amadi Creek in Rivers State was conducted to: Identify and Geo-reference affected navigable channels in Rivers 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 suspended litter hazards. The data for average depth revealed that the water body in Diobu had the highest depth of10 m while Nkpogu and Ogunabali had the least depth of 4 m; average width was highest (100m) at Ukwa Aki while the least (25m) was recorded in Elekahia. The average flow velocity was highest (1.4 m/s) at Amatangbolo, and lowest (0.5 m/s) at Amadi-Ama. Characterization of suspended debris showed that the debris comprised of plastic, nylon, can, and foil. Plastic and nylon recorded the highest amount, accounting for over 70%. Average weight of suspended material per square kilometer ranged from the least value of 7553.33 kg/km^2 at Amatangbolo to the highest value of 126,410 kg/km^2 at Ogbunabali. Based on 20 tons capacity dumper trucks estimate, this study location would require between 1-7 dumper trucks to evacuate the suspended debris per square kilometers. In conclusion, plastics and nylon are the top ranking floating litter in the study area and as they do not biodegrade easily is a serious concern to the whole ecosystem wellbeing. Therefore it is our duty to safeguard our environment through global best practices and enlightenment campaigns.

Keywords: Plastics, Nylon, Foil, Navigable Channels, Suspended debris

1. INTRODUCTION

Solid waste management has emerged as one of the greatest challenges facing municipal authorities worldwide especially in developing countries like Nigeria (Ezeah and Roberts, 2012). The volume of solid waste been generated has continually increased at faster rate than resources available to contain it. In developing nations, the situation is more critical since their resources are usually meager and more priority issues like health and education beat municipal solid waste management (MSWM) to the top of the list (Guerrero et al 2013).

The consequence is ill conceived and operated epileptic MSWM systems that leave monuments of solid waste adorning the streets of urban centres in countries like Nigeria posing serious risk to both human and environmental health as these wastes find their way into surrounding waterways (Babatunde et al 2013). The Niger Delta has witnessed rapid urbanization and high influx of migrants in search of good jobs in the oil rich region. This has no doubt increased the consumption patterns and consequently waste generation and more pressure on the municipal authorities responsible for solid waste management (Babatunde and Uche, 2018).

Despite efforts made by municipal authorities, solid waste still adorn streets due mainly to non-compliance attitude of the populace. Indiscriminate disposal of waste materials on the street, gutters and waterways remains the most recalcitrant problem of solid waste management (Amuda et al 2014). People conducting their daily activities on and around waterways are even more recalcitrant to the problem of indiscriminate disposal of solid waste as they find it convenient throwing waste out into the waterways without consideration for potential risks associated with such actions (Babayemi and Dauda, 2009). Large and small vessels and commuters usually empty their trash directly into waterways and all including regulators is culpable. The presence of solid waste in navigable waterways in Nigeria is exacerbated by the presence of water hyacinth, a fast prolific water plant clogging the waterways. These suspended materials have caused untold hardship to navigation hampering socio-economic development on affected channels (Babatunde and Uche, 2018).

This study was done in Rivers State, one of the Niger Delta States of Nigeria. This state has high oil and gas deposits which is the major source of Revenue for Nigeria. The state has a population of about 5.2 million people (NPC, 2012; Babatunde et al. 2013). It also has a large network of tributaries, creeks, rivers and estuaries. The main aim of this study was to evaluate the marine litter in major estuary and creek delivering marine debris into the Atlantic Ocean.

2. MATERIAL AND METHODS

2.1 Study Area

The study area is New Calabar/Bonny River system and Amadi Creek in Rivers State a maritime state in the southern geopolitical zone of Nigeria (Figure 1 and 2). Rivers State is located on 4°45′0″ and 4.75 N and 6°50′0″ and 6°83′3″ E. The state comprises 23 local government areas with Port Harcourt, the state capital as one of the Local Government Areas.

Nine channels along the New Calabar/Bonny River system and Amadi Creek were surveyed in 2016 (Fig. 2, Table 1a and b). Typical conditions and activities in the creeks of the study locations in Rivers 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).

2.1.1 Diobu

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. A small hub of commercial activities can also be seen at the jetty. Lots of boats and ships with law enforcement personnel can be seen in this area. Local water transportation to Bakana Island from here is lucrative as boats can be seen moving off constantly. The water in this region is black and oil. Other major oil companies can also be seen around here

2.1.2 Ukwu Aki

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, mostly mangrove vegetation. A fishing community resides here, living in both wooden and block houses. Some areas have been cordoned for farming activities. Massive dredging activity is also very visible.

2.1.3 Bakana

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, mostly mangrove vegetation. Lots of modern block houses can be seen within this region. Some areas have been cordoned for farming activities. Massive dredging activity is also very visible. Toilets have been built above the water such that the sewage enters the river directly. The water current around this area is quite strong. A prominent jetty can also be seen in this region

2.1.4 Amatangbolo

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, mostly mangrove vegetation. A fishing community resides here, living in both wooden and block houses. Some areas have been cordoned for farming activities.

2.1.5 Old Bakana

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, mostly mangrove vegetation. A fishing community resides here, living in both wooden and block houses. Some areas have been cordoned for farming activities. The jetty here is greatly dilapidated.

2.1.6 Nkpogu

A community of dense human settlement with massive non-biodegradable waste problem. Block houses can be seen in the area. Very few boats can be seen in this region. Vegetative cover can be seen at intervals with fishing activities

2.1.7 Amadi-ama

This community has high human settlement density and has high quantity of non-biodegradable waste problem. Block houses can be seen in the area. Very few boats can be seen in this region. Vegetative cover can be seen at intervals with fishing activities

2.1.8 Ogbunabali

A community of highly dense human settlement having large quantity of non-biodegradable waste problem. Block houses can be seen in the area. Very few boats can be seen in this region. Vegetative cover can be seen at intervals with fishing activities

2.1.9 Elekahia

A community of highly dense human settlement with loads of non-biodegradable waste problem. Block houses can be seen in the area. Very few boats can be seen in this region. Vegetative cover can be seen at intervals with fishing activities.

