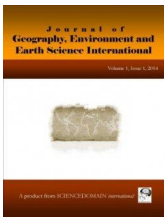

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Industrial Water Supply in Nnewi Urban Area of Anambra State, South Eastern Nigeria

Michael Chukwuma Obeta[1*]

[1]Hydrology and Water Resources Research Unit, Department of Geography, University of Nigeria, Nsukka, Nigeria.

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

This paper examines the pattern and problems of industrial water supply in Nnewi urban area. Fifteen industries within the urban area were purposefully selected and investigated. Relevant data were collected through the use of oral interview, structured questionnaire, and field observations. The data were analyzed through the use of descriptive statistics and Principal Component Analysis (PCA). PCA was used to isolate major underlining dimensions responsible for inadequate water supplies to the sampled industries. Twenty eight (28) predictor variables were used in the analysis. The results revealed the total water need of the sampled industries as well as the gap between supply and demand. Public water supply schemes in the urban area are incapacitated to the extent of near total collapse Poor service delivery and limited service coverage has forced industrialists to resort to alternative supply sources, as opposed to supply from state water utilities. Five of the analyzed variables returned the highest mean values indicating that they had the strongest influence on industrial water supply in the study area. Three principal components were extracted; PC1 represents the influence of inadequate water infrastructure. PC2 and PC3 indicate the influence of poor service delivery and the absence of suitable alternative water supply sources

**Corresponding author: Email: michaelobeta@yahoo.com;*

respectively. Improvement in public water supply in Nnewi is a matter that requires immediate attention and the use of innovative strategies as suggested in our recommendations.

Keywords: Industrial water supply; urbanization; self-supply efforts; constraints; Nnewi urban area.

1. INTRODUCTION

Water is a precious natural resource, vital for life, development and the environment [1]. Adequate and regular water supply is a basic requirement for industrial development. Infact, industries after agriculture, are the second largest consumer of water in most nations of the world [2]. It is estimated that 15% of the world's total water used are in the industrial sector alone [3]. Major industrial users include power plants, ore and oil refineries, and manufacturing industries. Water is used in industries for a variety of purposes such as cooling, heat transfer and transmission, sanitation, as a raw-material and for the production of goods like drugs, beverages etc [4].

Previous researches show that inadequate supply of water is the primary logistical challenge facing industrial development in many countries. [5], for instance, observed that inadequacies in quantities of water supplied to industries are not new developmental problems. He noted that in the 19th century Europe, industrialists lamented about the deciding quantities in the amount of water supplied to them for industrial production. [4], described the spatial and quantitative growth of the water system in Lagos during its period of rapid growth in the 1970s. They posited that the high-level of industrial production in this city was largely due to adequate water supplies to industries. Conversely, [6], discovered that supply of water for industrial uses in the northern Nigerian city of Kano has suffered from various constraints including over-aged water infrastructure, poor funding, poor service coverage and epileptic supply. [7], observed that whilst most of the industries in Mexico depend on public water supply sources for their water needs, less than 55 percent of the industries have uninterrupted water supply. Many industries, especially, those in the rural countryside suffer from inadequate water supplies. In India no fewer than 60 percent of industries suffer from inadequate water supplies [8].

In southern Nigeria, [9], observed that regular and adequate water availability is the "life wire" of manufacturing activities. Although he emphasized the importance of effective leadership, innovations and planning as necessary for industrial growth and expansion, he drew attention to the contributions of regular water supplies to sustainable industrial development. Reading [9,10,11,4] and [1,12], noted that inadequate water availability is a leading factor constraining industrial production generally in Nigeria. [13], agreed with Okoro's views but added that industries in Nigeria, almost always prefer to locate at sites where sustainable water supply sources exist.

Recently, [14], have raised concerns about inadequate water supplies for industrial production in Nigeria. They noted that inadequacies in quantities supplied to industries result from various factors. Many of these factors are physical, economic, technological and socio-political in nature. The issues of industrial water supply patterns in Nnewi urban area, including the functionality of existing supply schemes etc. have not yet received the attention of Nigerian researchers. Nnewi urban area is the fastest growing and rapidly expanding industrial centre in eastern Nigeria. The urban area is, after Onitsha, the most renowned industrial center in Anambra state. Industries are growing rapidly in the central and surrounding rural areas of the city. The high rate of industrial expansion in Nnewi area has been attributed to natural, socio-economic and political factors [15]. The natural factors include the abundant natural resources. The other factors include the resilience of the Igbo people as well as cheap labour, government policies, large markets, security and in-migration [16]. The city is known nationally for vehicles spare parts and plastic manufacturing as well as for its skilful artisans and other entrepreneurial endeavours.

