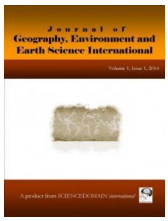

Journal of Geography, Environment and Earth Science International
2(4): 163-172, 2015; Article no.JGEESI.2015.015

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An Examination of Safe Water Supply Determinants in Some Peri-Urban Communities of South-East Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author EEE designed the work, collected and statistically analyzed the data. Author HOA wrote the initial draft of the manuscript while author BME participated in the language correction. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JGEESI/2015/14767
Editor(s):
(1) Anthony R. Lupo, Department of Soil, Environmental and Atmospheric Science, University of Missouri, Columbia, USA.
Reviewers:
(1) Anonymous, University of Port Harcourt, Nigeria.
(2) Anonymous, Federal University, Nigeria.
(3) Frederick Amu-Mensah, Water Research Institute of the Council for Scientific and Industrial Research, Ghana.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=1105&id=42&aid=9512

Original Research Article

Received 20th October 2014
Accepted 15th May 2015
Published 30th May 2015

ABSTRACT

In most peri-urban communities of south east Nigeria, shortages of domestic water supply relative to demand is a common feature of such areas. This is because most of these peri-urban communities usually fall outside the urban water supply projects physical boundary, thus forcing the people who live in such areas to consume water from doubtful sources which most often contain pathogens found in human faeces. Apart from consuming water from doubtful sources, most inhabitants of this area also travel long distances to collect it or pay dearly to purchase from water vendors. The study was therefore undertaken to determine the factors necessary for safe water supply in such areas. Towards achieving this objective, 2000 questionnaire were designed and administered to households in the area between January and June, 2013. A total of 15 factors were isolated and analysed in 10 peri-urban communities of the region. The major analytical tool employed was multiple regression analysis with which we were able to determine the relative

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importance of each variable using SPSS version 20. Based on the result obtained, important determining factors for safe and sustainable water services namely open defeacation near the water source, dominant type of land use near water source and distance to refuse dumpwere discussed in terms of their implications to the formulation of needed policy that will ensure improvement in supply of the service to meet demand.

Keywords: Shortages; water supply; vendor; periurban; feaces.

1. INTRODUCTION

In most peri-urban communities in Nigeria, there are multiple sources of water supply with municipal, shallow wells, vendors, streams and rain water sources being the most common. One common feature of all the sources is that water collected from them is of poor quality although in varying degrees. Water collected from the municipal source is always adjudged the best in terms of quality although the standard is far short of prevalent international standards. Conversely, both shallow wells and streams are recognized as the sources with the lowest quality [1-3]. The problem of inadequate safe drinking water supply is, therefore, of national concern in Nigeria. The continued increase in the population of such areas with associated – economic activities impose enormous pressure on the fresh water supply to the extent that WHO minimum recommendation of per-capita water consumption of 20 litres per day is becoming increasingly difficult to realize in parts of such urban and peri-urban communities [4,5]. Increasing access to safe water supply is a sure way of ensuring a healthy populace. A number of researchers have investigated the pollution level of rivers, streams and shallow wells that serve as source of water supply to peri-urban communities of South Eastern Nigeria and their health implications [6-8]. In all developing countries including Nigeria, the principal risks to human health associated with the consumption of polluted water are microbiological in nature although there are significant concerns about chemical contamination. The risk of acquiring a waterborne infection increases with the level of contamination by pathogenic micro-organisms There are indeed a wide variety of technologies for treating water at the point of need or use and the common methods include aeration, filtration and disinfection which are employed to remove physical and microbiological contaminants, but not chemical contaminants [9].

In South Eastern Nigeria, government efforts at improving sanitation and hygiene has made some inhabitants of peri-urban settlements to embark of various forms of water treatment before use. [10] reported on how many peri-urban communities in Owerri urban area uses the method of water boiling as a way of disinfecting their water before consumption. Boiling is a very effective methodof disinfecting water, but it is energy consuming. Apart from the high cost of the energy involved in boiling water, the other disadvantage is the change in taste of the water. Apart from boiling many other ways exist to ensure that water available for consumption is safe from contaminants.

