Urbanization and Water insecurity in Nigeria: A Study of Abuja Metropolis, Nigeria

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ABSTRACT

Nigeria is endowed with massive water resources, with the capacity to meet emergent requirements. This requires both resources and a robust plan of action, to be managed by competent and dedicated experts through a well devised institutional framework. Therefore, it is critical that attention is paid to the envisaged effects of urban sprawl on the physical, economic and social environments of urban centres. Because Nigeria's rate of urbanization (and consequently, urban sprawl) is among the fastest in the world, it is important to study the consequences of urban sprawl in the rapidly expanding Federal Capital Territory of Abuja, particularly with respect to water resource management and climate variability and change. A literature review and a conceptual framework emerging from the study are provided. The framework is envisaged as the platform for developing the recommendations from the emerging study and to provide directions for future research.

Keywords: Environment, Physical, Urban Sprawl, Water Resource Management

INTRODUCTION

The impact of urban development and ground-water represents one of the most important aspects of growing cities. The interaction between urban development and ground-water may be explained in relation to land use patterns and stage of city evolution and affects on ground-water quantity and quality. Quantity and quality changes are affected by increased ground-water abstraction and new sources of recharge (Putra, 2007). Previous studies of the effect of fast growing cities on ground-water include Foster *et al.* (1993), Morris *et al*. (1994) and Vasquez-Sune *et al.* (2005). The main issues concluded from these studies are: urbanized areas change ground-water recharge and cycling, with modification of the existing recharge and the introduction of new sources, discharging of new sources of recharge in urbanized areas causes extensive but essentially diffuse ground-water contamination, and fluctuations in ground-water levels affect engineering structures.

Informative and comprehensive reports of the problem of contaminated ground-water in urbanized areas of developed and developing countries include Morris *et al*. (1994), Lerner and Barrett (1996), Massone *et al.* (1998), Chilton (1999) and Wakida *et al*. (2005). However, it is clear that human activities in urbanized areas pose multiple threats to ground-water, especially diffuse contaminant loading from urban recharge systems. This means that the different forms of land use, such as landfills, urban agriculture, industry and trade, as well as diverse residential types with their corresponding wastewater systems, influence the emission of pollutants in surface and ground-water, including ground-water recharge (Strohschön *et al.,* 2011).

In Abuja, a survey on sources of drinking water in the FCT revealed that most of the population depends on water vendors, sachet water and pond water (FCT Baseline Data, 2010). The public water utilities are challenged by the rapid development within the FCT. Thus, many residents and estate owners construct private boreholes to meet their water needs, resulting in ground-water depletion.

SCOPE OF THE STUDY

This study explores inter-relationships between increasing urban population, exploration of ground-water sources to meet water needs and impacts on the sustainability of ground-water resources within the FCT. There is currently insufficient capacity within the utilities and other stakeholders, including the domestic private sector, to properly tackle the issue of lack of access to water services for the urban poor (WaterAid, 2006). Water supply is integral to slum improvement and urban environmental health, yet there is disconnect between water resource management and the housing and urban development sector in the FCT. Rapid urbanization and the proliferation of slums and urban poor settlements pose major challenges in Nigeria. It is therefore timely to undertake detailed studies and make concerted efforts toward the improvement and co-ordination in the urban development sector and integrate water resource management into urban development planning. There will be a review of existing literature, reports and publications and research on water resource management issues. This will be followed by geophysical investigations, water resource mapping exercises and ground-water monitoring at selected locations. Resultant data will be analysed and thus assist the formulation of recommendations.

The study will improve understanding of urbanization pattern impacts on the ground-water of the City of Abuja. Therefore, the study intends to develop viable strategies, such as reduction of high dependency on ground-water, conjunctive use of ground-water and surface-water, rainwater harvesting, preservation of wetlands in and around the City, artificial recharge and decreased waste. These may contribute to effective and sustainable utilization of ground-water resources.

The research programme will be co-ordinated on the basis of primary and secondary data sources. Desk review of existing literature will be conducted, and other baseline information on urbanization and ground-water abstraction will be collected from multiple sources (i.e. books, journals, NGOs, international and national reports and government data-bases).

Primary data on ground-water will be collected using ground-water monitoring loggers at selected observation wells, located 30 km apart within the FCT. Data will be collected and analysed using relevant tools and ‘win-situ’ (water mapper software).

