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UNDERSTANDING THE IMPACT OF CLIMATE CHANGE ON SURFACE WATER CONTAMINATION OF RIVERINE AREAS IN ABIA STATE, NIGERIA

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ABSTRACT

An assessment of the impact of climate change on surface water contamination of riverine areas in Abia State where rural dwellers solely depend on as water sources for domestic and agricultural purpose was examined in this research. Five (5) selected Local Government Areas in Abia State with two (2) communities each from the same Local Government Area was used for this study. Composite sample of surface water to a depth of 30cm were collected. Physico-chemical parameters of water- Temperature, pH, Alkalinity, Electrical Conductivity (EC), Hardness, Total Dissolved Solids (TDS), Degradable Organic Matter (COD), Ammonium – Nitrogen (NH_4-N), Nitrite (NO_3-), Phosphate (PO4), Heavy metals [Lead (Pb), Cadmium (Cd), Mercury (Hg), Copper (Cu), Chromium (Cr), and Total Hydrocarbon (THC)] were determined using standard analytical methods. Data were analysed using descriptive statistics, correlation and t-test at P= 0.05 values obtained were compared with recommended World Health Organization and Federal Environmental Protection Agency (FEPA) guidelines. Results of the study showed that each location had unique water parameters that were different from each other. Some values were higher than recommended standards, while some values fell below the recommended standards. The impact of climate change from the study showed that there was contamination of water sources from the five selected Local Government Areas, the impact affecting fish population, their abundance, economic wellbeing, and the community's livelihood. This research revealed that water quality varied significantly due to impact from climate change and anthropogenic activities which made most of the rural dwellers vulnerable. From the research, it is recommended that the selected communities should be exposed to several adaptive capacities to climate change impacts and reduce contribution to pollution into the water bodies from activities that promote the impact of climate change.

Keywords: *Climate change, Sustainability, water quality, pollution, surface water*

INTRODUCTION

Sustainable development goals are threatened by climate change, with the heaviest impacts on poor countries and poor people (Chen and Ravallion, 2008). Climate change cannot be controlled unless growth in both rich and poor countries become less greenhouse-gas-intensive. The latest challenge to sustainable human development especially in Nigeria is climate change (Ibe*et al*., 2010). This has shown to have negative impacts on the efforts to achieve Nigeria's development objectives including the targets set out in Nigeria. In Abia State, climate change is already having an impact as weather-related disasters have become more frequent especially flooding, ecosystem degradation and reduced availability of water and food (IPCC, 2001). This has resulted to uneven distribution of development benefits to rural dwellers, particularly among women and men and the sustainable livelihoods of the vulnerable groups. Research shows that most rural dwellers have a heavy dependence of their economy and individual livelihoods on rain- fed agriculture, which is highly susceptible to fluctuations in rainfall and water supply and that has increased the rate of poverty and hunger in the State. According to studies, the existence of the coastline areas in Nigeria are exposed to threats arising from accelerated sea level rise and increased storm surge risk, which has impacted most communities, infrastructure, endemic species of flora and fauna, and spawing grounds for fish (Nwosu and Holzlohner, 2009; Ukwe and Ibe, 2011 and Enin, 2012). Observed climatic change in Nigeria are in the reports of BNRCC (2011) and NIMET (2013). The report of the experience of late onset of rains in Abia State has created shorter raining season and is affecting the amount of water available for rural farmers to initiate early planting season (Audu*et al*., 2008; NRCRI, 2014). As a result of these vulnerability, the impact of climate change on rural dwellers needs a close monitoring to reduce the implications on health challenges that will arise from such neglects. This research intends to understand the changes that has occurred due to climate change and determine future warning or likely dangers of greater impacts of climate change on our ecosystem water resources, diversity and livelihoods and the adaptive capacity that have been adopted by the rural dwellers in the riverine areas in Abia State. In addition, the expected changes as predicted or observed by IPCC (2001) has projected that sea levels will rise as a result of increasing global temperatures which will expose most communities to increased erosion, storm damage, inundation on low lying area and other impacts as noticed in the area. According to reports presented by World Bank (2010), as the planet warms, rainfall patterns shift and extreme events such as drought and flooding become more frequent, no country or state is immune. Riverine areas will live their homes as the sea level rises, crop failures will be on the increased and reduce agricultural productivity (Ayanlade*et al*., 2018; Morton, 2017; Ateeq-Ur-Rehman *et al*., 2018; Aniah*et al*., 2019). This research significantly investigated the impacts of climate change on water resources, health, social and economic status of the rural dwellers of five (5) Local Government Area in Abia State (Ohafia, Ukwa East, Ukwa West, Bende, and Ikwuano). It furthers reveals the need to guide rural communities in selected areas the need to develop adaptive capacities and resilience to tackle contamination of their water sources.