Many studies in peri-urban water supply in South-East Nigeria largely involve investigations into the degree of water scarcity and its associated water pollution and in some instances local ways of purifying them. [11-13] but the study of determinants of safe water supply in these communities has remained scanty. The aim of this paper, therefore, is to determine the factors that have tended to inhibit safe water supply in the study area. The result of this study will provoke government interest in tackling the age long problem of providing safe water to the inhabitants of the area as well as attract donor agencies that wish to partner with the governments of the area to tackle the problem.

2. MATERIALS AND METHODS

2.1 Area of Study

The South East geopolitical zone of Nigeria has ten out of fifteen urban areas in Eastern Nigeria, and consists of five States namely Abia, Anambra, Ebonyi, Enugu and Imo States and which are located between Latitudes 5º.00^{1}N and 7º.00^{1}N and Longitudes 6º.42^{1}E and 8º.20^{1}E, (Fig. 1). It is surrounded by Benue and Kogi States in the north, Rivers and Akwa-Ibom States in the South, Cross-River State in the east as well as Delta State in the west. It covers an approximate area of 29,000sqkm and has a 2013 projected population of 20,003,200 from the 2006 base figure of 16, 595, 555 (NPC, 2006).

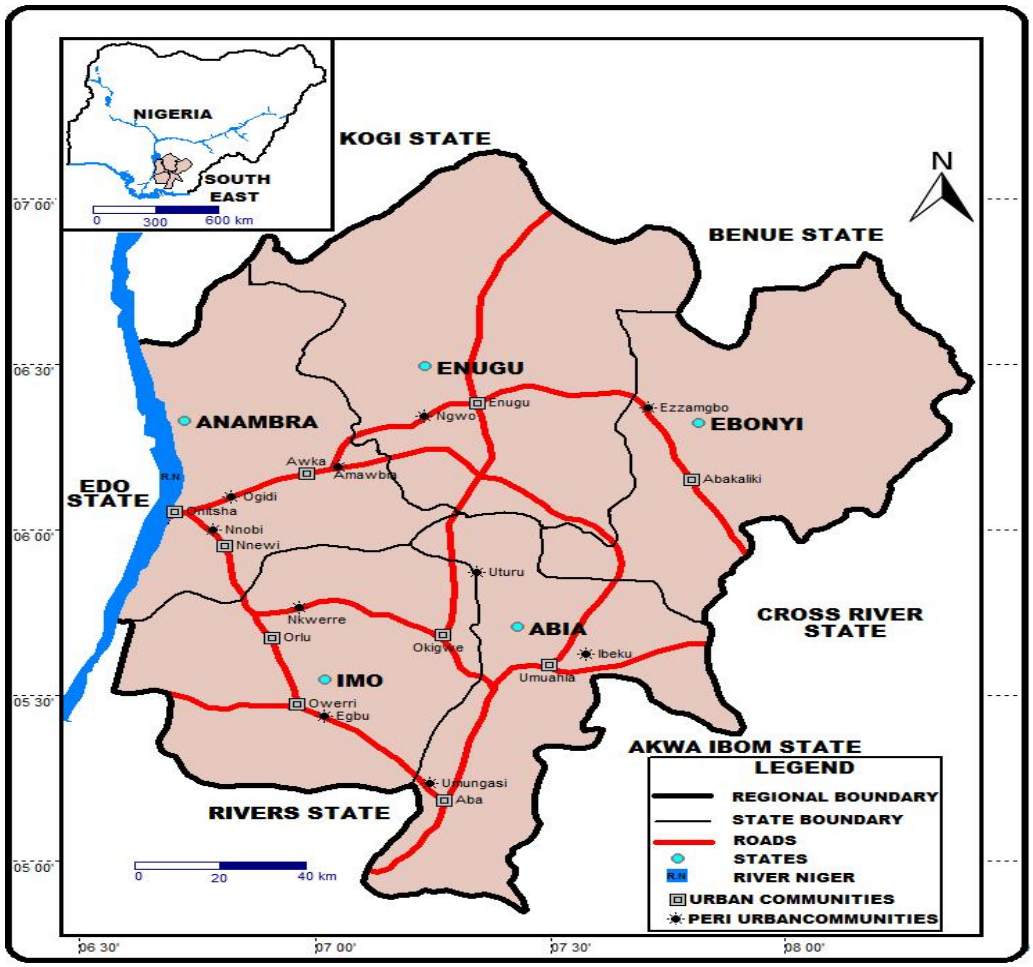

Fig. 1. Map of South East Nigeria showing peri urban communities

The climate of the area is Hot-Wet Equatorial with average maximum annual temperature of 28°C and a minimum of 24°C. Rainfall begins in March and ends in October while thedry season begins from November and ends in February. The total annual rainfall amounts hover between 1500 mm in the northern parts of the region to 2000 mm in the southern area of the region. Vegetation is typically rainforest, but has largely been disturbed by human activities thus leaving derived Savanna vegetation as patches of the outliers within the area.

Geologically, the northern parts of the region in Anambra, Enugu and Ebonyi States are made up of variegated formations which include the Imo clay shales, upper coal measure, lower coal measure etc. In the southern area around Imo State and a substantial part of Abia State there are Awgu/Ndiabo and Afikpo formations as well as a significant presence of basement complex formation [14]. Ten peri-urban communities were selected for the study from ten urban