International Journal of Scientific Research and Engineering Development-– Volume 2 Issue 4, July – Aug 2019
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Application of Geo-Informatics on Assessing Impact of Climate Change and Flood Risk on Groundwater Quality in Abia State

Enyinna Gregory. C

Department of Project Management Federal University of Technology Owerri, Nigeria.

Email: pycongrego@yahoo.com

Mobile Phone: +2348036293888

Mobile Phone:+4915216946858

Postal address/ Code: Department of Project Management, School of Management Technology, Federal University of Technology, PMB 1526 Owerri, Imo state, 234Nigeria.

Abstract

This research is aimed at developing adaptation to climate change induced flooding and groundwater contamination so as to curbenvironmental and health hazards associated to the vulnerability of Abia state in relation to flooding and groundwater contamination. The research implored scientific method of collecting groundwater samples that were analyzed in government certified laboratories using membrane filtration technique, while the results were displayed on tables and graphs in comparison with world health organization standard to prove that water samples were actually contaminated. Climatic data on rainfall and temperature were collected from national root crop research institute umudikeUmuahia and were analyzed using excel spread sheet showing corrections between temperature and time.Mean while temperature analysis shows that R^2= 0.325 while average rainfall frequency showed R^2 = 0,018. Flood risk map was cartographically designed using ArcGIS 10.2 to show the parts of the state that are more vulnerable to flooding and the contaminants were overlaid on flood risk map to show how flooding influenced the rate of groundwater contamination. Measures of adaptation to climate change induced flooding and groundwater contamination were recommended to drastically reduce the possible future damages that this climate change induced flooding can cause if not sustainably handled in a proactive way.

Key Word: Climate Change, Flood Risk, Groundwater Contamination, Adaptation, WHO standard.

1.0: Introduction

United nation framework convention on climate change “UNFCCC” [1] explained that climate change is the direct or indirect natural or anthropogenic effect on climate variation which may create a difference in the global atmospheric systems over a period of more than 35 years. Thus, a corresponding rise in temperature resulting from climate change causes elevation of the surface temperature of the water bodies which melts the ice caps and increases the volume of water in seas and Oceans. IPCC [2] specified that this event forces the water bodies to over flow into the land areas which manifests as devastating flooding. Therefore considering the closeness of the Niger Delta to the Atlantic Ocean, most of the flood events are linked to over flow of river banks with a corresponding contamination of boreholes and hand dug wells in the region. This has necessitated this research to device means of adaptation to climate change induce flooding that causes regular contamination of groundwater.

Groundwater contamination has been a very serious environmental issue in Nigeriadue to high dependence of the country’s dominant population on groundwater resources for human consumption and considering the role of climate change induced flooding in contamination of groundwater in the area, it becomes very necessary to investigate the situation on ground in other to use certain adaptation measures to remedy the resultant human health implication of groundwater contamination.Máñez et al [3]stated that all water policies and management strategies should consider the possible adaptation measures to be taken to ameliorate the effects of forecasted climate change impact on water resources.

The role of climate change in occurrence flooding especially during rainy seasons within this research area cannot be under estimated since the devastating flood effect has been an agent of groundwater contamination especially in the flood risk areas.Nigeria environmental study/action team; NEST [4] in Amadi et al [5]specified that Niger delta region has experienced rise in sea level with reoccurring over flow of the ocean that has already been an established cause of coastal flooding and erosion, marine water intrusion and its subsequent groundwater contamination.Udofia et al [6]gave the value of the mean sea level rise as 0.462m above zero level in tidal gauge.Uyigue et al [7] stated that different condition of sea level rise in Niger Delta resulted in such estimates of land loss to coastal erosion and flooding and low estimates as, 0.2m sea level rise, resulted to 2,826km^2 land loss, 0.5m sea level rise resulting to 7452km^2 land loss, 1.0m and 2.0m sea level rise resulting to 15125km^2 and 18398km^2 land loss. They also specified that 0.2m rise in sea level resulted in human displacement of 0.10 million population, 0.5m to displacement of 0.25 million people, 1.0m to displacement of 0.47million displaced people and 2.0m sea level rise to 0.21 million displaced people.

Climate change induced flooding and groundwater contamination is not only triggered by rise in sea level but also as a resultant effect of high intensity of rainfall and rise in rainfall frequency which causes flooding within the areas of shallow water table and rainfall infiltration quickly saturates the soil due to this shallow water table and contaminates the groundwater sources of both unprotected hand dug wells through flushing of eroded contaminations into water wells and solute transport of contaminants into boreholes. This is because of resistance to attenuation due to the short distance and time it takes the contaminants to be transported to the water table. Adindu et al [8] stated that the water table of Niger delta falls within the range of 8m-26m with aquifer potential of 1500m thickness. Therefore, this research deems it necessary that adaption to climate change induced flooding is the best approach to sustainable use of this valuable resource that is threatened by pollution during flooding and contamination through these pollution sources.

2.0: Materials and Methods

Climatic data was collected from National root crop research institute Umudike, Umuahia showing temperature ranges over a period of 30 years and rainfall data over a period of 20 years for Abia state.

Groundwater samples were collected from 12 local government areas out of 17 local government areas in Abia state where 24 samples were collected during the rainy season and 24 samples were collected during the dry season making up to 48 water samples. These samples were taken to certified government laboratory for microbiological analysis to trace the level of microbial contamination in groundwater when the results are compared with the world health organization drinking water standard. The cartographical display below shows the water sampling locations and local government areas samples were taken from.

