Civil and Environmental Research
ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online)
Vol.6, No.11, 2014

Estimation of Surface Siltation Rate in Tagwai Reservoir, Minna, Niger State, Nigeria

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Abstract
This study examines the level of sediment deposit in the reservoir by estimating the reduction in surface area of the reservoir. In achieving these, a traverse survey was run through the bank the dam using TC 1201 Leica Total Station and its accessories from three set of control points namely; CSN 239,CSN 240 and CSN 241. Coordinates of the control points were given in three dimension (x,y,z) and hence the perimeter of the reservoir was obtained using Microsoft excel and surfer8 software in year 2010. Five years interval was chosen for estimation; therefore, a digitized spot5 satellite image of the reservoir was acquired for the year 2005. The perimeter area of the reservoir plotted from the field data in 2010 was superimposed on the digitized satellite image for 2005. The two areas measured 356ha and 340ha respectively. The result of the perimeter traverse revealed that about 3.7% of the surface area of the reservoir has been taken over by sediment deposit. The reduction is attributed to the environmental impact and long time morphological changes of the natural water. It is also as a result of particles transported through the runoff that entered the reservoir which is a function of watershed characteristics. Its effect is that, it present hazard to navigation, changes water stage and ground water condition. With this, vegetation growth around the bank of the reservoir, continuous monitoring of the sediment yield, conservation and erosion control is recommended.

1.0 Introduction

All reservoirs ultimately get filled with sediments. The river carries sediments to the reservoir which is deposited in the reservoir. As more and more sediments are deposited in the reservoir, a stage comes when the reservoir is not able to serve its intended purpose and its useful life is over. If the annual sediment inflow is large compared with the reservoir capacity, the useful life of the reservoir would be very short. While planning a reservoir, it is essential to consider the rate of sedimentation to know whether the useful life of the proposed reservoir will be sufficiently long to justify the expenditure on its construction.

Reservoirs are created by construction of dams across a river causing water to back up and allowing it to be stored. The height of the dam, type of spillway, size and shape of the reservoir pool, amount of precipitation, rate of evaporation, and the size and characteristics of watershed are among the physical characteristic that determine the volume of water that maybe stored behind the dam. All reservoirs trap some of the sediment load transported by incoming flows, and therefore, experience a continual reduction of storage capacity volume (Mustafa and Yusuf, 1997). According to Siyam (2002) sedimentation is the major problem which endangers and threatens the performance and sustainability of reservoirs. It reduces the effective flood storage volume, present hazards to navigation, changes water stage and underground water conditions, affects operation of low-level outlet gates and values and reduces stability, water quality and recreational benefits. Arman et al, 2009) confirmed that sedimentation and decrease of large dam reservoirs' capacity reduces efficiency and productivity of the dam power house. To prevent sedimentation, basin management must identify the sources and causes of sedimentation from surface erosion, mass wasting, sediment transport and final deposition (Anderson, 1949).

In Nigeria, the forest land covers about 15% of the entire land area (Jimoh, 2010). The area is exposed to erosion activities. Some of the sediments are trapped by the existing reservoirs available records on sediment yield and water quality are of short length, and are records taken during the design and construction of major dams (NWRMP, 1995). For example, FMAWRRD (1986) stated that sediment yield in most rivers in the River Gurara Basin ranged between 1.0 and 2.0g/l. Further studies by Jimoh (1992b) showed that the low value is adequate for estimate during the dry season, but the sediment yield during the rainy season is higher than 2g/l.

1.1Tagwai Reservoir

The study area for this research work is Tagwai dam reservoir located in Chanchaga Local Government Area, in south-west zone of Minna. Minna the state capital of Niger state has an origin that dates back to 1905; during the construction of Lagos - Kaduna rail link when it becomes an important work camp/station for the railways. Originally, Minna was simply a Gwari town, and obtained its name from the annual fire ritual of Gwaris (Umar, 1979).

