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Spatial Distribution and Quality of Water Vending in Nsukka Urban, Enugu State Nigeria

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ABSTRACT

The availability of potable water is a challenge in most developing countries, In Nigeria, more than 100 million people are required to meet Millennium Development Goals (MDGs) target for improved water by 2025 and it is unlikely to be achieved only by public supply. The Nsukka inhabitants have resorted to water vending activities in order to circumvent this problem. This aligns with SDG 6 for developing countries and propelled the quest to investigate the activities, spatial distribution and quality of vended water in Nsukka urban, Enugu State. For the study, a total number of 162 copies of questionnaire were administered to vendors which were selected by simple random sampling respectively. The result showed two main categories of water vendors namely; formal and informal vendors and their operations in Nsukka urban. Water analysis was done in the laboratory to ascertain the quality index of the source (formal vendors) which is 5 major boreholes in Nsukka urban and also samples were collected from two informal vendors for end users to ascertain the quality. Findings revealed that the water vending business especially the large scale water vendors make up to ₦8000 on daily basis while the small scale vendors gain an additional N5000 naira on the initial cost of a full truck load of water. Laboratory analysis shows that the quality of water retailed from the different boreholes was good, in tandem with W.H.O standard but on the contrary the water quality from the vendors was not potable and contaminated from containerized supply especially rusty water tanks. We unequivocally recommend a routine and quality assurance checks before vendors are allowed to retail water to the masses in order to ensure compliance with W.H.O standard. We advocate that government should prioritize the provision of adequate pipe-borne water to residents of Nsukka Urban.

Keywords: Water vending, Formal sector, Informal sector, Water quality, Spatial distribution

1.0. Introduction

The privatization of urban water supply in Africa has remained an issue since the 1980s till date (WHO/ UNICEF 2015). Access to water of sufficient quantity and acceptable quality remains one of the major problems for many households in most cities of developing countries especially in low income areas (Kjellen 2000; Acey 2008; Sansom and Bos 2008). Water vending tends to be an integral part of water supply system in developing countries especially in poorer, low income or informal settlements (Whittington et al. 1991; Snell 1998; Opryszko *et al*, 2009; Ishaku *et al*, 2010; Olajuyigbe *et al*, 2012; Onyenechere *et al*, 2012; Ayalew *et al*, 2014). It is highly contested who actually benefits from this privatization; the consumers, or rather those selling water to the households. On the other hand there are those who regard water in terms of public goods, basic needs and human rights, and they strongly oppose commercialization of water services. Thus, water sales, water vending and water privatization are currently of concern to individuals, groups and government (Emmanuella *et al*, 2012).

In most developing countries especially in Africa, it has been recognized that conventional water utilities have fallen short in providing adequate water services to the ever growing population (Olajuyide, Rotowa and Adewumi, 2012). From time immemorial up until now, the supply of potable water for domestic use is

a major challenge for the development effort in Nigerian cities. Unfortunately, the increasing gap in the demand and supply of water has acquired crisis proportions. In Nigeria most State Water Agencies (SWAs) are grappling with the multiple problems of erratic power supply, corruption policies, diversion and theft of heavy equipment's, poor maintenance culture, faulty distribution system, and the topography of the area (Emmanuella *et al*, 2012).

Many people in Africa rely on water supplied by tankers or other forms of vendor supplies and this water may come from hydrants connected to utility supplies or may be drawn from alternative sources (Ishaku, 2010). In many cases, the consumer will not be aware of the source of the water and there may be significant concerns about the quality of the water (Kjellen, 2010). Vended water has been associated with outbreaks of diarrhea disease as some of the vended water is obtained directly from unprotected source such as unprotected wells and surface water including rivers/streams, ponds and canals etc (WHO, 2006).

The cost of water is not uniform everywhere, instead its price varies widely between cities, rural areas and between economic sectors. Increasing cost of water has slowly provided incentives to change the way water is valued. In water vending, the following are considered; pumping, treatment, storage and purchase costs. Price is, no doubt, the most important determinant of a household's decision to opt for a new source of supply. Residents that resort to buying water from vendors often do so at extremely high prices, often 5 - 10 times existing tariffs for public water supply (Baisa, Davis, Salant, and Wilcox, 2008). The cost consideration is one aspect but beyond that vending is sometimes linked to health problems as vendors may source from polluted sources, hawkers sell from fouled containers as well as contamination incurred at each point of handling, collection and transportation.

Researchers who have studied water vending in urban areas have shown interest in investigating West Africa and particularly Nigeria. There are few well documented efforts; the first on Onitsha, Anambra State and the second on Yola North in Adamawa State and others. At the request of the World Bank's Infrastructure Division for West Africa, a study was undertaken in 1987 of water vending in Onitsha, Nigeria by (Whittington and Mu, 1991*)*. This study showed that in the dry season water vendors delivered twice, as much water as the public water system and that payment for vended water was more than 20 times the payments made for water from the utility. In Bangladesh, the poor spend two percent of their income on drinking water because lack of portable water (World Bank, 1992). In Port of Spain, the capital of Trinidad and Tobago, the poorest people also spend 20 percent of their income for water. In Honduras, it was found that many poor households spend 8 percent of their income in vended water in the rainy season and 12 percent in the dry season. In Addis Ababa, Ethiopia, the urban poor spend up to 9 percent of their income purchasing water from vendors. Water vending is also widespread in such cities as Lima, Peru, Karachi, Pakistan and Jakarta, Indonesia (Kjellen, 2010).

