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Delineation of saline water intrusion to safe-guide inland groundwater resources

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ABSTRACT

This work is intended to study the groundwater potential of Lagos Island in Nigeria and delineate appropriately, the depth at which saline water intrude into the groundwater resources of the area. Saline intrusion into groundwater resources of Lagos Island has rendered potable percentage of under-groundwater undrinkable. Better understanding and proper delineation of the saline water will proffer efficient household use of the resource. A direct current electrical resistivity method of geophysical prospecting using the Schlumberger electrode configuration was adopted. Electrical resistivity with natural gamma was carried out to accurately delineate prolific sand aquifer(s), determine the exact lithology of the well and nature of saturated fluid at Lagos Island. The same test was repeated at Lagos Inland in order to proffer engineering control techniques that will be necessary for controlling saline intrusion into inland groundwater. Quantitative interpretation of curve types obtained from the field data of the sounding curves revealed that the site is underlain by topsoil, clay, sandy clay and saline water sand intercepted at a depth of 136 m. Groundwater development through deep borehole drilling is recommended to a minimum depth of 220 m; the borehole depth should not exceed 250 m. Technique for controlling seawater intrusion into inland groundwater should include construction of subsurface barrier in excess of 136 m deep perpendicular to the coastal creeks and lagoons.

1. Introduction

The regional and local reference of the study area is shown in Fig. 1. Nigeria is located in Western Africa and shared boundaries with countries like Ghana to the south, Cameroun to the east, and Republic of Benin to the west, Niger Republic to the north and Chad to the northeast. Lagos is situated in the Southwest of Nigeria, surrounded with lagoon that empties its content into the Atlantic Ocean.

Lagos is densely populated. Although Lagos state is the smallest state in Nigeria, with an area of 356,861 ha of which 75,755 ha are wetlands, yet it has the highest population. In 2006 national census, Lagos population was estimated at 9.1 million (National Population Commission, 2006). Even though another national census is yet to be conducted, Lagos population is gazetted at 17.5 million in 2015 (see Fig. 2). Of this population, Metropolitan Lagos, covering 37% of the land area of Lagos State is home to over 85% of Lagos population. The rate of population growth is about 600,000 persons per annum with a population density of about 4193 persons per square km. In the built-up areas of Metropolitan Lagos, the average density is over 20,000 persons per square km (National Population Commission, 2006). Current demographic trend analysis revealed that Lagos population growth rate of 8% has resulted in its capturing of 36.8% of Nigeria's urban population (United Nations, 2012; Lagos State Government, 2009). Lagos population is the fastest growing megacity and world's 11th largest municipal (UN-Habitat, 2004), increasing ten times faster than New York and Los Angeles (between 2000 and 2015, see Fig. 2).

Coastal cities throughout the world are attractive areas for socio–economic activities, with rising population and rapid economic development (Gan et al., 2009; Ke et al., 2011). The growing population and rapid urbanization of coastal cities exert more pressure on demand for natural resources of coastal ecological system, causing continuous deterioration of natural reserve's ecosystem including water resource quality and water environment. Therefore, there is urgent need to protect ecological sustainability of coastal urban ecosystem with relative good eco-environment condition from been degraded at a high rate as result of rapid urbanisation?