MATERIALS AND METHOD

The assessment of climate change impact on the water resources and livelihood of riverine dwellers in this study was carried out in five (5) selected Local Government Areas of Abia State (Ohafia, Ukwa West, Ukwa East, Bende and Ikwuano). Two (2) communities/villages were selected from each Local Government Area. Abia State lies between Lat. 5^o 28'N and Long. 7^o 35' E and altitude of 112mm above sea level in the moist rainforest zone, with an average rainfall of 2177mm per annum with relative humidity of about 72% and monthly ambient temperature ranges from 17^oC to 36^oC (Meteorological Station of NRCRI, 2014). The vegetation is of tropical rainforest (NEST, 1991). Primary and Secondary data was used in the study. Primary data was collected using a well-structured questionnaire (Angelsen and Lund, 2011). The validity of the semi-structured questionnaire was pre-tested before it was used in collecting data from the sampled community members. A pre-test of 10 percent of sampled respondents in the communities was carried out to ensure that the questionnaire is compatible with the field situation to address the set objectives. In addition, the pre-test helped to remove irrelevant questions. Responses to the questionnaire was examined to see if respondents understood the content of the questions, or whether they were reluctant to answer some questions or not. Secondary data was collected from the Meteorological Center and Clinics and Hospitals in different locations. In the study, purposive sampling technique was used to select the five (5) local government areas out of the 17 local government areas and two (2) communities/villages in each LGA, making it a total of ten (10) communities/villages from the five (5) L.G.As. The reason for using the purposive sampling method is because this LGAs have water bodies (riverine areas), this will ensure a proper representation of peoples' views in Abia State. Systematic sampling method was used to select every 6th house in each village, so as to cover every corner of the community. The respondents selected was 20% of the number of households from each of the ten villages. Qualitative and quantitative data was used in the study. Qualitative tools were used to elicit information from the households. These include the use of participatory tools such as Focus Group Discussions (FGDs), In-depth Interviews (IDIs) with key informants (village leaders) as well as field notes and direct observations based on what is seen. The FGDs include one group from each of the selected villages; therefore, a total of ten FGDs was interviewed. Male groups comprising of 5 elderly and 5 youths, Female groups comprising of 5 elderly and five youths.

The IDIs was 2 from each of the villages included (Eze, and Chief Farmer). The same questions were channelled to all the respondents. Ambient monitoring of water quality within each of the two communities/villages selected for the study was carried out to evaluate the status and trend of the water parameters, test for the water quality with recommended standards and to calculate the loads. Preliminary surveys of the type and the nature of the water body was carried out prior to the assessment. Sampling in the study locations was carried out on monthly basis and samples collected with pre-rinsed glass and polythene bottles were analysed for the following parameters using APHA (1998) standardized methods of analysis for Temperature (in situ), Colour, Odour, Total Dissolved Solids (TDS), Electrical Conductivity (EC), pH, Dissolved Oxygen (DO), Degradable Organic Matter (COD), Ammonium – Nitrogen (NH_4-N), Nitrate (NO_3^-), Phosphate (PO_4), Alkalinity, Heavy Metals (Pb, Cd, Hg, Cu and Cr) and Total Hydrocarbon (THC). Biological monitoring to characterize the quality of the ecosystem was carried out in this study to monitor indicator bacteria present in the water for faecal pollution. Statistical analysis carried out in this study comprised of calculations of means, standard deviation, the exclusion of outliers, regression, and variance analysis. Data obtained from this study are presented in tables and graphs in order to communicate complex results obtained with clarity to the stakeholders and rural dwellers.