The case in Nigeria is not different as water vending activities have become a common sight in major cities (Ishaku *et al*, 2010). These cities include Kano, Jos, Lafia, Makurdi, Enugu, Aba, Onitsha, Abuja and Lagos etc. For Onitsha, the public water system was built in the 1940's the city's infrastructure and especially its water system was hard hit during the 1967- 1970 civil war and since then, it has been totally inadequate to meet the needs of the population (Olajuyigbe *et al*, 2012). The vast majority of Onitsha residents however obtain their water from an elaborate water vending system, which has been created and is operated by the private sector. Approximately, 275 tanker trucks, purchase water from about 20 private boreholes and then sell to household and businesses equipped with storage facilities (Olajuyigbe *et al*, 2012). These households and businesses resell the water by buckets to individuals who cannot be reached by the tanker trucks (Olajuyigbe *et al*, 2012).

The Yola North study by Ishaku *et al*, 2010 revealed that the non-evolution of special programs for regularizing informal settlements, meaning legalization of land tenure is responsible for the absence of piped water networks and the upsurge in water vendor patronage. Little is still known about urban water vending activities in Nigeria. To provide or improve service delivery in Nigerian cities, the study area inclusive, a greater understanding of the dynamics of water vending is needed. This is because until recently the value of information on these activities was not appreciated by water resource engineers or policy analysts (Ezenwaji, 2009).

Nsukka local government has been characterized by recurrent water scarcity as is the case with most cities of developing nations. As the town grows, the limitation in water availability to competing regions becomes more obvious. It was observed that some parts of Nsukka urban area have water occasionally especially Obollo, Obukpa, Ugwuoye . Unfortunately some areas are yet to be included in the water supply scheme like Barracks, Aku road axis etc. The use of water in households within Nsukka incurs variations in cost with few areas having access to the supply. It is imperative to study the contribution and activities of water vendors whose patronage are now gaining grounds in Nsukka as a result of the failure of government to

provide adequate water supply to the people. This study will not only dwell on locational attributes of water vending, it will also examine some cost implications of water vending activities. It is hoped that the findings of this study will provide policy relevant information that would serve as a policy guide to the state government in the intervention and provision of safe water for the people. It will also aid in the planning and management of the water resources in any similar region. Finally, it will contribute to the ongoing research on water privatization. The aim of this research work is to investigate the activities of water vendors in Nsukka Urban in Enugu State Nigeria. To achieve this aim, the following objectives were pursued; To examine the activities of water vendors in the study area, to analyze the spatial distribution of water vendors and to determine the quality of water sold in Nsukka urban area.

2.0. Methodology

2.1. Study Area

Nsukka Local Government is located approximately within latitudes 6°51'E and 7°00'N of the equator and longitude 7°23'E and 7°45'E of the Greenwich Meridian. It covers a total landmass of approximately 407, 50km^2 (Orji, 2010) with an elevation of 1,810ft (552m). Nsukka local Government Area shares boundary with Igbo-Eze south Local Government Area to the north, Udenu and Isi-uzo Local Government Area to the East, Igbo-Etiti Local Government Area to the south and Uzo-Uwani Local Government Area to the west. It is made up of fifteen autonomous communities namely; Alor-Uno, Edem-Ani, Eha-Alumona, Ibagwa-Ani, Lejja, Nguru, Nru, Nsukka, Obimo, Obukpa,Okpuje,Okutu and Opi (Fig.1),(Fig.2). Generally, the study area experiences two main climatic seasons yearly, namely; the rainy season and the dry season. The rainy season starts in April and ends in October. In the month of August, there is usually a short lapse of rainfall, which is generally known as "August break" or little dry season. It is caused by the passage of the tropical jet stream which is an easterly wind that originates from east Africa and blows across Africa parallel to the equator to the coast of Africa. The beginning and the end of rainfall in Nsukka is always associated with violent thunderstorms (Anyadike, 2002). According to National Population Census of 2006, Nsukka LGA has a total population of 303, 633 persons (NPC, 2006). A breakdown of this figure shows that the area is made up of 149,241 males and 160,392 females. This means that the population of the females is greater than that of the males.

On the other hand, settlements in the area are mostly on highlands, the reasons being that the low lands are prone to erosion and flooding as well as being malaria infected (Sada, 1978). Generally, there are two forms of settlements in Nsukka LGA, namely; nucleated urban settlement and dispersed rural settlement.