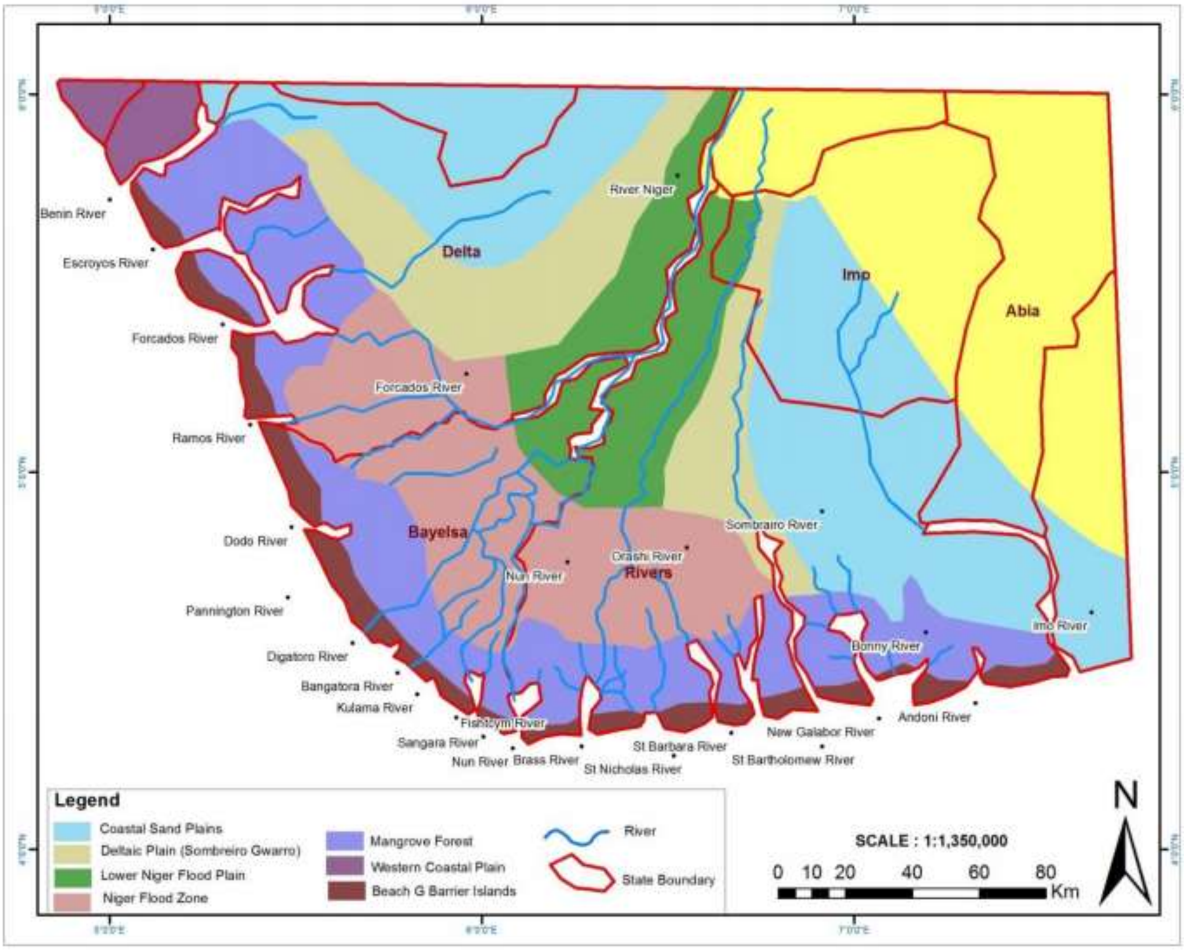


Fig 1: Map of Niger Delta showing major rivers and the wetland watershed
Source: Google, 2019