RESULTS AND DISCUSSION

The range of values of the physico-chemical parameters of water and there are presented in Table 1 and 2 below.

Table 1: Mean and Standard Deviation of Physico-chemical Parameters of Water Quality Assessment in Study Locations:

Sampled River	DO (Mg/L)	COD (Mg/L)	EC (Mg/L)	Alkalinity (Mg/L)	Turbidity (FTU)	TDS (Mg/L)	pH	NO_3^- (Mg/L)	PO_4 (Mg/L)
Eriu- Nkpa (Bende LGA)	13.61 ±0.02	70.04 ± 0.03	5.91 ±001	160.20 ± 0.01	4.48 ± 0.05	638.80 ± .05	6.00 ± 0.02	0.561 ± 0.03	0.892 ± 0.01
Ebem (Bende LGA)	14.16 ±0.03	73.23 ±0.02	3.38 ± 0.05	152.40 ± 0.03	3.76 ± 0.04	334.60 ±0.02	6.99 ± 0.01	0.673 ± 0.02	0.940 ± 0.05
Ukwa East 1 LGA	14.40 ± 0.01	84.43 ± 0.01	5.03 ± 0.01	88.10 ± 0.02	1.45 ± 0.02	489.50 ±0.01	5.95 ± 0.02	0.690 ± 0.03	0.930 ± 0.01
Ukwa East 2 LGA	13.14 ± 0.01	67.40 ± 0.02	4.34 ±0.02	641.20 ± 0.05	2.97 ± 0.05	569.10 ± .03	5.86 ± 0.06	0.371 ± 0.02	0.950 ± 0.02
AhabaOloko (Ikwuno LGA)	13.39 ± 0.02	70.81 ± 0.05	3.58 ±0.01	172.00 ± 0.03	2.90 ± 0.02	448.60 ±0.05	6.06 ± 0.05	0.508 ± 0.02	0.883 ± 0.01
Anya River (Ikwuno LGA)	12.73 ± 0.50	66.90 ± 0.03	3.54 ± 0.05	401.12 ± 0.05	2.70 ± 0.05	337.20 ±0.07	5.90 ± 0.06	0.690 ± 0.90	0.780 ±0.06
OhaAkoli (Ohafia LGA)	13.46 ± 0.51	69.84 ± 0.02	3.88 ± 0.01	127.40 ± 0.04	3.03 ± 0.01	437.20 ±0.09	5.88 ±0.08	0.286 ±0.05	0.868 ±002
Isiugwu (Ohafia LGA)	13.76 ± 0.04	71.50 ± 0.04	4.13 ± 0.01	168.30 ± 0.05	1.35 ± 0.02	273.80 ±0.07	5.85 ± 0.05	0.722 ± 0.70	0.890 ± 0.06
Ukwa West 1 LGA	14.86 ± 0.04	76.94 ± 0.02	8.70 ± 0.03	88.20 ±0.02	1.56 ± 0.01	842.10 ±0.02	5.82 ±0.01	0.673 ±0.04	0.965 ± 0.04
Ukwa West 2 LGA	13.67 ± 0.03	72.00 ± 0.01	10.90 ± 0.05	96.10 ± 0.07	1.33 ± 0.06	364.20 ±0.01	5.38 ± 0.04	0.721 ±0.01	0.880 ± 0.01

