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Comparison of different methods for Bathymetric Survey and Sedimentation Evaluation of a Small Reservoir in Nigeria for Sustainable Management

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Abstract: Sustainable management of small reservoirs requires adequate information on reservoir volume, sedimentation load and rates which are lacking in most small reservoirs. Echo Sounder (ES) is a modern technique in bed measurement, especially in clear waters. This work compared the use of ES and manual BATHYBOX which was a concrete metal box to develop a simple and affordable techniques for reservoir capacity evaluation towards sustainable management of small reservoirs. With ES and BATHYBOX, depth, reservoir volume, sediments level and sedimentation rate estimations were made following standard procedures. Calibration of the ES transducer dual High Frequency (HF) and Low frequency (LF), as well as BATHYBOX, ensured the accuracy of measurement. The ES measured reservoir capacity at LF and BATHYBOX were 104,292.49m^3 and 105,104.03m^3 which were 94.81% and 95.55% of the designed reservoir capacity (110,000m^3) respectively. Sediment deposition of ES was 7835.08m^3 (sediment rate of 652.9m^3/yr) and BATHYBOX was 4895.97m^3 (sediment rate of 407m^3/yr). A difference of less than 10% existed between the current reservoir volume estimation from the two methods. Although ES saves time, it is limited in part of reservoir with heavy reservoir vegetation unlike BATHYBOX which can be used in rough and less clear water. BATHYBOX is time and labour demanding though could be an affordable alternative especially in small reservoirs.

Keywords: Bathymetry, Echo Sounder, Small reservoirs, Sedimentation rate.

Introduction

Dam construction is the leading water conservation effort for flood control, meeting irrigation water demand, hydroelectric power generation, tourism and maintenance of ecosystem functions (Aiinsworth, 2005). In Africa, there has been increasing interest and debates on effective management and sustainable utilization of existing large, small and mini dams towards deriving optimum benefits from the investments (Skinner *et al*., 2009). The management of dams and other ancillary structures determines their safety, health and productivity over the designed period (Handidu, 1990). One of the immediate consequence of poor management of a dam could be seen in the state of dam's embankment and reservoir, which often results in the loss of capacity from siltation and sedimentation due to erosion within a dam catchment (Tiit *et al.,* 2015; Laurent *et al*., 2014). Radwan, 2016 and Anna and Apple, 2013 had reported how the morphometric variables of reservoirs or lakes can be greatly affected by the activities within the catchment feeding it. Reservoir sedimentation primarily is a continuous process that can be unnoticed for a significant portion of the life of a reservoir as sediments transported by the upstream river system are deposited into a reservoir. The distance of deposition is dependent on decreasing water velocities. As sediment accumulates in the reservoir, storage capacity is reduced (Radwan, 2016; Williams *et al*., 1987). The continued deposition develops distribution patterns within a reservoir that is greatly influenced by both operations of the reservoir and timing of large flood inflows (Chanson and James, 1998). For instance, Williams *et al*. 1987, reported that over a period of 61 years, Lake Decatur lost 9100 acre-feet of storage capacity through the accumulation of 9,830,000 tons of sediment. On average, each acre of watershed delivered 21.4 tons of soil to the lake over the 61 years. Chanson and James (2005) had also observed that sedimentation problems were more pronounced in small to medium size reservoirs (catchment area less than 100km^2). Catchment size, vegetal apron, the topography of catchment, human activities especially agricultural activities and climatic effects have been identified as some of the factors that heighten sedimentation extent in dams and reservoirs. (Aynekulu and Atakliti, 2006; Nagle, 2001; Bullock *et al*., 1990).

Measuring the level of sedimentation and reservoir capacity has been a major challenge in dam management. With the advancement in multibeam technology, echo sounders have become a major instrument in bathymetric surveys (Radwan and Tarek, 2016; Laurent *et al*., 2014). Multibeam systems are fan beam acoustic systems consisting of a number of narrow single beam transducers mounted in close proximity and focused at an equally spaced angle from a location on or under the survey boat (Selva *et al*., 2013). This technology has been enhanced with the parallel revolution in satellite supported Global Positioning System (Mayer 2006; Parkinson *et al*., 1995). Echo sounders bathymetry operate with frequencies between 12 kHz and about 500 kHz. Joseph *et al*., 2017, in the survey of Ruiru reservoir, Kenya used dual echo sounder with a frequency between 200 KHz and 350 kHz. The shorter the wavelength of the signal, the higher the spatial and temporal resolution of the measurements (Selva *et al*., 2013; Smith, 1993). Common multibeam echo sounders for typical open ocean water depths work with frequencies of around 12 kHz or 30 kHz (Smith, 1993). In order to achieve high spatial resolution, the signals have to be focused on beams of typically between 0.5° and 4° opening angle. For a multibeam installation, therefore it is important to include a highly accurate inertial motion sensor and a positioning system to keep track of the vessel's orientation and position in space. For each detection and *t*, position (xT , yT , zT) as well as roll, pitch and yaw angles (*ÁT* ,*µT* ,*ÃT*) are recorded too. The latest generation of multibeam echo sounders is capable of delivering a spatial resolution of up to 10m at 1000m water depth, scaling approximately linearly with water depth. Such systems are fully compensated for in vessel motion, including yaw and heading (Calder and Mayer, 2003). The beam angles at the transducer may be optimized to yield equidistant spacing of the soundings on the seabed (Smith, 1993). Although multibeam only provide hydrographic data along a single path directly beneath the track of a surveying ship, the systems based on acoustic echo sounding methods require surface vessels to carry them and thus the speed of acquisition of bathymetric data is limited by the speed of the vessel (Selva, 2013).