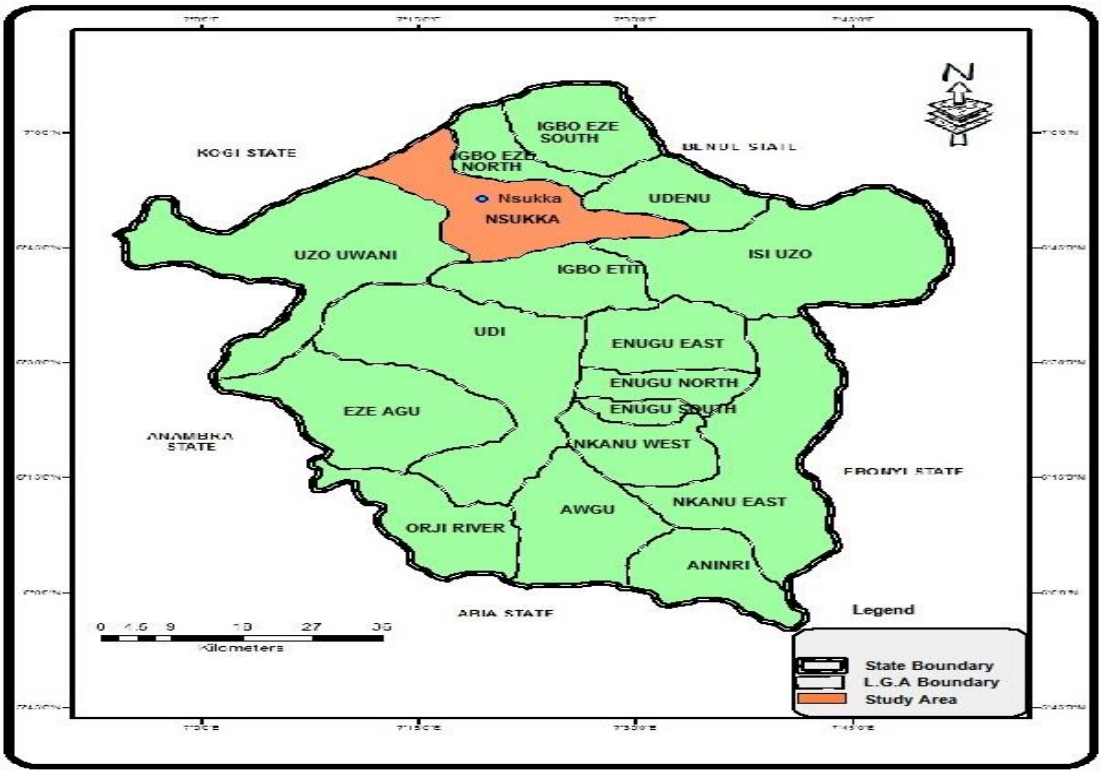

Figure.1: Nsukka in Enugu State. Source: Adapted from Ministry of Lands and Survey 2019

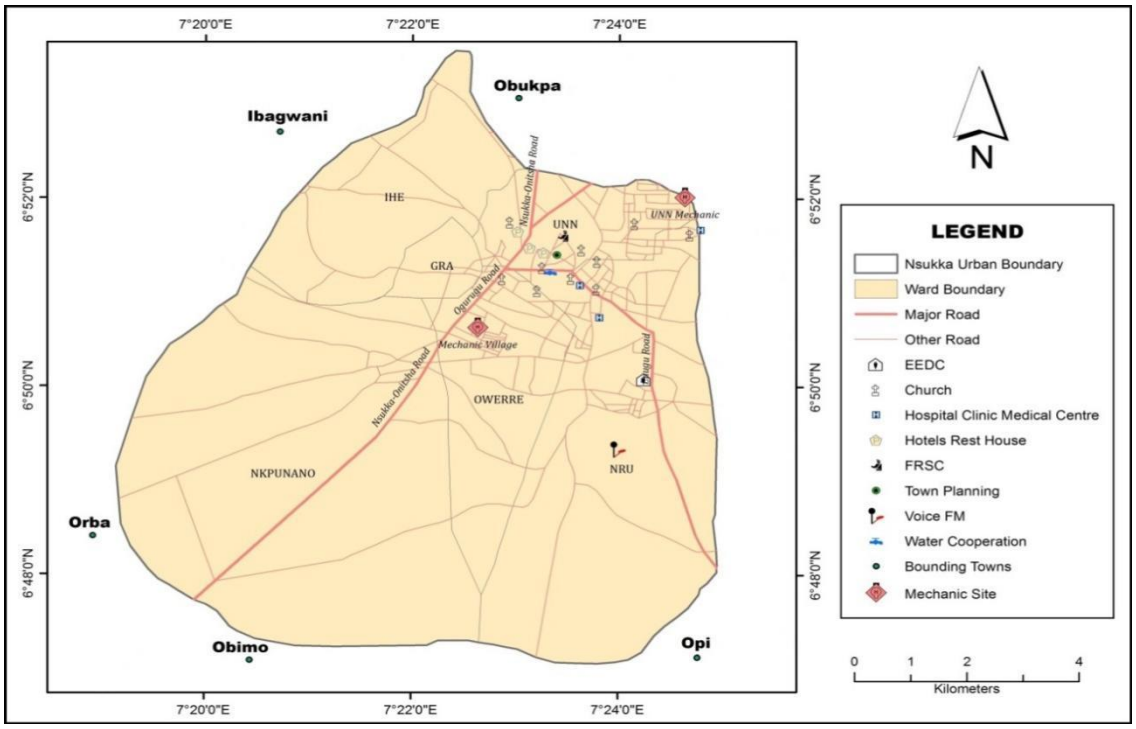

Figure.2: Nsukka Urban. Source: Adapted from Ministry of Lands and Survey 2019

Nsukka urban forms the study population, but due to time constraints coupled with limited resources, residents of, Obukpa, Ihe (unn) axis, Ugwuoye, Obollo road axis, Barracks, Aku road axis, Orba road axis, Odenigwe in Nsukka urban were chosen to constitute the sample population. These areas were chosen because of their centrality to the study area as well as the nature of economic activities that take place there. Interview was done in the different communities to determine area that had public water management scheme setup by governmental and non-governmental organization.

2.2 Questionnaire

Questionnaire was designed for (2) major categories of vendors identified in the study area which include; tanker vendors, small-scale water vendors

A total of 162 copies of questionnaire were administered between small-scale water vendors (72), registered tanker vendors (65) and other vendors (25). A questionnaire designed and administered to vendors was used to collect information on the respondents' personal data. Information's on alternative source of water was also gotten from 96 out 100 sampled household heads.

2.3 Methods of Data Analysis

Data collected in the course of this research was analyzed using SPSS Version 20; nearest neighbor analysis was used to show the degree of clustering and scattering of boreholes selected. Tables, charts, percentage were also used in the presentation of results obtained from the administered questionnaires.

