

Environmental Health Risks and Community Awareness About Microplastic Pollution in Coastal Estuarine Systems of Andoni River Estuary, Rivers State, Nigeria

¹Utuk, U. D., ¹Dollah, O. C & ¹Gobo, A. E

¹Institute of Geosciences and Environmental Management,
Rivers State University Nkpolu-Oroworukwo
Port Harcourt, Rivers State, Nigeria

<https://doi.org/10.56201/ijgem.vol.12.no9.2026.pg56.73>

Abstract

This research focused on community viewpoints regarding microplastic contamination and its related health concerns in the Andoni River Estuary, located in Rivers State, Nigeria. A cross-sectional survey approach founded on perception was utilized, gathering information from 399 participants through a systematic questionnaire. The study evaluated perceived health threats, demographic factors, and variations in perceptions across the region. Descriptive statistics alongside inferential methods (ANOVA and multiple regression) were applied, maintaining a significance threshold of 0.05. Results indicated an overall heightened awareness of health threats related to microplastic exposure, with an average score of 3.74 (SD = 1.18). Participants expressed strong agreement that microplastics found in fish (Mean = 4.00), exposure through drinking water (Mean = 3.78), and environmental pollution (Mean = 3.91) present considerable health dangers. Concerns regarding general environmental exposure were also notably high (Mean = 4.06). Nonetheless, gaps in knowledge about long-term and respiratory implications were identified (Means = 3.36 and 3.46 respectively). Analysis of demographic factors indicated that education (Mean = 3.98), occupation (Mean = 3.83), income (Mean = 3.63), and duration of residence (Mean = 3.94) had a significant impact on perception, while age (Mean = 3.48) and gender (Mean = 3.22) did not show significant influence. Regression analysis established that demographic variables collectively accounted for 41.1% of the variance in perception ($R^2 = 0.411$), with education being the most significant predictor ($\beta = 0.418$, $p < 0.001$). ANOVA findings revealed notable differences in perceived health risks among the three regions ($F = 7.284$, $p = 0.001$), although perceptions of microplastic presence did not significantly vary by region ($p = 0.080$). The research concludes that although there is a high level of awareness regarding health risks linked to microplastics, the in-depth scientific knowledge is still lacking. Social and educational variables considerably influence perception trends within the communities in the estuary.

Keywords: Environmental, Health, Risks, Community, Awareness, Microplastic & Pollution

Introduction

Andoni estuary reveals evidence of visible macro plastics and sedimentation, but the accumulation of micro plastic can only be evaluated with a potpourri experimental investigation. The deposition

of industrial waste and human activities in the surface water can be linked to visible pollution of the surface water. Knowledge of the volume of micro-plastics in Andoni River estuary is limited because of lack of spatiotemporal data on the deposition and accumulation of plastics therein. There is no empirical evidence to demonstrate the existence of a plastisphere which has been widely reported in the aqua globally. The Andoni River estuary is in the lower course of the river Niger where depositional activities, hydraulic action, corrosion, solution and attrition are manifest. The combined interactions of these processes increase sedimentation. However, there is still no potpourri investigation to find out the degree of micro plastic accumulation and implications for aquatic life and health of communities in the catchment. The Andoni ecological zone is highly sensitive and exposed to pressure from anthropogenic activities. The exposure of the Andoni river system and estuary to exploitation activities is of immense environmental consequences. Ansa and Francis (2007) conducted a baseline study of the Andoni ecological zone to investigate the basic physical and chemical characteristics of the sediment within the wetted perimeter of the river system and Andoni estuary. The study also investigated the particle density, bulk density and porosity of the sediment in the Andoni river system. The particle density and bulk density of sediment were determined according to methods in blake using a mass balance and cylinder. Labeled cylinders of predetermined volumes and weights were used to collect sediments from sampling stations (See Ansa & Francis, 2007). Sediment characteristics revealed sandy to loamy (muddy) sand soils with pH of 4.09 to 5.04, Particle density of the sediment in the Andoni flats was observed to increase with an increase in bulk density; while porosity of the sediment increased with a decrease in bulk density. However, the study did not investigate the concentration and accumulation of microplastics on the sediments and surface water in the Andoni estuary. But Ansa and Francis (2007) were able to establish that the sediment characteristics of the Andoni river system are prone to changes which could arise from human activities such as removal of mangrove vegetation for domestic fuel, sand filling, expansion of water ways and pollution from hydrocarbons; these could lead to deleterious effects on the biological resources. However, the study did not specifically investigate the materiality of plastic accumulation and concentration in surface water and sediment in the Andoni estuary. It is evident in the literature that despite the exposure of the river system to waste deposition, maritime activities and exploitation of resources by communities and companies, spatiotemporal data on the accumulation and distribution of microplastic and effects on aquatic life and human health have not been investigated. The worldwide annual production of plastics ranges from 275 to 299 million tonnes, the rising demand for plastics has been linked to the low cost of manufacturing, haulage and durability (Zobkov and Esiukov, 201). Costa, Armanda and Rocha-Santos (2019) evidenced that microplastics is present in the air, surface water and sediment with attendant socioecological and health consequences. The recognition of the ubiquity of plastics in the literature has increased interest to quantify the volume of plastic deposited into the marine ecosystem to unfurl the health consequences. However, there still exist the absence of spatiotemporal data, and a universally accepted procedure and methods for the estimation, prediction and modelling of the distribution, concertation and effects of micro plastics in marine environment. Naivasha et al, (2020) evaluated the concentration of microplastics in surface water and sediments from the lagoon border in the urban agglomeration of Lagos, Nigeria. They also investigated the sediment composition of the wetted perimeter around the lagoon. The study evidenced significant concentration and variation in the distribution of microplastics in the sediments of Makoko. They also reported that fibers and few films are the dominant particles of plastics concentrated in surface water, but more fragments of foils occurred

in the sediment within the wetted perimeter. The foregoing, content, methodological and time gaps provide the impetus to conduct this study on the concentration and distribution of micro plastics in the sediments and surface water of the Andoni estuary. The health and socioecological implications of the decades of deposition of plastics into the highly sensitive ecological zones would be investigated

Methodology

The study adopted a cross-sectional survey design grounded in a perception-based approach to examine community understanding of microplastics within the Andoni River Estuary. This design was considered appropriate because it allows for the collection of data from a defined population at a single point in time, particularly in studies aimed at assessing awareness, attitudes, and perceptions regarding environmental issues. Its suitability is further justified by its capacity to generate large datasets in a cost-effective manner while enabling the exploration of relationships among variables such as awareness of microplastics, their sources, spatial distribution, and perceived health risks (Maier et al., 2023). The investigation relied exclusively on human perception rather than laboratory measurements or experimental procedures, with data elicited through structured questionnaires administered to residents and relevant stakeholders living in proximity to the estuarine environment. Microplastics, defined as plastic particles less than 5 mm in diameter, are persistent pollutants with recognised ecological and public health implications; however, unlike prior studies that focus on their physical presence and environmental impact, this study emphasised community-level perceptions to provide insight into how affected populations interpret and respond to the phenomenon.