Keys: DO=Dissolved Oxygen, COD= Chemical Oxygen Demand, EC= Electrical Conductivity, TDS= Total Dissolved Solids, NO_3^-= Nitrate, PO_4=Phosphate

The range values for Dissolved Oxygen (DO) as indicated in Table 1 was below the recommended standards by WHO (2011) guidelines for surface water which is 20mg/L. Dissolved oxygen as defined by Prajapati and Divivedi, 2016 as the amount of oxygen gas that is dissolved into water from any source, and it is used in measuring the degree of pollution by organic matter, the destruction of organic substances as well as the self-purification capacity of the water body. When values are lower than recommended standard it indicates a level of concern for health and wellbeing of the users. Although, the result in Table 1 shows that Dissolved Oxygen was higher in Ukwa West (14.86 ± 0.04) as compared to the Anya River (12.73 ± 0.50) over the period of study. For Ukwa East I, had a higher value for COD (84.43 ± 0.01) against FEPA (1995) of 40.00mg/L permissible limits, whereas Anya River recorded the lowest range of 66.90 ± 0.04. The amount of Nitrite ($NO3-$) in the surface water also fall below the recommended limits of 10mg/L. This low value indicates that climate change and climatic variability must have lowered crop yields and poor livestock production that has resulted to reduction in sewage intrusion into the water bodies. This is in line with reports from similar studies by Quareshimatva *et al*., 2015 and Waziri and Ogugbuaja, 2012. The report of contamination of surface water from other sources other than agricultural production as observed in this study also agrees with the findings of Ajah, 2002. The range of hardness across the location was higher than WHO (2011) guidelines for 500mg/L especially at Ukwa West LGA sampling location.

While other locations fell below the standards. This shows that the levels of cations from erosion, siltation in the location will lead to destruction of breeding grounds for fish species. Such concentrations will have effects on the rural dwellers especially in terms of domestic consumption, water treatment requirement and may cause road wash outs, which make it difficult to access farms and to market products. The range of pH also fell below WHO (2011) and FEPA (1995) guidelines of 6.5 – 8.5. The pH of natural water determines the solubility and chemical forms of most substance in water, which according to Quareshimatva *et al*., 2015 is the intensity of the acidic or basic character of a solution at a given temperature. With higher surface water temperatures recorded over the periods, the tendency for pH to change due to erratic weather interferences will lead to habitat loss for some temperature sensitive organisms, and increased abundance of undesirable species (e.g. algal blooms and pest species) as noted in the study locations. Turbidity level in water as indicated in the study area is in tandem with studies by Waziri and Ogugbuaja (2012) that rainfall and river flow are related to turbidity. Although, the level of turbidity was significantly higher in some river that had anthropogenic activities due to runoff and other exploratory activities brought about by high rainfall characteristics of the sub-tropical region. Total Dissolved Solids (TDS) in all locations fell below WHO (2011) and FEPA (1995) guidelines of 1000mg/L and 2000mg/L respectively.

Table 2:**Table 1: Mean and Standard Deviation of Physico-chemical**

Sampled River	NH_4-N (mg/L)	Cr (mg/L)	Hg (mg/L)	Pb (mg/L)	Cu (mg/L)	Cd (mg/L)	THC (mg/L)
Eriu- Nkpa (Bende LGA)	0.784	0.036	0.011	0.146	0.194	0.051	0.523
Ebem (Bende LGA)	0.781	0.049	0.001	1.120	0.141	0.062	0.714
Ukwa East 1 LGA	0.828	0.060	0.004	0.786	0.311	0.019	0.333
Ukwa East 2 LGA	0.472	0.067	0.001	1.066	0.082	0.065	0.666
AhabaOloko (Ikwuno LGA)	0.795	0.039	0.001	0.370	0.461	0.040	0.476
Anya River (Ikwuno LGA)	0.771	0.029	0.006	0.281	0.159	0.031	0.571
OhaAkoli (Ohafia LGA)	0.387	0.115	0.001	0.056	0.235	0.026	0.238
Isiugwu (Ohafia LGA)	0.812	0.039	0.001	1.056	0.169	0.074	0.619
Ukwa West 1 LGA	0.849	0.029	0.001	0.705	0.411	0.113	0.190
Ukwa West 2 LGA	0.793	0.055	0.001	1.059	0.202	0.048	0.056