2.4 Nearest Neighbor Analysis

We collected the Gps locations of the different boreholes and retail vendors across the study area, with the help of GIS tool we were able to look at the spatial distribution of the different boreholes and vendors in study area. To calculate this, we use nearest neighbor analysis formula

$$R_N = 2\,Do\,\frac{\sqrt{n}}{A} \qquad (1)$$

R_N- The nearest neighbor index,
2Do – The mean observed nearest neighbor distance
n- The total number of points
A-The area of the map which the point lie

Do is obtained by measuring the distance between each point and its nearest neighbors, divided by the total number of measured points.

Hypothesis

Let Ho be: "There is no significant difference between the distribution of water Vendors in Nsukka urban and a random distribution."

2.5 Water analysis

The water samples collected from five boreholes as the source and two different samples from a water truck vendor and an individual vendor in Nsukka urban. The samples were sent for laboratory analysis to determine the quality of vended water. Samples were analyzed in University of Nigeria water resources management laboratory to determine the physiochemical characteristics of vended water in the study area. They include; Temperature, PH, Turbidity, Total dissolved Solid, COD (chemical oxygen demand), BOD (biological oxygen demand), Nitrates, Dissolved, Oxygen, Calcium, Magnesium, Sodium, Iron, Lead, Chromium, Total Plate Count, Total Coliform Group.

3.0. Results and Discussion

3.1 Sources of Water Supply in Nsukka Urban

The major sources of water supply in the study area are presented in table 1. Some parts of the urban area especially Ugwoye and Odenigbo also enjoy water supply from the government but residents who enjoy this are very few because the water corporation has not been able to accommodate every part of the urban area.

Table 1: Source of domestic water supply in Nsukka urban

S/No	Sampled areas	Sources of domestic water supply					
		Stream	**Rain water**	**River**	**Water Vendor**	**Borehole**	**Bottled/Sachet Water**
1	Ugwuoye	Nil	6	Nil	3	1	2
2	Obukpa	Nil	4	Nil	4	3	1
3.	Ihe(unn) axis	Nil	4	Nil	4	2	2
4.	0bollo road axis	Nil	7	Nil	3	2	-
5.	Barracks	Nil	5	Nil	3	4	-
6.	Aku road axis	Nil	6	Nil	3	1	2
7.	Orba road axis	Nil	5	Nil	2	2	3
8.	Odenigwe axis	Nil	7	Nil	4	1	-
	Total	Nil	44	Nil	26	16	10
	Percentage %	Nil	44	Nil	26	16	10
	Ranking	6th	1st	5th	2nd	3rd	4th

Source: Fieldwork, 2019

Result from table 1 shows that 44% of the people utilize water from rain water harvest which ranked first which is the highest. It is majorly for subsistence purposes as the water is not treated. 26% of the respondents utilize water from vendors which ranked second while borehole ranked third with 16% of the respondents. The major source of domestic water supply in Nsukka urban is rainwater havesting from the result in table one.

3.2 Analysis of Spatial Distribution of Vended Water in the Study Area

Twenty seven water vendors were identified in the study area and they were classified by remoteness (based on drive times within the urban areas) and size (based on quantity supply). The data show that the population of water vendors is heavily spread around the urban area. These vendors include formal and informal vendors that is the borehole vendors and others including the tanker vendors and small scale outlet vendors.

