ACCESS TO POTABLE DOMESTIC WATER IN THE RURAL COMMUNITIES OF SOUTHWESTERN ANAMBRA STATE, NIGERIA

By

OKEKE, IFEYINWA OGOCHUKWU (Matric. No. 999008126)
B.Sc.Ed (Geography) Nsukka, M.Sc. (Geography), Lagos

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CERTIFICATION

This is to certify that the Thesis:

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is a record of original research carried out

By

OKEKE, IFEYINWA OGOCHUKWU
In the Department of Geography

OKEKE, IFEYINWA OGOCHUKWU	[signature]	11/12/09
AUTHOR'S NAME	**SIGNATURE**	**DATE**
L. OYEBANDE (PROF)	[signature]	11/12/09
1ST SUPERVISOR'S NAME	**SIGNATURE**	**DATE**
DR. IDOWU BALOGUN	[signature]	11-12-2009
2ND SUPERVISOR'S NAME	**SIGNATURE**	**DATE**
DR ADEMOLA OMOJOLA	[signature]	11/12/09
3RD SUPERVISOR'S NAME	**SIGNATURE**	**DATE**
DR SAMUEL IYIOLA ONI	[signature]	11/12/09
1ST INTERNAL EXAMINER	**SIGNATURE**	**DATE**
Dr. Nwa O. ULUOCHA	[signature]	11/12/09
2ND INTERNAL EXAMINER	**SIGNATURE**	**DATE**
Prof Olasimbo Martins	[signature]	11-12-2009
EXTERNAL EXAMINER	**SIGNATURE**	**DATE**
Dr. K.O. Ayeyemi-Maju	[signature]	11/12/09
SPGS REPRESENTATIVE	**SIGNATURE**	**DATE**

DEDICATION

This thesis is dedicated to the **ALMIGHTY GOD.**

For life, wisdom, resources and an excellent spirit to accomplish this great commission

and

To my dear husband Barr. Donatus Okeke, the love of my life, for his inspiration, thoughtful and inexorable support throughout this Ph.D programme.

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TABLE OF CONTENTS

Children 48.3%

See page 99

Women & Children 43.0%

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Abstract

Fresh water especially for domestic consumption is a crucial resource for life sustenance on earth. The dwindling supply and growing demand however, is resulting to water crisis because climate change, water pollution from agricultural wastes, chemical runoff, raw sewage are straining water resources in many parts of the world. These deplete large volumes of domestic water every year and worse still causes sickness and death in those without choice than to drink unsafe water. The complexity of the problem is that as domestic water supply decreases, population growth increases domestic water demand. Attempts and measures to improve access to safe water supply and distribution have been made at the different water development plan stages and water initiatives in Nigeria, yet the MDG target of 75% for the year 2007 was unattained. In the rural areas challenged by water shortages and poor quality, water demand estimations and quality assessments have been carried out without establishing a control variable vital for rural water planning. The research therefore attempted the identification and characterization of domestic water sources; examination of patterns of access to water by rural households; quantification of household water consumption; water quality sampling and examination using WHO and FMEnv standard limits; and the impact of reasonable access to water on the socio-economy and health of rural consumers in the Southwestern parts of Anambra State. The concepts of Community Water Supply Management(CWSM), Water Supply Protection(WSP) and Threshold (Tc) as well as the methodology of related literature review, field studies and water sampling, laboratory and statistical analysis; development of the Rural Threshold Water Consumption (RTWC) model to establish a control variable and delineate areas of water supply deficits, surpluses or balance were employed. The research findings show the nature of rural domestic water sources, average domestic water consumption of 25 - 29.2litres, threshold control variable of 139 litres and variations in the water quality of the sampled rural water. The implications of poor health, food insecurity and unsustainable water sector are resultant issues that require both private, community and government participation so as to advance the rural water resources data bank of the Southwestern parts of Anambra State.

CHAPTER ONE

BACKGROUND TO THE STUDY

Water is an essential life-sustaining element. It pervades human lives and embraces different cultures. A vast portion of the earth surface is covered by water yet; water shortages have been a life long challenge to people of all ages and epoch. Water accounts for about 65 percent of the human body and the minimum needed for proper daily function is about 90 - 112 litres per day. Human beings require 1-3 litres of water per day for survival (Doodge, 1985). In the rural areas of Nigeria, the main water needs are for domestic and agricultural purposes and a higher percentage of the rural dwellers utilize domestic water for household purposes. The problem is more acute due to increasing rural population, the dispersed and scattered nature of rural settlements, limited social amenities, relatively low income, expertise and skills to use existing or develop new water schemes as well as lack of appropriate institutions for governance. To satisfy their water demands for diverse purposes, most rural dwellers rely on natural water sources such as rainwater, shallow wells, streams, boreholes and rivers. The availability and quality of these water sources is however affected by environmental factors such as changes in climate, pollution by man and animals using and defecating in the streams as well as industrial effluents upstream from the urban centres.

The net result of the above factors is recurrent water shortages, poor quality and deteriorating health conditions of the rural dwellers. Buttressing this, Scholz (2003) observed that despite efforts made towards developing water supplies in rural areas, poor health cases are rampant due to water shortages and use of polluted drinking water. UNUS (2005) reports that half of the to water shortages and use of polluted drinking water. UNUS (2005) reports that half of the worlds population does not have access to clean water supply; the unfortunate majority dwell in unsanitary conditions and are exposed to high disease risk. The World Water council (2000) estimates that more than 1 billion people in developing countries do not have access to clean water whilst 2 billion lack adequate sanitation. Rosen and Vincent (1999) in the case of Sub-Saharan Africa, estimate that about 67% of the rural population (about 250 million people) lack safe and accessible water supply. Opara (2006) similarly identified unsafe water as a factor in the spread and communication of water-borne or water related diseases. Unsafe water supplies could result from natural or man made pollution. Water is critical to human survival, health and economic development yet millions of people in the developing countries are faced with acute water stress from inadequate supplies. The official World Health Organization figure suggests that between 1980 and 1990, at least 170million people in urban areas lack access to potable water close to their homes while evidence from rural areas reveals that more than 855million are still without safe water; the figure estimated may have increased dramatically by the turn of the century (World Bank, 1993).

The search for potable water has become a preoccupation in most rural communities engaging women and children in long distance treks for this vital resource. The scarcity of potable water at times results in a new phenomenon which Tearfund (2001) referred to as "Water Refugees". This is a situation whereby millions of people are forced to leave their homes in search of water. High population growth rate due to the culture of large families also increases the demand and competition for potable water and accelerates pollution from domestic and agricultural activities.

Luijten (1999) reiterates that the complexity of water problems impact sustainable development and quality of life, which in turn threatens food security, human health and natural ecosystems. This is because water implies food security which is very significant at the local level. Presently, many households, often the poorest end up dissipating their energy and time in water collection as well as purchasing water from private vendors at more expensive rates than public water supply. Annan (2003) at the International Year of Freshwater celebration therefore emphasizes that "No single measure would do more to reduce disease and save lives in the developing world than bringing safe water and adequate sanitation to all".

Mega foras and water-oriented conferences to examine and address water problems held during the 1977 World Water Conference in Mar del Plata, Argentina launched the water supply and sanitation decade of 1981–1990; others include the 1992 Dublin Water Conference, the 1992 Rio de Janeiro summit on Environment and Development; the Millennium Declaration goals adopted by the General Assembly of the United Nations (UN) in 2000; the 2001 International Conference on Freshwater in Bonn, Germany as well as the outcome of the Johannesburg World Summit for Sustainable Development in 2002 and the 2003 Third World Water Forum in Kyoto, Japan. Most recently, the UN General Assembly declared the period from 2005 to 2015 as the International Decade for Action, "Water for Life."

In Nigeria, the June 2003 initiative "Water for people, water for life" programme aimed at achieving 100% water supply coverage for all state capitals by the year 2007 already was not achieved (This day, 2005). Access to safe drinking-water is important as a health and development issue at the national, regional and local level. It can also help to alleviate poverty in the rural areas. Water is also an index of rural development which serves for domestic, agricultural and food processing, traditional medicine and healthcare, fishing, transportation and a lot of other activities (Bob-Duru, 2001). Water supply sources therefore require proper and adequate protection, conservation, planning and management to meet the demands of the present and future users. It is against this background that this research is being conducted in the rural communities of Southwestern Anambra State to determine the state of water supply for domestic consumption.

1.1: Statement of Problem

Water is required for domestic, agricultural and food processing, traditional medicine and health care, fishing, transportation and lots of other activities (Bob-Duru, 2001). Yet despite the existent of different water sources in the study area such as rivers, streams, springs and boreholes; several rural communities still experience water scarcity due to inadequate supply, technical problems and peoples' ignorance (JICA/NWRMP, 1995) as well as seasonal variations, misuse and increase in water demand for domestic purposes. A case in point is the eastward migration of Nigeria's lake-shore populations which followed Lake Chad as it receded into the Cameroon during 1971 -1994. Pollution also deteriorates water quality and leads to health disorders of common water-borne or water related diseases like cholera, typhoid, river blindness, dermatitis, hepatitis and shigellosis as well as malaria (WHO, 2004a). Similarly, World Health Organization (2004b) stated that unclean water is responsible for diseases such as diarrhoea, cholera, guinea worm, typhoid and intestinal worms, which kill more than 8 million people throughout the world each year. However, Gash et al (2001) reinstated that human health depends on adequate supply of safe water because the consumption of water containing bacteria and parasites or even contact with water containing non-biological pollutants all impair human health.

The rural communities of Orsumoghu, Mbosi and Isseke in Ihiala LGA, lack adequate access to water supply because their dwellers engage in exhaustive, time and energy consuming treks of about 1km to water points and convey gallons of water back home on their heads or in wheel barrows as shown in Plate 1.

Plate 1: Children traveling distances to and from water points at Orsumoghu, Ihiala LGA December 7, 2006

Gender sensitive streams such as "Iyiahaba" in Osumenyi community of Nnewi South LGA limit access to water collection because it is a taboo for young girls to fetch water from it. Therefore only boys, elderly men and women have access to it and they are mostly unwilling to do so because it is not their duty in the traditional family division of labour.

The communities of Utuh, Osumenyi and Ekwulumili communities of Nnewi South LGA; Nnokwa and Awka Etiti communities of Idemili South LGA rely heavily on rain water harvesting through the popular roof catch method (Plates 2 and 3).

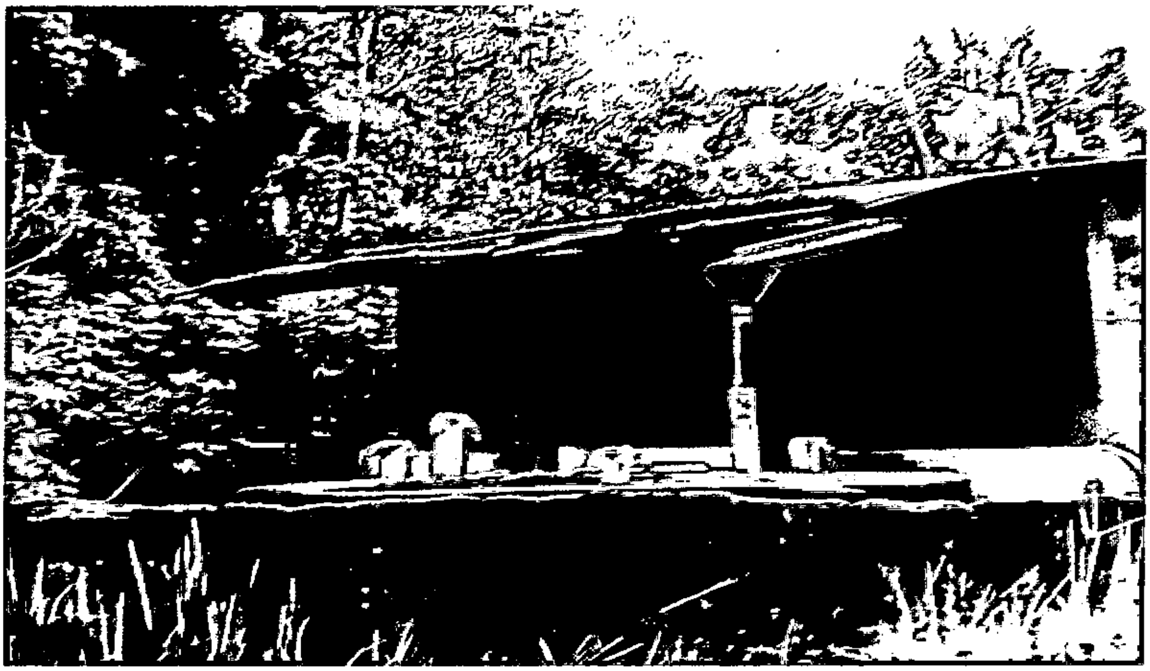


Plate 2: Roof Catch rain harvest at Mbosi, Ihiala LGA
December 7, 2006

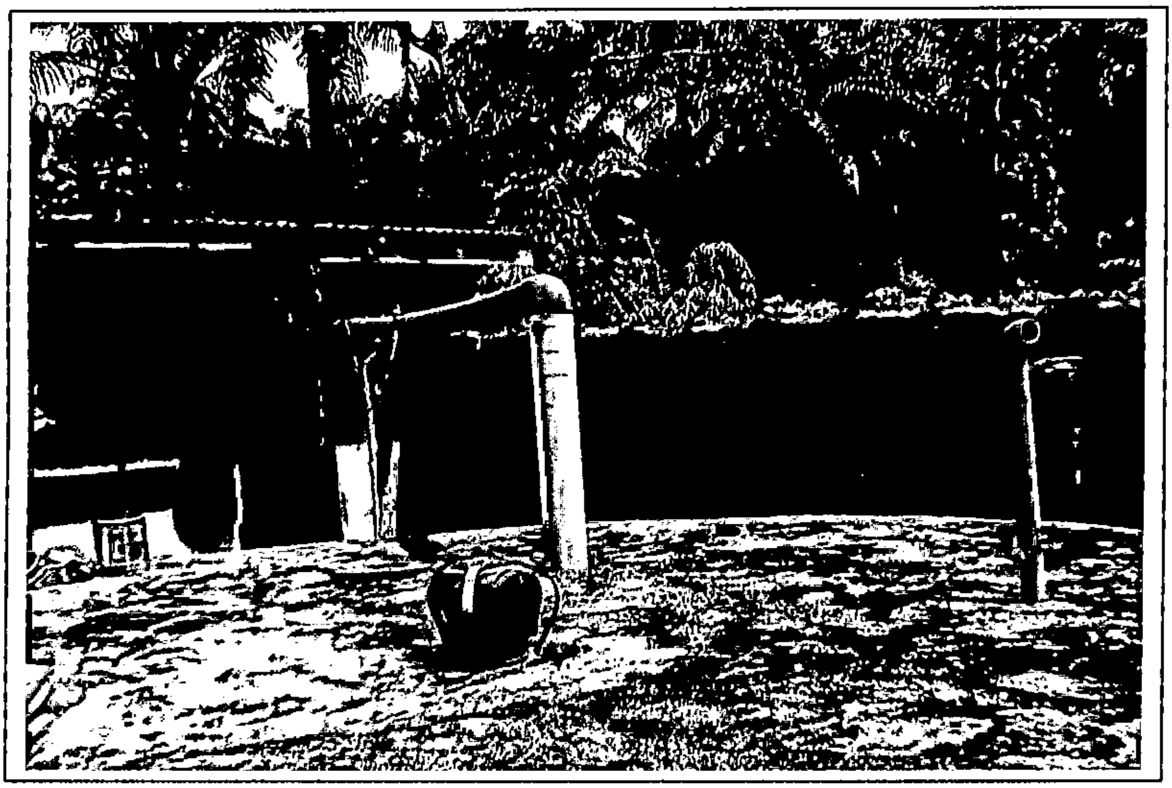


Plate 3: Roof catch, channeled into underground tank at Utuh, Nnewi South LGA December 7. 2006

This process of collection and storage of rainwater could lead to water contamination especially when the receptacles and reservoirs are not properly protected from dust and other pollutants. In addition, water crisis could result during dry periods when people exhaust their stored rainwater.

The seasonality of most rivers and streams which overflow during the rains and diminish during dry seasons further turns out to be problematic for most rural communities that depend heavily on them. A typical example is Orashi River in Ogwuani-Ocha community of Ogbaru LGA which is the only source of water for the indigenes apart from rain harvest (Personal communication: Anene, December 9, 2006). Other seasonal streams are Ekulo Ibollo of Oraifite in Ekwusigo

LGA and Opiegbe in Ideani, Idemili North LGA. The indigenes resort to alternatives such as rain harvest, hand dug wells, boreholes and patronage to water vendors.

Streams such as Omaiyi in Azzia, Ihiala LGA (Plate 4); Opiegbe in Ideani, Ukwuakpu in Eziowelle and Esigbo in Abatete, all in Idemili North LGA serve as centres of domestic activities of bathing, washing, food processing, relaxation as well as economic activities of fishing, sand dredging, brick making and sacrifices.

Plate 4: Recreation and water gathering activities at Omaiyi stream, Azzia, Ihiala LGA December 7. 2006

In addition, rivers such as Idemili and Niger at Iyiowa Odekpe and Orashi at Ogwuani-Ocha, both in Ogbaru LGA, serve as transportation links and refuse dump sites. These activities contaminate and pollute water sources resulting to changes in physical (colour, taste and odour) as well as in chemical and micro-biological properties, thereby affecting the water quality.

The existing boreholes have some restrictions varying from high water charges for commercial boreholes, inconvenient times to fetch water for private boreholes and time-regulated boreholes (Plate 5) and lack of electricity or breakdown of generators for the electricity powered boreholes. This results to unsteady water supply although the Emeka Offor electric operated water project in Oraifite, Ekwusigo LGA and 'Nwa Fada' borehole in Ezinimo village of Abatete, Idemili North LGA are exceptions with standby generators for steady supply.

Plate 5: Time regulated private borehole at Orsumoghu, Ihiala LGA. Opens: 6.00am-7.00am and 4.00pm-5.00pm December 7, 2006

Boreholes disorders and cases of abandoned borehole projects in the study communities also intensify water problems. These include Ichi World Bank project in Ekwusigo LGA (Plate 6) which has no SUMO pump installed (Personal Communication: Okemili, December 9, 2006).

Plate 6: Abandoned World Bank water project at Ichi, Ekwusigo LGA
December 8, 2006

Defective and non-functional boreholes such as the Oraifite PTF water project in Ekwusigo LGA (Plate 7) and the Federal Government borehole at Akili Ozizor (Plate 8) could result from misuse of facility or poor design capacity. Incomprehensive geophysical survey for borehole locations such as the Ogbaru Federal Government boreholes at Ossomala and Umunankwo communities (Personal Communication: Obiorah, December 6, 2006), results in provision of poor water quality. This is due to the soils high iron content which turns the water brownish, few minutes after collection. This could pose some health risks to consumers of such water sources.

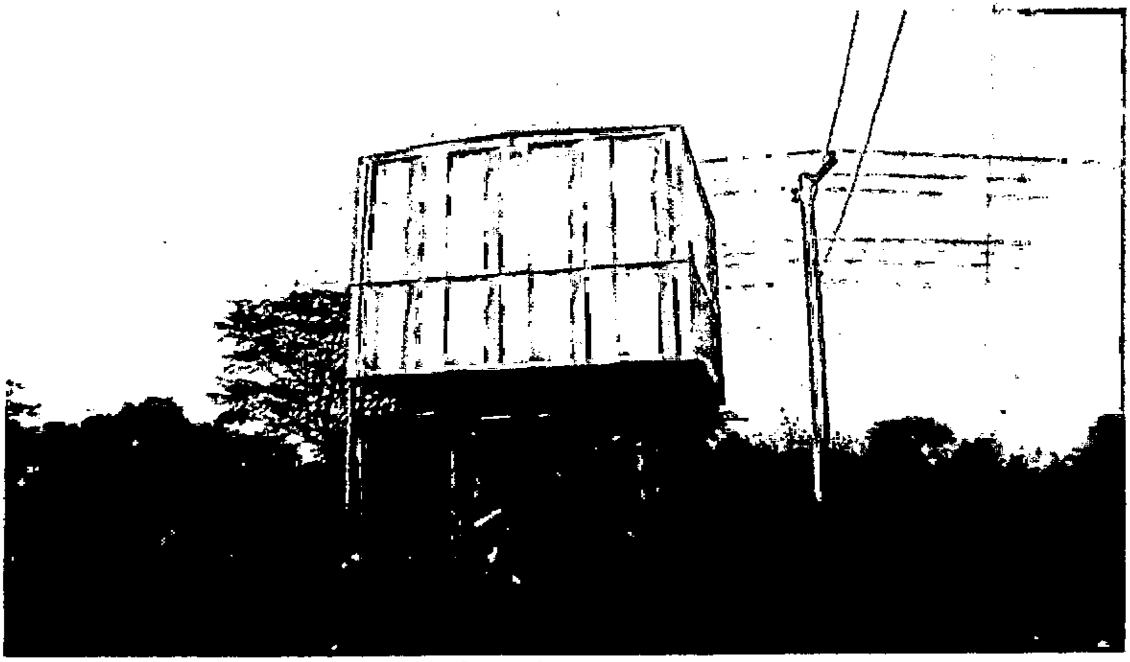


Plate 7: Defective PTF water project at Oraifite, Ekwusigo LGA
December 8, 2006

Plate 8: The defective Federal government borehole at Akili Ozizor, Ogbaru LGA
December 6, 2006

Conservatism, ignorance and the idea by the indigenes that the government is solely responsible for water provision as well as poor enlightenment, lack of adequate information on groundwater characteristics of an area and the use of poor water quality are other peculiar problems in the study area. The deep brownish colour change of water soon after collection which results from oxidation of high iron content of the soil compels most Ogbaru LGA indigenes such as the Umunankwos', Akilis' and Ossomalans' to isolate the Federal Government borehole schemes in their area and instead rather resort to Onukwu stream in Umunankwo and the River Niger.

Agriculture is a key occupation in Ogbaru LGA because of the presence of the Niger flood plains. The chemical fertilizers (NPK) applied on crops for growth is thus, normally washed off into nearby streams and rivers during the rains thereby making such water sources susceptible to contamination. Further limitations to effective and efficient rural water supply are poor funding and lack of skilled operators for routine maintenance, thereby hindering or delaying repairs, expansion and modernization of water facilities as well as limiting existing water sources.

Water supply problems in the rural communities of Southwestern, Anambra State therefore could be viewed as natural or man made or a combination of both. Several attempts have therefore been made to provide alternative water supply sources to rural dwellers through community participation initiative, new water sources construction and protection. These have however been undertaken without estimating water demand and supply which helps in determining water shortage, surplus or balance periods as well as the water quality. The research, therefore, sets out to examine the quantity and quality aspects of domestic water in the rural communities of Southwestern Anambra State.

1.2: Research Questions

- What are the major characteristics of the existing sources of water supply under study?
- Which group of the rural dwellers and how far do they travel to water points for domestic water?
- What is the average time spent on water collection per day?
- What is the nature of the balance between water supply and demand in the study area?
- How safe and reliable is the water quality for domestic consumption?
- How does safe and adequate potable rural water supply contribute to the broader goal of rural development in the study area?

1.3: Aim and Objectives

Rural research is difficult to conduct due to its resource and time consuming nature, poor access and low prospect of implementation of research findings. The rural water quantity, quality and usage patterns are all matters of great concern for a healthy rural economy.

The main aim of this research therefore, is to examine access to safe and affordable water and its impact on the well-being of rural dwellers in the Southwestern parts of Anambra State. The specific objectives are to:

1) Identify and characterize the various sources of water supply in the area
2) Examine the patterns of household access and water consumption in the study area
3) Determine the domestic water supply and demand in the study area
4) Assess the quality of water from various rural water sources
5) Evaluate the impact of reasonable access to potable water supply in the socio-economic life of the rural communities of the study area.

1.4: Justification of the Study

The study is justified because improved access to rural water is a part of the United Nations millennium development goals agenda and an important factor of livability as well as to express the challenges of poor water quality, unsteady supply and scarcity faced by most rural communities despite the numerous water sources in existence.

1.5: Operational Definition of Terms

Reasonable access to water: Not more than 1000 metres from a house to a public stand post or any other improved drinking water source and provision of at least 20 litres per capita per day.

Water accessibility: The ability to reach a desired water source, collect water of good quality and sufficient quantity at minimal cost, time and discomfort rate.

Water supply: The amount of water made available to a community while *Water supply coverage* is the percentage of population with reasonable access to potable water.

Improved water sources: Water sources protected by nature of its construction from external contamination especially feacal matter.

Potable water: Water fit for human consumption that must be free of pathogens, have a desirable taste, odour free, clear and colourless and contain no harmful chemicals to health according to WHO guidelines or national standards for drinking water quality.

Water scarcity: is a situation whereby available water is in small quantity that is not enough to meet the necessary minimum requirements for basic needs.

Water shortage: is often associated with a temporary water imbalance such as ground and surface water over-exploitation, degraded water quality and disturbed land use.

Water Pollution: is the contamination of water by foreign matter such as micro-organisms, chemicals and industrial or other wastes, or sewage which lowers water quality and renders it unfit for its intended uses.

Water quality guideline value: The concentration of a constituent that does not exceed tolerable risk to the health consumers over a lifetime of consumption.

Coliform: Bacteria indicator of sanitary quality of food and water.

Minimum amount of water: The amount of water needed to satisfy metabolic, hygienic and domestic requirements. This is usually defined as twenty litres of safe water per person per day.

Maximum amount of water: A greater proportion of water needed to satisfy metabolic, hygienic and domestic requirements.

Threshold balance (K): A control variable that will be ideal for rural water planning

SUMO pumps; Machines designed for pumping clean water or fluids out from the ground.

Opportunity cost: The price paid for a need forfeited or at the expense of obtaining a good.

Industrial water consumption: represents the volume of water used for small scale industrial functions such as agro-industrial processing of cassava, oil palm and local soap making.

Agricultural water consumption: represents the volume used for household agriculture in maintaining of vegetable gardens popularly called "mbubo" and vineyards.

Rural areas: Sparsely settled localities far away from the influence of large cities, characterized by agriculture, limited public services and utilities yet constitutes an extensive part of any economy.

1.6: Location and Extent

The study area (Figure 1.1) covers the rural communities of Southwestern Anambra State. Geographically, it extends from about latitude $5^{0}\ 43^{1}\ 50^{''}$ to $6^{0}\ 09^{1}\ 30^{''}$ and longitude $6^{0}\ 38^{1}\ 37^{''}$ to $7^{0}\ 02^{1}\ 32^{''}$. The local government areas are Idemili North and South; Ekwusigo, Nnewi South; Ogbaru and Ihiala. Anambra State lies in the south-eastern part of the Federal Republic of Nigeria and lies within latitudes $5^{0}\ 40^{1}$N and $6^{0}\ 48^{1}$N and longitudes $6^{0}\ 35^{1}$E and $7^{0}\ 30^{1}$E. It shares boundaries with Kogi State to the north, Imo State to the south, to the east with Enugu State and to the west with Delta State. The State derived its name from the Anambra River; the largest southerly tributary of the Niger River. The Old Anambra State was created in 1976 from the East Central State with former capital at Enugu while a further re-organization on August 27, 1991 divided Anambra into two states, Anambra and Enugu.

Anambra State has its capital at Awka, one of Nigeria's centres of metalwork and carving industries. The State is made up of twenty-one Local Government Areas (LGAs) namely; Aguata, Anambra East, Anambra West, Anaocha, Awka North, Awka South, Ayamelum, Dunukofia, Ekwusigo, Idemili North, Idemili South, Ihiala, Njikoka, Nnewi North, Nnewi South, Ogbaru, Orumba North, Orumba South, Onitsha North, Onitsha South and Oyi. They are made up of several urban and rural communities respectively in the ratio of (1:8). The local government areas and communities selected for detailed study are due to unsteady water supply nature and cases of recurrent water problems. Table 1.1 presents the various communities in the study LGAs.

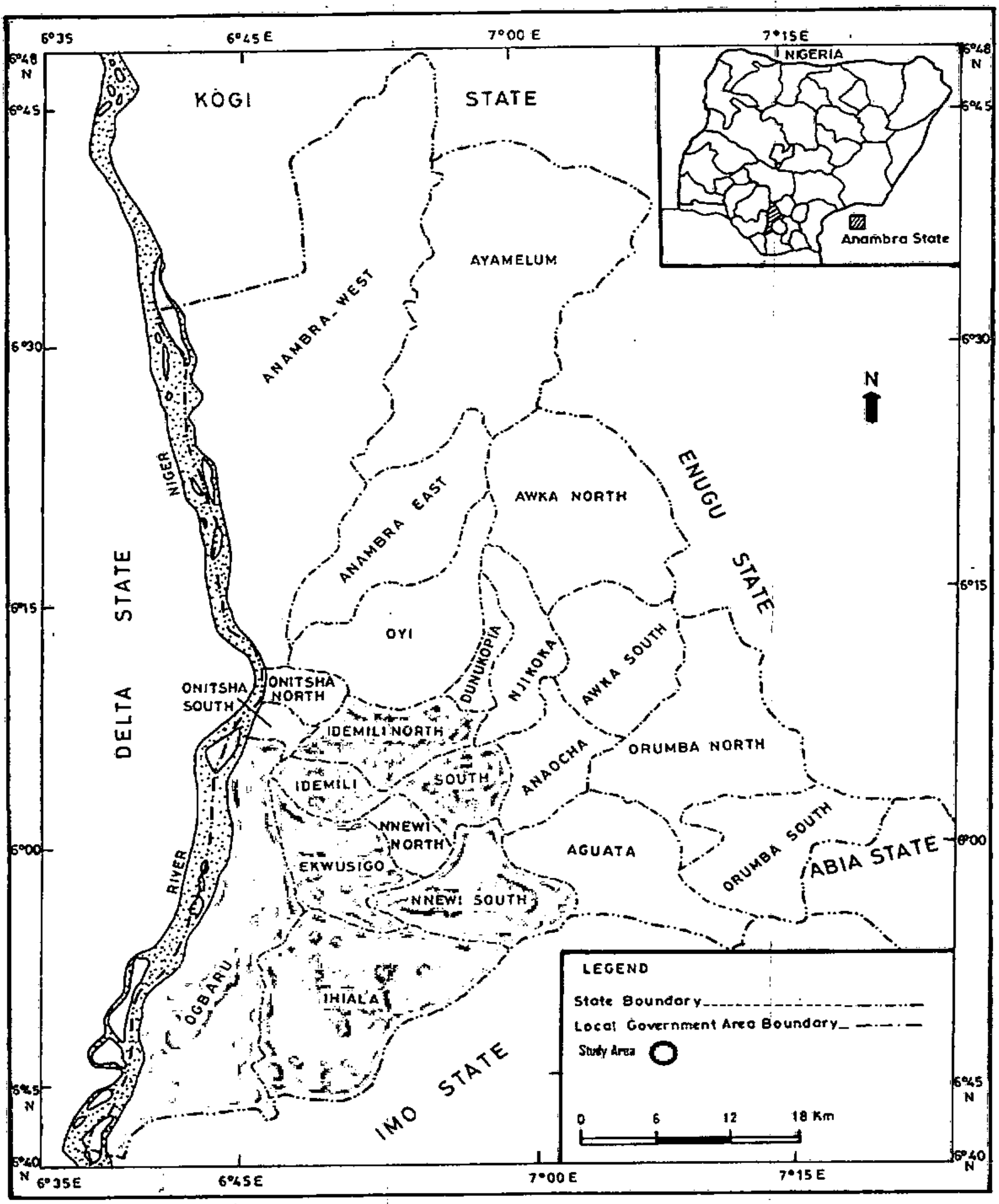


Fig.1.1: LGAs with rural communities within Southwestern Anambra State
Source: Anambra State Survey Awka, 1997

Table 1.1: Study LGAs and Communities in SW Anambra State

IDEMILI NORTH	IDEMILI SOUTH	NNEWI SOUTH	IHIALA	OGBARU
1. Abacha	1. #Akwukwu	1. *Ukpor	1. #Azzia	1. Atani hq
2. #Abatete	2. #Alor	2. #Utuh	2. #Amorka	2. Akili-Ogidi
3. #Eziowelle	3. #Awka-Etiti	3. Akwaihedi	3. Ihiala hq	3. #Akili-Ozizor
4. #Ideani	4. *Nnobi	4. Ezinifite	4. #Isseke	4. Amiyi
5. *Nkpor	5. #Nnokwa	5. #Osumenyi	5. Lilu	5. Mputu
6. *Obosi	6. Oba hq	6. Ebenator	6. #Mbosi	6. Obeagwe
7. Ogidi hq	7. *Ojoto	7. Amichi	7. #Okija	7. Ohita
8. Oraukwu	**4(4)**	8. Azigbo	8. Ubuluisiuzor	8. #Iyiowa Odekpe
9. #Uke		9. #Ekwulumili	9. Uli	9. Ogbakugba
10. #Umuoji		10. #Unubi	10. #Orsumghu	10. Ochuche Umuodu
11. Nsuku		**9(4)**	11. Ihiala ulo	11. #Ossomala
12. Odida			12. Ifite	12. #Ogwu-aniocha
10(5)			**11(6)**	13. #Umunankwo
				14. Umuzu
ONITSHA NORTH	**ONITSHA SOUTH**	**NNEWI NORTH**	**EKWUSIGO**	15. *Okpoko
1. *Onitsha	1. *Fegge	1. *Nnewi	1. *Ozubulu	16. #Ogwu Ikpele
0(0)	**0(0)**	**0(0)**	2. #Oraifite	**15(6)**
			3. #Ichi	
			4. #Ihembosi	
			3(3)	

*Urban centres (towns); Hq - LGA headquarters; # selected rural study communities (28)
10(5) = Total no of rural communities and selected communities

A random sampling design for all the six study LGAs is conducted in the following order:

- LGAs with > 8 rural communities (randomly choose ½ but not more than 6 communities)
- LGAs with 4 – 8 rural communities (choose 4 or 5 randomly)
- LGAs with < or = 3 (choose all)

A total of 28 rural communities represented with (#) symbol are randomly selected from the Idemili North and South; Nnewi South; Ihiala and Ogbaru LGAs. These LGAS have several communities and seem to be mostly comprised of rural communities. On the contrary, the local government areas with few communities namely, (Nnewi North, Onitsha North and South) have no rural communities per se and yet are large enough on their own.

1.6.1: Physical Setting

a) Climate

The climate of Anambra State is tropical with distinct wet and dry seasons. The warm and humid tropical maritime tropical ($_M$T) air mass (South west trade wind) which originates from the southern high pressure belt crossing the equator and picking up moisture over the Atlantic Ocean from the Atlantic usher in the rainy season. On the other hand, the dry and dusty Continental ($_C$T) air mass (North east trade wind) from the Sahara ushers in the dry season. The interaction of the air masses ($_C$T and $_M$T) at the Inter-tropical discontinuity (ITD) zone result to high and low rainfall months. The rainy season occurs from the month of April to October with heaviest rainfall in the month of July, making rainwater harvesting feasible (considering the number of rain days' distribution) while dry season takes place from November to early March.

December and January are low rainfall periods (Appendix I). The monthly average rainfall is 569 mm in July while the annual total is 3452 mm with average as 287.8 mm (Figure 1.2). Months that contribute less than 5% of the annual rainfall total (173 mm) represent the dry months.

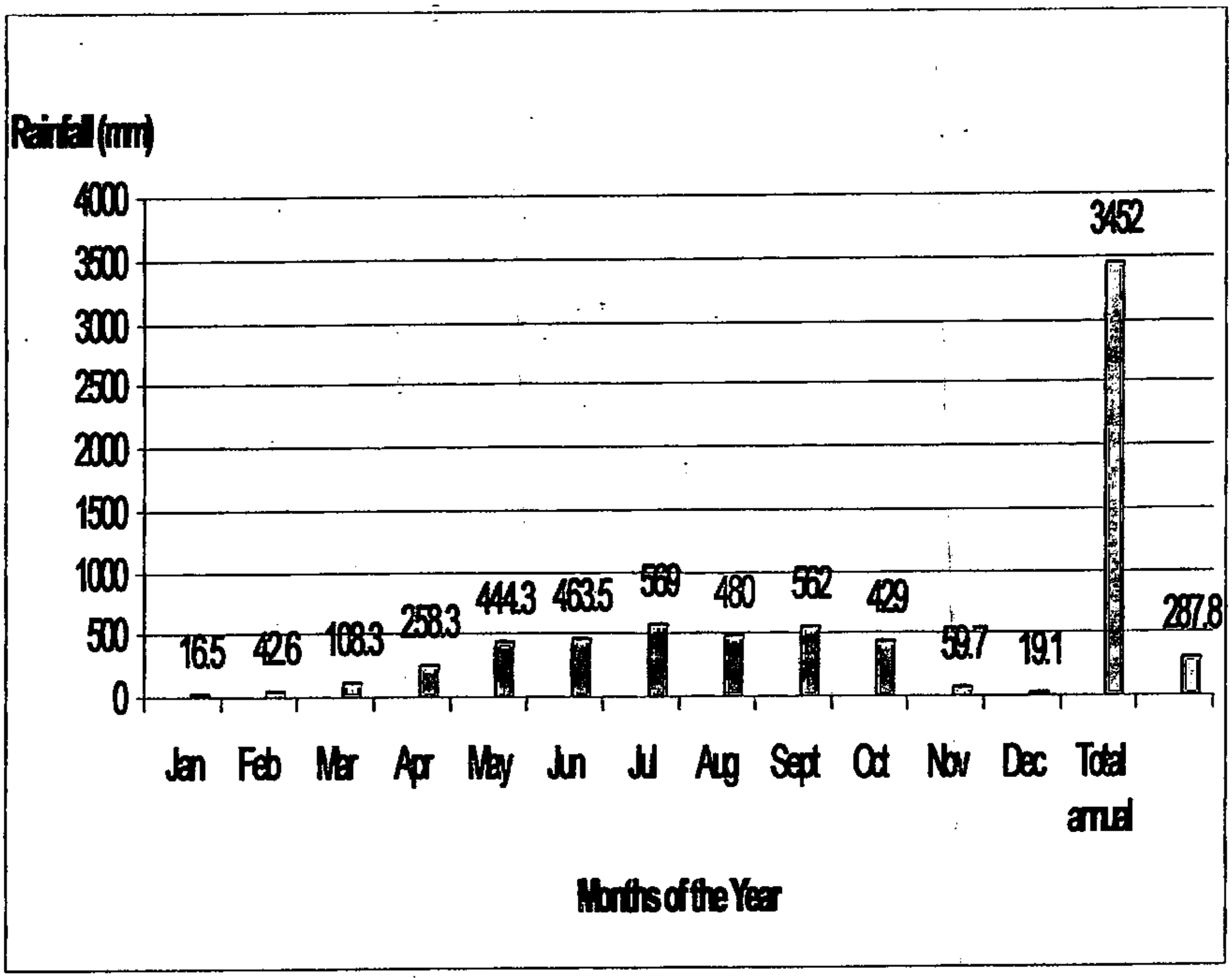


Fig.1.2: Monthly Rainfall (mm) Average of Onitsha, Anambra State
Source: NIMET, 2006

Average daily temperature is between 23.5^{0c} and 32^{0c}, evaporation is 3.2 cm, and water vapour is 27 ml, wind velocity 65 m/s, mean cloud 6.75 $_{10ths}$ and relative humidity 77% (NIMET, 2006). Evaporation is greatest during dry season and reduced towards the rainy season.

b) Drainage, landforms, hydrology and water resources

Rainfall is the major source of the water resources of the State. The surface and groundwater resources are important storages of rainfall. Niger River, the major river in Nigeria forms the western boundary of Anambra State with Anambra River as the main river system which rises from the false-bedded sandstone in Igala plateau around Ankpa in Kogi State. The River flows 230 km before joining the River Niger at Onitsha (Onwumerobi, 1993). River Mamu with its headwaters in the Okigwe axis of the Enugu escarpment is the major tributary of the Anambra River. Most of the left bank tributaries of River Mamu rise from the Awka-Orlu cuesta forming a hydrographic divide between the Mamu and Idemili basins. The Ezu, Idemili, Urasi, Oyi and Nkissi as well as Eze, Ojieli, Kpokor, Ale, Oforifo, Ochichi, Obianla, Odulu, Araka, Awia, Ekulo, Ololo, Urasi, Ariba, Aghewili and Awo Rivers form the States' drainage network. The drainage pattern is mostly trellis with Itolo, Osiam and Agulu Lakes as principal lakes. Figure 1.3 is the river network of Anambra State.