Tagwai dam is the major source of water supply in Minna metropolis. The dam lies on Latitude 9˚ 33'55" to 9˚ 36'07N and Longitude 6˚ 39' 20" to 6˚ 39'58"E. The dam is at east of Tunga Goro about 10km, south-east of Mobil Market & North-East of Paiko. The dam is an earth dam that was constructed in the year 1978 by the Kano State Water Resources and Engineering Construction Agency (NSWB, 1991).

The activities of people settling within the dam environment are mainly farming and fishing although fishing activities is restricted. The dam is under the care of Niger State Water Board. Tagwai dam serve as primary reservoir for the city of Minna, the largest metropolis in Niger State. Since its construction, a detailed bathymetric survey of the dam reservoir has not been conducted.

2.0 Methodology

This study focuses on the estimation of surface siltation rate in Tagwai reservoir. There are numerous techniques available for sediment volume estimation. E.g . Survey techniques, Empirical techniques, Analytical techniques and sediment coring techniques. However, survey techniques through the use of a Leica total station and its accessories for the determination of the perimeter Traverse and acquisition of a digitized spot5 satellite image of the reservoir.

2.1 Material/ Equipments

The following materials and equipments were used in the course of the study; digitized spot5 satellite image of the study area, radio for communication, Hand held Global Positioning System(GPS), TC1201 Leica total station and its accessories, Kern automatic level and leveling staff.

In this research work a traverse was run through the bank of the dam using TC1201 leica Total station. Work started from three set of control points namely, CSN239, CSN24O and CSN241. Coordinates of these control points was given in three dimensions, hence the coordinates traverse stations was generated directly. A close loop traverse was run that is starting from set of known point and closed on the same known point.

To run the perimeter traverse of the study area, the Leica total station was mounted on top of a tripod that was set over CSN240S. The instrument was leveled using laser plummet method. A file was created through management menu and the file was named "'TAGWAI RESERVOIR". The coordinates of CSN24OS and CSN241S were then entered. From survey menu, the instrument was set up and orientation set to a reflector at CSN24IS. A reflector at forward station was observed and the coordinates of next point (TD 01) was determined. The instrument was however moved to TD 01 and the same procedures were carried out. The traverse was run from CSN240 and Close back to CSN24IS.

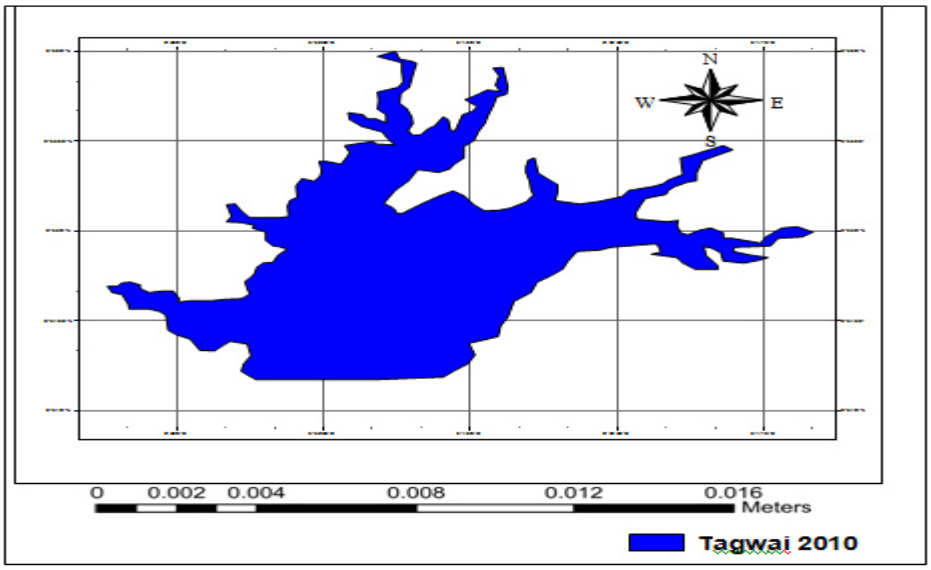
The perimeter data collected from Tagwai dam reservoir during the perimeter transverse were processed in the computer using Microsoft excel program for data entering and opened in Surfer8 software to generate the perimeter.