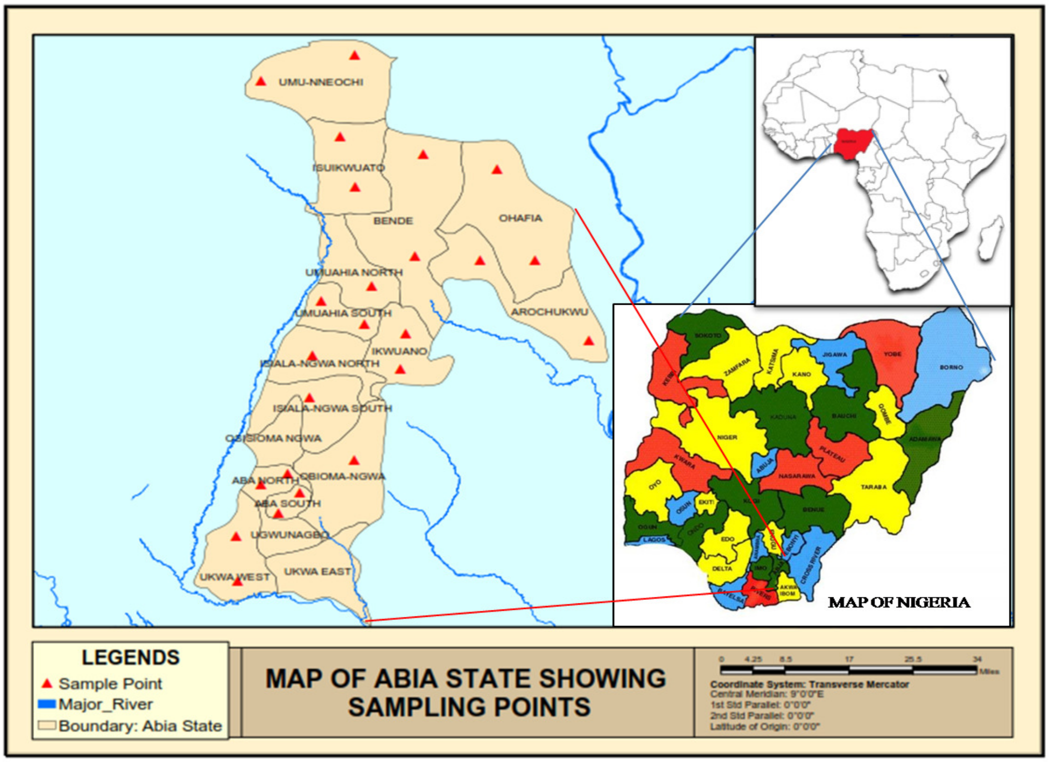

Figure 1 Map of Abia state extracted from map of Nigeria and Africa

The laboratory technique that was used for water analysis was the membrane filtration techniques where 100ml of sample were filtered under vacuum on sterilized Nitrocellulose filter of pore size of 0.45mm with the help of filtration rack. I placed the filter paper on a prepared Marcokey agar, Nutrient ager Eosin Methylene blue ager, Salmonella Shigella agar, centrimide ager and Sabrouse dextrose ager. I inverted the petri dish in an incubator at 37-41.5^{o}C for 24hrs for bacterial growth and between 72hrs-120hrs for fungi growth. At the end of the incubation, growth of colonies was counted with a colony counter and resultswere recorded.

Arc GIS version 10.2 was used for the cartographical designs for overlay of contaminants on flood risk map.

Excel spread sheet was used in plotting the graphs of temperature and rainfall data as well as plotting the graph showing the extent of contamination of groundwater.

3.0: Results and Discussion

Contamination of groundwater could be in form of physical, chemical or microbial contamination.Chima et al [9] in their research on the physico-chemical and bacteriological analysis of water samples from selected points in Umuahia urban noted that the area's water samples collected and scientifically analyzed in the laboratory showed higher values of acidity, BOD, nitrate values, total dissolved solids, total suspended solids and coliform organisms than values for WHO standard, showing that groundwater contamination was prevalent in the area.

Figure 1-2 shows rainy season laboratory result sample point 1 to sample point 12 (P1-P12) measured in cfu/100ml, for Total vibrio count (TVC), Total salmonella count (TSC), and Total fecal count (TFC) and Total E coli count (TEC) in comparison with world health organization (WHO) standard.

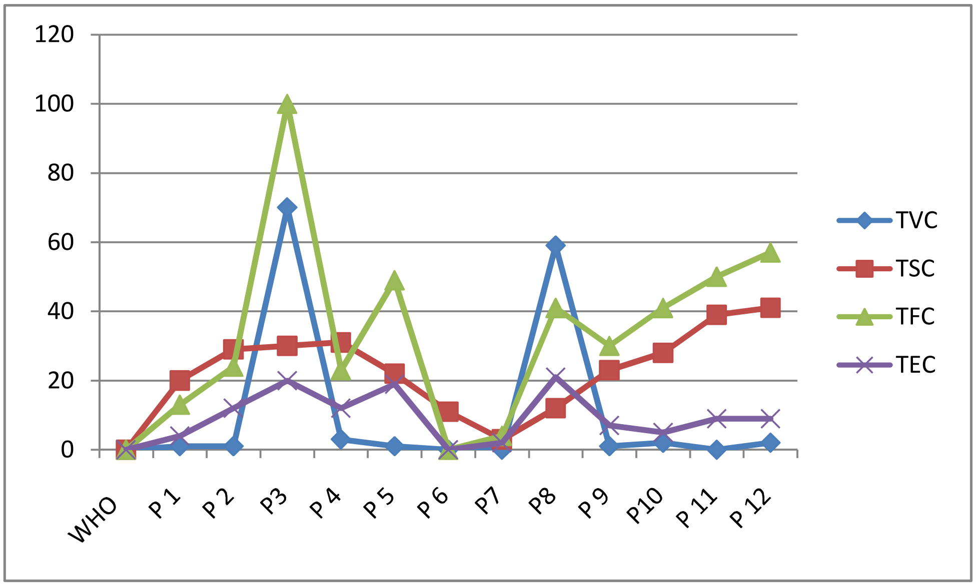

Figure 1-2 Microbial contamination of groundwater compared with WHO standard

The laboratory results were compared with WHO standard for total vibrio contamination .9 out of the 12 water samples were above the standard and are tagged contaminated water samples. Total salmonella count was also compared with WHO standard and the 12 water samples were all contaminated. Results for total fecal count was compared with WHO standard and 11 samples out of 12 water samples were contaminated and the results for total fecal count were compared with WHO and 11 samples out of 12 water samples were contaminated.

Figure 1-3 shows the graph total vibrio count, total salmonella count, total fecal count and total E coli count for rainy season point 13 to 24 (P13-P24) in comparison with world health standard (WHO). P 21 and P22 are leachate samples collected from waste dump sites close to the water wells to verify if the waste dumps where the sources of groundwater contamination in the area. Therefore the results for P21 and P22 will not be shown on this graph.