The Urasi River rises from Dikenafai in Imo state and flows on the Ulasi shales up to Ozubulu where it meanders in a wide loop and heads for the Atlantic Ocean. Agulu Lake is the source of the Idemili River. Ox-bow lakes are also found in the Niger-Anambra river flood plains with alluvial deposits. The lakes provide potentials for tourism and fishing while the rivers and streams provide water for domestic, livestock and recreation purposes. Most rivers such as Opiegbe in Ideani and Eze in Nnewi run low during the dry season but increases during the rainy season when the riverbanks are filled, forming a major source of domestic water supply for the indigenes. Rivers like Ogbonuonu in Utu is fed by the groundwater effluent yet; the inhabitants depend on them for domestic purposes. The mean average runoff value is about 139 m3/s.

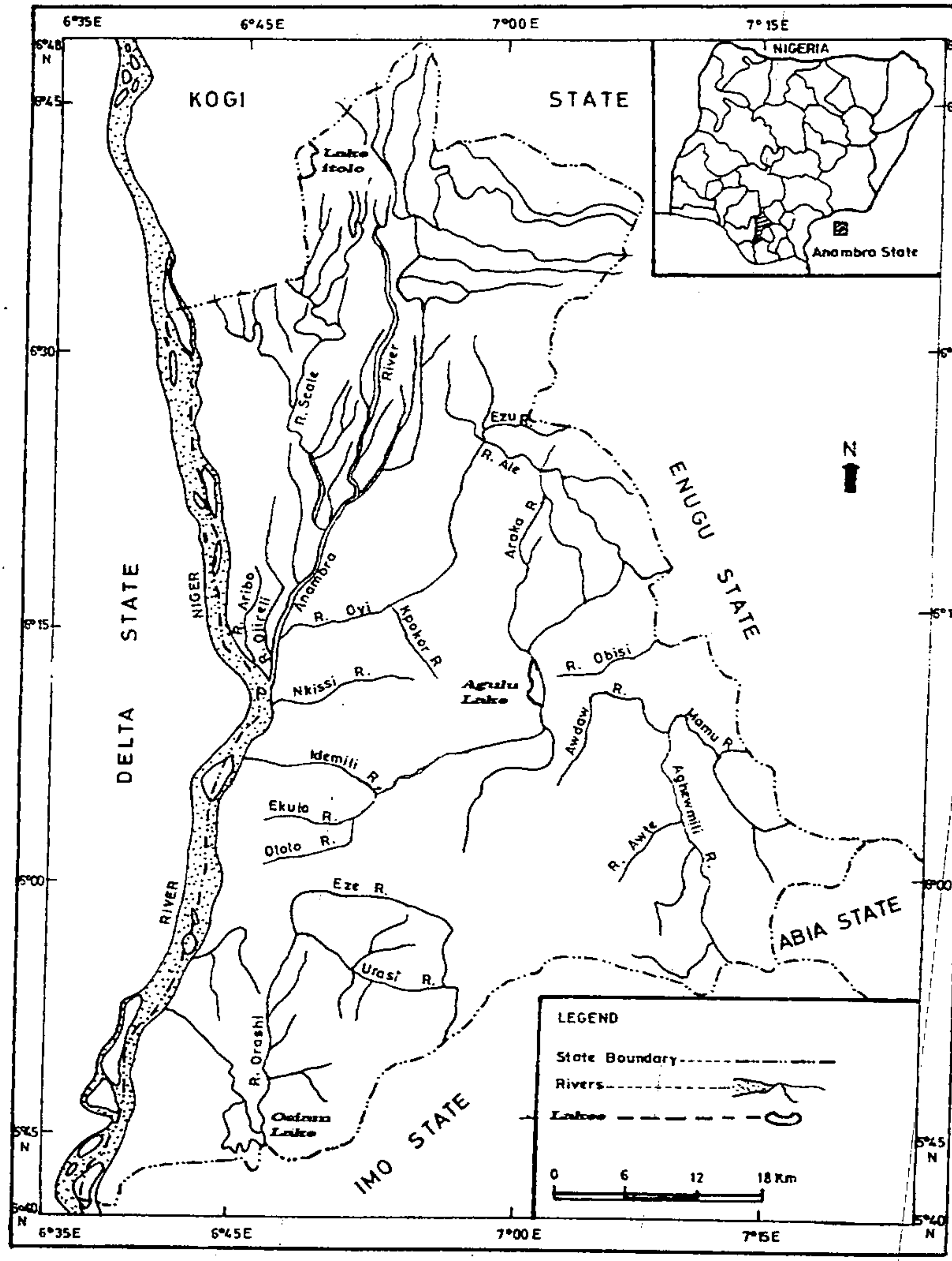


Fig.1.3: Anambra State River Network
Source: Anambra State Survey Awka, 1997

The State's landform has three physiographic units that are closely related to the surface geology and they are: (Onwumerobi, 1993)

i. The lowlands which are made up of lands below 100 m above sea level and occur in the areas of alluvium along river valleys with shale as the dominant rock;

ii. The land above 100 m but below 200 m of the gentle rolling plains developed mainly on the Nanka sands on the dip slope of Awka-Orlu cuesta with highest point of 378 m at Isuofia;

iii. An upland on the east with a dip slope on the west developed on the Bende-Ameki formation which is upland of sandstone with severe cases of gully erosion due to physical and anthropogenic factors.

c) Geology and Hydrogeology

Anambra basin has about 6,000 m of sedimentary rocks (Online Nigeria, 2003) comprising of ancient cretaceous deltas, similar to the Niger Delta, with the Nkporo Shale, the Mamu Formation, the Ajali sandstone and the Nsukka Formation as the main deposits. The geological formations have their strike in a north-west to south-east direction dipping gently at an average angle of 10^{o} 30 in a south-west direction. However, Anambra state is underlain by rocks belonging to four major geological formations namely (Online Nigeria, 2003);

1) The Imo clay shales of the Paleocene epoch on the surface of the dominant sedimentary rocks having a sequence of grey shales, occasional clay iron stones and sandstone beds. The Imo shale underlies the eastern part of the state, particularly in Ayamelum, Awka North, and Orumba North LGAs.

2) The Bende-Ameki formation of the Eocene epoch which includes laid down Nanka

Sands. The rock types are sandstone, calcareous shale, and shelly limestone in thin bands. Outcrops of sandstones occur at various places on the higher cuesta, such as at Abagana and Nsugbe, where they are quarried for construction purposes. Nanka sands out crop mainly at Nanka and Oko in Orumba North LGA.

3) The Oligocene to Miocene rocks including the Ulasi shales and lignite formation deposited with outcrops occurring in Onitsha, Nnewi, Ukpor, Okija and Ozubulu towns

4) The latest of the four geological formations is the Benin formation or the coastal plain sands deposited from Miocene to Pleistocene. The Benin Formation consists of yellow and white sands and underlies much of Ihiala LGA. Thick deposits of alluvium were laid down in the western parts of the State, south and north of Onitsha in the Niger and Anambra river floodplains.

Hydro-geologically, the Anambra basin appears to represent an inverted triangular depression with its base along the Benue river axis and its apex pointing towards Onitsha, the main trunk of River Niger. The Nanka sand of the Ameki formation is the major aquifer formation. Figure 1.4 is Anambra River basin Hydrological Area V and VII. Groundwater is a very important source of water. Thus, the location of wells and their yields as well as aquifers mostly exploited by various communities are of great importance.

d) Soils and Vegetation

Three soil types dominate Anambra State (Online Nigeria, 2003) and they are as follows:

i. Alluvial soils: The alluvial soils are pale brown loamy soils found in the low plains of Niger at Ogbaru and Onitsha which sustains longer continuous cropping.

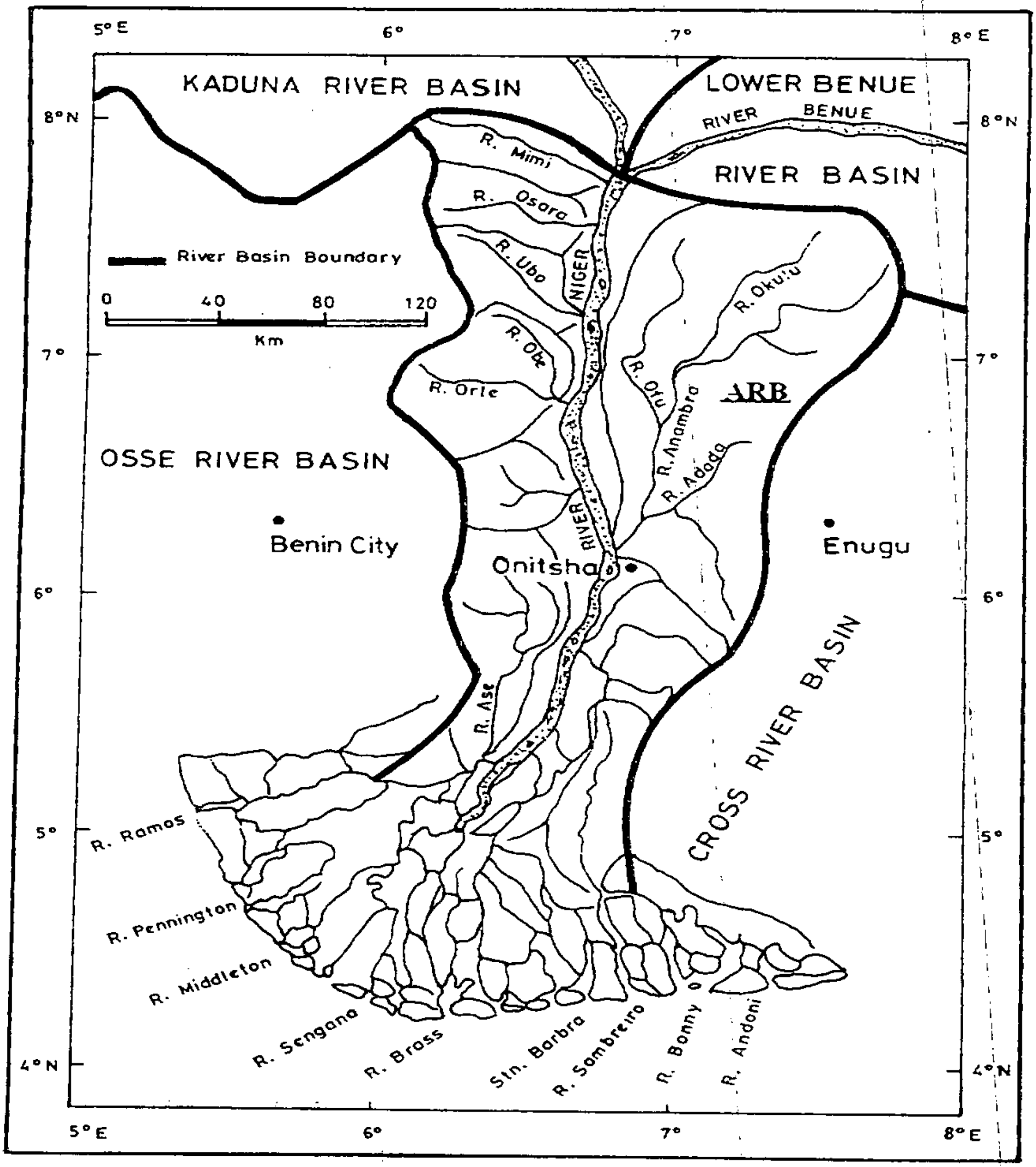


Fig. 1.4: Anambra River Basin (ARB) HA V and VII
Source: Anambra State Survey Awka, 1997

ii. Hydromorphic soils: Hydromorphic soils of the Mamu plain extends north and east of Anambra River floodplain, with underlying impervious clayey shales causing water logging at rainy seasons. The soils are fine loam, with faintly mottled lower layers and strongly mottled and spotted, subsoil layers containing stiff grey clay, which are good for yam, cassava, maize and rice cultivation.

iii. Ferallitic soils: The ferallitic soils are deep red to reddish brown loamy sands often referred to as "red earth" or acid sands because of their low fertility and are found in the cuesta and elevated areas. They develop on the sandstones and shales of the Ameki Formation and Nanka Sands. The soils are easily eroded into gullies.

The natural vegetation of Anambra State is tropical with the deciduous forest, which originally comprised tall trees with thick under growth and numerous climbers. Consequent of the high population density in the State, human activities such as farming, fishing, urbanization and industrialization have consumed a greater part of the forest. Secondary regrowth or a forest savannah mosaic where oil palm is predominant with selectively preserved economic trees exists presently. Relics of the original vegetation may be found in some "juju" shrines or some inaccessible areas (Online Nigeria, 2003).

1.6.2: Cultural Setting

Anambra State is densely populated with approximately 4,182,032 inhabitants (NPC, 2006) and a total land area of 4,844 sq km with a density of 863 - 900 persons per square kilometre. The rural settlement patterns are secluded yet most rural communities are densely populated and the population exceeds the minimum figure of 20,000, which is accepted as the principal criterion for urban settlement in Nigeria (Onwumerobi, 1993). Table 1.2 is the population chart of the Study LGAs and the 1996 locality list projection figures of the study communities.

Table 1.2: Population of selected rural communities within the study LGAs

Year	Population Figures	LGAs					
		Ekwusigo	**Nnewi South**	**Ogbaru**	**Ihiala**	**Idemili South**	**Idemili North**
2006	Male	82,210	121,862	117.975	156.019	108.990	225.288
	Female	76,021	111,796	103.904	146,139	98.693	205.495
	Total population	**158,231**	**233,658**	**221,879**	**302,158**	**207,683**	**430,783**
	Locality list						
1996	Community	**Ihembosi**	**Osumenyi**	**Ogwu Ikpele**	**Okija**	**Awka Etiti**	**Umuoji**
	Population	9, 610	16,681	8,584	44,280	18.563	26,747
	Community	**Oraifite**	**Utuh**	**Ogwuani-Ocha**	**Azzia**	**Nnokwa**	**Abatete**
	Population	29,649	9,190	14.011	11,384	14,378	22,665
	Community	**Ichi**	**Ekwulumili**	**Ossomala**	**Orsumoghu**	**Alor**	**Uke**
	Population	10.329	13,132	6.951	10,167	19,227	14.560
	Community		**Unubi**	**Umunankwo**	**Amorka**	**Akwukwu**	**Ideani**
	Population		19,132	3,524	7,371	3,449	6,778
	Community			**Akili Ozizor**	**Mbosi**		**Eziowelle**
	Population			3,527	8,339		11,465
	Community			**Iyiowa Odekpe**	**Isseke**		
	Population			25,213	9,383		

Source: National Population Commission; 2006 Census figures and 1996 projection figures

Communities such as Oraifite, Iyiowa Odekpe, Okija, Umuoji and Abatete are not urban despite their population because they lack access to most social amenities and central place services. The State is rich in skilled manpower and endowed with tourism attractions, agricultural resources, crafts and industries. It has fairly good communication and transport links with other States of Nigeria. The River Niger with the famous Niger Bridge links the commercial town of

Onitsha with the ports of Port Harcourt in the Rivers State, Burutu and Warri in Delta State while the Anambra River is navigable by small vessels and pontoon services up to the riverine communities of Ogbaru, Anambra East and Anambra West LGA's. The main ecological hazards in the State are accelerated gully erosion and flooding.

1.7: Overview of Rural Water Supply in the Study Communities of Southwestern Anambra State

1.7.1: NNEWI SOUTH LOCAL GOVERNMENT AREA

1.7.1.1: OSUMENYI

The major sources of water in Osumenyi community are Streams, boreholes (private and commercial) and roof-catch rain harvest channeled into tanks. The indigenes also trek to neighbouring communities of Amichi and Utuh in search of water. The 'Nwota' stream is rarely fetched these days because of distance while the "Iyi Ahaba" (Ahaba stream) is gender sensitive and is not fetched by young girls for cultural reasons.

1.7.1.2: UNUBI

Unubi community major sources of water are springs, streams, boreholes and roof catch rain harvest. The spring water is very good for drinking, while the 'Ngene and Etiti' streams flow all year round. The Integrated Rural Development Project is in progress for instance the community borehole project scheme from age grade association supplies water to the entire community free of charge. Water vendor activities are also in existence.

1.7.1.3: EKWULUMILI

The people of Ekwulumili are in critical need of water all year round. They depend mostly on rain water harvest because there is neither borehole nor pipe borne water supply. They also fetch water from "Iyi Ahaba" or Ahaba stream which is far away in Osumenyi and most times buy from vending tankers.

1.7.1.4: UTUH

The Utuh communitys' major source of water are the 'Isi iyi, Ohia and Ofaraohia' streams. They are located far away from the village square. The indigenes also depend on rain water harvest during rainy season. Borehole owners vend directly to water tankers who in turn sell to the people. The water chain diagram for Utuh community is represented in Figure 1.5.

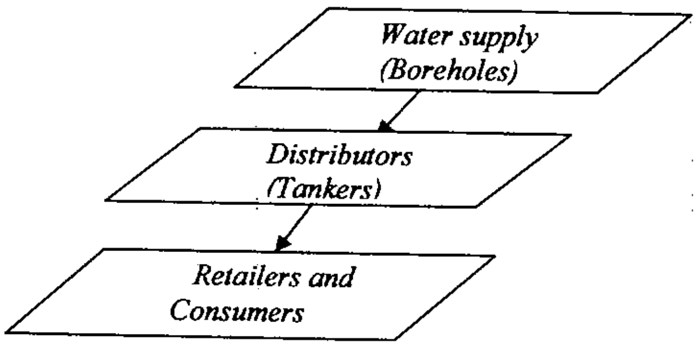


Fig. 1.5: Utuh water distribution chain (Source: Field survey, 2006).

1.7.2: EKWUSIGO LOCAL GOVERNMENT AREA

1.7.2.1: ORAIFITE

The Oraifite community has streams and boreholes as the major water sources. The boreholes which are private and community are located at Nkwo and Obi Nwankwo square. The 'Ose and Ekulo Ibollo' streams overflow during rainy season and dries during dry season. There is no pipe borne water in Oraifite and the Petroleum Trust Fund (PTF) water project is defunct due to lack of Sumo. The Emeka Offor water project in the community however operates with electricity at no cost. Plate 9 is the research team with Chief Gilbert Udoji the Igwe of Oraifite.

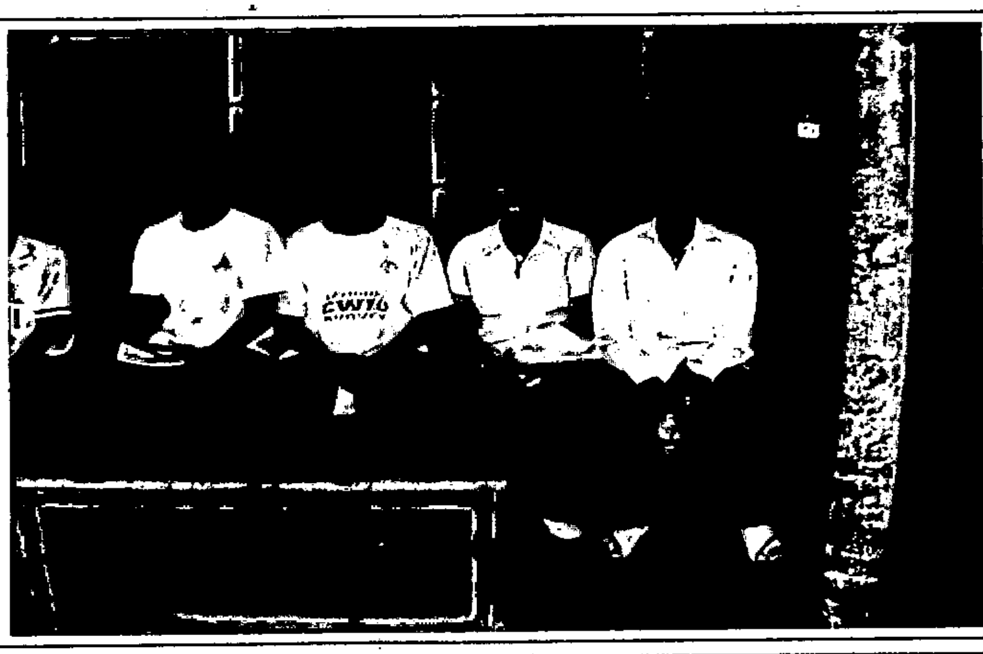


Plate 9: Research team during personal interview session with Igwe Oraifite December 8, 2006

1.7.2.2: ICHI

The Ichi community depends mainly on private boreholes, which is collected free of charge and extended by pipes to different points. Roof catch rain harvest and streams such as 'Mmili Ekulu', 'Mmili Akwu', 'Mmili Obollo' and 'Nne mmili' are used for drinking and other purposes. There is no pipe borne water and water vendors. The World Bank Assisted Project was abandoned during Governor Mbadinuju's administration and has no sumo to pump water.

1.7.2.3: IHEMBOSI

The Ihembosi community depends mainly on roof catch rain harvest, the neighbouring 'Urasi Okija' River as well as private boreholes for water supply without any existing pipe borne water.

1.7.3.3: IHIALA LOCAL GOVERNMENT AREA

1.7.3.1: OKIJA

The 'Urasi Okija' River is the major source of water for Okija indigenes. The pipe borne water available is far away so people tend to resort to 'Urasi' River, which has many points at the

Okija Bridge, Ihembosi and Oru (Imo State). The river overflows during rainy season and diminishes during dry season, serves for drinking, domestic activities, vending for tankers and agricultural purposes. Roof catch rain harvest is also a prevalent practice and community boreholes projects for instance Okija United States of America residents sponsored borehole promotes water supply in the community.

1.7.3.2: AMORKA

Water supply in Amorka is mainly from rain harvest and 'Amorka' stream and they serve for washing, swimming and drinking. The boreholes are mostly commercialized at the rate of ₦5.00 per 25 litres.

1.7.3.3: MBOSI

Intense scarcity of water exists in Mbosi town hence; the people depend on roof catch rain harvest for washing. Omaiyi stream in Isu Mbosi is a flowing stream for drinking, washing, swimming and food processing. The Hand-dug wells popularly called 'Umi' are seen in prominent compounds. Mbosi people also travel to neighbouring communities of Azzia for water supply.

1.7.3.4: ISSEKE

The Isseke community has no stream, river or pipe borne water. They depend on rain harvest during rainy season for washing, deep wells and boreholes for drinking and domestic activities. The government abandoned boreholes were sunk in Etitini-Ukpo village primary school opposite Afor – Isseke market and Community Secondary School Edeke – Isseke during Governor Mbadinuju's administration. The private boreholes dug by Barrister E. Obiagwu and Professor F. Madubuike are for commercial purposes.

1.7.3.5: AZZIA

Azzia community has several streams such as 'Omaiyi' for drinking, washing and swimming. 'Iyioha' stream, 'Ukwube' stream and River 'Ulasi Okija'. The indigenes cover a maximum distance of about 500m to 1 km in search of water. As a result, they resort to nearby boreholes which are private (free and commercially) owned for ease. Hand-dug wells are also in existence but there is no pipe borne water.

1.7.3.6: ORSUMOGHU

Borehole is the major source of water for the Orsumoghu people, although the government borehole at St. Mary's Catholic Church Isingwu village is no more functional making people travel far distances to private borehole points to fetch water free of charge. Interestingly, most boreholes are time regulated and open only between the hours of 6.00 a.m to 7.00 a.m in the mornings and 4.00 p.m – 6.00 p.m (Plate 7) in the evenings creating queues, yet people resort to it because there is no pipe borne water. The 'Mkpogwu and Ubeokpoko' streams are also situated far away.

1.7.4: IDEMILI SOUTH LOCAL GOVERNMENT AREA

1.7.4.1: AWKA ETITI

The major source of water supply in Awka Etiti is roof catch rain harvest channeled into private underground tanks with filtration nets. The water is used mostly for washing and cooking while drinking water is normally purchased. Water vending supplements rain harvest during dry seasons while water tankers vend at point of need due to lack of streams, rivers, pipe borne water and Water works.

1.7.4.2: ALOR

The Alor community depends on the 'Obiaja' River (between Ideato and Alor towns) and 'Okebuloye' River (Alor and Abatete communities) for domestic purposes. The 'Nwangene' Stream is impure and is used for only bathing. Other water sources are private wells approximately (27.4cm circumference X 61.0cm depth) in virtually all compounds, roof catch rain harvest and the Ngige Government Man Power water project at Nkwo Ide for drinking and domestic purposes. The Alor Community healthcare borehole also serves the villagers.

1.7.4.3: NNOKWA

Nnokwa community depends on private boreholes to supplement the dominant roof catch rain harvest source of water which is channeled into underground tanks serving for different purposes all year round even in the absence of water corporation.

1.7.4.4: AKWUKWU

The 'Ose Akwukwu' and 'Ekulo Akwukwu' streams flow round and through the villages but the water is humanly polluted by bathing, washing, food processing and religious activities. However, several free borehole projects exist in the community for water supply needs. The Proper table water factory in Plate 10 vends the packaged water normally called "pure water" but distribute water free of charge to the people. The UNICEF water project called "Manpower" established in 2004 was reliable until 2005 when the water became undrinkable, not even for cooking due to its brownish, yellowish, bluish and red colour change and taste. Private and community boreholes serve the community needs instead, while most others resort to water vendors from Oraifite community.

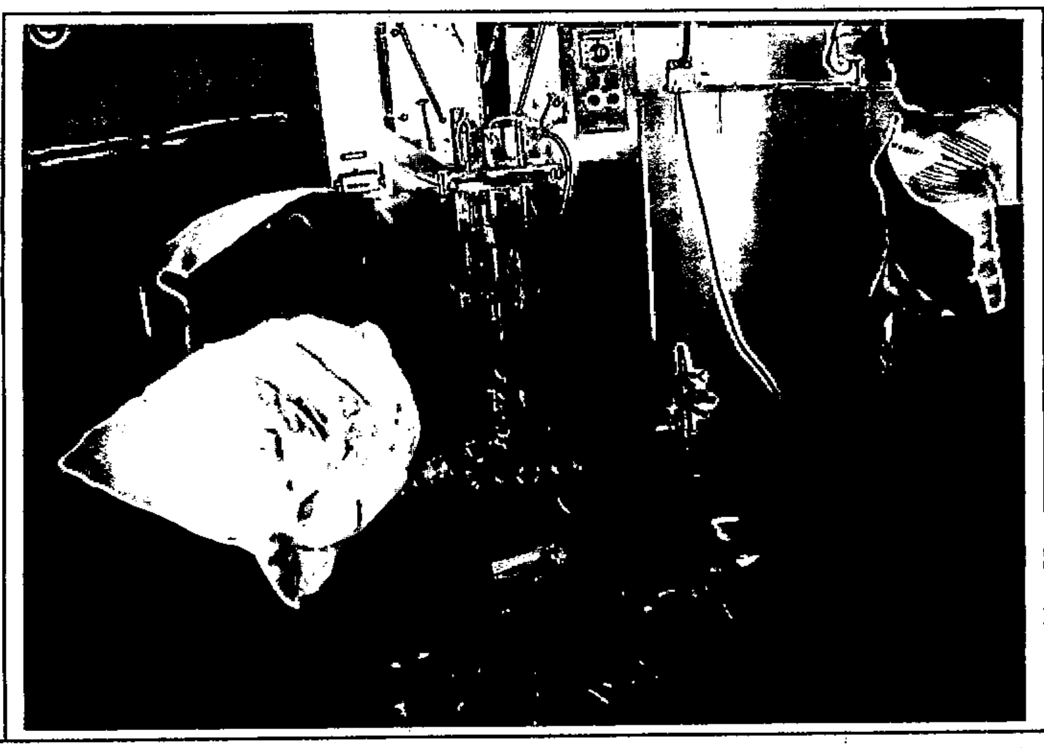


Plate 10: Water sample collection at Proper table water production plant, Akwukwu December 8, 2006

1.7.5: IDEMILI NORTH LOCAL GOVERNMENT AREA

1.7.5.1: EZIOWELLE

Boreholes serve as the major source of water for Eziowelle community however these boreholes are mostly commercial costing ₦5.00 per litre. Power failure affects the boreholes functioning except the "Nwa Fada" borehole in Ezinimo village, which has generator and the water is free of charge. This attracts a lot of people, so people spend up to as much as (3 – 6 hours) in queue for water at the expense of other things. There is no pipe borne water and the 'Ukwuakpu' stream is far away although it is used mostly during dry season and intense scarcity when people are forced down the very steep slope. The 'Abacha' stream on Abacha neighbouring town also serves Eziowelle community.

1.7.5.2: ABATETE

Abatete community depends on the 'Esigbo' stream at Odida which serves for washing, relaxing, domestic and commercial sand dredging purposes. People trek long distances to fetch water from the stream although the water has colour and odour. The 'Ideogbu' stream also serves the people while most others resort to commercial boreholes at Ekeagu which costs from ₦5.00 for (1/2 – 5 litres) and ₦10.00 for (6 – 10 litres). Roof catch rain harvest is also a popular practice during rainy seasons.

1.7.5.3: UMUOJI

The major source of water in Umuoji town is the private and commercial boreholes. The 'Ideakpulu' River in Dimgboko village is a good source of drinking water but because of the distance, people resort to buying from boreholes and roof catch rain harvest practice since there are no government water projects and pipe borne water.

1.7.5.4: UKE

The Uke community major water source is private individual boreholes most of which are approved by NAFDAC, thus they do not boil the water before drinking. Roof catch channeled into underground tank is practiced during rainy season while water vending exists during dry season. The 'Obiaja' river which lies between Uke and Alor was formerly a drinking water source but due to human pollution, pagan sacrifices and farming activities, the water presently has colour, odour and taste making it unfit for drinking.

1.7.5.5: IDEANI

The Ideani community has a lot of water sources most especially streams for drinking and domestic purposes namely the 'Awa Ani', 'Uzi', 'Okide', 'Udengwu' and 'Ide Ofili' streams. Agulu Lake is also a source of water for the Ideanians. The 'Opiegbe' stream also called 'mmili Obiaja' is a multi purpose stream for domestic and religious activities on the leftside while the right side is used for economic activities of sand collection for sale, building and brick making.

The people however depend on community boreholes and private reservoirs for easy access.

1.7.6: OGBARU LOCAL GOVERNMENT AREA

1.7.6.1: OGWUANI-OCHA

The major source of water supply in Ogwuani-Ocha with a population of above 14,000 is the 'Orashi' River which passes through the community and is used for domestic, food processing and transportation activities. Wastes are dumped by the river sides which overflow during the rainy seasons. Records of diarrhoea, dysentery and typhoid fever are rampant in the area especially in children (Ogbuefi Boyce Anene, 2006 personal communication). Boiling of drinking water is not compulsory and rain harvest during the rainy season supplements the community's water source.

1.7.6.2: OGWU–IKPELE

The Ogwu-Ikpele community has the Niger River as the chief source of water supply. Roof catch rain harvest serves during rainy season when River Niger is flooded. There are no water vending activities, streams or government boreholes instead there are three private boreholes built by prominent individuals which are only accessible when they are around. Water hyacinth dominates the River Niger at Ogwu-Ikpele and the flood plains for farming are flooded during wet season and extremely dry at dry season making access difficult.

1.7.6.3: OSSOMALA

Ossomala community, a riverine community has the River Niger as the major source of water for domestic purposes. Most people boil their drinking water and use chemicals like alum, while others do not. They do not have any stream and the government borehole project shown in Plate 11 is of no value to them because it changes colour after 5 minutes and is thus neither drunk nor used for washing or bathing personal communication with Osani, 2006.

Plate 11: Photo with Osani Obiorah (respondent) at Ossomala federal government borehole December 6, 2006

1.7.6.4: UMUNANKWO

The Umunankwo community depends on 'Onukwu' stream for washing and food processing while private boreholes serves for drinking and other domestic activities. The Niger River is very clear and is the major drinking water source. Water treatment is not common and thus typhoid fever is prevalent in the area. The federal borehole project at Umunankwo is not good for drinking, bathing or washing because of the brownish colour change associated with the high iron content of the soil.

1.7.6.5: AKILI OZIZOR

THE Akili Ozizor community has the River Niger as the major water source. The Niger River serves for drinking, washing, transportation and farming which is their major occupation. The flood plains are flooded during rainy season and dries up at dry season. The community has 6 defective boreholes and 9 non-functional community boreholes with no pipe borne water.

1.7.6.6: IYIOWA ODEKPE

Iyiowa Odekpe community is surrounded by River Niger and River Idemili which serves as the major source of water supply to the Odekpe people for washing, cooking and food processing. Drinking water from Niger is normally fetched early in the morning while the private standpipes built by house owners serves for drinking all day long, since they are built close to the houses. There is no water vending or traveling of distance for water. Industrial pollution from Premier, Life and Savannah breweries contaminate the water but with the self-purification quality and flow, it is safe. (Personal communication: Ogbueluu, December 7, 2006).

1.8: New Water Project Initiatives in the Study Area

The rural water supply and sanitation initiative (RWSSI) was initiated by the African Development Bank (ADB) towards the attainment of African vision water goals declared at the second world water forum in The Hague, Netherlands. The initiative is also backed up by the Millennium Development Goals (MDGs) agenda and is intended to mobilise resources for easy access to rural water supply and sanitation, reduce rural poverty and water related diseases. The RWSSI programme propagates for minimum of 30 litres of water per person per day in rural areas, encourages improvement of traditional water quality monitoring and evaluation as well as private sector participation for better decisions and management (ADB, 2004). In Nigeria, the specific objective of the project is to increase access to safe, adequate and sustainable water and sanitation services in the six focal states of Anambra, Cross River, Jigawa, Kano, Osun and Yobe as well as promoting improved water governance at federal level, state and local government levels.

In Anambra State, the rural water supply and sanitation agency (RUWASSA) project in conjunction with the water supply and sanitation sector reform programme (WSSSRP) are European Union funded projects with the major achievements of rural water supply, sanitation and hygiene promotion services delivered in most rural communities especially Ogbaru LGA rural communities.

The efficiency, effectiveness and sustainability of the programme is that increased part of the rural communities have gained access to improved quality and safe sources of water; spend less time on water collection, increased population have access to basic sanitation, improvement in health and hygiene conditions, increased community participation, mobilization and willingness to pay for maintenance costs to ensure full ownership and sustainability.

The field office of RUWASSA, Anambra State is unfortunately not yet able to give accurate data and statistics to quantify the initial impact, due notably to the limited availability of consolidated base line survey data. However, educative services and full ownership of government's water and sanitation facilities located in their community are encouraged thereby creating solid premises for future economic and financial sustainability. Plates 12 and 13 depict some of the RUWASSA reform projects in the study area.

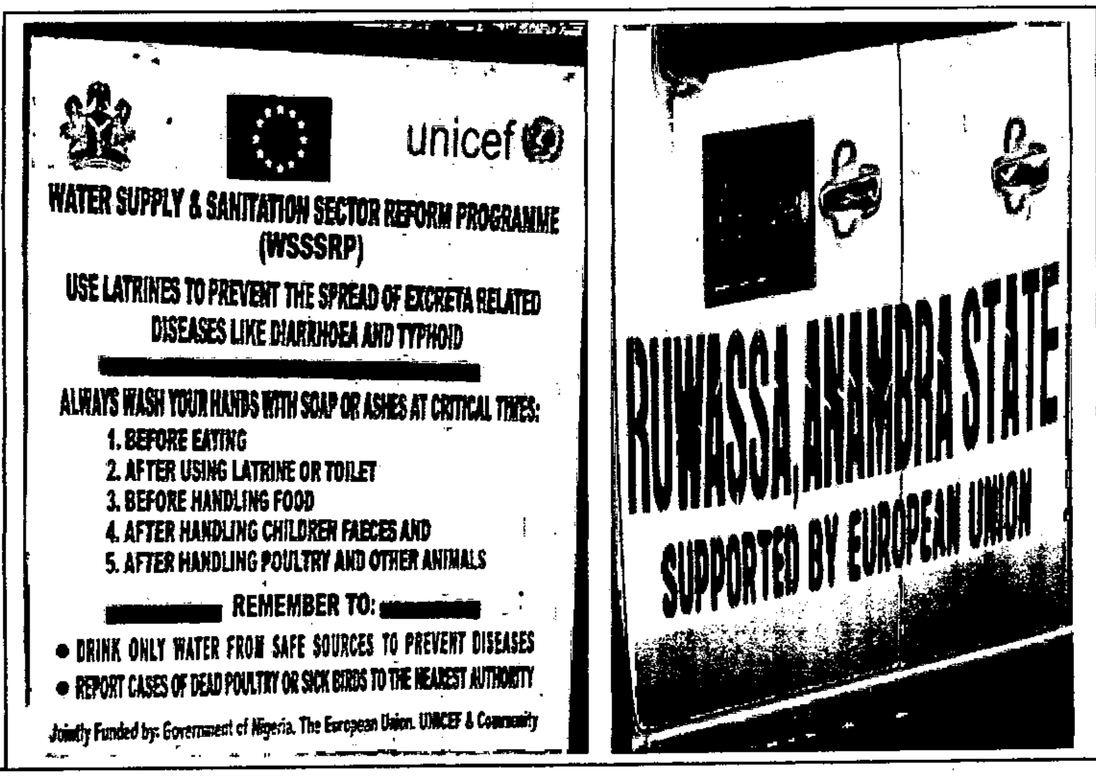


Plate 12: RUWASSA water supply and environment reform programme in the study area December 6, 2006

Plate 13: Executed contract in Umunankwo Ogbaru LGA by Causon Nig. Ltd. December 6, 2006

1.9: Thesis Layout

Chapter one is the introductory part that states the background of study, defining the problems of study with research questions that may arise. The aim and objectives and justification of the study as well as definition of operational terms, a detailed description of Anambra Southwest local government area and the study rural communities, the physical, cultural and human aspects as well as an overview of rural water supply in the study communities of Southwestern Anambra State and the new water project initiatives in the area are also included in this chapter.

Chapter Two discusses the relevant concepts and theories to potable domestic water in the rural communities of the study LGAs and the relevance in the existing field of knowledge as well as the existing literatures on rural water supply quantitatively and qualitatively.

Chapter Three explains the study methodology adopted for the research.

Chapter Four presents and discusses water supply sources, access and consumption patterns in Anambra SW rural communities.

Chapter Five develops and discusses the Rural Threshold Water Consumption (RTWC) model and the economics of water supply in the study area.

Chapter Six discusses the water distribution patterns, water shortages and threats to water supply, verifies the physico-chemical and biological water quality of the rural water sources in the study area: discusses the socio-economic and health implications of poor quality water and the effect on rural consumers. The chapter also discusses rural development and the strength, weakness, opportunities and threats to rural water in the study area.

Chapter Seven summarizes the findings, concludes the study and presents the policy implications.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND THEORETICAL BACKGROUND

2.1: Conceptual Framework

The concepts of accessibility, community water supply management, water supply protection and threshold are relevant to the rural water supply study.

2.1.1: Accessibility

Geographically, ***access*** explains location characteristics of events that occur in space and time. Accessibility is the simplicity or just the ability to reach desired goods, services, activities and destinations. Access to potable domestic water therefore reflects on factors of distance, travel time, energy and cost (distribution and quantity; transportation, water quality and treatment; and opportunities forfeited) and risks incurred in the process of obtaining water.

The concept is often evaluated in terms of convenience, that is, the ease with which they can reach what they want. It measures the degree and type of disaggregation, the definition of origins and destinations, the measurement of travel impedance and the measurement of attractiveness as stated by Handy and Niemeier (1997). Accessibility to improved water sources therefore features on aspects of water quality and the fundamental significance to human health. The socioeconomic variables including sex, age, level of education and income level also makes it a good universal indicator for human development (Uluocha, 2006).

2.1.2: Concept of Community Water Supply Management (CWSM)

Community water supply management concept developed by the International water and Sanitation Centre (IRC, 2003) is a common and leading concept in water supply that involves active participation of benefiting local communities in water service provision since water supply promotes good health and food security. The government sponsors capital investment while the benefiting communities foster a sense of ownership and maintenance.

The primary objective of water supply development during the colonial era was to improve the quality of drinking and domestic water as well as to reduce the effect of water-borne diseases on the population. Similarly, the third National Development plan (1975-1980) water supply development objective in Nigeria was to make potable water available to an increasing proportion of the population at reasonable rate while expanding inadequate and existing water works.

