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Awareness of Climate Change and Saltwater Intrusion to Underground Water in Selected Coastal Areas of South-Western Nigeria

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Abstract: The study assessed the awareness salt water intrusion to freshwater and underground water and the effect on coastal areas. Simple random sampling technique was used to select 200 respondents Primary and secondary data were used to accomplish the objectives, and the primary data were collected through the use of questionnaire and focused group discussion. Descriptive and inferential statistics were applied to data collected. Results showed that 87% claimed awareness of climate-change and linked it to natural occurrence (44 %) and greenhouse gases (23 %) respectively. About 49 % asserted that they had seen impacts of climate change on water quantity and quality while 51 % claimed ignorance. About (92 %) used groundwater source, 58 % of this had self-ownership source while the rest depends on other facilities. About 55.5 % borehole well had salinity above safe level while 44.5 % exceeded not the safe levels but (18.5 %) rated salinity mild 16.5 % low, and 6.0 % high. About (46 %) indicated that the main cause of salinity was flooding and proximity to sea. About (47 %) claimed that high salt concentration in drinking water could lead to skin diseases, diarrhea and cough while (40.5 %) claimed ignorance of consequences. Vulnerability factors showed that elderly people (38%) were mostly affected followed by pregnant women (27 %). The study established that respondents had good awareness of climate change but poor level of awareness on salt water intrusion to underground water and danger of drinking contaminated water.

Key words: Awareness · Climate change · Salinity · Groundwater and health

INTRODUCTION

Water is essential for life and it is obtained basically from surface and underground sources [1]. Although both sources contribute immensely to supplying water for human activities, groundwater remained one of the most precious sources which are exploited for domestic, irrigation and industrial purpose all over the world. The quality of water is very important. There is the belief that groundwater is purer than surface water which results in increasing demand and demand exceeds supply [2]. In recent times there are challenges to accessibility of groundwater due to so many factors: urbanization, industrialization and agricultural activities coupled with environmental pollution/degradation and indiscriminate disposal of all kinds of wastes. These are perceived to pose serious pollution threats with all its concomitant health hazards on groundwater quality especially in urban areas as reported by [3]. Besides the case of unstable extraction of groundwater which may result in declining water level, adverse salt balance and salt water intrusion in coastal environment. The contamination caused by saltwater intrusion is a major challenge in coastal aquifers. Increasing salinity of natural drinking water sources is one of the many problems that affect low-income countries which have not been fully explored. This problem is exacerbated by rising sea-levels, owing to climate change, and other contributing factors, like changes in fresh water flow from rivers and increased shrimp farming along the coastal areas. Many interrelated processes control the chemical quality of ground water, understanding and awareness of such processes is essential before one can act toward achieving a safe water quality status and improvement. In coastal areas, the process of recharge causes groundwater to flow from inland areas with higher water-table elevations toward the sea at a lower elevation. Sea water also saturates the ground along the coast, creating a boundary along which

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saltwater meets freshwater beneath the surface and since saltwater is denser than freshwater, saline groundwater may "intrude" beneath into fresh groundwater, creating a saltwater "wedge" at the coastline. Also the local hydraulic and density gradients, the nature of saltwater-freshwater interaction is controlled by numerous factors, including the characteristics of the aquifer (such as permeability and thickness) and the characteristics of any layers of rock underlying or overlying the aquifer [4]. The resulting saltwater-freshwater interface is not so much a firm boundary as a transition zone (or zone of dispersion) reflecting changes in salinity. Saltwater intrusion can distort the suitability of groundwater for both drinking and agricultural purposes. The world health organization standards specified that the salinity of drinking water should not be greater than 800 EC units (approximately 500 mg/L). Khan *et al*., [5] reported that groundwater salinization would affect livelihoods of people and increases health risks through contamination of drinking water. The Inter-salt epidemiological study showed an association between dietary salt intake and high blood pressure [6] and reported that a sodium intake of higher than 1.8 g/day (approximately 100 mmol/day) caused a rise in systolic blood pressure and diastolic blood pressure of approximately 3–6/0– 3 mmHg. According to a review by Macgregor *et al (REF)* reducing salt intake from 10–12 to 5–6 g/day will have a major effect on blood pressure, thereby preventing cardiovascular mortality [7]. High blood pressure throughout the range seen in developed countries is the major cause of cardiovascular disease, responsible for 62% of strokes and 49% of coronary heart disease. In fact, Vineis *et al*., [8] reported that if salinity on the coasts remains unchecked, a global crisis related to freshwater availability and quality with clear human health implications may increase. In developed nations, much has been done on saltwater intrusion assessment with respect to status, significance and possible variation with seasons. Desalination plants are used to partly remove salt and other minerals from water sources, but this is unlikely to be a sustainable option for low-income countries affected by high salinity. In Nigeria, studies through geophysical and geochemical techniques have shown that some parts of the zones have been deeply contaminated with saltwater intrusion due to diverse reasons [9] but the social perception survey of the people about saltwater intrusion and possible health implications of taking such water on the long run remained very few.