However, the enormous transducers and the complex installation make deep-water multibeam echo sounders expensive equipment and thus difficult to acquire for evaluation of small reservoirs. In sub-Saharan Africa, there are many of such reservoirs (Bolee *et al*., 2009; Jens *et al*., 2007) used for agricultural water supply and smallholder irrigation. Many of these small reservoirs are located within catchments with high farming activities and consequent erosion rates and lesser efforts are made to monitor their sedimentation patterns

(Tatenda *et al*., 2012). The sedimentation committee of the International Committee on Large Dams could only get some data from just about 11 reservoirs for the review of sedimentation of dams in Africa (ICOLD BULLETIN, 2009). Funds have been a major limitation to Echo Sounder acquisition and deployment for the survey of many small reservoirs. Selva (2013) has suggested that where finance is a limiting factor, reservoir bed depth can be measured manually. Thus, with a lack of
data on current actual capacity, sedimentation level and sedimentation rate, sustainable management of these water infrastructure is hindered. The focus of this work is to compare the use of simple bathymetric box (manual bathymetry) with echo sounder, towards developing an affordable protocol for the survey of small earth dams in Nigeria.

Methodology

Study location and instruments

The Akufo dam (Lat. $7^{0}29^{l}7.31$”N and Long. $3^{0}48^{l}50.02$”E) is situated at Akufo Farm Settlement, in Oyo State, Ibadan within south-western Nigeria (Figure 1). The dam was constructed by the State Agricultural Development Programmes in the year 2008 to serve the community as a source of household water supply and smallholder irrigation.

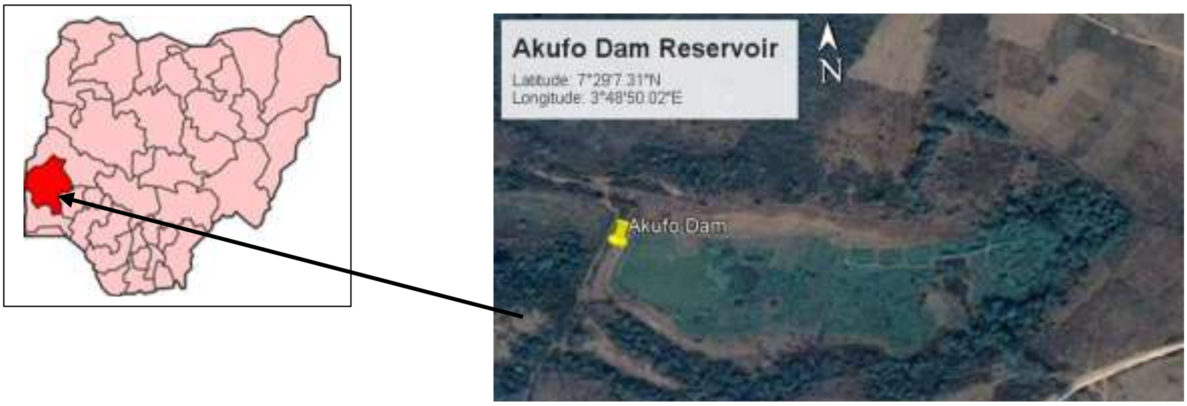


Figure 1 - Study location: Akufo Dam reservoir

Akufo Dam is an earth-filled dam 8.5m high. Its embankment length is 150m with a freeboard of 1.75m, a spillway length of 20m and a designed storage capacity of 110,000m^3. The catchment area is 7.38ha of which about 36.9ha (36,900m^2) constitute the reservoir surface area. The survey work followed the protocol shown in Figure 2. Two major devices were employed in the bathymetric survey. Echo Sounder HD 380 with Bathymetric range of 0.3m-600m, Accuracy of ±10mm +0.1% and Resolution of 1cm (Hi-Target, 2010) and a cuboid-shaped concrete filled metal box (BATHYBOX). The same survey operation methodology was employed for the two devices while the results were analysed independently to make a comparison between the two methods.