areas. For each urban area and one prominent peri-urban community close to it was selected as they are Abakaliki (Ezzangbo), Awka (Amawbia), Enugu (Ngwo), Owerri (Egbu), Umuahia (Ibeku), Okigwe (Uturu), Orlu (Nkwerre), Onitsha (Ogidi), Aba (Umungasi), Nnewi (Nnobi): The 2013 population of each peri-urban community are Ezzangbo (73,010), Amawbia (112,301), Ngwo (72,111), Egbu (101, 210) and Ibeku (68, 392), Uturu (112,120), Nkwerre (69,286), Ogidi (102,620), Umungasi (98,266), and Nnobi (78,214).

2.2 Data Collection

Data for the study were collected from households with the questionnaire which was designed and administered to them between January and June 2013. A total of 2000 questionnaires were served on the respondents

according to worked out proportion for each peri-urban community. At the end of the questionnaire administration 1,600 were recovered as some respondents misplaced their copies while a small percentage did not fill the ones served on them. Stratified and random samplings techniques were employed in the administration of questionnaire with each of the ten peri-urban communities forming a stratum. The total number of households in each community are as presented in Table 1 together with sample sizes and the total number of questionnaire returned from each community. Sample proportions from each peri-urban area was determined by dividing the number of households by the total number of households.

From the questionnaire 15 determinants of safe water supply were extracted Table 2 shows the variable label, code, description and their parametization aimed at converting them to mathematical values.

The field data of safe water determinants from each community were calculated using the above parametization technique and presented in Table 3.

2.3 Data Analysis

The above data were analyzed with the Multiple Linear Regression (MCR) statistical technique often employed to analyze causal relationships among dependent and independent variables. The dependent variable is the quantity of water supply in each of the communities during the period of the study obtained from various government publications while data in Table 3 are used as independent variables. The technique may be viewed as a descriptive tool by which the linear dependence of a variable or the other can be summarized and decomposed, or an inferential tool by which the relationships in the population are evaluated from the examination of sample data.