The community involvement concept has been adopted by the international community at various water foras such as the 1977 Water Conference in Mar del Plata, Argentina; the 1980's International Drinking Water and Sanitation Decade (IDWSSD) declaration; Rio de Janeiro Earth summit in June 1992; Dublin Principle of 1992 and the global forum of Water Supply and Sanitation Sector (WSSCC) in Iguaçu Brazil, November 2000. The forums all centered on water for all through self reliance, creativity and community participation at household levels for effective water supply and adequate sanitation services at the local level.

The Anambra SW communities typically are engaged in individual, family or community self-help projects due to their communal way of life, rapid population growth and the need for steady water supply. However, the impact of their efforts is still minimal as a result of lack of funds and the wrong mind-set that it is solely the responsibility of government to provide water facilities for the rural populace. Thus the CWSM concept show the relationship between rural water and community participation, which needs to be reinforced so as to achieve maximum results.

2.1.3: Concept of Water Supply Protection (WSP)

Water supply protection is relatively a basic environmental health programme or concept (BAHC, 2007) whose goal is to achieve protection of public potable water supply sources through adequate knowledge of the natural and human components of water pollution; water chemistry and treatment options through methods of water sampling and field exercises. The study area has varieties of natural water sources such as rivers, streams and springs as well as man-made water sources of hand dug wells and boreholes which need to be protected from indiscriminate human activities, pollutants and contaminants so as to minimize water related diseases. Thus, the need for water quality monitoring and evaluation on the physical, chemical and microbiological content of major domestic water sources for the rural dwellers are indispensable.

Water sources protection is usually done locally by methods such as periodic dredging of the water bodies; outlawing fishing in some rivers or streams or forbidding the eating of fish and other marine food from some waters. In some communities certain activities such as bathing, washing of clothes, and fermenting of food crops in some streams are considered a taboo. The official designation of some water bodies as objects of traditional worship and the act of attaching healing importance to some rivers are also local water conservation measures. Besides, it is a common practice in most of the communities to erect preventive buffers in form of bamboo fences along the banks of some delicate or threatened water bodies, thus limiting direct access to such water. The improved well and borehole structure construction also minimizes direct pollution on the groundwater sources. These water management strategies go a long way to protecting the surface water resources in these rural communities against eutrophication, siltation and other kinds of pollution, thereby ensuring the continued existence of the water bodies (Uluocha, 1998).

2.1.4: The Threshold Concept (TC)

The threshold concept (Abrahams, 1996) *is* a framework for effective capacity building at the local government and community levels so as to ensure sustainable water supply and sanitation services. This concept promotes local participation as an affordable option for water supply and sanitation services in the rural areas which is vital at the stages of initial assessment, planning, implementation, monitoring and evaluation as well as operation and maintenance so as to achieve long term sustainability of water projects. The threshold approach is evident in the study communities where community boreholes and other water projects are carried out through communal efforts. However the establishment of a threshold constant variable will serve as a planning regulator to both the government and community. Sustainability is however determined by the level of access, skills and abilities, affordability and willingness to pay and to a large extent, public awareness and enlightenment. Communities are therefore, encouraged to develop their own perspectives and creativity for maximum results more especially since improved water supply and quality attracts consumers.

The schematic in Figure 2.1 illustrates the integrated efforts of private individuals, communities and government towards protection and promoting of improved and sustainable rural water in the rural study communities of Southwestern Anambra State.

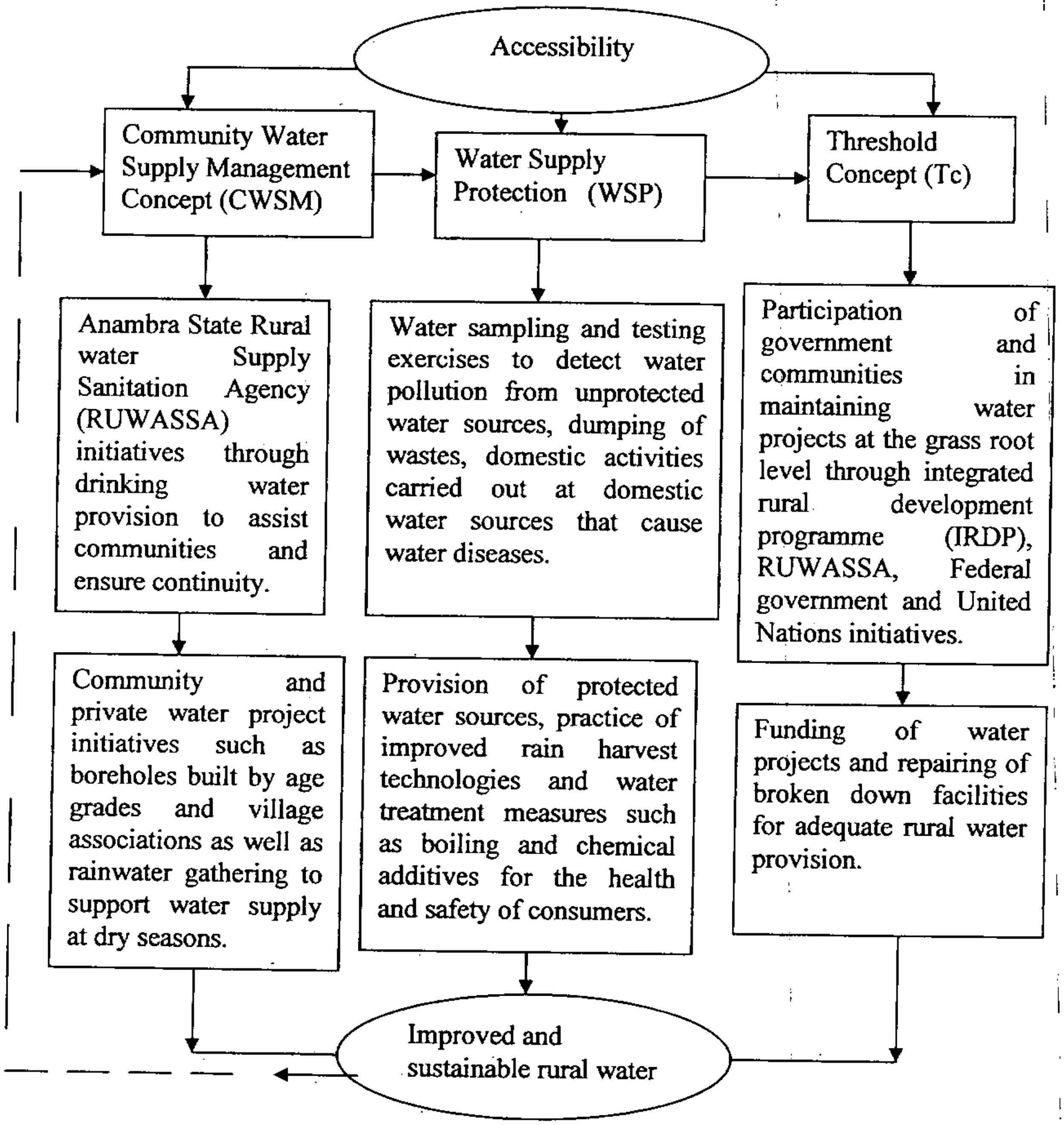


Fig.2.1: Rural Water Supply Management Concepts

Source: IRC (2003); BAHC (2007); Abrahams (1996) and Field Survey (2006).

2.2: Theoretical/Analytic Framework

Globally, the central theory of water is the 'water balance' which explains the relevance of each component in relation to surface and groundwater systems. The River basin theory also expresses the environmental processes and the geomorphic components which play a significant role in the chemical constituent of water.

2.2.1: The Hydrological Cycle (HC) is the central theory of hydrology with complex events. The Cycle involves the continuous circulation of water in the Earth-atmosphere system with the hydrologic processes of evaporation, transpiration, condensation, precipitation and runoff. It involves both input and output processes and although the total amount of water within the cycle remains essentially constant, its distribution among the various processes is continually changing (Encyclopedia Britannica, 2003). Figure 2.2 is a schematic view of the hydrology cycle.

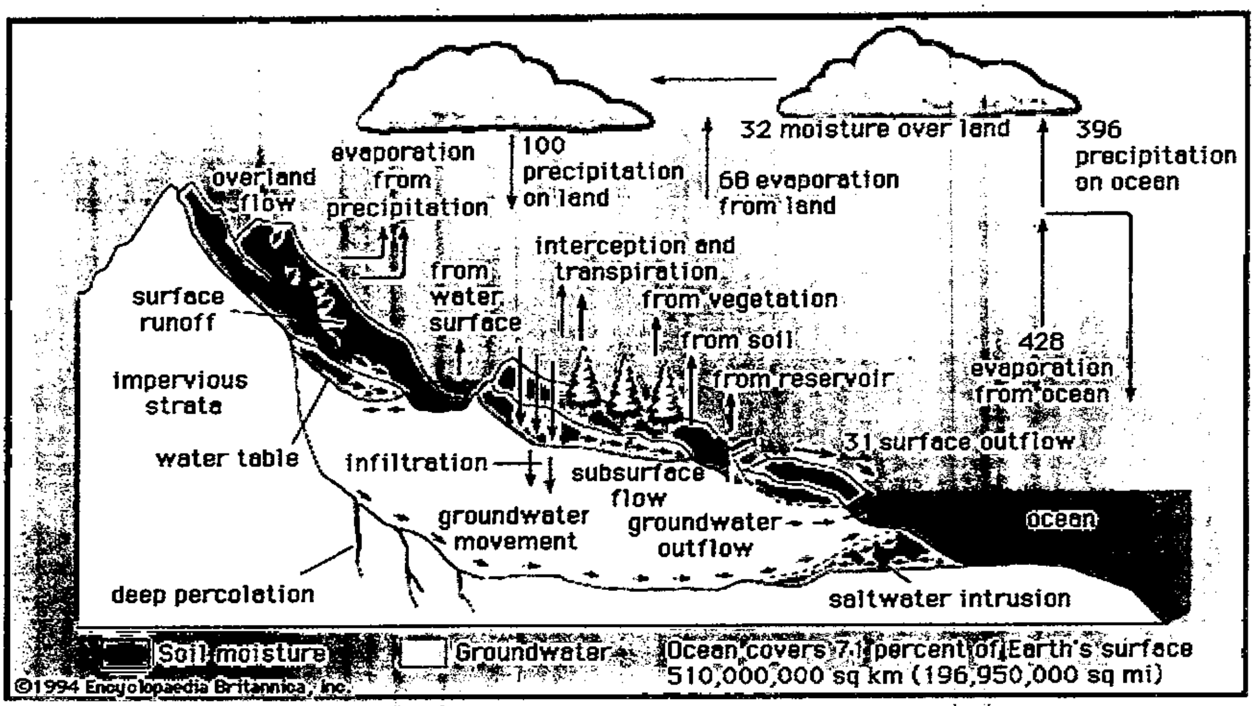


Fig. 2.2: The hydrological cycle.
Source: Encyclopedia Britannica, (2003)

Rainfall infiltrates the soil system, percolates to deeper groundwater, evaporates or transpires through vegetation back to the atmosphere or flows into the nearest streams or rivers. Infiltrating water is the main source of recharge to the root zone and groundwater aquifers below. Rivers can recharge aquifers or act as discharge points for aquifer outflows. The ocean is the ultimate receptor of surface and groundwater contributions from surrounding landmasses and provides the main source of water for evaporation back to the atmosphere.

The hydrologic budget or water balance equation is expressed mathematically as Oyebande (1998):

Input = Output + change in storage

R + I = E + Q + ^S + ^G (when applied to part of a river system or its basin).-------- (Eqn 2.1)

Where R = Rainfall

I = Inflow

E = Evaporation

Q = Outflow (runoff or discharge)

^S = Change in soil moisture storage

^G = Change in groundwater storage

Rainfall is the major contributor to water balance and water resources of an area and could be measured in daily values of millimeters with a rainguage network. Rainfall (input) is a major water source in most rural settlements and is spatially distributed with some areas in plentiful supply and some other areas experiencing scarcity. Rain water harvesting is a predominant practice to conserve water. Surface streams, rivers and springs receive rainfall directly as well as outflow from runoff while inflow activities and storages are also of immense contribution to the rural water as recharge and groundwater provision. The stored groundwater sustains low flows of rivers, boreholes and wells which are major alternative water sources in the study area.

Mans numerous activities through water use and water development projects, design and construction of various hydraulic structures, disrupt the water cycle by causing delay or reduction in the amount of water supply. The farming activities such as deforestation, bush burning, cultivation and soil crusting affect rainfall distribution causing variability and unpredictability, evapotranspiration and consequently reduced or excessive runoff and soil water imbalance. The decreasing water availability caused by ignorance of the local inhabitants and stakeholders on the interdependence of land and water resources, the impact of using these resources, or any upstream-downstream connections and inadequate resource management strategies and regulation is a matter for concern.

Water as a natural resource has both aspects of quantity and quality that needs to be developed, protected, managed and conserved. The schematic in Figure 2.3 demonstrates the interrelationship between human activities and water use.

The United Nations Water Conference Mar del Plata 1977 in its resolution No1 "Assessment of Water Resources" recognized the importance of water assessment (quantity and quality) for rationalization while the 1990 and beyond had the overall objective of ensuring the assessment of water resources, water use and efficiency, environment; health and pollution control; policy, planning and management; natural hazards; public information, education, training and research;

regional and international cooperation (UN/WMO, 1988).

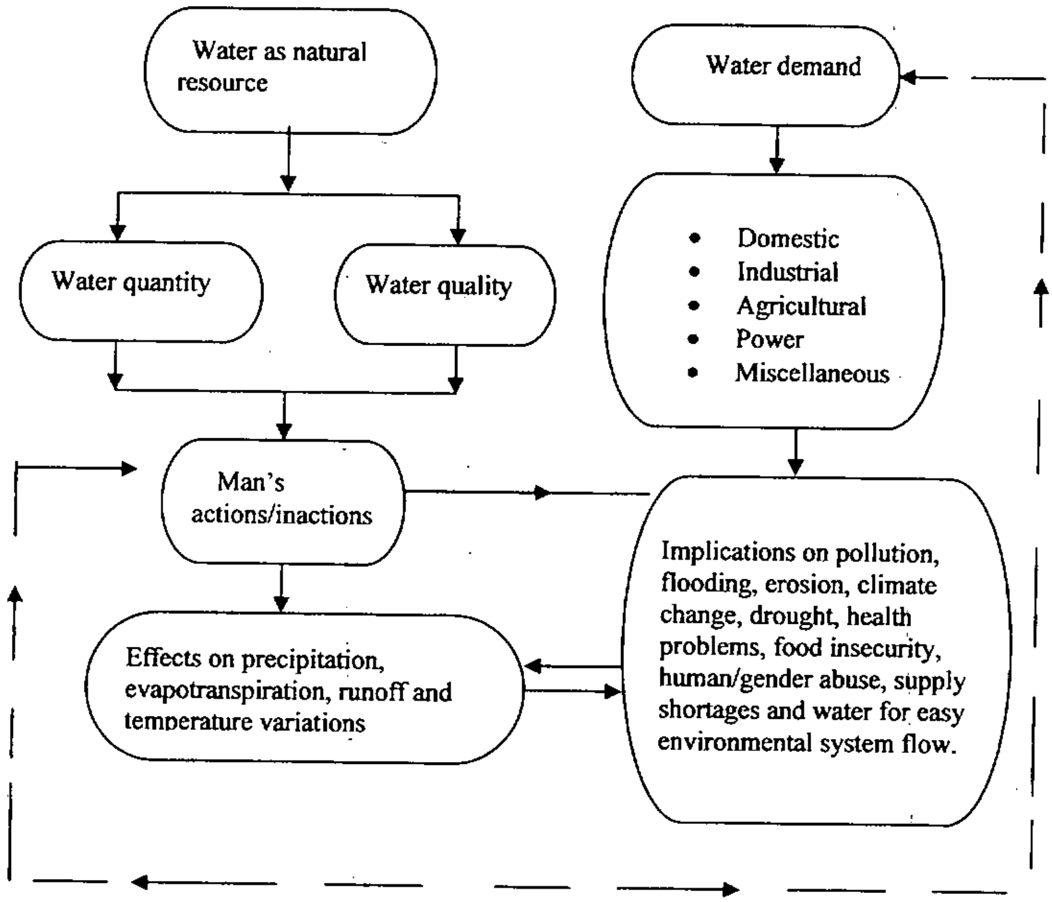


Fig. 2.3: Water, Human Actions and Implications (Adapted from Oki et al, 2006)

⟶ Information flow

⟵ Feedback Mechanism

2.2.2: The River Basin represents a spatial framework for environmental development, a geomorphologic unit in which the geomorphic processes operate although they are limited and clearly defined (Jeje, 2001). The basin components however vary from one region and river to another. The Anambra river basin is vital to the water resources development of Anambra State and is a major tributary of the Niger River occupying a mushroom shaped area east of the Niger mostly within Anambra State and then stretches a little into Benue State. It is underlain by cretaceous sediments of which Ajali false bedded sandstone constitutes the most important aquifer. The basin has ample surface water even during dry seasons due to the false-bedded sandstone that forms the main groundwater aquifer. This results in the rivers, streams and springs as well as boreholes which are mostly perennial sources serving as resorts to rural indigenes especially during dry seasons and periods of water scarcity.

The streams and rivers are basically the major sources of rural water supply, yet the nature of stream flow in a region is a function of the hydrologic input (precipitation) in that region as well as the physical, vegetative and climatic activities (soils, geology and topography). Table 2.1 characterizes some major sources of rural water in the study area. The stream ordering ranges from the 1st to 5th order.

Precipitation (rainfall) is harvested in the region as a water source, recharges the surface and groundwater sources and supports farming and agricultural activities which is the major occupation of the rural indigenes in the study area. Man's activities of clearing, bush burning and cultivation also affect the vegetation and the basin characteristics leading to flooding, leaching and pollution of water sources.

Table 2.1: Characteristics of some major Rural Water Supply sources in the study LGAs

LGAs	Water source	Origin	River networks	Landforms	Vegetation	Seasonality	Flow type	Order
All LGAs	Anambra River	River Niger	River Niger, River Idemili, R.Oyi, R. Ojireli, R. Scale	Ajali (false bedded) sandstone	Shrub, scattered cultivation and light forest	All year round	Perennial	5th
Idemili North	Ukwuakpu stream, Abatete	River Idemili	Nkissi River Ekulo River	Ulasi shales and lignite formation	Light forest with scattered cultivation	All year round	Perennial	2nd
Idemili North	River Opiegbe, Ideani	River Idemili	Nkissi River Ekulo River	Ulasi shales and lignite formation	Light forest with scattered cultivation	Seasonal	Intermittent during part of the year especially, wet season	1st
Idemili North and South	River Idemili	Agulu Lake	Rivers Ekulo, Ezu, Otolo, Ale, Mamu	Ulasi shales and lignite formation	Light forest with scattered cultivation	All year round	Perennial	3rd
Ogbaru	River Niger at Iyiowa Odekpe, Akili Ozizor, Ossomala and Umunankwo	Guinea	River Anambra, River Orashi at Ogwuani-Ocha	False bedded sandstone and alluvium deposits	Shrub, scattered cultivation, light forest liable to flood	All year round	Perennial	Nth
Ogbaru	River Orashi, Ogwuani-Ocha	Dikenafai, Imo State	Njaba, Awbana, Asa, Eyinla and Akazi Rivers	Alluvium deposits and coastal plain sands	Light forest with scattered cultivation	All year round	Perennial	4th
Ihiala	River Urasi, Okija	Dikenafai, Imo State	River Urasi at Ogwuani – Ocha, Omaiyi, Awgbu, Ofala and Obo Rivers	Oligocene to Miocene rocks,Ulasi shales and lignite formation	Shrub, scattered cultivation and light forest	All year round	Perennial,	4th
Ihiala	Omaiyi stream, Azzia	River Idemili and Urasi Okija	R. Urasi at Okija, River Idemili	Benin formation	Palm bush, scattered cultivation	All year round	Perennial overflowing during the rains	3rd
Ekwusigo	Ekulo Ibollo stream, Oraifite	River Idemili and Urasi Okija	R. Urasi at Okija, River Idemili	Oligocene to Miocene rocks,Ulasi shales and lignite formation	Shrub, scattered cultivation	All year round	Perennial	2nd

Source: Field Observation (2006)

2.3: Introduction to Literature Review

Water composes over 80% of the human tissues. Given the importance of water and its róle in human health and socio-economic development, the World Water Council (WWC, 2000) reaffirms that water is part of immutable hydrological cycle that must be respected for sustainability. The UN secretary general, Dr. Kofi Annan similarly mentioned that "No single measure would do more to reduce disease and save lives in the developing world than bringing safe water and adequate sanitation to all" (Vanguard, 2004).

Access to water poses great challenge to quantity and quality of both surface and ground water resources. The quality of human life is dependent on the ability to match supply and demand of appropriate water quality to specific communities and users at specific times. The rural sector constitutes an extensive part of the Nigerian economy with about 80% of the population engaged in agriculture. It combines the past and present, economic, cultural, historical and ecological factors. Okpalamma (1989) mentioned that water is a relevant parameter and an indicator of rural, physical and farm infrastructures and is mostly needed for domestic consumption and food production.

By definition, each rural settlement has population of less than 20,000 people, although most rural communities of Anambra State exceed this figure, since size distribution is a reflection of changing socio-economic conditions (Onwumerobi, 1993). These problems have geographic backgrounds and thus the solution requires an improved understanding of the fundamental components and processes. Rural water supply studies therefore, generally aims at improvement of the public water supply situation in rural areas in order to meet certain commonly adopted international, regional and local standards. This could be achieved through adequate distribution, water quality monitoring and regulation of the physical, chemical and biological water properties. Evaluation of the existing infrastructures, water development projects and activities of the government, communities and private sectors are also relevant for water development of any community. The use of geographic technologies such as global positioning systems (GPS) assists in data generation of locating water sources, co-ordination and zoning as well as mapping or graphical presentation.

2.3.1: History and Trends of Water Supply in Nigeria

The objectives of water supply development at different eras have been to improve the quality of drinking and domestic water; reduce the effect of water-borne diseases on the population; make potable water available to an increasing proportion of the population at reasonable rate and expanding of inadequate and existing water works. Yet, the different phases of water supply development plan in Nigeria indicate a low level of water supply despite all the efforts put in place.

During the pre-Independence period or colonial era, the provision of domestic water supply was largely through individual and community efforts. Hanidu (1990) in an overview of water supply in Nigeria stated that during the post-colonial era, the objective of the third National Development plan (1975-1980) was to make potable water available to an increasing proportion of the population at a reasonable rate, expand inadequate existing works and meet the minimum target of 25 litres per person per day in major urban centres. This led to the establishment of Water Boards by the regional government to provide water supply services. However, the drought of the early seventies prompted the intervention of the Federal Government to establish some Federal agencies such as the Federal Ministry of Water Resources (1973 and 1976), National Water Resources Institute (1977) and the River Basin Development Authorities (1976). The Ministry of water resources formulates national water polices towards ensuring adequate water supply for agricultural, industrial, recreational, domestic and other programmes that would enhance greater productive economic activities, quality of life and standard of living in the rural areas. The Nigerian Institute of Water Resources trains manpower and carries out research while the RBDAs are the executing agencies that provide irrigation water and domestic water supply to communities.

The post colonial period also centered on "Water and Sanitation for All" with the kick off of the United Nation's International Drinking Water Supply and Sanitation Decade (1981 – 1990) campaign aimed at providing water for all by the year 1990 at 20 litres/day (WHO standard), for domestic use. However, just before the commencement of this programme, only 22% of the rural and 55% of urban population which was below the target enjoyed potable water. The International decade for water supply and sanitation (IDWSSD) adopted community participation as a low cost approach that is capable of extending water and sanitation services to poorer urban and rural areas (Hanidu, 1990).

Water supply approaches in year 2000 and beyond reinforced practical activities that will improve hygiene, sanitation and water for poor people as well as food production. Thus, each rural dweller in 1986 had access to 25 litres of potable water per day while his urban counterpart had access to 60 litres of water per day (Hanidu, 1990). The Nigerian national water supply and sanitation policy aims at providing potable water to all inhabitants of Nigeria by the year 2020, increase water services to 120 liters per capita per day to urban and 60 litres per day, to peri-urban and rural areas respectively.

The rural water supply and sanitation policy of Nigeria approved the rendering of assistance to rural communities so as to obtain basic water supply facilities. However, priority assistance is granted to communities that are prepared to maintain their facilities. The Federal Republic of Nigeria maintains that concerned rural communities are meant to plan, manage and maintain their water supplies while the local government rural water supply and sanitation divisions will assist, so as to promote improved health and sanitation (FRN, 2000). The policy restates the need for reforms, private sector participation, gender and special needs as well as improved sanitation link for promotion of safe water supply wide coverage targets as imperative.

Unfortunately, despite these approaches, the rural area water supply coverage in Nigeria is still low with poor level of water service and environmental pollution. Society for family health (SFH, 2007) also noted that two out of every three Nigerians still lacked access to improved water supply, thereby making diarrhoea a leading cause of death especially among children less than five years of age.

The World Bank, World Meteorological Organization (WMO) and United Nations Educational Scientific and Cultural Organization (UNESCO) water assessment programme similarly points out that water needs are not met in third world countries with a large proportion of rural inhabitants being affected (UNESCO, WMO, 1988).

Bumatay (2004) equally demonstrated that most water supply systems have equally failed to provide economically efficient and adequate water supply as a result of increase in demand capacity.

Oyebande (2004) therefore, suggests that the Federal Ministry of Water Resources (FMWR) with the overall leadership responsibility of the water sector should establish clear policies and guidelines for its own role and those of other operational agencies and stakeholders (including the private sector) so as to improve water supply services.

The Ministry of Water resources is charged with responsibility for water supply matters in Anambra State, to ensure that water gets to the final consumers (any person or persons supplied with water from Water Corporation or person liable with payment of water rates, rent or charges). Anambra State Water Corporation (ANSWC) as the major water agency which develops, manages, constructs, and distributes water in the State for public, domestic and industrial purposes. Other roles include:

i. Planning for maintenance of Department of Water Projects
ii. To abstract water from any lake, river, aquifer stream or other natural water sources within the state.
iii. Examination of surface and underground waters within the state for the purpose of pollution existence determination.
iv. To enter into any commitment, agreement or other arrangement in respect of the provision, distribution, supply and sale of water.
v. To determine adequate fees or charges for water supply and to ensure effective collection.

vi. To license all existing boreholes, wells and hydraulic works in the state as well as approve the construction of new ones.

vii. To determine the quality of all sources of water supply in the state and to continue monitoring such sources to ensure that the World Health Organization (WHO) drinking water standard is maintained (Anambra State of Nigeria Official Gazette, 1999).

Anambra State Water Corporation (ANSWC) operates NKISI HEADWORKS which is made up of different zones namely: Awka zones 1 and 2, Njikoka, Anaocha, Oyi, Ihiala, Aguata, Nnewi and Onitsha zones 1, 2, 3, 4 and 5 and is supplemented by boreholes. Figure 2.4 show the organizational structure of Anambra State Water Corporation.

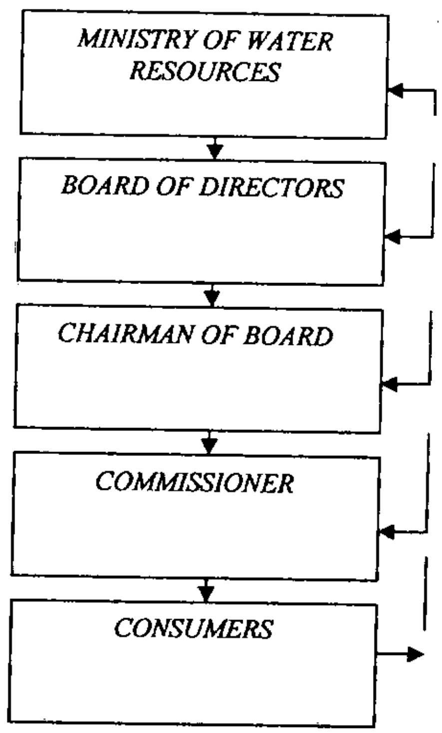


Fig. 2.4: Organogram for Anambra State Water Corporation (ANSWC)
Source: Anambra State of Nigeria Official Gazette (1999)

The low level and average of water service is however a consequence of poor management of the existing institutional structure at the federal, state and local levels which are not optimal for accelerated access. In Nigeria, the federal government leads in the national water policy while the state government handles water supply and sanitation. The local government handles less meaningful role in water supply activities, while private sector participation activities (PSP) is now being highly encouraged because the State water boards seems unable to cope with the increasing man-water relationship.

2.3.2: Access to Water Supply

Water is a basic need in man's environment and the United Nations interest in water as a 21st century global resource lies in the fact that it is central to agriculture management, ecosystem services, sanitation, human health and natural disasters and hence a key factor to meeting the millennium development goals (MDG's). Lack of access to safe drinking water thus, creates the need for household water security.

Household water security concept however encompasses the age old issues of water is timely availability, accessibility as well as adequacy of quantity and quality to satisfy basic human needs. Water insecure households adopt various coping strategies such as the use of multiple water sources and commuting long distances to access water. However, coping with seasonal and periodic water scarcity is tasking and costly as much time and energy is expended in fetching water (Asare, 2004). Such scarcity also constitutes threats to food security and health of people especially in the study area and similar parts of the developing world. Adequacy, equity, service efficiency and consumption safety are therefore important factors for consideration while, arbitrary price hikes need to be regulated. New technologies of solar electric powered pumps and manual boreholes (e.g. hand pump operated) instead of electric pumps due to power failure should also be more widely adopted in the rural areas.

'Accessibility' to water is the ability to reach a desired water point, collect water of good quality and sufficient quantity with minimal cost, time and discomfort. Access to potable water is a central issue because it is a crucial asset for food production and a key factor for individual livelihood and community development not only in rural areas, but in urban and semi-urban settings. In addition to these, the quality of water is important because households can not be secure from water-borne and water-related diseases when water quality is questionable.

UNICEF, (2006a) defines access to safe water by households living less than 30mins away from a good water point. Thus the considerable amount of time women and children spend fetching water could be spent more effectively on other tasks and improved economic productivity.

Reasonable Access to water as prescribed by United Nations (WHO and UNICEF Joint Monitoring) refers to improved water sources as the availability of at least 20 litres of water per person per day within one kilometer of the user's dwelling (UNICEF, 2006b). The United Nations also considers universal access to clean water as the proportion of population with access to an improved drinking water source located within a convenient distance from the user's dwelling.

The Nigerian water policy states that access to water is the minimum of 30litres potable (clean, good quality) water collected within 0.25km of the user's home while United Nations and South

Africa accepts 20litres as minimum (Oyebande, 2006).

The United Nations Organization (UNO) uses water as a yardstick for measuring a country's development since lack of water is a limiting factor and in fact one of the most important constraints of development. The demand for water is thus expected to increase in a particular location when the community population increases. The United Nations water conference in Mar del Plata, Argentina in 1977 realized that accelerated development and orderly management of water resources are prerequisites for improving the economic and social conditions of mankind especially in developing communities.

Willem (2007) pointed out various global water problems of excessive supply, shortage or scarcity and poor quality in different places at different times. Thus the critical short supply of water services in Nigeria, results in many households often the poorest purchasing water from private vendors at very high prices and at the expense of their other needs (Oyebande, 2006). Rural water supply sources are also mostly of low quality, unreliable, unsustainable and inefficient with poor operations and cost management (Oyebande, 2006).

United Nations (WHO, UNICEF, 2000) also recorded that 1.1 billion people in the world lacked access to any form of improved water supply within 1km of their homes. Furthermore, the United Nations water and sanitation report card for Nigeria in Table 2.2 recorded that only 33% and 31% of the rural population had access to improved drinking water for the years 1990 and 2004 respectively. The 75% target by the year 2015 is yet to be achieved and represents a daunting task.

Table 2.2: Water and Sanitation Report Card for Nigeria

Country	Improved drinking water Coverage % 1990			Improved drinking water Coverage % 2004			Improved drinking water Coverage % 2015	Progress towards the MDG drinking water target
	Total	Urban	Rural	Total	Urban	Rural	MDG Target	
Nigeria	49	80	33	48	67	31	75	Not on track

Source: UNICEF, 2006b

Masley (2004) postulated that an average person needs about 30 to 50 litres of water per day for drinking, cooking and cleaning. Unfortunately, an average African does not utilize up to 50 litres even in areas where they have access to surface water.

Handy and Niemeier (1997) integrated the spatial, socio-economic (population, income, gender and age) variables; origins and destinations (water collection points and points of water use); measurement of travel impedance (distance and time variables) and measurement of attractiveness (quantity, quality and price) as part of the issues to be resolved for adequate accessibility.

Joint monitoring programme (JMP) of WHO/UNICEF for monitoring progress towards the Millennium Development Goals (MDGs) targets defined access to safe drinking water using proxy indicators of 'improved' or 'unimproved' water sources (Table 2.3). Access to safe water involves people that rely on improved sources as their main source of drinking water and sanitation need. The JMP access however, does not always reflect on water quality, access indices, reliability, intermittence or the seasonality of improved sources. This type of access therefore is not precise for rural water studies of which distance to water points, cost, time and energy expended as well as the water quality are prime issues that need not be neglected.

Table 2.3: Classification of Improved and Unimproved Drinking Water Sources

Improved drinking water sources	**Unimproved sources of drinking water**
Piped water (into dwelling, yard or plot)	Unprotected dug well
Public tap/standpipe	Unprotected spring
Tube well/borehole	Vendor provided water
Protected dug well	Tanker truck water
Protected spring	Surface water (river, stream, dam, lake, pond, canal, irrigation channel)
Rain water collection	
Bottled water*	

*Bottled water is considered an 'improved' source of drinking water only when there is a secondary source that is 'improved'.

Source: UNESCO, 2006

Howard and Bartram (2003) however proposed four access categories (Table 2.4) based on the relationship between accessibility expressed in time or distance and the likely quantities of water collected or used. The JMP monitored access is global and is thus classified as basic access.

Water accessibility therefore reflects the generalized costs, discomfort and risk, time and energy expended in search of water with gender mainstreaming not left out. Individuals often evaluate accessibility in terms of convenience, which is the ease with which they can get what they want. It measures the degree and type of disaggregation, the definition of origins and destinations, and the measurement of travel impedance and of attractiveness. The indices are:

Table 2.4: Water Service Levels and Health Implications

No	Service level	Access measure (distance or time)	Needs met	Level of health concern
1	No access : quantity collected often below 5 litres (L) per capita per day	More than 1000metres(m) or 30 minutes total collection time	Consumption cannot be assured. Hygiene not possible (unless practiced at the source)	Very high
2	Basic access : average quantity unlikely to exceed 20 litres per capita per day	Between 100 and 1,000m or 5 to 30 minutes total collection time	Consumption should be assured. Hand washing and basic food hygiene possible; laundry and bathing difficult to assure unless carried out at source	High
3	Intermediate access : average quantity about 50 litres per capita per day	Water delivered through one tap on plot or within 100m or 5 minutes total collection time	Consumption assured. All basic personal and food hygiene assured; laundry and bathing should also be assured	Low
4	Optimal access : average quantity of 100 litres per capita per day	Water supplied through multiple taps continuously	Consumption: all needs met. Hygiene: all needs should be met	Very low

Source: Howard and Bartram, 2003

a. Time referring to the average travel time required to reach water sources and to obtain potable water.

b. Cost reflecting the total expenditure made in making water available. It ranges from the activities of water vendors to water treatment and transportation fares to the required location. It also includes the cost of water infrastructural repairs and maintenance.

c. Distance measures are the simplest accessibility measures. It calculates the distance from one location to different opportunities. It can be measured as average distance, weighted area distance or distance to the closest opportunity (water point). The amount of water used daily depends on the distance to the nearest well, running tap or other water sources. Distance increases when hand pumps are defective. An impedance formulation is a very simple measure that counts the distance from one location to a given destination. For example the central business district (CBD) concept signifies that the closer the destination, the higher the accessibility.

d. Gender mainstreaming needs to be integrated as a cross-cutting issue in water policies and programme. Women play a central role in providing, managing and safeguarding water according to the Dublin principles and thus are the most vulnerable to water hazards. They are the major water gatherers in many rural communities and end up bearing the inequalities of limited and unsafe water services. Okeke (2004) further emphasized that inadequate access to safe water and sanitation facilities particularly in the rural areas overburden women and their families with consequent negative health impacts. Therefore, water developmental efforts could be more efficient, effective and at the same time achieve equity if gender aspects are properly addressed.

Water availability is the ability of households to obtain the required quantity of suitable quality water for drinking, personal hygiene, other domestic purposes and other economic activities. Access to adequate water supply is therefore not only a fundamental need and human right but has considerable health and economic benefits to households and individuals. On the other hand, the lack of access to adequate water contributes to deaths and illnesses, especially in children.

2.3.3: Rural Water Supply Sources

Stoveland and Bassey (2000) studied types of water supply sources used by households of small towns in Nigeria and reported that the most popular sources of water are rivers and streams which are used by more than one quarter (27.4%), followed by yard wells used by about one-quarter (24.5%) of households respectively. Other water sources are community wells, water sellers, springs, boreholes and water tankers and needs to be adequately protected. Only 0.4 per cent of the households use pipe-borne water. Similarly, these sources of water are obtainable in typical rural settings.

The World Health Organization in 1976 reported that 86% of the world's rural inhabitants were without potable water. Similarly, Sounders and Warford (1976) attempted to describe and create awareness on the extent and nature of the water supply problem, with suggestions for dealing with the problems. They discussed the character and magnitude of the problems connected with water supply and sanitation, the relationship between water supply and water-borne disease and socio-economic activity and examined the effects of improved water supply and sanitation on productivity, incomes, rural-to-urban migration and overall development. They also dealt with the problems of water supply program planning, administration, operation and maintenance and the importance of cost recovery programs. These coupled with widespread adoption of traditional water harvesting techniques and community action remain relevant and indeed the hope of meeting the water needs of the teeming populations of rural communities and small towns in many developing countries including Nigeria.

Rainwater harvesting is a prominent practice in the eastern parts of Nigeria and in all the rural communities investigated. Expectedly, rainwater harvesting is best carried out during the wet months of May to October (rainy season) when the water is collected from the roof through the popular "roof catch" method. Oni et al, (2004) explains rain harvesting as a store and release process where rain water is collected during rainy season and utilised during dry periods. The process involves the use of concentration and conveyance where water is channeled from the roof directly into a gutter or PVC pipe with or without inlet filters for filtration into a receptacle such as underground or surface tanks (Plates 2 and 3), ditches, pits, ponds, wells and some other receptacles where it is stored and can be drawn or released when needed. Water is then drawn using facilities of rope and bucket, pulley system, electric and hand pumps.

Trees are also used to harvest rainwater in some communities in Eastern Nigeria. For instance, in some areas hollows are bored in the trunks of large evergreen trees where water could percolate. In some other areas shallow depressions are cut in the external bark of oil palm and coconut trees to channel down rainwater into some containers. The water harvesting technology for human purposes could be vastly improved with the addition of unit filtration and purification systems and of the conduit to the tank. In this way, at least the quality of water for human consumption would be guaranteed. Since the addition of these unit systems has a direct impact on the family economy, the use of stone filters and earthen pots to keep the water cool is recommended. This technology is widely known and used to increase the supply of safe water free of bacteria and other pathogens.

It is necessary to implement programs to disseminate, demonstrate, and promote the use of the technology on a large scale in rural or urban housing development programs and in comprehensive rural development programs.

Traditional African rainmaking is another popular method adopted in the rural communities so as to meet up with water needs. This is usually done during the wet season when the clouds still hold enough vapour. Typically, the rainmakers use local items like *ugo* (eagle), *ite* (fired clay pot), *okosiko* (native wooden gong), *ogene* (native metal gong), *ekpete* (native drum), *oji* (kolanuts), *okwute* (pebbles) and the herbs and barks of certain trees to force down rainwater from the vapour-laden clouds (Uluocha, 1998).

The rural communities also devised a simple watershed management technique, which is employed to effectively collect and distribute rainwater. The approach involves deliberate blocking of natural drains during storms with embankments or earth dams constructed using mud, stones and leaves (particularly palm fronds) to prevent water from flowing into open fields. The embankments help to trap the runoff, thereby causing it to form into sizeable pools. The water is subsequently released gradually to nearby farmlands. Traditional water retention structures like ridges and bumps are also built across sloppy farmlands to reduce the speed of runoff. In some areas, pits or ditches of about 1.5m deep and 1m wide are dug down slope to harvest rainwater and excess runoff (Field Survey, 2006). During the dry season water is lifted from such ditches with buckets or rubber bags and applied to crop fields.