- What are the profiles of the respondent on the basis of their socio-demographic attributes?
- What is the degree of awareness of the effects of salinity on fresh water resources?
- What are the degrees of awareness of the possible effects of salinity on Agricultural soils?
- What are the degrees of awareness of the possible health implications of drinking saline water? Is there awareness of any implication of salinity on Agricultural soil? What are the degree of awareness of the existing strategies or control measures or mitigation of hazards and associated risks (if any) on fresh water resources?

The objectives of the study include: to identify the socioeconomic characteristics of respondents; to determine the level of awareness of climate change among respondents; to estimate the degree of awareness of salt water intrusion to underground water in coaster line areas and the health implication of such intrusion. The study is aimed at bridging the gap in knowledge via administration of questionnaire to assess the people awareness about saltwater intrusion. This will help policy makers on how to guarantee safe water for coastline area dwellers and preservation of the natural ecosystem in the study areas.

MATERIAL AND METHOD

Study Areas: The study area is shown in Figure 1 comprises of Badagry, Ikorodu and Epe areas of Lagos State and Ilaje area of Ondo State popularly referred as Ondo water side. These locations are situated on longitude 7.5°N and latitude 3.25°N, and have derived savannah vegetation, described with Precambrian crystalline basement complex rocks. The dominant rocks constitute suites of gneisses and quartzite. Three locations were taken in Lagos because of it large coastal characteristics with another prominent sea side in Ondo state. The coastal zone is characterized with a tropical climate consisting of rainy season (April to November) and dry season (December to March). Moreover, high temperatures and humidity as well as marked wet and dry seasons are common features of the region. In term of rainfall, the areas have an annual rainfall ranging between 1, 500 and 4,000 mm [10]. The geomorphology of the Lagos Lagoon is classified under the Barrier-Lagoon Complex, which extends for about 250km from the Nigerian/Benin Republic border to Ajumo village.

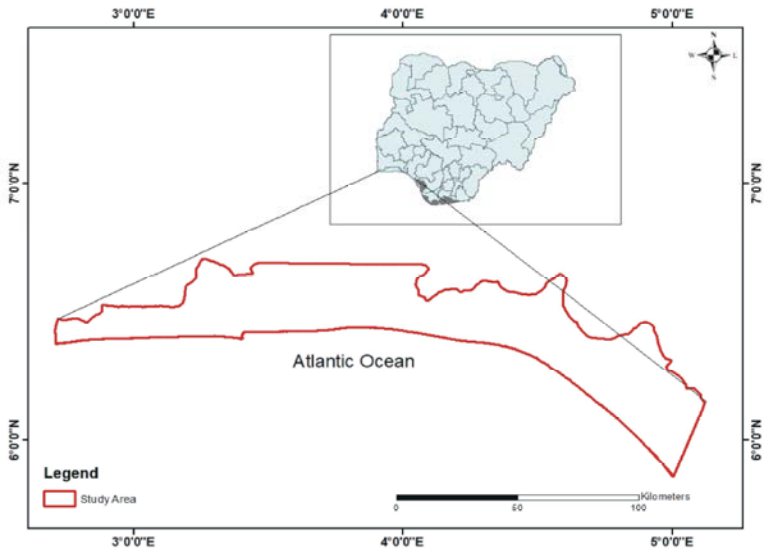

Fig. 1: Map of Study areas

Table 1: Selected communities and numbers of respondents

Serial Number	Selected Local Government	Numbers of respondents
1	Badagry	50
2	Ikorodu	50
3	Epe	50
4	Ilaje	50
Total	200	

Source: Field Data 2 018

Sampling Techniques and Size: Data on saltwater intrusion were generated through the use of questionnaire. Proportional random sampling was used to select one Local Government Area from Ondo state and three Local Government Area of Lagos State followed by disproportional random sampling of fifty respondents each from Badagry, Ilaje, Ikorodu and Epe Local Government Areas in the two States giving a total sample size of two hundred respondents for the study. Since most of the groundwater are concentrated in the selected areas, household living in these areas were interviewed using focused group discussion and the use of questionnaire to collect primary data. Information collected were from the household heads where there was none, relevant information were obtained from knowledgeable members of the family as shown in Table 1.