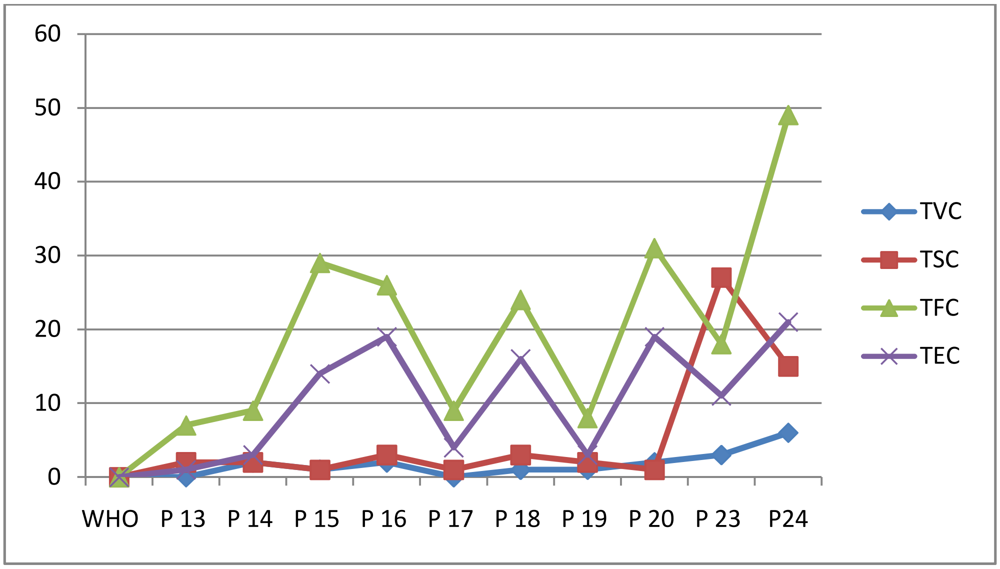

Figure 1-3 Microbial contamination of groundwater compared with WHO standard

Water sample results were compared with WHO standard for total vibrio contamination, 8 samples out of the 10 water samples were above WHO standard while results for TSC shows that 10 water samples were above WHO standard for total salmonella contamination when they were compared with WHO standard. Results for total fecal contamination was compared with WHO standard and 10 water samples were found to be contaminated while the results for total E coli contamination was also compared with WHO standard and all the 10 samples were contaminated.

Water samples were also collected in two phases for the dry season. Phase one is P1-P12 while phase two is P13-P24 but P21 and P22 are samples from leachate contamination. Figure 1-4 will show the graph of microbial contaminations for dry season P1-P12.

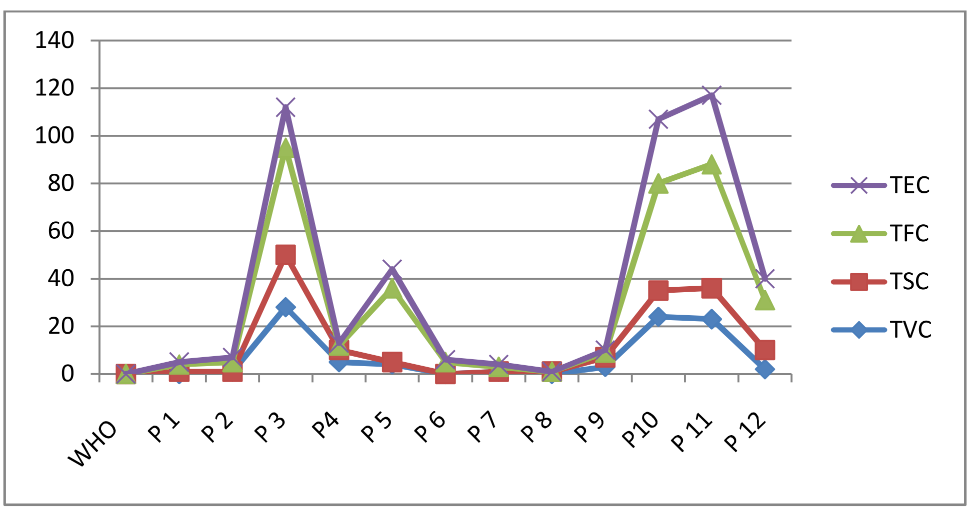

Figure 1-4 Microbial contamination of groundwater compared with WHO standard

The comparative analysis of microbial contaminations with WHO standard for drinking water shows that 10 water samples were contaminated with total vibrio contamination, 9 samples were contaminated with total salmonella contamination, 11 samples were contaminated with total fecal contamination and 11 samples were contaminated with total E coli contamination.

Figure 1-5 below will show the comparative analysis of microbial contamination with WHO standard for dry season samples P12-P24. Samples P21 and P22 were leachate samples and they would not be included in the graph.

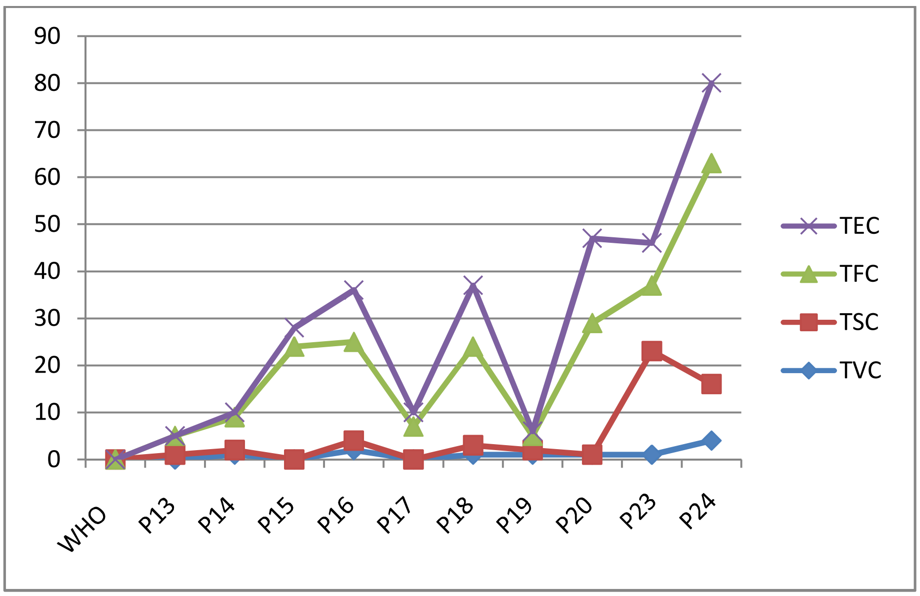

Figure 1-5 Microbial contamination of groundwater compared with WHO standard

The comparative analysis of microbial contamination of groundwater with WHO standard shows that 7 water samples were contaminated with total vibrio contamination, 7 water samples were also contaminated with total salmonella contamination, 10 water samples were contaminated with total fecal contamination and 9 water samples were contaminated with total E coli contamination.