Some other water management methods adopted by the villagers in the study area include deepening and widening of ponds to store more water, recharging dried wells, as well as constructing underground tanks or ponds with plastic lining that prevents the water from becoming unpleasant. Wastage of water is often minimized by reusing wastewater for agriculture, livestock, food processing and other uses that do not require high quality water. These processes however require adequate supervision and protection so as to minimize contamination from dust and receptacles.

2.3.4: Water Quality

Water quality is closely linked to water use and the state of economic development. The eutrophication of surface waters from human and agricultural wastes and chemicals such as nitrates affects most study communities in Ogbaru LGA. The United Nations Environmental Programme reinstates that way back from the chemical age, water quality has been heavily affected by industrial and agricultural chemicals while acidification of surface water by air pollution threatens man and environment with outbreaks of cholera and gastro-enteric disease occurring at alarming rate especially in developing countries (UNEP, 1995).

Agricultural and industrial wastes, seepages of mineral fertilizers (phosphates and nitrates), pesticides and herbicides into surface and ground waters affect the quality of water rendering it unsafe for domestic consumption and causing water-related diseases (Moss, 2007). The pollution of rivers and streams with chemical contaminants can be classified according to the nature of its sources: point pollution and non-point pollution. Point pollution involves those pollution sources which can be specifically identified, such as factories, refineries, or outfall pipes. Non-point pollution involves pollution from sources that cannot be precisely identified, such as runoff from agricultural or mining operations or seepage from septic tanks or sewage drain fields. It is estimated that each year 10 million people worldwide die from drinking contaminated water (Encarta, 2006).

Gash et al (2001) also asserted that human health is seriously at risk due to poor water quality problems which is common in developing countries. This is due to the fact that poor state of human health can be closely correlated with pollution and degradation of water sources especially at the rural level.

Furthermore, World Health Organization (2004b) reaffirmed that unclean water is responsible for diseases such as diarrhoea, cholera, bacillary dysentery, guinea worm, typhoid and intestinal worms which kill more than 8 million people throughout the world each year. To this effect, March 22nd of every year is declared as "world water day" and has provided opportunities for both health and water authorities to organize educational forums and activities on benefits of water as well as associated problems. The year 2008 is marked the United Nations International year of sanitation with the global hand washing day (GHD) launched on October 15 echoing and reinforcing the need for improved hygiene practices and hand washing with soap especially after contact with excreta. This reduces diarrhoeal diseases by over 40% which is responsible for 30% infections that cause diseases in children (Dooley, 2008). Water therefore being a key component to food security, health, efficiency and individual well being must be free from any substance hazardous to health.

The World Health Organization guidelines on water quality represent the concentration of a constituent that does not exceed tolerable risk to the health of the consumer over a lifetime of consumption. Thus, the exceedance of a guideline value does not necessarily result in a significant risk to health, however, deviations above the guideline values in either short or long term do not necessarily mean that the water is unsuitable for consumption but depends upon the specific substance involved and should be a signal to investigate the cause, take a remedial action and seek advice from the authority responsible for public health (WHO, 2006).

2.3.5: Community Development

Rural areas are interior areas consisting of dispersed settlements of farmhouses, hamlets and villages with small populations ranging from a few hundreds to thousands who are usually engaged in agriculture or fishing and craft making (Ologe, 2004). In terms of infrastructure, most rural areas lack adequate social amenities such as good road networks, potable water and electricity supply. The Integrated rural development programme (IRDP) by Koinyan (1989) popularly called the 'peoples programme' was established to bridge the gap between urban and rural inequalities through infrastructural improvement; co-ordination of rural water supply projects by rehabilitating broken down water facilities, constructing mini water supply schemes and adoption of improved rainwater harvesting techniques. At the community levels, village or town improvement and development unions or associations such as co-operative societies, age grades, men, women and youth organizations engage in rural water supply projects. Immeasurable progress has been achieved in most Anambra State SW rural communities where home associations based at different states of the federation and even outside the country contribute in carrying out infrastructural support projects for their villages. This includes water supply systems of pipe borne water, borehole drilling, well construction as well as rural health care delivery systems for water diseases eradication.

The Federal Ministry of Water Resources (FMWR) in its water supply and sanitation programme has taken steps to rehabilitate 10 broken down boreholes, construct two new hand-pumps boreholes per LGA and one small town water supply (motorised boreholes with overhead tanks) and sanitation scheme in each of the 109 senatorial districts (FMWR, 2003). This was a disaster in most places as most of them are not in good working condition. The new water resources minister Shagari has declined to intervene directly at the State and LGA level which means supporting the MDG programme through relevant institutions.

The Nigerian National Assembly under the 2004 Appropriation Act (Punch, January 30, 2005) similarly passed a bill which involved awarding of contracts of motorised boreholes in different States of the federation. This is in the bid to improve water supply for health and safety of consumers while supporting the federal rural water supply programme but was however a disaster in most places. In Anambra State, the study LGAs are part of the listed beneficiaries (Table 2.5), boreholes have also been constructed in most areas such as in Ogbaru LGA although most of these boreholes are not in good working conditions presently.

Table 2.5: Rural Water Supply Programme, Contract Awardees

State	Constituency/ Area	River Basin	Scheme Type	Contractor	Address	Proposed Intervention	No of Boreholes
Anambra	Idemili North Idemili South	Anambra-Imo	Motorised	Bomboko Limited	No 1 Iseke street Independence layout, Enugu.	Umuagu, Nnobi	Not specified
Anambra	Ogbaru	Anambra-Imo	Motorised	Causon Nig. ltd	No 113 Weatheral Rd. Owerri	Okpoko	Not specified
Anambra	Nnewi South Ekwusigo	Anambra-Imo	Motorised	Wellworth Ltd.	No 218 Leventis Rd. Apapa, Lagos	Obinugwu Village Nnewi South	Not specified
Anambra	Ihiala	Anambra-Imo	Motorised	Roston Nig. Ltd.	26A Okigwe Rd. Aba	Umudike village	Not specified

Source: Punch, January 30, 2005

Water Aid, a non governmental organization in collaboration with some relevant agencies advocates for national plan on water and environment so as to co-ordinate a mechanism to harmonize investment in water supply and sanitation at the three tiers of government (Federal, State and local) on monitoring and evaluation to enhance transparency at each level. However, in spite of these efforts made by the Federal government, community and village development unions in provision of water in these rural communities, the water quality and volumes consumed by these rural communities remain uncertain. Therefore, this research fills the gap by providing precise information on rural water quality, volumes of domestic water consumed by households while generating a threshold value that will point out areas of deficits, inconsistency or variation and balance in the study area. This will avail planners and decision makers of information for proper risk assessment, safety and sustainability of rural water.

2.3.6: Models for Water Supply Studies

Hydrological models assist in simulating the occurrence of different conditions on the basis of real time operations and monitoring of water systems through continuous inspection, observation of water quantity and quality, protection of water sources and analysis of occurring changes as well as future change predictions and forecast.

Water sources such as streams, rivers and wells deserve adequate protection from pollution while borehole projects require quality supervision because of daily increase in water demand. In the rural areas, ways of estimating mans' water need for domestic purposes (supply and demand) has unfortunately not been reliable because it requires adequate understanding of human lifestyles and behaviours such as household size, socio-economic variables of age, marital status, sex, occupation and educational background for accurate estimation. The complexity of the problem is that there is no universally acceptable water consumption model.

a. The Dynamic Hydrological Model

The dynamic hydrological model is generated by Luijten (1999), a GIS Specialist and Systems Modeler of the International Center for Tropical Agriculture (CIAT) in Cali, Colombia. Water shortages and the degradation of water supplies threaten the food security and health of people in many parts of the world especially in developing countries that are experiencing rapid population growth but have limited means to manage water resources such as Nigeria. In application of this model, streams are the primary source of water to satisfy domestic, industrial, and agricultural needs. Thus, decreasing water availability caused by the lack of local government regulation, inadequate resource management strategies and nearly unregulated use of stream water is a major concern. Quantitative information is therefore essential so as to improve local level decision making and guiding local rural development and water management.

b. The Spatial Water Budget Model (SWBM)

This is a continuous, distributed parameter, watershed scale model developed by Luijten (2001). It simulates water supply and demand over space and time on daily basis using Geographical Information System (GIS) data structures. SWBM delineates streams and computes availability of stream water as it flows down slope or is (partially) extracted to for domestic, industrial and agricultural uses. The model can simulate the effects on hydrology and water yields of changes in land use, water use for domestic, industrial and agricultural purposes, different locations of water extraction, and impedance by dams on a daily basis. SWBM is a tool for assessing water availability and use under different development pathways at a watershed scale to determine whether water security is a potential problem, and if so, when and where it occurs (Luijten et al, 2001). The model has been developed in particular for application in agricultural hillside watersheds in Latin America and the Caribbean of up to approximately 50,000 hectares in size and for which few biophysical data are available, but it can be applied to watersheds in other areas as well. SWBM fills the gap between current needs of rural communities in developing countries and data demands of established, more complex models designed for application in developed countries. Simulation results obtained with SWBM can be used for supporting local decision-making processes to guide development to the benefit of local communities, as well as for teaching local stakeholders about basic functions of multiple community watershed components such as relationships between land and water resources, effects of water use and upstream-downstream relationships.

c. GIS Micro Simulation Model

A simple map based micro simulation model designed in a GIS environment by Uluocha (2006) and applied in Lagos metropolis of Nigeria as a technique for water demand estimation and forecasting integrating spatial dimensions states that domestic demand for water is never constant. Similarly, population increase leads to more quests for water, thus the GIS-oriented domestic water demand model integrates water uses such as domestic, industrial and agriculture as well as the number of users to estimate the minimum quantity of water needed per household member.

In comparing the models, the Spatial Water Budget Model (SWBM), is a continuous, watershed model applied on a landscape which simulated water supply and demand on a daily basis using the water balance parameters but failed to integrate human behavioural parameters. Similarly, the GIS micro simulation water model was applied in urban households and failed to duely consider rural variables such as small scale industrial activities (cassava and food processing, oil palm processing and soap making) and agricultural water use activities such as vegetable gardens ('mbubo') located around rural households.

These models applied different spatial techniques for water demand estimation and forecasting but failed to establish a control variable which is vital for rural water planning. Identification of areas of water deficit or surplus and balance moreover, were not pointed out by the models.

The aforementioned shortcomings of these models therefore, necessitated the need for developing a new model called the 'Rural Threshold Water Consumption' (RTWC) model. The

RTWC model is proposed to integrate both domestic (drinking, cooking, washing) and local processing activities (oil palm, soap, cassava) for effective predictions in the rural areas. The RTWC model integration with the Community Water Supply Management (CWSM), Water Supply Protection (WSP) and Threshold concepts structure and processes as well as the water quality and access data in Figure 2.5 aids effective predictions, reliability and solutions to rural water problems.

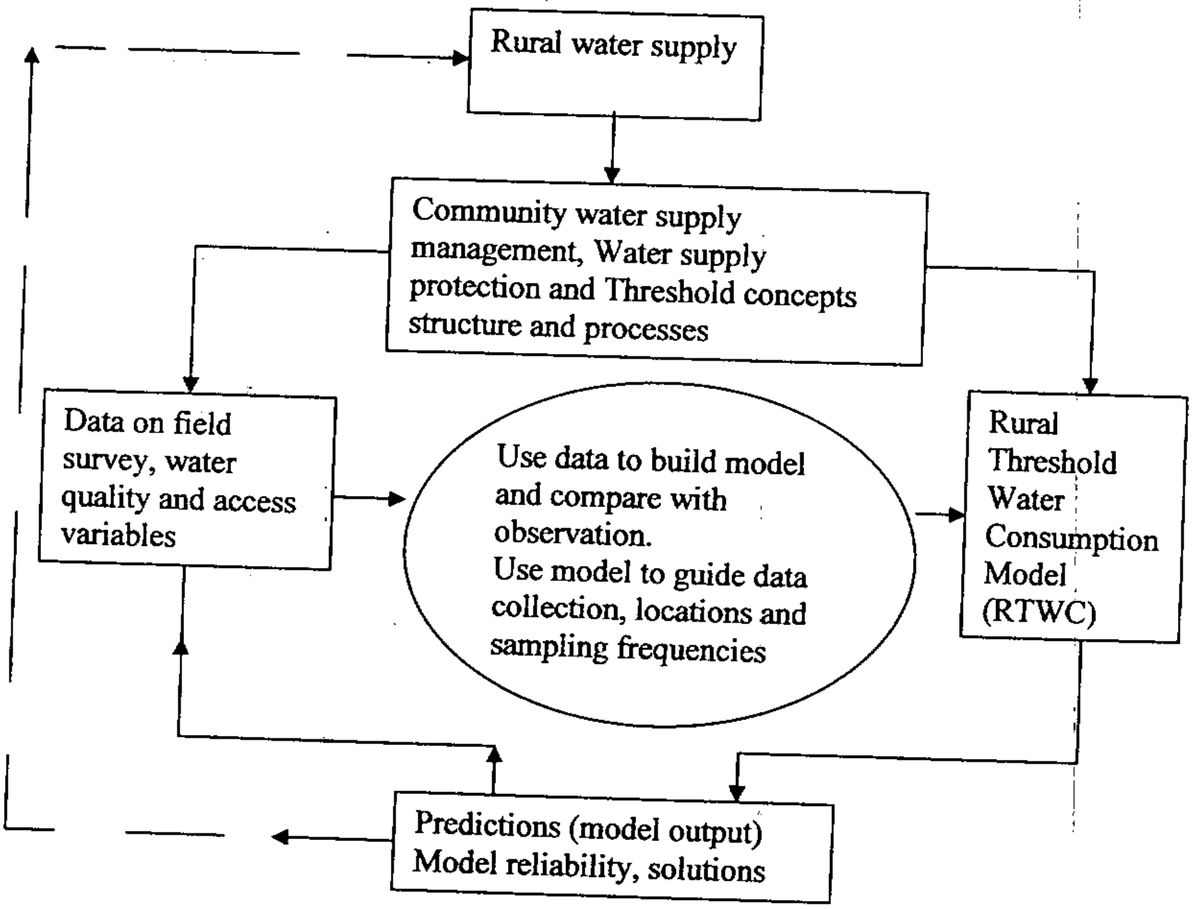


Fig. 2.5: The rural water supply model concept

Source: Field Survey 2006.

The water supply process integrates the source of supply, treatment, storage, transmission and distribution systems necessary to dispense water to a community. Water demand considers both current and expected water consumption in any given area over a specific time period. Due to varying requirements and spatially explicit characteristics of individual users, water demand must be determined separately for individual user groups or sub-sectors such as domestic, industrial or commercial processes and irrigation.

Domestic water is a basic need for drinking, cooking, washing irrigation, fishery, and livestock breeding water in both rural and urban areas.

Industrial water is a raw material in manufacturing process and non consumptive water for cooling. The major industrial processes requiring water are cooling, processing, boiler water and general use but in rural areas the local processing activities are integrated.

Agricultural water is the largest consumer of water especially where irrigation for crop growth or rain fed agriculture is required. The water use varies from one rural community to another depending on the indigenes occupation, climate, water availability and interrelated economic factors.

CHAPTER THREE

RESEARCH METHODOLOGY

The research investigation flow chart in Fig 3.1 is a detailed procedure adopted for this rural water supply study. The research incorporated the procedures and data (Table 3.1) which are generated from different sources to achieve the study objectives. The study data are classified into:

1) Spatial data which comprises the census and water quality data.
   - Maps and topographic sheets of study area for study LGAs location as well as characterization of some existing water sources.
   - Census population records for community locality list and water consumption projections.
   - Water quality data generation from water sampling and laboratory testing for determining physico-chemical, oxygen demand and microbiological water quality using World Health Organisation (WHO) and Federal Ministry of Environment (FMEnv) standard limits. Water sampling was carried out during dry season or low flow period when there is tested parameters have a relatively high concentration and there is easy access to remote communities.
2) Non- spatial data which comprises:
   - Questionnaire survey for the indigenes' perception on rural water supply. Survey for Water Corporation officials on rural water facilities and health centre records on water related diseases.

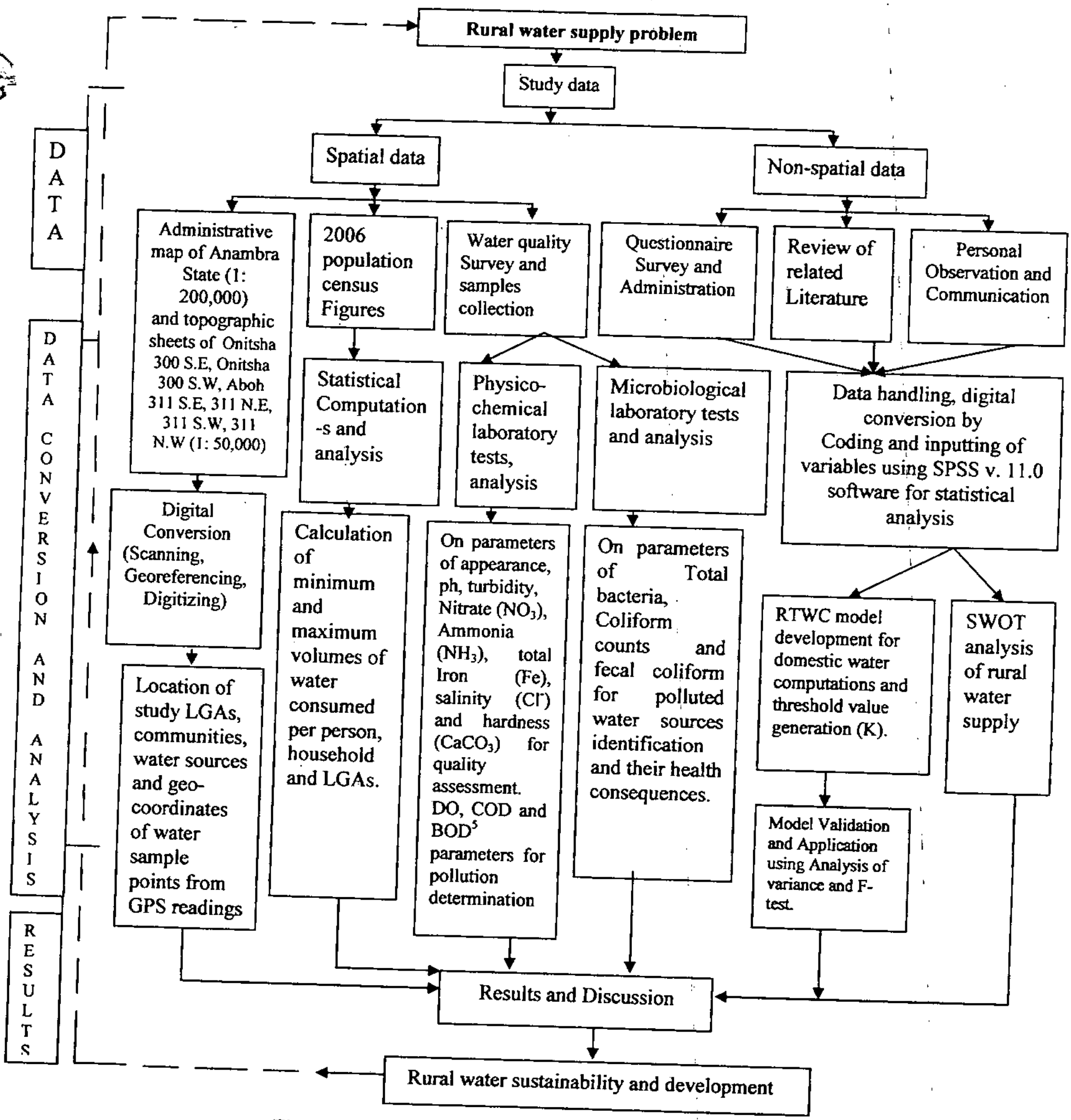


Fig. 3.1: RESEARCH METHODOLOGY FLOW CHART

— — ←— Feedback mechanism

Table 3.1: Data Sources and Features of Rural Water Supply in Anambra SW

Data	Date	Acquisition source	Analytic technique and application
Census population	1991 2006	National Population Commission	To measure the per capita water demand of the individual LGAs and entire Anambra State SW
Rainfall	2006	NIMET, Oshodi	Peak rainfall periods of study location
Related literatures	Current	Internet, media, journals, books and scientific papers, published and unpublished, and personal interviews	To obtain an understanding of the history and trends of rural water supply
Administrative map of Anambra State. Scale: 1:200,000	1997	Anambra State Survey, Awka	Digitally converted by scanning, georeferencing and digitizing and used in locating the Southwestern part of the State and this is made up of nine (9) LGAs. Three of these LGAs, Onitsha North, Onitsha South and Nnewi North are totally urban with no rural community
Topographical sheets – Onitsha 300 S.E, Onitsha 300 S.W, Aboh 311 S.E, N.E, S.W, and N.W. Scale: 1:50,000	1969	Federal Surveys Lagos, Nigeria	To identify and characterize water sources in the study area.
Data sampling		Field surveys	
Random sampling of 28 rural study communities	2006	Ekwusigo, Nnewi South, Ogbaru, Ihiala, Idemili North and Idemili South LGAs of SW Anambra State	• LGA's with > 8 rural communities (randomly chose ½ but not more than 6 communities) • LGA's with 4 – 8 rural communities (chose 4 or 5 randomly) • LGA's with 3 or less rural communities (use all).
Questionnaire sampling	Dec.2006		Random distribution of a total of 1456 questionnaires for the views of water consumers and suppliers in the following order: • Questionnaire survey on rural water supply (50copies for each of the 28communities =1400)

			• Questionnaire survey for water agencies and NGOs on water supply distribution (1copy for each community =28) • Questionnaire survey for health centres on rural health (1copy for each community =28).
Water sampling			
First phase	December 5 - 9, 2006	Streams, Rivers, boreholes and roof catch rain harvest sample collection during dry season or low flow period with high concentration.	The samples were collected using sterile containers, were refrigerated and transported to the laboratory within a few days of collection for physico-chemical analysis such as appearance, pH, Turbidity, Nitrate (NO_3), Ammonia (NH_3), Total Iron (Fe), Salinity (Cl^-) and hardness ($CaCO_3$).
Second phase	March 1 - 2, 2007	Streams, Rivers, boreholes and roof catch rain harvest depicted in (Fig.4) and carried out during dry season or low flow period with high concentration.	Water sample from one major water source of each select LGA prone to human pollution were collected for oxygen and microbiological tests. The water samples for dissolved oxygen (DO), chemical oxygen demand (COD) and biological oxygen demand (BOD_5) tests were collected using sterile containers, stored with ice packs and transported to the laboratory within 84hours of collection
GPS readings	December 5 - 9, 2006 and March 1 - 2, 2007	Streams, Rivers, boreholes and roof catch rain harvest sample locations.	For geo-coordinates and ground measurements of all the sampled points while Arc map Geographic Information System software was used in plotting water sample collection points or locations (Fig.9).
Data analysis			
Questionnaire analysis	2007		The questionnaire responses were converted digitally by collating, coding, inputting, screening and analyzing of datasets using SPSS (version 11.0) statistical analysis software to perform descriptive and frequency analysis of the entire survey.

Laboratory analysis	2006, 2007		The physico-chemical samples were analysed in the chemical laboratory of Chevron Escravos. Warri, using the World Health Organization (WHO) standard limit for potable water. The American Society for Testing and Materials (ASTM), American Public Health Association (APHA) and various test methods for particular tests were adopted The dissolved oxygen (DO), chemical oxygen demand (COD) and biological oxygen demand (BOD_5) samples were analysed in the chemistry laboratory of University of Lagos using the Federal Ministry of Environment (FMEnv) standard limit. Microbiological analysis of samples were conducted upon 48hours of collection in the water quality laboratory of rural water supply and sanitation agency (RWASSA) on total bacteria, coliform and feacal coliform counts to identify presences of disease causing micro-organisms. The membrane filtration and most probable number (MPN) methods were adopted.
Statistical analysis	-		Frequency statistics of percentages was used for the inputted variables from the questionnaire survey while the analysis of variance (ANOVA) was used to carry out F-tests on water consumption and variations in the study LGAs. Microsoft Excel was also used for statistical computations and plotting of graphs on water supply parameters.
SWOT analysis	-		SWOT analysis was used to evaluate the strength, weakness, opportunities and threats to water supply in the rural communities of Anambra SW.
RTWC model	-	Data generated from questionnaire survey on different water uses	To help measure domestic water consumption rates in the different LGAs at both minimum and maximum periods and to establish a threshold balance that helps in determining areas of water demand deficit, balance or surplus.

Source: Field Survey, (2006)

- The survey results which were used to generate household and access indices of water as well as correlating water disease records in the study area.
- Archival data and review of related literatures for historical trends on rural water issues using past reports from media, internet, books and journals.
- Personal communication with village heads such as Chief Gilbert Udoji, the Igwe of Oraifite, Engr. Ernest Onyekwelu, the director of Anambra State Water Corporation (ANSWC), Awka, Nnamdi Nwanze of Rural Water Supply and Sanitation Agency (RUWASSA) water quality department and some indigenes on rural water issues in the study area.

The various data sets are gathered, converted and analysed using the Statistical Packages for Social Sciences (SPSSv.11.0), Standard limits of (WHO and FMEnv), Rural Threshold Water Consumption (RTWC) model, the analysis of Strength, Weakness, Opportunities and Threats (SWOT) for the results and discussion.

- The Rural threshold water consumption (RTWC) model is developed to determine household water consumption rates across the study LGAs.

------ Input data: Domestic, industrial, agricultural and miscellaneous water uses for domestic water consumption in study areas.

------ Periods: Regular and supplemental times.

------ Objective: To quantify domestic water demand in each LGA and generate a threshold constant while identifying areas of deficit, balance and surplus.

------ Methodology: Using the generated RTWC model equations.

------ Output data: The domestic water consumption values, threshold values and graphs for various demand levels.

------ Computational details: The computations and explanations.

- Model validation using regression model, Analysis of Variance (ANOVA), F-test and United Nations reasonable access standard limit.
- Statistical computations and analysis using statistical packages for social sciences (SPSS) Version.11.0 and Microsoft Excel.
- SWOT analysis of rural water for general evaluation of rural water in the study area.

3.1: Water Sampling and Standard Testing Limits

Adequate and accurate information on water quality is necessary for any potable water project as well as the post project information on socio-economy so as to guide future regulatory actions and approaches. Water sampling technique is adopted in this research to collect samples from the selected locations (Plates 14 and 15). The containers for chemical sample collection were washed with soap and rinsed with warm water as well as particular water sample before collection of sample. On the other hand, the mercathe bottles for microbiological samples were washed, rinsed and dried and sterilized at oven temperature of 170^{0c} for 2 hours before collection of samples. Gloves are worn for collection and sample bottles are wrapped with foil and ice packs are used to preserve samples from the point of collection before refrigeration and transportation to the laboratories for analysis. The GPS readings of sample point locations, sampling dates and their co-ordinates are recorded in Table 3.2.

Plate 14: Location reading and sample collection at a commercial borehole in Amorka, Ihiala LGA
December 7, 2006

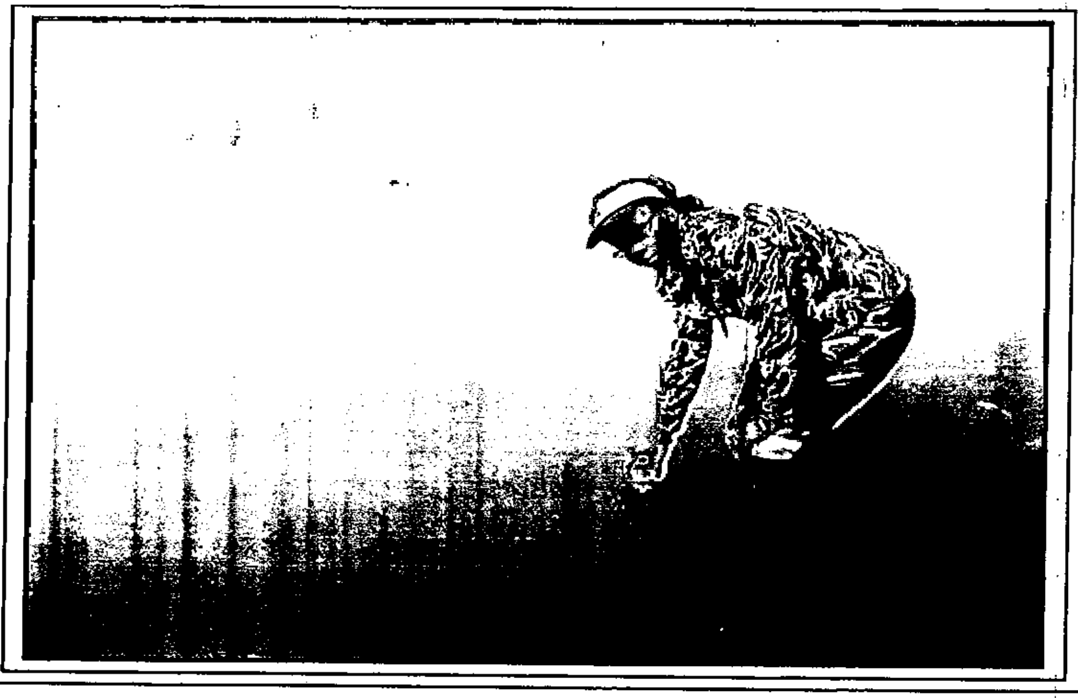


Plate 15: Water sample collection at River Niger at Iyiowa Odekpe, Ogbaru LGA
December 6, 2006

Table 3.2: Geographic Co-Ordinates of Water Sample Points

Name	Date	Location	LGA	X Coordinates				Y Coordinates		
Opiegbe stream	7/12/2006	Ideani	Idemili N.	6	5	10		6	56	7
Ukwuakpu stream	7/12/2006	Eziowelle	Idemili N.	6	9	30		5	59	47
Roof catch	7/12/2006	Awka Etiti	Idemili S.	6	2	8		6	57	59
Roof catch	7/12/2006	Nnokwa	Idemili S.	6	3	10		6	58	9
Community health centre borehole	7/12/2006	Alor	Idemili S.	6	4	55		6	57	39
Osemeham community borehole	8/12/2006	Akwukwu	Idemili S.	6	2	32		6	48	34
Ekulo Ibollo stream	8/12/2006	Oraifite	Ekwusigo	6	0	35		6	49	41
Private, free borehole	8/12/2006	Ihembosi	Ekwusigo	5	55	44		6	51	40
Private free borehole	8/12/2006	Ichi	Ekwusigo	6	02	52		6	52	0
Urasi Okija stream	7/12/2006	Okija	Ihiala	5	55	16		6	51	30
Omaiyi stream	7/12/2006	Azzia	Ihiala	5	53	10		6	52	38
Private, free and Time regulated borehole	7/12/2006	Orsumoghu	Ihiala	5	52	5		6	54	52
Commercial borehole	7/12/2006	Amorka	Ihiala	5	45	12		6	52	48
Roof catch rain harvest	7/12/2006	Mbosi	Ihiala	5	51	35		6	54	25
Private commercial borehole	7/12/2006	Isseke	Ihiala	5	50	2		6	54	56
R.Niger at Ogwu Ikpele	6/12/2006	Ogwu Ikpele	Ogbaru	5	43	50		6	38	37
R. Urasi at Ogwuani-Ocha	8/12/2006	Ogwuani-Ocha	Ogbaru	5	47	47		6	45	18
Fed. Government borehole	6/12/2006	Ossomala	Ogbaru	5	52	6		6	40	54
Onukwu stream	6/12/2006	Umunankwo	Ogbaru	5	52	51		6	41	40
R. Niger at Akili Ozizor	6/12/2006	Akili Ozizor	Ogbaru	5	59	23		6	43	53
Idemili R. at Niger	6/12/2006	Iyiowa Odekpe	Ogbaru	6	6	31		6	45	31
Aso commercial borehole	7/12/2006	Osumenyi	Nnewi S.	5	57	3		6	45	37
Roof catch rain harvest	7/12/2006	Utuh	Nnewi S.	5	58	10		6	58	18
Community borehole	7/12/2006	Unubi	Nnewi S.	5	57	11		7	2	32

Source: Field Survey, (2006)

The collected samples were analysed chemically using the WHO standard testing limits for potable water. The World Health Organisation water quality (WHO, 2004) specifies the following criteria for potable water:

- Appearance: clear and colourless
- Optimum Ph: 6.5 – 8.5
- Turbidity (NTU): 5
- Nitrate: 50 mg/L
- Ammonia (NH_3): 1.4 mg/L
- Total Iron (Fe): 0.3 mg/L
- Salinity as Chloride (Cl^-): 250 mg/L

The dissolved oxygen test was analysed using the Federal Ministry of Environment (FMEnv) standard limit of 7.5 ppm. while chemical oxygen demand is negligible and biological oxygen demand zero. Verification of the microbial quality of drinking-water includes testing for Escherichia coli as an indicator of feacal pollution. The membrane filtration and most probable number (MPN) selective methods were also used in isolating the micro-organisms.

Membrane Filtration Method

Each of the samples (100ml) were filtered through sterile white, grid-marked, 47mm diameter, Millipore HA-type cellulose filters, with pore size 0.45 mm using vacuum pressure filtration unit. The filters were placed with the grid-side up on plates of MacConkey agar (MCA), Eosine methylene blue (EMB) agar, Sabauround dextrose agar (SDA) and plate count agar (PCA). The plates of MCA were incubated at room temperature (33 ± 2^{0C}) for 24 hours while plates of SDA were incubated for 3 – 5 days for fungal growth. Colonies on MacConkey and EMB plates were used to estimate coliform counts while the colonies on PCA plates were used to estimate the total aerobic mesophilic bacterial counts. Pure cultures of each bacterial isolates were identified using morphological characteristics and biochemical tests including grams react on, catalyse test, methyl red test, acid and gas production on lactose and glucose broths, Indole test, Citrate test, sugar fermentation. Physiological tests (germ-tube formation), biochemical characteristics, including carbohydrate oxidation/assimilation and fermentation, morphological characteristics were employed to identify the yeasts. The identification of the mold was based on macroscopic and microscopic morphology and the use of colour atlas.

Most Probable Number Method

A five tube most probable number method (MPN) according to standard procedure was used. Three sets of five test tubes containing inverted Durham's tubes were provided and 10 m double strength MacConkey broth (Oxoid) was added into each of the first set of tubes. 1ml single strength of the broth was added into each of the second set while 0.1ml single strength was added into each of the last set of tubes. The tubes were capped and sterilized by autoclaving at 121^{0C} for 15 min. The first set of tubes was each inoculated with 10ml of the water sample while the second and the third sets were each inoculated with 1ml and 0.1ml of the water sample respectively. The tubes were incubated and those tubes showing acid and gas production after 24 hrs were used to determine total coliform counts (cfu/100 ml) from the MPN table. Culturing the positive tubes on brilliant-green lactose bile broth (BGLB), Eosine methylene Blue agar (EMBA) (Oxoid) and biochemical tests especially the IMVIC test were used to confirm the coliform and Escherichia coli.

3.2: Questionnaire Administration

A sum total of one thousand, four hundred and fifty-six (1456) questionnaires were structured in three categories for the rural water users, Water Corporation and rural health centres. They were administered to the twenty-eight (28) rural study communities under the six LGAs in Table 3.3.

Table 3.3: Questionnaire samples and administration in Anambra SW

No	LGAs	No of communities	No sampled	% of total	No returned	% of total
1	Ekwusigo	3	156	10.72	156	100
2	Nnewi South	4	208	14.28	208	100
3	Ogbaru	6	312	21.43	304	97.43
4	Ihiala	6	312	21.43	309	99.04
5	Idemili South	4	208	14.28	208	100
6	Idemili North	5	260	17.86	260	100
	Total	28	1456	100.00	1445	99.24

The questionnaire distribution is based on the number of randomly selected communities for each LGA. A community is entitled to 50 copies of rural water survey each and two copies of water corporation and health survey respectively. A total of 30 field assistants (UME candidates and undergraduates) were trained to administer the questionnaires. The training and administration period lasted for five days. Ogbaru and Ihiala LGAs with the highest rural communities returned only 97.43% and 99.04% respectively. The questionnaire survey using SPSS (version 11.0) statistical analysis software to perform descriptive and frequency analysis helps in generating domestic, industrial and agricultural water consumption figures for further projection in the study LGAS by using the RTWC model.

3.3: Rural Threshold Water Consumption (RTWC) Model Development

The Rural threshold water consumption (RTWC) model is developed as a result of the unsuitability and inapplicability of other water models in the rural environment. The model is built to integrate domestic, agricultural, industrial and other miscellaneous water uses. Particularly it is meant to estimate domestic water consumption at both periods. The RTWC model will help in determining water demand variations while establishing a threshold value that will delineate areas of water demand deficits, balances and surpluses.

Model Assumptions:

The RTWC model is developed based on the following assumptions:

i. Domestic water consumption (drinking, cooking, and washing) is the major water use in the rural areas.
ii. Water consumption or demand varies by individuals, seasons and locations.
iii. Water demand depends on human lifestyles and behaviours (age, sex, marital status, occupation, education).
iv. Demand variation occurs due to minimum and maximum water consumption trends.
v. Water consumption is directly proportional to human population growth and activities.

The Rural threshold water consumption (RTWC) model was applied in the rural communities of SW Anambra State using the data generated from questionnaire survey on different water uses. This is to help predict water consumption rates in the different LGAs. The RTWC model is therefore mathematically expressed as Uluocha, (2006):

$$Q_1 = d_1 + i_1 + a_1 + m_1 \qquad \text{------------ } Eqn\ (3.1)$$

$$Q_2 = d_2 + i_2 + a_2 + m_2 \qquad \text{------------ } Eqn\ (3.2)$$

Where

Q_1 = Total minimum volume of water used daily by households

d_1 = minimum volume used for domestic functions

i_1 = minimum volume used for small scale commercial and industrial functions (food processing and local soap making)

a_1 = minimum volume used for household agriculture (Vegetable gardens "mbubo")

m_1 = minimum volume used for miscellaneous purposes

Q_2 = Total maximum volume of water used daily by households

d_2 = maximum volume used for domestic functions

i_2 = maximum volume used for small scale industrial functions (Food processing, local soap making)

a_2 = maximum volume used for household agriculture (Vegetable gardens "mbubo")

m_2 = maximum volume used for miscellaneous purposes.

$$K = \frac{Q_1 + Q_2}{2} \qquad \text{-------- Eqn (3.3)}$$

Where

K = Threshold balance (planning constant or control variable for rural water supply)

$$\text{Thus } K = \frac{1}{2}\sum_{n=1}^{2} (d_n + i_n + a_n + m_n) \qquad \text{-------- Eqn (3.4)}$$

Source: Field Survey, (2006)

Q_1 values are used to estimate volumes of water used during water shortages (deficit) while Q_2 values are used for water surplus volume estimates. K is used to estimate a balance or planning constant that will be used for decision making to meet periods of water surplus and deficit. This is because water supply planning or investing using Q_1 (minimum level) may not meet the people's requirements and water demands. Similarly planning at Q_2 (maximum level) may result in abandoned or unfinished projects due to insufficiency or misuse of funds and several other factors. Therefore in order to establish the variation at both the minimum and maximum water consumption periods an equation was further given by:

$$Q = Q_2 - Q_1 \quad \text{------------------------------------} \quad \textit{Eqn (3.5)}$$

$$\textit{Thus } Q = (d_2 - d_1) + (i_2 - i1) + (a_2 - a_1) + (m_2 - m_1) \quad \text{--------------} \quad \textit{Eqn (3.6)}$$

$$K_b = K - Q \quad \text{------------------------------------} \quad \textit{Eqn (3.7)}$$

Source: Field Survey, (2006)

Where

Q = water demand variation

Q_1 and Q_2 values = as stated in (Equations 3.1 and 3.2)

K_b = Threshold balance at both minimum and maximum water consumption periods

K = as stated in (Equation 3.3 and 3.4)

The domestic water consumption for each LGA is further derived by determining the average water consumed per person regularly and in times of need and multiplying out by the total population. The volume of water consumed in each LGA is thus mathematically expressed as:

Total volume of water consumed per LGA = Total population **X** minimum or maximum volume consumed per individual.