Data were obtained from two major sources. Primary data were obtained through the administration of questionnaire to selected respondents from communities of Badagry, Ikorodu, Epe and Ilaje areas. Secondary data were sought from published materials such as textbook, journals, internet items. Considering the nature of the area of the research, the size of the population and the resources available for the work, location of the key areas of the study were selected through sampling taking into consideration, the population, proximity to the sea and availability of wells.

RESULTS

Socio-economic and Demographic Variables of the Respondents: A total of two hundred completed survey questionnaire copies were collected from representatives in the entire study area with a response rate of 100% . Majority (73.5%) of the respondents are between 10 – 40 years of age, 60- 80 (22.5%) while 3.5% was above 80 and 0.5% did not respond. The respondents were made up of 51 % males and 49% females respectively. Majority (55%) of the respondents were married while 39.0% were singled. The remaining 5.5% were widows as shown in Table 2. Majority of the household heads or representatives were educated or literate (95%). Respondents with no formal education were very marginal (5%). The principal occupation pursue of the household head was civil servants (60%), followed by selling labour (18.5%). Only 6% was farmers while 20.5% comprises of students' teachers, applicants, among others.

Climate Change: The survey showed that 87% of the respondents claimed awareness of climate-change while 13 % claimed ignorant. Some household heads (44%) linked climate change to natural occurrence, greenhouse

Table 2: Socio-economic and demographic variables of the respondents in the study area

Characterization	Frequency
Gender	
Male	102 (51%)
Female	98 (49%)
Marital status	
Single	78 (39%)
Married	111 (55.5%)
Widower	11 (5.5%)
Age group	
10 – 40	147(73.5%)
41 – 80	45 (22.5%)
80 and above	7 (3.5%)
No response	5 (0.5%0
Educational Status	
Primary	41 (20.5%)
Secondary	55 (27.5%)
Tertiary	94 (47%)
no formal	10 (5%)
Occupational distribution	
Civil servant	110 (60%)
Farmers	12 (6%)
Buying and selling	37 (18.5)
Applicant	12 (6%)
Student s' Teacher	29 (14.5%)
Household size	
2 – 4	81 (40.5%)
5 – 7	81 (40.5%)
8 – 11	19 (9.5%)
12 – 16	8 (4%)
no response	11 (5.5%)

Source: Field Data 2018

gases (25%), and the act of god/goddesses (6%). Only 28.5 % of the respondents had no idea of possible causes of the phenomenon as shown in Table 3.

Water Facilities: The result indicated majority (97.5%) of the residents had their drinking water source within fifty meter to their homes. Analysis revealed that majority of the respondents (58%) owned their water sources in forms of shallow or deep well while about 25.5% of the respondents depended on their neighbor, 12.5% (Government), 3.5% (Non-governmental organizational) and 0.5% (community water assisted projects) respectively. Water quality rating as indicated by the respondents showed that majority (43 %) agreed that the quality of the water they drink was very good, (15%) while (42%) of the respondents claimed the water was poor. Majority of the respondents (55%) were not aware of cases of saline water intrusion while 45 % claimed they had awareness. The respondents who observed saline water intrusion in their drinking water was about 55% in

Table 3: Climate change and soil water variables of the respondents

Characteristics	Frequency	Percentage
Causes of climate change		
Greenhouse gases	50	25.0
Act of gods	5	2.5
Natural	88	44.0
I don't know	57	28.5
Effects of climate change(Agriculture)		
Salinity	15	7.5
Infertility	26	13.0
Stunted growth	33	16.5
Low yield	49	24.5
Salinity, infertility, stunted growth, Low yield	11	5.5
I don't known	55	27.5
Infertility, stunted growth, low yield	4	2.0
Stunted growth, low yield	7	3.5
Effects of proximity to sea(farm land)		
Salinity	45	22.5
Flood	20	10.0
Infertility	38	19.0
Salinity flood		
,infertility	9	4.5
Salinity, flood	3	1.5
Salinity, infertility	2	1.0
No idea	83	41.5
Sources of drinking water		
surface water	3	1.5
shallow well	87	43.5
Borehole	97	48.5
rain harvested	3	1.5
public water	10	5
Rating of drinking water		
Very good	86	43
Good	30	15
Bad	51	25.5
Worse	29	14.5
Salt water noticed		
Yes	71	35.5
No	129	64.5

Source: Field Data 2018

deep wells while 44.5 % observed it in shallow wells respectively. Only 0.5 % observed it in river water as illustrated in the Table 3.