Table 1 Laboratory results of microbial contamination during for rainy season

PM	WHO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
TVC	0	1	1	70	3	1	0	0	59	1	2	0	2
TSC	0	20	29	30	31	22	11	3	12	23	28	39	41
TFC	0	13	24	100	23	49	0	4	41	30	41	50	57
TEC	0	4	12	20	12	19	0	2	21	7	5	9	9
PM	**WHO**	**P13**	**P14**	**P15**	**P16**	**P17**	**P18**	**P19**	**P20**	**P21**	**P22**	**P23**	**P24**
TVC	0	0	2	1	2	0	1	1	2	180	204	2	6
TSC	0	2	2	1	3	1	3	2	1	301	317	27	15
TFC	0	7	9	29	26	9	24	8	31	247	1420	18	49
TEC	0	1	3	14	9	4	16	3	19	90	741	11	21

Table 1-2 will display the results of microbial contamination of groundwater in comparison with WHO standard for dry season water samples.

PM	WHO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
TVC	0	0	1	28	5	4	0	1	0	3	24	23	2
TSC	0	1	0	22	5	1	0	0	1	4	11	13	8
TFC	0	3	4	45	2	31	5	2	0	2	45	52	21
TEC	0	1	2	17	1	8	1	1	0	1	27	29	9
PM	**WHO**	**P13**	**P14**	**P15**	**P16**	**P17**	**P18**	**P19**	**P20**	**P21**	**P22**	**P23**	**P24**
TVC	0	0	1	0	2	0	1	1	1	170	140	1	4
TSC	0	1	1	0	2	0	2	1	0	290	190	22	12
TFC	0	4	7	24	21	7	21	3	28	190	1240	14	47
TEC	0	0	1	4	11	3	13	1	18	70	690	9	17

Laboratory results have shown that groundwater contamination actually exist in the area and since several literature have shown that flooding has been the major factor behind contamination of ground water in Abia state, it has become very necessary to analyze temperature and rainfall pattern since the increase in temperature can result to high evaporation and transpiration which could also result to condensation in the atmosphere and subsequent rainfall. Diagram below show the annual maximum temperature variation for Abia state for the last 30 years

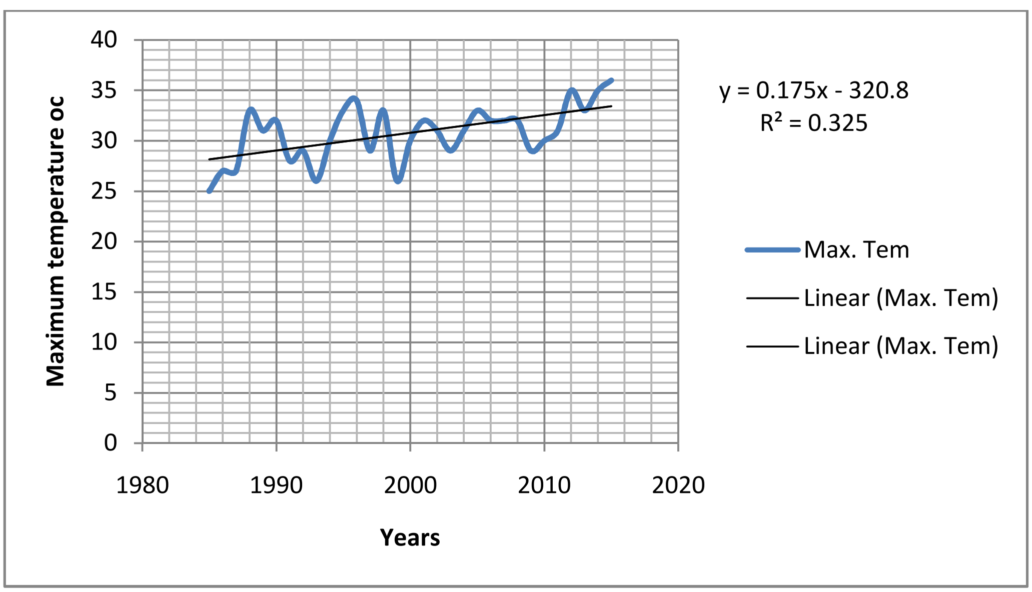

Figure 1-6 Annual maximum temperature variation within 1985-2015

Though the variation in temperature over this period of 30 years has fluctuated, 1980 was the only period when the temperature was 25°c. Subsequently the maximum temperature has risen to 36°c in 2015. R^2=0.325 shows a correlation between the years and temperature increase. Therefore the temperature increased with time.

This rise in temperature may have triggered higher occurrence of rainfall in the area which has been another source of flooding considering the shallow water table of the area which allows the saturation of the soil during rain fall period as well as overflowing of the rivers into the land areas causing continuous flooding. Diagram below show the graph of rainfall frequency in Abia state.

