SEDIMENTATION AND PHYSICO-CHEMICAL CHARACTERISTICS OF OYAN RESERVOIR, SOUTH WEST NIGERIA

By

[1]Adewara M.B, [2]Adedokun A.M and [3]Ayoola S.B

[1, 2] Department of Surveying &Geoinformatics, Federal Polytechnic, Ilaro.

[3]Legit Geospatial Consult Ltd, 19A, Babalola Street, off Fakoya junction, Egbeda Lagos.

Paper submitted for presentation at the

National Association of Surveying & Geoinformatics Lecturers (NASGL) Conference,

Oyo

9th – 13th March, 2020

ABSTRACT

The paper presents the results of a study of Sedimentation and physico-chemical characteristics of Oyan dam reservoir, Ogun state, Nigeria. The public outcry about the fear of the quality of water from the reservoir by local communities near the dam as well as the effect of sedimentation on the unproductive hydropower functionalities of the dam necessitated this study. The spatial positions of the details within the study area as well as bathymetric survey to determine the sediment depths was carried out. Obtained data were processed and presented in Microsoft Excel, Notepad, HYPACK, Autodesk's AutoCAD Civil 3D 2012, suffer 11 and ArcGIS 10.6 respectively. The volume of sediment for the portion of the dam sounded was calculated in Model Maker 13.03. Test for the physico-chemical characteristics of the water samples collected from the dam were conducted. Results of the test was compared with the World Health Organization (WHO) threshold and the Nigerian Standards for Water Quality (NSWQ) limits for portable water. Although the dam water quality is fit for its intended purposes, but then sedimentation is on the increase and this increase can trigger the concentration of the tested parameters. This may affect the quality of water in the future as well as reduce the power supply capabilities of the dam since high sedimentation will reduce the water carrying capacity required to power the turbines. The government will save millions of naira from diesel generators used in running the dam if sedimentation is monitored at regular intervals.

Keywords: *Dam reservoir, NSWQ, Physico-chemical characteristics, Portable water, Sediment, Volume, WHO*

1.0 Introduction

Water is a source of wealth to those who have it and has remained one of the most valuable properties in the life of man and his evolvement from time immemorial through the period of agricultural development to the period of industrial revolution. Hence, supplying adequate water with a reasonable quality is a major constraint in both local and regional planning for urban and rural areas (Ufoegbune, Yusuf, Eruola, & Awomeso, 2011).

There is a public outcry about the fear of the quality of water from the reservoir by local communities near the dam as well as the unproductive hydropower functionalities of the dam. Reservoirs that are formed by dams on natural water courses are liable to some degree of sediment inflow and deposition. The Oyan dam is one of such. Estimating the rate of these sedimentation and its resultant physico-chemical composition and causes are problems confronting the project planner. The dam is meant to serve the people in the region in terms of water provision, irrigation farming, hydro power generation, fishery, recreation, navigation and other purposes.

According to Olatunji (2012), the National Water Resources Institute (NWRI), Kaduna developed a Concept Note on Reservoir Sedimentation Study for Bakolori, Goronyo and Oyan dams. The Oyan river system downstream of the dam was explored to determine along the main channel suitable sections for discharge measurement and Sediment sampling for onsite determination of sediment concentrations. Ten sites on the Oyan and Ogun rivers system were visited noting their hydro-environmental peculiarities. The study concludes that an improvement in the stream gauges installations and monitoring can significantly help mitigate the impacts of flood in the Oyan Dam downstream communities. With timely warnings, people in flood prone areas can plan to move to high grounds should persistent heavy rains occur.

Sediments cause water from the dam to over flow its boulders. An example of this is observed in the Ona River flood in Ibadan. According to Olayinka et al, (2013), the channels are too narrow and blocked with sediments, sand dune, bamboo trees and debris, and could not contain excess water.

Sediment determination are prerequisite for better management and use of the water, sustainment and control of water resources as well as sediment load modelling.

There is an increasing interest of the engineers and ecologists in sediment load (Karagiozova & Gergov, 2007) because:

- of their wide spread use in the building industry,
- they form a biotope for aquatic organisms,
- they participate in the fluvial process by the formation of deep and plan forms, thus changing the geomorphological features of the rivers,
- they might be used in the assessment of soil erosion process within the limits of river basin.