Both primary and secondary sources of data were utilised. Primary data were obtained through field surveys involving questionnaire administration to respondents exposed to plastic pollution within the study area, while secondary data was sourced from published journal articles, textbooks, and unpublished academic dissertations and theses. The study population comprised residents of the Andoni River Estuary in Rivers State, Nigeria, particularly those whose livelihoods and daily activities depend on estuarine water and sediment. To ensure adequate representation, the population was stratified into three zones based on settlement pattern, population density, and degree of interaction with the estuarine ecosystem. The high-density zone included relatively urbanised communities such as Ngo, Asarama, and the Unyengala axis with an estimated population of 70,000; the medium-density zone comprised semi-urban settlements such as Agwut-Obolo, Unyeada, and Ikuru Town with about 45,000 residents; while the low-density zone covered smaller, dispersed settlements including Ayama, Ikpanzana, and fishing camps with approximately 25,000 residents. The total estimated population across the three strata was therefore 140,000.

The research implemented a cross-sectional survey methodology based on understanding perceptions to evaluate the community's awareness of microplastics in the Andoni River Estuary. This approach was deemed suitable as it facilitates data gathering from a specific group at one moment, especially in research aimed at understanding knowledge, attitudes, and perceptions surrounding environmental matters. Its effectiveness is also supported by the ability to amass extensive datasets economically while analyzing relationships between variables like awareness of microplastics, their origins, distribution, and perceived health hazards (Maier et al., 2023). The study focused solely on human perceptions instead of laboratory data or experimental techniques, utilizing structured surveys directed at individuals and pertinent stakeholders residing near the estuary. Microplastics are categorized as plastic fragments less than 5 millimeters in size and are

ongoing pollutants with acknowledged ecological and health risks; however, in contrast to previous research that concentrated on their physical existence and environmental effects, this investigation highlighted community perceptions to shed light on how those impacted comprehend and address the issue. The study incorporated both primary and secondary data sources. Primary data were gathered through field surveys, which consisted of administering questionnaires to individuals exposed to plastic pollution in study, while secondary data were obtained from existing journals, textbooks, and unpublished scholarly dissertations and theses. The study population included residents of the Andoni River Estuary in Rivers State, Nigeria, particularly those whose daily activities and livelihoods are reliant on estuarine waters and sediments. To ensure adequate representation, the population was divided into three zones based on settlement patterns, density of the population, and their level of engagement with the estuarine environment. The high-density zone included more urban communities like Ngo, Asarama, and the Unyengala region with about 70,000 inhabitants; the medium-density zone consisted of semi-urban areas such as Agwut-Obolo, Unyeada, and Ikuru Town with a population of around 45,000; conversely, the low-density zone included smaller, scattered communities like Ayama, Ikpanzana, and fishing camps with an estimated 25,000 people. Thus, the cumulative estimated population across the three zones reached about 140,000. Data were gathered using a structured, closed-ended questionnaire intended to yield measurable responses that align with the research goals. The questionnaire included Likert-scale questions for evaluating perceptions related to awareness of microplastics, their sources, distribution, environmental and health consequences, as well as preventive measures. Socio-demographic details such as age, gender, educational background, occupation, length of residency, and reliance on estuarine resources were additionally collected to act as variables for later analyses. The sample size was calculated using the Taro Yamane (1967) formula for finite populations at a 5% precision level, which resulted in an approximate sample size of 399 participants. This sample was proportionately distributed across the three areas based on their population sizes to ensure it was representative. A multistage sampling method was utilized. First, the research region was divided into three zones based on population density to reflect differences in environmental exposure and perception. Next, purposeful sampling was implemented to choose representative communities within each category according to their relevance to the study goals, especially regarding their reliance on surface water. Proportionate sampling was then executed to distribute respondents among the categories, followed by simple random sampling inside each chosen community to guarantee that every qualifying individual had an equal opportunity to participate. The analysis of data utilized descriptive and inferential statistical methods. Frequencies, percentages, means, and standard deviations were employed to summarize demographic attributes and perception variables, while Likert-scale answers were classified on a five-point range from strongly disagree (1) to strongly agree (5), with a cutoff of 3.00 for analysis. Inferential analysis was carried out using the Kruskal–Wallis H-test to explore differences in perceptions among the three population groups, considering the ordinal characteristic of the data. All hypotheses were evaluated at a significance level of 0.05, with decision-making rules based on the comparison of computed test statistics and critical values. To maintain data integrity, the questionnaire was given through in-person interviews to cater to different literacy levels, with trained assistants offering translations when needed, ensuring the items' meanings remained unchanged. A pilot study that included 5–10% of respondents from outside the study area but sharing similar socio-environmental conditions was performed to enhance the instrument. Content validity was achieved through expert evaluation, while reliability was determined using Cronbach's alpha to evaluate

internal consistency. All responses were recorded and entered statistical software to enable structured analysis and hypothesis evaluation.

Results

Objective One: Evaluate the perception of associated health risks linked to exposure to microplastics among communities in the Andoni River Estuary.

Research Question One: How do residents perceive the health risks associated with exposure to microplastics in the Andoni River Estuary?