This study is motivated by the need to present new data and analyses that help update and clarify the nature of the challenges which manufacturing industries in Nigeria in general and in Nnewi urban area in particular face in accessing water. Although this is a case study, the problems faced by industries in Nnewi may be illustrative of the kinds of difficulties which confront manufacturing plants in other rapidly industrializing urban areas in the developing

countries. It is based on a survey of selected industries.

2. THE STUDY AREA

The urban area lies in an undulating part of Mamu River basin between latitudes 6º .01` and 6º57` N and between longitudes 60.45` and 6.55` E. The altitude ranges from 105 m to 300 m above sea-level [2]. The climate is hot and humid and the year is divided into 2 major seasons, namely rainy season (April-November) and dry season (December-March). The month of December and March constitute transitional periods between rainy and dry seasons. The annual rainfall ranges from 165 mm in April to 1025 mm in September. The mean annual temperature ranges from 13ºC in February to 22ºC in October. The urban area is divided into four wards, namely, Otolo, Nnewiichi, Umudim and Uruagu (Fig. 1). The local government headquarters is located at Umudim; the famous Nkwo market is sited at Uruagu; the Nnamdi Azikiwe University Teaching hospital is situated at Nnewichi while Otolo ward houses most of the major industries in Nnewi urban area. Generally, the soils of the area are composed mainly of iron rich tropical soils which may be in the form of loamy, clay, sandstones and sandy clays.

3. METHODOLOGY

Recent (2013) industrial directory available at the office of Nnewi Chamber of Commerce, Industry, Mines and Agriculture, Nnewi; indicates that 62 industries exist in Nnewi urban area. Various types of industries ranging from vehicle manufacturing, motor oil, fruit drinks, plastic production, and battery to cable etc. were listed. Field investigations revealed that one of the industries (Rogeni) has relocated to Lagos, while another (Gboko Bros) was not functional. Out of the remaining 60 industries, 15 or 25% were purposefully selected and used in this study. The sampled industries (see Table 1) were selected on the basis of the following criteria:

(1) The industry must have substantial water needs
(2) The industry must be willing to provide water use information- sources of supply and supply constraints etc.

3.1 Data Collection

Relevant data were collected through oral interview, field observations, use of structured questionnaire and from available records in the sampled industries and urban water supply schemes. Information was sought on different aspects of industrial water supply situation including existing water sources and pattern of dependence on the sources by industries as well as on the constraints limiting quantity supplied. A total of 120 questionnaires were administered in the four wards (Otolo, Nnewiichi, Umudim and Uruagu) within the study area by interview method. 60 questionnaires (4 per industry) were administered on appropriate persons within the sampled industries while the rest were administered on the staff of urban water works units, water vendors, boreholes managers, planning officers of Nnewi urban local government area and ward councilors. They sought information on the nature of industries, water use habits etc. Finally, information which made up the secondary data was obtained from published works.

3.2 Data Analysis

The data collected were analyzed through the use of descriptive (means, totals, percentages, graphs and standard deviations) statistics and Principal Component Analysis (PCA). PCA is a robust statistical tool that is widely used in geographical studies to clarify relationships, eliminate redundant variables and collapse large variables to a few underlying dimensions [17].

4. RESULTS AND DISCUSSION

6.1 Sources of Water Supply to the Sampled Industries

Industrial water in Nnewi urban area is obtained from 2 categories of sources- the public piped supply systems (primary sources) and alternative supply sources (vendors, streams, wells, private boreholes, harvested rain etc). Generally, several factors were reported to influence the choice of water source. The reported factors include availability, accessibility, proximity, affordability, quality and cost of alternative source(s). Availability was reported to be a very important consideration as many of the respondents posited that they source water from streams, wells or borehole because they are, available and close to manufacturing centers. Similarly, the inaccessibility of Ubeh stream was repeatedly identified as the major factor constraining its use for industrial production by many respondents. These identified, sources are briefly described below:

4.2 Public Piped Water Supply Systems

The Anambra state government established two public water supply schemes in the study area. These are the Nkwo-Nnewi urban water supply scheme and the Amuko water supply scheme. The former was established in 1978 to supply water through a network of pipe lines to households and industries in Nnewi urban area while the latter was built by Anambra state government in 2006 to expand the capacity of the urban water supply systems. Nkwo-Nnewi Water Scheme is very old. Water is pumped and distributed through gravity and boosting.