The general expression for the multiple linear regression relation is written as follows:

$$Y=a + b_1 X_1 + b_2 X_2 + b_3 X_3 + \ldots + b_n X_n + e \quad (1)$$

Where y is the dependent variable
$X_1, X_2, X_3, \ldots X_n$ are independent variables
While $b_1, b_2, b_3 \ldots b_n$ are regression

Coefficients; a is the base constant and e is the error term or the proportion of the variance not explained. All data were analyzed using SPSS programme package Version 20.

3. RESULTS

The total amount of water supply was regressed against 15 variables. The combined strength of the relationship between the 15 variables was assessed by multiple correlation coefficient (R). The level of variation was computed to be 85.23% leaving 22.7% unexplained. This shows that 77.7% of the variation in water supply safety is explained by our 15 variables working together. The multiple correlation coefficient (R), the coefficient of determination (R^2) and the standard error of estimates (SEE) of the determinants of water safety in the per-urban areas are presented in Table 4.

Table 1. Sample proportion and size from the peri-urban areas

Stratum (Peri-urban community)	Total no. of household	Proportion	Sample size
Ezzangbo	12, 168	.082	131
Amawbia	18, 168	.123	196
Ngwo	12, 019	.085	136
Egbu	16, 868	.114	182
Ibeku	11, 399	.077	123
Uturu	18, 686	.126	201
Nkwerre	11, 548	.078	125
Ogidi	17, 103	.116	187
Nnobi	13, 036	.088	141
Umungasi	16, 377	.111	178
Total	147, 372	1.00	1600

Source: Field work

Table 2. Variable description and their parametization

S/N	Variable label	Variable code	Variable description	Parametization of variables
1.	CONT	X_1	Average no. of water containers not covered by the household.	The average number of uncovered containers in the household were determined and recorded
2.	SANI	X_2	Average no. of days water stored in the container before use	The number was determined from the respondents and recorded.
3.	OPEN	X_3	Whether or not there is an open defecation around the water sources	If there is open defecation (I) was recorded and if there are none (O) was recorded.
4.	COST	X_4	Total cost of water supply to household per month	Total cost was supplied by the respondents and recorded.
5.	LEAK	X_5	Average number of water leakages in the distribution pipe around the household	This was determined by the respondent while the average for each community was recorded.
6.	TECH	X_6	Type of Technology used in the treatment of water at the point of use.	Each treatment technology was assigned numbers according to its sophistication – Aeration (1) filtration (2) Disinfection (3). The number assigned to a relevant technology in each case was recorded and average found for the peri-urban community.
7.	CUPS	X_7	The average hygienic condition of CUPS for drinking water.	The hygienic condition was determined by examining the E-Coli content of the CUPS and recorded.
8.	ACCE	X_8	The average level of water access in terms of distance.	This distance was determined from respondents and recorded.
9.	WELL	X_9	Sanitary condition of ropes and buckets used in drawing water from wells.	This was determined by examining the E-Coli content of the ropes and buckets.
10	ECON	X_{10}	Average number of human activities near the water source	The average number was determined by the total number divided by total locations.
11.	TYPE	X_{11}	Dominant type of land use near the water source	Dominant land use was observed. Each land use was assigned number according to its pollution potential as follows: Residential (1) Commercial (2) Agricultural (3) and Industrial (4)
12.	PIPES	X_{12}	Whether or not water distribution pipes pass through poor sanitation environment.	When it passes through poor sanitation environment (1) was recorded and when not (O) was recorded.
13.	HOUS	X_{13}	Cost of water purification by households per month	This cost was supplied by respondents and recorded.
14.	PLACE	X_{14}	Whether or not water safety plan is in place in the study area	If the plan is in place (1) is recorded if not (O) is recorded
15.	DIST	X_{15}	Average distance of refuse dumps to water sources	This distance was determined and average found for each peri-urban community and recorded.