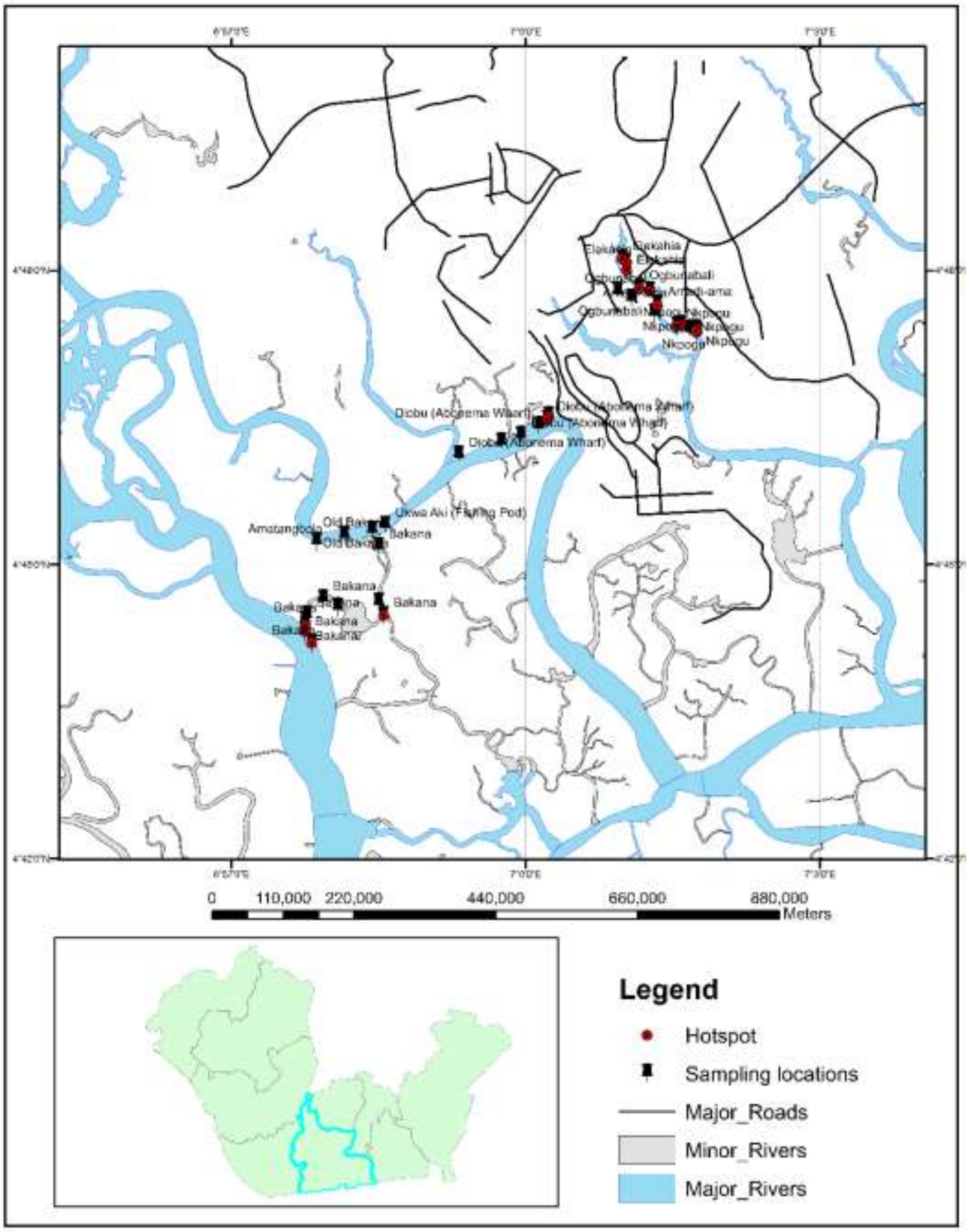


Fig. 2: Map of study area showing channels surveyed in Rivers State
Source: Fieldwork, 2016

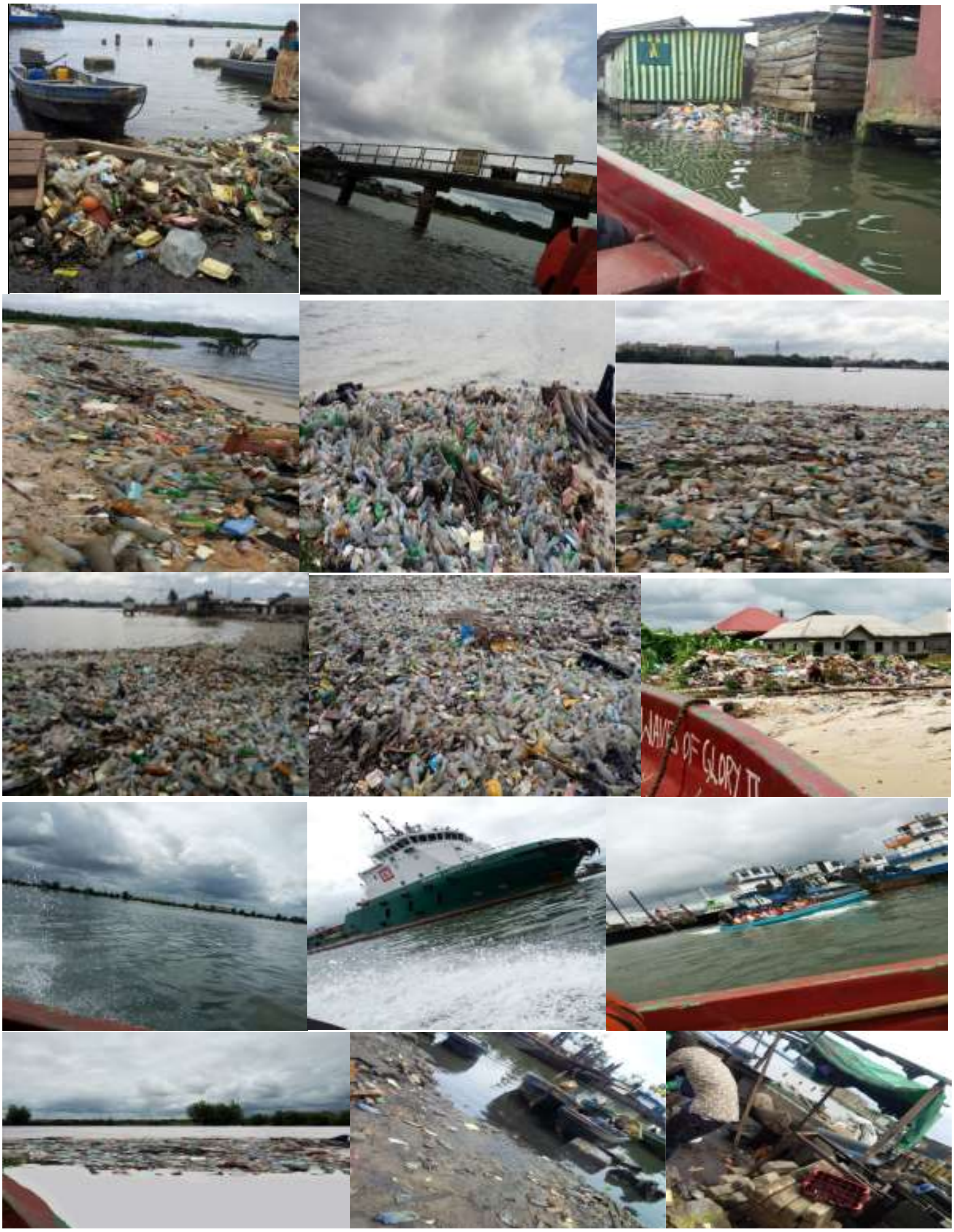


Plate 1: Some Typical Scenarios along Amadi Creek and New Calabar/Bonny River
Source: Fieldwork, 2016

Plate 2: Some Stakeholders meeting in Rivers State
Source: Fieldwork, 2016

Table 1a: Studied Channels along the New Calabar/Bonny Estuary

	Location	Coordinates
1	**Diobu (Abonema Wharf)**	N 4° 46' 31" E 7° 0' 14" (hotspot)
	Port Harcourt LGA	N 4° 46' 29" E 7° 0' 13" (hotspot)
		N 4° 46' 25" E 7° 0' 8"
		N 4° 46' 19" E 6° 59' 57"
		N 4° 46' 15" E 6° 59' 45"
		N 4° 46' 07" E 6° 59' 19"
2	**Ukwa Aki (Fishing Pod)**	N 4° 45' 24" E 6° 58' 34"
	Asari-Toru LGA	
3	**Bakana**	N 4° 45' 11" E 6° 58' 30"
	Asari-Toru LGA	N 4° 44' 37" E 6° 58' 30"
		N 4° 44' 29" E 6° 58' 33" (hotspot)
		N 4° 44' 34" E 6° 58' 5"
		N 4° 44' 23" E 6° 57' 45" (hotspot)
		N 4° 44' 12" E 6° 57' 49" (hotspot)
		N 4° 44' 19" E 6° 57' 45" (hotspot)
		N 4° 44' 26" E 6° 57' 45"
		N 4° 44' 29" E 6° 57' 46"
		N 4° 44' 39" E 6° 57' 56"
4	**Amatangbolo**	N 4° 45' 14" E 6° 57' 52"
	Asari-Toru LGA	
5	**Old Bakana**	N 4° 45' 21" E 6° 58' 26"
	Asari-Toru LGA	N 4° 45' 18" E 6° 58' 9"