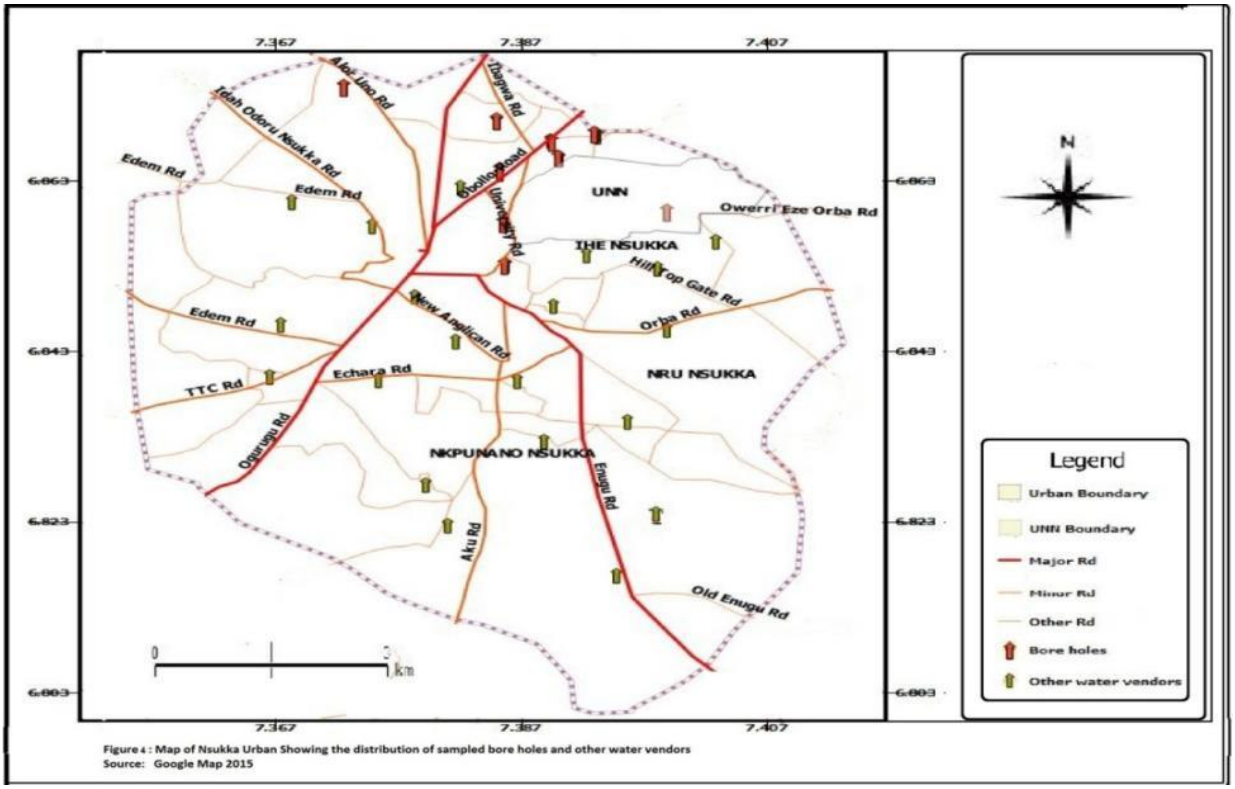

Figure 3: Nsukka Urban Showing the Distribution of Vendors *Source: Adapted from Google Earth 2019*

Nearest Neighbor Analysis was carried out to analyze the pattern in which the water vendors are located. It determines the degree of clustering or scattering of phenomena. It was used to analyze the arrangement of formal and informal vendors which include boreholes and other water vendors in the study area.

Observed mean distance: 0.00555651062115

Expected mean distance: 0.00409503923007

N: 30, and Z-Score: 3.73958803785

Nearest Neighbor Index (Rn): 1.35688825161, (Note: since Rn of 1.357 is close to 1.0, objectively the pattern of water vendors is described as regular. It shows that the water vendors are located in a pattern where it is easily accessible by all the communities in the urban area.

So Let H1: "There is a statistical significant difference between the distribution of water Vendors in Nsukka urban and a regular distribution."

3.3 Activities of water vending in Nsukka Urban

There are two main categories of water vendors identified in the study area and they include formal and informal vendors. Formal vendors are licensed water truck vendors that are registered as water delivery agents in Nsukka urban. They own water trucks that convey water to other end users and their source of water is not affected by variation in season as they largely depend on boreholes. On the other hand the informal vendors are individuals that also own stationary water tanks domiciled in either their place of residence or commercial point of sale. They buy water directly from registered water truck vendors to make water available to residents.

3.4 Categories of Formal and Informal Water Vendors

3.4.1 Large Scale Water Vendors

This involves the borehole vendors that sell to mobile water truck vendors that distribute to small scale water vendors across geographical areas. These mobile water truck vendors purchase water to fill their tanks from privately owned bore-holes to pipe-borne water system or state owned water co-operations and then sell it to households and businesses equipped with water storage facilities. Water trucks can hold from 1000-2500 gallons of water the mobile truck vendors drive around neighborhoods of the urban area supplying water to their customers. In the dry season, a mobile water truck vendor sells six to eight truck loads per day: while in the rainy season, about three to four truck loads.

Plate 1: Mobile Water Truck Vendor filling his tank from a privately owned borehole

3.5 Small Scale Water Vendors (Informal)

This refers to individual that purchase water from tanker vendors and then resell the water to people who cannot afford to pay for tanker trucks or large storage tanks. They are the middle men between the tanker vendors and consumers. They sell water in bits that is in small gallons for domestic purposes majorly.

Plate 2: Mobile Water Truck Vendor supplying water to Stationary Tank Vendor along Odenigwe axis.

3.6 Other vendors (Informal)

Wheelbarrow Water Vendors provide water services with gallons or with the customer's gallons. Tricycle Water Vendors also partake in delivery of bottled/sachet water, they help to ease the stress of having to visit water companies and buy water products. It is very convenient and fast. Figure 4, shows the pattern of water vending in Nsukka urban.

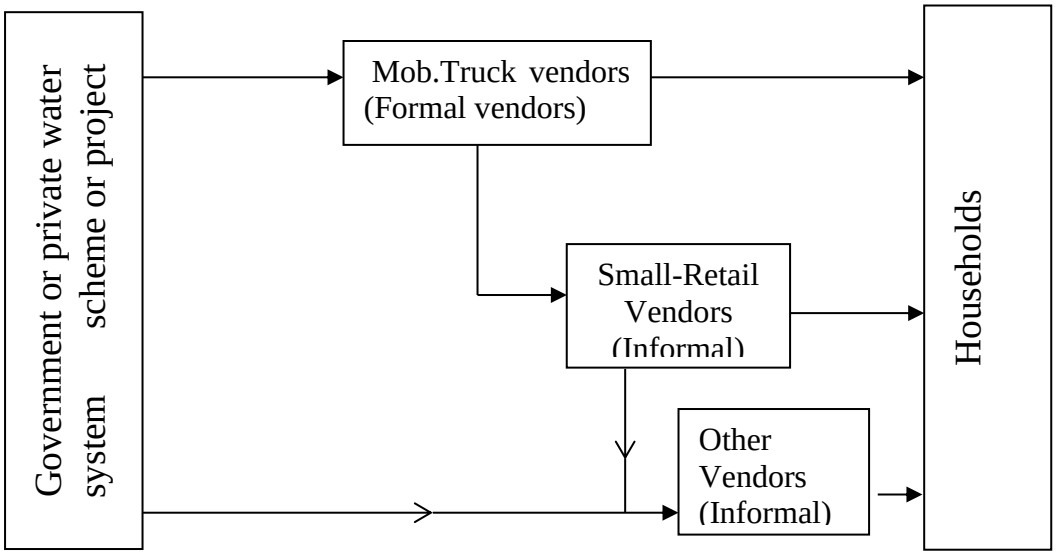

Figure 4: The pattern of water vending in Nsukka urban Source: Authors' Fieldwork, 2019

It is important to note that water vendors in Nsukka urban mostly obtain their water from three major means for onward sale to households. Households obtain water from any of the three means of water vendors depending on which of them is easier or most accessible to them, their level of income and the size of their household.
In other developing countries, water vending has been found to be a competitive industry in which the prices of vended water are determined by market forces, and vendors are not making excessive profits (Whittington, Lauria, Okun and Mu, 1988). This is the case in Nsukka urban, because mobile truck vendors do not enjoy monopoly, since there are other water vendors in the town i.e. the small retail water vendors and other vendors.