Parameters of Heavy Metals in Study Locations

Keys: NH_4-N= Ammonium-Nitrogen, Cr = Chromium, Hg = Mercury, Pb = Lead, Cu = Copper, THC = Total Hydrocarbon

Table 2 shows that heavy metal examined in the study locations exceeded limits recommended by WHO (2011) especially for Lead (0.05mg/L), Chromium (0.05mg/L), Total Hydrocarbon (0.1mg/L). Higher value of Lead (pb) was recorded in Ebem river (1.120mg/L) in Bende LGA, Ukwa East (1.066mg/L) Isigwu (1.056mg/L) and Ukwa West LGA (1.059mg/L). Chromium had higher value in Oha Akoli river in Ohafia LGA (0.115mg/L). The activities surrounding this water bodies clearly indicates the cause of the results obtained from study locations. Although, other locations were low with recommended WHO values for Hg (0.50mg/L), Cu (10mg/L) and Cd (5.0mg/L), however, with the impact of climate change on the surface water, it is necessary that activities that triggers more of such contamination be reduced drastically in order to ensure that water temperature and water quality do not increase the depletion of species in this location. This is in line with studies conducted by several authors on the water quality and seasonal changes in the tropic region (Akpan *et al.,*2003; Ajah,2002).

Table 3: Bacteriological Examination from Study Locations:

Sampled River	***E. coli***	***Klebsiella spp***	***Enterobacter spp***	***Salmonella spp***
Eriu- Nkpa (Bende LGA)	2.7 x 10^8cfu/ml	nil	nil	nil
Ebem (Bende LGA)	nil	nil	nil	nil
Ukwa East 1 LGA Ukwa East 2 LGA	nil	2.4 x 10^8cfu/ml	1.4 x 10^8cfu/ml	nil
AhabaOloko (Ikwuno LGA)	nil	nil	nil	nil
Anya River (Ikwuno LGA)	nil	nil	nil	nil
OhaAkoli (Ohafia LGA)	nil	nil	nil	1.2 x 10^8cfu/ml
Isiugwu (Ohafia LGA)	2.0 x 10^8cfu/ml	nil	nil	nil
Ukwa West 1 LGA	nil	1.2 x 10^8cfu/ml	nil	nil
Ukwa West 2 LGA	nil	nil	nil	nil

Results obtained from these studies indicate that *E.coli* was present in Eriu-Nkpa and Isiugwu river while Ukwa East and Ukwa West had *Klebsiella spp.* While, *Enterobacter spp* was only present in Ukwa East and *Samonellaspp* only present in Oha Akoli river. Results shows that the most contaminated riverine area is Ukwa East I LGA, and this makes the water not fit for drinking. However, field study reveals that the major source of water to riverine communities in the study locations are these rivers. Therefore, contamination of surface water in the communities should be discontinued to reduce the impacts of various activities that affects for drinking purposes, fisheries and breeding grounds for native species. The government in collaboration with the National and South - East Zone recognizes a changing climate as a threat to sustainable growth. The result of the perception of the people done to understand their level of awareness on critical issues affected by climate change is presented in Fig.1. Result shows that though annual production is in single season, farmers have adapted rotational production as a climate smart practice that regulates production of crops in specific periods of each season. Commonly produced crops includes maize, cassava, plantain, okro and cocoa all produced in one season, once every year but planted at the different peaks based on crops' best performing period. This complied with the findings of Morton (2017) who said that though good agricultural management practices have the potential to be the basis for effective climate change adaptation methods, local knowledge should be used in conjunction with scientific knowledge systems for impact reduction. The distance to the market is about 14km and the population is a Christian community with a few families practicing traditional religion. This aligns with the opinion of Muhammad *etal.,* (2018) who found that diversification of food production is a climate smart strategy in food agriculture. Although, the rural communities experiences intense flooding but they have built their resilience to survive its adverse effects. Fig. 1 further shows that common diseases experienced in the community include cholera, foot rot, measles and heat rash. Children are most vulnerable to diseases compared to men and women.

