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Extension of Designed Public Potable Water Distribution Channel to Igberen-Aboloyin Community, Ota, Ogun State, Southwestern Nigeria

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Abstract: **Igberen–Aboloyin Community of Ado-Odo/Ota local government Area of Ogun state, Southwestern Nigeria is susceptible to disease outbreaks due to the presence of Kurata dumpsite located in the heart of the community. Over the years, leachate from this dumpsite had percolated through the soil to contaminate the water table, rendering groundwater in this environment unfit for consumption. To ensure the availability of potable water to this community, the design of a water distribution network was made in this research. Coordinates and elevations were taken at various points in the field using the Global Positioning System (GPS). The elevation data was simulated using a mathematical function to generate a colour-coded Digital Elevation Model (DEM) depicting varying heights across the area; facilitating an easy identification of the most suitable part to site a storage tank to serve the community. The geospatial road network of the environment was imported and manipulated using architectural design software while referencing the generated Digital Elevation Model (DEM) for the pattern and structure of the terrain to produce the new water distribution network for the Igberen-Aboloyin community. Results from this study showed that the population of this community would increase to about 60 thousand by the year 2040 with a maximum daily water demand of about 8.64 million litres. The execution of this research would ensure an uninterrupted supply of this required quantity of water to the community till at least the year 2040 thereby reducing the health risk posed to the populace through the use of contaminated water. This study has been able to design a distribution channel for the inhabitants of the Igberen-Aboloyin community in Ota, Ogun State, Southwestern Nigeria which can meet the Sustainable Development Goals (SDG 6 and 15) of "Clean Water and Sanitation" and "Life on Land" when the design is implemented.**

Keywords: **Distribution network, Dump sites, Groundwater, Leachates, Potable water, Water demand.**

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I. INTRODUCTION

The exposure of surface water makes it prone to different forms of contamination such as agricultural, industrial, domestic wastes, etc, hence it usually cannot be used for direct consumption without treatment. On the other hand, groundwater is relatively cleaner due largely to the natural filtration process as a result of soil arrangement and movement of water through the pore spaces. To maintain good health, it is imperative to have access to clean water. One-sixth of the world's population is affected by a lack of access to fresh water. Infectious diseases, such as cholera, and typhoid fever, and other diseases such as gastroenteritis, diarrhoea, vomiting, skin, and kidney problems are increasing via contaminated water [1]. Water sources located around dumpsites are largely vulnerable to water pollution due to the components of wastes dumped. Monitoring the underlying aquifer in the vicinity of a dumpsite is mandatory for groundwater protection. The dumpsite leachate permeates through the underlying sediments and pollutes the source of drinking water [2] [3].

Kurata dumpsite is located in the Igberen-Aboloyin community, Ota, Ogun State, Nigeria. The types of waste found in this site can be categorized into industrial (due to industrial activities because Ota is an industrial hub in the state), domestic, medical, and agricultural wastes. The inhabitants of this community are faced with the challenge of potable water and air pollution. Preliminary investigation shows that the groundwater at the other side of the dumpsite is relatively clean indicating that the groundwater flows from the other side towards the valley (Kurata dumpsite) where it gets contaminated and then flows toward the study area. The community on the other side of the dumpsite is also faced with the peculiar challenge of air pollution as the path for wind direction follows their end.

