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ASSESSMENT OF THE FACTORS RESPONSIBLE FOR POOR DRINKING WATER QUALITY IN AWKA URBAN AREA, NIGERIA

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Abstract

The problem of poor drinking water quality impacts on public health and economic ineffectiveness globally. This study employed correlation analysis and principal component analysis in assessing drinking water quality in Awka urban area aimed at analyzing factors responsible for poor drinking water quality in Awka urban. Data used were from questionnaires distributed to the 33 villages making up the study area at 10 per village. 330 questionnaires were distributed. The statistical analytical methods employed in the study were Correlation and Principal Component Analysis (PCA).Analytical results revealed the dominance of five components such as heavy metal pollution, leachates from municipal wastes, poor management of water sources, pollution from animal wastes and environmental practices. Lead concentration in the water samples was above WHO permissible level for all drinking water. PCA analysis revealed that of the physico-chemical and heavy metals analyzed in the laboratory for the sampled areas, three dominant components determine the quality of water and are $PbNO_3$, FeS_2, and water hardness. WQI revealed that the water quality status of all sampled locations is unsustainable. There is dire need for identification of city-wide point and non-point sources of pollution to minimize pollution, it is important to take Periodic verification and auditing of the quality of water sources, finally the need to resuscitate waterworks, all to ensure availability of safe drinking water supply by the State government for all individuals.

Keywords: Water Quality, Urban area, PCA, Correlation, WHO

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Introduction

In Nigeria, problem of drinking water supply to people have become a difficult issue despite lots of efforts made at various levels of governments to improve access especially by the Federal Government through funding from development partners like United Nations Development Programme, World Bank, UK aid and USAID and others. Despite these efforts, Nigeria still ranks high in the number of people without access to portable water (Kale, 2018). Nonetheless, considerable progress has been made in Nigeria through the expansion of access to water supply services in an effort to attain the Sustainable Development Goals (SDG) especially the SDG 6:1 and 2. In Awka urban area, limited access to safe drinking water has

always resulted in the pollution of water sources (Orji, Ezenwaji & Anyaegbunam, 2006) and negative impact on community health as a result of continuous exposure to harmful contaminants (Alderman et al., 2012). Centre for Disease Control in Nigeria described access to safe drinking water as the percentage of the population having access to and using improved drinking water sources (CDC, 2022). Access to clean and portable water is necessary towards ensuring a healthy population and control over potential breakout of water related diseases. Globally, efforts have been made to provide portable water to people, but billions of people still lack access to safe drinking water facilities. The observed lack of access or the reduced access to safe drinking water in urban areas has been linked to the socio demographic characteristics of the people such as poverty, education, family size, household behavior, and home ownership by studies like Adams et al., (2016) and Dasgupta (2008). In addition, the perception of water quality also determines household's preference to certain sources of water and/or motivates them to seek alternative sources for consumption. However, water quality is a global issue that requires both environmental and human health assessments.

Consequently, despite the efforts of successive state governments and international donor organizations like United Nations Development Program (UNDP), European Union (E.U) and USAID towards ensuring that the water supplies are healthy and efficient, the epileptic water supplies had forced the consumers to resort to unconventional sources to meet their daily water demand needs (Obeta, 2016).Most people have resorted to sourcing water to meet their daily needs from unprotected shallow wells, streams, ponds, private boreholes, and harvested rainwater. These sources of water are mostly polluted by physical, chemical, and microbial activities (Ezenwaji, 2014; Obeta, 2016). More so, socio-economic factors such as high cost of water, time consumed in sourcing water and health threats associated with untreated water, affects water the consumers abilities of meeting their daily water needs. However, assessing the quality of drinking water supply in Awka is vital given the strategic importance of the city

to socio-economic and political development of Anambra State. Ensuring access to quality drinking water supply will equally play a key role in maintaining a healthy population and which is also capable of spurring economic growth within the city. In addition, assessing quality drinking water supply will enable this study identify possible factors affecting water quality access for which solutions may be proffered for ensuring sustainability in water supply planning.