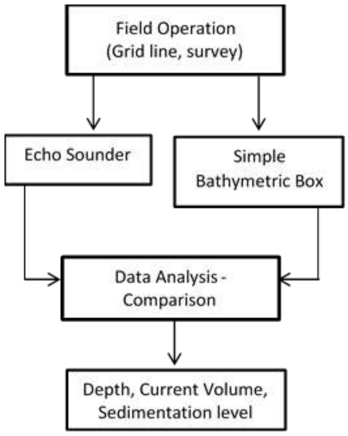


Figure 2 - Protocol for the survey operations

Survey gridlines and navigation

The survey operations involved gridding of the dam reservoir for guided navigation. A pre-determined line at the opposite sides of the reservoir banks (X-axis) were marked at 10m intervals. Pegs, 1m above ground level, with colored flags were erected at 10m intervals to guide navigation. On the Y-axis (by the dam embankment), a similar pre-determined line with pegs at 10m interval was also erected (Figure 3). The canoe navigates along each line on X-axis from one side to the other following the gridlines in the order of X1, X2… Xn. As the canoe moves toward the end of the X1 on X- axis, it turns to align with the next grid line marked X2 along the X-axis until the last line (Xn) was located (Figure 4). A Garmin GPS (eTrex Legend model with spatial accuracy of 3.0m) set at WGS 84 projection was used to track 10m point that corresponded to the pegged line on the Y-axis (gridlines perpendicular to the dam). During the survey with BATHYBOX, as the canoe navigates along the gridline, the bathymetric box was lowered to reach the reservoir bed at the appropriate point, the depth measured and the geographical position of the point taken by the handheld GPS were recorded electronically and manually in a logbook. However, with Echo Sounder, following the gridlines the depth and geographical positions were acquired and stored automatically. This is similar to the approach of Joseph *et al.*, 2017, Innocent and Henry, 2015 and Dunbar *et al.,* 2010 in a related survey.

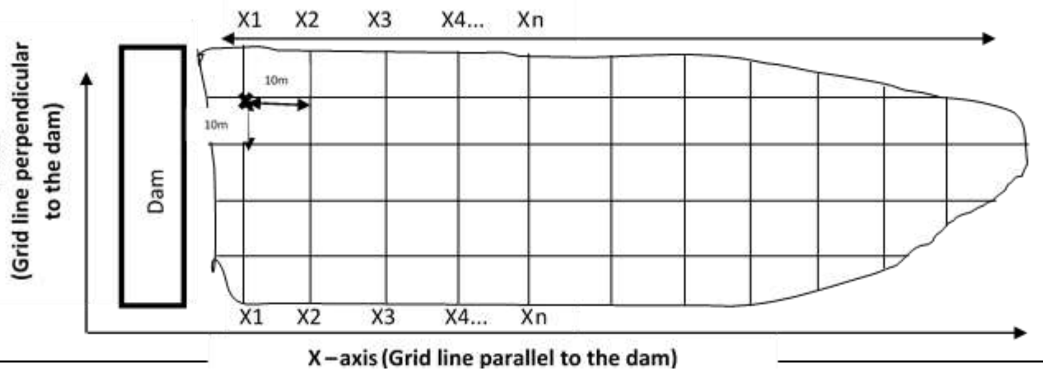


Figure 3 - A plan view of the gridded reservoir for canoe navigation and data acquisition

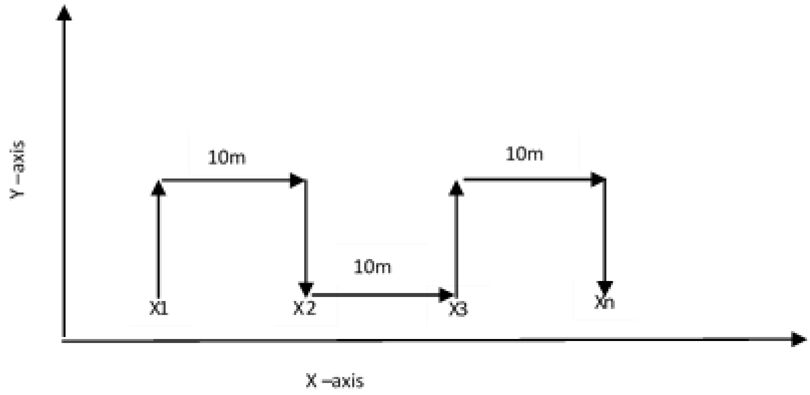


Figure 4 - Movement of the canoe along and across the reservoir

The data was later processed using surfer and Autodesk Land development software

Bathymetric Box (BATHYBOX)

A bathymetric box was fabricated for manual bed depth measurement. The major considerations for the design of the BATHYBOX were the weight, size, shape and the depth of the dam. The maximum depth of the dam from design drawing was 9.0m which became the minimum for the chain length for lowering of BATHYBOX. The chain was marked at an interval of 0.25m with the use of measuring tape. Paper tape was fixed with the mark boldly written and covered with a waterproof nylon material. Thus, the entire 10.0m length of the chain was marked. The designed weight of the bathymetric box was 4kg. This is heavy enough to avoid possible drag from the water current and water vegetation within the reservoir. The weight was achieved with a unit weight of 24kN/m^3 from the concrete mixture of 1:2:4 poured inside the box (15cm x10cm x 10cm, cuboid shape) through a side until it was filled. Thereafter, the opening was sealed and the metal box painted.