Houses are situated as close as 5 meters to about 200 kilometres away from the dump site. This site is located in a valley of about 230 meters deep and it covers an area of about 30 km^2. Over time, the gorge has been filled halfway and this has attracted scavenging activities, melting of metals, and burning of the refuse itself which in turn leads to air and land pollution. The groundwater in this area of study has been completely polluted as a result of leachate percolation through the soil profile to the underlying aquifers over the years. Also contributing to this groundwater contamination is the fact that Ado-Odo/Ota as a local government in Ogun state generally has the prevalent challenge of poor drainage. Since this dumpsite is located in a low plain, most of the domestic and water runoff after rainfall usually finds its way to the valley hence further contamination of the groundwater reservoir. The radon concentration in the water samples around the dumpsite ranged from 2.3 to 34.5 Bq L^{-1}, with a mean of 7.7 Bq L^{-1} and the annual effective doses due to the absorption of radon varied from 0.017 to 0.252 $mSvy^{-1}$ with a mean of 0.056 $mSvy^{-1}$ [4]. It was also detected that 15% of the samples have radon concentration above the 11.1 BqL^{-1}; the action level recommended by the United States Environmental Protection Agency (USEPA). Furthermore, in the water samples, the mean concentration of potentially toxic elements were 0.02, 0.014, 0.048, 0.010, and 0.003 mgL^{-1} for Cd, Pb, Se, Cr, and As, respectively which presented that concentrations of Pb, Se, and As were higher than the World Health Organization (WHO) permissible limits [4]. The high concentrations of these potentially toxic elements in water in the study area may have some harmful effects on the inhabitants. Although individual households can afford to sink a well or borehole for domestic purposes, it is quite difficult for them and even as a community to include a water treatment system that can effectively eliminate the effect of physicochemical, biological, and radiological contaminants in the groundwater due to the cost of implementing one. Those that still have boreholes make use of it without any form of treatment thereby predisposing them to health issues.

There is a designed and improved water system for Ota, in Ogun state, capable of sustaining this local government area for a period of twenty-five (25) years (between the years 2015 to 2040) [5] In this research, the projected population of Ota inclusive of Igberen–Aboloyin community was factored in the design of the water works and distribution of water through distribution mains along Sango-Idiroko road to the service reservoirs at five (5) identified locations within the local Government. However, the project did not take into cognizance the peculiar challenge faced by people of this community (Igberen-Aboloyin) and the distribution network was not extended to cover this community to address their peculiar challenge of potable water due to the effect of the dumpsite.

To ameliorate the water challenges faced by the community around this dumpsite, this study looked into distributing government potable water to the community via tapping from the distribution mains along the Sango-Idiroko road.

This study identifies a suitable location to site an overhead tank for the distribution of potable public water supply and the extension of the distribution network to cover the study area. This distribution network is intended to serve this community effectively for the period in which this water works is expected to sustain the whole local government.

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II. MATERIALS AND METHOD

Study Area (Geographical Location)

Igberen- Aboloyin Community Development Area is located in Ado-Odo/Ota Local Government Area, within Ogun State, Southwestern part of Nigeria. The Ado-Odo/Ota Local Government Area is one of the key industrial and residential zones within the state, characterized by its mix of urban and semi-urban landscapes.

Fig, 1: Map of Local Governments in Ogun state showing the study area

Map and Satellite Imagery

The map of the Igberen -Aboloyin Community Development Area was obtained using Google satellite imagery. This high-resolution satellite data provides an accurate and detailed view of the area, including the spatial distribution of the dumpsite, residential areas, and other relevant landmarks.

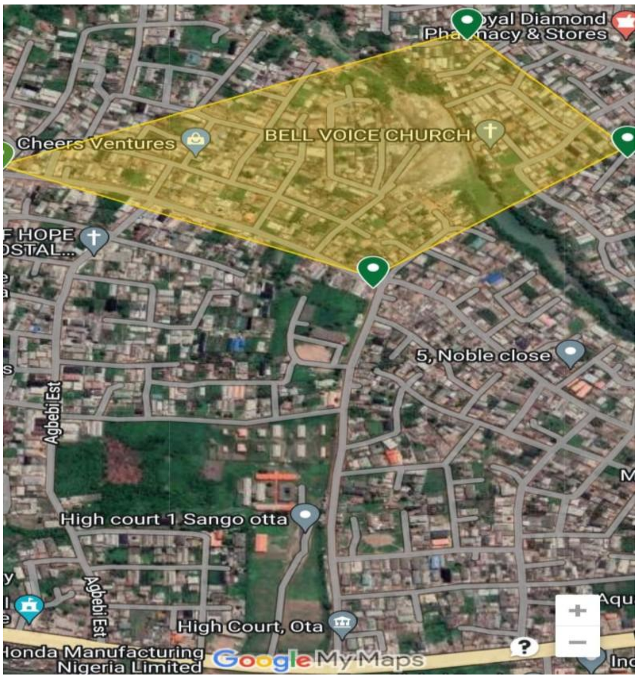

Fig. 2: Aerial Survey of Study area (Google Earth Imagery)