Table 1b: Studied Channels along the Amadi Creek

Location	Coordinates
1 Nkpogu	4°47'24.51"N 7° 1'44.27"E (hotspot)
Port Harcourt LGA	4°47'22.52"N 7° 1'44.62"E (hotspot)
	4°47'23.09"N 7° 1'43.85"E (hotspot)
	4°47'24.16"N 7° 1'40.32"E
	4°47'26.79"N 7° 1'35.05"E (hotspot)
	4°47'26.25"N 7° 1'32.18"E (hotspot)
2 Amadi-ama	4°47'34.03"N 7° 1'18.50"E
Port Harcourt LGA	4°47'38.84"N 7° 1'20.26"E (hotspot)
	4°47'39.33"N 7° 1'20.55"E
3 Ogbunabali	4°47'47.55"N 7° 1'15.86"E (hotspot)
Port Harcourt LGA	4°47'49.29"N 7° 1'9.47"E (hotspot)
	4°47'43.01"N 7° 1'4.43"E
	4°47'47.24"N 7° 0'56.30"E
4 Elekahia	4°48'0.39"N 7° 1'1.71"E (hotspot)
Port Harcourt LGA	4°48'5.12"N 7° 1'1.42"E (hotspot)
	4°48'7.31"N 7° 0'58.98"E (hotspot)

2.2 Depth Measurement

The depth of the rivers was measured using a type H1-lTL 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.

2.4 Width Measurement

Width of the rivers were measured using a tape.

2.5. Quantitative Assessment of Material Type

A quadrat technique was used to assess the amount of material. Quadrat size of 50 cm^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 (2008) standard procedure (Plate 3).

Plate 3: Instrument used during field survey

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 were employed in the present study.

3. RESULTS AND DISCUSSION

Results and discussion of data collected and analyzed for all river channels surveyed in Rivers State are presented in below.

3.1 Stakeholders Meetings

The stakeholders meetings in all communities along the study area had similar queries which have been summarized as follows:

- They desperately need government intervention to help remove the wastes from the water ways
- These wastes cause problems for them when they navigate through the water
- The wastes do not only result in loss of man hour (from route diversion when heavy wastes block their path) but also causes loss of fish as the wastes sometimes result in incomplete detonation of traps.

- Other aesthetic uses of the river is almost impossible as non-biodegradable wastes liter almost the entire bank of the river
- The waste problem is increased during the dry seasons.

3.2 Depth, Width and Velocity of the Studied River Channels in Rivers State

Table 2 contains the data for the depth, width and velocity of the studied water bodies. The average depth data revealed that the water body in Diobu had the highest depth (10m); while Nkpogu and Ogunabali had the least (4m). This depth observed in Diobu (New Calabar/Bonny River) is a natural phenomenon (owing to its proximity to the Atlantic Ocean) which has made it a jetty for large ships to pass through for various shipping activities. This depth observed agrees with a study by Iyama and Edori (2014) who reported a maximum depth of 15m.

The highest average width (100m) of this study was in Ukwa Aki (New Calabar/Bonny River) while the least width (25m) was recorded in Elekahia. The highest average width of this study is far less than the maximun width (2000m) reported by NEDECO, (1961) which was about 55 years ago. However, studies by Izuafuo et al (2004) who studied the upper reaches of Bonny Estuary some 15 years ago reported a reduced maximum width of 700m. This reduction in width was linked to increased human settlement leading to sand filling for reclamation and siltation of the water body from runoffs due to various human activities.

The average velocity of all studied creeks revealed that those at Amatangbolo (New Calabar/Bonny River) had the highest flow velocity (1.4 m/s) while the least flow velocity (0.5 m/s) was recorded in Amadi-ama (Amadi Creek). The pattern of flow velocity recorded in this study agrees with studies by Otene and Davies (2013) who recorded flow velocities ranging from 0.3 – 0.8m/s and 1.0 – 1.8m/s during high and low tide respectively in their study of Bonny Estuary and Amadi Creek. This can be linked to the morphology of the water bodies with Amadi Creek being a tributary of the much larger Bonny Estuary.

Table 2: Average depth, width and velocity of the river at the study area in Rivers State

S/N	Location	Average Depth (m)	Average Velocity (m/s)	Average Width (m)
1	Diobu (Abonema Wharf)	12	0.8	75
2	Ukwa Aki (Fishing Pod)	7	0.6	100
3	Amatangbolo	8	1.4	92
4	Bakana	7	1.3	83
5	Old Bakana (Bundu-Ama)	7	1.0	90
6	Nkpogu (Amadi Creek)	4	1.1	35
7	Amadi-ama	9	0.5	30
8	Ogbunabali	4	1.2	25
9	Elekahia	6	1.2	23

Source: Fieldwork, 2016

3.3. Characterization of Suspended Debris in the Studied River Channels in Rivers State

Result of the characterization of the suspended debris in creeks in Rivers State is presented in Fig. 3 – 7 and Table 3. The categories of debris comprised plastic, nylon, can and foil. Plastic recorded the highest amount in composition followed by nylon, can 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 337.67 kg/m^2 at Amatangbolo to the highest value of 6,320.50 kg/m^2 at Ogbunabali. This translates to least value of 7553.33 kg/km^2 at Amatangbolo and the highest value of 126,410 kg/km^2 at Ogbunabali. Based on 20 tons capacity estimate for dumper trucks, this study location would require between 1-7 dumper trucks to evacuate the suspended debris per square kilometers Table 3.

The quality and severity of the distribution of suspended debris in Rivers State is presented in Figs 3 – 7. Foil material ranged from 35 kg/m^2 to 432.1 kg/m^2 and recorded its hotspots at Bakana, Diobu, Nkpogu, Ogbunabali, and Amadi-ama Fig. 3 and 4. Plastic ranged from 100 kg/m^2 to 3521 kg/m^2 at hotspots such as Bakana, Abonnema Wharf, Marine Base, Nkpogu, Elekahia, Ogbunabali, and Amadi-ama creeks Fig 3 and 5. Nylon ranged from 84 kg/m^2 to 3,256 kg/m^2 and its hotspots were at Diobu, Abonnema Wharf, Budu-ama, Marine base, Nkpogu and Amadi ama Fig 3 and 6. The distribution of can material ranged from over 26 kg/m^2 to 650 kg/m^2 with hotspots Diobu, Abonnema, Marine Base, Nkpogu, Amadi-ama and Ogbunabali creeks Fig. 3 and 7.