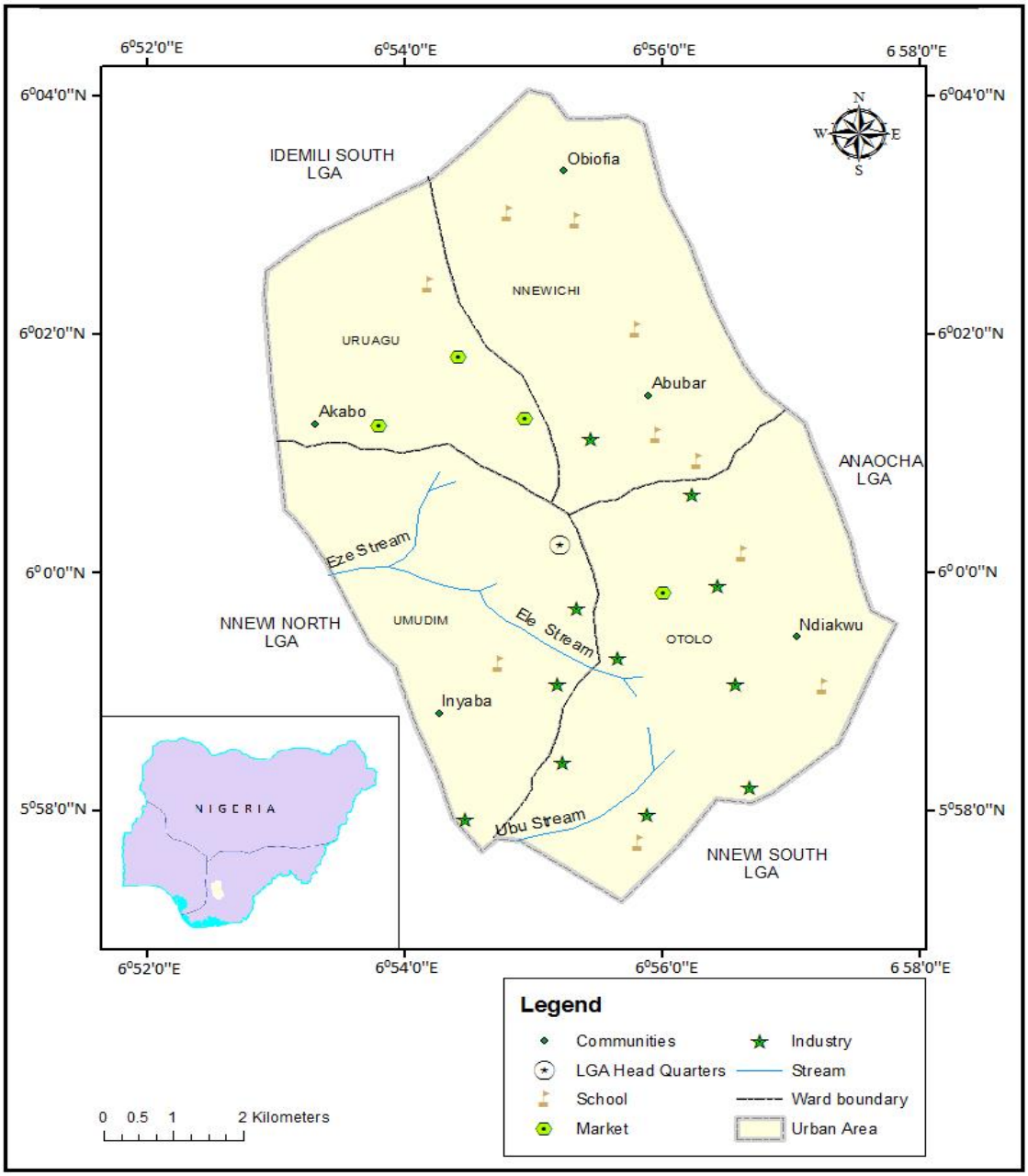

Fig. 1. Map of Nnewi Urban Area Showing the Spatial Location of the Wards and other urban infrastructure Source: Anambra State Ministry of Commerce and Industry, 2013