Okoye, Ezenwaji & Awopeju (2014) analyzed the impact of flooding on surface water quality of Awka town. They achieved this by conducting a physicochemical and microbiological analysis of four water samples were collected from each pond in the study area before the rain and after. ANOVA was used to analyze the results of the laboratory tests. Twenty-seven parameters were analyzed for in each of the samples. The outcome of the laboratory result showed that 12 parameters exceeded WHO permissible limit before the rain while fourteen exceeded after the rain. The study also revealed a significant increment in the values of the analyzed parameters after the rain when compared with the value before the rain as shown by ANOVA. They discovered that there was also a major increase in the bacteriological parameters after the rain which points 7o potential health impact as most people use these ponds as processing sites for bitter leaf, cassava and even washing of meats. The study showed that there are obvious changes in water quality after rainfall due to contribution from flood. Okeke & Okoye (2023) studied water quality of three domestic water sources of Awka and Nnewi towns of Anambra state to ascertain their health risk and safety for human consumption. A total of 60nwater samples were collected from both study locations. The study employed the Canadian Council Water Quality Index (CCME WQI) methodology to determine borehole, well, and rainwater samples collected from Awka and Nnewi towns of Anambra. They used nine parameters for the evaluation namely: pH, electrical conductivity, nitrates, sulphates, chlorides, copper, iron, lead and zinc. The CCMEWQI values showed that the water samples

were good, therefore making the water samples gotten from these metropolises safe for human consumption. This study therefore seeks to assess the factors responsible for poor drinking water quality in Awka urban area.

Method

Area of the Study

Awka is the capital of Anambra State located in southeastern part of Nigeria. It is located within Awka South Local Government Area. It is composed of seven districts divided into thirty-three villages. It is located between Latitudes $6^0 11'$N and $6^0 17'$N and longitudes 7^0 2′E and 7^0 7.8′E (fig 3.1 and 3.2). Awka has an estimated land area of 60.2 square kilometers (Ezenwaji et al., 2018).

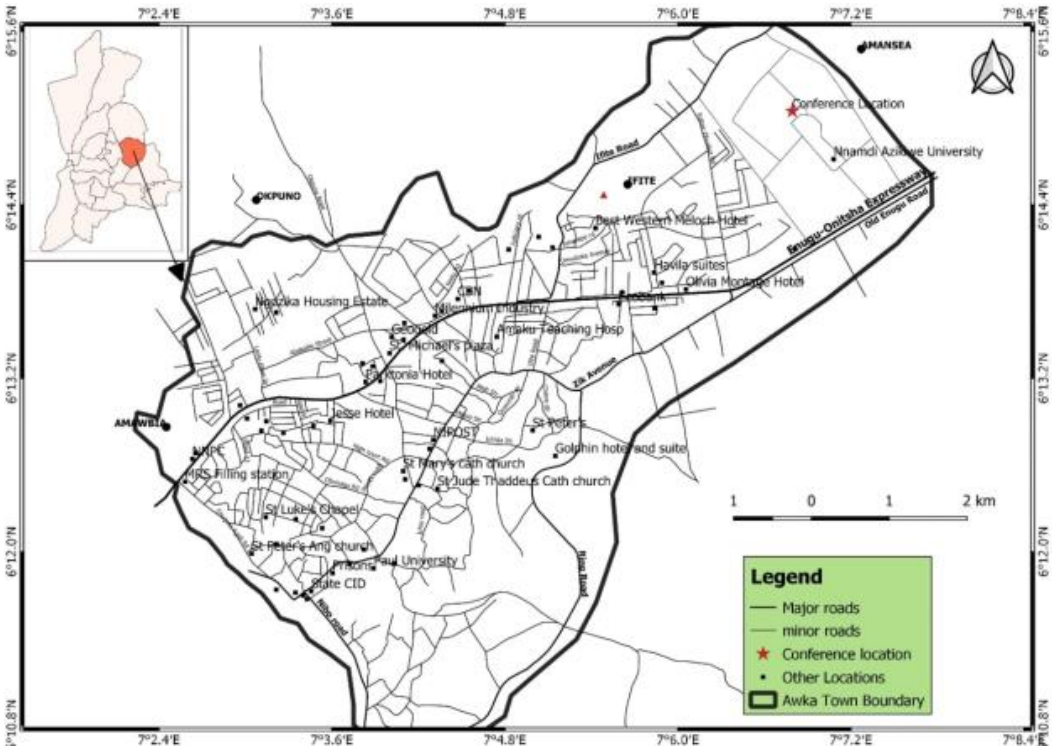


Fig 1: Map of Awka

In terms of geology Awka urban area is situated within the Anambra Basin underlain by the sedimentary rocks of Nkpolo shale, Mamu formation, Ajalli sandstone and Nsukka formation (Jone & Hocky, 1964). On the surface, the dominant sedimentary rocks are the Imo shale,