3.7 Age range of Water Truck Vendors

Age is an important determinant of an individual's physical productivity. It affects the ability to carry out certain activities that will help improve the economic wellbeing of the individual. Table 2 shows the age of truck drivers in the study area.

Table 2: Age range for WaterTruck Vendors

Age Range (Years)	No. of Respondents	Percentage (%)
<20	15	23.1
20-40	25	38.5
40-60	20	30.8
>60	5	7.7
Total	**65**	**100.0**

Source: Fieldwork, 2019

From table 2, the highest number of respondents falls in the age range of 20-40 years (38.5%), followed by those between 40 and 60 years (30.8%). The reason for this is that driving a fully loaded water truck around town requires both strength and experience and these age bracket are very active. Those below 20 years with 23.1% recognition are the boys who assist their masters i.e. those above 50 years are expected to be retiring. Those in this bracket who are still in the business, no longer play very active roles.

3.8 Financial Aspects of Tanker vendors

Despite the competition truck vendor's face, truck vendor's charges are the most expensive amongst the three water vendors. The tanker vendors charge as high as ₦4000 to ₦4500 per full load trip depending on the seasons via rainy or dry seasons. Below is a description of their revenue.
Table 3 presents the daily revenue and profits of a typical distributing vendor in Nsukka urban that carry water on the head per trip. At average tanker vendors daily revenue is around ₦8000 on daily bases. This amounts to about N208, 000 by the end of the month.

Table 3: Revenue of a Tanker Vendor in Nsukka urban

Capacity of truck	**2000gallons**
Average number of trips per day	2
Price charged	₦4000 to ₦4500
Daily revenue	₦8000
Net Revenue	
(a) Per day	₦8000
(b) Per month/working days	₦208,000

Source: Fieldwork, 2019

3.9 Small-Scale Water Vendors:

From the table 4, it is observed that the highest number of respondents fall in the age range of 20-40 years (48.6%), followed by those between 40-60 years (27.8%). The reason for this statistics is simply because, first and foremost, those involved in the small-scale retail water vending business are women. Secondly, these women are married women or housewives who engage in this business to support their various households, and they happen to fall within these two age brackets. They mount storage tanks in front of their houses from which they sell water to people in their various neighborhoods.

Table 4: Age range for small scale vendors

Age Range (Years)	No. of Respondents	Percentage (%)
Below 20	12	16.7
20-40	35	48.6
40-60	20	27.8
Above 60	5	6.9
Total	**72**	**100.0**

Source: fieldwork, 2019

3.9.1 Financial aspects of small-scale vendors

Small-scale retail vendors are making much gain considering the fact that, of the three water vendors, they are the most accessible to people since they live among them. They charge households ₦50 per gallon; about 150 times what they pay tanker truck water vendors to fill their storage tanks. They make use of storage tanks mostly 1000 gallons capacity for their business. This on the average costs the small-scale retail water vender ₦8000 to fill. If the vendors successfully sell off all the 1000 gallons, they stand the chance of making a profit of ₦5000 after each delivery from the tanker vendors. They are however, highly limited by the fact that, they and their households depend on the same storage tank for their household chores, thus, making it very difficult to account for profits at the end of the month.

3.10 Other Vendors

These involves individual that use wheelbarrow to fetch water for individuals as source of livelihood to generate income for themselves. They can be found around the urban area, when patronized they make use of their wheelbarrow to make water available for household use.

3.10.1 Age range for Other vendors

Age is a very important factor in this business. This is because, the act of selling water which at times involves moving along streets and in hot weather, is really an exercise that requires youthful competence. The age distribution of the respondents presented in table 5 is thus self-explanatory.

Table 5: Age range for other vendors

Age Range (Years)	No. of Respondents	Percentage (%)
Below 20	6	24.0
20-40	15	60.0
40-60	4	16.0
Above 60	0	0
Total	**25**	**100.0**

Source: Fieldwork, 2019

The highest number of respondents falls in the age range of 20-40 years (60%), followed by those below 20 years (24%). The least number are those above 50 years (0%). The reason for this situation as earlier highlighted is because people in the age bracket of 20-40 years are more physically fit and active which enables them to cope with this strenuous activity, that involves moving for long distance in search of patronage or to fetch water from various sources.

3.11 Physio-Chemical and Bacteriological Analysis of Vended Water in the Study Area.

The parameters analyzed include Temperature, PH, Turbidity, Total Dissolved Solid, COD (Chemical Oxygen Demand), BOD (Biological Oxygen Demand), Nitrates, Dissolved, Oxygen, Calcium, Magnesium, Sodium, Iron, Lead, Chromium, Total Plate Count, Total Coliform Group. The result are presented table 7 below.

Table 6: The Result of Physio-Chemical and Bacteriological Analysis of five boreholes in Nsukka urban.