Table 1. Industries used in the study

S/N	Name of industries	Year established	Location	Products	Staff strength	Sources of water	Primary use of water
1	Ibeto	1983	Otolo	GP tanks and all types of batteries and films	67	Private borehole	* General purpose
2	Kotec	2003	Otolo	Packaged food, Tummy-Tummy noodles etc.	143	Private borehole and wells	Processing of raw material
3	Cutic Cable	1988	Otolo	Electric cables, wire, nail, etc	218	Private borehole	*General purpose
4	Ogbunwa Tyres, Tubes, Motorcycles Spare Parts	1986	Otolo	Tyres, tubes and motorcycle spare parts,	516	Harvested rain, water vendors and public borehole	*General purpose
5	A-Z Oil Polythene Products	2004	Otolo	Lubricants and semi-liquids (engine oil, brake fluids etc)	1141	Water vendors and private borehole	*General purpose
6	A-Z Rimco	2006	Otolo	Vegetable oil	27	Water vendors	*General purpose
7	Innoson	2003	Otolo	Polythene products and all types of plastics: Vehicle assembly	1124	Private boreholes, water vendors	*General purpose
8	EjioforBlock	1981	Uruagu	Blocks, slabs, bricks, concrete poles, slates etc	13	Water vendors and Harvested rain	As raw material
9	Our Lady High-Class Bread	1989	Uruagu	High-class quality Bread and cakes etc.	17	Urban water works, harvested rain, water vendors	As raw material
10	Afro-Asia	2006	Otolo	All types of Plastics	67	water vendors and private bore holes	*General purpose
11	Hilux Premier	2007	Otolo	Premier paints (Premier Wall Marshall and Premier Gloss Paint etc)	213	Private boreholes	Processing of raw materials
12	Izuchukwu Furniture	1986	Uruagu	All types of wooden furniture	07	Public water supply scheme, water vendors rain	Sanitation
13	Star Auto	2008	Nnewiichi	Brake pads and lining and auto parts	44	Water vendors, Harvested rain	Sanitation
14	KDR	2009	Otolo	Table milk (micro packs, sachet packs etc.) washing liquids	35	Private boreholes	Processing of raw materials
15	Godwin Chris	2010	Otolo, Uruagu and Nnewiichi	Fruits drinks, sachet and bottled water,	58	Private borehole	As raw material
Total					3690		

**General purpose= cleaning, washing, sanitation, mixing of raw materials, cooling etc.*
Source: Authors Field Work, 2013.

The total length of the distribution network is just 87.18km. The distribution network of the 1978 scheme covers only parts of Otolo ward (the old, urban center) while newly developed areas and slums are completely unserved. The water infrastructure according to our respondents is over-aged; service delivery is poor, breakdowns are frequent and services coverage is very limited. This is largely due to inadequate maintenance and neglect by government and the urban residents. In 2010 the National Emergency Management Authority (NEMA) flagged of the rehabilitation of the scheme. As a result the urban water supply scheme functioned from 2010 to 2011 and suffered another major breakdown. The distribution network of Amuko water supply scheme is limited only to one ward (Nnewichi) which is predominantly residential in nature. There is no house to house connection. Poor service delivery form these public water supply systems has forced many users to seek alternative sources particularly, streams, wells, private boreholes, commercial suppliers, harvested rain water etc.

4.3 Alternative Sources: These Include the Following

4.3.1 Water vendors

Commercial water suppliers have operated in Nnewi Urban area since the early 1980s due to a combination of factors such as growing water scarcity, rapid population increases, and incessant pollution of nearby streams, industrial growth and increasing water demand in each of the 4 wards within the urban area. Various industrial operators patronize water vendors. Big time vendors use vehicles and sell in tanks and drums while small-scale vendors sell to households in small containers (gallons, buckets, basins etc). A 3000 liter tank is filled by tanker vendors for ₦3000 to ₦4000. Many of the commercial block molders prefer these sources because it is readily available

4.3.2 Streams

As Fig. 1 shows, three streams flow within the urban landscape. These streams form the major sources of water supply to some industrial owners. 26.7% of the sampled industries source their water partly from streams and from vendors. Two sampled industries depend exclusively on the streams. The use of stream is hampered by accessibility, seasonality and pollution. The observed streams are heavily polluted due to constant dumping of waste discharged from industries.

4.3.3 Private boreholes

Although private boreholes were found to be recent, alternative sources of water supply in Nnewi urban area, they have grown to become major sources of water supply to 60% of the sampled industries. Private boreholes presently constitute the commonest and most reliable source of water supply to industrial operators in Nnewi urban area. The private borehole initiative, according to our respondents, came into being in the 1990s due to poor service delivery by public water supply utilities.73.3% of all the sampled industries have private boreholes while 60% of the industries depend exclusively on these sources.

4.3.4 Wells

Well is relatively a large source of water to some of the sampled industries. Many of the observed wells are old, hand dug and lack protection rings. The distribution of wells varies across the urban landscape with Umudim ward on the western section of the urban area having the highest concentration. Well is the dominant source of water to two of the sampled industries.

4.3.5 Harvested rainwater

Rainwater harvesting is a very common practice in the study area; though it is not yet a major source of water supply to the sampled industries, because alternative sources are available. However, some of the blocks molding industries depend largely on this source, especially, during the rainy season.