Table 3. Field data of determinants of safe water in peri-urban communities of south east Nigeria

Community	X1	X2	X3	X4	X5	X6	X7 cfu/ 100 m	X8 (M)	X9 cfu/ 100 m	X10	X11	X12	X13	X14	X15
Ezzangbo	8	1	1	4	10	3	3	300	10	4	2	0	2	0	150
Amawbia	10	0	1	4	7	3	1	250	12	4	1	0	3	0	50
Ngwo	4	1	1	6	10	3	3	300	10	6	1	1	2	0	30
Egbu	6	1	1	5	13	2	2	500	14	5	1	1	1	1	100
Ibeku	6	0	1	3	8	2	5	300	10	4	4	1	3	0	60
Uturu	4	1	1	4	6	1	5	350	15	4	2	1	3	0	120
Nkwerre	0	1	1	4	0	3	2	300	10	4	1	0	2	0	50
Ogidi	5	0	1	4	5	1	3	300	10	5	1	1	2	0	30
Nnobi	0	0	1	5	0	3	5	400	14	3	1	0	2	0	20
Umungasi	10	1	1	4	8	1	2	300	12	5	4	1	2	0	20

The standard error of estimates of 182 litres explains the standard error and it is a measure of the magnitude of the likely error that may occur if the regression equation is used to estimate values of dependent variable. In a simple explanation the ±182 litres is a range implying either an over estimation or under estimation of safe water supply using the 15 independent variables. The low standard error of estimates of ±182 litres indicates that safe water supply in the area can be sufficiently predicted by the 15 variables working together.

Table 4. Result of the multiple regression analysis, the determinants of safe water supply in the peri-urban communities

Statistics	Result
Multiple correlation (R)	0.8815
Coefficient of multiple determination (R^2)	0.7770
Standard error of estimates (litres) SE	182

The relative importance of each of the independent variables in the Multiple Regression Analysis can be determined in a number of ways [15]. However, because of the weakness of some of the methods, the method involving calculation of successive values of the multiple correlation coefficient obtained by introducing independent variables at each computation i.e. R_y, X_1, R_y. X_1, X_2, Ry. X_1, X_2, X_3 etc is the most universally employed. The difference between the Squared Multiple Correlations (R^2) may be regarded as the contribution of each variable(s). In our own case all variables altogether contributed 77.7% and so we used the formula to determine what individual variable contributes to the variation (Table 5).

To clearly show the size of the contribution of the variables, we plotted a bar chart (Fig. 2).

4. DISCUSSION

From Table 5 it can be seen that all the 15 variables contributed in safe water supply in the 10 peri-urban centres under study but on varying degrees. One essential feature of their contribution is that three of them contributed very highly (Fig. 2). For example apart from the variable X_3 (whether or not there is an open defecation around the water source) with 21.1%, X_{11} (Dominant type of land use near the water source) with 16.5% and X_{15} (Average distance to the refuse dump) has 14.1% all others contributed low values with many contributing less than 1.0%. The three top factors altogether contributed 51.7%. Based on this, we shall discuss more on the variables that contributed highly.

4.1 Open Defecation near the Water Source

We had earlier noted that the inhabitants of these 10 peri-urban communities rely on a range of water sources. These include rivers, shallow wells, public water sources, vendors rainwater harvesting etc. It is important to say that the level of open defecation in these towns is high which resulted in defecation even around the water sources. This has given rise to high cases of water borne diseases reported in the area. For example over 48% of daily hospital visits in the area is as a result of typhoid fever while dysentery and cholera constitute about 30% of the remaining ones which are mostly affect children [16,17]. This is in line with the opinion of Humphries (2009) that more children under the age of five die from diarrhoea than from HIV, Malaria and Tuberculosis put together in Africa. And many more children according to him are irreversibly debilitated and stunted by water related illness during their earlier years. Furthermore, [18] vividly described the menace of open defecation in the following ways:

> *During a "transect walk" to common areas of open defecation, the problem stares people right in the face: 'shit' is everywhere and seeing it, smelling it and stepping in it is highly unpleasant …. the effect this exercise has on the people is written largely on their faces. Combined with exercises that illustrate the paths from shit to the mouth and the way food and water gets contaminated, this generally leads to a moment of ignition.*

The high rate of growth of slum and squatter settlements in and around these peri-urban areas is alarming where the above observation is a daily occurrence. A visit to these settlements reveals that toilet facilities are not made part of their housing development, as only few houses have toilets.