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Table 1: The approximate geographical coordinates of the selected study area are given as:

Points	Latitudes (N)	Longitudes (E)
A	6.6888	3.19983
B	6.69117	3.19462
C	6.69383	3.20114
D	6.69147	3.20336

Elevation data for the selected coordinates was obtained with the use of Global Positioning Systems (GPS). The coordinates obtained were used to create a mesh grid, which served as the basis for plotting elevation data. Uneven elevation data was simulated using a combination of mathematical functions to represent realistic terrain features. MATLAB code (R2014a) was then used to generate the Digital Elevation Model (DEM) with color coding to represent different elevation levels in the study area.

The road network of the study area was extracted from the Google Imagery satellite which was then imported into the AutoCAD environment (Auto-Cad 2018) and manipulated making all necessary adjustments and extensions to generate a distribution network while also putting into consideration the necessary size of pipes and appurtenances needed along the distribution network.

In this study, secondary data was obtained at the Community Development Association (CDA) office regarding the population. This information was used to extrapolate the possible population figure by the year 2040 using peculiar equations fit for the nature of the environment and making assumptions where necessary to generate a near-perfect figure. Ufoegbune *et. al.* 2016 adopted 80 litres of water as per capita per day consumption in the earlier research carried out; the same figure was also used in this research for the same purpose. The total volume of water necessary to cater for the maximum daily water need of the population was thus estimated through the multiplication of per capita consumption per person per day and the total estimated population by the year 2040 as well as the safety factor.

The estimated population of Igberen- Aboloyin community for the year 2040 was thus calculated using the compound growth rate equation;

$$P_n = P_o(1 + \frac{r}{100})^n \qquad (1)$$

Where P_n is the projected population for the nth year, P_o is the initial population figure, and r is the growth rate of 3.18% (source: NPC 2006).

The population of the Igberen-Aboloyin Community was 32,084 as of the year 2020 according to the information obtained at the Community Development Office.

Hence, the estimated population of the community in 2040 will be

$$P_{2040} = 32,084\left(1 + \frac{3.18}{100}\right)^{20} \qquad (2)$$

The required daily water demand for the projected population by the year 2040 can be computed as;

$$The\ average\ daily\ water\ demand\ for\ the\ projected\ population = Projected\ population \times per\ capita\ per\ day\ consumption \times safety\ factor \qquad (3)$$

Where per capita per day consumption is 80 litres, assumed safety factor is 1.5; the safety factor covers for losses due to damaged pipes, reservoir overflow, etc.

$$Maximum\ water\ demand = 12 \times average\ daily\ demand \qquad (4)$$

$$Maximum\ water\ demand\ for\ the\ year\ 2040 = 12 \times 60,007 \times 80 \times 1.5 \qquad (5)$$

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III. RESULTS AND DISCUSSION

The projected population by 2040 is 60,007 persons.

Table 2: The Maximum water demand by the projected population in the community

Maximum Water Demand	Million liters/day	m^3/hr	m^3/min	m^3/s
Year 2040	8.64	360.0	6.0	0.1

The maximum daily water demand by the community is given by

$$8{,}641{,}008\,\frac{litres}{day} = \left(\frac{8641008\text{L}}{1000}\right)\, m^3$$