4.4 Quantities of Water Demanded and Supplied to the Sampled Industries

Table 2 shows the sampled industries, sources of supply, mean quantities of water supplied and the gap between quantities of water demanded and supplied. None of the industries accessed enough quantities to satisfy all legitimate uses. Of the 15 industries surveyed, 9 or 60% depend exclusively on private boreholes, while other depends on a combination of sources. 10 or 66.7% access more than 70% of their total water needs while 5 or 33.3% access less than 70% of their total water needs.

4.5 The Pattern of Dependence on the Identified Sources by the Sampled Industries

Fig. 2 shows the pattern of dependence on the identified sources by the sampled industries

As Fig. 2 shows, private boreholes are the most frequently cited sources of water for industries within the study area. Nine or 60% of the sampled industries depend exclusively on private boreholes while two or 13.3% depends on water vendors. Four or 26.67% depend on a combination of alternative sources including streams, wells, and harvested rain water. This clearly demonstrates the failure of public water supply system in the area. Field observation revealed that even other users such as households now turn to private boreholes for water supply. Other alternative sources (private wells, streams, harvested rain water) are generally not very popular even though they do not involve direct financial expenditures. Their unpopularity was attributed to the fact that much time and efforts are invested in accessing water from them. Field observation actually revealed that fetching water from these sources require great efforts and risks, though assessing this is outside the scope of this work.

4.6 Constraints to Public Water Supply in the Study Area

On the major constraints to efficient water supply to the industries surveyed in the study area, we analyzed a range of factors influencing the supply pattern in order to ascertain or isolates the factors with the highest appeal among the respondents. Based on questionnaire responses, we synthesized 28 common factors influencing water supply to industries in the study area (Table 3). The respondents ranked these factors based on how they affect their decision. The variables incorporate physical, human, economic and institutional factors.

From the analysis, the mean value of 24 variables is greater than 1; this indicates that these variables, in the perception of the respondents, have positive influences on industrial water supply in the study area. Five of these factors have the highest influence on water supply to the sampled industries with mean values of 3.90, 3.68, 3.50, 3.30 and 3.28 respectively. These factors are shown in Table 4.

Other factors such as long distance to streams (with mean value of 2.99), inadequate No of public water schemes (mean value of 2.87), absence of public taps (mean value 2.81) and poor quality of stream water (mean value of 2.64) also affect industrial water in Nnewi urban area.

The 28 variables were further subjected to Principal Component Analysis (PCA). This was done in order to identify major underlining components responsible for water supply inadequacies to the sampled industries. For the purpose of this research, our significant loadings were considered form an arbitrary loadings of 0.812 based on the size of our principal component loadings. The results is shown in Table 5.

4.7 Interpretation of the Underlying Components

Our results of the principal components analysis have reduced the 28 variables influencing industrial water supply in the study area to three underlying components. These three components together accounts for 96.9% of the cumulative variables thus leaving 3.1% of the total variance unexplained. The components are described briefly below:

Component I has significant loadings on six variables, namely x^2 (absence of public taps), X^{11}improper location of public taps, x^{12}(inadequate supply of power), x^{15} (poor funding) x^{25} and x^{23} low yield of boreholes. This component has an Eigen value of 11.26 and explained 40.2% of the total variance. These are all inferred to be indicators of combined effects of inadequate public water supply infrastructure. The underlying component is therefore christened the influence of inadequate water supply infrastructure.

Table 2. Quantities of water demanded and supplied to the sampled industries in Nnewi urban area

S/no	Sampled industries	Source(s) of supply	Mean daily quantities supplied in liters (Nov. 2013)	Daily quantities demanded in liters	Shortfall in liters	% of Demanded satisfied by supply
1	Ibeto	*Private boreholes	1570	2040	470	76.96
2	Kotec	*Private boreholes	2300	3800	1300	65.79
3	Cutic cable	*Private boreholes	1025	1300	275	78.85
4	Ogbunwa	*Water vendors and harvested rain	975	1200	225	81.25
5	A-Z Oil	*Private boreholes, Well, Water vendors	675	1250	575	54.00
6	A-Z Rimco	*Private boreholes	805	1000	195	80.50
7	Innoson	*Private boreholes	4550	6000 5800	1300	78.45
8	Ejoor block	*Water Vendors, Stream and Harvested rain	1550	1850	300	83.78
9	High-class bread	*Water Vendors,	1900	2300	400	82.61
10	Afro-asia	*Private boreholes/vendors	640	860	220	74.42
11	Hilux premier	*Private boreholes	1135	1850	715	61.35
12	Izuchukwufuniture	*Urban water works	375	550	175	68.18
13	Star auto	*Water vendors, Private boreholes	950	1200	250	79.17
14	KDR	*Private boreholes	1165	1660	498	20.18
15	Godwin chris	*Private boreholes	111,500	153,000	41500	72.87
	Total	*Primary source	131, 315	177,060	48,395	74.16%