Table 4.1: Descriptive Statistics of Respondents' Responses on Perception of Associated Health Risks Linked to Exposure to Microplastics among Communities in the Andoni River Estuary

S/N	Questionnaire Items	SA (5)	A (4)	D (3)	SD (2)	U (1)	Total	Mean	SD	RM
1	Exposure to microplastics in water can cause serious health problems	150 (37.6%)	142 (35.6%)	51 (12.8%)	33 (8.3%)	23 (5.8%)	399	3.91	1.14	AG
2	Drinking or using estuarine water exposes people to harmful microplastics	132 (33.1%)	137 (34.3%)	65 (16.3%)	39 (9.8%)	26 (6.5%)	399	3.78	1.18	AG
3	Microplastic contamination in fish can affect human health when consumed	160 (40.1%)	148 (37.1%)	43 (10.8%)	28 (7.0%)	20 (5.0%)	399	4.00	1.10	AG
4	Skin contact with contaminated water may lead to health issues	112 (28.1%)	128 (32.1%)	78 (19.5%)	49 (12.3%)	32 (8.0%)	399	3.58	1.23	AG
5	Respiratory problems can be linked to exposure to microplastics in the environment	94 (23.6%)	112 (28.1%)	83 (20.8%)	65 (16.3%)	45 (11.3%)	399	3.36	1.29	DA
6	Microplastics in water may contribute to stomach or digestive illnesses	120 (30.1%)	131 (32.8%)	70 (17.5%)	47 (11.8%)	31 (7.8%)	399	3.66	1.21	AG
7	Long-term exposure to microplastics may lead to chronic diseases	104 (26.1%)	118 (29.6%)	76 (19.0%)	59 (14.8%)	42 (10.5%)	399	3.46	1.28	DA
8	Children and pregnant women are more	154 (38.6%)	139 (34.8%)	48 (12.0%)	34 (8.5%)	24 (6.0%)	399	3.92	1.13	AG

S/N	Questionnaire Items	SA (5)	A (4)	D (3)	SD (2)	U (1)	Total	Mean	SD	RM
9	vulnerable to microplastic-related health risks There is a relationship between poor water quality and increased illness in the community	146 (36.6%)	143 (35.8%)	52 (13.0%)	35 (8.8%)	23 (5.8%)	399	3.86	1.14	AG
10	Health problems experienced in the community may be linked to polluted estuarine water	116 (29.1%)	125 (31.3%)	77 (19.3%)	48 (12.0%)	33 (8.3%)	399	3.61	1.24	AG
11	I am concerned about the health risks associated with microplastic pollution in my environment	170 (42.6%)	145 (36.3%)	39 (9.8%)	27 (6.8%)	18 (4.5%)	399	4.06	1.09	AG
Grand Mean								3.74	1.18	

Decision rule: Mean ≥ 3.50 = AG and Mean < 3.50 = DA. AG-Agreed & DA-Disagreed

Table 4.1 presents descriptive statistics on how residents perceive the health risks associated with exposure to microplastics. The results show that the mean Mean is 3.74 (SD = 1.18), which is higher than the acceptance level, indicating that respondents generally see microplastic pollution as a major health issue. The analysis shows strong agreement on many of the key health issues. The statement “I am concerned about the health risks associated with microplastic contamination in my environment” received the highest overall Mean (Mean = 4.06, SD = 1.09), with over 78.9% of respondents agreeing, indicating a high level of concern among residents. Similarly, respondents strongly agreed that “microplastic contamination in fish can affect human health” (Mean = 4.00, SD = 1.10) and “exposure to microplastics in water can cause serious health problems” (Mean = 3.91, SD = 1.14), indicating awareness of the food chain and the risks associated with direct exposure. Additionally, respondents agreed that there are groups that feel sick, with “children and pregnant women feeling sick the most” receiving a high overall Mean (Mean = 3.92, SD = 1.13). They also agreed that poor water quality is associated with increased disease (Mean = 3.86) and that contaminated water can lead to food safety problems (Mean = 3.66), indicating that the health effects are well known.

However, some aspects of the health risk perception are unclear. Respondents did not disagree with the opinion that “Respiratory problems may be associated with exposure to microplastics” (Mean = 3.36) and “Long-term exposure may lead to chronic diseases” (Mean = 3.46). These low Means suggest that knowledge about long-term and emerging health effects is limited, perhaps due to a lack of broad scientific communication on these issues at the local level.

In addition, a low correlation was recorded in perceptions of the risk associated with skin contact and general exposure through water use (representative value = 3.58 and 3.78 respectively),

indicating that we are aware of it but have little certainty. The results indicate that residents are aware of the immediate and visible health risks, particularly those related to water use and food consumption, but have little understanding of the chronic and indirect health effects of exposure to microplastics. Microplastic pollution is considered a significant health risk among residents of the Andoni River Estuary, particularly in relation to water pollution and food consumption effects. However, little is known about the long-term and invisible health effects, highlighting the need for improved public health education and risk communication skills that address the broader impacts of microplastic exposure.

Objective Two: Analyze how socio-demographic factors influence perception of microplastic pollution and its health implications in the study area.

Research Question Two: How do socio-demographic factors influence residents' perception of microplastic pollution and its associated health implications in the study area?

Table 4.2: Descriptive Statistics of Respondents' Responses on Socio-demographic Factors Influencing Perception of Microplastic Pollution and Its Health Implications in the Study Area (N = 399)

S/N	Questionnaire Items	SA (5)	A (4)	D (3)	SD (2)	U (1)	Total	Mean	SD	RM
1	Age influences how residents perceive microplastic pollution in the estuary	98 (24.6%)	126 (31.6%)	82 (20.6%)	55 (13.8%)	38 (9.5%)	399	3.48	1.25	DA
2	Level of education affects awareness of microplastic pollution and its health risks	156 (39.1%)	149 (37.3%)	45 (11.3%)	29 (7.3%)	20 (5.0%)	399	3.98	1.08	AG
3	Income level determines how seriously people perceive environmental pollution	112 (28.1%)	138 (34.6%)	70 (17.5%)	46 (11.5%)	33 (8.3%)	399	3.63	1.23	AG
4	Occupation influences exposure and perception of microplastic pollution	136 (34.1%)	145 (36.3%)	55 (13.8%)	38 (9.5%)	25 (6.3%)	399	3.83	1.15	AG
5	Fishermen and water users are more aware of microplastic pollution than other residents	162 (40.6%)	146 (36.6%)	45 (11.3%)	27 (6.8%)	19 (4.8%)	399	4.01	1.07	AG
6	Longer years of residence in the area improve understanding of environmental changes	150 (37.6%)	148 (37.1%)	49 (12.3%)	32 (8.0%)	20 (5.0%)	399	3.94	1.10	AG