which is a sequence of grey shale with occasional clay, iron stones and sandstone beds, (Ejikeme, Okosun, Obi &Uchegbu, 2016). Its topography presents a rugged relief as it lies completely on Awka Orlu upland. South of the town on the slopes of the Awka-Orlu Uplands are soil erosion and gullies (Ejikeme et al., 2016).Generally, the average height ranges from 91m in the west around Enugu Ukwu and Abagana to 60.2m in the lowland and plains of the east and north which could be seen around Ezinato and other communities (Ezenwajiet al, 2013; Ezenwaji et al., 2014).The climate of Awka falls within the tropical wet and dry type based on Koppen's classification. Thus, Awka experiences two distinct seasons due to the predominant winds of the South-west monsoon from the Atlantic Ocean and the Northeastern dry winds from the Sahara Desert. It has seven months of rainy season starting from April to October and followed by five months of dryness from November to March. The harmattan, a particularly dry and dusty period usually occurs during this period. During long period of rains, there is tendency of flooding which has become a common occurrence mostly due to blocked drainage systems within the Awka urban area, lack of drainage system in some parts of the city and poor maintenance of the already existing ones.

Awka is situated within the tropical rainforest vegetation belt but most of the original rain forest vegetation has been lost to clearing of land farming and human settlement. A few examples of the rain forest remain in places like the Imo Awka shrine (Ezenwaji et al., 2015). Rich fertile soils, which support agriculture, are found throughout Awka. The Mamu plain as seen in Agu Awka, Ezinato, and parts of Umuawulu and Isiagu communities has hydromorphic soil; other areas within the location have fine loamy soil. The existence of rivers and lakes in and around the study area, gives the study area an adequate dendritic drainage pattern. The rivers in Awka urban area include Mamu, Obibia and Obizi. Data for the study was collected mainly from primary data sources. The primary data sources consist of data generated from water sample collection from the water sampling locations and from the field through questionnaires, key

informant interview was conducted on the staff of the Ministry of Public Utilities and the water source owners (shallow wells and boreholes) other relevant MDAs in the state to extract information on water. Information was gotten from focused group discussions with select members of the public comprising water consumers, water vendor groups, and owners of the water sources in the study area. Secondary data for this study was collected from published and non-published materials. Example includes reports, academic journals, papers, government documents and books and other relevant information

Table 1: Locations of the water Sampling Sites

S/N	Villages	Districts	LOCATION	
			Latitudes	Longitudes
1	Umuayom,Umunnoke, Umuoramma,Umuokpu, Umuoruka	AyomnaOkpala (Umuoramma)	6^{O} 12' 52''N	7^{O} 04' 47''E
2	Achallaoji, Umunamoke, Agbana, Umudiaba	Nkwelle (Umudiaba)	6^{O} 13' 03''N	7^{O} 05' 10.3''N
3	Amachalla, Amudo, Umuzocha	Amachalla (Umuzocha)	6^{O} 13' 15''N	7^{O} 03' 49''E
4	Enu-ifite, Ezinato-ifite, Agbana-ifite	Ifite-oka	6^{O} 14' 55.9''N	7^{O} 05' 53.1''E
5	Umudiana, Okperi, Igweogige, Isiagu, Obunagu	Amikwo (Umudiana)	6^{O} 12' 24''N	7^{O} 03' 48''E
6	Omuko, Umueri, Umuogwala, Umuogbunu, Umudioka, Umukwa	Ezioka (Umuogwali)	6^{o} 12' 32''N	7^{O} 04' 18''E
7	Umuogbu, Umubele, Umuanaga, Umuike, Umujagwo, Umuenechi, Umuoruka	Agulu (Umuogbu)	6^{O} 11' 51''N	7^{O} 04' 07''E