3.4: Model Verification

Regression analysis using the coefficient of verification (r) was employed to determine the strength of the relationship between population and water consumption. The input data for regression model verification were the population (independent variable) and water consumption (dependent variable). The coefficient of determination (r^2) was used as the accuracy criterion for the RTWC model and population growth direct proportionality.

The RTWC model was further validated to verify the variables and model parameters used in water consumption computations across the six study LGAs at both minimum and maximum periods. The test of variance (ANOVA) was employed by running an F-test on the population and household sizes as well as water quantity consumed per household. The variations were compared at 5 degrees of freedom and 95% significance level to find out if the model simulated adequately.

CHAPTER FOUR

RESULTS AND DISCUSSION: WATER SUPPLY SOURCES, ACCESS AND CONSUMPTION PATTERNS

4.1 Sources of Water Supply and Preferences in the Study Area

The existing rural water sources of Southwestern parts of Anambra State are rainwater; rivers, streams, private and commercial boreholes; hand dug wells, private stand pipes, water vending and Lakes (Table 4.1). The water sources in rural communities are mostly rainwater harvesting, streams, rivers, boreholes and others.

Table 4.1: Existing Rural Water Supply Sources in the Study LGAs

Existing water sources	LGAs						
	Ekwusigo	Nnewi South	Ogbaru	Ihiala	Idemili South	Idemili North	Average
Rain water	†	†	†	†	†	†	†
Springs		†					
Streams	†	†		†	†	†	†
Rivers	†		†	†	†	†	†
Boreholes	†	†	†	†		†	†
Wells				†	†		
Private stand pipes			†				
Water vendors		†			†		
Lake						†	

Source: Field Observation, 2006

The assessment in Table 4.2 show that 41.7% of rural dwellers in the six study LGAs depend on rivers, streams and springs, 25.2% depend on deep wells and boreholes while 9.2% rely on rainwater and a low percentage of 7.1% on water vendors for their water needs.

Table 4.2: Sources of Water and Major Preferences in Anambra SW

Sources of water	LGAs						Total (%) ∑(1 - 6)	Ave % of total within LGAs
	(1) Ekwusigo	(2) Nnewi South	(3) Ogbaru	(4) Ihiala	(5) Idemili South	(6) Idemili North		
Rain water	-	5.9%	8.2%	16.5%	56.5%	12.9%	100.0	9.2
Shallow well	33%	16.7%	8.3%	8.3%	16.7%	16.7%	100.0	1.3
Deep well/borehole	24.7%	7.7%	10.7%	26.5%	10.7%	19.7%	100.0	25.2
Rivers/stream/springs	8.8%	18.6%	38.8%	11.4%	9.0%	13.4%	100.0	**41.7**
Seasonal water collector	-	37.5%		12.5%	37.5%	12.5%	100.0	.9
Public tap	30%	9.1%	10.6%	24.2%	13.6%	12.1%	100.0	7.1
Water vendor	-	4.5%	54.5%	16.7%	12.1%	12.1%	100.0	7.1
All of the above	1.5%	41.8%	16.4%	10.4%	4.5%	25.4%	100.0	7.2
Others			50.0%		50.0%		100.0	.2
Major water sources								
Rivers/stream/spring*	7.1%	20.1%	36.1%	18.4%	6.3%	11.9%	100.0	**37.1%**
Deep well/boreholes*	16.8%	6.2%	9.1%	26.2%	13.5%	28.2%	100.0	26.5
Preference to major water sources								
Reliable	40.7%	23.3%	44.3%	25.1%	22.6%	18.0	100.0	28.9
Accessible	23.4%	40.6%	29.4%	37.3%	45.8%	51.3	100.0	**38.4**
Cost Free	35.2%	33.3%	21.6%	35.7%	25.8%	28.5	100.0	29.7
Others	.7%	2.8%	4.7%	1.9%	5.8%	2.2	100.0	3.1

* Represents the mode in major water sources. Source: Field Survey, 2006

Similarly, a greater percentage of the respondents (37.1%) prefer rivers, streams and springs as their major sources of water because they are accessible (38.4%), free (29.7%) and naturally reliable. These existing water sources are situated in the rainforest belt of Eastern Nigeria and are mostly perennial sources that provide domestic water for the indigenes all year round, even at dry seasons.

4.2: Access to Water Supply

The accessibility indices of time, cost, affordability and opportunity forfeited, distance and gender (Table 4.3) vary widely from one LGA to another. Water sources are accessible when energy and unnecessary costs are minimized, so the closer the water point destination, the greater the accessibility. Lack of access on the other hand often results in spending excess time in search of water; poor sanitation, denied education, food shortages and poor health leading to water related diseases and in severe cases death especially amongst children. It also aggravates unsustainable development for the rural areas.

The average length of time spent to get to a water source and return to point of consumption is between 10 – 30 minutes by 36.1% of the respondents in the different LGAs. 25.1% spend less than 10 mins while 21.4% spend between 31 and 60 minutes. The time would have been spent in other activities.

The cost representing the total expenditure to ensure water availability ranges from the activities of water vendors to water treatment, transportation fares to the required location and cost of water infrastructural repairs and maintenance.

Table 4.3: Water Accessibility Parameters in Anambra SW

Variables		LGAs						
		(1) Ekwusigo	(2) Nnewi South	(3) Ogbaru	(4) Ihiala	(5) Idemili South	(6) Idemili North	Ave % of total within LGAs
Timing (minutes, hours)	Less Than 10mins	17.8%	28.1%	**35.1%**	18.2%	29.1%	22.1%	25.1
	10-30 Mins	**49.3%**	**29.6%**	26.0%	**36.8%**	**39.3%**	**40.0%**	**36.1**
	31-60 Mins	20.5%	17.1%	24.4%	26.5%	14.8%	21.7%	21.4
	Above1hour	12.3%	25.1%	14.5%	18.6%	16.8%	16.2%	17.4
Cost (Naira)	**Cost Free**	44.5%	46.4%	44.2%	8.2%	18.3%	5.7%	**24.9**
	₦5 - ₦25	9.1%	25.5%	5.3%	33.0%	17.2%	40.7%	24.1
	₦26 - ₦50	23.6%	17.9%	3.4%	31.5%	19.4%	19.5%	19.5
	₦51 - ₦100	15.5%	1.0%	20.4%	14.2%	16.7%	13.8%	13.5
	Above ₦100	7.3%	9.2%	26.7%	13.1%	28.3%	20.3%	18.0
Distance (metres, kilometres)	Less Than 5m	4.7%	17.1%	**35.8%**	8.3%	15.2%	14.6%	16.9
	5m - 100m	**52.7%**	**48.7%**	29.2%	33.4%	**43.6%**	37.8%	**39.2**
	100-500m	27.7%	21.6%	24.8%	**33.8%**	22.5%	36.2%	28.3
	500m-1km	6.1%	5.5%	7.7%	12.1%	9.3%	6.9%	8.2
	Above 1km	8.8%	7.0%	2.6%	12.4%	9.3%	4.5%	7.3
Water haulers by gender	**Children**	48.5%	48.7%	32.8%	54.2%	65.2%	40.7%	**48.3**
	Women	20.8%	3.2%	4.6%	5.3%	1.5%	1.6%	4.9
	Men	3.0%	1.1%	1.7%	2.8%	4.5%	5.3%	3.0
	Women And Children	27.7%	47.1%	60.9%	37.7%	28.9%	52.4%	**43.8**
Opportunity forfeited for buying water	**Food Items**	38.5%	65.8%	27.3%	49.7%	44.7%	35.7%	**44.6**
	Clothing	19.2%	9.2%	6.8%	12.7%	12.6%	16.7%	12.2
	Shelter	-	5.3%	6.8%	7.0%	8.7%	7.1%	6.7
	Education	38.5%	18.4%	45.5%	29.3%	32.0%	40.5%	**33.1**
	Miscellaneous	3.8%	1.3%	13.6%	1.3%	1.9%	-	3.4

Source: Field Survey, 2006

In the study communities, 24.9% obtain their water free of charge, while 24.1% of respondents spend an average of ₦5 to ₦25 on 25litres of water. Thus, a household of 4 to 6 persons may spend as much as between ₦20 and ₦100 daily on water. The implication of cost of water to the socio-economic life of any rural dweller is of great significance. This entails the options of affordability as well as forfeiting certain luxuries or necessities such as food items (44.6%) education (33.1%), clothing (12.2%) and shelter (6.7%) amongst others so as to have access to potable domestic water.

Distance is a measure of the kilometers traveled from one's location to a water point. The standard distances of less than 100metres are covered by 39.2% of the respondents to their water sources. On the other hand, 28.3% travel as far as 100 to 500metres to their water points which in the present age, is energy and time consuming. Unusable and polluted water sources also increase distances and time to alternative water points. Thus, access improves when there is proximity to a water point.

In terms of gender, children (48.3%) are the major water haulers. The second group is the women and children (43.8%). This often leads to insecurity and spending of excess time on water collection. The fieldwork studies and access indices of time, distance and likely quantities of water consumed signifies that there is basic access to water supply. This is however with a high level of health concern because, although consumption, hand washing and basic food hygiene are possible; laundry and bathing activities are difficult to assure unless carried out at source and these activities pollute water sources.

4.3: Water Consumption Patterns

Water consumption patterns vary seasonally, daily and hourly. In the study area, domestic water uses of 84.8% (Table 4.4) surpass the industrial (6.1%), agricultural (7.5%) and other miscellaneous (1.6%) water consumption purposes. Averages of 100 litres (minimum) and 175 litres (maximum) of water are consumed per household by 42.6%. These quantities however do not satisfy 52.3%, a greater portion of respondents and this creates the need for more quests for supplementary water consumption.

Averages of 150 litres to 250 litres supplementary water quantities are consumed by 33.4% of respondents. The household sizes of 4 to 6 persons (43.8%) consume the greater portion of water in the study LGAs. The nuclear families household sizes however differ from the polygamous families where average population may differ.

Table 4.4: Household Water Consumption Patterns in Anambra SW

Water uses	LGAs						Ave. (%) of total within LGAs
	(1) Ekwusigo	(2) Nnewi South	(3) Ogbaru	(4) Ihiala	(5) Idemili South	(6) Idemili North	
Domestic	76.7%	93.5%	66.3%	84.8%	92.6%	92.6%	**84.8**
Industrial	2.7%	5.4%	12.0%	9.3%	3.2%	2.1%	6.1
Agricultural	19.2%	1.1%	18.8%	4.1%	3.2%	3.3%	7.5
Miscellaneous	1.4%	0%	2.9%	1.7%	1.1%	2.1%	1.6
Household Size							
1-3 Persons	12.6%	21.0%	24.5%	15.3%	9.7%	10.2%	16.0
4-6 Persons	40.4%	52.0%	35.9%	35.4%	46.4%	56.3%	**43.8**
7-9 Persons	36.4%	16.5%	25.5%	33.3%	27.5%	22.0%	26.7
Above 10 Persons	10.6%	10.5%	14.1%	16.0%	16.4%	11.4%	13.5
Household Water Consumption							
25 - 100 Litres	12.1%	10.9%	14.2%	20.9%	12.8%	6.9%	13.4
100 - 175 Litres	55.0%	27.9%	34.2%	51.0%	45.3%	44.3%	**42.6**
175 - 250 Litres	20.1%	19.9%	27.3%	21.6%	25.6%	31.7%	24.7
Above 250 Litres	12.8%	41.3%	24.4%	6.5%	16.3%	17.1%	19.3
Sufficiency Level							
Yes	40.8%	43.2%	63.8%	41.7%	46.0%	45.2%	47.7
No	59.2%	56.8%	36.2%	58.3%	54.0%	54.8%	**52.3**
Supplementary Consumption							
25 – 150 Litres	19.4%	24.4%	16.2%	40.4%	35.7%	29.8%	29.2
150 – 250 Litres	44.9%	22.0%	17.7%	35.1%	41.9%	38.7%	**33.4**
250 – 375 Litres	12.2%	8.9%	12.3%	15.4%	3.1%	6.5%	10.0
375 – 500 Litres	2.0%	3.3%	7.7%	6.7%	10.1%	10.7%	7.1
Above 500 Litres	21.4%	41.5%	46.2%	2.4%	9.3%	14.3%	20.2

Source: Field Survey, 2006

4.4: Socio-Economic Variables Influencing Water Consumption in the Study Area

Water availability and volume of water consumed varies from the population size of individuals to family as well as socioeconomic characteristics of age, sex, marital status, literacy and occupation of the consumers (Table 4.5).

- Household density is significant for an estimation of the demand for water consumption. Overall, average household density in the study communities varies from about 4 to 6 persons. This however depends on whether it is nuclear or polygamous family. Distinction between children and adults is necessary for further water consumption analysis.
- Sex: Male or female. Female folks (56.7%) tend to utilize more water than their male counterparts (43.3%) due to household and personal hygiene purposes.
- Age: The age range of under 18 years utilize less water, between 18 to 40years utilize largest portions of water, 41 to 60 years consumes more water and above 60years water usage declines.
- Marital status: married, divorced, single (Polygamy, monogamy): Married folks (53.0%) and families with new babies consume additional volumes of water.
- Educational Background: Formal, primary, secondary and post-secondary education is vital for proper water demand and supply assessment. In the study area, senior school certificate is the basic education level.
- Employment status: self employed, government employed, apprentice, employer and employee. The career of household members is important for the assessment of ability to pay for improved water services and facilities however, the indigenes of the rural study communities are mostly self-employed with farming and trading as the major occupation.

Table 4.5: Socio-Economic Variables of the Rural Population of Anambra SW

Variables	High respondent group	LGAs						
		(1) Ekwusigo	(2) Nnewi South	(3) Ogbaru	(4) Ihiala	(5) Idemili South	(6) Idemili North	Ave. (%) of total within LGAs
Age (years)	12 -20	23.2%	19.0%	19.2%	15.0%	28.0%	22.3%	20.6
	21-30	25.8%	37.0%	38.5%	38.9%	27.1%	29.8%	33.7
	31 -50	33.1%	32.5%	27.3%	34.1%	30.4%	26.0%	30.4
	Above 50	17.9%	11.5%	15.0%	11.9%	14.5%	21.9%	15.3
Sex	Male	38.0%	43.9%	52.8%	38.2%	42.0%	42.2%	43.3
	Female	62.0%	56.1%	47.2%	61.8%	58.0%	57.8%	56.7
Marital status	Single	41.3%	36.9%	38.5%	41.9%	45.1%	40.6%	40.7
	Married	55.3%	52.5%	54.2%	52.7%	51.0%	52.5%	53.0
	Separated	.7%	2.5%	2.4%	1.0%	-	1.6%	1.4
	Widow	2.7%	7.1%	4.5%	3.4%	3.9%	4.5%	4.3
	divorced	1.0%	.3%	1.0%	-	.8%	.6%	1.0
Education	None	10.1%	12.6%	8.7%	6.6%	8.9%	9.4%	9.1
	Pry school	26.2%	17.2%	20.9%	13.5%	15.8%	13.9%	17.4
	JSSCE	27.5%	24.2%	21.6%	16.3%	27.7%	22.4%	22.6
	SSCE	31.5%	37.9%	38.7%	40.3%	31.5%	40.4%	37.6
	Tertiary	4.7%	8.1%	10.1%	23.3%	14.4%	13.9%	13.3
Occupation	Government workers	6.1%	8.2%	11.1%	12.2%	11.2%	10.3%	10.2
	Private Sector	7.4%	14.8%	12.5%	16.2%	12.2%	8.2%	12.3
	Self employed	42.6%	29.6%	22.8%	36.1%	21.5%	31.3%	30.1
	Students	21.6%	22.4%	27.0%	20.3%	35.1%	33.3%	26.7
	Farmers	16.2%	17.3%	25.6%	7.8%	15.1%	13.2%	15.8
	Others	6.1%	7.7%	1.0%	7.4%	4.9%	3.7%	4.9

Source: Field Survey, 2006

4.5: Affordability of Water Services

Affordability has a significant influence on the use of water as well as selection of water sources because high cost of water reduces the volumes of water used by households and may force rural dwellers to resort to cheap alternative sources which may be of poor quality. This may influence hygiene practices and increase disease risk. The average income of a rural dweller ranges from ₦800 to ₦1199 weekly (Table 4.6). Therefore, an average family of 4 to 6 persons spending between ₦20 to ₦100 on water daily will be spending between ₦140 and ₦700 weekly on water automatically consumes more than half of their income.

Table 4.6: Weekly Rural Income or Earning in the Study Area

Weekly rural Income (₦)	LGAs						Ave. (%) of total within LGAs
	(1) Ekwusigo	(2) Nnewi South	(3) Ogbaru	(4) Ihiala	(5) Idemili South	(6) Idemili North	
Below ₦ 800	6.1%	8.2%	11.1%	12.2%	11.2%	10.3%	10.2
₦ 800 - ₦ 1199	55.3%	52.5%	54.2%	52.7%	51.0%	52.5%	53.0
₦ 1200 - ₦ 1699	23.2%	19.0%	19.2%	15.0%	28.0%	22.3%	20.6
above ₦ 1700	16.2%	17.3%	25.6%	7.8%	15.1%	13.2%	15.8

Source: Field survey, 2006

The relatively low income of the rural dwellers therefore reflects on their perception in paying for additional domestic water (Figure 4.1). A higher percentage of 45.6% are unwilling to pay extra costs for water in the study area; on the contrary, 30.1% of respondents indicate willingness to pay additional costs while 24.4% are undecided because the quality of water, timely availability and hike in water prices may influence their decisions.

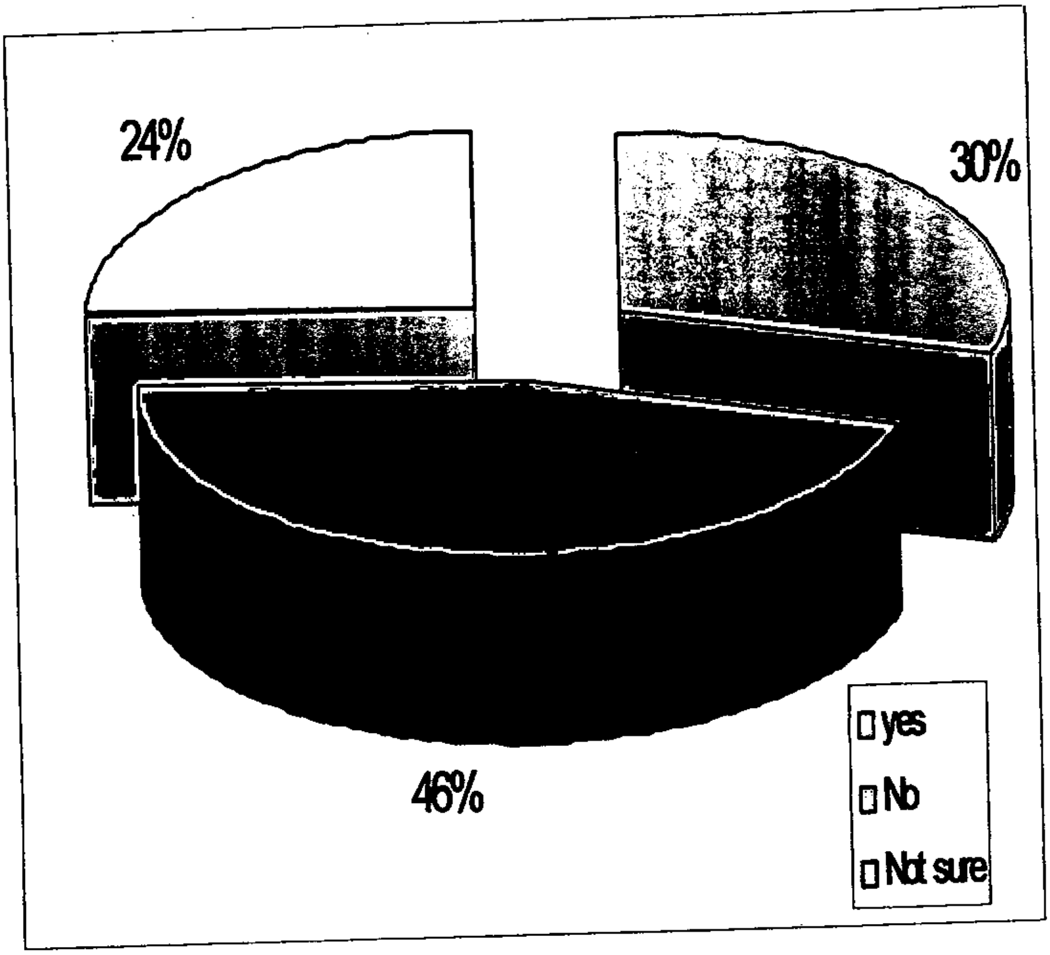


Fig.4.1: Willingness to pay for more water
Source: Field survey, 2006

Cost of water and pricing; income and affordability as well as the quality of water are all variables that work in combination in determining a consumer's choice and quantity of water consumed.

CHAPTER FIVE

RESULTS AND DISCUSSION: ECONOMICS OF WATER SUPPLY IN ANAMBRA SW

Supply and demand are important rural water variables that reflect on aspects of water consumption, distribution and availability. The variables are mathematically represented using the generated rural threshold water consumption (RTWC) model.

5.1: Rural Threshold Water Consumption (RTWC) Model

Modeling water demand and supply using the RTWC model involves identification of all possible water sources, consumer use patterns and potential factors that could influence consumer demand. This necessitates the derivation of relevant and reliable coefficients for modeling, estimating and predicting water consumption.

Equations 3.1 and 3.2 identify the minimum and maximum volumes of water consumed respectively for domestic, industrial, agricultural and miscellaneous purposes by each household while Equations 3.3 and 3.4 establish a threshold value or planning constant. The computations are derived from the household water uses and supplemental household water consumption variables discussed in Table 4.4.

On the average 100 (minimum) – 175 (maximum) litres of water are consumed per household and an average of 4 - 6 persons constitute a household (Table 4.4). Thus on a regular basis, each person uses a minimum of 25 litres of water (100 litres/ 4 persons) and maximum of 29.2 litres (175 litres/ 6persons).

Similarly during supplementary periods when additional water are used, 150 (min) to 250 (max) litres of water are consumed by each household. Therefore each household member uses a minimum of 37.5 litres (150 litres/ 4 persons) and maximum of 41.7 litres (250 litres/ 6 persons). The total water demand per household in Anambra SW study LGAs can be thus be quantified at both regular and supplemental water consumption periods

On a regular basis therefore, each person consumes an average of 25 litres to 29.2 litres of water per day and supplemental amounts of 37.5 - 41.7 litres in times of insufficiency. Thus, 12.5 litres per individual indicates the variation between supplemental and regular water consumption values.

5.2: RTWC Model and Regular Water Consumption in Anambra SW

The total water demand per household in Anambra SW rural communities can therefore be quantified by multiplying out the minimum and maximum volumes of water consumed per household (100 and 175) litres by the domestic, industrial, agricultural and miscellaneous uses. The values generated are shown by LGAs in Table 5.1 with the domestic water consumption values exceeding the industrial and agricultural uses.

Table 5.1: Regular Water Consumption Values (Litres/Day)

Period	LGAs	volumes	d_1	i_1	a_1	m_1	volumes	d_2	i_2	a_2	m_2
Regular water	Ekwusigo	M	**76.7**	2.7	19.2	1.4	M	**134.2**	4.73	33.6	2.45
consumption	Nnewi South	I	**93.5**	5.4	1.1	0	A	**163.6**	9.45	1.93	0
	Ogbaru	N	**66.3**	12	18.8	2.9	X	**116.03**	21	32.9	5.08
	Ihiala	I	**84.8**	9.3	4.1	1.7	I	**148.4**	16.28	7.18	2.98
	Idemili South	M	**92.6**	3.2	3.2	1.1	M	**162.1**	5.6	5.6	1.93
	Idemili North	U	**92.6**	2.1	3.3	2.1	U	**162.1**	3.68	5.76	3.68
	Average	M	**84.4**	5.8	9.9	2.7	M	**148**	10.1	14.5	2.7
		(100)					(175)				

d_1 = minimum volume used for domestic functions; i_1 = minimum volume used for small scale industrial functions (food processing and local soap making); a_1 = minimum volume used for household agriculture (Vegetable gardens "mbubo"); m_1 = minimum volume used for miscellaneous purposes; d_2, i_2, a_2, m_2 = maximum volumes used.

Equation 3.1 variables are therefore computed by summing up the minimum domestic, industrial, agricultural and miscellaneous water consumption by each LGA (Table 5.2) to derive the Q_1 *value.*

$$Q_1 = d_1 + i_1 + a_1 + m_1 \qquad \text{------------------} \textbf{\textit{Eqn (3.1)}}$$

Table 5.2: Q_1 Computations (Litres/Day)

Ekwusigo	Q_1	(76.7 + 2.7 + 19.2 + 1.4)	**100**
Nnewi South	Q_1	(93.5 + 5.4 +1.1 + 0)	**109.9**
Ogbaru	Q_1	(66.3 + 12.0 + 18.8 + 2.9)	**100**
Ihiala	Q_1	(84.8 + 9.3 + 4.1 + 1.7)	**107.9**
Idemili South	Q_1	(92.6 + 3.2 + 3.2 + 1.1)	**100.1**
Idemili North	Q_1	(92.6 + 2.1 + 3.3 + 2.1)	**100.1**
Average	Q_1	(84.8 + 5.8 + 9.9 + 2.7)	**103**

Q_1 = Total minimum volume of water used daily by households

Equation (3.2) variables are therefore computed by summing up maximum volumes of the domestic, industrial, agricultural and miscellaneous water consumption by each LGA (Table 5.3) to derive the Q_2 *value*.

$$Q_2 = d_2 + i_2 + a_2 + m_2 \qquad \text{------------------------ Eqn (3.2)}$$

Table 5.3: Q_2 Computations (Litres/Day)

Ekwusigo	Q_2	= £ (134.2 + 4.73 + 33.6 + 2.45) =	**174.9**
Nnewi South	Q_2	= £ (163.6 +9.45 +1.93 + 0) =	**174.9**
Ogbaru	Q_2	= £ (116.03 + 21 +32.9 + 5.08) =	**175.01**
Ihiala	Q_2	= £ (148.4 +16.28 +7.18 +2.98) =	**174.84**
Idemili South	Q_2	= £ (162.1 + 5.6 + 5.6 + 1.93) =	**175.2**
Idemili North	Q_2	= £ (162.1 +3.68 + 5.76 + 3.68) =	**175.2**
Average	Q_2	=£ (148.4 + 10.1 + 14.5 + 2.7) =	**175.01**

Q_2 = Total maximum volume of water used daily by households

The computation of Equations (3.1 and 3.2) variables helps in the generation of the volumes of Equations 3.3 and 3.4, which calculates the threshold balance (k), a control variable or planning constant for rural water supply. This is meant to generate a balance that will help in eliminating planning shortages or surpluses. The values are derived by adding up the minimum water consumption values (Q_1) and the maximum values (Q_2) in Tables 5.2 and 5.3 respectively and then dividing the figures by 2 to obtain the (Table 5.4) values. The computation can be similarly carried out for supplemental water consumption in the different study LGAs.

$$K = \frac{Q_1 + Q_2}{2} \qquad \text{------------------------ Eqn (3.3)}$$

$$Thus\ K = \frac{1}{2}\sum_{n=1}^{2} (d_n + i_n + a_n + m_n) \text{ ---------------------------------- } Eqn\ (3.4)$$

Table 5.4: Threshold Value (K) Computation (Litres/Day)

LGAs	Q_1	Q_2	$K \frac{(Q_1 + Q_2)}{2}$	K
Ekwusigo	100	174.9	$\frac{100 + 174.9}{2}$	137.45
Nnewi South	109.9	174.9	$\frac{109.9 + 174.9}{2}$	**142. 4**
Ogbaru	100	175.01	$\frac{100 + 175.01}{2}$	137.51
Ihiala	107.9	174.84	$\frac{107.9 + 174.84}{2}$	**141.37**
Idemili South	100.1	175.2	$\frac{100.1 + 175.2}{2}$	137. 65
Idemili North	100.1	175.2	$\frac{100.1 + 175.2}{2}$	137.65
Average	103	175.01	$\frac{103 + 175.01}{2}$	**139**

Q_1 = Total minimum volume of water used daily by households; Q_2 = Total maximum volume of water used daily by households; **K** = Threshold balance (planning constant or control variable for rural water supply).

Table 5.4 records an average threshold balance of k = 139 litres. Nnewi South and Ihiala LGAs with above threshold values of 142.4 litres and 141.37 litres respectively are identified as probable water surplus zones while Ekwusigo, Ogbaru, Idemili South and North LGAs are areas of possible water supply deficits.

Furthermore, variation in water consumption by the different LGAs (Table 5.5) is calculated using Equations 3.5, 3.6 and 3.7.

$$Q = Q_2 - Q_1 \qquad \text{Eqn (3.5)}$$

$$\text{Thus } Q = (d_2 - d_1) + (i_2 - i_1) + (a_2 - a_1) + (m_2 - m_1) \qquad \text{Eqn (3.6)}$$

$$K_b = K - Q \qquad \text{Eqn (3.7)}$$

Table 5.5: Variations In Household Water Consumption (Litres/Day)

LGAs	$Q = Q_2 - Q_1$	K	$K_b = K - Q$
Ekwusigo	74.9	137.45	62.55
Nnewi South	65	**142. 4**	77.4
Ogbaru	75.01	137.51	62.5
Ihiala	66.94	**141.37**	**74.43**
Idemili South	75.1	137. 65	62.55
Idemili North	75.1	137.65	62.55
Average	**72.01**	139	67

Q = water demand variation; Q_1 = Total minimum volume of water used daily by households; Q_2 = Total maximum volume of water used daily by households; **K** = Threshold balance; K_b = Threshold balance (planning constant or control variable for rural water supply) at both minimum and maximum periods.

The average water demand variation (K_b) of 67 litres signifies that a gap of 33 (100 – 67) litres across the LGAs needs to be augmented

5.3: RTWC Model and Supplemental Water Consumption in Anambra SW

Supplemental water is needed when regular water allocations of 25 - 29.2 litres per individual or 100 – 175 litres per household are insufficient to satisfy their daily domestic needs. In such case, the field verification records in table 4.4 records that 150 - 250 litres of water per household or 37.5 – 41.7 litres per person are consumed. Thus additional 12.5 litres are consumed per person or 50 – 75 litres per household. Computations for supplemental water consumption in the study area are carried out by multiplying out 150 and 250 litres by the minimum and maximum volumes consumed per household respectively to derive the Equations (3.1 and 3.2) domestic, industrial, agricultural and miscellaneous (diam 1 and 2) values. The generated values for supplementary water consumption are shown in Table 5.6.

Table 5.6: Water Consumption at Supplemental Periods (Litres/Day)

Period	LGAs	Volumes	Q_1				Volumes	Q_2			
			d_1	i_1	a_1	m_1		d_2	i_2	a_2	m_2
Supplemental water consumption	Ekwusigo	MINIMUM (150)	**115.1**	4.05	28.8	2.1	MAXIMUM (250)	**191.8**	6.75	48	3.5
	Nnewi South		**140.25**	8.1	1.65	0		**233.6**	13.5	2.75	0
	Ogbaru		**99.45**	18	28.2	4.35		**165**	30	47	7.25
	Ihiala		**127.2**	13.95	6.15	2.55		**212**	23.25	10.25	4.25
	Idemili South		**138.9**	4.8	4.8	1.65		**231.5**	8	8	2.75
	Idemili North		**138.9**	3.15	4.95	3.15		**231.5**	5.25	8.25	5.25
	Average		**127**	8.7	12.4	2.3		**211**	14.5	20.7	3.8

d_1, i_1, a_1, m_1 and d_2, i_2, a_2, m_2 parameters are as defined in Table 5.1

The Equations (3.1 and 3.2) values derived for supplemental water consumption (Table 5.7) further helps in generating the threshold (K) value for Equations (3.3 and 3.4).

Table 5.7: Supplemental Household Water Consumption and Threshold (Litres)

LGAs	Period	Q_1	Q_2	K
Ekwusigo	Supplemental	150.05	250.05	200.05
Nnewi South		150	249.9	199.95
Ogbaru		150	249.25	199.63
Ihiala		149.85	249.75	199.8
Idemili South		150. 15	250.25	200.2
Idemili North		150.15	250.25	200.2
Average		150	250	**200**

Q_1, Q_2 and K parameters are as defined in Table 5.4

The supplemental water consumption average threshold balance of 200litres across the study LGAs show a form of consistency in comparison with each LGA threshold value. This indicates that at periods of additional water consumption, no deficits or surpluses exists across the six study LGAs. In establishing variations during water consumption supplemental times, Equations 3.5, 3.6 and 3.7 are applied with calculated values shown in Table 5.8. The average K_b values of 100 litres cuts across the LGAs confirming the balance in water supply consumption at supplemental times. The supplemental volumes generated are advised for planners due to the balance established.

Table 5.8: Supplemental Variations in Household Water Consumption (Litres/Day)

LGAs	$Q = Q_2 - Q_1$	K	$K_b = K - Q$
Ekwusigo	100	200.05	100.5
Nnewi South	99.9	199.95	100.5
Ogbaru	99.25	199.63	100.38
Ihiala	99.9	199.8	99.9
Idemili South	100.1	200.2	100.1
Idemili North	100.1	200.2	100.1
Average	**100**	**200**	**100**

Q_1, Q_2, K and K_b parameters are as defined in Table 5.5

5.4: *Population and Water Consumption*

The minimum and maximum volumes of water consumed by the entire population are derived by multiplying out the minimum and maximum volumes of water consumed regularly by the population figure. Table 5.9 show that Idemili North and Ihiala LGAs with highest populations of 430,783 and 302,158 record high water consumption values of 12,578,864 and 8,823,014 litres respectively. On the other hand, Ekwusigo LGA with least population of 158,231 records the lowest consumption values of 4,620,345 litres.

Table 5.9: Total Domestic Water Consumption in the Study LGAs (Litres/Day)

LGA	Population	Minimum vol. (litres/day)	Total Minimum vol.(litres/day)	Maximum vol. (litres/day)	Total Maximum vol.(litres/day)
Ekwusigo	158.231	25	3,955,775	29.2	4.620,345
Nnewi South	233,658	25	5,841,450	29.2	6,822.814
Ogbaru	221,879	25	5,546,975	29.2	6.478.867
Ihiala	302,158	25	7,553,950	29.2	**8,823,014**
Idemili South	207,683	25	5,192,075	29.2	6,064,344
Idemili North	430,783	25	10,769,575	29.2	**12,578,864**
Total	1,554,392		**38,859,800**		**45,388,248**

Water consumption thus tends to have a linear relationship with population growth in that water consumption increases with population. The RTWC model assumption that water consumption increases with population growth rate and activities is thus accepted.

5.5: Model Verification

The analysis of variance (ANOVA) is conducted using F-test to ascertain the validity of the rural threshold water consumption (RTWC) model for Anambra SW rural communities. The key variables of population, household size and volumes of water consumed are adopted to determine the degree of relationship existing between rural communities, their indigenes and water consumption levels.

The analysis of variance (Table 5.10) indicates that:

- Fcal household size (4.921) < F-table (5.05)
- Fcal regular water quantity consumed (19.736) > F-table (5.05)
- Fcal supplemental water quantity consumed (27.334) > F-table (5.05)
- Degree of Freedom = n-1 (5^0)

- ά = 95% level of significance

The variations in the size of households and the volumes of water consumption signify that the RTWC model assumption that water consumption depends on individuals and could be minimal or maximal is accepted. Thus, the model simulated the parameters adequately and further necessitates the need to introduce the computed threshold value (k) as a relevant variable for rural water supply planning.

Table 5.10: Analysis Of Variance (ANOVA)

Variables	Sum of Squares	Degree of Freedom (df) n-1	Mean Square	Frequency (f)	Significance level (sig.)	F_{tab}
2006 population	46179997	5	92359995		95%	
Household size	20.023	5	4.005	**4.921**	95%	5.05
Regular domestic water consumption	83.446	5	16.689	**19.736**	95%	5.05
Supplemental Water consumption	259.194	5	51.839	**27.334**	95%	5.05

5.6: RTWC and United Nations Reasonable Water Access Levels

The application of the RTWC model values in the rural communities of SW Anambra State establishes that 25 – 29.2 litres regular volumes of water are consumed by an individual. The United Nations reasonable access level of 20 litres (UNICEF, 2006b) per person per day for both rural and urban communities, as well as developing and developed nations is therefore exceeded indicating a reasonable access in the study area. However, the exceedance of this global limit does not consider the water quality and associated health risks. The bar graph in Figure 5.1

compared the computed 25 - 29.2 litres to the United Nations 20 litres of water consumption using the trend line Equation of y = 20 ---------------Eqn (8).

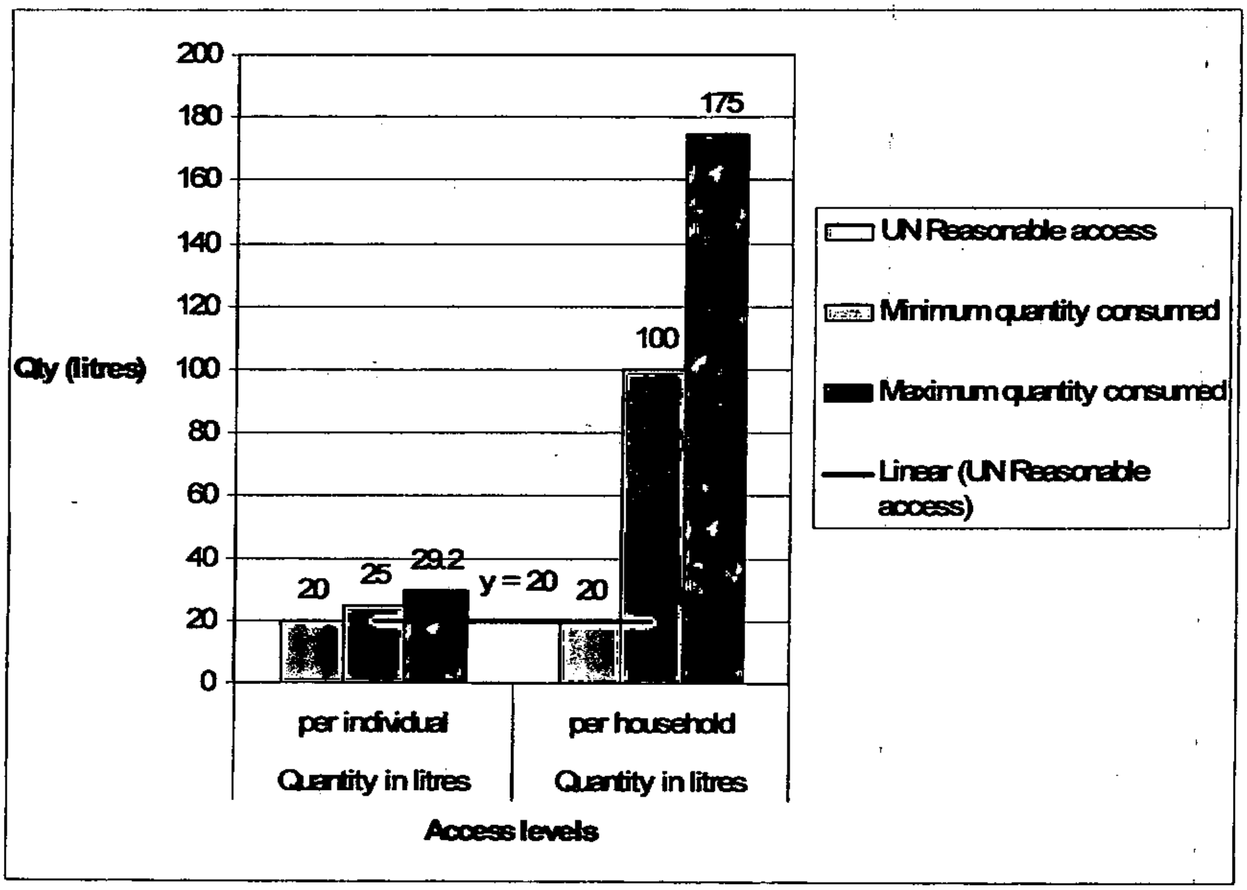


Fig.5.1: Levels of access to domestic water consumption

CHAPTER SIX

RESULTS AND DISCUSSION: RURAL WATER DISTRIBUTION AND WATER QUALITY

The water distribution patterns in the study area, the rural water quality verification using the standard recognized limits explores the intrinsic relationship between water quality and the health of water consumers.