POPULATION GROWTH AND THE CHALLENGES OF PROVIDING WATER SERVICES IN ABUJA

The growing demand for the use of water resources, in particular from rapidly expanding urban centres, is posing serious threats to sustainable development, especially in Africa. Ground-water exploitation exceeds sustainable yield, with some projections forecasting total demand increasing to double the sustainable yield by 2020 (Allison *et al.*, 1998, Stephen *et al.*, 2008). Abuja is well planned, but, with the rapid population growth, services to ameliorate this population pressure may prove inadequate.

A Federal Government study between 2008-2010 showed that little progress had been made in providing safe drinking water through taps and boreholes to most communities within the FCT (FCT Baseline Data, 2010). Ameto (2012) found that only 7% of households in the FCT had access to safe drinking water from taps; while 43% depended on rivers and streams, and 27% depended on boreholes. With increasing influx of people from neighbouring states, the FCT water utility (Water Board), with a daily production of 192,000 m^3, is struggling to satisfy water demands. The National Water Supply and Sanitation Policy (2000) stipulates 120 litres/per capita/day for urban water supply.

Access to safe water from the utility is sporadic, even in areas accommodating the FCT elite. Some inhabitants of Maitama District still struggle to store water regularly to meet daily requirements, as supply from the Water Board is irregular.

The Federal Capital Territory (FCT) was formed in 1976 from parts of former Nasarawa, Niger and Kogi states. It is the central region of the country on an area of 7,315 km^2, of which the actual city (Abuja) occupies 275.3 km2. It has a population of 1,406,239 people (2006 Census). Within the last 10 years, the population living in the FCT has grown by 9.3% (2006, Census), and the projected population of FCT in 2014 is 3,028,807 (UNFPA Report, 2010), ranking it as the highest in Nigeria and far in excess of the initial city plans.

Admittedly, the planners of Abuja did not envisage that the population would grow suddenly, thereby exerting pressures on available government facilities, amenities and infrastructure. Most of the City does not have pipe reticulations for water supply from the only available surface source, Usuma Reservoir, which is fed by the River Usuma. The reservoir has a capacity of 120 million m^3 of raw water and is sited 26 km from Abuja City Centre, along the Dutse-Bwari road, and 10 km from Bwari. Thus, even new government buildings are difficult to connect, as the network distribution does not cover such areas in the original plan, let alone bringing water to individual homes. As a result, each household is forced to sink its own borehole, which in the long-term has negative implications for ground-water quality and quantity.

People who relocated to the FCT find it cheaper to settle in areas lacking potable and sustainable water sources. These include Lugbe, Karimu, Nyana, Deidei, Gwagwa, Idu, and Gwagwalada. These towns have fast become giant slums, with no public space where pipes can be run. The indiscriminate sinking of boreholes without proper surveillance is common and, consequently, many boreholes are close to pit latrines and garbage dumps.

When developers loose sight of the fact that people need to be at the centre of planning, there is every chance of chaotic settlements, a phase FCT is gradually becoming if remedial actions are not taken. The United Nations Population Fund (UNFPA, 2010) stated that the sustainable development agenda to improve well being and preserve the quality of the environment cannot succeed without a core focus on population.

MAPPING AND GROUND-WATER ANALYSIS OF SAMPLE HOUSEHOLDS IN EFAB CITY ESTATE, LOKOGOMA DISTRICT, ABUJA

Gathering information is key for adequately assessing both the ground-water pollution potential and safety of drinking-water sources. The establishment of an information inventory is therefore a central tool in developing a sound understanding of potential pollution sources and the likelihood that pollutants may reach ground-water in concentrations hazardous to human health (World Health Organisation, 2006).

A pilot phase study was conducted in Efab City Estate (Figure 1) to understand the extent to which water usage patterns, depth of boreholes and distance between boreholes and soak-aways is linked to the quality of water consumed by households.

Figure 1: Map of Efab City Estate showing water and latrine facilities (source: Google Maps, accessed 11/02/2014).

Study materials and methods

The data required for assessing ground-water pollution potential (i.e. the likelihood that diseases, pathogens or chemicals reach ground-water) can be achieved through several methods. These include: (1) site and catchment inspections; (2) public consultation (i.e. communication with the local population); (3) collating ground-water data; (4) targeted hydro-geological field surveys (e.g. for aquifer vulnerability mapping), and (5) ground-water quality screening or monitoring programmes involving laboratory analyses (World Health Organisation, 2006).

The pilot study adopted the combination of quantitative and qualitative methodologies. The sampling technique used for the study was both systematic and simple random sampling techniques in selecting questionnaire respondents.