Plastics and nylon were the highest ranking suspended litter found in this study (accounting for more than 70% of debris) and this is in tune with worldwide findings where plastics and nylon make up most of the suspended litter in aquatic environment (Babayemi and Dauda, 2009; King et al 2013; Babatunde and Uche, 2018). This wide spread plastic sources has resulted in plastic waste being present in various aquatic environment in a wide range of sizes (the size range of 1 nm to < 5 mm). Microplastics are now an emerging threat, having both ecotoxicological and ecological risk for water ecosystems (Bożena, 2017).

Sadly, approximately 80 percent of ocean plastics come from land-based sources, indicating poor waste management practices by inhabitants on land. This has resulted in massive plastic wastes in the aquatic environment. In 2010, about 8 billion tonnes plastic were estimated to be found in water bodies, however, the latest figures estimates that there are 236,000 tonnes in water bodies. Although estimating the quantity correctly is difficult, the highly lesser recent value indicates a huge reduction (Wagner and Lambert, 2018). Given the lifespan of plastics in the environment, the mystery of missing plastics may be in the bellies of terrestrial and aquatic animals or down ocean floor of river beds. If the former is the case, it translates to an impending doom for humans and wildlife alike.

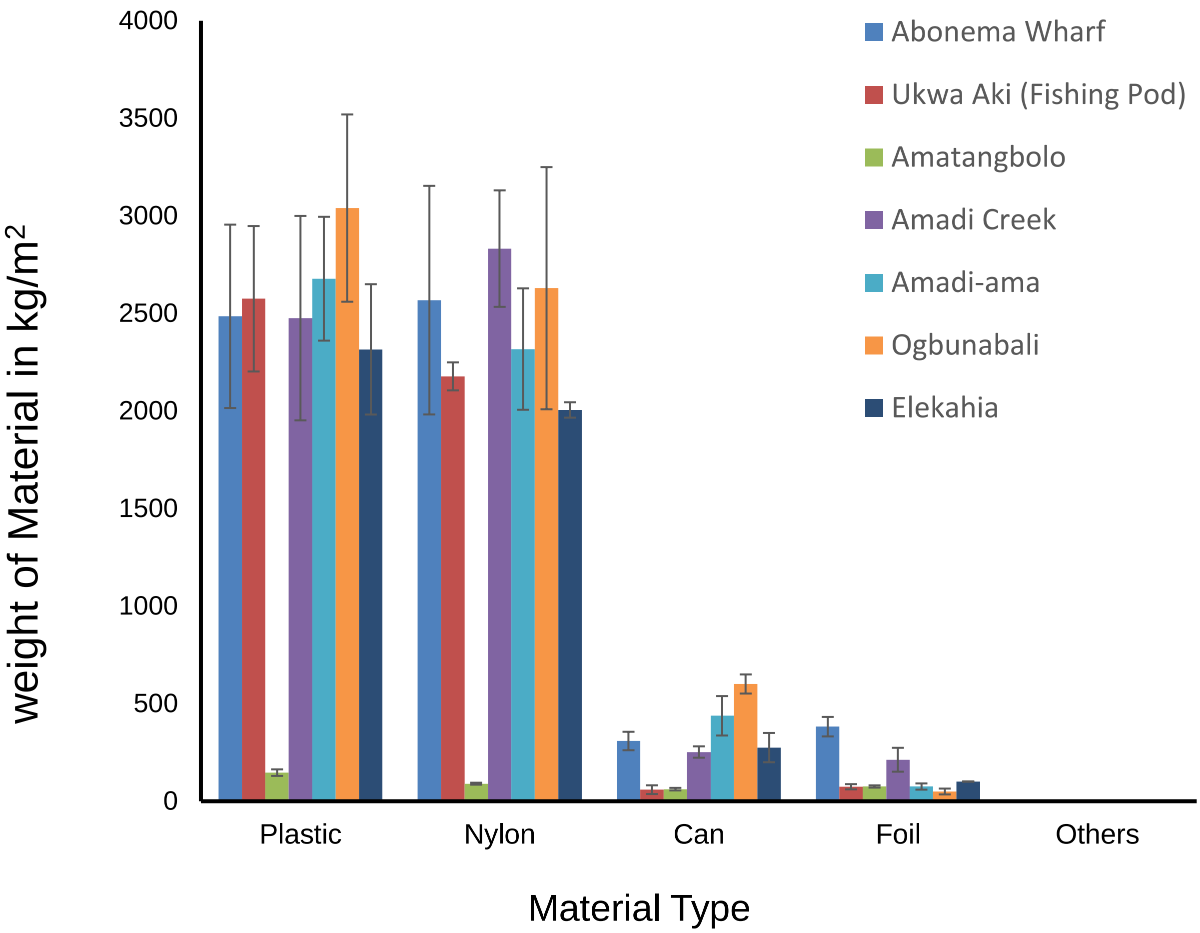


Fig 3: Mean composition of material at different sampling locations in Rivers State (SEM =n=30)

Table 3: Average Weight of Material per unit Area at study Locations in Rivers State

Location	Average Weight of Material (kg/m^2)	Average Weight of Material (kg/km^2)	No of Dumper Trucks
Abonema Wharf	5744.45	114889.00	6
Ukwa Aki (Fishing Pod)	4885.80	100581.33	5
Amatangbolo	377.67	7553.33	1
Bundu-Ama	4273.51	110251.25	6
Amadi Creek	5792.20	115844.00	6
Amadi-ama	4677.00	93540.00	5
Ogbunabali	6320.50	126410.00	7
Elekahia	4623.67	92473.33	5