6.1: Water Supply and Distribution Patterns

The Water Corporation or water works survey in the different study LGAs structures the various installed capacity, consumers, water rates/billings, water sources, water distribution patterns and the constraints limiting effective water supply service. The reports for the different communities are discussed in Tables 6.1.1 to 6.1.7. A greater number of the communities have no water works while most others do not have any installed design capacity.

The Anambra State capital, Awka is the operational headquarters of Anambra State Ministry of Water Resources (ANSWC). The water distributed in this capital city is mostly for domestic purposes and at a cheap rate of 45k per litre, although the water sources are rivers, streams and springs as well as boreholes. Water reservoirs are used for water distribution and the monthly billing method of payment is adopted because it is an urban centre. Adequate water distribution is however restricted by pipe leakages and malfunctioning of service equipment. Water demands are also rarely satisfactorily met because of the population density in the State capital, so most households resort to drilling private boreholes or water supply from water vendors at a higher price than the ANSWC price.

Table 6.1.1: Water Distribution Pattern in Awka (State Capital)

S/N	Awka water works	**Awka**
1	Location	Awka Borehole Field
2	Year of establishment	1958
3	Installed capacity	-
4	Major distribution equipment	-
5	Water sources	Rivers, springs, boreholes and wells
6	Distribution pattern	Reservoirs
7	Major consumers	Domestic
8	Parameter for water allocation	Population
9	Actual water supplied	-
10	Location variations	Population density
11	Water quality	very good
12	Water treatment	-
13	Ability to meet demand	No
14	Reason	due to reticulation
15	Problems	Inadequate water source, pipe breakage
16	Billings	Flat rate per litre
17	Rate per litre	45k per litre
18	Collection of bills	Monthly
19	Major constraints	Lack of planning, trained and skilled workers, service equipment, maintenance and funds.
20	Suggestions	a) Harnessing of surface water in most L.G.A. b) Increasing subvention to water agencies by state government. c) Employment of skilled manpower.

Source: Field Survey, 2006

Table 6.1.2: Water Distribution Pattern in Ogbaru LGA

Ogbaru water works	**Umunankwo**	**Ossomala**	**Ogwu Ikpele**	**Ogwu Aniocha**	**Akili Ozozor**	**Iyiowa Odekpe**
Location	R. Niger/Eziobi	R. Niger at Ossomala	R. Niger at Ogwu-Ikpele	-	Private borehole	-
Year of establishment	Sept. 2006	Nov. 2004	-	=	-	-
Installed capacity	Public borehole	-	-	-	-	-
Major distribution equipment	Pipes, Tanks	Motor Tankers	-	-	Private lorries	-
Water sources	Boreholes/wells	Rivers, Springs	Rivers/Springs	-	Boreholes	-
Distribution pattern	Stand pipes, reservoirs	Stand pipes	Reservoirs	-	Boreholes	-
Major consumers	Domestic	Domestic users	Domestic	-	Domestic	-
Parameter for water allocation	-	-	None	-	-	-
Actual water supplied	1000 tanks	1500 tanks	-	-	20 lorries	-
Location variations	-	No	-	-	No	-
Water quality	Poor	Fair	Good	-	Very poor	-
Water treatment	Filtration	Alum and filtration	-	-	Alum application	-
Ability to meet demand	Yes	Yes	Yes	-	No	-
Reason	-	-	-	-	-	-
Problems	-	Power failure to pump water	-	-	High pricing so that most people prefer cheap contaminated water	-
Billings	No bill	No bill	No bill	-	Per litre	-
Rate per litre	-	-	-	-	N20 per litre	-
Collection of bills	-	Point of supply	-	-	Point of supply	-
Major constraints	Lack of planning, trained and skilled workers, service equipment maintenance and lack of funds	Lack of service equipment maintenance	Lack of planning, trained and skilled workers, service equipment maintenance and funds	-	Lack of funds	-
Suggestions	Improved service and reticulation	Construction of water tap, industrialists to stop direct channeling of wastes to water	Government provision of pipe borne water	-	Pipe borne need as well as clean and good water quality	-

The Ogbaru LGA rural communities adopt a different water distribution approach of using stand pipes and reservoirs while motor tankers and Lorries are the distribution equipment used for domestic consumers as is shown in Plate 16. The major water sources are R.Niger and boreholes. Most consumers pay nothing for water especially from R.Niger while others pay at the point of supply especially for the commercial boreholes.

Plate 16: Motor Tanker for water distribution

Precisely, Ihiala and Nnewi South rural communities have no water works; the rural indigenes depend on rain harvest, streams and boreholes for water collection.

Table 6.1.3: Water Distribution Pattern in Ihiala LGA

Ihiala water works	Okija	Amorka	Isseke	Azzia	Orsumoghu	Mbosi
Location				N		
Year of establishment				O		
Installed capacity						
Major distribution equipment				W		
Water sources				A		
Distribution pattern				T		
Major consumers				E		
Parameter for water allocation				R		
Actual water supplied						
Location variations						
Water quality				W		
Water treatment				O		
Ability to meet demand				R		
Reason				K		
Problems				S		
Billings						
Rate per litre						
Collection of bills						
Major constraints						
Suggestions						

Source: Field Survey, 2006

Table 6.1.4: Water Distribution Pattern in Nnewi South LGA

Nnewi South water works	Osumenyi	Unubi	Utuh	Ekwulumili
Location	-	-	-	-
Year of establishment	-	-	-	-
Installed capacity	-	-	-	-
Major distribution equipment	-	-	-	-
Water sources	-	-	-	-
Distribution pattern	-	-	-	-
Major consumers	-	-	-	-
Parameter for water allocation	-	-	-	-
Actual water supplied	-	-	-	-
Location variations	-	-	-	-
Water quality	-	-	-	-
Water treatment	-	-	-	-
Ability to meet demand	-	-	-	-
Reason	-	-	-	-
Problems	-	-	-	-
Billings	-	No bill	-	-
Rate per litre	-	-	-	-
Collection of bills	-	-	-	-
Major constraints	-	-	-	-
Suggestions	-	-	-	-

Source: Field Survey, 2006

Table 6.1.5: Water Distribution Pattern in Idemili North LGA

Idemili North water works	**Uke**	**Ideani**	**Abatete**	**Eziowelle**	**Umuoji**
Location	-	-	Igwe's borehole Nsuku Abatete	-	-
Year of establishment	-	-	2004	-	-
Installed capacity	-	-	-	-	-
Major distribution equipment	-	-	Overhead Tank	-	-
Water sources	-	-	Borehole	-	-
Distribution pattern	-	-	Reservoir	-	-
Major consumers	-	-	Domestic	-	-
Parameter for water allocation	-	-	-	-	-
Actual water supplied	-	-	50, 000 litres	-	-
Location variations	-	-	No because community is very small	-	-
Water quality	-	-	Good	-	-
Water treatment	-	-	Chlorine, Alum	-	-
Ability to meet demand	-	-	Yes	-	-
Reason	-	-	-	-	-
Problems	-	-	High cost of billing	-	-
Billings	-	-	Per litre	-	-
Rate per litre	-	-	N10.00 per litre	-	-
Collection of bills	-	-	Point of supply	-	-
Major constraints	-	-	Lack of service	-	-
Suggestions	-	-	Reduce selling cost, need for boreholes for easy distribution.	-	-

Source: Field Survey, 2006

Idemili North and South rural communities are served mostly by borehole water which costs #10.00 per litre. Payment is made at point of supply. The price is however too high for the indigenes and most of the time power failure renders these boreholes non-functional.

Table 6.1.6: Water Distribution Pattern in Idemili South LGA

IDEMILI SOUTH water works	Alor	Nnokwa	Akwukwu	Awka Etiti
Location	Ikenua borehole, Okebunoye village	-	UNICEF manpower	-
Year of establishment	2004	-	2004 – 2005	-
Installed capacity	-	-		-
Major distribution equipment	Overhead Tank	-	Overhead tank, manpower	-
Water sources	Boreholes	-	Borehole	-
Distribution pattern	Stand pipes	-	Stand pipes	-
Major consumers	Domestic	-	Domestic users	-
Parameter for water allocation	-	-	Public tap	-
Actual water supplied	5, 000 litres	-	-	-
Location variations	No because water vendors are in charge	-	Yes village by village	-
Water quality	Good	-	Poor	-
Water treatment	Chlorine, Alum	-	Boiling by filtration	-
Ability to meet demand	Yes	-	Yes	-
Reason	-	-	-	-
Problems	Inadequate borehole and payment cost	-	Lack of good drinking water	-
Billings	Per litre	-	No bill	-
Rate per litre	N10.00 per litre	-	-	-
Collection of bills	Point of supply	-	-	-
Major constraints	Lack of service equipment maintenance	-	Lack of service equipment maintenance	-
Suggestions	Minimizing cost of water.	-	Need for adequate water supply, good equipment and funds for maintenance.	-

Source: Field Survey, 2006

Ekwusigo LGA communities have boreholes which are mostly free of charge, however lack of electricity or break down of generators limits water supply to the indigenes.

The different approaches to water distribution using reservoirs and pipes are adopted by the water corporation in the different LGAs and communities. Boreholes, springs and rivers are the major supply sources while the consumers are mostly domestic households. The price hikes, lack of skilled staff are some of the challenges facing the rural water consumers. The common storage devices in the rural study communities are jerry cans, tanks and artificial ponds. Water storage receptacles mostly without filters (for rain harvest) and careless exposure could also contaminate water. Water tanks are thus more secured if routinely washed and covered. Therefore, safety of domestic water from point of distribution or collection to point of consumption or storage is very vital for the health and safety of consumers.

Table 6.1.7: Water Distribution Pattern in Ekwusigo LGA

Ekwusigo water works	Ichi	Ihembosi	Oraifite
Location	NO WATER WORKS	-	Oraifite Water Scheme Isingwu (Emeka Ofor Project)
Year of establishment		-	2003
Installed capacity		-	-
Major distribution equipment		-	Pipe
Water sources		-	-
Distribution pattern		-	Stand pipes
Major consumers		-	Domestic users
Parameter for water allocation		-	-
Actual water supplied		-	2, 000 gallons
Location variations		-	Yes
Water quality		-	Very good
Water treatment		-	-
Ability to meet demand		-	-
Reason		-	-
Problems		-	Power failure
Billings		-	No bill
Rate per litre		-	-
Collection of bills		-	-
Major constraints		-	Lack of planning, lack of trained and skilled workers, lack of service equipment, maintenance and lack of funds.
Suggestions		-	Need for community water provision

Source: Field Survey, 2006

6.2: Water Shortages in the Study Area

Water shortages are also frequent in most study communities and LGAs at different seasons. The patterns of water shortage (Table 6.2) portray the respondents' view that water shortages occur occasionally (66.2%).

Table 6.2: Patterns of Water Shortages in Anambra SW

Shortages	Events	LGAs (1) Ekwusigo	(2) Nnewi South	(3) Ogbaru	(4) Ihiala	(5) Idemili South	(6) Idemili North	Ave.(%) of total within LGAs
Water shortages	Always	10.1%	17.6%	20.5%	14.6%	8.4%	15.0%	14.9
	Occasionally	63.5%	58.0%	36.6%	78.6%	82.3%	78.9%	66.2
	Not at all	26.4%	24.4%	42.9%	6.8%	9.4%	6.1%	18.9
Shortage periods	All year round	53.0%	23.9%	39.4%	20.3%	7.9%	4.3%	22.4
	Dry months	36.8%	61.3%	45.5%	62.3%	86.3%	78.7%	63.7
	Wet months	.9%	1.3%	6.6%	2.2%	1.6%	1.3%	2.5
	Irregular periods	9.4%	13.5%	8.5%	15.2%	4.2%	15.7%	11.5
Shortage sources	Distant streams and rivers	33.3%	45.1%	32.4%	33.2%	40.1%	19.8%	33.2
	Vendors and boreholes	60.3%	41.5%	39.7%	61.9%	41.8%	74.9%	54.4
	Other sources	6.3%	13.4%	27.9%	4.9%	18.1%	5.3%	12.4
Shortage factors	Inadequate sources	50.9%	42.2%	49.0%	32.8%	19.1%	48.7%	39.7
	Inadequate storage	21.9%	21.8%	25.5%	25.1%	40.5%	29.2%	27.7
	Rainfall seasonal variation	6.1%	20.4%	15.1%	33.2%	36.4%	12.8%	22.0
	Industrial consumption	14.9%	2.0%	4.2%	4.7%	.6%	2.6%	4.3
	Pipe leakages	1.8%	5.4%	1.0%	3.0%	2.3%	2.1%	2.6
	Others	4.4%	8.2%	5.2%	1.3%	1.2%	4.6%	3.9

Source: Field Survey, 2006

The periods of water shortages are mostly at dry periods (63.7%) when most water sources are limited. Majority of the households obtain their domestic water at this period from boreholes and water vendors (54.4%) at a cost while others rely on distant streams and rivers (33.2%), although most stream levels may have become low; and finally other sources (12.4%) such as stored rainwater.

The water quality guideline (WHO, 2004a) further explains that water vendors' uses different modes of transport to carry drinking-water for sale directly to the consumer, including tanker trucks and wheelbarrows/trolleys. In this context water vending does not include bottled or packaged water or water sold through vending machines.

There are a number of health concerns associated with water supplied to consumers by water vendors. These include access to adequate volumes and concern regarding inadequate treatment or transport in inappropriate containers, which can result in contamination. Where the source of water is uncertain or the quality of the water is unknown, water can be treated or re-treated in small quantities to significantly improve its quality and safety.

Factors responsible for water shortages vary from inadequate sources (39.7%), inadequate storages (27.7%) to rainfall seasonal variation (22.0%) amongst other factors. Consumer satisfaction however, depends on adequate water quantity and excellent quality whereas dissatisfaction results from inadequate quantity and poor water quality. The major constraints to water distribution in the study communities include lack of planning, maintenance and servicing of public water facilities as well as funds to establish new projects.

6.3: Major Threats to Available Water Sources and Implications

Threats to domestic or drinking water sources are issues of major concern. Pollution could result from industrial, human and bacterial contamination. Other use activities include land use change influence (land cover modification), extraction activities, various forms of recreation, industrial and military sites, sewage and septic system discharges, major spills, changes in land use, inadequate buffer zones and vegetation, soil erosion and failure of sediment traps, storm water flows and discharges, active or closed waste disposal or mining sites, contaminated sites / hazardous wastes, geology (naturally occurring chemicals), unconfined and shallow aquifer (including groundwater under direct influence of surface water), inadequate wellhead protection, uncased or inadequately cased bores and unhygienic practices and climatic and seasonal variations (e.g., heavy rainfalls, droughts) and natural disasters" (WHO, 2004a). These often have adverse short and long term effects on the quality of water, increase developmental, distribution and water treatment costs, and if not treated causes poor health conditions.

As the population in different localities increases, human pollution and land use activities increase. These often have adverse long term and short term effects on the water bodies exposing them to invasive weeds such as water hyacinth dominating the River Niger at Ogwu- Ikpele as well as chemical pollution and growth of microbes as a result of fertilizer, herbicides, pesticides and other chemical application. The overall result is the water quality being far short of the standard limits

Table 6.3 records the average solid and liquid waste discharges across the LGAs as 44.2%. Urasi River in Ogwuani-Ocha, Omaiyi in Azzia, and Opiegbe in Ideani, are typical water source degradation cases due to indiscriminate human waste disposal at the river banks, food processing, transportation, swimming, sand dredging and sacrifices peculiar to them.

Table 6.3: Major Pollution Threats to Rural Water Supply

Constraints	LGAs						
	(1) Ekwusigo	(2) Nnewi South	(3) Ogbaru	(4) Ihiala	(5) Idemili South	(6) Idemili North	Ave. (%) of total within LGAs
Poor and limited quantity/quality	39.1%	33.3%	14.7%	45.2%	47.2%	33.0	34.9
Industrial pollution**	5.5%	4.0%	19.4%	3.7%	7.4%	3.8	7.8
*Solid waste**	11.1%	20.0%	13.7%	11.5%	22.5%	9.8	13.9
*Liquid waste**	16.7%	72.0%	56.9%	26.5%	45.0%	36.6	41.9
*Solid and liquid waste**	72.2%	8.0%	29.4%	61.9%	32.5%	53.7	**44.2**
Human pollution	27.3%	17.5%	20.3%	26.6%	39.9%	40.5	28.8
Bacterial pollution	2.7%	44.4%	20.3%	19.9%	2.5%	18.4	18.1
All of above	25.5%	.8%	25.3%	4.6%	3.1%	4.3	10.4

* (Industrial pollution types) Source: Field Survey, 2006

The implications of limited water quantity (water shortages), include limitation of suitability, contribution to indecent sanitation or poor hygiene and denial of children education right due to time spent in search of water. Poor water quality deteriorates health and may lead to water diseases and epidemic situations. The major causes include water shortages and scarcity, poor quality of water consumed and high rate of faecal and human pollution that is often accelerated by flooding. UNICEF, 2006 reports that over one billion people still use unsafe drinking water sources and thus thousands of children die from diarrhoea and other water sanitation and hygiene related diseases daily, while many others suffer and are weakened by illnesses.

6.4.: Water Quality and Approaches to Its Verification

Water testing and analysis is conducted to aid understanding of geochemical and hydrologic relationships in natural systems, so as to evaluate the influence of nature, as well as man and his activities on water sources. The quality of a particular water source is dependent on several physical parameters including colour, taste, odour, hardness as well as chemical and micro-biological parameters. Potable water should be tasteless, odourless, colourless, safe to drink, free of pathogens (disease-causing organisms) and should contain no harmful chemicals.

Consumer perceptions as well as health related and aesthetic conditions attached to assessing domestic water supplies are important aspects of assessing water quality. Changes in the normal appearance, odour or taste of drinking water may signal changes in the quality or deficiencies in water source and affect acceptability.

The field survey on potable water indicators (Table 6.4) depicts the people's perception on water quality that a greater portion of water sources in the study area has no colour (74.6%), no taste (69.0%), no odour (81.1%), is not hard (73.7%) and require no treatment (57.0%).

Table 6.4: Perception on Potable Water Indicators in Anambra SW

Potability variables	Responses	LGAs						
		(1) Ekwusigo	(2) Nnewi South	(3) Ogbaru	(4) Ihiala	(5) Idemili South	(6) Idemili North	Ave. (%) of total within LGAs
Colour	yes	3.3%	8.0%	68.8%	20.3%	26.0%	7.9%	25.4
	no	96.7%	92.0%	31.2%	79.7%	74.0%	92.1%	**74.6**
Taste	yes	6.6%	26.2%	57.7%	31.7%	40.7%	9.9%	31.0
	no	93.4%	73.8%	42.3%	68.3%	59.3%	90.1%	**69.0**
Odour	yes	2.7%	11.1%	35.1%	21.5%	25.4%	7.8%	18.9
	no	97.3%	88.9%	64.9%	78.5%	74.6%	92.2%	**81.1**
Hardness (Not Foam With Soap)	Yes	2.0%	29.2%	47.3%	16.2%	39.9%	14.8%	26.3
	no	98.0%	70.8%	52.7%	83.8%	60.1%	85.2%	73.7
Water Treatment	yes	23.3%	19.7%	64.0%	40.4%	60.7%	38.0%	43.0
	no	76.7%	80.3%	36.0%	59.6%	39.3%	62.0%	**57.0**

Source: Field Survey, 2006

For in depth-studies, water sample collection and analysis was conducted in the rural study communities to determine the chemical, biological and microbiological drinking water composition and the suitability for domestic purposes using the World Health Organization and Federal Ministry of Environment potable water limits.

6.5: Test and Analysis of Physico-Chemical Parameters

The physico-chemical test on water samples (Table 6.5) on water constituents of taste, odour and colour, pH, turbidity, nitrate, ammonia, hardness, iron and chloride were analysed using the standard limits.

Table 6.5: Chemistry of Sampled Water in SW Anambra State

LGA/ towns	Sample point	GPS Long. Lat.		Appearance	pH	Turbidity (NTU)	Nitrate (mg/L)	Ammonia (mg/L NH_3)	Hardness (mg/L $CaCO_3$)	Total Iron (mg/L Fe)	Salin-ity as Chlori-de (mg/L Cl^-)
			Method		ASTM D1293	ASTM D1889	APHA Std Mtd 4500 - NO_3^- E	ASTM D1426	ASTM D1126	APHA Std. Mtd. 3500 – Fe D	ASTM D512-89
			WHO Limit	Clear and Colourless	6.5 – 8.5	5	50	1.4		0.3	250
			FMEnv Limit	-	-	-	-	-	-	-	-
Ekwusigo											
Ihembosi	Private, Free Borehole	5° 55' 44' 6° 51' 40'		Clear and Colourless	4.53	0.13	5..28	0.45	3	0.08	2.5
Oraifite	Ekulo Ibollo Stream	6° 00' 35' 6° 49' 41'		Brownish with small brownish deposits	6.64	27.8	7.48	0.96	21	2.43	1.8
Ichi	Private Free Borehole For Public Use	6° 02' 52' 6° 52' 40'		Clear and Colourless	4.49	0.48	5.72	0.00	2	0.25	1.0
Nnewi S.											
Osumenyi	Aso Commercial Borehole	5° 57' 03' 6° 45' 37'		Clear and Colourless	6.24	0.27	11	0.16	43	0.07	3..3
Utuh	Commercial Borehole	5° 57' 39' 6° 58' 22'		Clear and Colourless	5.49	0.23	5.72	0.28	6	0.29	0.9
Ekwulumili	Ekwulumili Roof Catch	5° 58' 49' 7° 00' 23'		Clear and Colourless	9.02	0.49	6.16	0.09	19	0.14	1..2
Unubi	Community Borehole	5° 57' 11' 7° 02' 32'		Clear and Colourless	4.29	0.69	7.48	0.40	2	0.20	1.1
Ogbaru											
Ogwu Ikpele	R. Niger At Ogwu Ikpele	5° 43' 50' 6° 38' 37'		-	-	-	-	-	-	-	-
Ogwu Aniocha	R. Orashi At Ogwuani - Ocha	5° 47' 47' 6° 45' 18'		Colourless with brown deposits	4.92	3.49	5.72	0.55	7	0.60	1..9
Ossomala	Federal Government Borehole	5° 52' 06' 6° 40' 54'		Deeply brownish with some tiny brownish deposits	5.90	460	0.00	2.66	18	15.38	2.7
Umunankwo	Onukwu Stream	5° 52' 51' 6° 41' 40'		Colourless with some tiny dark deposits	6.37	3.01	6.6	0.63	24	0.49	1.2
Akili Ozizor	R. Niger At Akili Ozizor	5° 59' 23' 6° 43' 53'		Brownish with lots of brown deposits	6.16	52.9	1.76	0.57	21	1.42	3.0
Iyiowa Odekpe	Idemili R. At Niger	6° 06' 31' 6° 45' 31'		Brownish colour with tiny brown particles	6.78	48.6	1.32	0.73	18	1.18	NA
Ihiala											
Okija	Urasi Okija River	5° 55' 16' 6° 51' 30'		Colourless with few brown deposits	5.29	0.90	7.92	0.26	2	0.20	1.9
Azzia	Omaiyi Stream	5° 53' 10' 6° 52' 38'		Colourless with some brownish deposits	4.96	2.75	3.96	0.15	2	0.22	1.4

LGA/ towns	Sample Point	GPS Long. Lat.		Appearance	pH	Turbidity (NTU)	Nitrate (mg/L)	Ammonia (mg/L NH_3)	Hardness (mg/L $CaCO_3$)	Total Iron (mg/L Fe)	Salinity as Chloride (mg/L Cl^-)
Orsumoghu	Private Borehole, Free And Time Regulated	5° 52'05' 6° 54'52'		Clear and Colourless	4.51	0.59	7.04	0.40	2	0.13	1.4
Amorka	Commercial Borehole 25litres @ 5 NAIRA	5° 45'12' 6° 52'48'		Clear and Colourless	4.58	0.27	8.8	0.37	4	0.18	NA
Mbosi	Roof Catch	5° 51'35' 6° 54'25'		Clear and Colourless	5.56	0.32	7.48	0.00	NA	NA	8.3
Isseke	Private, Commercial Borehole	5° 50'02' 6° 54'56'		Clear and Colourless	4.91	0.36	7.48	0.39	2	0.09	NA
Idemili S.											
Awka Etiti	Roof Catch Rain Harvest	6° 02'08' 6° 57'59'		Clear and Colourless	8.77	0.48	7.48	0.01	30	0.07	1.3
Nnokwa	Nnaku Villa Roof Catch	6° 03'10' 6° 58'09'		Clear and Colourless	8.12	0.43	8.36	0.13	19	0.07	1.2
Alor	Community Health Centre	6° 04'55' 6° 57'39'		Slightly brownish with brown deposits	7.60	5.64	6.16	0.43	52	0.74	4.9
Akwukwu	Osemenam Borehole	6° 02'32' 6° 48'34'		-	-	-	-	-	-	-	-
Idemili N.											
Umuoji	Commercial Borehole	6° 06'14' 6° 53'17'		-	-	-	-	-	-	-	
Abatete	Esigbo Stream	6° 06'18' 6° 57'33'		Colourless with some brownish deposits	5.75	4.86	3.96	0.11	5	0.45	2.2
Uke	Private Nafdac Approved Borehole	6° 05'39' 6° 55'23'		Clear and Colourless	5.10	0.15	9.68	0.13	10	0.09	2.7
Ideani	Opiegbe Stream	6° 05'10' 6° 56'07'		Colourless with brownish deposits	5.53	2.32	6.6	0.19	5	0.8	1.7
Eziowelle	Ukwuakpu Stream	6° 09'30' 6° 59'47'		Colourless, few brown deposits	4.65	0.69	6.6	0.11	3	0.12	1.2

(Source: Field Survey and Laboratory analysis, 2006)

Note:NA = Not analyzed due to insufficient sample; --- = No sample collected; Salinity measured was as in chloride; ASTM =Acronym for American Society for Testing and Materials; APHA = American Public Health Association; D's = various test methods for particular tests; WHO Limit = World Health Organization Limit for potable (drinking) water.

The WHO standard limit for potable (drinking) water remains the globally acceptable limit with the primary purpose of public health protection and the achievement of a water safety goal. The water quality analysis results show that except for the pH values, all parameters below the WHO limit, meet the specifications for potable water. Water samples with parametric results above the limit however, depending on the specific substance involved may be acceptable for drinking but may create some effects in the long run. Figure 6.1 depicts the sampled water sources in the study LGAs.

The laboratory results for *Idemili North LGA* show that the water samples were only mildly acidic except for sample from Ukwuakpu stream in Eziowelle which had very acidic ph of 4.65. The presence of brownish deposits in some of the samples (Esigbo and Opiegbe) may be linked to their high total iron (Fe) levels of 0.45 mg/l and 0.89 mg/l respectively, which are above the WHO recommended limit.

In *Idemili South LGA,* Alor sample had some brownish deposits, above limit turbidity of 5.64 NTU and high iron (Fe) concentration of 0.74 mg/l.

Ekwusigo LGA samples were very acidic except for the Ekulo Ibollo stream with ph 6.64; presence of brownish deposits, turbidity value of 27.8 NTU and high iron concentration (2.43 mg/l). Ichi borehole sample had a below iron (Fe) level of 0.25 mg/l.

Samples from *Ihiala LGA* were all acidic and had iron (Fe) levels below the 0.3 mg/l WHO limit.

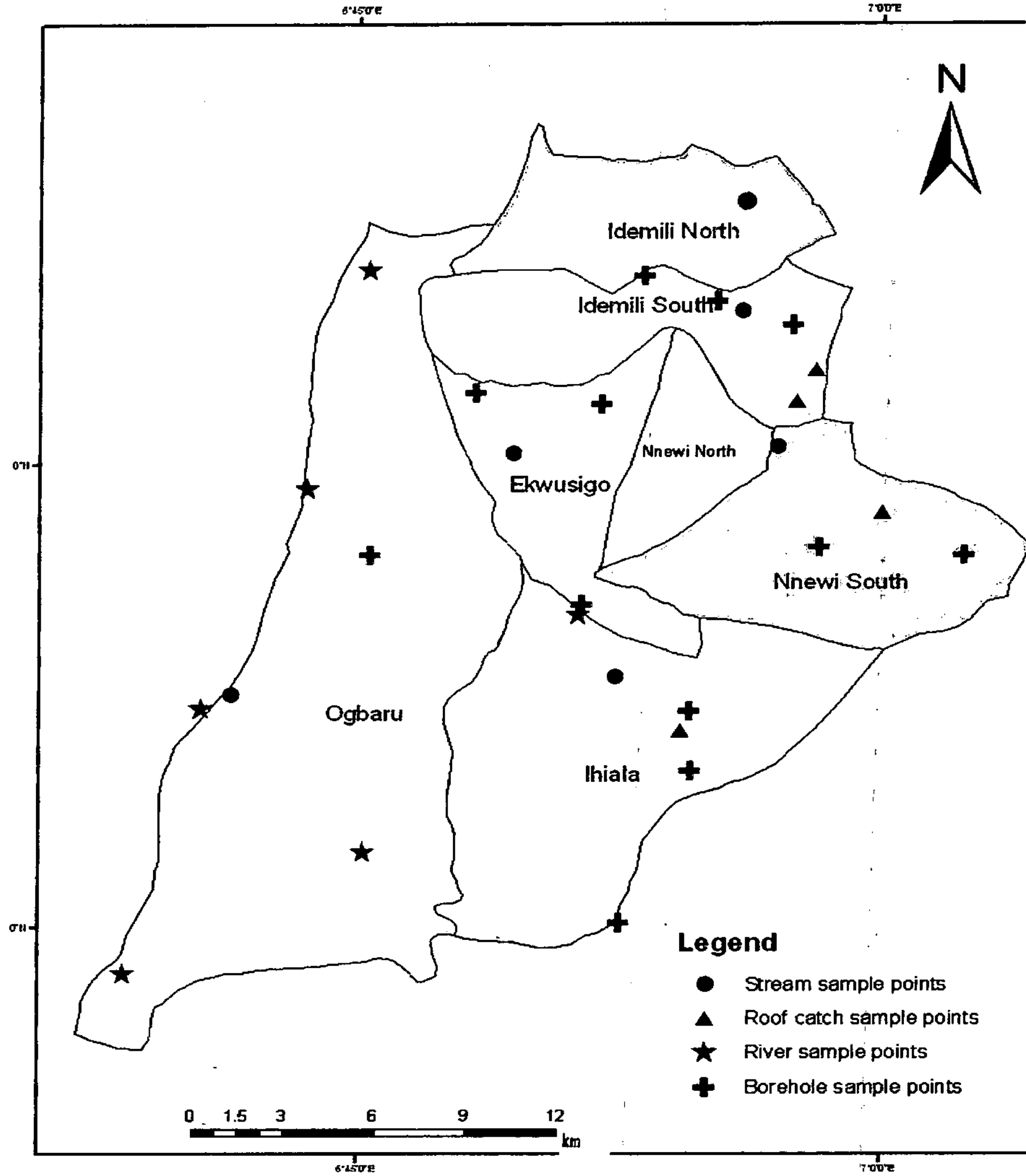


Fig. 6.1: Water sample collection points within Southwestern Anambra State

Source: Field Studies, 2006

The samples from *Nnewi South LGA* show tolerable levels for all parameters analysed except for Unubi boreholes' acidic pH of 4.29. The iron (Fe) concentration and turbidity levels for all samples were below the established limit.

Ogbaru LGA samples had mostly brownish deposits with iron (Fe) levels correspondingly higher than the WHO limit and although Iron (Fe) is not classified as a chemical with great risk in water, its high levels in samples could impair water colour and taste. The Ossomala and Umunankwo samples had iron levels as high as 15.38 mg/l and 21.00 mg/l, respectively. These two samples also had the highest degree of turbidity with values of 460 NTU and 339 NTU, respectively which could impair taste and appearance of water.

Generally, ammonia contents except for Ossomala with 2.66 mg/l, nitrate and hardness levels for all sampled points were below the WHO and FMEnv set limits. Samples mostly from free private boreholes and streams had very acidic ph while most roof catch rainwater harvest samples had alkaline ph values. This indicates a tendency that health risks could result from intake of water with these parameters.

i. *Taste, Odour and Appearance*: Microbial, chemical, physical water constituents, corrosion, water treatment such as chlorination, storage, distribution and pollution may affect the appearance, odour or taste of the water making the water undrinkable. Colour in drinking-water is usually due to the presence of coloured organic matter (primarily humic and fulvic acids) associated with the humus fraction of soil. Colour is also strongly influenced by the presence of iron and other metals either as natural impurities or as corrosion products.

ii. *Temperature*: The variation in temperature is an important variable that influences rate of chemical and biological processes in surface waters especially oxygen level, photosynthesis and algal production. Temperature impacts on the acceptability of a number of inorganic constituents and chemical contaminants. High water temperature enhances the growth of microorganisms and may increase taste, odour, colour and corrosion problems.

iii. p*H*: This parameter is linked closely to biological productivity in aquatic systems and thus a limiting factor for certain water uses. Figure 6.2 are the pH plot of the sampled water sources in the study LGAs and communities.

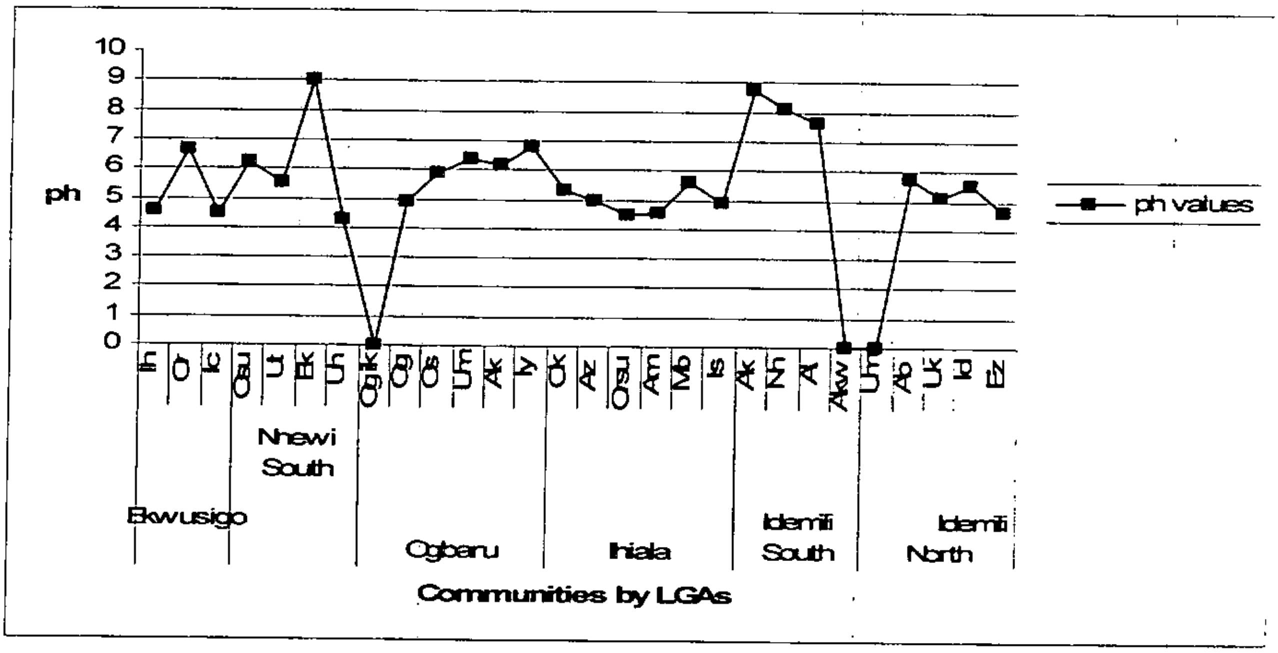
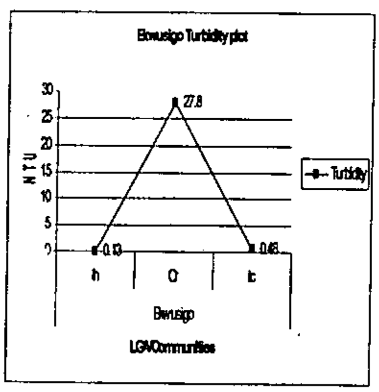


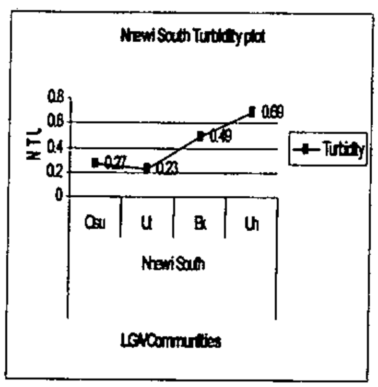
Fig. 6.2: pH Plot of Sampled Water Sources

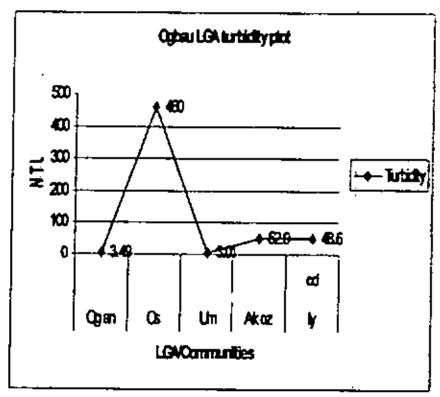
Note: Ih= Ihembosi, Or= Oraifite, Ic= Ichi, Osu= Osumenyi, Ut= Utuh, Ek= Ekwulumili, Un= Unubi, Og ik= Ogwu Ikpele, Og an=Ogwuani-Ocha, Os= Ossomala, Um= Umunankwo, Ak oz= Akili Ozizor, Iy od= Iyiowa Odekpe, Ok= Okija, Az= Azzia, Orsu= Orsumoghu, Am= Amorka, Mb= Mbosi, Is= Isseke, Ak Et= Awka Etiti, Nn= Nnokwa, Al=Alor, Akw=Akwukwu, um= Umuoji, Ab= Abatete, Uk= Uke, Id= Ideani, Ez=Eziowelle.

The optimum pH required for drinking water varies in different supplies according to the composition of the water and the nature of the construction materials used in the distribution system, but it is usually in the range 6.5 – 8. pH values are generally used in determining the corrosive action of water. Low ph values indicate acidic tendency and such water samples may affect teeth formation in little children, while high pH values indicate alkaline tendency and may lead to scale formation. Rainwater is naturally acidic (pH 5.7) due to dissolution of atmospheric carbon 11 oxide. It is also increased by sulphur dioxide (So_2) and nitrogen oxides (No_x), atmospheric pollutants from fossil fuel combustion.

iv. *Turbidity (Suspended solids)*: Organic and mineral particles comprise the total suspended solids transported to the water column. Turbidity ranges from 5mg per litre to 30,000 mg per litre in some rivers and is an important erosion and river transport measure especially of phosphorus metals. Turbidity determination measurement is carried out with a simple turbidity tube that allows a direct reading in nephelometric turbidity units (NTU). High turbidity is caused by the presence of suspended and dissolved particles of gas, liquid or solids of organic or inorganic matter and may affect water use by limiting light penetration and can limit reservoir life through sedimentation of suspended matter. Figure 6.3 are the NTU plots of the sampled water sources.