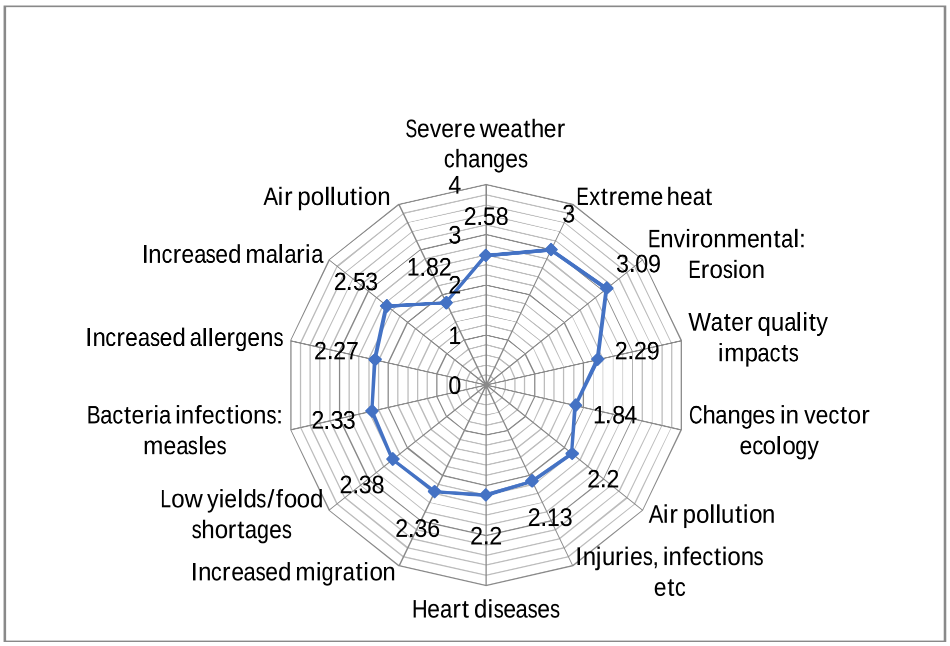

Figure 1: Radar Analysis on the level of knowledge of climate change impact by respondents

Results obtained showed that increased temperatures created uncomfortable conditions and cause heat stress in their various homes, which has resulted to unconducive environment for teaching and learning activities, poor attendances to school and poor performance in academic work in line with the report submitted by WRI, 2008; McGranaham*et al*., 2007. More extreme weather reports include reduction in water quantity, contaminated water from sewage, industrial and chemical waste as observed during focal discussion group meeting is similar to reports by Raj and Azeez, 2009. Health impacts associated with brackish drinking water due to saltwater intrusion, increased outbreaks of waterborne diseases (giardia, cholera, typhoid, hepatitis A, shigellosis, and cryptosporidium were observed in this study and they confirm to the findings by Haines *et al.,* 2006. Reports of increase in malaria due to more breeding sites for mosquitoes was observed in this study. The heat stress observed from respondents revealed reduction of human labour use on farms and lower labour productivity. This action has resulted to rapid deterioration and wastage of farm produce in the State. From this study, results shows that most of the riverine areas in Abia State are vulnerable and requires emergence approach by the government in building mangrove areas as suggested by Nwosu and Holzlohner, 2009 and the people in tackling areas that are vulnerable as described in the findings of WU *et al*., 2002 in order to provide mitigation strategies for rural dwellers.

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