Data acquisition using an echo sounder

After successful setting up of the equipment (Plate 1), the echo sounder was turned on and its data acquisition software (NAV 380) launched. The coordinate system was set at WGS84 (Ketut *et al*., 2017). Also, the recording interval was set to 5 seconds while the HIGH and LOW-frequency signal gate, pulse length, and gear were set to AUTO. Under terms menu, the High frequency (HF) was set to 200 kHz, Low frequency (LF) set to 15 kHz and the penetrating range set to 10 meters for optimum penetration (Ajith, 2016; Selva *et al*., 2013). Then a file was created under file menu where the observation was saved to commence the logging of data the record tab was clicked (Calder and Mayer, 2003).

Echo sounder adopts the formula below to calculate the depth of the water body.

$$D = \frac{c\Delta t}{2} \qquad 1$$

Where D is the acoustic depth, c is the speed of sound in water and t is the time of travel of the acoustic pulse to and from the reservoir bed. The movement of the canoe parallel to the dam was assumed x-axis and the y-axis was its movement perpendicular to the dam.

HD 380 Dual frequency downloads and processing

The dual frequency echo sounder automatically logged and saved depth and navigation into its hard disk. These data were automatically corrected for draft using the draft value measured during equipment set up. These data were copied as a text file from the echo sounder. The equipment takes the depth level at High and Low frequency. The dual frequency enables the computation of the sedimentation level (thickness) between the sediment surface and reservoir bed level. In shallow waters, it is recommended that two frequencies are used at the same time to differentiate soft sediments from the bed rock (IHO, 2005). The low frequency penetrates to the deep layer while the high frequency measured the unconsolidated surface.

Plate 1- Field set up with Echo Sounder and BATHYBOX

Calibration of Echo Sounder and BATHYBOX

To ensure the accuracy of measurement, calibration of echo sounder and transducer were performed using bar check technique. The bar check involves lowering a flat plate below the echo sounder transducer (to several precisely known depths) below the surface and comparing the actual and measured depth (Reha *et al*., 2006). The depth measurement was made at an interval of 0.5m between 0.5m – 3.0m. As the bar is moved down, the sound velocity in the echo sounder is adjusted until the measured depth matches the actual depth. At the end of the test, the echo sounder has been fixed with the average sound velocity over the water column. Bar check have been known to be a reliable calibration technique in Echo Sounding system (Calder, 1975).

For the BATHYBOX, a draft of 0.15m was added to the recorded depth at each position. The draft represents the height of the BATHYBOX. With a weight of 4kg, the BATHYBOX overcame the vegetal materials in parts of the dam reservoir, which enabled easy penetration of the BATHYBOX down to the bed of the dam.

Data processing and analysis

The data acquired from the two devices were processed using SURFER 13 to determine the depth profiles, dam area, reservoir volume capacity and the sedimentation level of the dam. Autodesk Land development software was also used to get the topography of the dam. The contour maps bed profiles were generated with

SURFER. Reservoir volume capacity from the two methods was based on the Trapezoidal Rule in SURFER (Nazzan, 2018; IHO, 2005). Nazan 2018 explained that Surfer approximates the necessary one-dimensional integrals using classical numerical integration algorithms to arrive at the extended trapezoidal rule (equation 2 and 3). In Surfer, the volume under a function *f* (*x*, *y*) is defined by a double integral. This is computed by first integrating over X (the columns) to get the areas under the individual rows, and then integrating over Y (the rows) to get the final volume

$$A_i = \frac{\Delta x}{2}\ [H_{i,1} + 2H_{i,2} + 3H_{i,3} + \ldots + 2H_{i,ncol-1} + H_{i,ncol}] \quad \ldots\ldots\ldots\ldots \quad 2$$
$$V = \frac{\Delta y}{2}\ [A_{i,1} + 2A_2 + 2A_3 + \ldots + 2A_{i,ncol-1} + H_{i,ncol}] \quad \ldots\ldots\ldots\ldots\ldots \quad 3$$

Δx represents the grid column spacing, Δy represents the grid row while H_{ij} represents the grid node value in row i and column j.

The sediment deposition from Echo sounder was estimated from the difference between reservoir capacities computed (equation 4) from depth survey at High and Low Frequencies (Joseph *et al*., 2017; Selva *et al*., 2013). The sediment deposition estimated from BATHYBOX is computed from equation 5 following, Adwubi *et al.,* 2009. Annual sedimentation rate was estimated as a ratio of sediment load to the number of years the dam has been in operation (equation 6).

Method 1: Echo Sounder at High (HF) and Low (LF) Frequencies

$$V_{ES} = V_{LF} - V_{HF} \quad \text{---------------------------} \quad 4$$

V_{ES} = Sediment Load (m^3) from Echo Sounder; V_{HF} = Reservoir volume at HF(m^3) V_{LF} = Reservoir volume at LF(m^3)

Method 2: BATHYBOX Manual measurement

$$V_B = V_{DV} - V_{EV} \quad \text{--------------------------------} \quad 5$$

V_B = Sediment Load (m^3) using BATHYBOX; V_{DV} = Reservoir volume at Design (m^3) V_{EV} = Reservoir Current Estimated volume from BATHYBOX (m^3)

Annual Sedimentation rate (m^3/yr) = Sediment Load/No of years of Dam operation ………….. 6