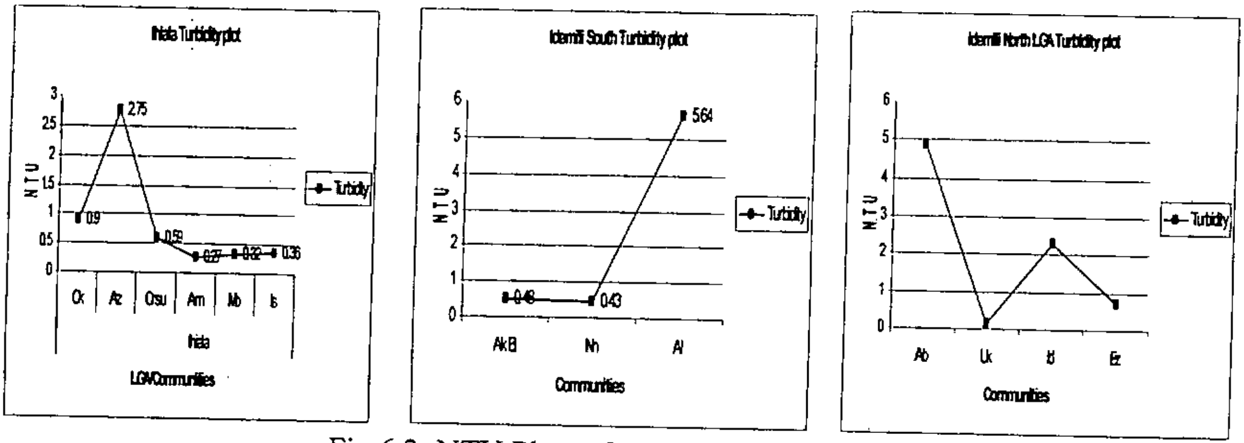
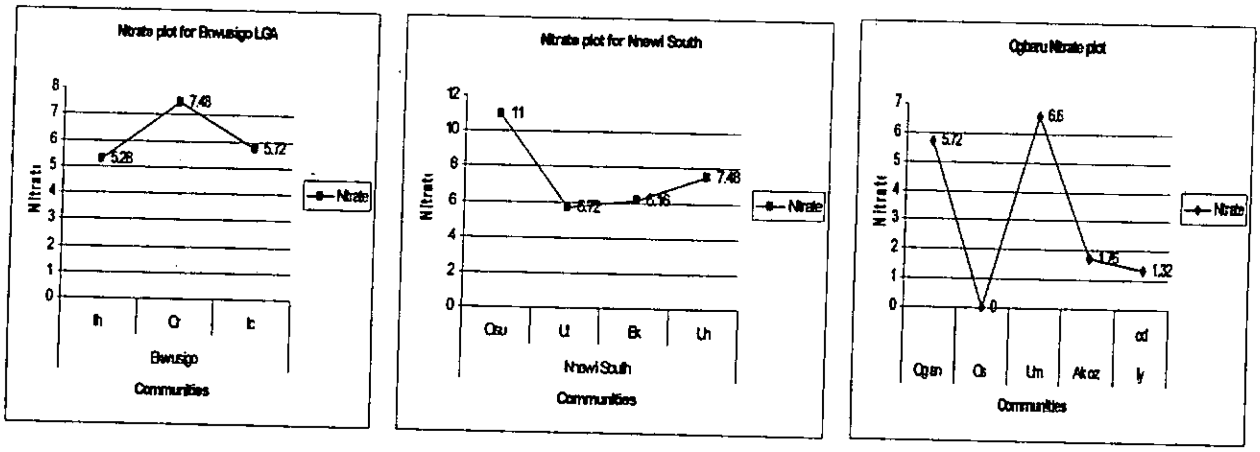


Fig.6.3: NTU Plots of Sampled Water Sources

v. *Nitrate*: This parameter represents the most completely oxidized state of nitrogen commonly found in water. The presence of nitrate and nitrite in water may arise from the excessive application of fertilizers, leaching of wastewater or other organic wastes into surface water and groundwater. Nitrate pollution in groundwater is a major problem in many parts of the world. In oxidized form, phosphates (Po_4-^{3} and No^-_3) and nitrates have both population and agricultural impact on environment indicators (UNEP, 1995). Point sources Po_4-^{3} and No^-_3 originating from wastes are marked by algae. Nitrates can degrade water quality by excessive growth of algae and aquatic weeds in reservoirs, lakes and rivers and could as well result in adverse neurological effects. Figure 6.4 are the nitrate plots of the sampled water sources.



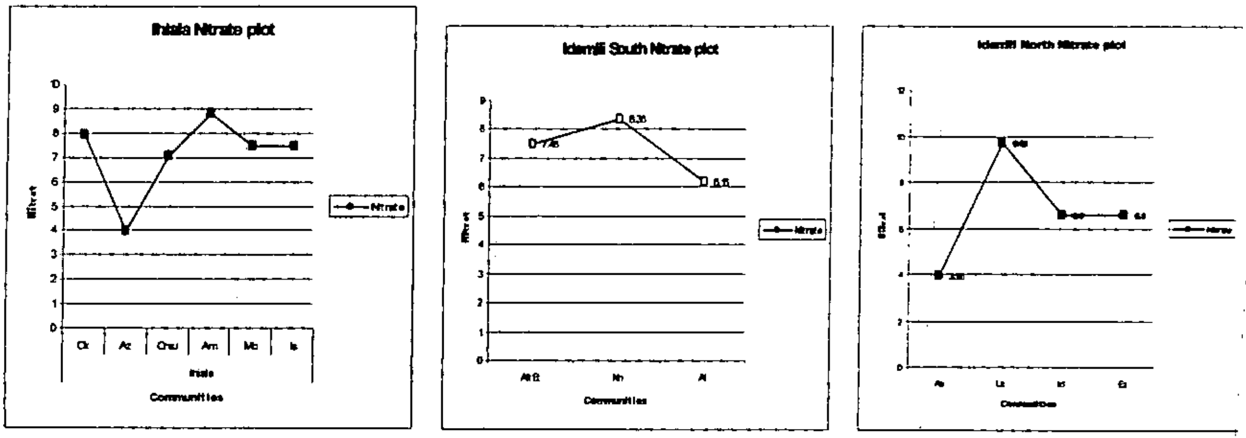
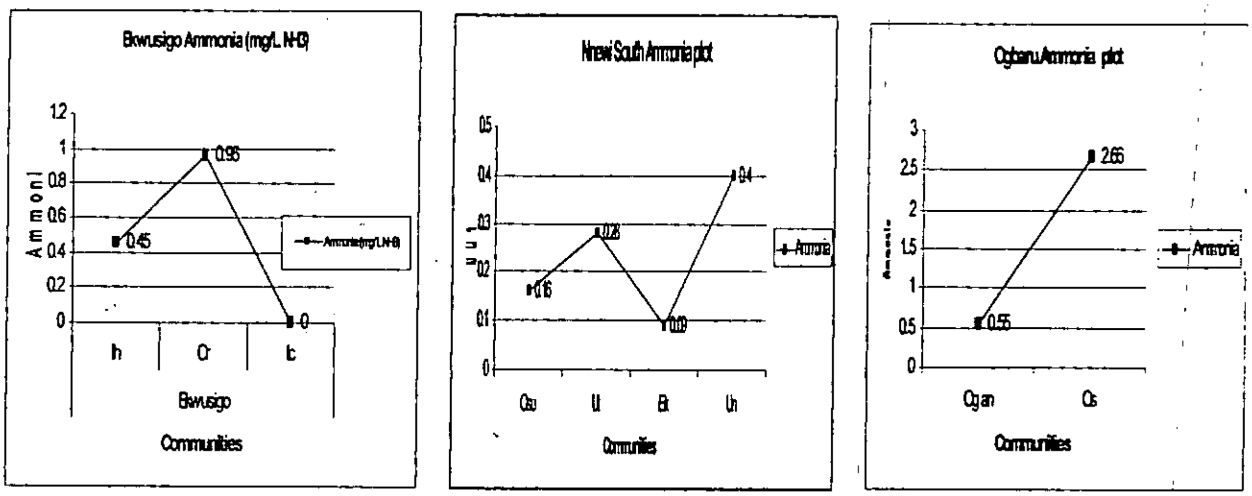


Fig.6.4: Nitrate Plots of Sampled Water Sources

vi. *Ammonia*: Anaerobic decomposition of nitrogen-containing compounds in water produces Ammonia. Phosphorus (P) and nitrogen (N) are primary nutrients and major constituents of agricultural fertilizer, animal wastes and municipal wastes to rivers and lakes that cause nutrient enrichment and leads to eutrophication of surface waters (UNEP, 1995). Figure 6.5 are the Ammonia plots of the sampled water sources in the study LGAs and communities.



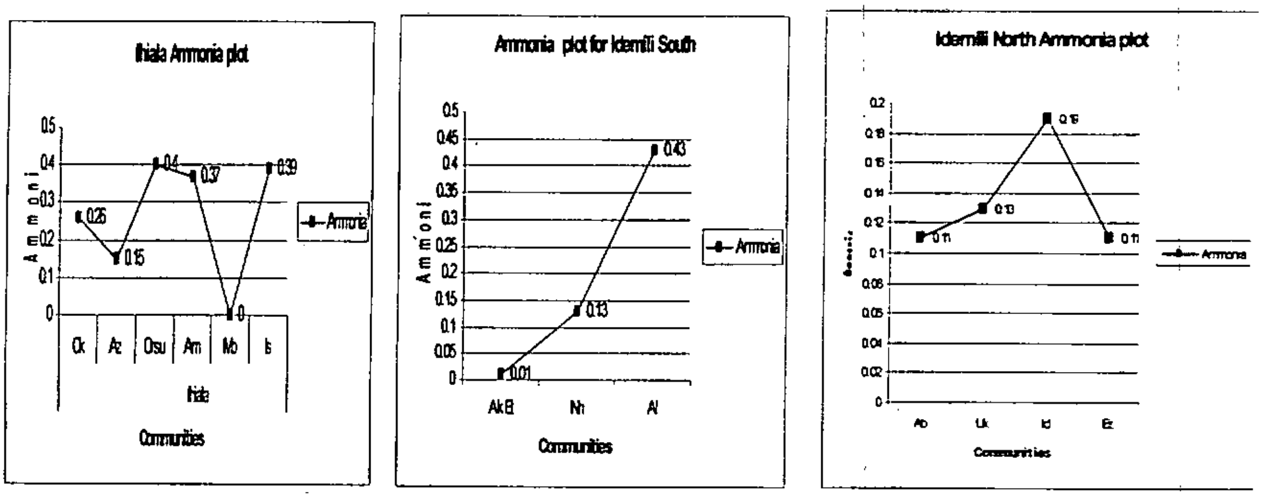
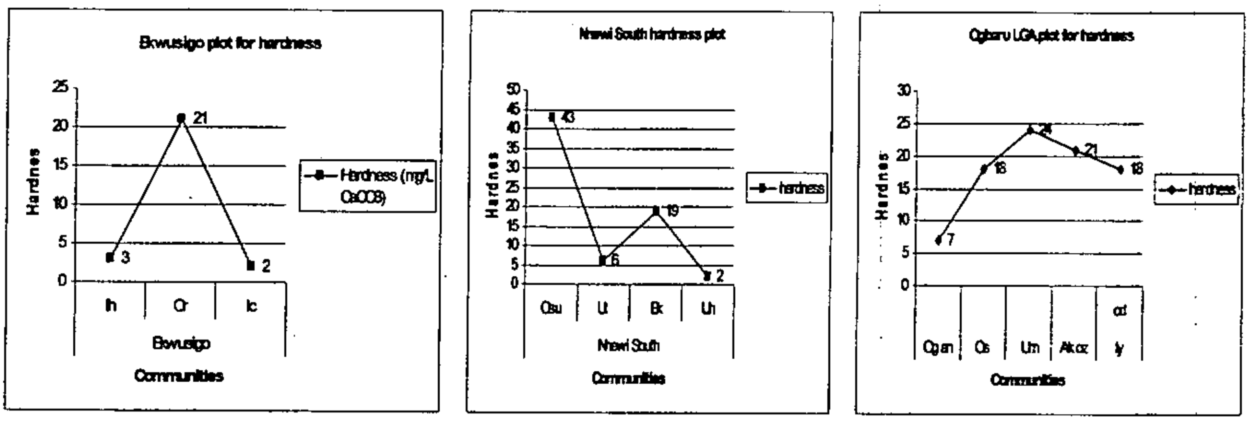


Fig.6.5: Ammonia Plots of Sampled Rural Water Sources

vii. *Hardness*: Dissolved calcium and magnesium (calcium carbonate) in water results to hardness. It is usually indicated by precipitation of soap scum and thus the need for excess use of soap. Ecological and analytical epidemiological studies have also shown a statistically significant inverse relationship between hardness of drinking water and cardiovascular disease (WHO, 2006). Hardness salts in water notably calcium and magnesium are the primary causes of tubes and pipes scaling which results in clogging or loss of heat transfer, or both. Figure 6.6 are the hardness plots of the sampled water sources in the study LGAs and communities.



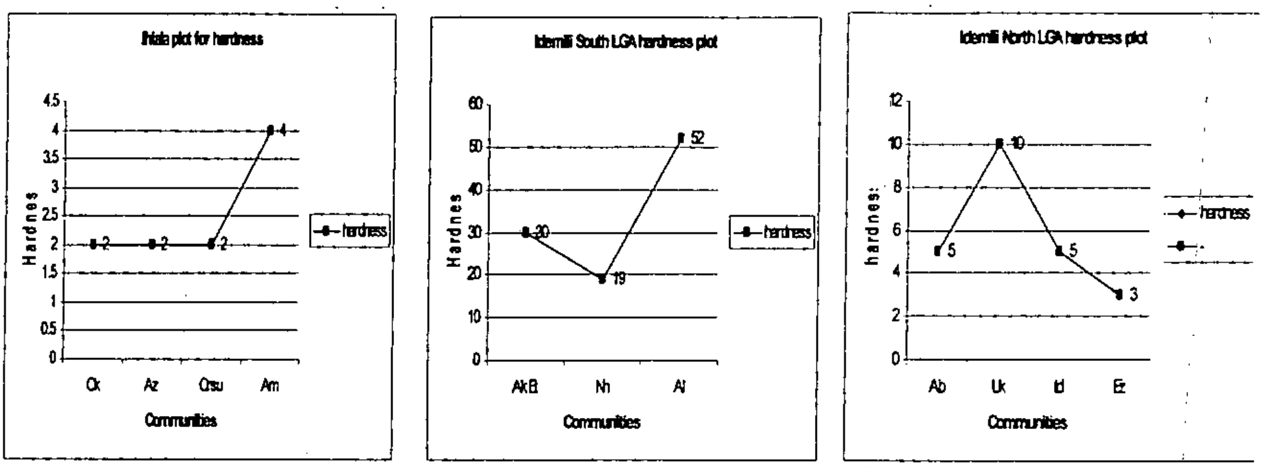
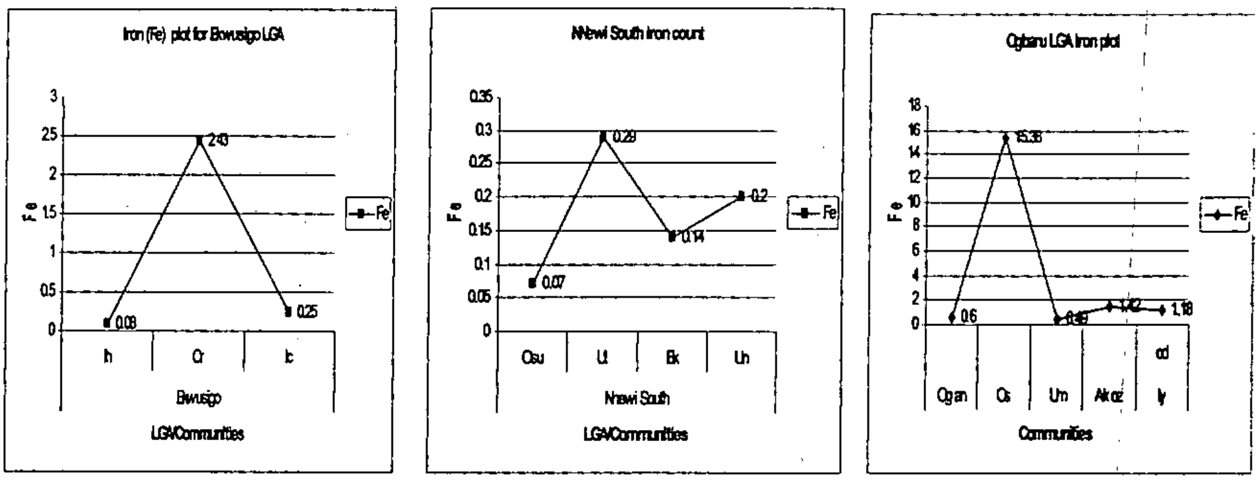


Fig.6.6: Hardness Plots of Sampled Water Sources

viii. *Iron and Manganese*: These are of widespread significance because of their effects on acceptability. Oxidation or exposure of ferric water to the atmosphere results to reddish-brown water colour. At levels above 0.3 mg/litre and 0.1 mg/litre, iron and manganese stains laundry and plumbing fixtures and develops taste, turbidity and colour respectively. Figure 6.7 are the iron plots of the sampled water sources in the study LGAs and communities.



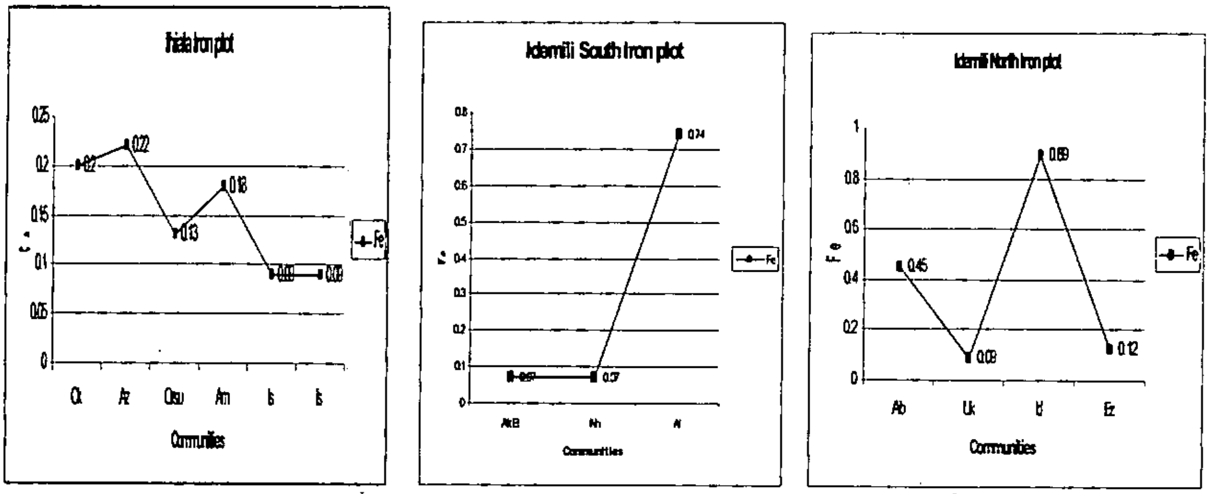


Fig.6.7: Iron (Fe) Plots of Sampled Water Sources

ix. *Chloride*: High concentrations of chloride give a salty taste to water and beverages. Figure 6.8 are the chloride values of the sampled water sources in the study LGAs and communities.

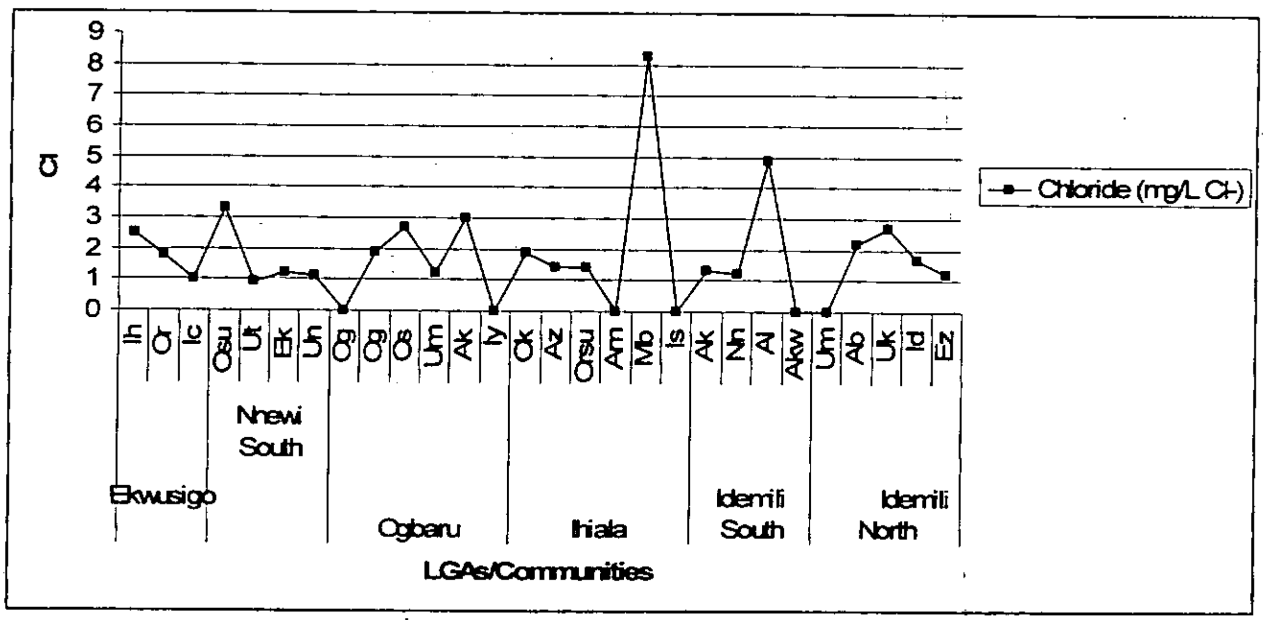


Fig.6.8: Chloride Plot of Sampled Water Sources

Note: Ih= Ihembosi, Or= Oraifite, Ic= Ichi, Osu= Osumenyi, Ut= Utuh, Ek= Ekwulumili, Un= Unubi, Og ik= Ogwu Ikpele, Og an=Ogwuani-Ocha, Os= Ossomala, Um= Umunankwo, Ak oz= Akili Ozizor, Iy od= Iyiowa Odekpe, Ok= Okija, Az= Azzia, Orsu= Orsumoghu, Am= Amorka, Mb= Mbosi, Is= Isseke, Ak Et= Awka Etiti, Nn= Nnokwa, Al=Alor, Akw=Akwukwu, um= Umuoji, Ab= Abatete, Uk= Uke, Id= Ideani, Ez=Eziowelle.

Taste thresholds for the chloride anion depend on the associated cation and are in the range of 200 – 300 mg/litre for sodium, potassium and calcium chloride. Concentrations in excess of 250 mg/litre are increasingly likely to be detected by taste. High salinity as chloride is highly detrimental to high-pressure boiler systems and stainless steel.

6.6: Dissolved Oxygen Parameters

Dissolved oxygen is an analytical measure of clean or polluted water condition. Oxygen contents of water are influenced by source, raw water temperature, treatment and chemicals or biological processes taking place in the distribution system. Dissolved oxygen reduction in water supplies can encourage microbial reduction of nitrate to nitrite and sulfate to sulfide and increase the concentration of ferrous iron in solution. Subsequently, discoloration occurs when the water is aerated. Conversely, sufficient quantity of dissolved oxygen improves self purification of a river. BOD_5 is a water pollution parameter while COD values are high in polluted water sources.

The results of the DO, BOD_5 and COD tests carried out in the laboratory show the levels and are compared to the recommended standard limits. DO levels of all samples were lower than the 9.0ppm oxygen saturation for fresh water at 20^{0C} and the 7.5 ppm FMEnv limit. The Unubi community borehole sample is the lowest (3.3 ppm). The low reduction in DO values may be due to the time lapse between the sample collection point and the laboratory, but not necessarily due to pollution. The Ekulo Ibollo stream (Ekwusigo), Osemeham borehole (Idemili S.), Orashi River (Ogbaru) and Omaiyi stream (Ihiala) are not really deficient in oxygen.

The high BOD_5 values for Omaiyi stream (Ihiala); Osemeham borehole (Idemili S.) and Opiegbe (Idemili N.) samples indicate that water from these sources contains high organic matter and thus are likely pollution sources. Moreover, the high COD values for Ihiala, Ogbaru, Nnewi S. and Idemili North LGA samples show likelihood that the samples contain high oxidizable organic matter components and may not be fit for consumption. The variations in DO, BOD_5 and COD values are depicted in Figure 6.9.

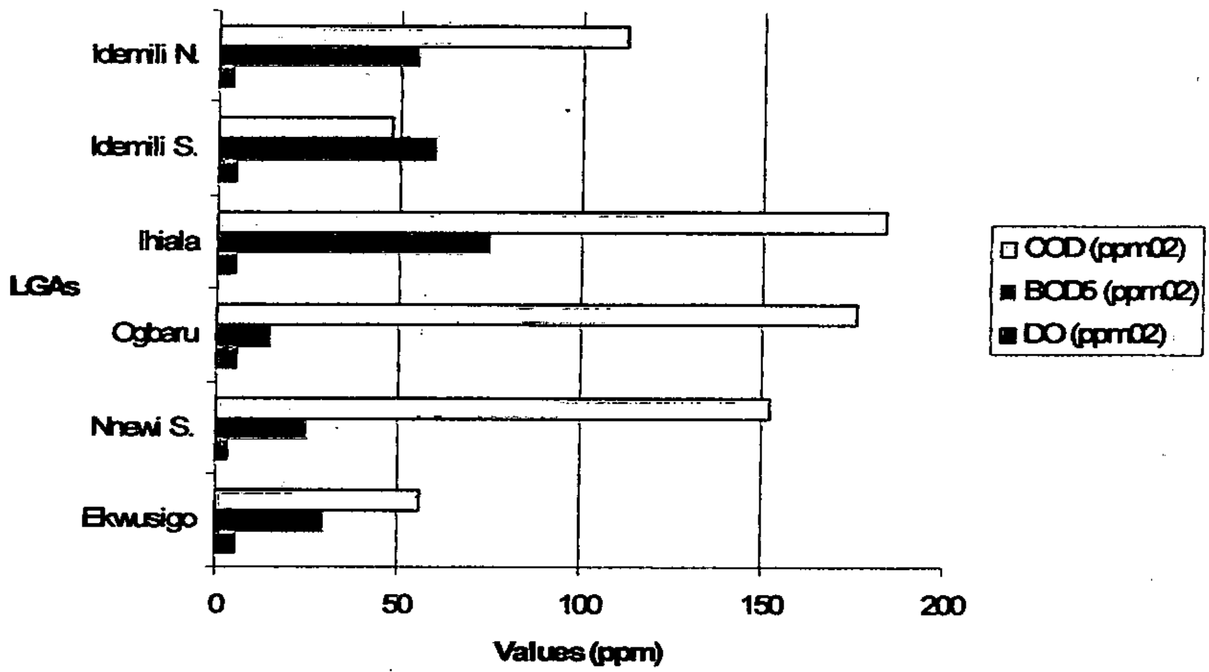


Fig. 6.9: Variations in DO, BOD_5 and COD of water samples
FMEnv limit: DO =7.5ppm; BOD_5 = 0.0; COD = NIL

6.7: Microbiological Parameters and Analysis

The most probable number (MPN) and the membrane filtrate in (MF) methods discussed in the methodology section were used to determine the total coliform, fecal coliform (Escherichia coli), and the aerobic mesophilic bacterial and fungal counts of the water samples.

Significant high *total bacterial* count for *Ogbaru, Ekwusigo and Idemili North LGAs* were recorded. Ogbaru count of 120ctu/ml and Ekwusigo count of 102 ctu/ml are the highest count values and therefore indicate high presence of total mesophilic bacteria and disease-causing organisms. Omaiyi stream, Azzia in Ihiala LGA with (16 ctu/ml) is slightly above the WHO limit of (10 ctu/ml) while Idemili South sample (8ctu/ml) is a bit below the recommended limit so both samples are fairly acceptable. Table 6.6 shows the count values.

Table 6.6: Microbial Count values in Anambra SW

Microbial Counts	Sample Names and Locations					
	Oseheham Community Borehole Akwukwu, Ekwusigo LGA	Orashi River Ogwuani-Ocha, Ogbaru LGA	Community Borehole Unubi, Nnewi South LGA	Opiegbe Stream Ideani, Idemili North LGA	Ekulo Ibollo Stream, Oraifite Idemili South	Omaiyi stream Azzia, Ihiala LGA
Total (Mesophilic Bacterial Count(ctu/ml)	8	120	54	86	102	16
Coliform Count (ctu/mol)	0	25	2	6	6	1
Feacal Coliform Count (cfu/mol)	0	2	0	0	1	0
Micro Organisms Isolated	Bacillus Spp	Klebsielle Sp, Bacillus Sp, Proteus Sp, Escherich a Coli, Aspergilus Niger	Bacillus Sp, Klebsiella Sp	Staphylo-Coccus Sp, Klebsiella Sp, Bacillus Spp, Alternaria Spp. Aspergillu s Spp,	Proteus Spp, Enteroba oter Spp, Seriatia Spp	Chromo genic Bacteria, Citrobac ter Spp, Staphylo coccus Spp, Aspergil lus Sp, Cladosp orium Sp

WHO Limit: Total (Mesophilic Bacterial Count) = 10 ctu/ml; Coliform Count = Nil; Feacal Coliform Count = 0 cfu/mol

The *coliform* count for Ogbaru sample is very high at 25 ctu/mol, while the *feacal coliform* count is 2 cfu/mol as against the standard limit of zero indicating significant pollution. Other samples have low values indicating presence of little or no coliform. Thus, Ekwusigo, Ogbaru and Idemili North samples could cause diseases in the near future if not treated and protected.

The isolated micro-organisms from water samples in the study area simply aligns with JICA/NWRMP, 1995 statement that "The presence of disease causing micro-organisms in the study area is not unexpected because tropical climates have historically been conducive for a wide variety of disease organisms and vectors with the exposure cycle revolving around water".

Pollution and agricultural wastes, water contaminants of foreign matter such as micro-organisms, chemical run off, and industrial or other wastes, or, raw sewage takes large supply of water volumes away every year and worse still causes sickness and death in those without choice than to drink tainted water that is unsafe (Gonzalez and Sherer, 2004).

Pollution deteriorates water quality rendering it unfit for its intended uses. Traditional risks of infectious and parasitic diseases are often the resultant effects. Therefore, contaminated water could be the source of large outbreaks of diseases such as cholera, dysentery, typhoid fever, diarrhoea, hepatitis and cryptosporidiosis. Water borne pathogens are most times responsible for contamination and transmission to victims and are introduced into drinking-water supplies through human or animal faeces. Infection is thereby initiated into the gastrointestinal tract by ingestion, inhalation (leading to infections of the respiratory tract) and contact (leading to skin and brain infections). The disease causing microorganisms isolated in study samples are as follows:

i. Escherichia Coli

Escherichia coli (thermotolerant coliforms) are of vital importance in drinking water monitoring and verification. Escherichia coli are present in very high numbers in human and animal faeces thus serve as an indicator of faecal pollution. Waterborne transmission of pathogenic E. coli is dominant in recreational waters and contaminated drinking-water therefore can cause serious diseases such as urinary tract infections, diarrhoea (ranging from mild and non-bloody to highly bloody, which is indistinguishable from haemorrhagic colitis), bacteraemia, meningitis and potentially fatal haemolytic uraemic syndrome (HUS), which is characterized by acute renal failure and haemolytic anaemia (WHO, 2006). E. coli is also a major cause of travellers' diarrhoea detected by coliform counts.

ii. Total Coliform Bacteria

Total coliform bacteria involve aerobic and anaerobic bacteria that grow in the presence of relatively high concentrations of bile salts with the fermentation of lactose and production of acid or aldehyde within 24 hours at 35 –37$^{oC.}$ The group includes a wider range of genera, such as Serratia and Hafnia, which occurs in sewage (feacal) and natural waters (environment) and grow in water distribution systems, particularly in the presence of biofilms. The presence of total coliforms in distribution systems and stored water supplies reveal inadequate treatment, regrowth and possible biofilm formation or contamination of foreign material such as soil or plants.

iii. Bacillus Spp.

Bacillus spp. commonly occurs in a wide range of natural environments, such as soil and water. Resistance of spores to disinfection processes of water treatment. Bacillus cereus is known to cause bacteraemia in immunocompromised patients as well as symptoms such as vomiting and diarrhoea. Bacillus anthracis causes anthrax in humans and animals. The routes of transmission of these bacteria include inhalation and contact (bathing), with infections occurring in the respiratory tract, in skin lesions or in the brain.

iv. Klebsielle

Klebsiella spp. is non-motile bacilli that belong to the family Enterobacteriaceae. The genus Klebsiella consists of a number of species, including K. pneumoniae, K. oxytoca, K. planticola and K. terrigena. Klebsiella spp. are natural inhabitants of many water environments and may multiplies in waters rich in nutrients, such as pulp mill wastes, textile finishing plants and sugar-cane processing operations. In drinking-water distribution they occur in the 40- to 70-year age group. Risk factors include cancer, diabetes, chronic respiratory or kidney disease and immunosuppression, as in transplant recipients. For Pontiac fever symptoms are similar to those of influenza such as fever, headache, nausea, vomiting, aching muscles and coughing.

v. Vibiro Spp.

Vibrio spp. are pathogenic species, including V. cholera, V. parahaemolyticus and V. vulnificus. Vibrio cholerae is the only pathogenic species of significance from freshwater environments. Cholera outbreaks continue to occur in many areas of the developing world. Symptoms are caused by heat-labile cholera enterotoxin carried by toxigenic strains of Vibiro detected in the absence of E. coli.

vi. Staphylococcus Spp.

Staphylococcus aureus is an aerobic or anaerobic coccus, associated with diseases in humans. Although *Staphylococcus aureus* is a common member of the human microflora, it can produce disease through two different mechanisms. One is based on the ability of the organisms to multiply and spread widely in tissues, and the other is based on the ability of the organisms to produce extracellular enzymes and toxins. Infections based on the multiplication of the organisms are a significant problem in hospitals and other health care facilities while multiplication in tissues can result in manifestations such as boils, skin sepsis, post-operative wound infections, enteric infections, septicaemia, endocarditis, osteomyelitis, pneumonia and even abortion in pregnant women.

vii. Enterobaoter Spp

a. Salmonella spp.

Salmonella spp. belongs to the family Enterobacteriaceae. They are bacilli that do not ferment lactose, but produce hydrogen sulfide or gas from carbohydrate fermentation. Salmonella infections typically cause four clinical manifestations: gastroenteritis (ranging from mild to fulminant diarrhoea, nausea and vomiting), bacteraemia or septicaemia (high spiking fever with positive blood cultures), typhoid fever / enteric fever (sustained fever with or without diarrhoea). In regard to enteric illness, Salmonella spp. can be divided into Salmonella typhi and

S.Paratyphi. It is mostly prevalent in areas with poor sanitary and there are many millions of cases each year. Waterborne typhoid fever outbreaks have devastating public health implications.

b. Shigella Spp.

Shigella spp. is a member of Enterobacteriaceae family and they grow in the presence or absence of oxygen. Their presence in drinking- water indicates recent human faecal pollution. Shigella spp. can cause serious intestinal diseases, including bacillary dysentery which may proceed to an ulceration process, with bloody diarrhoea and high concentrations of neutrofils in the stool. Most cases of Shigella infection occur in children under 10 years of age. Other symptoms include abdominal cramps, fever and watery diarrhoea in early stage.

Other organisms isolated are Seriatia spp. (part of total coliform bacteria), Chromogenic bacteria, Citrobacter spp., Cladosporium spp., Proteus spp., Aspergilus spp., Aspergilus niger and Alternaria spp.

Water treatment is recommended in cases of doubtful water quality, to remove or destroy pathogenic micro-organisms present in the water. Several measures are often adopted by the villagers to treat and preserve their water, especially for domestic uses which includes boiling water, the most commonly recommended method that is widely understood and simple to carry out and is effective against virtually all pathogens. The cost however of at least 1kg of wood or charcoal to boil 1litre of water for domestic use has some cost implications.

Chemical additives of chlorine and alum are also used in treating water. Water stored over long periods is purified and made healthy for consumption with native substances like alum and certain local weeds. Also certain native spicy substances, notably *uhiokirihio* and *ohiri*, are used in water treatment to give the water some lovely taste. The villagers also practice the act of using white transparent cloth to filter their drinking water. Water containers are often covered with lids to prevent pollution and discourage breeding of mosquitoes and other vector-carrying insects in the stored water.

6.8: Health and Socio-Economic Implications of Poor Water Quality

a. Water Diseases and Causative Micro-Organisms

Limited quantity of water implies water insufficiency which limits suitability, contributes to poor hygiene, indecent sanitation and denies children education right due to time spent in search of water. On the other hand, poor quality deteriorates health leading to water diseases and epidemic situations. Mass killer diseases such as cholera, infectious diarrhoea, Onochocercias, schistomiasis, dengue fever, malaria and others remain global threats and challenges to countries without access to safe drinking water and sanitation.

In 2001, global deaths from infectious diarrhoea were 2 million for all ages with over 70% occurrence in developing countries (Vanguard, 2004). UNICEF (2006), reports that over one billion people still use unsafe drinking water sources with thousands of children dying from diarrhoea and other water sanitation and hygiene related diseases daily. Intestinal worms infect about 10% of the population of the developing world and could lead to malnutrition, anaemia or retarded growth and diminished school performance in severe cases. Trachoma, a disease caused by the lack of water combined with poor hygiene practices has caused blindness in about 6 million people while Schistosomiasis has about 200 million infected people. Cholera which is a world-wide problem, especially in emergency situations can be prevented by access to safe drinking water, sanitation and good hygiene behaviours.

Unprotected water sources also get contaminated easily and the quality of drinking water suffers while consumers' health is endangered. This could be in form of water diseases, epidemic break out and deaths in severe cases. Moss, (2007) reiterates that excessive amounts of microbes or chemicals derived from human and animal wastes, agricultural runoff, industrial chemicals and even natural pollutants also make water unsafe and cause water-related diseases.

The 1993 WHO guidelines for drinking water quality classify diseases transmitted by drinking water as occurring always, commonly and occasionally. Cholera, E.coli, hepatitis A. and typhoid fever are common; Drancunculiasis (guinea worm) occurs always while Shigella is occasional (Reiff, 1994). Table 6.7 shows the prevalent water diseases and their causative organisms in the study area.

Table 6.7: Prevalence of Water Borne Diseases in the Study Area

Water borne diseases	Major causative organism	LGAs (1) Ekwusigo	(2) Nnewi South	(3) Ogbaru	(4) Ihiala	(5) Idemili South	(6) Idemili North	Ave. (%) of total within LGAs
Cholera	Vibrio spp.	25.9%	2.3%	**47.3%**	12.3%	3.1%	10.2%	17.8
Dysentery	Shigella spp	17.2%	8.4%	11.8%	13.2%	13.7%	12.0%	12.3
Diarrhoea	E. Coli	5.2%	12.2%	9.4%	14.5%	15.3%	8.4%	11.4
Typhoid Fever	Salmonella	51.7%	39.7%	11.3%	54.5%	50.4%	**58.1%**	**42.6**
Dermatitis	Bacillus spp	2.3%	13.8%	3.2%	5.3%	9.6%	2.3%	6.7
Others	Staphylococcus	35.1%	2.0%	.5%	.8%	1.2%	35.1%	5.9
All Of Above	all	4.4%	1.8%	11.5%	.6%	4.4%	1.8%	3.2
☼Isolated Microorganisms	-	Proteus spp, Enterobaoter spp, Seriatia spp	Bacillus sp, Klebsiella spp	Klebsielle sp, Bacillus sp, Proteus sp, Eschericha coli, Aspergilus niger	Chromogenic bacteria, Citrobacter spp, Staphylococcus spp, Aspergillus sp, Cladosporium spp	Bacillus spp	Staphyloccus sp, Klebsiella spp, Bacillus spp, Alternaria spp. Aspergillus spp.	

Source: Field survey and Microbiological (☼) result, 2007

Cholera (47.3%) is dominant in Ogbaru LGA rural communities but typhoid fever cuts across the study LGAs (42.6%) but importantly affects more than half of the people in Ekwusigo (51.7%), Ihiala (54.5%), Idemili North (58.1%) and Idemili South (50.4%) LGAs. Dysentary, diarrhoea and dermatitis are other common diseases and unlisted are malaria, intestinal worms, trachoma, schistosomiasis and hepatitis.

The rural health centre records (Table 6.8) align with the high rate of typhoid fever across the study LGAs as well as malaria. Cholera cases are dominant in Ogbaru LGA and an average of 19 persons monthly suffer from water related diseases while in extreme cases averages of 6 deaths are recorded across the LGAs.

Table 6.8: Rural Health Centre Records on Water Borne diseases and Deaths

Water Borne Diseases	LGAs						
	(1) Ekwusigo	(2) Nnewi South	(3) Ogbaru	(4) Ihiala	(5) Idemili South	(6) Idemili North	Avc. (%) of total within LGAs
Cholera			Ω				
Dysentery				Ω			
Diarrhoea		Ω		Ω			
Typhoid Fever And Malaria	Ω	Ω	Ω	Ω	Ω	Ω	Ω
Dermatitis			Ω				
Ω Monthly Report Of Affected Persons	< 10	<31	>26	< 10	< 10	21 – 31	19
Ω No Of Death Cases	Nil	21	5	Nil	Nil	11	6

Source: Field Survey; Health centre (**Ω**) reports, 2006

Thus, poor health affects human labour for food production and diminishes rural income. Time and money are also spent in treating the diseases and water sources. Prevention of these diseases could thus be achieved through access to safe drinking water, sanitation and good hygiene behaviours (UNICEF, 2006).