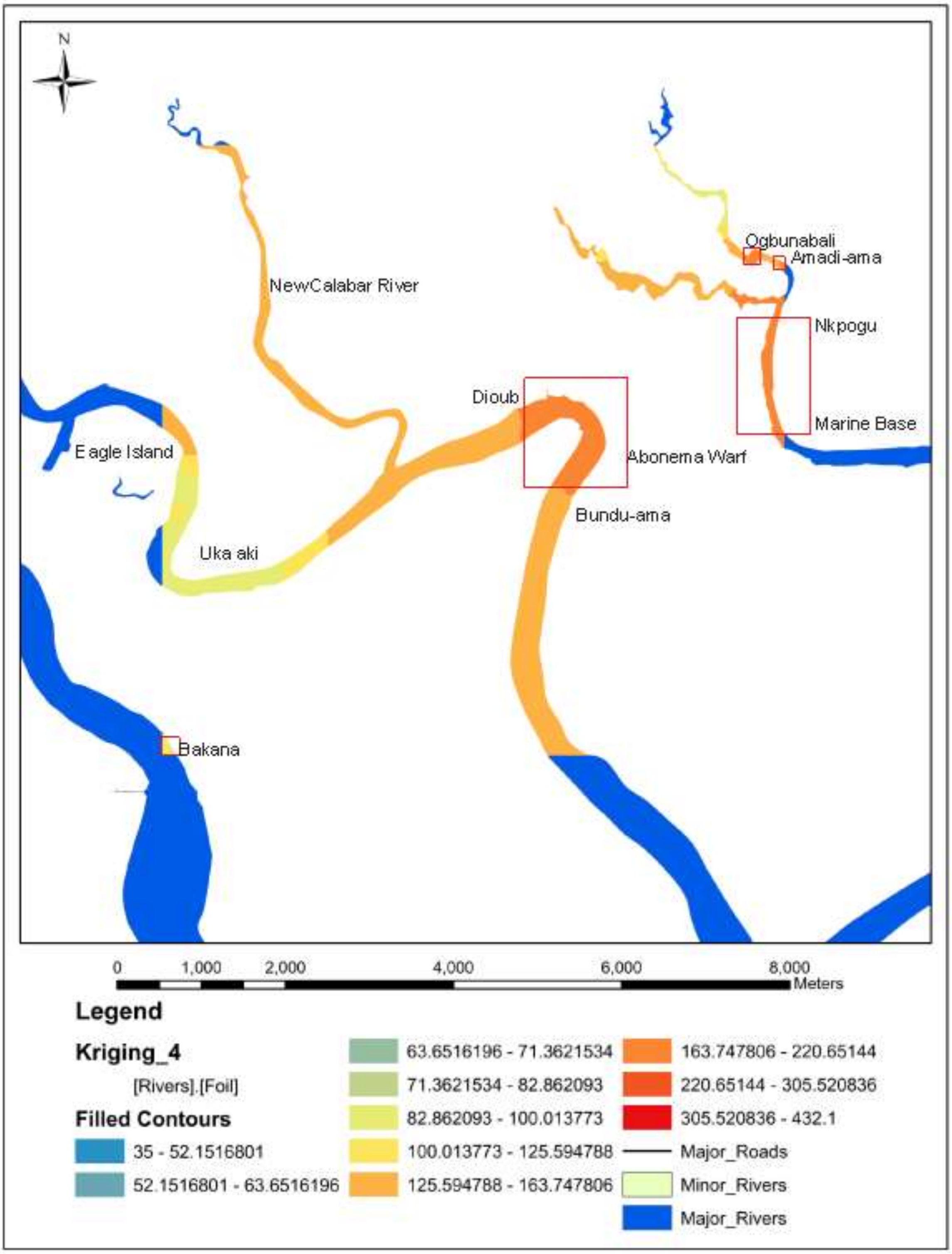


Fig 4: Interpolated map showing the severity of foil distribution at study locations in Rivers State.