4.2 Dominant Type of Land Use Near Water Sources

Type of land use is an important determinant of safe water supply, because some land use generates more harmful wastes to the environment than others. Although most of the peri-urban areas in the study area have

residential land use as the dominant one, few others have heavy industries located in the peri-urban communities. Out of 10 peri-urban areas under study only two – Ibeku and Umunagasi have industries, two others namely Ezzangbo and Uturu have commercial activities, while residential land use dominate the rest. Residential areas generate household wastes, some of them microbiological and others chemical contaminants. The poor disposal of these wastes is one of the reasons why many water sources are contaminated as refuse dumps are seen indiscriminately in most of these peri-urban communities. [19] in his investigation of the effect of household wastes and refuse dumps on water sources in parts of Lagos, Nigeria, concluded that household wastes that usually find their way to the water bodies contaminate them with both high microbiological and chemical substances and suggested that both the inhabitants and local governments authorities should always ensure that the areas around these sources are kept clean.

4.3 Distance of Refuse Dump Sites to Water Sources

This is very closely related to the previous determinant which is the type of dominant land use near the source of water. The land use generates refuse which for unknown reasons are usually found very close to either shallow well, at the river back, close to public water stand pipe or even dumped inside the storm drains or river channels from where the inhabitants collect the water they consume daily. Lack of appropriate refuses disposal mechanisms one of the central problems of environmental sanitation in Nigeria. [20] was of the view that continued lack of interest by the relevant government authorities in this regard continues to be a veritable source of worry. One reason for this is that the environmental sanitation programmes in the inner city areas are often not extended to these peri-urban communities.

5. POLICY RECOMMENDATIONS

The three most important determining factors for safe water supply already discussed namely; open defecation near the water source, dominant type of land use near water source and distance of refuse dump sites to water sources should be drawn into the policy development of the sector in the affected peri-urban communities. The objective of such a policy is to limit the activities leading to these isolated determinants. The policy instruments to be employed to achieve this should include laws and regulations, economic incentives such as subsidies for those that keep clean environment near the water source and fines for offenders of those activities. Also to be included are sensitization and education programmes that will be designed to create safe water supply for the inhabitants.

In terms of laws and regulations, the various Houses of Assembly in the affected States should closely work with their State governments who are expected to prepare and send executive bills to the House in this regard.

Table 5. Relative contribution of safe water determinants

Variable label	Variable code	Multiple R	R^2	R^2 Change	% R^2 Change
OPEN	X_3	0.469	0.2199	0.2119	21.1
TYPE	X_{11}	0.620	0.3844	0.1645	16.5
DIST	X_{15}	0.725	0.5260	0.1412	14.1
LEAK	X_5	0.788	0.6209	0.0953	9.5
CONT	X_1	0.820	0.6720	0.0511	5.1
SANI	X_2	.841	0.7023	0.0303	3.0
COST	X_4	0.852	0.7259	0.0236	2.4
ACCE	X_8	0.861	0.7413	0.0154	1.5
WELL	X_9	0.869	0.7551	0.0138	1.4
ECON	X_{10}	0.874	0.7639	0.0088	0.9
PIPES	X_{12}	0.879	0.7726	0.0087	0.9
PLACE	X_{14}	.882	0.7779	0.0053	0.5
HOUS	X_{13}	0.884	0.7814	0.0035	0.4
CUP	X_7	0.885	0.7832	0.0018	0.2
TECH	X_6	0.886	0.7850	0.0017	0.2