Water diseases could be categorized through either of the following transmission methods namely: water-based, water-washed and water-borne and water related as is depicted in (Figure 6.10). The greatest risk from microbes in water is associated with consumption of drinking-water that is contaminated with human and animal excreta, although other sources and routes of exposure such as inhalation of droplets or contact with drinking-water may also be significant.

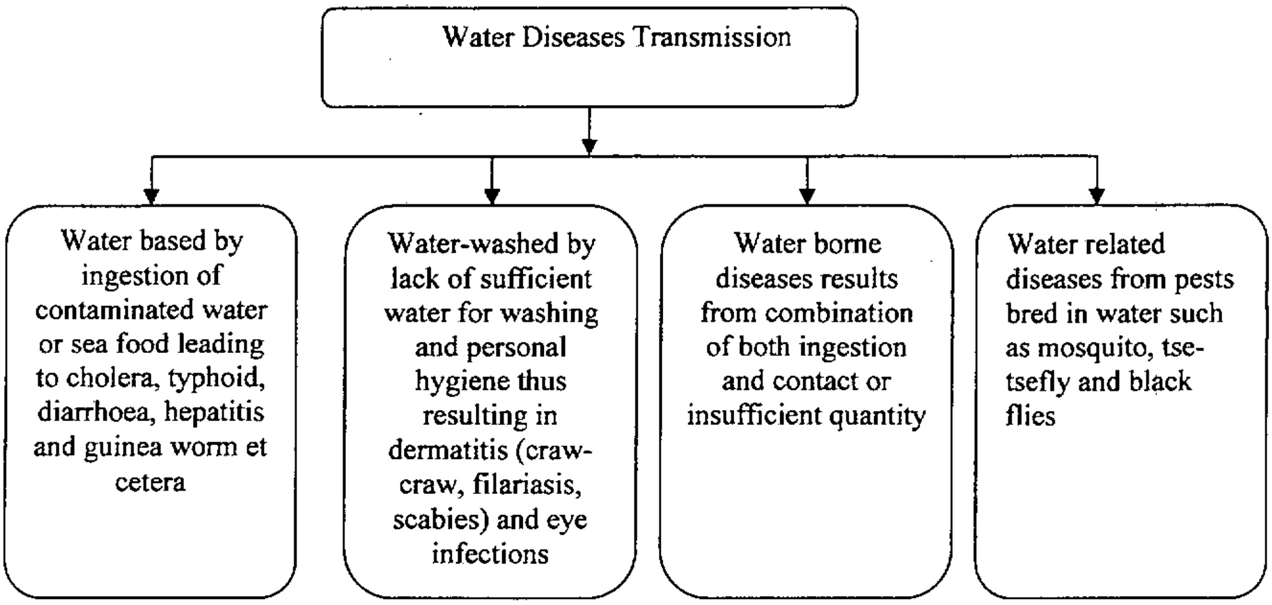


Fig. 6.10: Transmission Routes of Water Diseases
Source: UNICEF, 2006 and Oyebande, 1998

Diseases related to contamination of drinking-water constitute a major burden on human health; however, interventions to improve the quality of drinking-water provide significant benefits to health. The relationship between the drinking water quality and associated water diseases in the study area is an issue of concern due to the following lapses in the government, private and health sectors:

- Short time span of monitoring
- Difficulty in assigning disease cases to specific water supply routes
- Variations in record keeping of different clinics and health care centres and the need to standardize it.

The lapses create the need for intensive water quality monitoring and regulation from time to time by Anambra State Water Corporation. Water borne disease outbreak investigation and reporting should not only be for identification and early prevention but for identifying research needs and providing opportunities for studying the exposed population (Ojo, 1994).

b. Rural Water Supply and Development

*R*ural water promotes rural development by supporting economic activities such as inland navigation (transportation) and fishery, inter-intra community relations at R. Niger and R. Urasi, Ogwuani-Ocha in Ogbaru LGA; sand dredging for brick making and cultural (ritual) activities at Opiegbe stream in Ideani, Idemili North LGA and recreational activities at Omaiyi stream in Azzia, Ihiala LGA. Rural water sources also satisfy established seasonal shortages especially during the dry seasons.

The SWOT analysis also known as TOWS Matrix in Table 6.9 identifies the strength, weakness, opportunities and threats to water supply in the study area. The SWOT analysis report is instrumental to strategy formulation and selection as well as guideline assistance for future water projects development.

Every water consumer plays an important role in the collection, distribution, treatment and storage of water. Consumer actions may help to ensure the safety of the rural water they consume by wishing to treat domestic water so as to increase their confidence in its safety. The national activities of Rural Water Supply and Sanitation Agency (RUWASSA), an European Union funded project in the provision of potable water through drilling of boreholes in different rural communities; as well as the federal motorised borehole projects construction in the study area all aim towards achieving adequate access to potable water.

Table 6.9: SWOT Analysis of Rural Water Supply

	Strength	Weakness	Opportunity	Threat
1.	Cost free streams, rivers and springs, which boost economic activities of fishing, transportation, sand dredging and recreation.	Water pollution by washing, bathing, defecating, swimming activities and channeling or dumping of wastes in drinking water sources. This creates inadequate opportunity for self purification	Existence of alternative and variety of water sources such as rainfall, streams, rivers, boreholes and water vendors, thereby providing some competition and check on arbitrary price hikes.	Large and variable population concentration amongst different communities and study LGAs, thus poor water services for instance the Ogwuani-Ocha's of Ogbaru LGA with a population of above 14,000 (1996 census projection) being served by a single water source, the Orashi River.
2.	Community water project initiatives such as community boreholes and markets built by age grades and associations.	Poor funding of water projects and delays in repairing or replacing spoilt water facilities	Encourages borehole drilling in different homes and communities through private and community efforts respectively.	Unprotected water sources and water contamination causes threat to groundwater, failed boreholes, water diseases, illnesses and hospital visits for water consumers.
3.	Rural water supply and sanitation initiatives (RUWASSA) through drinking water projects that will assist communities and ensure continuity.	Limited water services due to distance to rivers and streams, seasonal shortages, time regulated boreholes, commercial borehole owners and water vendors.	Creates room for improvement and sustainability of rural water through provision of protected water sources as well as water treatment measures of boiling and chemical additives.	Poor hygiene and sanitation as a result of water shortages and epidemics in most cases.
4.	Seasonal variations as a preparatory step for rural dwellers to increase water gathering.	Time and energy consuming for water haulers.	Improved rain harvest technologies and water vending opportunities.	Educational and socio economic setback for most children and women that haul water.

Source: Field Survey, 2006

Similarly, private sector participation (PSP) through the efforts of community associations and development unions' has established several water projects free of charge for the rural dwellers. The Non-governmental organizations (NGOs) and international organizations such as the World Bank, UNICEF, the Department for International Development (DFID) amongst others contributes in funding rural water supply infrastructural projects and rural health care delivery systems. The socio-economic significance of the infrastructure provision activities, the problems and consequence is characterized in Table 6.10. Re-orientation of the beneficiaries will help in sustainability of these projects.

Table 6.10: Socio-Economic Significance of Rural Water Problems

Problems	Consequences	Economic and social significance
Climate variation	Fluctuation in water supply	Uncertain planning and development targets
High population growth	Increased water demand competition and pollution	Reduced living standard and health problems
Conflicts and lack of integrated water policy	Water pricing and allocation	Destabilizing the economy
Financial Constraints	Inadequacy in meeting demand	Increased health problems

CHAPTER SEVEN

SUMMARY OF RESULTS/FINDINGS AND MANAGEMENT IMPLICATIONS

7.1: Summary of Results and Findings

Anambra SW constitutes nine LGAs out of which Onitsha North, Onitsha South and Nnewi North have no rural communities. The sampled 28 rural communities are situated in the six LGAs of Ekwusigo, Ihiala, Ogbaru, Nnewi South, Idemili North and Idemili South LGAs. The rural water supply studies conducted show that the major sources of water in the study area are rivers, streams and springs (37.1%), deep wells and boreholes (26.5%) while other sources include roof catch rain harvest, public stand pipes as well as water vendors. These water sources, supply water for domestic consumption but are mostly unimproved water sources (Table 4.2) except for protected dug well, public stand pipes and rain water (UNESCO, 2006).

Access to potable domestic water in the study area is basic considering the accessibility indices: average timing of 10 – 30mins (36.1%), cost free (24.9%) and ₦5 - ₦25 (24.1%), distance of < 100m (39.2%), and children as major water haulers (48.3%). Howard and Bartram (2003) in their access categories (Table 2.4) however reiterate that health is not assured. Domestic water consumption for a typical rural household (nuclear) of 4 to 6 persons is between 100 and 175 litres with averages of between 25 litres (minimum) and 29.2 litres (maximum) per individual conforming to the UN global reasonable access level of 20litres. However at periods of water insufficiency, supplementary quantities of 37.5 (minimum) and 41.7(maximum) litres are consumed individually and between 150 and 250 litres by households.

The total domestic water consumption and population growth studies (Table 5.9) conducted in the study area exhibits a strong built-in and parallel relationship because as the population increases, the volume of water consumed becomes higher. The Rural Threshold Water Consumption (RTWC) model for domestic water consumption evaluation in the study area generated a threshold balance or planning constant value of k =139 thereby identifying Nnewi South and Ihiala LGAs as water surplus zones while Ekwusigo, Ogbaru, Idemili South and Idemili North LGAs are zones of water supply deficits. The water demand variation signifies that the demand gap of 33 litres needs to be bridged. Patterns of water distribution vary across the LGAs and communities ranging from water reservoirs to the use of overhead tanks, stand pipes, water tankers and vendors. Water shortages in the study area occur mostly occasionally (66.2%) and at dry periods (63.7%) thereby making people resort to boreholes and water vendors (54.4%) at a cost and on distant streams and rivers (33.2%) for domestic water.

The laboratory analysis of water samples for water quality verification reveals the acidic pH of most streams and free private boreholes; high alkalinity of most rainwater samples and extreme high iron and turbidity values of Ogbaru LGA samples which impair water appearance, taste, acceptability and could as well pose some health risks to consumers. The high BOD_5 values for Omaiyi stream (Ihiala); Osemeham borehole (Idemili S.) and Opiegbe (Idemili N.) samples and corresponding high COD values for Urasi River, Ogbaru (176 ppm), Omaiyi stream, Ihiala (184 ppm) and Opiegbe stream Idemili North (112.0 ppm) LGAs signifies the presences of high oxidizable organic matter and susceptibility to water pollution thus, are likely unfit domestic consumption sources. The prevalence of water diseases in the study area such as cholera (17.8%), dysentary (12.3%), diarrhoea (11.4%), typhoid fever (42.6%) and dermatitis (6.7%) as well as the health centre average monthly record of 19 people suffering from water related diseases confirm the growth and presence of micro-organisms in their water sources. Threats of epidemics and deaths are also registered in the study area, thereby underscoring the need for water treatment which is not a common practice in the concerned rural communities.

The socio-economic implications of inadequate access to potable domestic water supply in the study communities are evident in the case of children and women who spend most of their time in water collection and forfeiting some necessities such as education (33.1%), food, shelter and clothing in the bid to obtain potable water. Affordability and level of income of the rural water consumers has strong ties with the willingness to pay higher rates for water as well as water treatment costs and choice of water quality. Health wise, the prevalence of water borne diseases and health records of affected people and deaths decreases living standard and could possibly increase poverty levels.

7.2: Management Implications of Findings

This section appraises the efforts of rural consumers, local, state and federal government to maintain access to potable domestic water in the study LGAs. However, formulation of policies and management measures is required to:

- Identify the water needs of people, plan, monitor and design rural water system activities
- Establish minimum standards and targets using RTWC model and international guidelines
- Adopt local methods to support water services and education (Oyebande and Balogun 1992) such as improved rain harvest and water conservation techniques and minimization

of water pollution through direct channeling of wastes to water points

- Re-orientate the rural consumers towards the use and protection of rural water sources
- Harness surface water in most rural LGAs
- Increase subvention to rural water agencies by the State government
- Employ skilled manpower to handle water facilities;
- Provide pipe borne water and regulate boreholes for good water quality in different localities as well as to
- Adopt appropriate low cost water technologies which rural communities in Anambra State could maintain.

The rural water supply methodology for the study area will serve as a technique to redress inadequate rural water provision and services to all rural communities.

7.3: Contributions to knowledge

The research has been able to:

- Generate detailed information on major Anambra SW rural water characteristics and key domestic water access indices of timing, distance, cost and socio-economic variables.
- Develop a simple rural threshold water consumption model (RTWC) for domestic water consumption quantification at different periods as well as delineation of zones of water surplus, deficit and balance in the study area.
- Determine the water quality of the major rural water sources; physically, chemically and biologically while isolating the disease causing micro-organisms and their prevalent diseases in the study area
- Contribute valuable data to the multi-dimensional rural water data bank which will avail

the water sector planners and decision makers since inadequate domestic water access and poor water quality in the rural areas could lead to poor health, low productivity and food insecurity.

7.4: Conclusion

The rural water studies investigation has demonstrated the use of accessibility variables and water quality parameters to establish the level of domestic water consumption access and variations at the rural scale. The Rural Threshold Water Consumption (RTWC) model is developed as an analytic tool for water consumption measurements in rural communities as well as a planning kit for the water sector planners and decision makers for water allocations and management. The model provides first class and detailed information on the water sources of rural communities studied. The attainment of the basic and reasonable access level in the study area however does not ascertain excellent water quality in the study area because poor water quality and associated water related diseases are issues of concern for the health and safety of water consumers. At the same time, the exceedance of the United Nations reasonable access level of 20 litres of water per capita per day has not made the MDGs target of 75 litres per capita per day by the year 2015 achievable for Nigeria. Finally, proper utilization and management of available water through adequate water reforms and regulations such as protection, conservation, planning and re-development will improve continuity and sustainability of rural water especially in Anambra SW.

7.5: Recommendations

The following recommendations are proffered based on the research findings as a step towards long term solutions to water problems at the rural scale.

- The adoption of traditional and scientific knowledge for rural water solutions in the study area to improve water harvesting, conservation and protection.
- Reinforcement of environmental conservation practices in the study area through education and enlightenment programmes for adequate knowledge of the geophysical conditions for continued existence of rural water sources.
- Integration and implementation of the RTWC model threshold value of K by water planners and decision makers

References

Abrahams, L. (1996). Capacity building for water supply and sanitation development at local level. "The threshold concept". 2nd UNDP Symposium on water sector capacity building. Delft, The Netherlands, 4- 6 December. Web site: http://www.africanwater.org/index.htm

African Development Bank, ADB (2004). Rural Water Supply and Sanitation Initiative for Nigeria. African Development Bank and Swedish Consultant Trust Fund, Sept. 24.

Anambra State Survey (1997). Administrative Map of Anambra State, Awka, Nigeria.

Anambra State of Nigeria (1999). Official Gazette, Anambra State Water Corporation Edict No. 3, Vol. 9, May 7.

Annan, K (2003). International Year of Freshwater. Third world water forum, March 16-23, Kyoto, Japan.

Asare, Y. B.O (2004). Household water security and water demand in the Volta Basin of Ghana. Ph.D Thesis.

Basic Environmental Health Course, BAHC (2007). Concepts of Water Supply Protection. Retrieved June 30, 2007. Basic Environmental Health Course, School of public health, University of Albany, New York. Web site: http:// www.albany.edu/sph/coned

Bob-Duru, R.C. (2001). Rural Settlements in Nigeria: Survival or Demise? In Ofomata G.E.K and Phil-Eze P.O (Eds.), *Geographical Perspectives on Environmental Problems and Management in Nigeria* (pp.96). James Enterprises Nigeria.

Bumatay, C.G. (2004). Water Use in Metro Manila and Metro Cebu. National Water Sources Board, Quzon city, Phillipines. Web site: www.worldbank.org

Doodge, J.C.I (1985). Climate and Water Resources, WMO No. 675.

Dooley, T (2008). Millions mark United Nations Hand Washing Day. October 15. Website:

http://www.news.bbc.co.uk.

Encarta (2006). Water Access. In *Encarta Encyclopedia. Microsoft® Encarta®* 2006 [CD]. Microsoft Corporation.

Encyclopedia Britannica (2003) "Water Resources" Encyclopedia Britannica Deluxe Edition CD-ROM.

Federal Ministry of Water Resources, FMWR (2003). Water supply and sanitation Programme. Federal Ministry of Water Resources. March 15. Web site: www.nopa.net.

Federal Republic of Nigeria, FRN (2000). Water Supply and Sanitation Interim Strategy Note. Federal Ministry of Water Resources, Abuja, April and November.

Gash, J.H.C, Odada, E.O, Oyebande, L. and Schulze, R.E (2001). *Freshwater Resources in Africa*: Biospheric aspects of the Hydrology Cycle (BAHC) International Project Office, Potsdam Germany, (pp.3-6).

Gonzalez J. and Sherer Jr. T.E (2004). The complete idiots guide to Geography. 2nd Edition. Alpha Books New York, (pp.391 – 395).

Hanidu, J. A. (1990). National Growth, water demand and supply strategies in Nigeria in the 1990s. Nigerian Association of Hydro geologists (NAH) Vol. 2(1).

Handy, S.L and Niemeier, D.A (1997). Measuring accessibility. *An Exploration of issues and alternatives.* Environment and Planning A, Vol. 29 (7), 1175 -1194.

Howard, G and Bartram, J (2003). 'Access' in Water a shared responsibility. The United Nations World Water Development Report 2. Pg.224-227. UNESCO

International Water and Sanitation Centre, IRC (2003). Community water supply management. Retrieved June 28, 2007, from International Water and Sanitation Centre. Web site: http://www2.irc.nl/manage/index.html

Jeje, L.K (2001) Drainage basin Development and the Environment in Ofomata G.E.K and Phil-Eze P.O (Eds.) Geographical Perspectives on Environmental Problems and Management in Nigeria pp.53. James Enterprises Nigeria.

JICA/NWRMP (1995). The Study on National Water Resources Master Plan (NWRMP) Summary and main text. Japan International Co-operation Agency, Federal Ministry of Water Resources and Rural Development vol.1, 2-39

Koinyan, L.D (1989). "Integrated Rural Development". 'The Peoples' Programme. DFRRI, Lagos. Directorate for Food, Roads and Rural Infrastructure.

Luijten, J.C (1999). A tool for community-based water resources management in hillside watersheds. Ph.D dissertation. University of Florida, Gainesville, FL. http://etd.fcla.edu/etd/uf/1999/amp7392/luijten.pdf

Luijten, J.C., Knapp, E.B and Jones, J.W (2001). A tool for assessing the implications of development on water security in hillside watersheds. Agric. Syst. 70(2-3): 603-622.

Masley, E.P.K. (2004). How safe is the water that we drink everyday in Africa? Retrieved January, 2006. Web site: http://www.emag.uni-bremen.de/emag/2004/projects

Moss, J. (2007). New web site targets World's unsafe drinking water. Voice of America, September 16, 2007.

NIMET (2006). Rainfall data of Onitsha station, Anambra State. Nigerian Metrological Agency, Oshodi, Lagos.

NPC (2006). National Population Census figures for 2006. National Population Commission.

NPC (1996). Locality list, 1996 projection figures. National Population Commission.

Okeke, I.C (2004). The Role of Women and NGO'S in Food Security, Health, Climate. In Gbuiro et al (Eds.) Climate and water resources in the 21st century: challenges for food security and health conference Proceedings. NMS, Abeokuta, Nigeria. 16th to 18th November, (Pp.14 -21).

Oki, T.V.C. and Heal, K. (2006) Hydrology 2020. An Integrating Science to meet World Water Challenges. IAHS publication 300. IAHS Press, Oxford shire UK.

Okpalamma, L.U (1989). The Effect of Differential Modernization; Agricultural labour supply in Anambra State, Unpublished Ph.D Dissertation, University of Nigeria, Nsukka.

Ologe, K.O. (2004). *Geography of Nigeria.* CSS 108: Course development for National Open University of Nigeria. Heinemann Educational Books, Nigeria Plc. pp.59-62.

Ojo, O. (1994). Indicators of Health Risks from Surface Water and Groundwater Contamination in Urban Centres of Nigeria: In Assessing and Managing Health Risks from Drinking water contamination: Approaches and Applications. Reichard, E.G and Zapponi, G.A (Eds) IAHS publication 233, (pp 35 - 41).

Oni, S. I., Asenime, C and Ege, E. (2004). Rainwater Harvest Principles in Edo State, Nigeria: Challenges for food security and health: In Regional conference proceedings on Climate and Water Resources for food security and health. NMS, (pp.52-59)

Online Nigeria (2003, Jan. 29). Daily news. Anambra State, physical setting. Retrieved April 25, 2007. Web site: http://www.onlinenigeria.com

Onwumerobi, A.C. (1993). Anambra State. In Udo R.K and Mamman, A.B (Eds). Nigeria, Giant in the Tropics State Surveys. Heritage Edition, Gabumo Pub. Co Ltd, Lagos. Vol.2, pp.68-74

Opara, A.A. (2006, Feb. 28). Water supplies in some rural communities around Calabar. Cross River State, Nigeria: In African Journals Online, Tropical Freshwater Biology 2003/2004 Vol. 12/13, pp.93-98. Retrieved, March 7, 2007. Web site: www.ajol.info:article/24323

Oyebande L. and Balogun I. (1992) Water resources Development in West Africa beyond the year 2000. Problems, needs and priorities. In Sustainable water resources management in Arid Countries. Canadian Journal of development studies. Special issue. International water Resources Association.

Oyebande, L. (1998). The Water Cycle: Courier of Health and Wealth. How Sustainable is it? Unilag press. Inaugural lecture series. pp.34-35

Oyebande, L. (2004). Fostering Implementation: Know how for Action. African pre-Conference on Water for Food and Ecosystems: Make it happen. Sponsored by Govt. of Netherlands, IUCN and UNECA.Held at UNECA, Addis Ababa, Ethiopia. Nov 4-6.

Oyebande, L. (2006). Appropriate administrative structures in harnessing Water Resources for Sustainable growth in Nigeria: In Journal of Mining and Geology Vol.42 (1),15-20 Nigeria Mining and Geosciences Society (NMGS, Nigeria).

Punch Newspaper (2005, January 30). Federal Ministry of Water Resources, Federal Rural water Supply Programme. P. 37

Reiff, F.M (1994). Assessing and Managing Health Risks from Drinking water contamination: Approaches and Applications. Reichard, E.G and Zapponi, G.A (Eds) IAHS publication 233, (pp 27 -29).

Rosen, S. and Vincent, J.R. (1999). Household water resources and rural productivity in Sub-Saharan Africa: a review of the evidence, Development discussion paper No. 673, Harvard Institute for International Development, Harvard University.

Sanders, R.J and Warford, J.J (1976). In village water supply Washington, D.C. World Bank. World Bank Village Water Supply, Washington. http://www.unesco.org/science/wsc

Scholz, M. (2003). Tapping into the problem of water shortages in Nigeria Retrieved on May 5,

2007. Web site: http://www.id21.org Nov. 4

Society for Family Health, SFH(2007). Nigerian society for family health an NGO. Retrieved on June 14, 2007. Web site: http://www.psi.org/

Stoveland, S. and Bassey, B.U. (2000). Status of Water Supply and Sanitation in 37 Small Towns in Nigeria. Abuja, Donor Conference. 2 - 4 February. Web site: http://www.stoveco.com-Nigeria.

Tearfund, (2001, March). Running on Empty Report. World Water Day. Thursday March 22nd.

This Day Newspaper, "Water for People, Water for Life Programme" Friday Feb. 18, 2005, Vol. 11, No 3589 pp.42

Uluocha, N. O. (1998). *Reflections on Local Knowledge and Sustainable Environmental Resources Management*, Paper presented at the 41st Annual Conference of the Nigerian Geographical Association (NGA), Held at University of Uyo, Uyo, Nigeria. May 31-June 4, 1998.

Uluocha, N.O (2006). A GIS-oriented domestic water demand simulation and forecasting system. Abuja. 28th Annual National Conference of the Nigeria Cartographic Association, November 6th -10th

UNESCO, WMO (1988). Water Resource Assessment Activities. Handbook for National Evaluation, UNESCO-WMO, Paris/Geneva

UNEP, WMO (1995). Climate Change Information Unit (IUCC) dossier.

UNESCO (2006). Water, a shared responsibility. The United Nations World Water Development Report 2. Pp.224-227

UNICEF (2006a). Progress for children. A report card on water and sanitation. No. 5, Sept. P.30. Retrieved on 23 September, 2007. Web site: http://www.unicef.org/programme/wes

UNICEF (2006b). Water, the challenge. Retrieved on 23 September, 2007. Web site: http://www.childinfo.org

UNUS, S (2005). Water Supply. Retrieved on 20 April, 2007. Web Site: http://www.islamiconline.net

Vanguard Newspaper (2004, January 20). Water supply and sanitation.

WHO, UNICEF (2000). Global Water Supply and Sanitation Assessment Report, WHO/UNICEF, Geneva.

WHO (2004a). World Health Organization. *Water Quality*. 3rd Edition. Retrieved, September 9, 2007. Web site: http://www.who.intwater_sanitation_health/dwg

WHO (2004b). Atlas of Children's Environmental Health and the Environment. Geneva: World Health Organization.

WHO (2006). Guideline for Drinking Water Quality, Vol. 1, 3rd edition incorporating 1st and 2nd addenda. World Health Organization. Web site: www.who.int/water_sanitation

Willem, A. (2007). 'The Water Issue' in Holland Herald, KLM in-flight magazine, November. Pp.23-27

World Bank Water Demand Research Team (1993). The Demand for Water in Rural Areas: Determinants and Policy Implications, *the World Bank Researcher Observer*, 8(1) January.

World Water Council (2000). World Water Vision Commission Report: A water secure World, Vision for Water, Life and the Environment.

Appendix I: Average Monthly Rainfall (mm) Data of Onitsha Station (1974 - 2006)

Month/ Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Total	Ave
1974	0	9.7	83.3	135.4	156.7	205.7	345.4	270	216.9	210.9	0.5	36.1	1671	139
1975	0	7	27.4	120.7	273.8	232	153.7	115.4	213.5	169.9	71.9	10.4	1396	116
1976	0	153.2	53.8	121.6	185.9	289.1	230.4	276.3	308.3	335.5	79.7	31.7	2066	172
1977	8.7	0.4	77.7	64.1	194.1	180.4	303.4	248.6	326.3	264.5	3.8	20.9	1693	141
1978	0	66.4	46.5	248.4	334.9	238.9	192.6	188.6	228.5	236.9	7.9	7.6	1797	150
1979	0	23.5	28.1	189.2	204.1	254.6	182.5	403.6	316.1	146.1	75.2	0	1823	152
1980	0	43.1	88.7	79.9	249.3	174	361.1	173.7	232.4	193.9	67.1	15.6	1679	140
1981	5.6	20.7	32.9	79.3	337.3	315	375.7	123.7	311.8	222.7	24.2	0	1849	154
1982	16.1	53.5	96.4	103.1	235.5	260.3	287.2	177	264.3	211.5	12.8	0	1718	143
1983	0	0	83.4	16.9	216.8	232.4	294.2	114.4	342.2	72.4	6.5	0	1379	115
1984	5.3	0	90.6	116.6	241.1	309.6	237.1	297.3	253.1	117.9	18.6	0	1687	141
1985	6	0	197.3	156.4	255.1	223.4	312.2	273.3	234	127.2	9.5	0.1	1795	150
1986	2.6	27.2	60.2	95.5	222.7	107	265.8	138.6	410.2	216.9	71.2	0	1618	135
1987	0	9.7	21.2	8.1	72.8	257.2	254	505.4	203.2	163.4	3.7	13.8	1513	233
1988	11.1	0.4	93.6	81.4	154.4	247.2	478.2	204.6	529.7	192.1	1.8	13.7	2008	167
1989	0	0	19.2	135.8	213.7	268	213.3	360.8	276.5	267.2	27.5	16.4	1798	150
1990	1.8	0	0	266.6	131.9	268.5	449.3	314.9	312.8	179.3	32	52.5	2010	167
1991	0	42.3	64	186.3	216.4	268.4	290.5	390.4	341.1	243.1	6	16.9	2065	172
1992	0	0	13.5	99.7	266	311.3	475.6	200.4	280.2	101.9	56.3	0	1805	150
1993	0	17.2	9	94.7	84.6	234.3	325.7	364.1	311.9	166.3	37.5	8.9	1654	138
1994	23.6	0	17.2	175.6	285.4	215	326.1	256	348.5	377.7	56.4	0	2082	173
1995	64.1	60.2	118	120.4	249.3	382.7	429.4	347.2	295.4	362.5	49	0.3	2479	207
1996	1.1	22.3	79	103.1	281.3	236.8	171.9	352.4	317.6	256.3	4.9	0	1827	152
1997	1.6	0	114.2	305.7	300.1	216.7	214.5	188.5	247.3	252.7	45.9	19.8	1907	159
1998	0.2	24.6	30.4	170.3	344.3	291.5	362.7	91.2	360.6	407.1	0.5	2.6	2086	174
1999	27.9	12.9	52.2	98.6	320.9	186.2	279.9	255.6	347	353.9	53	0	1988	166
2000	36	36	36	36	36	36	36	36	36	36	36	36	432	36
2001	0.1	0.2	40.1	236.9	188	267.8	218.3	272.8	177.2	146.3	1.5	0	1549	129
2002	0	22.8	22.7	79.2	220.7	258.6	251.9	330.9	242.1	316.4	32	0	1777	148
2003	37.2	6.8	40.1	136.1	161.2	200.9	425.4	212.5	383.3	249.5	28.9	1.3	1883	157
2004	1.7	23.6	3.8	225.3	415.2	257.9	384.1	223.8	339.5	190.8	37.9	6	2110	176
2005	17	21	53.6	151.6	252	233.6	277.4	231.1	274.6	257.1	28.9	6.6	1804.5	278
2006	12.3	17	47.2	154	251.9	218.6	262.2	219.4	272.5	246.4	26.9	7.2	1735.6	267
												Cum Total	58684.1	5247
												Cum Ave	3452	308.6
Monthly total	280	721.7	1841.3	4392.5	7553.4	7879.6	9667.7	8158.5	9554.6	7292.3	1015.5	324.4	120820.2	10802.6
Monthly Ave.	16.5	42.6	108.3	258.3	444.3	463.5	569	480	562	429	59.7	19.1	3452	287.8

Source: Nigerian Metrological Agency, Oshodi, Lagos, 2006

Appendix 11

QUESTIONNAIRE SURVEY
ON
ACCESS TO POTABLE WATER SUPPLY IN THE RURAL COMMUNITIES OF SOUTHWESTERN ANAMBRA STATE, NIGERIA

I am a research student of the above named University. Please, kindly assist in providing correct answers to the following questions to enable us assess the status of water supply in your community. Any information provided will be used strictly for academic purpose only. Thank you.

Okeke, Ifeyinwa C. (Mrs.)
Registration No: 999008126

SECTION A: Personal Data

1) Where do you live? ....

2) How long have you been living in this area?
(a) Less Than 1 Year (b) 1-5 Years (c) 6-10 Years (d) More Than 10 Years

3) Age of respondent
(a) 12-20 years (b) 21-30 years (c) 31-50 years (d) Above 50 years.

4) Sex of respondent
(a) Male (b) Female

5) Highest level of Educational qualification attained?
(a) None (b) Primary school (FSLC) (c) Secondary school certificate (JSSE)
(d) Secondary school (SSCE/GCE) (e) Tertiary Institution

6) What is your marital status?
(a) Single (b) Married (c) Separated (d) Widow (e) Divorced

7) What is your occupation?
(a) Government Worker (b) Private Sector Worker (c) Self Employed
(d) Student (e) Farmer (f) Others (Specify)...

7b) what is your average income or earning per week?
(a) Below ₦ 800 (b) ₦ 800 - ₦ 1199 (c) ₦ 1200 - ₦ 1699 (d) above ₦ 1700

8) What is the total no of people in your household?
(a) 1-3 persons (b) 4-6 persons (c) 7-9 persons (d) 10 persons and above

SECTION B: Water supply

9) What are the sources of water supply in your area?
(a) Rainwater (b) Shallow well (c) Deep well/borehole (d) Rivers/Streams/Springs
(e) Seasonal water collector (f) Public Tap (g) Water Vendors (h)All of the above
(i) Others (specify)............ ....

10) Which of them is your major source of water?
(a) Rainwater (b) Shallow well (c) Deep well/borehole (d) Rivers/Streams/Springs
(e) Seasonal water collector (f) Public tap (g) Water vendors (sellers)

(11) Why do you prefer that particular source?
(a) Reliable (b) Accessible (Nearness) (c) No Cost (d) Others (Specify)...........
....

12) At what times of the year do you obtain water from the source?
(a) Dry season (b) Wet season (c)Wet and dry seasons

13) What quantity of domestic water does your household actually use daily?
(a) 1-3 gallons (b) 4-7 gallons (c) 7-10 gallons (d) More than 20 gallons

14) Is the quantity enough for your household?
(a) Yes (b) No

15) If no, how many extra gallons will you need?.
(a) 1-5 gallons (b) 6-10 gallons (c) 11-15 gallons (d) 15-20 gallons (e) More than 20 gallons

16) When is this extra needed?
(a) Wet season (b) Dry season (c) All year round

17) Does the water you collect have any of the following qualities?

Quality	Yes	No
Colour		
Taste		
Odour		
Foam with soap (Hardness)		

18) How often do you experience water shortage in you settlement?
(a) Always (b) Occasionally (c) Not at all

19) Which times or periods of the year?
(a) All year round (b) Dry months (c) Wet months (d) At irregular periods

20) What factors do you think are the responsible for the shortage?

(a) Inadequate sources (b) Inadequate storage capacity (c) Rainfall seasonal variation (d) Industrial consumption (e) Pipe leakages (f) Others (specify).........

....

21) What types of water borne diseases are widespread in your area?
(a) Cholera (b) Dysentery (c) Diarrhoea (d) Enteric Fever (Typhoid) (e) Dermatitis (skin problems of scabies, filariasis and craw-craw) (f) Others (Specify) (g) All of the above

22) Has your area ever experienced an epidemic breakout due to intense water shortage or use of contaminated water? (a) Yes (b) No (c) Do not know

23) If yes, when was that?

24) Where did you obtain your water during the shortage times?
(a) Water from more distant stream or river (b) Vendors .of borehole water
(c) Other sources (specify)..

25) What distance do you cover in search of water?
(a) Less than 5m (b) 5m to 100metres (c) 100m to 500metres (d) 500m to 1km (e). More than 1km

26) How long does it take you to get to the source of water and return with water?
(a) Less than 10mins (b) 10 to 30mins (c) 31-60mins. (d) More than I hour

27) Who are mostly responsible for fetching water?
(a) Children (boys and girls) (b) Women (c) Men (d) Women and children

28) Do you have water vendors (sellers) in your area?
(a)Yes (b) No

29) If yes, how would you assess their service in your area?
(a) Reasonable and regular cost (b) Expensive but regular (c) Expensive and irregular
(d) Inexpensive but irregular (e) Others (specify?)

30) How much does your household spend for water per day?
(a) No payment (b) #5 to #25 (c) #26 to #50 (d) #51 to #100 (e). Above #100

31) Are you willing to pay (more) if assured of a more regular supply?
(a) Yes (b) No (c) Unsure

32) Does water expenses affect your other basic needs?
(a) Yes (b) No

33). If yes, which of the needs?
(a) Food items (b) Clothing (c) Shelter (d) Education including children fees
(e) Others. Specify?...

34) Which water storage devices do you use for storing water?
(a) Artificial ponds/tanks (b) Jerry cans (c) Pots (d) Bowls (e) Others (specify)

....

35) How accessible in your opinion is rural water in terms of quality, quantity and distribution?
(a) Good (b) Average (c) Poor

SECTION C: Perception of people on water projects and health

36) Who provides and takes charge of water supply in your community?
(a) State government (b) Local government (c) Community effort (d) Non governmental organizations (e) Water users association (f) Water vendors and private borehole owners (g) Others (specify)

37) Who are the major water users in your community?
(a) Domestic users (b) Industrial users (c) Agricultural users (d) Others (specify)

38) How is water supplied to you?
(a) Standpipes (b) Reservoirs (c) Pumping from wells and boreholes (d).Others (specify)

39) What are the major constraints and threats to available water sources?
(a) Poor and limited quantity and quality (b) Industrial pollution (c) Human pollution (d) Bacterial contamination (e) All of the above

40) If industrial pollution, specify?
(a) Solid waste (b) Liquid waste (c) Solid and liquid wastes

41) Do you treat your water before use?
(a) Yes (b) No

41) If yes, which water purification techniques do you use?
(a) Chemical application e.g. alum (b) Filtration with leaves and clothes (c) Boiling (d) Industrial treatment (e) All of the above (f) Others (specify)............................

42) Where do you take treatment for water borne diseases?
(a) Government health centers (b) Private clinics (c) Personal medication
(d) Traditional healing homes (e) Others (specify)...

43) Have you heard about the integrated rural development programme (IRDP) activities on the water sector?
(a) Yes (b) No

44) If yes, how effective is the water programme of (IRDP) in your community?
(a) Highly effective (b) Partially effective (c) Ineffective

45) Are you aware of any plan to expand your present water capacity schemes or to install new schemes? (a) Yes (b) No

46) Do you know about any other water projects or programme in your community?
(a) Yes (b) No

47) If yes, please name it/ them?..
....

48) If yes, how effective is the project?
(a) Highly effective (b) Partially effective (c) Ineffective

49) Suggest some measures for improvement and development of water supply in your area?
....
....
....
....

Thank you for your response.

HEALTH SERVICES AND INSTITUTIONS QUESTIONNAIRE

1. What is the name of your health institution?..
2. Location of health institution?...
3. What is the category of the health agency?
   a. Federal Government owned
   b. State Government owned
   c. Private owned
   d. Traditional Health Centre
   e. Others? (Specify)
4. What type of health services do you render? (specify please)
5. Which type of health cases is prevalent in your centre? (specify please)
6. Do you have water related diseases patients?
   a. Yes
   b. No
   c. Others (Specify)
7. Average number of water related disease casualties report you get in your health centre per month?
   a. Less Than 10 Persons
   b. 10- 20 Persons
   c. 21 Persons And Above
   d. Others (Specify)
8. Reported cases of deaths resulting from, water related, water based and water washed diseases per month? Please specify

9. What treatments and precautionary measures do you advice? Please specify

10. What challenges or problems do you have in your health centre?..................
....
....

ANAMBRA STATE WATER SUPPLY QUESTIONNAIRE (WATER WORKS)

1) Name and Location? ....

2) Year of establishment? ....

3) What is the design capacity of the water works?
....
....

4) What are the equipment used in water works distribution system?..
....

5) What is the source of the water that is supplied?
i Groundwater
ii River / spring
iii Boreholes / wells
iv Others , specify ....
....

6) What pattern of distribution do you adopt?
i Pipes
ii Reservoirs
iii Others , specify ....
....

7) Who are the major consumers (water users)?
i Domestic users
ii Industries
iii Others, specify...

8) What is the perimeter used for allocating the demand of water in the area?
....

9) What is the actual quantity of water supplied? Does it vary by locations?...
....

10) Describe the actual water quality supplied?..
....

11) How is the water quantity and quality of water supplied used?..............................

12) Does increase in water demand equate water supply? Yes or no and state reasons why...
....

13) What are the factors affecting water supply and demand?.......................
....
....

14) What are the water supply problems your agency encounters?................
....
....

15) Which water treatment methods do you employ?
i Filtration
ii Fluoridation
iii Other chemical treatments , please specify
....
....

16) How do you collect your water rate?
i No bills
ii Flat rate
iii Metering
iv Others, specify...

17) What are the problem(s) associated with mechanism of transfer?...........
....

18) Which water conservation measures do you apply?..
....
....

19) What are your major constraints to effective and efficient operation?
i...
ii...
iii..

20) What are your suggestions towards improving water supply development in the local governments?
i ....
ii...
iii..

Thank you for your response.