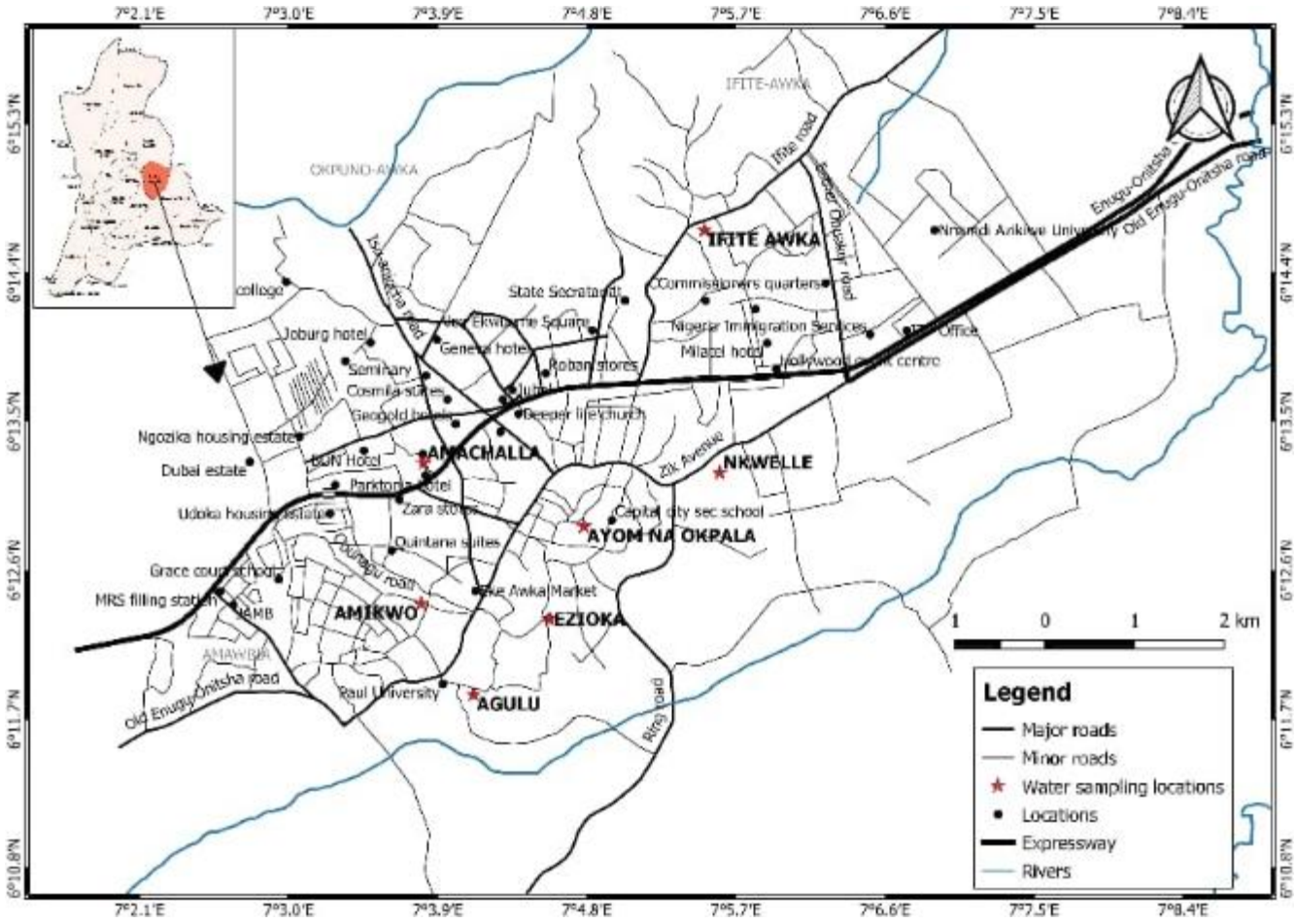


Fig 1: Map of Awka Showing the water sampling points and locations.

Database and Analysis

Principal Component Analysis

Principal component analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components (or sometimes, principal modes of variation). The number of principal components is less than or equal to the smaller of the number of original variables or the number of observations. This transformation is defined in such a way that the first principal component has the largest possible variance (that is, accounts for as much as the variability in the data as possible), and each succeeding

component in turn has the highest variance possible under the constraint that it is orthogonal to the preceding components. The resulting vectors are an uncorrelated orthogonal basis set. PCA is sensitive to the relative scaling of the original variables. The variable in this study are the physico-chemical variables obtained from laboratory tests of water samples collected and the perceived factors from respondents responsible for the poor state of drinking water quality in Awka gotten from the questionnaires. PCA was done by eigen-value decomposition of a data covariance (or correlation) matrix or singular value decomposition of a data matrix, usually after mean centering (and normalizing or using Z-scores) the data matrix for each attribute. The results of the PCA were discussed in terms of component scores, sometimes called factor scores (the transformed variable values corresponding to a particular data point), and loadings (the weight by which each standardized original variable should be multiplied to get the component score).

Water Quality Index Calculation

Water quality index (WQI) provides a single number that expresses the overall water quality, at a certain location and time, based on several water quality parameters. The objective of WQI is to turn complex water quality data into information that is understandable and usable by the public (Adelagun, Etim & Godwin, 2021).WQI was calculated by weighted index method to determine the suitability of the water sources for drinking purposes. In the formulation of WQI, the importance of various parameters depends on the intended use of water. Here, water quality parameters are studied from the point of view of suitability for human consumption (Toma, 2012). It was done by considering 10 important physicochemical properties using the WHO permissible limits for drinking water. The parameters involved in the weighted arithmetic water index method are outlined:

- Water quality rating scale, (qi)
- Relative weight wi)
- Overall WQI (Qi)