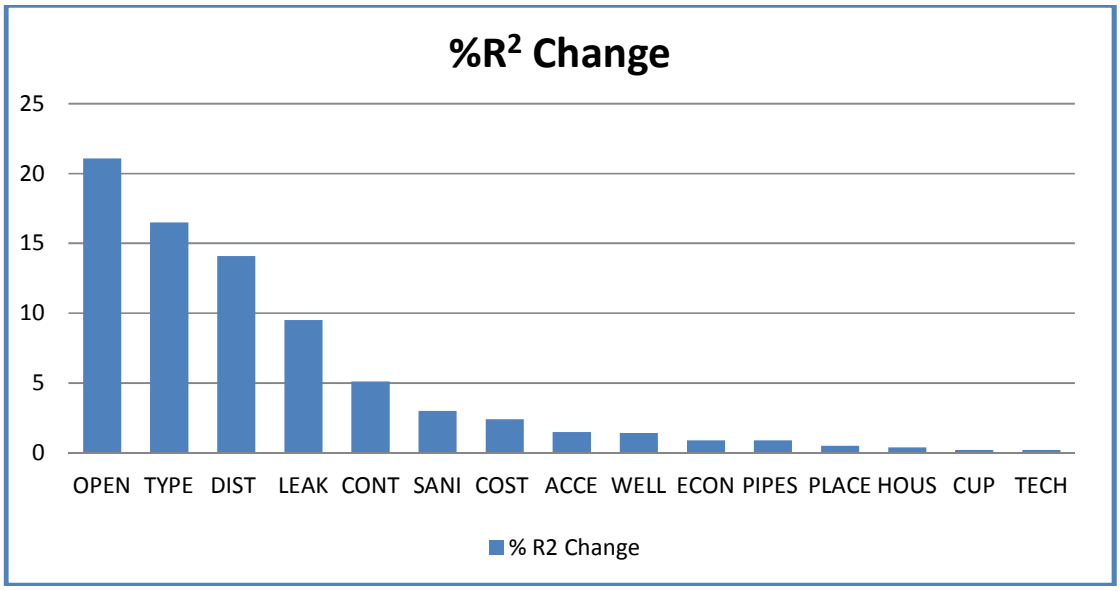

Fig. 2. Bar Chart showing the magnitude of the relative contribution of variables

Such bills should be thoroughly discussed and expeditiously passed. The important areas of such bill will include (i) designating an area about 500m radius of any water source as well as 500m from a stream or river as open defecation prohibited zone (ii) imposing appropriate fines for offenders (iii) providing incentives to staff of the water corporation who will ensure compliance (iv) discouraging open defecation by making a provision mandating government to provide public latrines in squatter and slum settlements. The bill should also include the prohibition of establishment of housing estates or building of any house very close to urban rivers or streams as well as imposing appropriate fines for all economic activities including the siting of industries near these rivers. Furthermore, there should be a combined policy that should focus on water supply and sanitation. Such a policy will make it an offence for individual households to dump refuse at authorized locations.

As it is not sufficient to look only on policy, but also on the conditions that need to be in place for policy to make a difference, it is recommended that all such conditions especially the need for stakeholders to accept the provisions of the policy should be pursued with clear commitment.

Furthermore, the people themselves should be sensitized on the dangers of consuming polluted water. The people should generate community action to ameliorate the contamination of water sources.

6. CONCLUSION

We have in this paper tried to determine the relevant factors that impede safe water supply in the peri-urban communities of selected urban centres in the South Eastern parts of Nigeria. The result of our study indicates that three factors with high percentage contributions which are already discussed should be drawn into the water policy documents of the relevant peri-urban communities. Policy implications of the existence of these factors were examined and it is our recommendation that various Houses of Assembly in the zone should work together since the same conditions apply to improve their water safety and further engage their respective governments to enact realistic laws that should check these activities. It is only when these activities are checked that we shall be sure that the citizenry of these areas would have safe water to consume. Also the communities should be made to understand the dangers of consuming contaminated water. This can be achieved by government agencies through change sensitization of the populace.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=1105&id=42&aid=9512