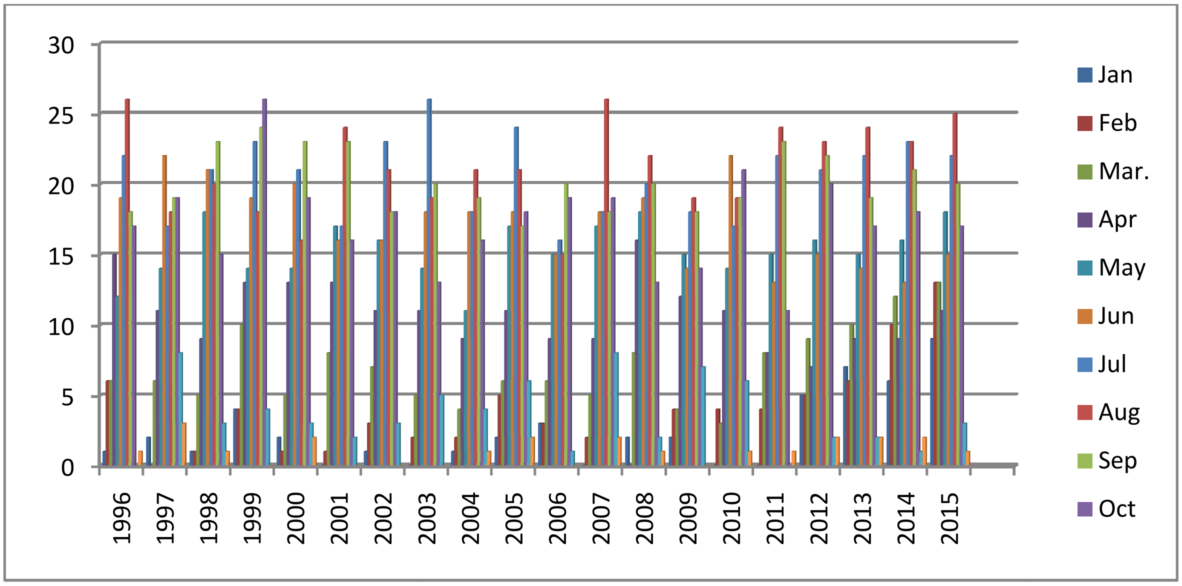

Figure 1-7 Rainfall frequency within 1996 to 2015 in Abia state (plotted in days)

Rainfall frequency of Abia state over 20 years period is displayed to show the variation in monthly rainfall for each year. December, January and February are the major months of dry season when there should be no rainfall but this graph has shown that within these months in the last 20 years, there was rainfall and the frequency of occurrence increased over the years.

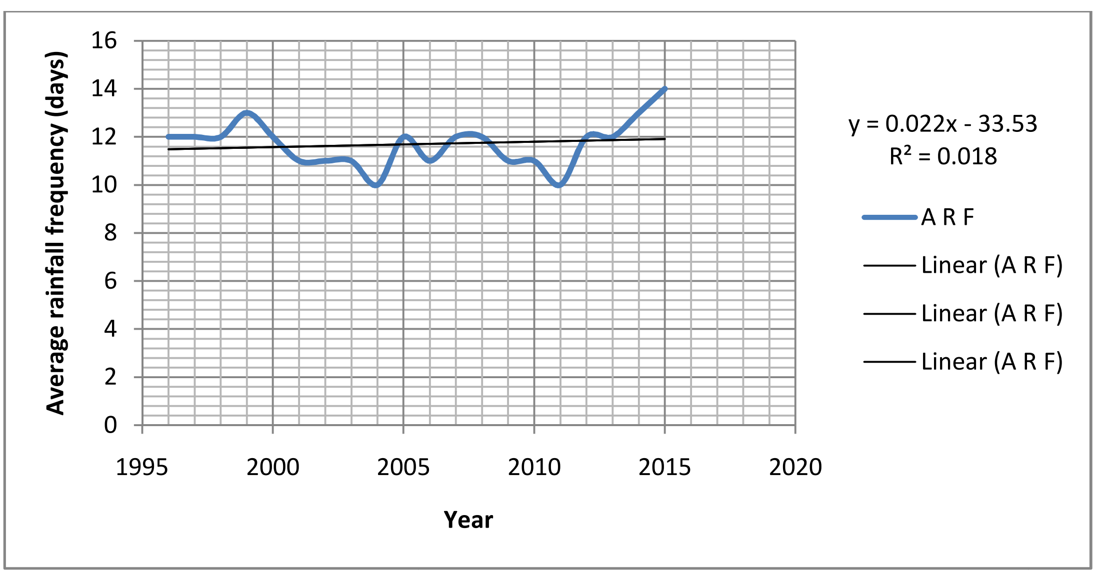

Figure 1-8 Average rainfall frequency over period of 20 years

The result from the graph shows a positive correlation since $R^2 = 0.018$. Therefore when this result is compared with the result of maximum temperature it will be discovered that as the temperature was increasing, the average rainfall frequency was also increasing and with the increase in average rainfall frequency, the rate of flooding also increased thereby causing groundwater contamination in the area.

NIMET [10] also observed the climatic condition of Nigeria within the period of 1941 to 2000 and specified from their results that annual rainfall decreased by 2-8mm in most northern part of the country and increased to 2-4mm in most southern parts of the country, situations that arose from either rainfall cessation or increase in rainfall frequency. They also stated that within 1941 to 2000, temperature increase was observed in extreme north east part of the country, extreme north west and extreme south west as 1.4-1.9^{o}c and other parts of the country also recorded significant increases. They also projected temperature increase of 0.04^{o}c from 2000 until 2046-2056 and increase of 0.08^{o}c in 2050.

The diagram below will display the flood risk map of Abia state with overlay of contaminants in line with effects of flooding in each area.