The quality rating scale for each parameter qi was calculated using the expression:

$$qi = \left({}^{ci}/_{si}\right) \times 100$$

where,

qi = quality rating scale

ci = concentration of i parameter

si = WHO standard value of i parameter

Relative weight (wi) is calculated by a value inversely proportional to the recommended standard (si) of the corresponding parameter as follow:

$$w = {}^{1}/_{si}$$

The relative weight is calculated by

$$wi = {}^{wi}/_{\sum_1^n wi}$$

Overall WQI was calculated using the expression:

$$WQI = {}^{\sum_i^n Q_i w_i}/_{\sum wi}$$

For computing the WQI, the sub-index, Si, is first determined for each chemical parameter, which is then used to determine the WQI as per the following equations:

$$Si = w_i \times q_i$$

Where, *Si* is the sub-index of the *ith* parameter and *qi* is the rating based on the concentration of the *ith* parameter

$$WQI = \sum S_i$$

Results

Ascertaining the level of water quality using Water Quality Index

The water quality parameters were selected based on their direct effects towards deteriorating water quality for drinking purposes. The standard for the drinking water adopted for calculation of WQI are the WHO and NSDWQ maximum permissible limit for each of the selected

parameters. These were considered for the computation of quality rating (qi) and unit/relative weights (wi). For the purpose of calculating WQI, ten water quality parameters were selected. They are pH, chloride, hardness, alkalinity, nitrates, conductivity, TDS, sulphates, lead and iron. The values of some of these parameters were found below permissible limit except for lead concentration which is high for all the water samples collected from the study area. The WQI values for each of the sampled sections of Awka urban were calculated separately based on the ten selected water quality parameters. The WQI values obtained from sections of the study area were compared to water quality classification based on WQI value in Ramakrishnaiah et al., (2009) given in Table 2

Table 2: Water quality classification based on WQI value (source: Ramakrishnaiah et al., 2009)

Water Quality Index Level	Water Quality Status
<50	Excellent
50 – 100	Good
100 – 200	Poor
200 – 300	Very poor
>300	Unsustainable

The table 2.1 below shows the responses compiled from the questionnaires distributed to the 33 villages to ascertain the factors responsible for poor water quality in Awka urban area.

Table 2.1: Responses on the factors responsible for poor drinking water quality in Awka

S/N	Factors affecting water quality	Yes	No	No Response	Total
1.	Urbanization	255	56	19	330
2.	Livestock production/animal waste	214	89	27	330
3.	Flood events	263	47	20	330
4.	Degrading rain water quality	206	45	79	330
5.	Poor geological composition	199	120	11	330
6.	Poor management of water sources	256	39	35	330
7.	Siting of boreholes near waste dumps	218	68	44	330
8.	Siting of boreholes/wells sources sited near graves	249	48	33	330
9.	Boreholes/wells sited near septic tanks	255	53	22	330
10.	Topography and slope	180	110	40	330
11.	Rusting of plumbing materials	273	22	35	330

12.	Excessive abstraction of groundwater	187	60	83	330
13.	Seepage from wastewater	282	21	27	330
14.	Industrial activities	243	57	30	330
15.	Transportation	201	33	96	330
16.	Municipal wastes	241	64	25	330
17.	Use of fertilizers	171	70	89	330
18.	Deforestation	255	52	23	330
19.	Mineral dissolution	244	50	36	330
20.	Land use practices	261	18	51	330

Table 2.2: Respondents' perceived responses on the factors responsible for poor water quality in Awka

Awka Urban	**X1**	**X2**	**X3**	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**	**X11**	**X12**	**X13**	**X14**	**X15**	**X16**	**X17**	**X18**	**X19**	**X20**
AyomnaOkpala	45	32	41	36	30	41	39	40	37	20	38	26	41	39	36	33	25	36	40	32
Nkwelle	43	29	37	29	36	37	46	32	35	23	34	27	45	45	32	24	17	28	31	32
Amachalla	31	26	40	33	28	24	35	41	35	35	40	27	34	31	27	46	23	36	43	40
Ifite-oka	40	35	45	30	23	42	23	44	39	29	42	30	37	35	33	42	32	48	44	39
Amikwo	24	32	35	23	23	39	24	37	33	15	33	33	46	30	23	39	21	33	37	35
Ezioka	49	27	32	28	32	43	31	35	42	35	46	23	42	30	35	35	29	35	28	44
Agulu	23	33	33	27	27	30	20	20	34	23	40	21	37	33	15	22	24	39	21	39