Sediment Load = V_{ES} or V_B for sediment load from Echo Sounder and BATHYBOX respectively

Results and Discussions

Bathymetric Survey Path

Figure 5 and 6 show the navigation path during the survey of the dam reservoir using Echo Sounder and BATHYBOX respectively. The outline of the dam covered was drawn and the survey path was overlaid on it. With the Echo Sounder, the whole area of the reservoir could not be covered with canoe navigation due to the presence of heavy vegetation towards the reservoir banks. Signals from the transducer were affected when places with high vegetal density were encountered which limit the depth sensing. The vegetation in the reservoir include. Reeds *(Phragmites australis)* and Water Hyacinth (*Eichhornia crassipes*). This is a major limitation to the use of Echo sounder especially in non-clear water bodies (Selva *et al*., 2013). However, with the use of BATHYBOX, more area of the reservoir was covered as the instrument was able to measure the depth within the areas having vegetation which could not hinder the weight of the box unlike the under canoe suspended transducer. The irregularity in the path noticed in Figure 5 was largely due to various vegetal mass (such as reeds, within the water body during canoe navigation which reduces very straight movement.

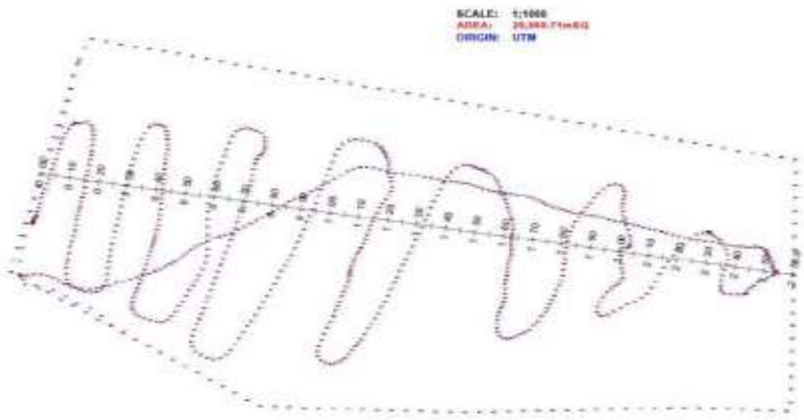


Figure 5 - Survey navigation path for Echo Sounder

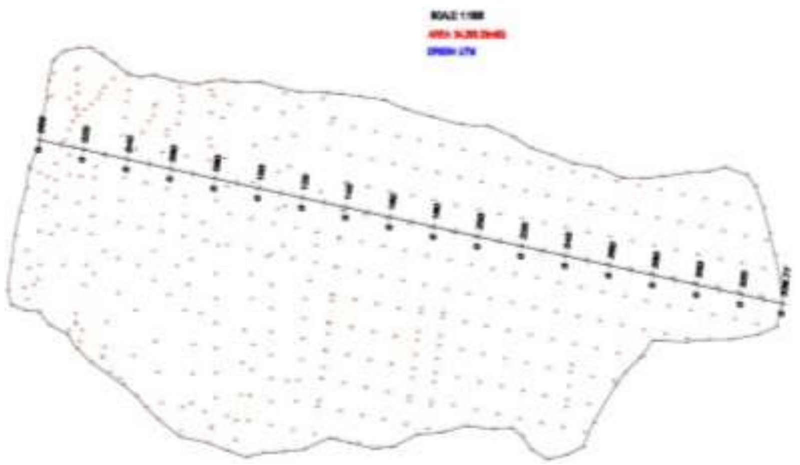


Figure 6 - Survey and measurement points for BATHYBOX

Contour characteristics of the dam from Echo Sounder and BATHYBOX

Figure 7 and 8 are contour maps from depth data generated from Echo sounder dual frequency survey. The maps show the depth/level at various points within the dam area as measured when transmitted with Low Frequency (LF) and High Frequency (HF) respectively. The depth ranged from 2.0m to 5.8m. The variations in reservoir depths between the HF and LF recordings are rather small. A closer look at Figure 6 and 7 shows that the contour from HF and LF show peculiar troughs which follows close similarity depicting related profile. Figure 9 represents the contour map showing the depth/level as obtained from BATHYBOX. The depth logged with BATHYBOX ranged from 4.5m to 6.2m. The BATHYBOX was able to push down vegetal material to the bed of the reservoir as evident in the depth recorded. These vegetal materials were inhibitors to the signals from the Echo Sounder transducer. Selvan *et al.,* 2013 has also observed a limitation to multibeam echo sounder systems functionality along shallow waters as the case is in the fringes or weedy banks of reservoirs.

Figure 10 further reveals how the bed laid from the surface from HF and deeper from LF. It was observed expectedly that the HF show higher elevation nearly across the entire bed. The peak elevation corresponds to the spillway end of the reservoir. The extra length covered by manual survey was shown in Figure 9.