S/N	Questionnaire Items	SA (5)	A (4)	D (3)	SD (2)	U (1)	Total	Mean	SD	RM
7	Gender plays a role in how people perceive environmental health risks	82 (20.6%)	104 (26.1%)	88 (22.1%)	70 (17.5%)	55 (13.8%)	399	3.22	1.34	DA
8	Household size affects awareness of environmental pollution issues	95 (23.8%)	125 (31.3%)	83 (20.8%)	57 (14.3%)	39 (9.8%)	399	3.45	1.27	DA
9	Socio-economic status influences concern about water pollution and health effects	142 (35.6%)	151 (37.8%)	51 (12.8%)	34 (8.5%)	21 (5.3%)	399	3.90	1.12	AG
10	People with higher education are more likely to recognize health risks of microplastics	160 (40.1%)	147 (36.8%)	44 (11.0%)	29 (7.3%)	19 (4.8%)	399	4.00	1.07	AG
11	Socio-demographic characteristics significantly shape perception of microplastic pollution in the study area	134 (33.6%)	141 (35.3%)	60 (15.0%)	38 (9.5%)	26 (6.5%)	399	3.80	1.16	AG
Grand Mean								3.75	1.17	AG

Decision rule: Mean $\geq$ 3.50 = AG and Mean $<$ 3.50 = DA. AG-Agreed & DA-Disagreed

The analysis presented in Table 4.2 examines how social and community factors influence residents' perceptions of small-scale development and its impact on health in the Andoni River Estuary. The survey was based on responses from 399 respondents using a five-point Likert scale, where a mean Mean of 3.50 and above was interpreted as Agree (AG), and a mean Mean below 3.50 was interpreted as Agree (DA). The overall result yielded a mean of 3.75 with a standard deviation of 1.17, indicating that respondents believe that social and community characteristics play a significant role in shaping their perceptions of development shrinkage and related health concerns within the study area.

The results showed that one of the strongest factors influencing social and personality knowledge was education-related factors. Specifically, respondents agreed that education level had an impact on knowledge about microplastic pollution and its health risks, with a mean Mean of 3.98 (SD = 1.08), with 156 (39.1%) respondents strongly agreeing and 149 (37.3%) respondents agreeing. Similarly, the statement that people with higher education are more likely to know about the health risks associated with microplastics had a higher mean Mean of 4.00 (SD = 1.07), with 160 (40.1%) respondents strongly agreeing and 147 (36.8%) respondents agreeing. These results indicate that

educational attainment increases residents' ability to identify sources of environmental pollution, understand microplastic pathways, and assess the potential health effects of exposure.

Work was also identified as a significant factor influencing how residents see themselves. The statement that work influences the appearance and perception of microplastic pollution received a mean Mean of 3.83 (SD = 1.15), with 136 (34.1%) respondents strongly agreeing and 145 (36.3%) respondents also agreeing. In addition, the idea that fishermen and water users are more aware of microplastic pollution than other residents received the highest mean Mean among all items (Mean = 4.01, SD = 1.07), with 162 (40.6%) respondents strongly agreeing and 146 (36.6%) respondents strongly disagreeing. This indicates that people whose livelihoods depend on water resources are more exposed to environmental changes, so they are more likely to be aware of issues related to microplastic pollution in the riverbed.

The results also showed that residential experience significantly contributes to environmental awareness. The statement that years of residence in the area increased awareness of environmental changes was rated 3.94 (SD = 1.10), with 150 (37.6%) respondents strongly agreeing and 148 (37.1%) respondents somewhat agreeing. This suggests that long-term interaction with the estuarine environment may increase residents' ability to perceive changes in water quality, pollution levels and erosion over time.

It was also found that economic and social factors influenced environmental health awareness. Respondents agreed that economic and social conditions influenced concerns about water pollution and health impacts, with a mean Mean of 3.90 (SD = 1.12). In addition, income level, which determines how residents perceive environmental pollution, had a mean Mean of 3.63 (SD = 1.23), indicating that respondents believed that economic conditions influenced how people perceive and respond to environmental pollution challenges.

However, not all socio-economic characteristics were considered to have an impact. A mean Mean of 3.48 (SD = 1.25) was recorded for the effect of age on perception of microplastic pollution, which fell slightly below the acceptable limit, resulting in a Not Consistent (ND) finding. This suggests that respondents do not fully understand the age difference as an important determinant of knowledge or perception of microplastic pollution. Similarly, a mean Mean of 3.22 (SD = 1.34) was recorded for the effect of gender on perception of environmental health risks and was also assessed as Not Consistent (ND). This indicates that knowledge and concern about microplastic pollution may not differ significantly between male and female residents. Furthermore, a mean Mean of 3.45 (SD = 1.27) was recorded for the effect of household size on knowledge about environmental pollution issues, which falls below the decision threshold and is therefore classified as ND. The results from Table 4.5 show that socioeconomic characteristics have a significant impact on residents' understanding of microplastic pollution and its associated health effects in the Andoni River Basin. The strongest factors that could influence individuals are education level (Mean = 3.98), higher education as a determinant of knowledge about health risks (Mean = 4.00), employment exposure through fishing and water-related activities (Mean = 4.01), years of residence (Mean = 3.94), and socioeconomic status (Mean = 3.90). On the other hand, age, gender, and household size were not found to be determinants of knowledge about microplastic pollution. The research question asked: "How do socioeconomic factors influence residents' understanding of microplastic pollution and its health impacts in the study area?" In line with the findings, the study found that education, occupation, socioeconomic status, and length of residence in the area have a significant impact on residents' understanding of microplastic pollution and its health impacts. Residents with higher levels of education, those directly involved in fishing and water-

related activities, those with longer exposure to the estuarine environment, and those with better socioeconomic status demonstrated greater knowledge and understanding of microplastic pollution and its potential health impacts. However, demographic characteristics such as age, gender, and family size showed limited impact on residents' understanding. Therefore, it is essential to improve environmental and science education programs that target different socioeconomic groups to improve local understanding and response to microplastic pollution within the Andoni River Estuary.