1.2 Aim of the project

The aim of the study is to assess the sedimentation and the physico-chemical characteristics of Oyan dam reservoir, Ogun state, Nigeria with the view to determine the reservoir water quality and effect of sedimentation on the unproductive hydropower functionalities of the dam.

1.3 Objectives of the project

The aim of the study was achieved through the following objectives:

- Geospatial position determination of all features within the study area
- Sounding to determine the depth of points below the water surface and sediment volume
- Water sampling

1.4 Study Area

The Oyan dam located on latitude 7°15'N and longitude 3°16'E at an elevation of 43.3 m above sea level which was commissioned on 29th March, 1983 is owned by the Ogun-Osun River Basin Development Authority (O-ORBDA).

It has a catchment area of approximately 9,000km². The lake covers an area of 4,000 hectares. It was designed to supply 525 million litres and 175 million litres of raw water per day to the Water Corporations at Lagos and Abeokuta respectively. It was also designed to provide water for the irrigation of about 3,000 ha Lower Ogun Irrigation Project under construction. In addition, it has the capacity to generate 9 Megawatts of hydroelectric power for distribution to Abeokuta and its environs. The three turbines of 3.0 megawatts each have been installed since 1983 but have never been commissioned (put into use). The Authority also controls fishing activities on the reservoir. The authority established three settlement camps for the displaced (22) communities submerged by the resulting lake: one on each bank of the lake in Ogun State and the third on the far end of the lake in Oyo State which were named Ibaro, Abule Titun and Igbo-Ora respectively (O-ORBDA, 1998) (Adekanye, Raphael, & Alhassan, 2016).

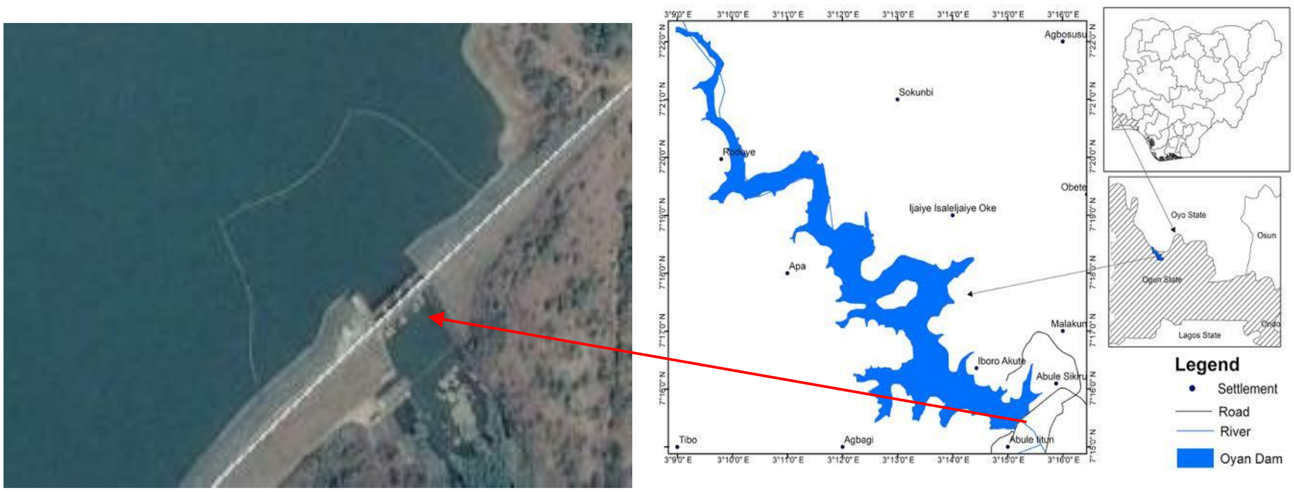

Figure 1: Map of the study area

2.0 Methodology

This chapter of the study outlines the methodology and procedure adopted during the execution (Figure 2).