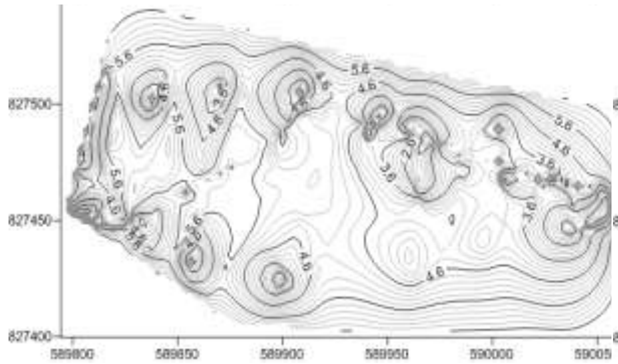


Figure 7 - Contour map from HF data

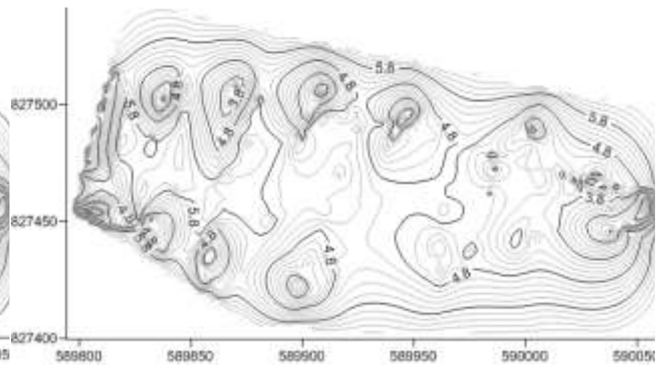


Figure 8 - Contour map from LF data

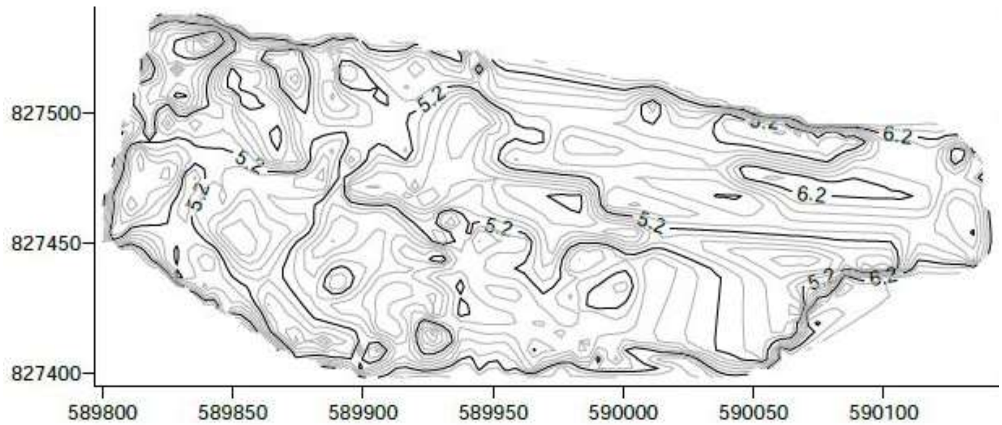


Figure 9 - Contour map generated from the processed bathymetric data

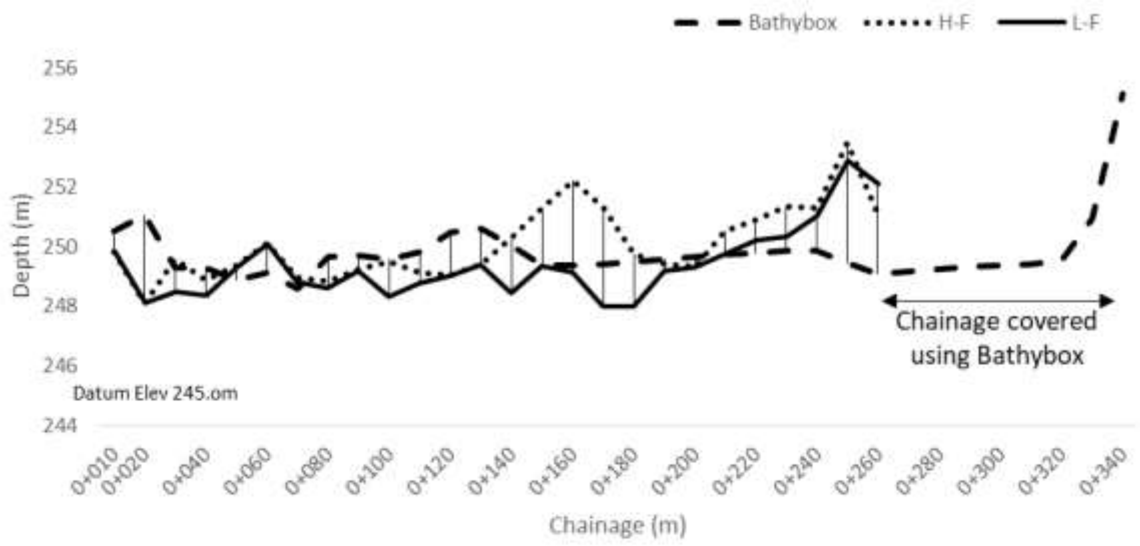
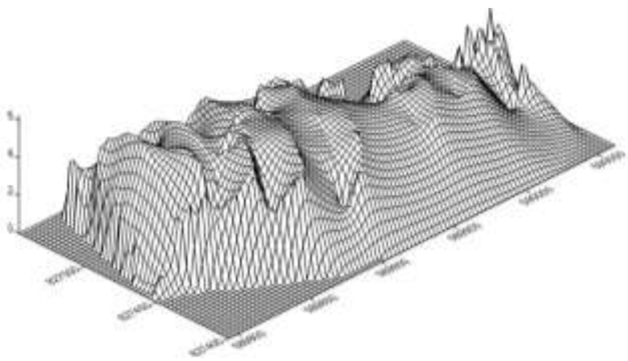