Table 2.3: Coding and labeling of the variables

S/N	**Name of variable**	**Variable label**	**Variable code**
1	Urbanization	URBAN	X1
2	Livestock production/animal waste	ANIMAL	X2
3	Flood events	FLOOD	X3
4	Degrading rain water quality	RAIN	X4
5	Poor geological composition	GEOLO	X5
6	Poor management of water sources	PMGTWS	X6
7	Siting of boreholes near waste dumps	BOREWAST	X7

8	Siting of boreholes/wells sources sited near graves	BOREGRAV	X8
9	Boreholes/wells sited near septic tanks	BORESEPT	X9
10	Topography and slope	TOPOSLOP	X10
11	Rusting of plumbing materials	RUST	X11
12	Excessive abstraction of groundwater	ABSTR	X12
13	Seepage from wastewater	SEEP	X13
14	Industrial activities	INDUS	X14
15	Transportation	TRANS	X15
16	Municipal wastes	MUNIWAST	X16
17	Use of fertilizers	FERTIL	X17
18	Deforestation	DEFORE	X18
19	Mineral dissolution	MINERD	X19
20	Land use practices	LANDUSE	X20

Correlation analysis was conducted to examine the relationship perceived factors responsible for poor water quality in the study area. The correlation showed some autocorrelation in the result as seen where X8 correlated highly with X16 and X18 and making it necessary to employ PCA analysis. The PCA analysis collapsed the 20 factors into significant and orthogonal components that explained the observed data obtained from the respondents in the study area. Following transformation, the dominance of five components revealed (table 2.3).

Table 2.4: Correlation of perceived factors responsible for poor water quality in Awka urban

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20
X1	1.000																			
X2	-.255	1.000																		
X3	.213	.352	1.000																	
X4	.498	-.165	.604	1.000																
X5	.602	-.594	-.299	.300	1.000															
X6	.607	.370	.064	-.122	.026	1.000														
X7	.593	-.545	.140	.535	.825	.009	1.000													
X8	.402	-.059	.734	.422	-.248	.291	.216	1.000												
X9	.799	-.155	.082	.261	.209	.580	.042	.341	1.000											
X10	.381	-.576	.080	.318	.204	-.230	.068	.233	.633	1.000										
X11	.401	-.179	-.032	.238	.000	.110	-.281	.075	.820	.804	1.000									

X12	-.167	.252	.469	-.228	-.492	.236	-.034	.652	-.277	-.379	-.550	1.000								
X13	.194	.021	-.392	-.470	.294	.599	.291	-.081	-.093	-.603	-.547	.339	1.000							
X14	.425	.128	.308	.370	.609	.175	.706	-.049	-.115	-.295	-.432	-.019	.300	1.000						
X15	.933	-.211	.437	.543	.404	.609	.596	.690	.702	.302	.253	.155	.200	.369	1.000					
X16	.001	-.173	.507	.181	-.523	-.050	-.153	.841	.206	.391	.215	.574	-.334	-.528	.285	1.000				
X17	.312	.307	.317	.182	-.429	.392	-.512	.357	.753	.482	.819	-.118	-.458	-.430	.305	.413	1.000			
X18	-.066	.594	.541	.154	-.675	.109	-.655	.272	.342	.272	.542	.033	-.645	-.318	-.018	.374	.847	1.000		
X19	.151	.063	.851	.464	-.376	.057	.166	.939	.052	.097	-.109	.708	-.218	.003	.477	.822	.223	.317	1.000	
X20	.004	-.306	-.280	-.186	-.197	-.128	-.502	-.043	.546	.776	.845	-.375	-.490	-.742	-.106	.331	.626	.415	-.192	1.000

Table 2.5: Varimax Rotated Component Matrix of the factors responsible for poor water quality in Awka urban