$$= 8{,}641\, m^3$$

Fig. 3: Road network of the study area

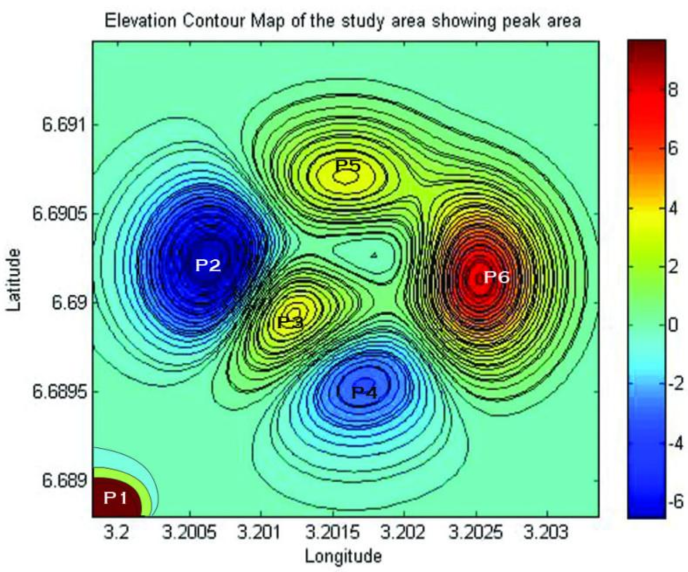

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Fig. 4: Digital Elevation Model (DEM) of the study area