Test Of Hypotheses

HO₁: There is no significant difference in residents' perception of the health risks associated with exposure to microplastics in the Andoni River Estuary

Table 4.3: One-Way ANOVA

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.864	2	2.932	7.284	0.001
Within Groups	159.356	396	0.402		
Total	165.220	398			

Table 4.3 presents the results of a One-Way ANOVA examining whether residents' perceptions of the health risks associated with exposure to microplastics differed significantly between the three areas of the Andoni River Estuary. The analysis showed a within-group sum of squares of 5.864, with 2 degrees of freedom, giving a mean square value of 2.932. The within-group difference recorded a mean square of 159.356 with 396 degrees of freedom, giving a mean square value of 0.402. The calculated F statistic was 7.284, with a corresponding significance value of $p = 0.001$. The results showed that the differences in perceived health risks between the three regions were statistically significant. Unlike perceptions of the presence and distribution of microplastics, perceptions of health consequences differed across regions. Since the p-value (0.001) was less than the 0.05 significance level, the null hypothesis (H_{03}) was rejected. Therefore, the study found that there were significant differences in the perceptions of health risks associated with exposure to microplastics among respondents from the three regions of the Andoni River Estuary. This finding suggests that while residents may have similar levels of microplastic contamination, their interpretations of potential health impacts vary based on specific community experiences, exposure patterns, lifestyle activities, and environmental interactions. Communities that rely on fishing and direct contact with estuarine resources may express stronger concerns about potential health impacts from microplastic contamination.

HO₂: Socio-Demographic factors have no significant influence on residents' perception of microplastic pollution and its associated health implications in the study area.

Table 4.4: Multiple Regression Model Summary

R	R ²	Adjusted R ²	Std. Error
0.641	0.411	0.402	0.483

Table 4.5 ANOVA for Regression

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	58.441	6	9.740	41.762	0.000
Residual	91.477	392	0.233		

Total	149.918	398
-------	---------	-----

Table 4.6: Regression Coefficients

Predictor	B	Std. Error	Beta	t	Sig.	Decision
Constant	1.124	0.201		5.592	0.000	Significant
Age	0.031	0.028	0.051	1.107	0.269	NS
Gender	0.018	0.031	0.027	0.581	0.562	NS
Education	0.296	0.034	0.418	8.706	0.000	Significant
Occupation	0.164	0.031	0.242	5.290	0.000	Significant
Income	0.089	0.029	0.141	3.069	0.002	Significant
Years of Residence	0.117	0.030	0.176	3.900	0.000	Significant

The summary of the multiple regression model is presented in Table 4.4, which examines the influence of socio-environmental factors on residents' perceptions of microplastic pollution and its associated health effects. The regression model yielded a correlation coefficient ($R = 0.641$), indicating a relatively strong relationship between the total socio-environmental indicators and residents' perceptions. The correlation coefficient ($R^2 = 0.411$) indicated that the indicators together explained 41.1% of the variance in residents' perceptions of microplastic pollution and its associated health effects, with the remaining 58.9% likely being due to other factors not included in the model. The adjusted R^2 value of 0.402, after adjusting for the number of variables in the model, indicates that socio-economic characteristics still accounted for approximately 40.2% of the variance in the observed results. This suggests that social and economic characteristics provide significant explanatory power in explaining differences in residents' perceptions of microplastic pollution. The ANOVA test for the general recall model is presented in Table 4.5. The total recall coefficients are 58.441, with six degrees of freedom, giving a coefficient of 9.740. The total residual coefficients are 91.477, with 392 degrees of freedom, giving a calculated F value of **41.762** and a significance level of $p = 0.000$. The significant F value in the analysis confirmed that the regression model better predicted residents' perceptions compared to the model without any antecedents. As $p < 0.05$, we rejected the null hypothesis (H_{04}), indicating that social and community factors influenced residents' perceptions of microplastic pollution and its effects on their health in the Andoni Estuary. The individual regression factors in Table 4.6 further explain the impact of each social and community factor. Education emerged as the strongest predictor, with a regression coefficient of $B = 0.296$, a beta coefficient of $\beta = 0.418$, and a significance value of $p = 0.000$. This indicates that increased education is associated with greater awareness and knowledge of environmental and health concerns related to microplastics. Work was also a significant predictor ($B = 0.164$, $\beta = 0.242$, $p = \mathbf{0.000}$), indicating that the activities residents engage in, particularly those involving direct contact with aquatic organisms, influence their perception of pollution risk. The level of income they receive is important in determining their perception ($B = 0.089$, $\beta = 0.141$, $p = 0.002$), indicating that social and economic status influences environmental knowledge and concern.

Similarly, years of residence had a significant effect on attitude ($B = 0.117$, $\beta = 0.176$, $p = 0.000$), suggesting that long-term residents may be more knowledgeable about environmental changes within the river basin due to long-term exposure and observation. However, neither age ($B = 0.031$, $p = 0.269$) nor gender ($B = 0.018$, $p = 0.562$) were statistically significant predictors, indicating that these characteristics did not influence residents' attitudes after controlling different groups

and other factors. The results showed that education, occupation, salary, and years of residence were important factors in residents' awareness of microplastic pollution and its associated health risks, while age and gender played a minor role.