	Perceived environmental factors	Components					h^2
		I	II	III	IV	V	
X1	Urbanization	.223	.035	.839	-.282	.406	1.000
X2	Livestock production/animal waste	-.380	-.061	.095	.917	.027	.999
X3	Flood events	-.075	.649	.056	.367	.643	.977
X4	Degrading rainwater quality	.194	.205	.071	-.111	.890	.890
X5	Poor geological composition	-.042	-.454	.321	-.742	.364	.993
X6	Poor management of water sources	-.155	.049	.935	.252	-.180	.997
X7	Siting of boreholes near waste dumps	-.277	.051	.266	-.749	.537	1.000
X8	Siting of boreholes/wells sources sited near graves	.094	.921	.316	-.002	.204	.999
X9	Boreholes/wells sited near septic tanks	.665	.029	.740	.029	.092	1.000
X10	Topography and slope	.118	.899	.022	-.263	.198	.931
X11	Rusting of plumbing materials	.944	-.119	.250	.161	.076	.999
X12	Excessive abstraction of groundwater	.802	-.491	.058	.121	-.254	.966
X13	Seepage from wastewater	-.647	-.104	.528	-.292	-.452	.999
X14	Industrial activities	-.578	-.229	.292	-.172	.652	.925
X15	Transportation	.116	.377	.792	-.250	.393	.999
X16	Municipal wastes	.364	.921	-.073	.035	-.099	.997
X17	Use of fertilizers	.688	.183	.366	.595	.033	.996
X18	Deforestation	.451	.219	-.008	.169	.842	.989
X19	Mineral dissolution	-.048	.942	.035	.099	.314	.999
X20	Land use practices	-.042	-.055	.927	.060	-.343	.985
Eigen values		**5.998**	**4.893**	**4.253**	**2.549**	**1.947**	
% of Variance		**29.991**	**24.464**	**21.266**	**12.744**	**9.737**	
Cumulative %		**29.991**	**54.455**	**75.722**	**88.465**	**98.202**	

Table 2.5 showing the outcome of the varimax rotation and the associated total variance explained, the five components explained 98.2% of the variance while all the five components had eigen values greater than 1.00.The screen plot of these components is shown in Fig2. The variables with

the highest loadings on each of the components were picked and shown in tables 2.6- 2.9i with their corresponding variables.