Figure 3 showed the proportion of common household diseases among the residents of these coastal zones which include malaria (64.5%), diarrhea (5.5%), skin diseases (2.5%), cholera (2.0%), measles and typhoid at (1%) respectively. Salinity or saltwater intrusion is believed to both natural and anthropogenic in origin, most of the respondents (46%) opined that salt concentration in water increased as a result of flooding, proximity to the sea (21.5%), nearness to the sea as influenced by climate change (14.5%), water source (3.5%), while 30.5% of the respondents were ignorant of possible causes. Most of

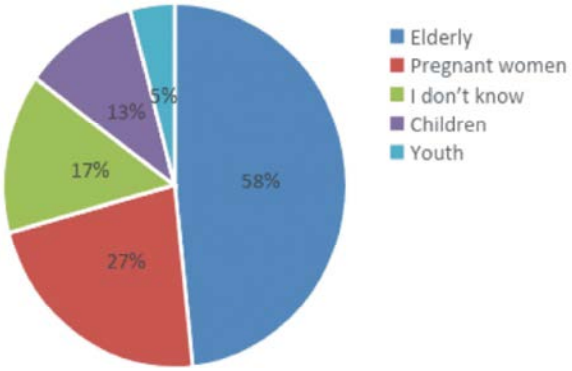

Fig. 2: Vulnerability perception of the respondents

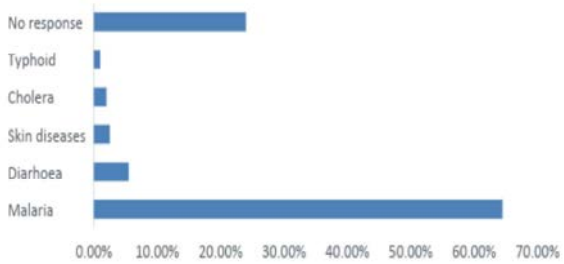

Fig. 3: Common Diseases distributions

the residents did not rank (62.5 %) their drinking water on salinity, medium (18.5 %), low (16.5 %) and high (6 %) ranking respectively.

Implication of drinking saline contaminated water by the respondents showed that majority (43.5 %) posited that negative consequences of intake of high salt or mineralized water was diarrhea, followed by cough (38 %), skin diseases (13.5 %), dysentery (4 %) and hypertension (1 %) respectively. More also, about 24 % of the respondents opined that salt water could be a source of mineral to the body while 74 % disagreed.

Vulnerability index showed that elderly people (38 %) were mostly affected followed by pregnant women (27%) and children (13%) and youth (5%) respectively. Only 17% of the respondents claimed ignorant of any possible implication of intake of salty water (Figure 2). About 33% of the respondents did not treat water for drinking while the rest claimed they used of boiling (10%), sieving (10.5%), addition of alum (20%), chlorination (21.5) and only 5% did not respond respectively as shown in Figure 3. Figure 3 showed the proportion of common household diseases among the residents of these coastal zones which include malaria (64.5%), diarrhea (5.5%), skin diseases (2.5%), cholera (2.0%), measles and typhoid at (1%) respectively.

DISCUSSION

A total of two hundred completed copies of a questionnaire were collected from respondents in the entire region resulting in a response rate 100% which indicated a good percentage response for the study. The household heads or representatives were educated or literate (95 %), the literacy level affected information generation as most of the respondents actively participate in answering the elicited questions. It was observed that the higher level of literacy of the respondents was directly linked with high response in the course of the survey, similar to Climate Change Survey Report (2012) which reported high response with high literacy percent. The prevailing occupation among the household heads showed a moderate economic situation of the areas. About 87% of the respondent claimed awareness of climate change and observed that climate change was due to different climatic event in the area where they live. The result is similar to Nega *et al.,* [11], where people claimed awareness of but it was based on climatic events where they live. About 72.5 % of the respondents indicated that the effects of climate change were water and soil salinity, infertility, stunted growth and low yield while about 27.5% did not state any kind of impacts. The survey outcome showed that crop failure due to climate change was a potential threat to food security at the face of unmitigated climate impacts on agriculture if adequate mitigation and adaptation measures were not taken.