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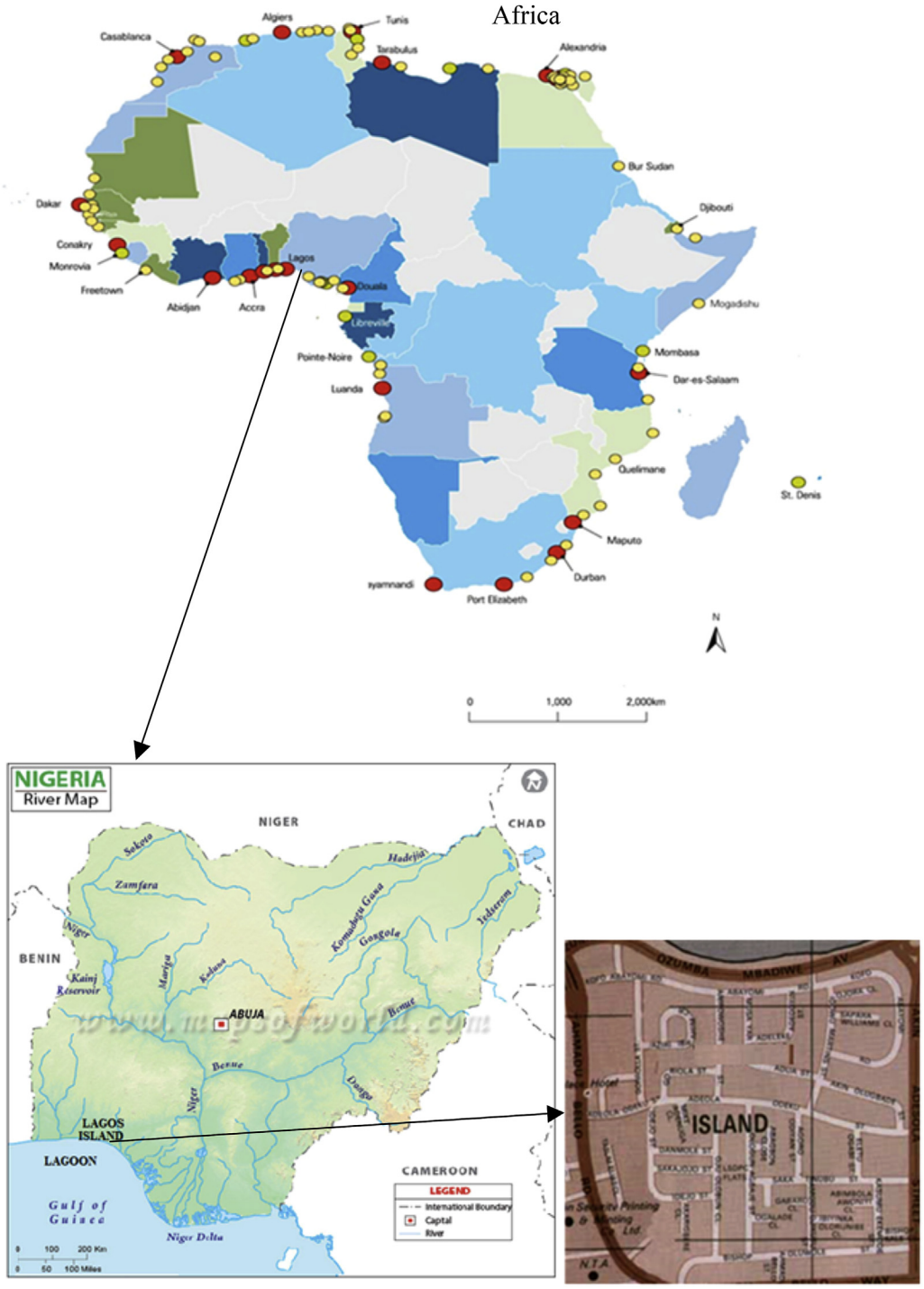

Fig. 1. Regional and local reference of the study area.

Several studies have surveyed water resource, water environment and wetland deterioration of natural resources of coastal ecological system (Zhang et al., 2012; Ma et al., 2013b). Some studies focus on developing and applying model tools to simulate water resource and water environment policy, such as applying Markov model (Ma et al., 2012a), system dynamic model (Ma et al., 2012b), and multiple indicator model (Ma et al., 2012c) to simulate coastal dynamics; developing modes for coastal ecological restoration (Ma et al., 2012d); and applying emergy analysis and pressure-state- response model to simulate ocean and costal ecological risk (Zhang et al., 2012). Some studies focus on assessing water resource and water environment policy and management, such as coastal resource management assessment (Ma et al., 2012e), coastal ecological requirement assessment (Ma et al., 2011), health status evaluation (Ma et al., 2013a), and assessment of economic development and marine conservation (Ma et al., 2013b). This includes land use policy change for boundary adjustment strategy to balance coastal wetland protection (Xie et al., 2012).

Lagos being the industrial hub of Nigeria generate million tons