However, Spot5 satellite imagery for 2005 of Tagwai dam reservoir was acquired from Global land cover facility (GLCF) for the purpose of comparism. The field data generated perimeter (2010) was superimposed on the acquired Spot5 imagery (2005) of the same reservoir. At the end, the distance between the perimeter generated from the 2005 imagery and the 2010 generated perimeter reveals the surface area that has been taken over by sediment.

RESULTS

Perimeter Traverse at Tagwai Dam Reservoir (2010)

S/N	Easting	Northing	R/Level
1	234533	1060753	524.853
2	243509	1060796	254.761
3	243421	1060770	255.233
4	243347	1060742	254.775
5	243277	1060577	253.91
6	243207	1060571	254.523
7	243125	1060447	254.262
8	243031	1060402	254.436
9	242961	1060216	254.36
10	242903	1060116	254.011
11	242898	1059986	254.526
12	242842	1059985	254.652
13	242698	1059989	254.893
14	242738	1059865	254.645
15	242898	1059604	254.855
16	242839	1059498	254.67
18	242671	1059097	257.073
19	242612	1059083	255.722
20	242488	1059092	255.438
21	242320	1059044	255.119
22	242179	1059226	255,192
,			
S/N	**Easting**	**Northing**	**R/Level**
23	242129	1059215	255.034
24	242114	1059200	255.142
25	242058	1059214	255.085
26	242031	1059259	254.702
27	241973	1059284	255.374
28	241932	1059304	254.571
29	241903	1059251	255.133
30	241873	1059247	255.106
31	241857	1059208	255.311
32	241906	1059149	254.942
33	241938	1059050	255.904
34	242172	1058937	256.402
35	242209	1058751	255.801
36	242243	1058689	255.754
37	242300	1058641	255.897
38	242349	1058567	256.187
39	242371	1058529	256.156
40	242521	1058539	255.942
41	242550	1058561	257.189
42	242614	1058572	259.553
43	242637	1058550	258.955
44	242642	1058527	260.97
S/N	**Easting**	**Northing**	**R/Level**
45	242629	1058475	262.557
46	242631	1058449	262.121
47	242632	1058400	260.196
48	242591	1058366	258.965
49	242570	1058255	258.323
50	242721	1058227	258.605
51	243698	1058238	257.959
52	243839	1058245	256.845
53	244014	1058466	255.909
54	244031	1058613	254.614
55	244145	1058739	254.596
56	244140	1058770	254.349
57	244289	1059029	255.374
58	244473	1059174	257.288
59	244591	1059436	255.652
60	244693	1059545	255.436
61	244757	1059554	255.436
62	244828	1059598	255.029
63	243533	1060753	254.853



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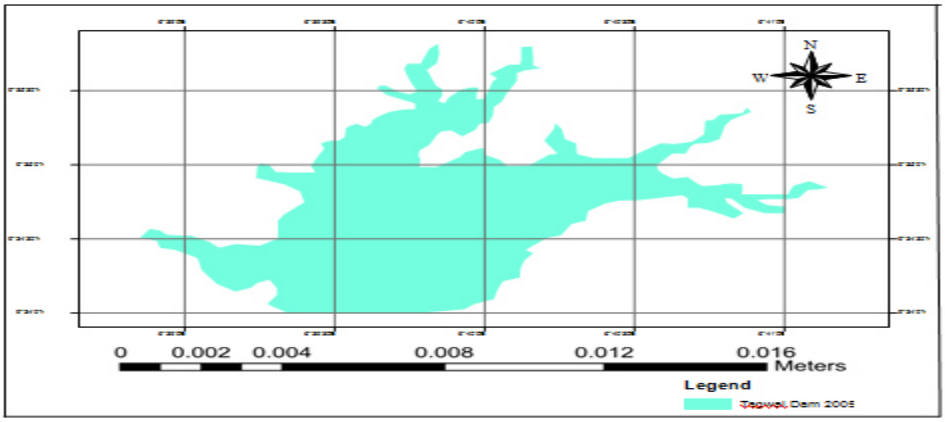