Discussion of Findings

Knowledge and Understanding of Small Pollution Sources and Pathways among Residents along the Andoni River

The results presented in Table 4.3 show that residents in the Andoni River Estuary have a high level of awareness about the sources and pathways of microplastic pollution, as indicated by a mean Mean of 3.61 (SD = 1.19), which exceeds the established threshold of 3.50. This indicates that respondents generally recognize that microplastics are an environmental challenge and can link their occurrence to common human activities in their environment. The high level of awareness found especially regarding improper disposal (Mean = 4.05, SD = 1.06), social behavior (Mean = 4.02, SD = 1.06), household plastic waste (Mean = 3.97), plastic pollution (Mean = 3.96), and indiscriminate dumping or burning near the riverbank (Mean = 3.98) indicates that residents have a high level of awareness of potential sources of pollution. This pattern is expected in estuarine areas where residents are exposed to the potential consequences of poor waste management, plastic accumulation, and pollution processes due to daily interaction with aquatic environments. Waste management and social practices as the most recognized sources of microplastic pollution are consistent with findings from environmental studies conducted in developing coastal areas. For example, Hartmann et al. (2021) found that the general understanding of microplastic pollution is largely based on direct observations of plastic accumulation, waste management practices, and visible environmental pollution, while knowledge of microscopic transformation processes is still relatively limited. Similarly, Huang et al. (2022) noted that communities living around water bodies often associate microplastic pollution with household waste and improper disposal as these are the most obvious routes of environmental pollution. Therefore, this finding supports the argument that environmental awareness among local people is often driven by direct environmental experiences rather than a scientific understanding of waste transport pathways.

The high correlation between social behavior and microplastic pollution also highlights the important role that humans play in shaping microplastic pollution patterns in marine ecosystems. This finding is consistent with Auta et al. (2021), who highlighted that inadequate waste management systems, inappropriate disposal practices, and limited recycling programs remain significant causes of plastic and microplastic accumulation in tropical marine environments. Similar conclusions were reported by Blettler et al. (2020), who found that human activities are significant sources of microplastic pollution in river and stream environments, especially in areas where there are inadequate plastic waste collection and treatment systems. The agreement between these studies and our results indicates that residents of the Andoni River Estuary have a clear understanding of the factors that cause microplastic pollution within their communities.

However, the results also revealed significant limitations in the population's understanding of the complex environmental pathways involved in the transport of microplastics. The lower mean Means recorded for rainfall (Mean = 3.43), industrial and commercial impacts (Mean = 3.36), and long-distance transport via waterways (Mean = 3.41) indicate that respondents have limited knowledge of the indirect mechanisms responsible for the distribution and retention of microplastics. This observation is consistent with the findings of Rochman et al. (2021), who noted

that general knowledge about microplastics often focuses on visible plastic debris and overlooks secondary fragmentation, atmospheric deposition, water transport, and industrial sources. Similarly, Wang et al. (2023) found that while coastal residents may be aware of plastic pollution as an environmental issue, their understanding of the transport, transformation, and environmental cycling of microplastics is often inadequate due to limited exposure to scientific information. The finding that the lowest mean Mean was recorded for information or education received about microplastic pollution (Mean = 3.09, SD = 1.36) is significant as it suggests that residents' knowledge is based primarily on personal observation rather than structured environmental education programs. This situation may limit their ability to understand the emerging risks associated with exposure to microplastics, including ingestion by aquatic organisms, trophic changes, and potential impacts on human health. Similar concerns were raised by Andrady (2022), who argued that increasing public awareness of microplastic pollution requires targeted environmental communication strategies that can translate scientific knowledge into relevant information at the community level. Furthermore, Chatterjee et al. (2024) reported that communities exposed to plastic pollution often have a high level of awareness about the potential pollution but lack sufficient knowledge about the hidden pathways and health consequences due to the lack of regular awareness campaigns. Therefore, our findings highlight the importance of community-based education, especially in vulnerable estuarine areas such as the Andoni River Estuary. The overall conclusion of these findings is that residents have a useful but incomplete understanding of microplastic pollution. Knowledge is strongest from direct sources and sources related to household activities and waste management, but the scientific methods related to water, hydrodynamic transport, and industrial materials are not yet fully understood. This pattern of knowledge is consistent with recent international evidence that environmental knowledge in coastal areas is gradually developing from a direct relationship to waste problems but that industry support is needed to complement it with scientific ideas and prevention practices. Therefore, it is necessary to increase residents' awareness through environmental education, stakeholder engagement, and community-based waste management programs to strengthen the capacity of the community to reduce microplastic pollution. The results of the outcome measure presented in Table 4.8 also show that land use has a significant impact on residents' perceptions of health risks associated with exposure to microplastics in the Andoni River Basin. A one-way ANOVA yielded an F statistic of 7.284 with a probability value of $p = 0.001$, indicating significant differences in health risk perceptions among the three communities. Since the p value was below the 0.05 significance level, we rejected the null hypothesis, confirming that residents had different perceptions of the health risks associated with microplastics according to their geographic location. This finding suggests that while residents may have similar experiences with the presence of microplastics in estuarine environments, their interpretations of the potential health consequences differed according to local exposure conditions, lifestyle, and environmental interactions. The observed regional differences in health risk perceptions support the findings of Santos et al. (2022), who reported that communities dependent on aquatic resources face higher risks associated with plastic pollution in water as their daily activities increase their exposure to polluted environments. Similarly, Kumar et al. (2021) found that perceptions of microplastic risks among coastal populations are associated with occupational exposure, particularly among fishing communities whose livelihoods depend on aquatic environments. These findings support the present study, where differences between the three regions of the Andoni River Estuary may reflect differences in fishing capacity, dependence on estuarine resources, and exposure to potentially

contaminated water and fish food. The significant difference observed between regions is also consistent with the findings of Borrelle et al. (2020), who highlighted the fact that awareness of the environmental and health risks associated with it is often higher in regions with increased environmental exposure to plastic pollution. However, this finding extends this understanding by showing that perceptions of health outcomes can vary spatially, even within the same estuarine system. Furthermore, Prata et al. (2021) highlighted the fact that public awareness of the health risks of microplastics is not only influenced by pollution levels but also by access to environmental information, local scientific systems, and perceived vulnerability.

Therefore, significant regional differences may reflect the relationship between environmental exposure and knowledge penetration. Areas close to heavily exploited fishing grounds, waste disposal sites, or direct contact with water may have increased health risks because environmental pollution has an immediate impact on residents. On the other hand, potential risks may be underestimated in areas with less direct exposure or limited communication with the environment. This interpretation is consistent with Zhang et al. (2023), who showed that spatial differences in environmental risk perception are often related to differences in exposure patterns, social networks, and knowledge levels among communities. The results showed that residents of the Andoni River Estuary showed a high level of awareness of local sources of microplastic pollution but had little knowledge of complex mechanisms and scientific methods. Furthermore, perceptions of the health risks associated with microplastics varied across estuaries, indicating that environmental exposure patterns and social characteristics influence risk interpretation. These findings highlight the importance of developing specific environmental education programs in the area that focus on public awareness of plastic pollution and improved understanding of microplastic pathways, environmental impacts, and potential impacts on human health. Such studies are particularly important in estuarine areas where dependence on aquatic resources creates a continuous relationship between environmental degradation and human well-being (Santos et al; 2022).