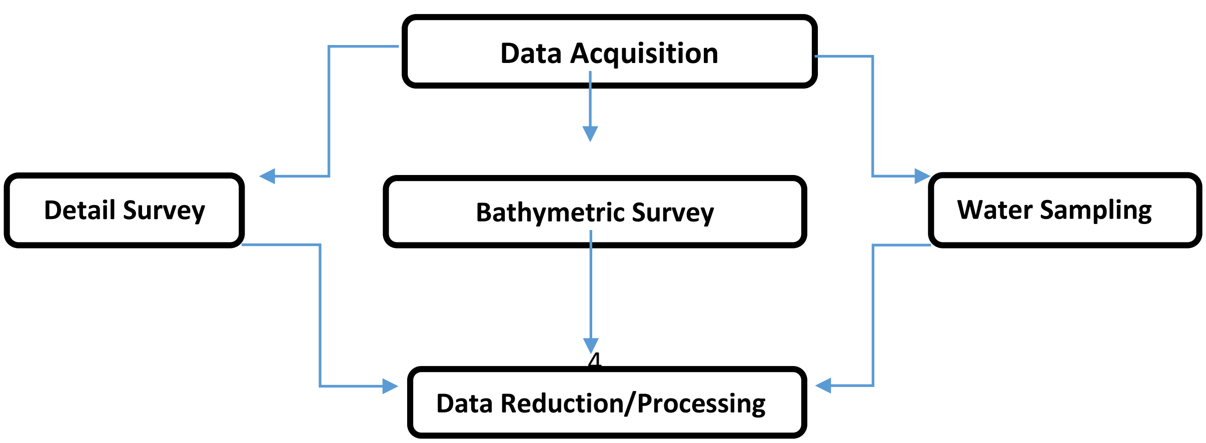

Figure 2: Flow Chart of the adopted approach for the study

2.1 Data acquisition

All equipment used were tested to be in good working condition before being used for data collection. The echo sounder was configured and calibrated before and after data collection. Linear calibration and Collimation tests were carried out on the total station. Observations were made to fix position of buildings, bridges, electric poles, gates, roads, chambers and drainages which were visible within a close extent.

All equipment used for sounding were loaded into the boat and everybody on-board put on life jacket. The echo sounder was calibrated while the boat was on the water and the transducer was set up by the side of the boat making sure the transducer faces lower into the water deep enough. The boat was headed back to starting sound line as planned (moving in a regularized speed in order to maintain a constant fixing interval) while fixes were done at appreciable distances. The cross lines were ran in a sinusoidal manner to the normal sounding lines as planned. This was done that so as to check the work which was carried out and to delineate the area more fully by interlining normal sounding lines.

Water samples were collected/ taken during data acquisition and were taken to public health engineering laboratory to determine different chemical and bacteriological properties of the collected samples.

The data acquired during detail survey operation were downloaded from the total station and further edited using Microsoft Excel and Notepad and the final edited copy was saved as text file containing X, Y, Z coordinates of all points observed in the field. These data sets were subjected to the further processes using the Microsoft Excel and Notepad. The raw data acquired by echo sounder is susceptible to an error known as false depth which occurs when there is false echo from the echo sounder. These were noticed when the depth is equal to draught of the transducer or when there exist a very sharp change in depth. The false depths were eliminated by going through the raw data to locate where there are sharp changes in depth. Sampling was done to correct the false depths and the corrected data was saved as .dep file extension.

Initial processing of the data involved the manual removal of false data points (outliers) such as single-point depths located substantially above or below the general dam-bottom trend, zero depths, or data that showed roll or vertical boat movement.

Outliers were generally the result of submerged debris or gas bubbles in the water column. Outliers were visually identified, tagged for deletion, and removed before additional data processing. Hypack was used to sort the data and grid them at 50m interval using the XYZ to Matrix function.

The Geometric and depth data in an X-Y-Z format were then imported into the ArcGIS software package for further processing.

3.0 Results and discussion

The coordinate locations at which water samples were subsequently imported into ArcGIS 10.2 as an event file. The event was converted into shapefile in order to add some other characteristic information into the attribute table (Figure 3).