A total of 110 households were sampled through a stratified random sampling technique. Household questionnaires were administered to elicit information about people's views on water services within the Estate. Co-ordinates of water points and sanitation facilities within households were also captured using the Garmin III GPS device. Subsequently, the 'win-situ' instrument for ground-water data will be used to collect data on water levels at selected locations within the FCT. Loggers will be installed, retrieved, recalibrated and reinstalled at regular intervals for data collection.

Study Area

Efab City Estate, Lokogoma is located at 8.97502^{o}N and 7.46161^{o}E. It occupies approximately 60 hectares with 800 housing units and is 5 km north from the City Centre. The local geology is underlain by Pre-Cambrian basement complex rocks, which include discontinuous and localized aquifers (Adakayi, 2000; Balogun, 2001). Mean annual rainfall is 1,631.7 mm. The mean annual temperature ranges between 25.8-30.2°C (Adakayi, 2000; Balogun, 2001). Local soils are alluvial soils and Luvisols.

Results

The survey captured the situation within the 110 households (HH) with respect to access to water supply, usage patterns, depth of boreholes, distance between boreholes and soak-away pits, and the mean depth of pits. Physico-chemical analyses were also conducted on water samples collected from 11 households, to determine the potability of water.

All 110 households have boreholes and a toilet facility, each located within the compound with mean land area of 450 m^2 (Figure 1). The location of boreholes and nearby soak-aways has implication for ground-water quality. Boreholes located within distances <50 m from sources of contamination (such as septic tanks and poorly drained areas, which receive contaminated run-off from slurry pits), are more likely to be polluted. Verheyen *et al.* (2009) found a significant positive correlation between viral contamination of a water source and at least one latrine within 50 m. Ground-water nitrate concentrations have also been correlated with proximity to pollution sources, including pit latrines, in Senegal and South Africa (Tandia *et al.* 1999; Vinger *et al.* 2012).

The estimated water consumed per household per day is 534 litres (Table 1) and water is pumped daily to meet this demand. This has consequent effects on the environment, especially when ground-water is removed from aquifers by excessive pumping. Thus, pore pressures in the aquifer drop and compression of the aquifer may occur. This compression may be partially recoverable if pressures rebound, but much of it is not. When the aquifer becomes compressed, it may cause land subsidence and associated infrastructure damage (Sophocleous, 2002).

Table 1: Summary of borehole results from Efab City Estate (n = 110, ± SD)

S/N	Parameters	Measures
1	Mean depth of borehole (m)	31 ± 0.79
2	Mean distance between borehole and soak-away (m)	8 ± 0.50
3	Mean depth of soak-away (m)	3 ± 0.08
4	Estimated water consumed per Household per day (litres)	534 ± 0.04
5	Mean number of people in household	7 ± 0.01
6	% Households with water odour problem	4 ± 0.04
7	% Households with water colour problem	5 ± 0.09
8	% Households with water taste problem	9 ± 0.09

Table 2 shows co-ordinates of sample HH water collected for water quality analysis. Some 11 water samples were collected and analysed for major physico-chemical parameters, including temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), Ca^{2+}, Mg^{2+}, as per the assessment of ground-water quality method described by APHA (1992). Water sample temperature, pH, electrical conductivity and TDS were determined at the point of sampling, using a Hach digital thermometer with a glass sensor. Total hardness and total alkalinity were estimated by standard methods of water and waste-water using the Hach DR2000 direct reading spectrophotometer.

Table 2: Co-ordinates of sampled boreholes for Water Quality Analysis in Efab City Estate

BOREHOLE (BH)	LATITUDE (^oN)	LONGITUDE (^oE)	ALTITUDE (M)
BH1	8.97252	7.45828	464
BH2	8.97726	7.45983	460
BH3	8.97722	7.45972	460
BH4	8.97472	7.45818	460
BH5	8.97720	7.46002	459
BH6	8.97721	7.46014	459
BH7	8.97716	7.46037	458
BH8	8.97868	7.45994	465
BH9	8.97577	7.45968	464
BH10	8.97329	7.45689	463
BH11	8.97560	7.46053	456

The membrane filter technique method was employed for all microbiological analyses. A 100 ml water sample was filtered through a membrane (pore size 0.45 μm), small enough to retain indicator bacteria to be counted. The membrane was incubated on the selective differential to allow bacteria to grow. Colonies were recognized by their colour, morphology and number.

There were considerable variations in the examined samples from different sources, with respect to their physiochemical characteristics (Table 3). Results indicated that intra-site water quality varies considerably. Some samples showed they possessed some perceived odour that was not quantified in this study. The occurrence of odour was probably associated with the presence of contaminants. Related to taste, water with a strong odour will obviously be rejected by consumers. Odours may be caused by dissolved volatile organic compounds, small concentrations of which may have considerable organoleptic effects.