Awareness of the Health Risks Associated with Exposure to Microplastics among Residents along the Andoni River

The results presented in Tables 4.4, 4.5, 4.9, and 4.10 provide important evidence on residents' perceptions of microplastic pollution and its health impacts in the Andoni River Estuary. The results show that residents generally view microplastic pollution as a major environmental and public health issue, as indicated by a mean Mean of 3.74 (SD = 1.18), which is above the proposed acceptance threshold of 3.50. This indicates that awareness of the health risks associated with microplastics is widespread among coastal communities whose livelihoods and daily activities depend on the aquatic environment. The strongest understanding was found for direct and observable exposure routes, particularly for health risks associated with microplastic contamination in the environment (Mean = 4.06), contamination of fish consumed by humans (Mean = 4.00), and exposure through contaminated water sources (Mean = 3.91). This pattern suggests that residents are generally more aware of the risks associated with microplastics when exposure routes involve food consumption and household water use.

The high level of concern found among residents of the Andoni River Estuary is consistent with recent global evidence that plastic pollution is growing as an emerging threat to environmental health. For example, Hartley et al. (2022) reported that public concern about plastic pollution has increased significantly due to increased awareness of its persistence in aquatic systems and its

ability to migrate through food chains. Similarly, Wang et al. (2021) found that communities exposed to plastic pollution had a strong perception of risk when the pollution was associated with fish consumption and drinking water safety. The finding of the current study that respondents associate microplastic contamination in fish with human health risks is consistent with the observations of Prata et al. (2021), who highlight the fact that seafood consumption represents one of the main routes through which humans may be exposed to microplastics and their associated chemicals. Therefore, the pattern of perceptions observed among Andoni residents suggests a broad general understanding that seafood systems are a key link between environmental pollution and human health.

However, the results also indicate a significant knowledge gap regarding the non-obvious and long-term effects of microplastic exposure. While respondents expressed high concern about the immediate health risks, they showed weak agreement regarding respiratory effects (Mean = 3.36) and the development of chronic diseases from long-term exposure (Mean = 3.46). This suggests that public knowledge is focused on the direct effects of exposure rather than the more complex effects of inflammation, oxidative stress, endocrine disruption, and long-term disease outcomes. This finding is consistent with the work of Vethaak and Legler (2021), who noted that while scientific evidence indicates the potential effects of microplastics on human health, the general understanding of the effects of chronic exposure remains limited. Similarly, Leslie et al. (2022) found that public awareness is often influenced by the visible effects of pollution rather than by the clear evidence of microplastic accumulation and systemic effects. The lower prevalence of chronic health outcomes in this study suggests the need for targeted environmental health communication programs that can translate scientific knowledge into meaningful public messages (Zhang et al., 2022).

Knowledge of vulnerable populations, particularly children and pregnant women (Mean = 3.92), also suggests that residents have limited understanding of the risks associated with exposure to various substances. This finding is important because recent empirical research has identified potential developmental concerns related to exposure to substances associated with smoking. Campanale et al. (2021) argue that vulnerable groups may face increased health risks due to differences in physical sensitivity, exposure patterns, and developmental stages. Thus, Andoni residents' perceptions of vulnerable groups reflect emerging knowledge about environmental inequalities and differential health outcomes.

The influence of socio-demographic characteristics on the perception of microplastic risk, as shown in Table 4.5, indicates that environmental awareness is not shared by all individuals. The overall Mean of 3.75 indicates that the population generally agrees that socio-demographic characteristics influence their perception of microplastic pollution and related health risks. Among these characteristics, education emerged as the most important factor, with respondents agreeing that educational attainment improves awareness of microplastic pollution (Mean = 3.98) and that people with higher education are more likely to be aware of the health risks associated with microplastics (Mean = 4.00). This result was further confirmed by regression analysis, where education produced the strongest predictive effect ($B = 0.296$, $\beta = 0.418$, $p < 0.001$), indicating that education itself contributes significantly to improving environmental health awareness.

The significant role of education observed in this study is consistent with recent evidence from environmental awareness studies. For example, Zhang et al. (2022) found that higher levels of education significantly increased awareness and concern about plastic pollution among coastal residents because education improves access to scientific information and strengthens

environmental knowledge. Similarly, Huang et al. (2023) reported that individuals with higher levels of education showed stronger recognition of the risks associated with plastic pollution and were more likely to support pollution reduction behaviors. Therefore, the current findings support the argument that education is an important means of improving community-level understanding of emerging environmental health risks such as microplastics.

The activity also had a significant impact on awareness, especially among residents involved in fishing and water-related activities. The overall Mean for the statement that fishermen and water users are aware of microplastic pollution (Value = 4.01), with a regression coefficient for the activity ($B = 0.164$, $\beta = 0.242$, $p < 0.001$), indicates that direct interaction with water-related systems increases environmental awareness. People whose livelihoods depend on fishing often notice changes in water quality, deterioration in water quality, and visible accumulation of pollution. This finding is consistent with the study by Li et al. (2021) who found that people who rely on water resources have a strong awareness of water pollution because environmental pollution directly affects their economic security. Similarly, Chen et al. (2023) found that the presence of work and dependence on water resources significantly influence perceptions of plastic pollution risk among coastal communities.