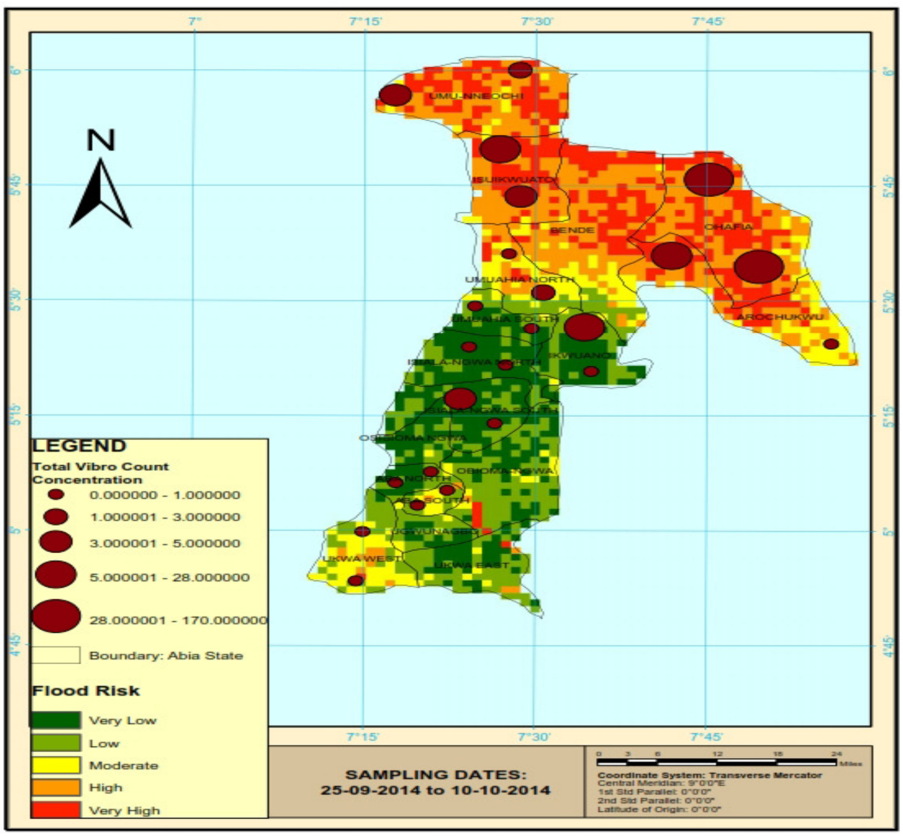

Figure 1-9 Total Vibrio contamination on flood risk map in Abia state

Figure 1-9 shows that Total Vibrio contamination had highest concentration within high flood risk and very high flood risk areas. The area dominated by high flood risk and very high risk is Abia state north senatorial district made up of 5 Local government areas LGAs including Arochukwu, Ohafia, Bende, Isikwuato and Ummunnochi LGAs. The middle part on the map known as Abia central distric shared the features of very low flood risk area, low flood risk area, moderate flood risk area and high flood risk area is made up of these LGAs; Umuahia north, Umuahia south, Ikwuano, IsialaNgwa north andIsialaNgwa south while the downward part of the map known as Abia south district which sheared the features very low flood risk area, low flood risk area, and slightly moderate flood risk area high flood risk area, and very high flood risk area is made up of Osisioma, Aba north, Aba south, Obingwa, Ugwunagbo, Ukwa west and Ukwa east LGAs. Vibrio contamination was also found in Abia central district and Abia south district. The topography and rainfall pattern in Abia north district affected the intensity of flooding in Abia north where people are basically resident down the slope lying between hills which allows flooding and heavy erosion in the area and subsequent contamination of groundwater. Abia central district also partially has that type of topography and such area with similar topography with Abia north shows the same flood risk intensity. Abia south district has a stable terrain but the shallow nature of groundwater table and poor drainage system has caused regular flooding in the area which contaminated groundwater. Lots of residents of Abia state still make use of hand dug wells which are always covered by flood during rainfall that heavily contaminates groundwater.

Map overlay of total salmonella count on flood risk map is displayed below forAbia state.

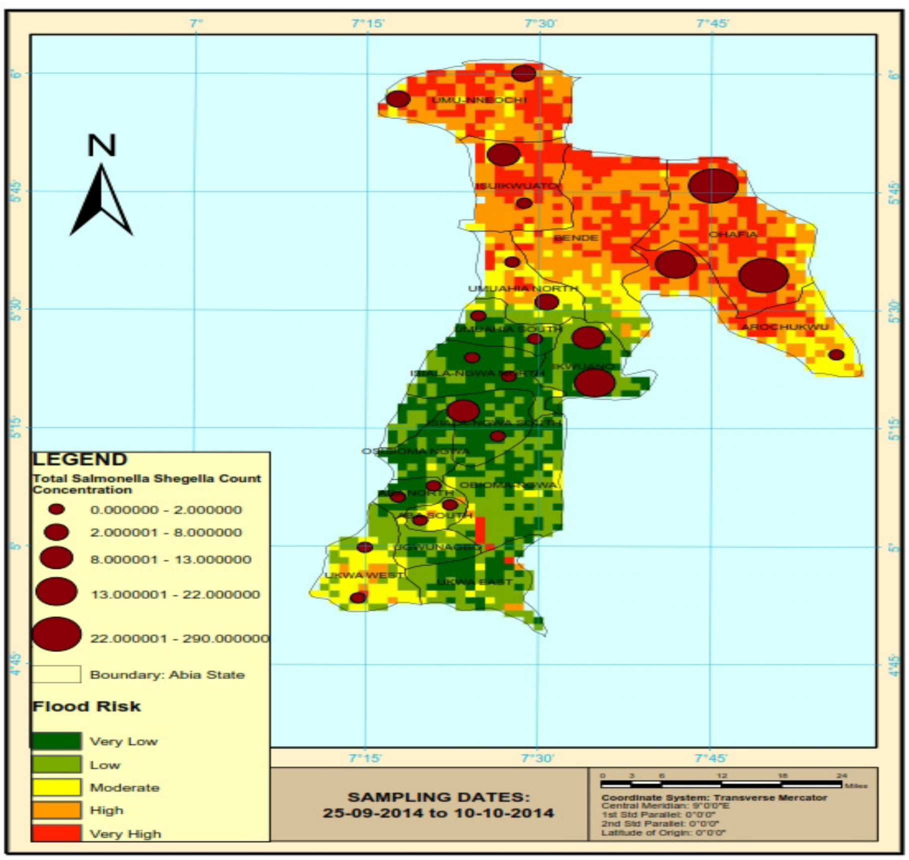

Figure 1-10 Total salmonella contamination on flood risk map in Abia state

The map overlay of total salmonella contamination also had highest concentration of contamination in Abia north district which shows that the contamination is affected by flood while Abia central had high concentration of salmonella contamination because of the replications of hand dug wells in the area which are always covered by flood during rainfalls while Abia south district had contaminations because the drainage system in the area is poor and mostly block with shallow water table causing saturation of the soil during rainy season which triggers flooding and groundwater contamination in the area.