PARAMETERS	X_1	X_2	X_3	X_4	X_5	W.H.O 2011
Appearance	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless
Temperature	23	22	23	23	22	25^0c
PH	7.0	6.0	6.0	7.0	7.0	6.5-8.5
Turbidity	3.0	4.0	4.0	3.0	3.0	5.0 NTU
TD Solid	12.0	5.0	6.0	12.0	0.0	500 $mg.dm^{-3}$
COD	6.0	8.0	6.0	9.0	8.0	10 $mg.dm^{-3}$
BOD	10	9.0	8.0	10	10	10 $mg.dm^{-3}$
Nitrates	50	38	36	46	48	50 $mg.dm^{-3}$
Dissolved Oxygen	5.64	5.93	5.13	6.0	5.21	6.0 $mg.dm^{-3}$

Calcium	73	74	74	72	75	75 $mg.dm^{-3}$
Magnesium	0.00	0.05	0.07	0.00	0.04	0.2 $mg.dm^{-3}$
Sodium	0.17	0.00	0.52	0.17	0.18	200 $mg.dm^{-3}$
Iron	0.0	0.1	0.0	0.1	0.1	0.3 $mg.dm^{-3}$
Lead	0.00	0.00	0.00	0.00	0.00	0.01 $mg.dm^{-3}$
Chromium	0.001	0.001	0.00	0.00	0.00	0.003 $mg.dm^{-3}$
Total Plate Count	20	30	40	40	60	100 $Cfu.(100cm^3)^{-1}$
Total ColiformGroup	0.00	0.00	0.00	0.00	0.00	0 $Cfu.(100cm^3)^{-1}$

Source: UNN table water test (2019).

X1= Gov. Borehole Opp. UNN Gate., X2= Borehole near car wash in Nsukka Urban., X3= Ibagwa road Borehole, X4= Milipart (Ugwuoye) Private Borehole, X5= Obollo Road Borehole, Nsukka.

The chemical characteristics of all the borehole water evaluated were within the acceptable maximum range of standard concentration values recommended by WHO for chloride, total hardness, nitrate, sulphate, iron, potassium, sodium and calcium. The implication of these results is that the different borehole maintained and adopted good standard operating procedures for chemical water treatment.

Table 7: Result of Physio-Chemical and Bacteriological Analysis of Water samples from vendors in Nsukka urban.

Parameters	**Tanker vendor**	**Small scale vendor**	**WHO 2011**
Temperature	26^0c	28^0c	25^0c
PH	7.0	7.0	6.5-8.5
Turbidity	3.0	3.0	5.0 NTU
Total dissolved Solid	12.0	6.0	500 $mg.dm^{-3}$
COD	3.20	5	10 $mg.dm^{-3}$
BOD	7.2	8	10 $mg.dm^{-3}$
Nitrates	12.9	22.52	50 $mg.dm^{-3}$
Dissolved Oxygen	4.0	3.0	6.0 $mg.dm^{-3}$
Calcium	2.56	1.28	75 $mg.dm^{-3}$
Magnesium	0.07	1.03	0.2 $mg.dm^{-3}$
Sodium	0.07	0.05	200 $mg.dm^{-3}$
Iron	1.41	1.42	0.3 $mg.dm^{-3}$
Lead	0.00	0.00	0.01 $mg.dm^{-3}$
Chromium	0.001	0.001	0.003 $mg.dm^{-3}$
Total PlateCount	20	30	100 $Cfu.(100cm^3)^{-1}$
Total Coliform Group	0.00	0.00	0 $Cfu.(100cm^3)^{-1}$

Source: UNN Table Water Test.

Table 7 is the result analysis of vended sources which shows that Temperature, PH, Turbidity, Total dissolved Solid, COD (chemical oxygen demand), BOD (biological oxygen demand), Nitrates, Dissolved, Oxygen, Calcium, Magnesium, Sodium, Lead, Chromium, Total Plate Count, Total Coliform Group were all good with W.H.O allowable limits for drinking water except for iron. This is as a result of contaminations originating from the containers and rusty iron tanks used by vendors for water sale. The ingestion of large quantities of iron can damage blood vessels, cause bloody stools and damage the liver and kidneys and even cause death (Su et al. 2013).

4.0. Conclusions

The Independent surveillance is an important element of ensuring that vended water is safe. One of the obstacles to effective monitoring can be lack of records and documentation identifying water vendors. Therefore implementation of registration systems should be considered. From the study of water vending in Nsukka Urban, we found out a number of issues. Firstly, the tanks and storage tanks used for water sale should be clean and monitored by government agencies to avoid contamination. Secondly, the government has not done much in providing adequate pipe-borne water to the inhabitants of Nsukka urban and this is the major reason for the prevalence of water vending activities in the town. Based on the research findings, the following conclusion has

been drawn. The water supply problem in the study area has given rise to the activities of water vendors, which is as a result of inadequate pipe-borne water facilities. Presently, only few people connected to the public supply actually receive supplies, a large majority of people are not connected to the public supply; which even compounds the problem and gives more room for the expansion of water vending activities in the study area. Government has a role to play in regulating the activities of these vendors and also in monitoring their distribution equipment.

References

Abdullah, R. (1999). The Role of Private Vending in Developing Country Water Services Delivery: The Case of Karachi, Pakistan. *Working Paper Series:World Bank*. Washington DC

Abubakar IR (2016) Quality dimensions of public water services in Abuja, Nigeria. Util Policy 38:43–51

Acey C (2008) Neighbourhood effects and household responses to water supply problems in Nigerian cities. J Transdiscipl Res South Afr 4(1):123–156 Ayalew M, Chenoweth J, Malcolm

Anyadike, R. N. C. (2002): Climate and vegetation. In Ofomata G. E. K. (2002) (ed). A survey of the Igbo Nation. *Africana First Publishers*. Nigeria.