In addition, years of residence appeared to be a significant predictor of their perceptions ($B = 0.117$, $\beta = 0.176$, $p < 0.001$), indicating that long-term interaction with the estuarine environment enables residents to be aware of changes in their environment. Residents with a long history may be more aware of changes in water quality, fish health, and pollution changes. This finding supports previous research by Wyles et al. (2021), who found that long-term place and environmental connections influence people's awareness of environmental pollution and lead to greater environmental concerns. Similarly, Vieira et al. (2022) reported that local experience and environmental awareness significantly influence public perceptions of marine pollution problems. Socioeconomic status also had a significant effect, although it was smaller than the effects of education and occupation ($B = 0.089$, $\beta = 0.141$, $p = 0.002$). This suggests that socioeconomic status may determine access to environmental information, the ability to respond to pollution threats, and the ability to participate in environmental protection activities. Similar results were reported by Liu et al. (2022), who noted that socioeconomic differences affect knowledge about environmental risk because people with greater economic resources have better access to environmental information and services. However, apart from education, occupation, income, and years of residence, demographic characteristics such as age ($B = 0.031$, $p = 0.269$) and gender ($B = 0.018$, $p = 0.562$) did not have a significant effect on knowledge after controlling for other variables. This indicates that awareness of microplastic hazards within the Andoni River Basin may be due more to knowledge, experience, and environmental interaction than to biological or human characteristics.

The results of the regression model provided further support for these findings. The model yielded an R value of 0.641, indicating a relatively strong relationship between socio-environmental factors and residents' perceptions of microplastic pollution. The regression analysis ($R^2 = 0.411$) showed that socio-environmental factors explained 41.1% of the variance in the visual attributes, and the adjusted R^2 value of 0.402 confirmed that the explanatory power was still significant after adjusting for the number of indicators. The results of the ANOVA ($F = 41.762$, $p < 0.001$) confirmed that the regression model predicted residents' perceptions, leading to the rejection of the null hypothesis that social factors had no effect on residents' perceptions and associated health risks (Zhang et al. (2022).

Findings from the Andoni River Estuary add to the growing body of evidence that microplastic pollution is not just an environmental challenge, but also a public health issue. While residents demonstrate awareness of the immediate risks associated with contaminated water and food, gaps remain regarding long-term exposure pathways and health consequences. The significant role of education, employment, income, and residential experience suggests that it is important to design community-specific environmental health interventions that take into account local social and economic realities (Zhang et al., 2022). These findings support recent recommendations by researchers that effective microplastic management requires not only technological solutions to prevent pollution, but also environmental education, community engagement, and risk communication strategies (Prata et al., 2021; Hartley et al., 2022). Therefore, it will be necessary to strengthen environmental education programs, especially among uneducated and economically disadvantaged groups, to improve community resilience and promote plastic pollution management within the Andoni River Estuary.

Conclusion

The research indicates that inhabitants of the Andoni River Estuary possess a broadly high understanding and concern for microplastic pollution and its related health hazards. Respondents distinctly recognize the existence of microplastics in surface waters, sediments, aquatic life, and drinking water, agreeing strongly that such exposure carries severe health risks. However, comprehension of long-term, chronic, and less detectable health impacts is still limited, reflecting a discrepancy between general awareness and scientific knowledge. Additionally, the findings confirm that socio-demographic elements play a crucial role in shaping perception. Key factors such as education, employment, income, and duration of residence significantly determine awareness and risk perception, whereas age and gender do not exert significant effects. This indicates that hands-on exposure and factors based on knowledge are more impactful than biological or demographic traits in influencing environmental views. Inferential analysis validated that demographic factors significantly clarify the differences in perception, accounting for more than 41% of the observed variations. Comparisons across regions illustrated that even though perceptions of health risks vary significantly among communities, views on the distribution of microplastics remain largely consistent. The research indicates that the issue of microplastic contamination is broadly acknowledged as a problem for both the environment and public health in the Andoni River Estuary, yet the local population's comprehension of its dynamics and long-term consequences is still in progress.

Recommendations

1. Government bodies and organizations focused on environmental health should expand educational programs within communities that highlight microplastic contamination, especially emphasizing its prolonged health implications, methods of exposure, and effects on ecosystems. This initiative will help address the identified knowledge gaps among the residents.
2. Campaigns designed to raise environmental consciousness should be directed at less informed demographics, such as those with lower education levels and lower-income groups, using fishermen and long-term residents as local environmental educators to improve the spread of knowledge.

References

- Anderson, A. G., & Kavanagh, K. (2020). Community perception of environmental pollution risks in coastal regions. *Marine Policy*, 118, 104–112.
- Ansa, E. J., & Francis, A. (2007). *Baseline study of sediment characteristics in the Andoni ecological zone, Niger Delta, Nigeria*. Department of Geography and Environmental Management, University of Port Harcourt.
- Browne, M. A., Crump, P., Niven, S. J., Teuten, E., Tonkin, A., Galloway, T., & Thompson, R. (2011). Accumulation of microplastic on shorelines worldwide: Sources and sinks. *Environmental Science & Technology*, 45(21), 9175–9179.
- Costa, M. F., Armanda, A. N., & Rocha-Santos, T. A. P. (2019). Microplastics in aquatic systems: A global threat to marine ecosystems. *Environmental Pollution*, 252, 101–109.
- GESAMP. (2016). *Sources, fate and effects of microplastics in the marine environment: A global assessment*. (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection).
- Lebreton, L., & Andrady, A. (2019). Future scenarios of global plastic waste generation and disposal. *Palgrave Communications*, 5(1), 1–11.
- Maier, D., Meyer, S., & Schmidt, T. (2023). *Public perception and environmental awareness of emerging pollutants in coastal ecosystems*. *Journal of Environmental Studies*, 45(2), 112–128.
- Naidu, R., Kumar, A., & Singh, P. (2020). Concentration and distribution of microplastics in surface water and sediments of Lagos Lagoon, Nigeria. *Marine Pollution Bulletin*, 160, 111–118.
- Taro, Y. (1967). *Statistics: An introductory analysis* (2nd ed.). Harper & Row.
- Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W. G., McGonigle, D., & Russell, A. E. (2004). Lost at sea: Where is all the plastic? *Science*, 304(5672), 838.
- United Nations Environment Programme (UNEP). (2021). *From pollution to solution: A global assessment of marine litter and plastic pollution*.
- World Health Organization (WHO). (2019). *Microplastics in drinking-water*.
- Zobkov, M. B., & Esiukov, A. Y. (2016). Microplastics in marine environment: Sources, transport, and distribution. *Oceanology*, 56(3), 392–402.