*Source: Author's field work, 2013 * Major sources*

Table 3. Respondents Identified Constraints to Industrial water supply in the study area

S/no	Variables	No	Range	Minimum	Maximum	Mean	Standard deviation	*Rank based on mean value
1	Absence of functional public taps	120	3.00	1.00	4.00	3.90	0.30	1st
2	Low water yield by available wells.	120	2.00	0.00	2.00	2.81	1.14	8th
3	Leakage of public taps	120	2.00	0.00	2.00	1.36	1.09	20th
4	Absence of wells	120	3.00	0.00	3.00	1.55	0.97	17th
5	Low water yield by available wells	120	2.00	0.00	2.00	2.81	1.14	2nd
6	Frequent breakdowns the supply system	120	1.00	3.00	4.00	1.94	0.74	15th
7	Burst of public water pipes	120	2.00	1.00	3.00	0.90	0.71	25th
8	Vandalisation of public pipes	120	2.00	0.00	2.00	2.11	0.82	12th
9	Over-use of public pipes	120	2.00	1.00	3.00	0.70	0.68	26th
10	Non contribution of urban residents to public water development	120	2.00	0.00	2.00	1.48	1.25	18th
11	Improper location of boreholes/public taps	120	3.00	0.00	3.00	1.84	0.92	16th
12	Improper location of public wells	120	1.00	0.00	3.00	1.35	0.94	21st

S/no	Variables	No	Range	Minimum	Maximum	Mean	Standard deviation	*Rank based on mean value
13	Inadequate no of public water schemes	120	1.00	3.00	4.00	2.87	0.86	7th
14	Inadequate power supply to water schemes	120	1.00	3.00	4.00	3.68	0.83	2nd
15	Inadequate funding of water schemes	120	2.00	3.00	4.0	3.50	0.96	3rd
16	Inadequate maintenance of water schemes	120	1.00	2.00	4.00	3.30	0.76	4th
17	Absence of surface water resources (streams)	120	2.00	1.00	3.00	2.02	0.69	14th
18	Seasonality of streams	120	3.00	1. 0	3.00	2.13	0.70	11th
19	Poor quality of stream water	120	1.00	10.00	4.00	2.64	1.11	9th
20	Long distance to streams (in KMS)	120	3.00	1.00	4.00	2.99	1.06	6th
21	Difficult terrain of stream environment	120	1.00	2.00	3.00	2.07	0.84	13th
22	Poor quality of borehole water	120	1.00	0.00	1.00	1.45	0.99	19th
23	Absence of Motorable roads to streams	120	1.0	0.00	1.00	0.47	0.50	27th
24	Absence of private boreholes	120	2.00	0.00	2.00	1.00	0.72	24th
25	Rapid growth in the number of industries and other water uses	120	1.00	3. 00	4.00	3.28	0.84	5th
26	Absence of water vendors	120	4.00	0 .00	4.00	1.20	1.22	23rd
27	High cost of water	120	3.00	1.00	4.00	2.31	1.30	10th
28	Seasonality of rain	120	1.00	0.00	2.00	0.40	0.59	28th

**Ranking was based on the size of mean values returned on the variables*
Authors Field Work, 2013

Table 4. The factors with the highest mean values

S/no	Variables	No	Range	Minimum	Maximum	Mean	Standard deviation	Rank based on mean value
1	Absence of functional public taps	120	3.00	1.00	4.00	3.90	0.30	1st
2	Inadequate power supply to water schemes	120	1.00	3.00	4.00	3.68	0.83	2nd
3	Inadequate funding of water schemes	120	2.00	3.00	4.0	3.50	0.96	3rd
4	Inadequate maintenance of water schemes	120	1.00	2.00	4.00	3.30	0.76	4th
5	Rapid growth in the number of industries and other water uses	120	1.00	3. 00	4.00	3.28	0.84	5th