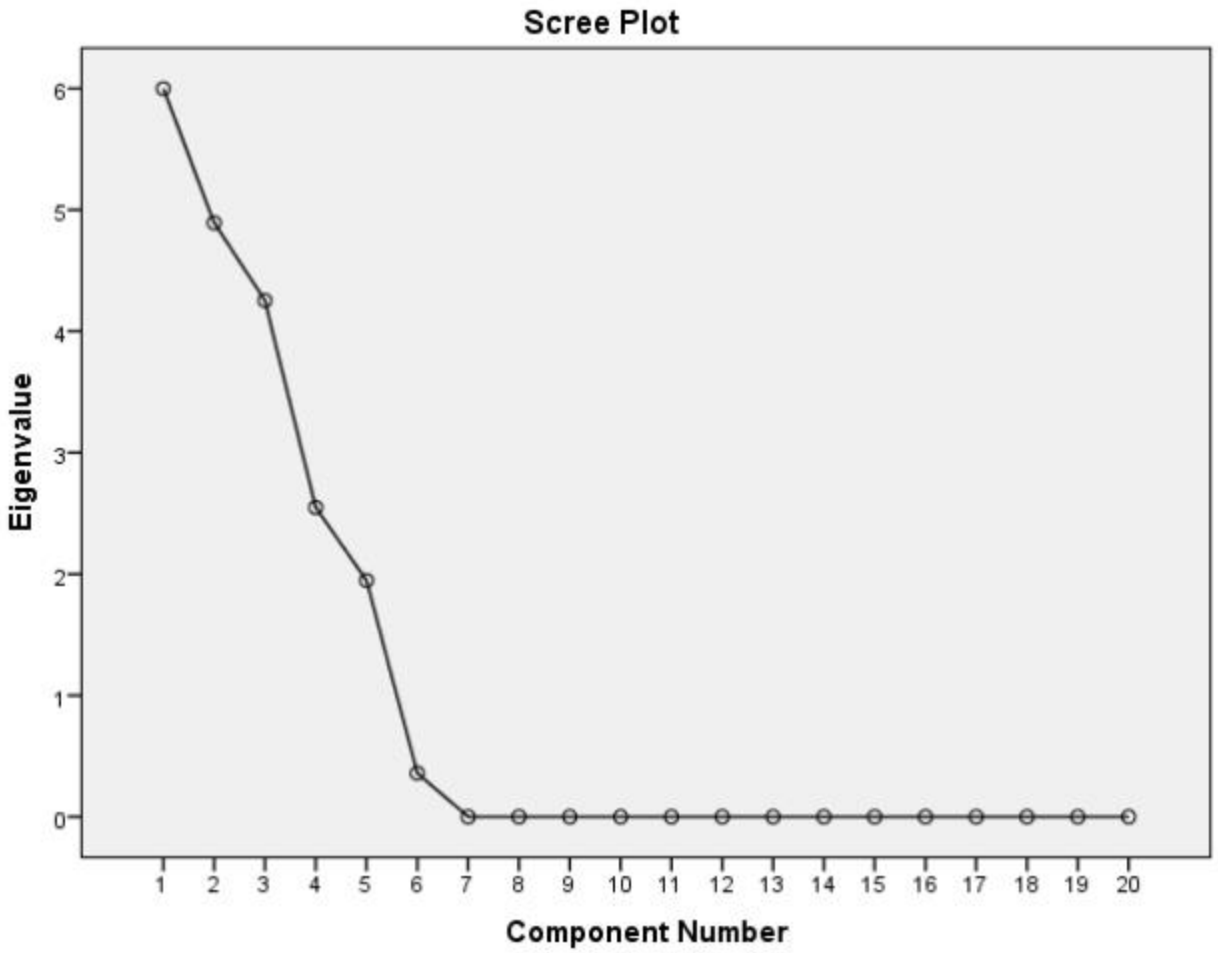


Fig 2: Scree Plot for perceived factors responsible for poor water quality

Table 2.6: Variables with high loadings on Component I

Variables	Hardness of water	Loadings
X11	Rusting of plumbing materials	0.944
X12	Excessive abstraction of groundwater	0.802

Table 2.7: Variables with high loadings on Component II

Variables	Physico- chemical parameters	Loadings
X19	Mineral dissolution	0.942
X8	Siting of boreholes/wells sources sited near graves	0.921
X16	Municipal wastes	0.921
X10	Topography and slope	0.899

Table 2.8: Variables with high loadings on Component III

Variables	Man-made factors	Loadings
X6	Poor management of water sources	0.935
X20	Land use practices	0.927
X1	Urbanization	0.839

Table 2.9: Variables with high loadings on Component IV

Variables	Agricultural practices	Loadings
X2	Livestock production/animal waste	0.917

Table 2.9i: Variables with high loadings on Component IV

Variables	Environmental practices	Loadings
X4	Degrading rain water quality	0.890
X18	Deforestation	0.842

Discussion

From the extracted component tables, it is clearly depicted that three of the factors are loaded highly on component one. By the nature of the parameters that loaded highly here, this simply implies the effect of heavy metal pollution associated with the nature of plumbing materials and fittings used in service connections in the study area. WHO (2004) acknowledged that the primary source of heavy metals like lead is from service connections and plumbing in buildings and

recommended that low lead alloy fittings should be used in repairs and new installations. This further explains why lead concentrations were found to above allowable limits and the presence lead sulphide as a component in the above section. In component two, four factors loaded highly, implying that leachates from municipal wastes and nearby graves contributes to poor water quality in Awka and this is supported by the slope of the land. This was supported by Onwueleka (2014) in his findings as regards sources of pollution affecting water quality of kaduna river deduced that anthropogenic influence (municipal, industrial wastewater and agricultural runoff For component three, poor management of water sources, land use practices and urbanization loaded highly. It is not surprising to see urbanization and land use on the same component with poor management of water resources. Thus, by evaluating their character, component three implies that poor management of water sources is a dominant factor contributing to poor water quality of sources in the study area. This was supported by Ezeabalisi (2014) who assessed the pollution of domestic water supply in Awka and concluded that the poor solid waste management, environmental problems and ranging from flooding, silting and eutrophication of streams and discharge of effluents and used motor oil into the environment were major factors affecting poor water quality in the area. In component four, the variables that loaded highly clearly show that pollution from animal wastes is a factor affecting water quality in Awka. Lastly, in component 5, two variables loaded highly and reflect on the contribution of environmental changeon the poor quality of water in Awka urban.

The factors perceived to be responsible for the poor drinking water quality in Awka were shown, through PCA analysis, to be heavy metal pollution, leachates from municipal wastes and nearby graves, poor management of water sources, pollution from animal wastes and environmental changes. The level of water quality in the study area was further assessed using water quality index (WQI). The WQI for all the water samples were shown to possess a water quality status of

unsustainable nature. This is clearly attributed to high presence of lead in all the water samples and consequently, none of the boreholes and the well are good sources of drinking water..

Conclusion

It is evident dominant factors perceived to be responsible for the poor drinking water quality in Awka urban based on this study are;

- heavy metal pollution
- leachates from municipal wastes and nearby graves
- poor management of water sources
- pollution from animal wastes
- environmental change

Furthermore the WQI of sampled water sources showed that these waters are of unsustainable water quality status. This has been related to the presence of lead beyond permissible limits in all the water samples. This outlook is quite risky for the domestic water supply chain in the study area. In the light of this, the findings of this study show that, despite the contributions of various stakeholders in improving domestic water supply, ensuring the availability of safe and quality drinking water still requires lots of work. There is need for increased verification of the quality of water sources in Awka. Auditing of quality of water sources is seriously needed as access to safe water is essential to unlocking economic growth and plays a key role in poverty reduction.

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