Majority (97.5 %) of the residents derive their drinking water within a 50 meter distance from their homes. This implied high water availability and accessibility in the zones. That was also expected since the location of the study was relatively closed to water bodies. The result agreed with Hassan *et al.,* [12], who reported that coastal residents had easier access to water within few meters to their residence but were only threatened by the quality of such water. Drinking water rating showed that about 58 % of the respondents claimed good quality of water. Personal observation and focused group discussion with the residence of the zone showed that the drinking water quality were bad due to nature of the zone and other environmental challenges. Peculiarity of the areas includes poor well construction, lack of apron, inappropriate citing of wells among others. Majority (99.5 %) of the respondents claimed they noticed saltwater in underground water type. It indicated that groundwater was more susceptible or vulnerable to

saltwater intrusion in the area of the study. Most people observed that saline contaminated water did not have any benefits but has rather increased cases of illness among the dwellers in the areas. Salt water is composed of highly mineralized water. Majority claimed that the high concentration of the essential mineral above the permissible limits actually constitutes unpredictable health challenges. This finding agrees with Khan *et al.,* [5] who reported that groundwater salinization would affect livelihoods of people and increase health risks. Hasan *et al.* [12], reported similar cases in the coastal region of Bangladesh that saline water intake was linked with diarrhea, dysentery and skin diseases among others. Water treatment is a viable means of making water fit for drinking irrespective of the pollution source. Some of the residence (33%) probably drank the water without treatment because of the notion that underground waters are less polluted even without observing the necessary sanitary conditions. It was observed that the treatment adopted by most (62%) of those who claimed water treatment were not wholesome. It was observed that no single method as indicated by the respondents could make water fit for drinking. it is a combination of these methods that make water fit physically, chemically and microbiologically for drinking. Identified common household diseases were (malaria (64.5%), diarrhea (5.5%), skin diseases (2.5%), cholera (2.0%), measles and typhoid (1%) respectively in the region. Dysentery, diarrhea and skin diseases as showed in this study have been reportedly associated with intake of contaminated water [12]. The study showed that one of the significant impacts of climate change over the year is invasion/intrusion of saline water into fresh water aquifers in coastal areas. Water quality changes have been considered as a consequence of saltwater intrusion among other factors. The quality changes are as a result of excess soluble salts due to mixing of seawater with freshwater or inland movement of seawater as revealed by this study. The need to verify whether the observed water quality is suitable for the intended use is the main reason for the assessments of the quality of the water because it would play a significant role in the development of water quality control and management in the area [13].

CONCLUSIONS

The study established that coastline dwellers had good awareness of climate change buts poor level of awareness on salt water intrusion to underground water and inadequate knowledge of the danger of drinking heavy metal contaminated water and significance of this coastline status via geochemical analysis so as to be able to adopt ameliorating measures to safeguard the population and eco-system of the region. The survey showed that good numbers of the coastline dwellers claimed awareness of climate-change and the respondents indicated the effects of climate change to include groundwater salinity, infertility, stunted growth and low yield in Agriculture among others things. Evidence of salt taste was observed in underground water mainly as reported by the dwellers of this zone due to rising sea level and other anthropogenic influences. The high concentration of the essential mineral above the permissible limits actually constitutes unpredictable health challenges. The survey outcome showed that the likelihood of crop failure due to climate change is a potential threat to food security at the face of unmitigated climate impacts on agriculture if adequate mitigation and adaptation measures are not taken and the high concentration of the essential mineral above the permissible limits due to salt water intrusion to underground water actually constitutes unpredictable health challenge

Recommendations: The research provides some baseline information and knowledge of the state of the area in relation to groundwater and soil salinity as both salinity gradually increased in the South Western coast of Nigeria, and the need for proactive measures to mitigate or adapt this menace. Arising from the outcome of this study the following recommendations are proffered:

- There is need for hydro-geochemical analysis of the water samples in the area to assess the status, significance and possible variations of salt water intrusion into the aquifers across the study areas.
- There is need for holistic development and implementation of monitoring program and water safety plan for the entire coastline to safeguard water resources and public health of the residents in the region.

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