Figure 10 - Reservoir depth profile from Bathybox, Echo Sounder High and Low Frequencies

3D Digital Terrain Model (DTM)

The 3D model of the reservoir bed profile from HF and LF are shown in Figures 11 and 12 respectively. This is the output of grid file prepared in the X, Y, Z format in Surfer. It is the precursor to generating map or wireframe. The figures show the DTM map with the characteristics of the reservoir bed at LF and HF respectively. The outline showed that the highest point was 6.75m which was the spillway level. There is a close pattern between the HF and LF model, the difference lies in the pitch of the profiles. The HF shows the pattern of the sediment surface while the LF shows the bed level. Figure 13 represents the bed terrain from the BATHYBOX data, which shows the characteristics of the sedimentation pattern in the reservoir bed. The not very distinct peak of the profile shows the disturbances of the sediment surfaces during the survey since the BATHBOX hits the sediments surfaces unlike remotely sensed data acquired from the Echo Sounder radio signals. The difference is seen in the wireframe surface patterns in Figures 11 – 12 as against Figure 13.



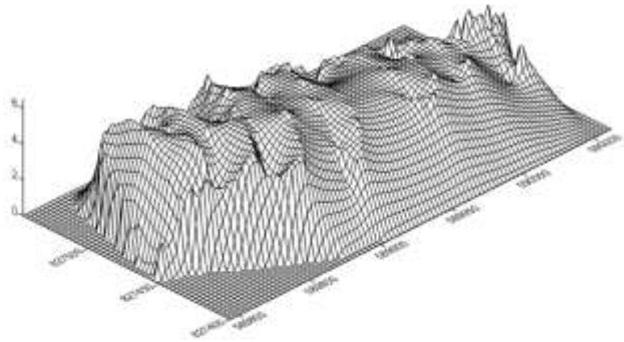


Figure 11 - 3D Wireframe DTM at HF *Figure 12 - 3D Wireframe DTM at LF*

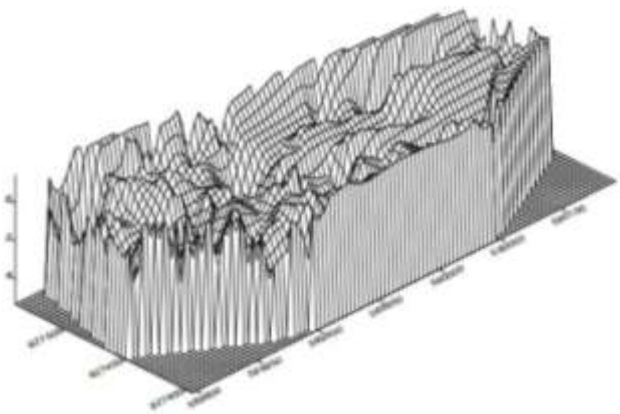


Figure 13 - 3D Wireframe DTM of the dam using the developed BATHYBOX

Reservoir Capacity

Estimated Reservoir capacity

Table 1 shows the surveyed area, estimated reservoir capacity and sediment deposition based on the two methods. The reservoir capacity estimates were based on the area accessible during navigation. Area covered for the ES was 27,970.92m^2 and for BATHYBOX, 35,020.98m^2 which constitute 75.8% and 94.9% of the original reservoir area (36,900m^2) respectively. Differences in the area covered were from the limitation encountered due to vegetation in the reservoir. More of the reservoir area were covered with manual BATHYBOX than the ES because of problem of vegetation which makes navigation difficult. The reservoir capacity with LF was estimated to be 104,292.49m^3 which is about 94.81% of the designed dam original reservoir capacity (110,000m^3). Similarly, reservoir capacity with the BATHYBOX was 105,104.03m^3 which is about 95.55% of the original dam reservoir capacity. A difference of 811.54 m^3 between the reservoir capacities estimated with BATHYBOX and Echo Sounder at LF was observed. There is approximately 20% percentage difference between the areas covered by the two methods yet ES estimated reservoir capacity was very close to the estimation from BATHYBOX. This suggests that ES may have overestimated the capacity than the manual measurement. Ajith (2016) explains that a dual frequency echo-sounder may not absolutely distinguish between fluff top depth and the consolidated bottom. Thus, BATHYBOX may offer some advantage in the bathymetry of roughed small reservoir. In absolute value, a difference of <10% (811.54m^3) between the estimation of volume from the two methods, it can be concluded that the difference is very minimal. Joseph *et al* (2017) have noted that an accuracy level of between 88% - 99 % may be feasible using modern bathymetric instruments.