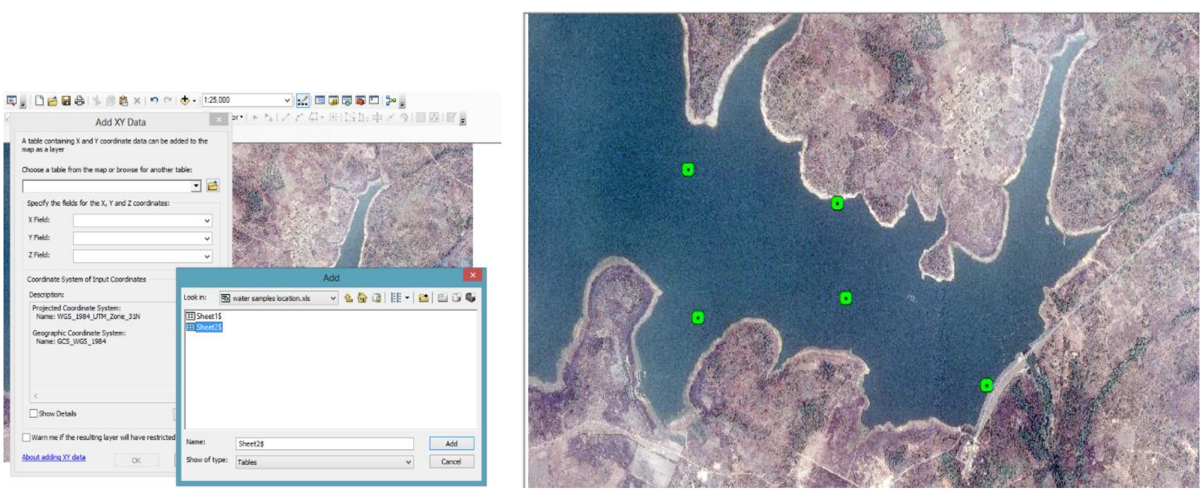

Figure 3: Showing addition of XY data of water samples and different sample locations

3.1 Generation of Bathymetric Chart

Hypack was used to interpolate the true depths. These depths were imported and plotted in ArcGIS environment and the bathymetric map was produced. The deepest depth of the reservoir bottom is categorized between -21.58 and -24.09 (Figure 4).

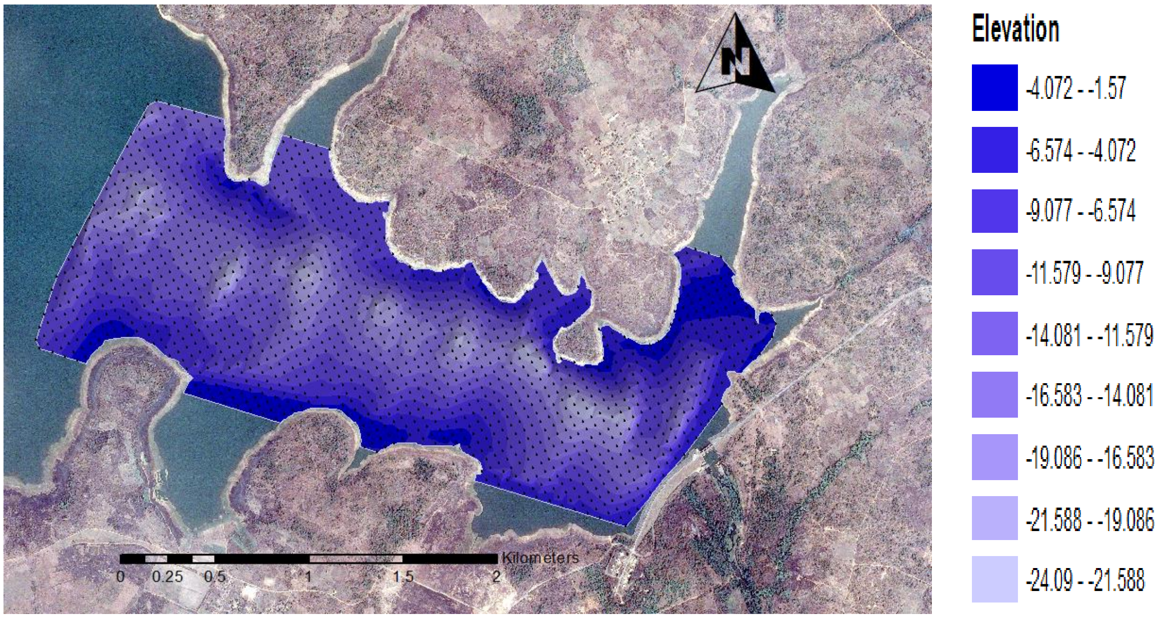

Figure 4: Bathymetric chat of the bottom of the Oyan reservoir

3.2 Surface Generation

The Triangulated Irregular Network (TIN) was created in order to produce 2D and 3D surface to describe the study site, and provide interpolations within its boundary. The Triangulated Irregular Network (TIN) surface was created using the 3D analyst tool in the Arc Toolbox.