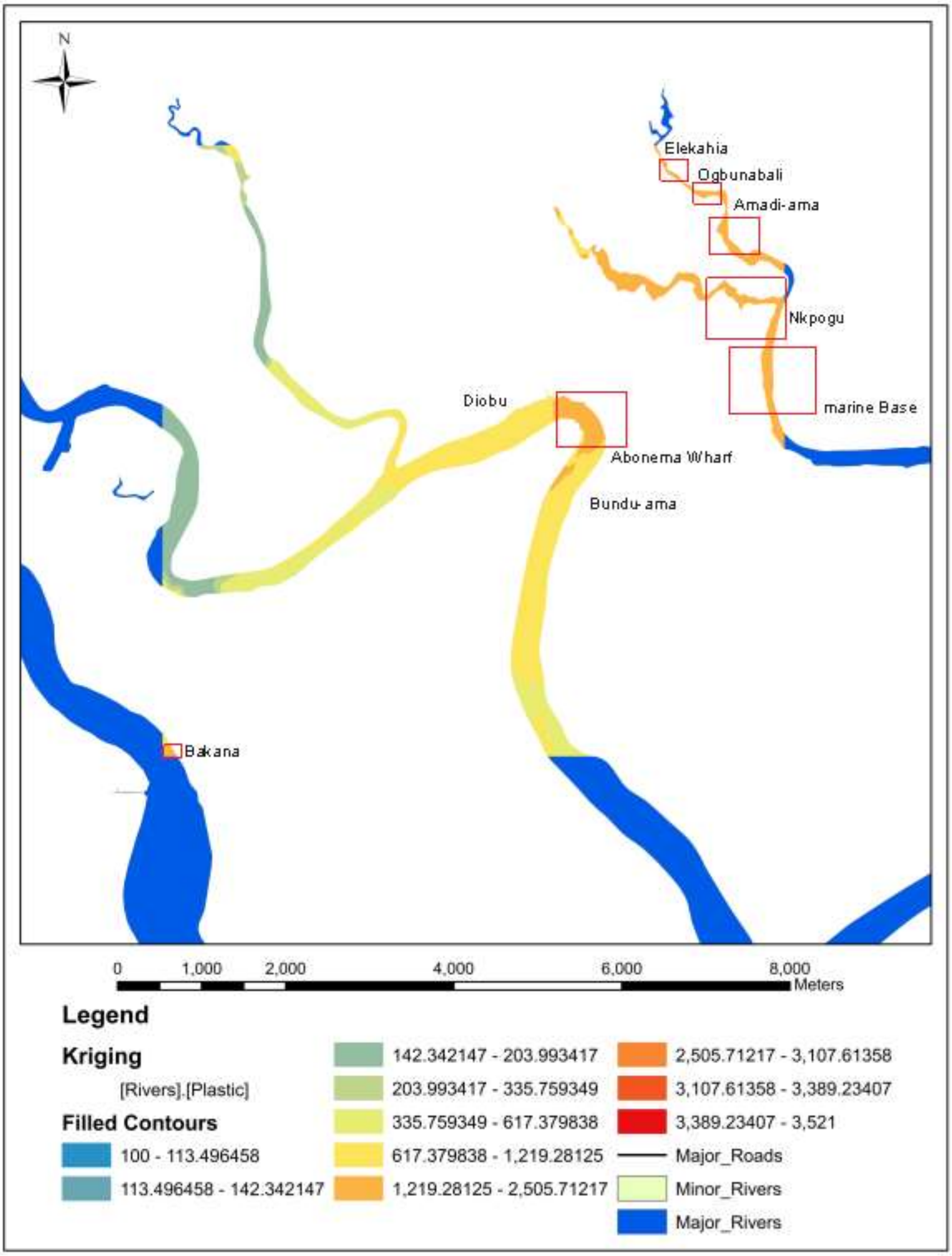


Fig 5: Interpolated map showing the severity of plastic distribution at study locations in Rivers State.

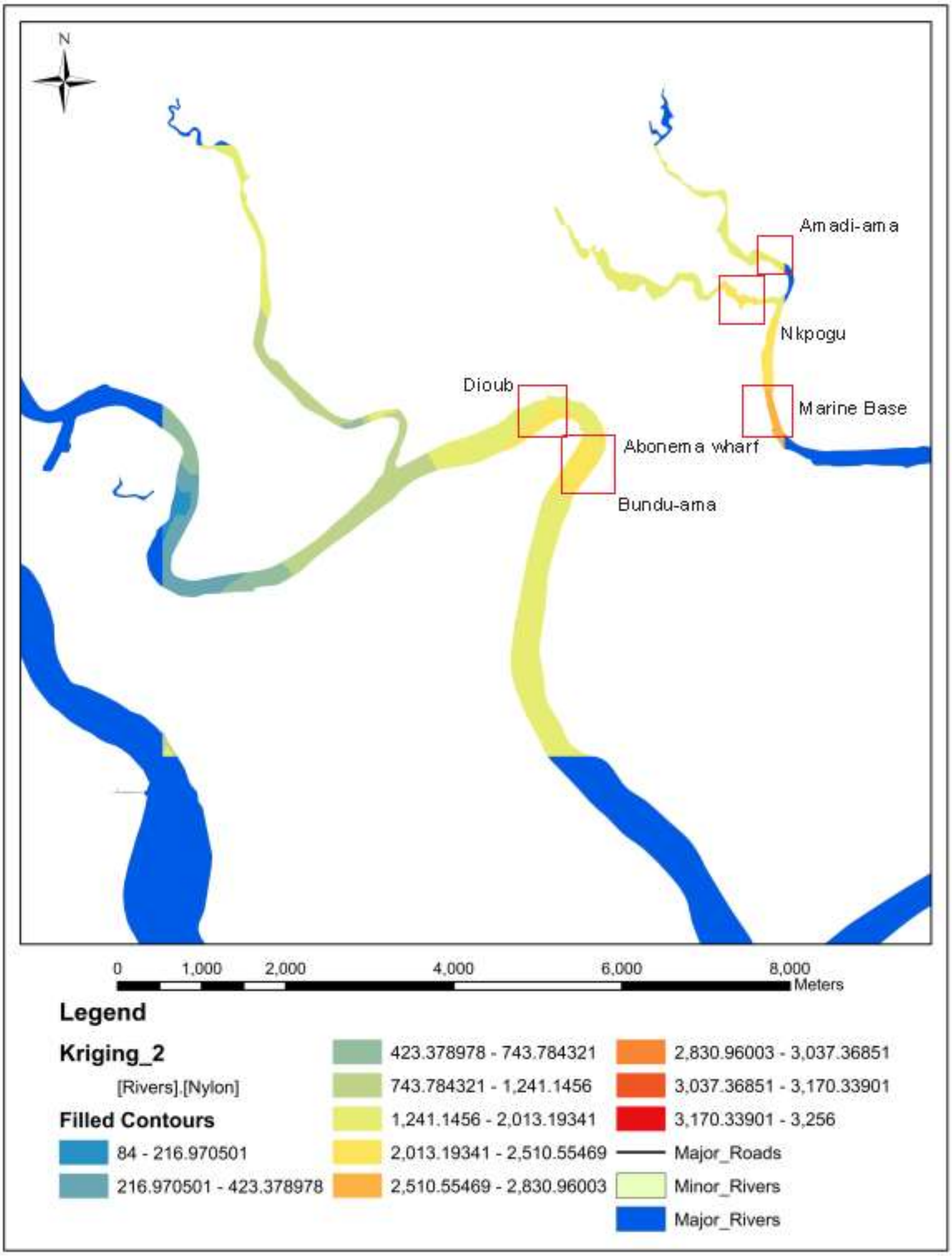
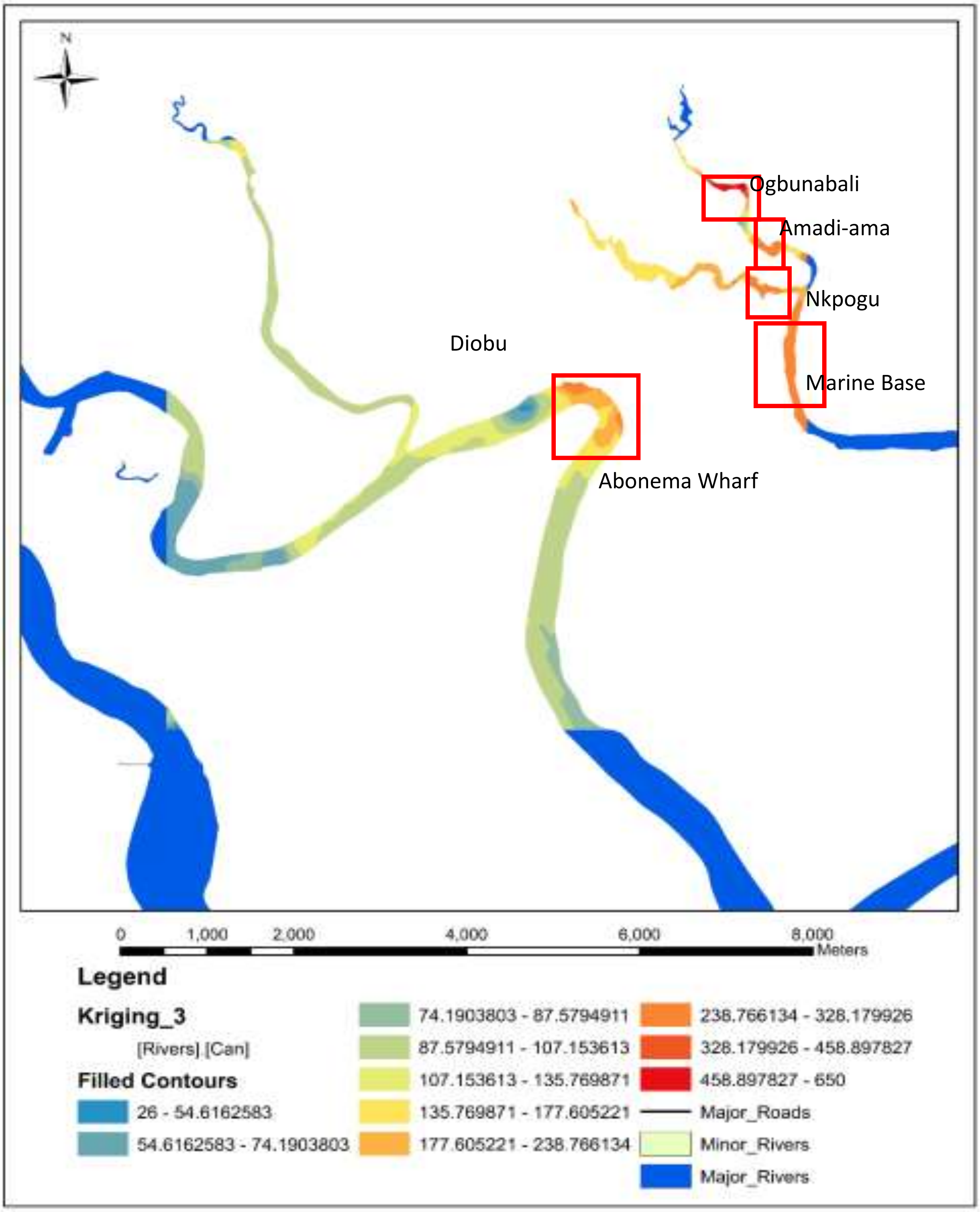