Diagram below is the flood risk map of Abia state showing overlay of total fecal count.

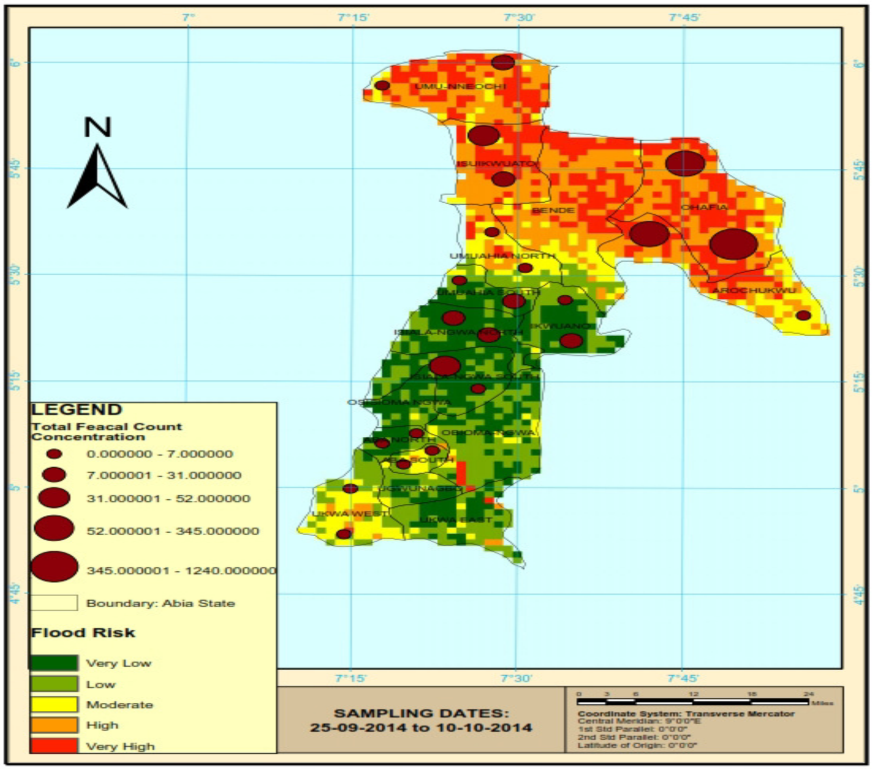

Figure 1-11 Total fecal contamination on flood risk map of Abia state

High concentration of total fecal count in Abia north district is clear on the map showing that the more flooded an area is the more contaminated the groundwater though this is dependent on the source of groundwater in the area but since the residents of Abia north still had hand dug wells the wells always get contaminated during flooding. Abia central senatorial district also had high contamination concentration due to the use of hand dug wells but contamination in Abia south district is influenced by the drainage system and water table in the area with lots of waste dump sites and pit toilets in the area.

Figure 1-12 below shows overlay of total E coli contamination on flood risk map of Abia state and the concentration of contamination in Abia north district, Abia central district and Abia south district. Abia north district has five Local government areas which include; Arochukwu local government area, Ohafia local government area, Bende local government area, Isukwuato local government area and Umunnochi local government area. Abia central district comprises of Umuahia north local government area, Umuahia south local government area, Ikwuano local government area, IsialaNgwa north local government area andIsialaNgwa south local government area while Abia south district include; Aba north local government area, Aba south local government area, Osisioma local government area, Ukwa west local government area, Ukwa east local government area, Obingwa local government area and Ugwunagbo local government area.

The concentration of E coli contamination was affected by the extent of flooding in the area, while flooding was affected by topography, drainage system and depth of water table.

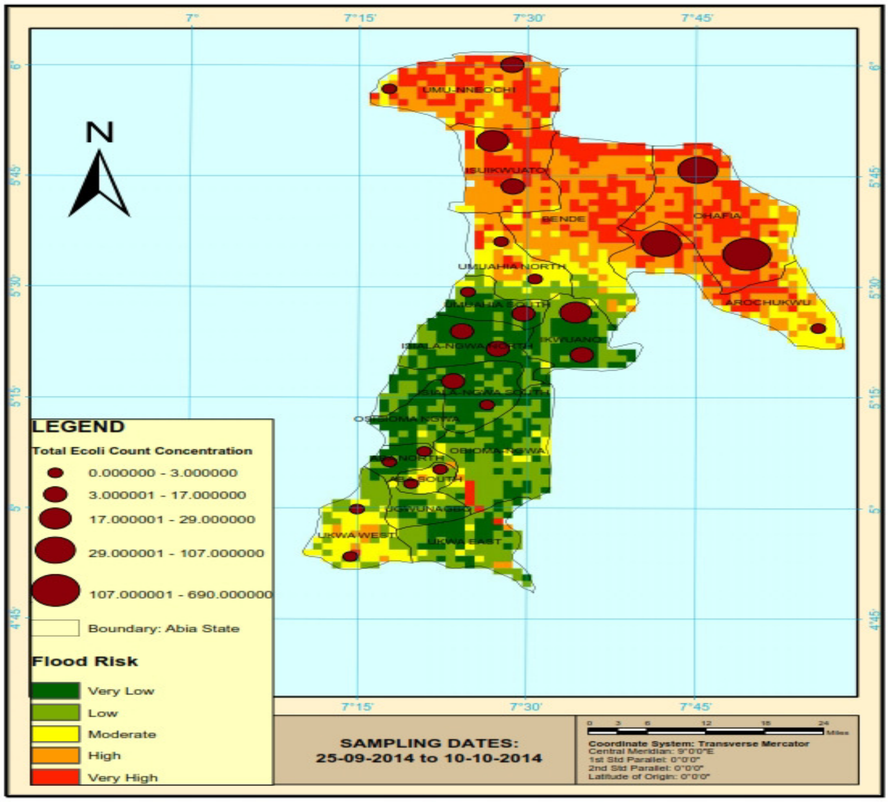

Figure 1-12 Total E coli contamination on flood risk map of Abia state

High concentration of E coli contamination in Abia north districts shows that the more flooded the area, the more contamination of groundwater the area will experience while contamination in Abia central district was determined by topography and flooding of hand dug wells, contaminations in Abia south was as a result of bad drainage system, shallow water table and rampant use of pit toilets in the area.