Apart from the differences in the area covered due to vegetation, the relatively higher estimated volume from the manual BATHYBOX could be explained because of penetrating ability of BATHYBOX to reach the dam bed level as the instrument is heavy enough to compress the vegetation and measure to the nearest dam bed surface. In shallow waters, it is recommended that two frequencies are used at the same time to differentiate soft sediments from the bed rock (IHO, 2005). The low frequency penetrates to the deep layer while the high frequency measured the unconsolidated surface. Selva *et al*., 2013, observed that as far as the depth measurements are concerned using a multibeam system such as Echo Sounder, the resolution will depend on the acoustic frequency, transmit and receive beam widths and on the algorithm used to perform seabed. The high frequency (200 KHz) is used to detect the top of the mud/sediment. Under favorable conditions, which include clear water, the low-frequency signal (33 KHz) can penetrate into the bottom and reveal information about the bottom structure. The level of vegetation in the reservoir especially at up to about 30m from the bank was such that it could affect the resolution of the equipment (Figure 9). When conditions of clarity of water body is not met, IHO (2005) also confirmed that the return signals from transducer transmitted can be affected by the conditions at the specific point of survey.

Table 1 - The Estimated Area, Reservoir Capacity and Sediment level

	Surveyed Area (m^2)	% of Navigable Reservoir surface (m^2)	Estimated Reservoir Capacity (m^3)	Estimated Sediment deposition (m^3)
ES - LF	27970.92	75.80	104292.5	(7835.08)*
ES -HF	27970.92	75.80	96457.4	
BATHYBOX	35020.68	94.91	105104.0	4895.97

** Difference between estimated volume at low and high frequencies (Equation 4)*

Sediment deposition

The difference between the estimated reservoir capacity using LF and HF is the sediment deposition level. Based on the surveyed areas from the two methods (Table 1) and following equation 4, a deposition of 7835.08m^3 over the covered area was estimated using Echo Sounder. This shows that about 7.12% of the dam designed reservoir capacity was lost to sedimentation over a period of 10 years (from 2008) when compared to the original reservoir capacity of 110,000m^3. This translates to a deposition rate of approximately 652.9m^3/yr or 0.6%/yr of original reservoir capacity. Similarly, a sediment deposition volume of 4895.97m^3 which is 4.45% of original reservoir capacity (or 407m^3/yr) was recorded with BATHYBOX. This is equivalent to 0.4%/yr of the original designed reservoir capacity taking over by sedimentation. The difference between the estimation from the two methods stem from the limitation from inability of ES to cover areas with heavy vegetation. Innocent and Henry (2015) estimated the volume of deposited sediment in some reservoirs in Zambia using boat navigation and direct measurement. In 4 of such reservoirs, they observed sedimentation rate ranges between 283.92m^3/yr – 14,595m^3/yr, 251.01m^3/yr; 2,200.99m^3/yr with respective age ranging from 35years, 45years, 55 years , 46years. This shows that sedimentation rates vary based on the peculiarities and activities within a watershed.

The implication for dam management

From the results obtained, about 4.45% of the dam designed reservoir capacity was lost to sedimentation when surveyed with the developed BATHYBOX or 7.12% when surveyed with an echo sounder. These figures are high for a reservoir that was commissioned in 2008 (10years). In a similar bathymetric survey, Joseph *et al*., 2017, reported a reduction of 14% in the Ruiru reservoir in Kenya which was commissioned in 1949 (about 70 years). Akufo dam is located within an active farm settlement with high tillage and agricultural activities. Eroded materials from the farms are often transported through the river course and being settled in the reservoir. The possible loss of reservoir capacity of the dam to sedimentation in the nearest future will continue to be high if no measure is taken to reduce erosion and sediment delivery. The management of the dam is expected to develop a relevant policy to create a buffer around the dam in a way to reduce sediment transportation into the river system and the reservoir at large.

Conclusion

An Echo Sounder with the calibrated transducer and a manual Bathymetric Box have been used to evaluate the depth profile of a small earth dam reservoir. The goal was to develop an affordable, simple but reliable method of monitoring sedimentation of small reservoirs. The surveys conducted using these two methods estimated reservoir bed profile, sedimentation level, sedimentation rate and current reservoir capacity. The data obtained from the two procedures were relatively very close, even though the differences exist majorly because of condition of water in terms of clarity and level of vegetation. Although, the use of BATHYBOX comes at a higher labour cost, it has advantage under rough reservoir condition where high vegetation level is predominant. The level of vegetal cover in many small reservoirs earth dams is a challenge. With the similar survey procedures employed to measure the current reservoir capacity from the two devices, the use of BATHYBOX can be an alternative to echo sounder in the estimation of sediment level in small reservoirs. The cost of BATHYBOX is far lower than the Echo Sounder system that makes it readily affordable as a possible alternative in sedimentation survey of earth dam and management of small earth dam reservoir.

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