Ayalew M, Chenoweth J, Malcolm R, Mulugetta Y, Okotto LG, Pedley S (2014) Small independent water providers: their position in the regulatory framework for the supply of water in Kenya and Ethiopia. J Environ Law 26:105–128. doi:10.1

Baisa, B., Davis, L., Salant, S. W. and Wilcox, W. (2008). The Welfare Costs of Unreliable Water Service. Unpublished MPRA Paper. http://www.mpra.ub.uni-muenchen.de/9812.

Emmanuella, C.O., Ebere, I.G., Okechi, D.A., and Sabina, O. (2012). The Dynamics of Domestic Water Vending in Enugu North L.G.A OF Enugu State Nigeria. *Journal of Water Resources and Protection.* Doi:10.4236/jwarp.2012.44025.

Ezenwaji, E. (2009). Sources of Rural Water Supply in Old Njikoka L. G. A of Anambra State, Nigeria. In Uzo M. Igbozurike and E. C. Onyenechere (Eds.)(2009). Rural Water Supply in Nigeria. Cape Publisher International Ltd, Owerri, Imo State, pp 51-60.

Falkenmark, M. (1989). The Massive Water Scarity now Threatening Africa: Why isn't it being addressed *Ambio*, Vol. 18, No.2, pp. 112-118

Falkenmark, M. and Widstrand, C. (1992). Population and Water Resources: A Delicate Balance. Population Reference Bureau Inc. Washington D.C.

Ishaku, H.T., Peters, A.A., Haruna, A. and Dama, F.M. (2010). The Role of Private Water Vending in Nigerian Peri-Urban Informal Settlements: Implication for Policy Makers. *Journal of Water Resource and Protection.* Vol. 2, pg 1082-1087.

Isreal, D.K. (2007). Impact of Increased Access and Price on Household Water in Urban Bolivia. *The Journal of Environment and Development.* Vol. 16, No. 3, pp. 58-83. doi:10.1177/1070496506298190.

Kjellen M (2000) Complementary water systems in Dar es Salaam, Tanzania: the case of water vending. Int J Water Resour Dev 16 (1):143–154. doi:10.1080/0790.

Kjellen, M. (2010). Water Vending in Dares Salaam, Tanzania. In: B. Calas and C. A. Mumma Martinon, Eds., Shared Waters, Shared Opportunities: Hydropolitics in East Africa, Nairobi. *Mkukina Nyota Publishers* Ltd., Tanzania, pp. 173-184.

NPC (2006) 2006 Population and Housing Census of the Federal Republic of Nigeria: Housing Characteristics and Amenities, Priority Tables (LGA), vol II. National Population Commission, Abuja.

Olajuyide, A.E., Rorowa, O.O. and Adewumi, I,J. (2012). Water Vending in Nigeria-A Case Study of Festac Town, Lagos, Nigeria.*mediterranean centre of social and educational research,* vol.3, No.1 doi:10.5901/mjss.2012.03.01.229.

Onyenechere CO, Eleazu EI, Azuwike OD, Osuji S, Igwe CF (2012) The dynamics of domestic water vending in Enugu North L.G.A. of Enugu State, Nigeria. J Water Resour Prot 4:224–230. doi:10. 4236/jwarp.2012.44025

Opryszko MC, Huang H, Soderlund K, Schwab KJ (2009) Data gaps in evidence-based research on small water enterprises in developing countries. J Water Health 7(4):609–622

Prescott, L.M., Harley, J.P., and Klein, D.N. (1999). Microbiology. 4th Edition. *The McGraw- Hill Companies, Inc*., Newyork, 685.

Sada, P.O. (1978). Geography in Nigeria, Perspective and Prospects: A Presidential Address. *Geographical Journal.* Vol. 26, Pp. 1-13.

Sansom K, Bos A (2008) Utility and non-state water service provision for the urban poor. Int J Water 4(3/4):290–303

Snell S (1998) Water and sanitation services for the urban poor. Small-scale providers: typology and profiles. Water and Sanita- tion Program, World Bank, Washington DC

Su S, Xiao R, Mi X, Xu X, Zhang Z, Wu J (2013) Spatial determinants of hazardous chemicals in surface water of Qiantang River, China. Ecol Indic 24:375–381 Whittington, D., Lauria, D.T., Okun, D.A and Mu, X. (1989). Water vending activities in Developing Countries; A case study of Ukunda, Kenya. *International Journal of Water Resources and Development.* Vol5, Issue 3, Pages 158-168.

Whittington, D. and Mu, X. (1991). A study of Water Vending and Willingness to Pay for Water in Onitsha, Nigeria. Washington, D.C; *World Developm*ent. Vol.19, Issues 2-3, Pages 179-198.

WHO (2006). Progress on Drinking Water and Sanitation. A 2008 Millennium Development Goal (MDG) Assessment on progress for Children: A Report Card."www.childinfo.org/water.html

WHO 2011. Guidelines for drinking water quality (online). 4th ed. Health criteria and other supporting information. Geneva. Vol. 2 ISBN 978-92-4-154815-1 pp 541.

WHO, UNICEF (2015) Progress on sanitation and drinking water— 2015 update and MDG assessment. World Health Organisation, Geneva. Vol. 3 ISBN 938-94-4-134345-1 pp 641.

World Bank Annual Report (1992). The significant impact and progress that was made in 1992.

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