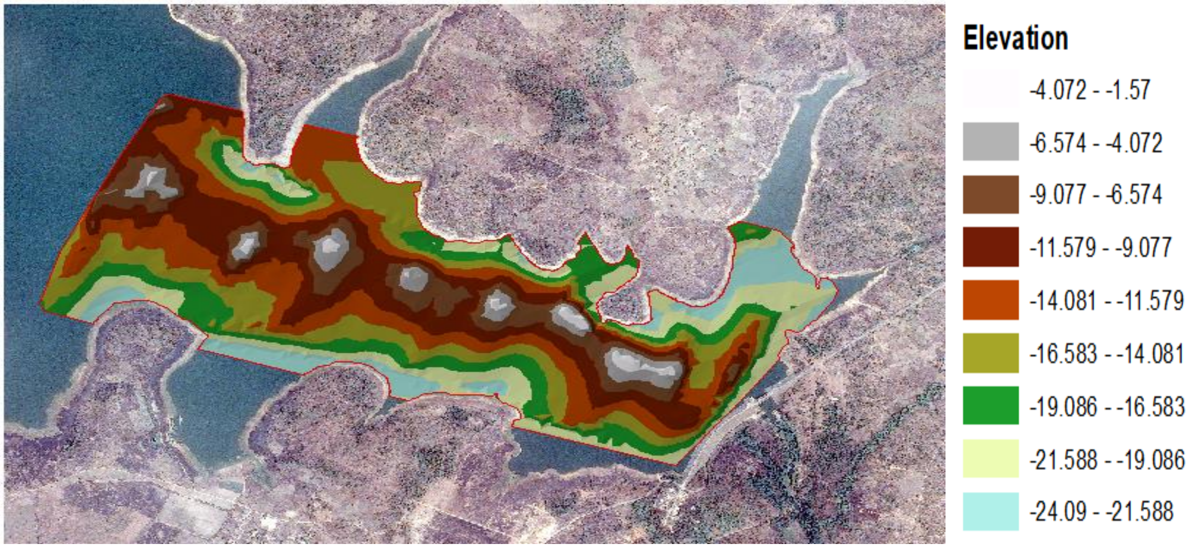

Figure 5: Triangulated Irregular Network (TIN) of the bottom Surface of the reservoir