Fig 6: Interpolated map showing the severity of nylon distribution at study locations in Rivers State.



n

Rivers State.

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Based on the study, plastics and nylon are the top ranking floating litter in the study area. Apart from obstruction of transportation which sometimes results in accidents, and reduction in aesthetic value, materials such as plastics and nylon do not biodegrade quickly, but steadily leach their toxic components into the water and are also consumed by aquatic organisms which in turn are consumed by humans.

Year 2018 theme for World Environment Day was "Beating Plastic Pollution" which gives voice to the fact that the menace of plastics in our environment is far reaching worldwide. It is our duty to safeguard our environment through global best practices and enlightenment campaigns.

4.2. Recommendation

Based on the study, it is recommended that:

- Various sources of litter into the aquatic environment should be studied;
- A project for removal of the suspended debris from navigable waterways is highly needed;
- The populace should be greatly sensitized on the best practices and impact of suspended litter;
- Efforts should be made to at least sort the materials into their various components.
- Plastics, cans and nylons can be recycled into other useful products.

REFERENCES

Amuda, O. S., Adebisi, S. A., Jimoda, L. A., & Alade, A. O. (2014). Challenges and possible panacea to the municipal solid wastes management in Nigeria. Journal of Sustainable Development Studies, 6(1).

ASTM D5231 – 92. Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste. ASTM International, West Conshohocken, PA. 2008

Babatunde B. B., Vincent-Akpu I. F., Woke G. N., Atarhinyo E., Aharanwa U. C., Green A. F., Isaac-Joe O (2013). Comparative analysis of municipal solid waste (MSW) composition in three local government areas in Rivers State, Nigeria African Journal of Environmental Science and Technology,. 7(9):874-881

Babatunde, B. B. and Uche, A. O. (2018). Suspended Marine Litter in Akwa Ibom State, Nigeria: A Case Study of Cross River, Qua Iboe River and Jaja Creek. Journal of Geography, Environment and Earth Science International 18(2): 1-13. DOI: 10.9734/JGEESI/2018/45448

Babayemi J.O, Dauda K.T (2009). Evaluation of Solid Waste Generation, Categories and Disposal options in Developing Countries: A Case Study of Nigeria. J. Appl. Sci. Environ. Mgt. 13:83-88.

Bożena Mrowiec (2017). Plastic pollutants in water environment. Environmental Protection and Natural Resources vol. 28, 4(74): 51-55. DOI 10.1515 /oszn-2017-0030

Ezeah, C., & Roberts, C. L. (2012). Analysis of barriers and success factors affecting the adoption of sustainable management of municipal solid waste in Nigeria. Journal of Environmental Management, 103, 9-14.

Guerrero, L.A, Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. Waste management, 33(1), 220-232.

Iyama, W.A. and Edori, O.S. (2014). Seasonal Variation in Water Quality During Dredging of Water Habitat in the Niger Delta, Nigeria. Trends in Applied Sciences Research, 9:153-159.

Izuafuo, W.A, Chindah, A.C., Braide, S.A., Iyalla, I.A., (2004). An assessment of sediment quality at the vicinity of marine landing jetties at the middle reach of Bonny Estuary, Niger Delta. Scientia Africana 3(2), 1- 10.

King, R.P, Akpan, B.A and King L.R (2013). The spectrum of solid waste pollutants on Qua Iboe River Estuarine Beach, Nigeria. *Journal of Aquatic Sciences* 28 (1): 57- 68

NEDECO (1961). The Waters of the Niger Delta. Report on an Investigation. The Hague Publishers, Netherland.

Nigeria Population Commission (NPC) (2019). 2006 Census figures http://www.population.gov.ng [Accessed January, 2019]

Otene, B. B., & Davies, O. A. (2013). The epipelic algal distribution of upper bonny estuary, Amadi-Ama creek, Niger delta in relation to sediment quality indices. Scintific Journal of Animal Science, 2, 26-34.

Wagner, M. and Lambert, S. (2018): Freshwater Microplastics – Emerging Environmental Contaminants? Springer, Cham. (ed.)