Flooding and groundwater contamination has been stated by Chima et al [11] to have been responsible for the occurrence of water related diseases in Niger delta region of Nigeria. Therefore it became very necessary to devise means of adaptation to this condition as a proactive measure to subvert the damages that accrue from flooding and groundwater contamination.

BNRCC [12]stated that natural resources in Niger Delta are vulnerable to climate change impacts with its negative effects on health. The health impacts of climate change include accelerated heat waves, flood events, droughts and windstorms while some of climate change impacts like health related situations from spread of water related diseases linked to pollution of water resources are indirect.Effects of climate change on groundwater resources will bring about limited availability of best quality water due to groundwater contamination caused by flooding in the area.

3.1: **Adaptation to Climate Change**

Adaptation to climate change induced flooding and groundwater contamination in Abia state will be focused on measures that can ameliorate any difficult situation occasioned by flooding and subsequent groundwater vulnerability to contaminations triggered by flooding in the area. Specific measures that could be used include:

(1) Introduction of use of large capacity overhead water storage tanks in the public water supply section which should always be treated before house hold supply during flood events.

(2) Construction of good drainage systems in the area that can reduce the rate of flooding the area and construction of central sewage system to encourage recycling of centrally collected waste water for use.

(3) Provision of drilled bore holes for the communities and placing a ban on use of unprotected hand dug wells that could be easily contaminated by flooding.

(4) Encouraging the use of modern toilet systems like water closet toilets and abolishing the use of pit toilets that always contaminate groundwater in the area.

(5) Encouraging domestic water treatment like boiling to 100^{o}c and sieving in individual households before consumption of water by inhabitants.

(6) Immunization of the inhabitants of the state against water related diseases that occur regularly as a result of groundwater contamination.

(7) Government intervention on public orientation on best sanitation practices that will reduce manifestation of water related diseases.

4.0: Conclusion

The aim of this study has been achieved since the research has shown that climate change actually exist in Nigeria with its subsequent flood situations that contaminate groundwater in the area bringing about the list of possible adaptation strategies that could reduce the negative impacts faced by the vulnerable areas of the state. This was achieved with help of combination of showcased laboratory results of analyzed water samples which proved that the groundwater was actually contaminated with microbial substances that caused regular occurrence of water related diseases. The analysis was done using membrane filtration technique and the results were shown on the graph with the help of excel spread sheet. Arc GIS 10.2 was used to design the flood risk map showing overlay on contamination in relation to the flood vulnerability. Finally, secondary data from different sources was used to show that there exits flooding in the area as a result of climate change which was showcased on the graphs of maximum temperature and rainfall frequency variations in Abia state. Therefore if all the adaption measures are put in place it will help to drastically reduce the impact of climate change induced flooding and groundwater contamination in Abia state, Nigeria.

Acknowledgement

I am very grateful to my PhD supervisors, Prof. Dr. Hans-Juergen Voigt and Associate Prof. Dr Alex Okparaas well asProf. Dr. Dr. H.C. Michael SchmidtDean of faculty of environmental science and process engineering and Dr. DmitryPalekhov LL.Mthe ERM ,PhD coordinator for all academic advice and mentorship on my PhD research and during my course work on latest development in environmental researchthat led to the conclusion of this research.

Reference

[1] UNFCCC (1992) United nation framework convention on climate change FCCC/INFORMAL/84 GE.05-62220 (E) 200705.

[2] IPCC: Working Group I Contribution to the Ipcc fifth Assessment Report (Ar5), Climate Change (2013) The Physical Science Basis, IPCC: Stockholm, available at:http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_Chapter13.pdf.

[3] Máñez M. , Cerdà A. (2014) Prioritization Method for Adaptation Measures to Climate Change in the Water Sector, CSC Report 18, Climate Service Center, Germany.

[4] Nigeria Environmental Study/Action Team (NEST) (2004) Study on Sea Level Rise and Repeated Ocean Surges, Causing coastal erosion and other Environmental Menace in Niger Delta Region of Nigeria 2004; African Journal of Environmental Science and Technology, Vol. 9(1), pp. 55 ISSN: 1996-0786.

[5] AmadiL. ,Ogonor Mac. C.U (2012). Climate change, environmental security and displacement in Nigeria: Experience from the Niger Delta flood disaster, 2012; African Journal of Environmental Technology, Vol .9(1), pp. 53-64, January 2015DOI: 10.5897/AJEST2014.1749 ISSN: 1996-0786.

[6] Udofa I, Fajemirokun F (1978). On a height datum for Nigeria. In: Proceedings of International Symposium on Geodetic Measurements and Computations. Zaria, Nigeria: Ahmadu Bello University, P. 12.

[7] Uyigue. E, Agho. M (2007). Coping with Climate Change and Environmental Degradation in the Niger Delta of Southern Nigeria, Community Research and Development Centre (CREDC) Nigeria.

[8] Adindu.R.U, Igoekwe. M.U, Lebe.N (2012) Groundwater mineralization analysis of Osisioma L.G.A Aba, Abia State, American Journal of Chemistry 2(3)PP. 121-125.

[9] Chima G.N, Nkemdirim V.U,Enyinna G.C (2008) phisico-chemical and bacteriological analysis of water samples from selected points in Umuahia urban: the implication for health. International Journal of biotechnology and allied sciences, Vol.3(1) pp 339-345.

[10] NIMET (2008). Nigeria Climate Review Bulletin 2007. Nigerian Meteorological Agency. February 2008. NIMET - No. 001.

[11] Chima.G.N., Enyinna G.C, Alozie .M.C, Diagh.O.N.(2007) Swamp reclamation for human habitation its implication for sustainability of wetlands. International Journal of biotechnology and allied sciences (IJOBAS) Vol.2 no.3 PP. 230-237.

[12] Building Nigeria's Response to Climate Change (BNRCC) project (2011) Electronic version: ISBN 978-0-9878656-5-6 Book version: ISBN 978-0-9878656-4-9. Federal ministry of environment special climate change unit. Issues on national adaptation strategy and plan of action on climate change for nigeria (naspa-ccn).