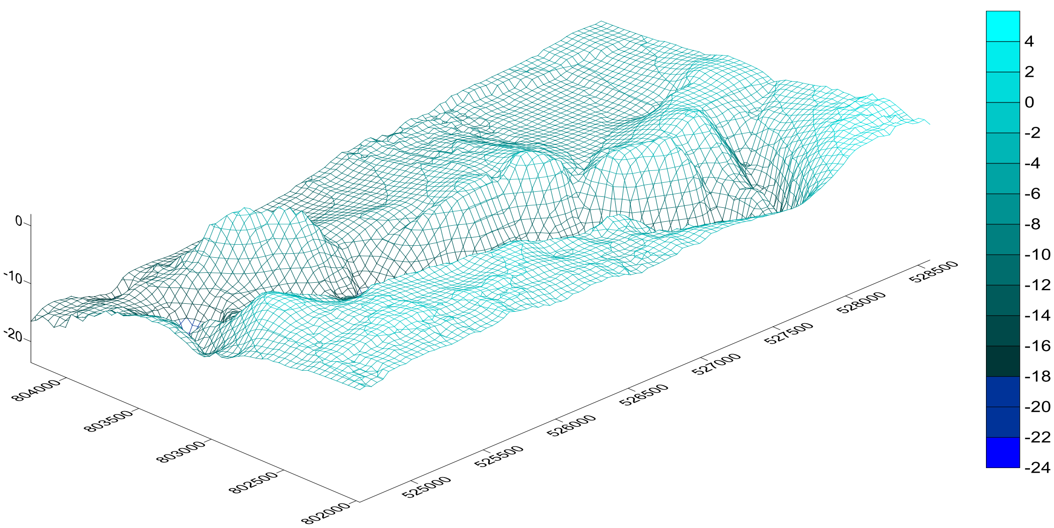

Figure 6: 3D Wireframe representation of the reservoir

3.3 Sediment Volume

The pre-construction height of the reservoir and Triangular Irregular Network (TIN) generated from the acquired geometric and deduced sediment (height) was used to compute the areas and volumes for a sounded section of the reservoir using Model Maker 13.13 version.

Model Maker has powerful volume calculation capabilities that allows for cut and fill volumes calculation between two dimensional Terrain Model (2-DTM) surfaces (i.e. Original ground level and the height of the sea bed) and determine the best elevation of a platform within a certain area. The computed volume of the sediment is 18,263,512.00m^3 (Figure 7 & table 1).

The study showed that level of sedimentation is on the increase when compared with previous studies. This will have adverse effect on electricity generation. Electricity production in small hydropower (SHP) plants can be increased without the need for the construction of new SHP scheme, but by upgrading and optimizing different aspects of existing plant's operations and sedimentation studies at regular intervals (Adegboye, Odunfa, & Ohunakin, 2014).

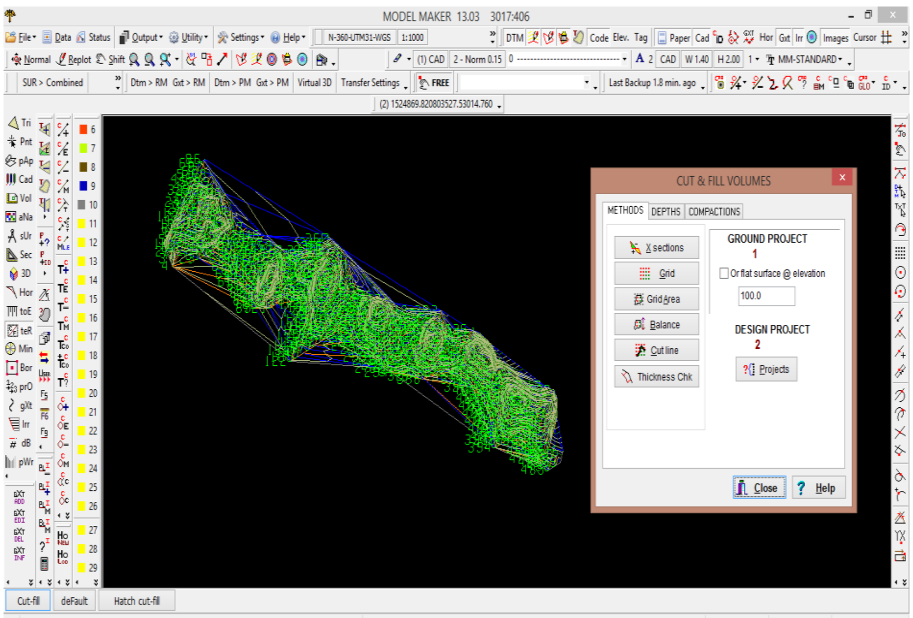

Figure 7: Terrace Menu for Cut and Fill Volumes Calculations in Model maker

Table 1: Summary of volume calculated with Model Maker 13.03 version

Grid Interval	*Final Fill Area (m^2)*	*Fill Volume (m^3)*
0.5 by 0.5	*1,907,492.25*	***18,263,512.00***

3.4 Physico-Chemical and Microbiological Characteristics of Sampled Water

The physico-chemical characteristics of the water samples were compared with the Nigerian Standards for Water Quality (NSDWQ) and World Health Organization (WHO), (Table 2). The electrical conductivity of the dam is low compared to the two standards. This is likened to be attributable to why the power generating ability of the dam is not optimally functional.