Water points (BH3, BH4, BH5, BH6 and BH10) are generally weakly acidic; and the remaining five are within the permissible pH range of 7.0±0.1. All underground water samples are characterized by either a weakly acidic or weakly basic pH, within the maximum permissible pH level (6.5-8.5) of the Nigerian Standard for Drinking Water Quality (2007).

Table 3: Results of Water Quality Analysis conducted on sample boreholes in Efab City Estate, Lokogoma

S/N	BOREHOLES	COLIFORM (CFU/100 mL)	ALKALINITY (as $CaCO_3$) mg/dm^3	HARDNESS (as $CaCO_3$) mg/dm^3	pH	TDS (mg/L)	INFERENCES	ADVICE
1	BH1	TNTC	49	49	6.59	63.9	Not Fit for consumption, except if treated	Install small portable water purification sytem
2	BH2	0	57	87	6.45	122.4	Good water source	
3	BH3	TNTC	21	21	6.03	33.8	Not Fit for consumption, except if treated	Install small portable water purification sytem
4	BH4	11	20	22	6.1	34.9	Good water source	
5	BH5	0	17	18	5.84	31.4	Excellent water source	
6	BH6	13	32	50	6.09	49.4	Good water source	
7	BH7	0	58	80	6.63	93.1	Good water source	
8	BH8	3	19	20	6.13	28.4	Good water source	
9	BH9	TNTC	72	96	6.74	120.9	Not Fit for consumption, except if treated	Install small portable water purification sytem
10	BH10	0	18	20	5.95	36.4	Excellent water source	
11	BH11	TNTC	65	94	6.61	133.6	Not Fit for consumption, except if treated	Install small portable water purification sytem

Conductance (total dissolved solids) is related to the ionic content of the water sample, which is in turn a function of dissolved (ionizable) solids. This property is related to water hardness, because the more dissolved ions (including Ca^{2+}, Mg^{2+}, SO_4^{2+}) present in a water sample, the more its conductance and hardness (Istifanus *et al.*, 2013).

Coliform, 'Too Numerous To Count' (TNTC) was observed in 36% of water samples (Table 3), indicating that the water is unsafe for human consumption. Because samples from these households showed a large presence of *E. coli*, the inference is that heavy, recent pollution by humans or from soak-aways has occurred. *E. coli* is bacterium that causes gastroenteritis in humans, and is abundant in human and animal faeces (>1,000,000,000 *E. coli* per gram of fresh faeces). Human faeces harbour many microbes, including bacteria, archaea, microbial eukarya, viruses, and potentially protozoa and helminths (Feachem *et al.* 1983; Ley *et al.* 2006; Ramakrishna 2007). Areas characterized by shallow water-tables and fractured rock aquifers have high faecal coliforms concentrations in domestic wells located near pit latrines and septic tanks (Pujari *et al*. 2012). This was corroborated by a study on ground-water quality in an unplanned settlement in Zimbabwe, which indicated detectable total and faecal coliforms in over two-thirds of study boreholes and existing domestic wells (Zingoni *et al.,* 2005).

CONCLUSIONS

This study suggests that sewage systems (soak-aways), close to shallow wells and boreholes contribute to high levels of ground-water contamination. The presence of *E. coli* in water always indicates potentially dangerous contamination requires urgent attention. Immediate chlorination processes should be embarked upon to eliminate negative impacts of water contamination where found. Water supply is more critical for urban development intervention.

These findings revealed the urgent need for water service providers, national government and beneficiaries alike, to work together to achieve better management outcomes for the sustainable utilization, conservation, and remediation of ground-water resources within the FCT and its environs.

Essentially, further study is required to develop a composite framework for ensuring that estate developers and urban development practitioners comply with best practices for urban planning and development while emphasizing public orientation programmes for conjunctive use of water resources. A framework that will improve understanding of sustainability of ground-water and how it can be achieved. A guide to bring about the lasting changes which those in low-income settlement (slum areas) and the FCT need and demand. A regulatory outline for extending water supply services; increasing water storage capacity, reducing indiscriminate sinking of boreholes and water collection times, and ensuring sufficient quantities are available to meet multiple water needs using a multiple use service approach where appropriate. Protecting and improving water quality and ensuring better water management use assented. Cited observations also suggest that a robust development framework for improvement and co-ordination in the urban sector and the integration of water resource management for effective urban development planning is essential for future progress.

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