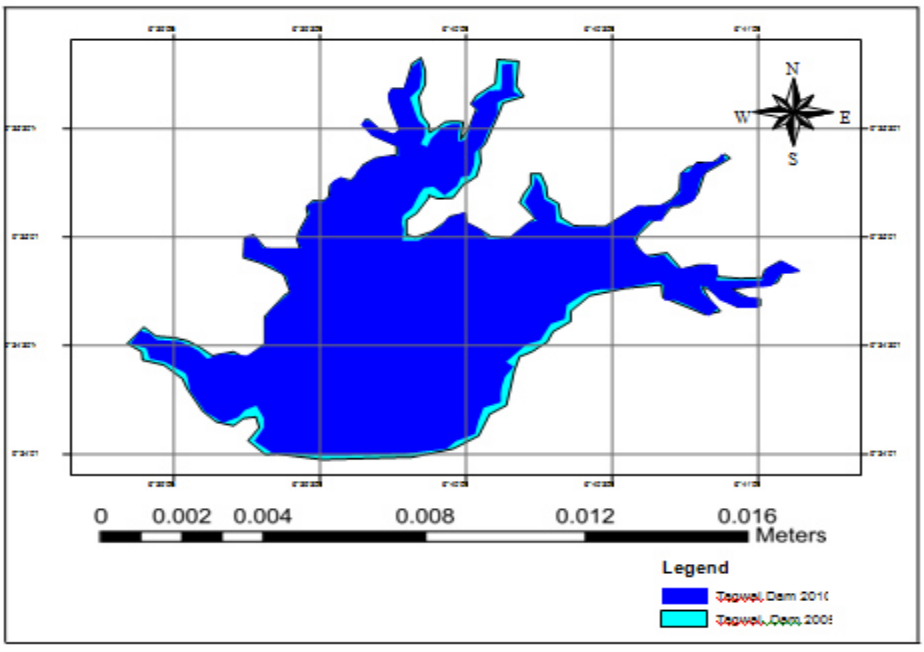

3.0Discussion of Results

The study shows the perimeter area of the reservoir plotted from the field data (2010) superimposed on the

digitized Spot satellite image area of Tagwai reservoir for 2005. The two areas measured 356ha and 340ha respectively. That is, 3.7% of the surface area was lost to sediment. It can be deduced from this research work that the reduction in the area is attributed to the environmental impact and long time morphological changes of the natural water. It is also as a result of particles transported through the runoff that entered the reservoir which is a function of watershed characteristics. Its effect is that it reduces the effective flood control volume, present hazard to navigation, changes water stage and underground water conditions, affects operation of low-level outlets gates and valve and reduces stability, water quality and recreational benefit.

3.1 Conclusion

The study has been able to produce the coordinates and the recent perimeter area of Tagwai reservoir. It has also reveals the differences in the level of surface sediment accumulation of the reservoir between year 2005 and 2010 as clearly shown by the superimposition. This is hoped to serve as a source of information for monitoring and maintenance of the reservoir.

3.2 Recommendations

The following recommendations are hereby made based on the results and findings in the course of this study:

1. Vegetations traps large amount of sediment, and also serve as screen and silt control when flood water passes through it before entering reservoir. Vegetation growth is recommended around the bank of the reservoir and the upstream of the dam.
2. Continuous monitoring of the sediment yield of the reservoir is recommended.
3. Sedimentation problem can be reduced when the soil erosion is reduced. With this I recommend that soil conservation and erosion control method be adopted in Tagwai dam reservoir.

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