Table 2: Comparison of Sampled Water Parameter with NSDWQ and WHO

PARAMETERS	323	324	325	331	NSDWQ	WHO permissible limits
PH	6.79	6.78	6.79	6.8	6.5-8.5	6.9-9.2
Conductivity (µ s/cm)	132.2	132.4	131.6	133.3	1000	900 - 1200
Alkalinity (mg/l)	68	40	32	52	Not Specified	500
Acidity (mg/l)	48	28	16	12	Not Specified	30 -500
Total Dissolved Solids (TDS) (mg/l)	87.4	86.6	86.1	87.7	500	500
Biochemical Oxygen Demand (BOD) (mg/l)	12.2	15.4	13.5	14.7	Not Specified	50
Sulphate (SO4) (mg/l)	5	6	5	5	100	250
Chloride (mg/l)	28	32	32	12	250	250
Ammonia (NH_3) (mg/l)	N. D	N. D	N. D	N. D	Not Specified	10
Temperature (°C)	27.7	27.7	27.7	27.7	Ambient	< 35
Salinity (ppm)	60	60	60	60	Not Specified	Not Specified
Dissolved Oxygen Content (DOC) (mg/l)	6.18	6.8	6.45	6.61	Not Specified	<3.0
Iron (mg/l)	0.142	0.111	0.033	0.023	0.3	0.3
Phosphate (mg/l)	N. D	N. D	N. D	N. D	Not Specified	4
Suspended Solids (mg/l)	12	3	7	6	Not Specified	25
Oil & Grease	N. D	N. D	N. D	N. D	Not Specified	Not Specified
Total Coliform (CFU/100ml)	1.2×10^2	0	1.10×10^2	2.10×10^2	10	1.0×10^2
Escherichia Coli(CFU/100ml)	1.0×10^1	0	1.0×10^1	1.10×10^2	0	0

Findings from the study has shown that the sedimentation level of the dam is on the increase when compared to previous studies and will continue to increase because of sediment deposits from the numerous tributaries associated with the reservoir. This will no doubt have effect on the amount of power to be generated from the dam. The water tests also reveal that the physico-chemical and microbial composition of the reservoir is within the NSDWQ and WHO standards. A holistic look at the NSDWQ showed that there are no specified standard for most of the tested parameters. This calls for professional contribution of Nigerian water resources personnel such as from National

Water Resources Institute (NWRI), Kaduna. In some cases the WHO standard may not be totally applicable to some tested results in some parts of the world including Nigeria. This is why each country has its own standard based on the peculiarity of their environment, economy and physicochemical characteristics of their waters.

4.0 Conclusion and Recommendation

There are prospects for the Oyan dam in terms of economic potentials such as tourist centers, fishing zones etc. if adequate steps toward full maximization of the potential of these engineering infrastructures are utilized.

High sedimentation will reduce the volume of water to power the hydropower turbines. Although the conductivity of the water is low but then a mini hydropower can be generated from the dam if the sedimentation level is monitored at regular intervals. This would save the government from spending millions of naira on diesel generators used in running the dam. The dam would serve as a cheaper energy source for lifting water away from the dam area to adjacent lands. This would be used for powering agro-processing factories.

References

Adegboye, O. R., Odunfa, K. M., & Ohunakin, O. S. (2014). Reactivation of a small Hydropower Plant (SHP)Oyan SHP Station, Nigeria. *Canadian Journal of Aplied Sciences*, 3105-3114.

Adekanye, T. A., Raphael, O. D., & Alhassan, A. E. (2016). Maximizing the Full Economic Potentials of Ikere Gorge and Oyan Dams for National Economic Development. *African Journal of Agricultural Science and Technology (AJAST)*, 633-641.

Olatunji, T. (2012). Towards effective Hydrological Measurements downstream of Oyan dam. *Hydrology for Disaster Management: Special Publication of the Nigerian Association of Hydrological Sciences*, 121-131.

Olayinka, D. N., Nwilo, P. C., & Adzandeh, A. E. (2013). From Catchment to Reach: Predictive Modelling of Floods in Nigeria . *FIG Working Week 2013: Environment for Sustainability* (pp. 1-16). Abuja: FIG .

Ufoegbune, G. C., Yusuf, H. O., Eruola, A. O., & Awomeso, J. A. (2011). Estimation of Water Balance of Oyan Lake in the North West Region of Abeokuta, Nigeria. *British Journal of Environment & Climate Change*, 13-27.