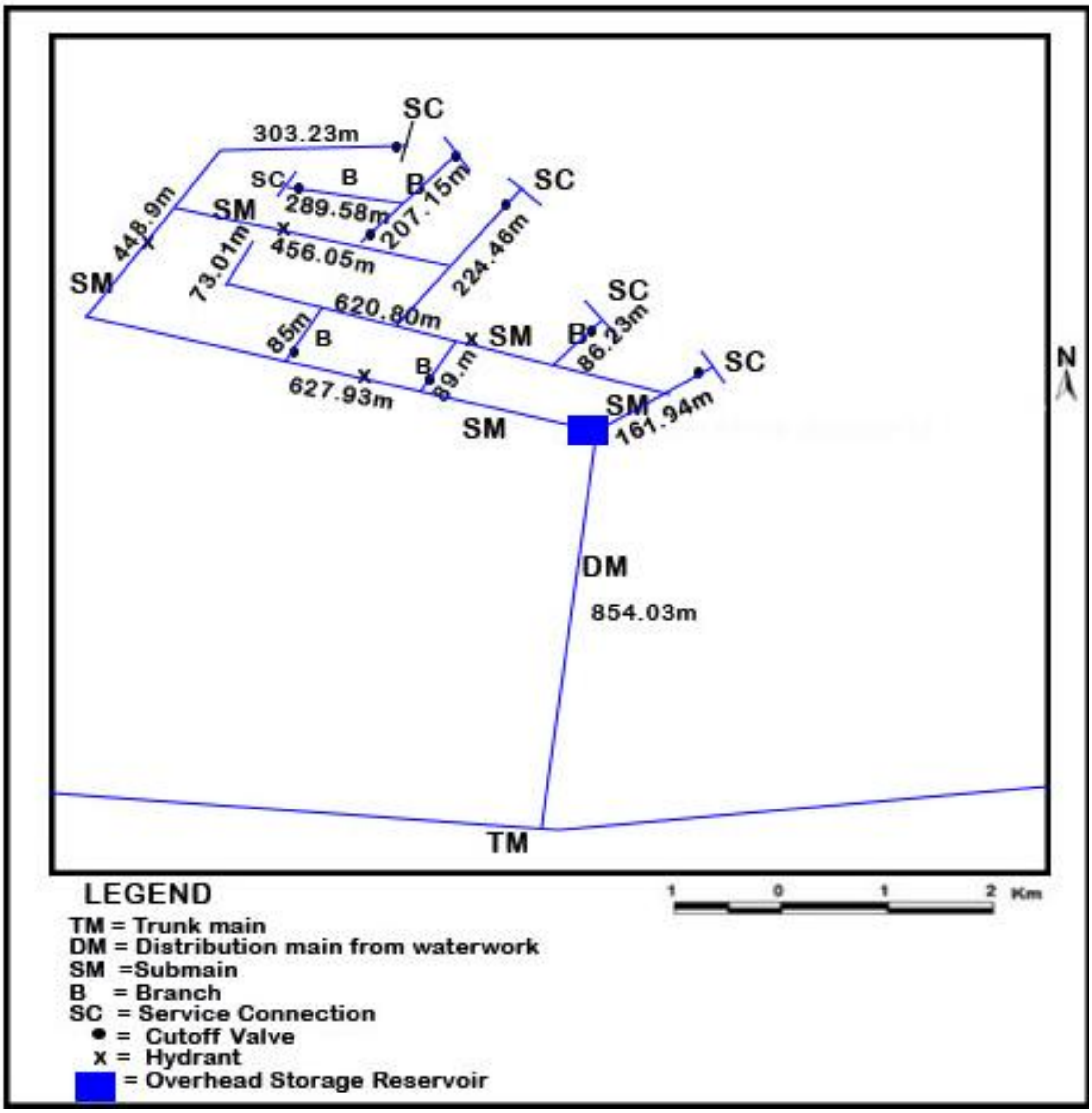

Fig. 5: Proposed Distribution Network for Aboloyin-Igberen Community

Table 2 shows that the population of the Igbenren-Aboloyin community will increase to 60,007 by the year 2040 due to a high influx of people from Lagos state; a highly congested area, as well as the proximity of the community to the industrial estate in Ota. Hence, making the community part of earlier options for workers seeking accommodation.

Table 3 shows that by the year 2040, the maximum daily water demand of the community will have increased to 8.64 million litres per day (8,641 m^3 per day). In this figure, other exigencies are factored in to include: water losses due to reservoir overflows, losses at pipe leakages as well as fire-fighting purposes. At the moment, there is no existing water pipeline servicing the community, hence this figure (maximum daily water demand) will help in determining the dimension of the storage tank/reservoir which will be designed for the community.

Fig. 4 shows the topographic nature of the environment. The Digital Elevation Model (DEM) shows the various elevation contour patterns across different segments using color coding. The highest point (peak) was simulated near coordinate A (6.6888N, 3.19983S) at around Point (P1) and was thus identified as the best suitable location for citing the water tank to aid efficient water distribution through gravity.

Fig. 5 shows the proposed distribution system for the community. The distribution network takes into cognizance the possibility of extension of the pipelines to new areas with the termination of channels at various points through the use of cut-off valves which also make it easy for flushing of the pipes at dead ends. Adequate provisions were put in place for fire-fighting along the channel with strategic positioning of hydrants at intervals not more than 150 m each. For this study, an overhead service reservoir of about 8,641 m^3 should be cited at the recommended point in the study area at a height of 25 meters above the ground to enable water flow under the action of gravity to every part of the study area with optimum pressure. It is recommended that an asbestos pipe of 340 mm should be used for the distribution mains which convey water from the adjoining trunk main to the service reservoir. A pipe of 340 mm in diameter should also be used in conveying water from the service reservoir into the distribution network.

Asbestos pipes of 300 mm in diameter are recommended as sub-mains while asbestos pipes of 150 mm should be used for the conveyance of water to major streets in the community.

IV. CONCLUSION

Despite the abundance of water on earth, one would expect that everyone should have access to clean and safe drinking water but that is not the case. Various issues abound and are responsible for uneasy accessibility to clean and drinking water in many communities. Contamination of water source is one of these issues just as in the case of the study area due to the presence of the Kurata dumpsite in the community. This study has been able to design a distribution channel for the inhabitants of the Igberen-Aboloyin community in Ota, Ogun State, Southwestern Nigeria which can meet the Sustainable Development Goals (SDG 6 and 15) of “Clean Water and Sanitation” and “Life on Land” when the design is implemented.

V. RECOMMENDATION

1. It is recommended that further research should be carried out to ascertain the extent and the total area of groundwater that has been contaminated by leachate in this study area over the years.

2. The dumpsite should be relocated to a remote region far away from the residential environment or properly managed by agencies set up by the government.

3. Individuals or agencies such as the United Nations (UN), World Health Organization (WHO), and Non-Governmental Organizations (NGOs) can also assist in the implementation of this project to mitigate potential health hazards such as cholera, typhoid, gastroenteritis, diarrhoea, etc. faced by residents of this community.

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Appendix:

Picture 1: Air pollution from dumpsite

Picture 2: The Kurata dumpsite

Picture 3: Scavenging activities on the dumpsite

Picture 4: Inhabitants struggling for cleaner water