Authors field work, 2013

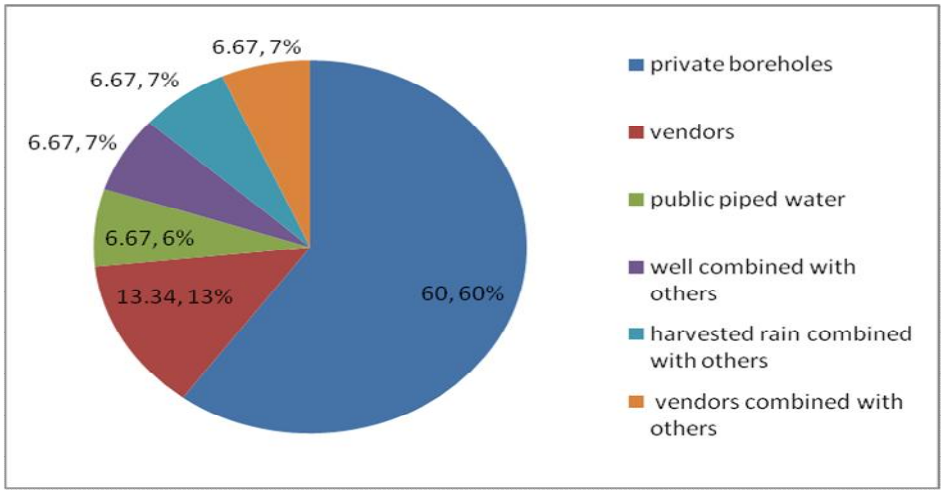

Fig. 2. The pattern of dependence on the identified sources by the sampled industries in percentages

Table 5. Rotated PCA of the variables influencing Industrial water supply in Nnewi Urban

		Components		
Variable label	**Variable code**	**1**	**2**	**3**
Afht	X1	-0.714	0.496	-0.494
Puta	X2	-0.922*	-0.386	0.028
Lepta	X3	-0.231	-0.964*	0.129
Inel	X4	0.332	-0.375	0.865*
Loyi	X5	-0.125	0.161	0.979*
Brek	X6	-0.055	0.694	0.718
Burs	X7	0.233	0.961*	0.147
Vaoa	X8	0.383	-0.687	-0.618
Ovaeu	X9	0.742	-0.513	0.432
Nocri	X10	-0.850	0.111	0.515
Loca	X11	0.992*	-0.013	0.129
Imput	X12	0.818*	-0.392	0.421
Wats	X13	-0.362	0.886*	0.289
Powns	X14	0.895	-0.164	0.414
Fund	X15	0.992*	-0.013	0.129
Mainp	X16	-0.568	0.691	-0.446
Surw	X17	0.915	-0.250	0.315
Ses	X18	0.300	-0.846*	0.441
Qasw	X19	-0.671	0.652	-0.353
Dist	X20	-0.212	-0.148	-0.966*
Tera	X21	-0.439	0.897*	0.050
Road	X22	-0.010	0.937	-0.348
Qabw	X23	0.992*	-0.013	0.129
Prib	X24	-0.531	0.341	-0.775
Urbag	X25	-0.812*	0.550	-0.195
Wave	X26	0.579	-0.029	0.815
Cost	X27	0.308	-0.395	0.866*
Sear	X28	0.621	-0.257	0.741
Eigen value		**11.263**	**8.639**	**8.098**
% of explained variance		**40.226**	**30.852**	**24.922**
Cumulative%		**40.226**	**71.078**	**96.922**

**Significant loadings exceeding 0.812*
Authors field work, 2012-2013

Component II has significant loading on five variables x^3 (leakage of public taps), x^7 (bursts pipes), x^{18} (seasonality of streams), x^{13} (limited number of water supply schemes) and x^{21} inaccessibility to streams. This component has an Eigen value of 8.639 and explained 30.8% of the total variance. This component highlights the effects which the decay in the urban water supply schemes has on water services delivery. The component is therefore named the effects of poor services delivery from the existing sources.

Component IV with an Eigen value of 8.098 explains 24.9% of the total variation in the data input. It has significant loadings on four variables x^4 (absence of wells), x^5(low water yield from wells), x^{20} (long distance to streams), and x^{27} (high cost of vended water). The underlying dimension as represented by its variables highlights the negative influences of the absence of suitable alternatives supply sources on industrial water needs within the study area. It is therefore christened as such.

5. RECOMMENDATIONS

The following recommendations, may, in our view, improve the availability, proximity and the regularity of industrial water supply in the study area.

5.1 The Adoption of Innovative Policies

The government of Anambra state should adopt new, innovative policies and pragmatic management techniques in the urban water supply sector in order to ensure sustainable supply of adequate and quality water for the existing and upcoming industries. Such policies should emphasize user participation, use of appropriate technology, regular system maintenance, external collaboration and appropriate tariff structure to ensure sustainability of water service delivery in the study area.

5.2 Partnership With the Private Sector

The government should partner with the private sector in order achieve sustainable provision of industrial water. The government can also embark on a major effort to expand Nnewi urban water works capacity and/or enlarge the areal extent of the distribution network in order to keep up with the rapid growth of industries in Nnewi urban area.

5.3 Developing New Water Supply Schemes

In addition, the government and groups of industries, especially, those at industrial sites and/or close to Ubeh and Ebeh streams, can build water schemes to be used exclusively for manufacturing activities. The ownership of such schemes can be transferred to the industrialists that made financial contributions for the development of the schemes to operate and maintain.

5.4 Research

There is an urgent need to investigate the effects of the indiscriminate development of private boreholes in Nnewi urban area because the development can lead to the lowering or declining of water tables or bring about increased salinity in the area. This will complicate the problems of in urban water supply in the city.

6. CONCLUSION

Nnewi urban area has registered growth statistics in the industrial sector that are rather astonishing. Some of the factors that account for this remarkable growth have been discussed. The resilience of the people is one such factor. Good governance which is taking slow but firm root in Nigeria is another. Another factor is demographics and urbanization. The urban population comprises of so many energetic young people that are becoming increasingly better educated. As the population and industries in this emerging industrial center continues to grow and expand, there is need for innovative and sustainable policies to address public water supply problems in area. Public water supply infrastructure in Nnewi is a deplorable situation. The government needs to put in place mechanisms to mitigate water infrastructural deficits and other risks to aid industrial growth and expansion in the area. The availability, of water supply sources is fundamental to the general economic-wellbeing of industries within the study area. The path to sustainable industrial development in the area may depend on government's ability to implement the recommendations outlined in this work.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Obeta MC. The Development of Rural Water Supply Infrastructure in Nigeria: A Geographical Perspective. Nigerian Journal of Geography and the Environment 2009; 1: 170-179.
2. Amadou J, Ofomata, GEK. Relief, Drainage and Landorms. A survey of Igbo Nation. Editor Ofomata GEK, Africana Publishers, Onitsha. 2002; 15-18.
3. Goni IB. The Challenges of Meeting Domestic Water Supply in Nigeria. Journal of Mining and Geology. 2006; 42: 51-55.
4. Oyegun RO. Environmental Problems of Water Development: A Geographical Perspective on Environmental Problems and Management in Nigeria. Editor Oyegun RO, Longmans Lagos. 2007; 236-257.
5. Mather JR. Water Resources, Distribution, Use, and Management. John Wiley and Sons Inc., New York. 1984; 143-166.
6. Sani M, Cost Recovery in Urban Water Supply: Prognostics and Implications. Abuja Journal of Geography and Development. 2007; 1: 68-77.
7. Loyal WT, Marston RA. Municipal and Industrial Water Supply in Ciudad Jaurez, Mexico. Water Resources Bulletin. (Published by American Water Resources Association). 1985; 21: 841-848.
8. Jansz S. A Study into Rural Water Supply Sustainability in Niassa Province, Mozambique. Journal of Geography and Rural Development. 2011; 4: 147-155.
9. Ezenwaji EE. Improved Water Supply as a Strategy for Poverty Alleviation in Rural Areas of Anambra State, Nigeria Environment and Poverty Reduction Journal. 2003; 3:52-63.
10. Oyebande L. Appropriate Administrative Structures in Harnessing Water Resources for Sustainable Growth in Nigeria. Journal of Mining and Geology. 2006; 42: 21-30.
11. Amobi IC. Unleashing Industrial Growth and Development in South Eastern Nigeria. Urban Development Review. 2006; 6: 24-27.
12. Okoro FI. Water Uses in Nnewi, Anambra state. Proceedings of the Anambra State Water Board. 2011; 3-7.
13. Ishaku HT, Majid MR, Ajayi AO, Haruna A. Water Supply Dilemma in Nigerian Rural Communities. Journal of Water Resources and Protection. 2011; 3: 598-609.
14. Ezemonye MN, Emeribe CN. Hydropower Generation. Fundamental of Hydrology. Editors Anyadike RNC and Obeta MC. Chucks Edu. Publishers, Lagos. 2012; 177-200.
15. Adegite SA, Ilori MO, Irefin LA, Abereijo IO, Aderemi HOS. The Performance of Small Scale Manufacturing Industries in Nigeria. Journal of Asia Entrepreneurship and Sustainability. 2006; 3: 42-52.
16. Uzor OO. Small and Medium Scale Enterprises; in South-Eastern Region of Nigeria. Proceedings of the Institute for World Economics and International Management. 2004; 86: 1-42.
17. Ezenwaji EE. Water Supply as a Strategy for Rural Development in Anambra State. Journal of Rural Development. 2004; 1: 71-80.

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