Asian Journal of Engineering and Technology (ISSN: 2321 – 2462)
Volume 02 – Issue 05, October 2014

Effects of Soil Erosion and Sediment Deposition on Surface Water Quality: A Case Study of Otamiri River

J. C. Osuagwu, A. N. Nwachukwu, H. U. Nwoke, K. C. Agbo
Department of Civil Engineering, Federal University of Technology, Owerri, Nigeria

ABSTRACT---- ***Soil erosion involves detachment soil particles and transportation by run-off with subsequent deposition of the sediments in river courses and land depressions. The otamiri river is one of the main rivers in Imo state, Nigeria and the source for Owerri water scheme. The river runs from Egbu in Owerri, Imo state to Ozuzu in Etche, Rivers State from where it flows to the Atlantic Ocean. It is a major receiver of sediments from numerous gullies in the watershed. The objective of study was to analyse the nature and extent of the effects of the sediments inflow on the major quality parameters of the river with a view to making recommendations on sustainable preservation of the river. Water samples were collected during runoff inflows at two different locations (A and B) simultaneously for physical and biochemical tests. Location A was near the source at Egbu while B is a location downstream near discharge point of a major gully. The results showed marked fluctuation in quality between samples from location A and B. . Measured values of Ph, hardness, Iron, chloride, BOD, TSS and TDS indicated 30.8%, 88.9%, 50%, 60% , 176%, 94.5% and 84.4% differences respectively. The value of pollution index computed for sample B is 2.43 while that of Sample A is 1.22. This is an indication of a higher level of level of pollution of sample B relative to Sample A. The results indicate that sediments adversely affected surface water quality.***

Keywords--- Run-off, erosion, sediments, gully, pollution.

1. INTRODUCTION

Erosion is a three phase process consisting of detachment of individual soil particles from the soil mass and their transportation by erosion agents (example, wind and water) with subsequent deposition of the related sediments into land depressions, as influenced by natural (geologic soil erosion) or human (accelerated soil erosion) activities (Hundson, 1981)[1]. Soil erosion is a major environmental threat to sustainability and productive capacity of Agriculture. During the last 40years, nearly one-third of the Worlds arable land has been lost to erosion and continues to be lost at a rate more than 10million ha/year. With the addition of a quarter of a million people each day, the world is increasing at a time when per capita food production is beginning to decline. (Penitel and others, 1975)[2].

Erosion poses a major ecological problem in various parts of the World. In United States, Western Iowa region has a reputation for big sediment loads in streams and severe gully erosion problems). Estimates indicate that 5,000 to 10,000 acres of potential crop land are lost or removed from production annually as a result of gully growth (Bettis, 1983)[3]. In many states of Nigeria, erosion has resulted in several environmental hazards such as disruptions of drains, and roads (Eze-Uzoamaka, 1991)[4]. Loss of Agricultural productivity, siltation and washing away of pollutants into river courses are major effects of erosion.

Sediments are naturally occurring materials that are broken down by the processes of weathering and erosion. Sediments enter a river either as fragments eroded from rocky channels or in dissolved form. McDowell (1989)[5]. The deposition of sediment into a waterway can significantly diminish the water quality and aquatic habitat. Sediment deposition in a waterway makes the water more turbid and does not allow as much light to penetrate the water. This causes problems for aquatic plants that need sunlight in order to perform photosynthesis. Furthermore, suspended sediments in the water have the potential of clogging the gills of aquatic organisms and covering the stream bottom. Deposition of sediment on the stream bottom can lead to the suffocation of fish eggs and benthic macro invertebrates and can cause the destruction of natural spawning substrate. Also, with an increased amount of particles in the water, dissolved oxygen levels are reduced because of higher water temperatures. (MCWG, 2012)[6].

Pesticides, some metals and other toxins may sometimes cling to suspended sediments in water and increase the concentration of toxins in water with high amounts of suspended sediments. Similarly, phosphate can also enter a waterway by attaching to eroded particles. When in high levels, phosphate in the water can lead to algal blooms and lower the amount of dissolved oxygen in a waterway.

The most troublesome nutrient element is phosphorous. Freshwater ecosystems developed under very low phosphorous can stimulate production of algae blooms. The organisms in the aquatic system decompose the algae to use as food source. In the process they also use significant amounts of oxygen. Pesticides, some metals and other toxins may sometimes cling to suspended sediments in water and increase the concentration of toxins in water with high amounts of suspended sediments. Similarly, phosphate can enter a waterway by attaching to eroded particles.

The otamiri River is one of the main Rivers in Imo State Nigeria. The river runs from Egbu Past, owerri and through Nekede, Ihiagwa, Eziobodo, Olukwu Umuisi, Mgbirichi and Umuagwo to ozuzu in Etche, in Rivers State from where it flows to the Atlantic Ocean. (Anyanwu 2009)[7]. The Otamiri watershed covers about 10,000km^2 with annual rainfall 2250-2500mm. The watershed is mostly covered by depleted rainforest vegetation, with mean temperatures of 27^{o}C throughout the year. (Onweremadu, 2007)[8] the River is joined by the Nworie at Nekede in owerri, a river of about 9.2km length. (Acholonu, 2008)[9].

The study covered the three local government areas in Owerri starting from the source at Egbu to Ihiagwa A total of 12 major gullies discharging into the river were located within the study area. The objective of study was to analyse the nature and extent of the effects of the sediments inflow on the major quality parameters of the river with a view to making recommendations on sustainable preservation of the river.

2. MATERIALS AND METHODS

The parameters of interest are Pathogenesis, PH, Biochemical Oxygen Demand (BOD), Hardness, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Turbidity, Iron and Chloride contents. Samples (A and B) were collected at two locations for relevant tests and comparative analysis.

Sample A was collected at a point upstream near the source of the River where there is no discharge into the river while sample B was collected at a point downstream near a discharge point of a gully. The samples were collected during a rainfall period when there was runoff inflow. Tests were carried out at the Public Health Laboratory of Department of Civil Engineering, federal University of Technology Owerri.

A Philip analog pH meter was used to determine the pH of the water samples at the collection points. The Total Dissolved Solids (TDS) was determined by the evaporation method. Evaporating dish was weighed, and later, 100 cm3 of the water sample was introduced into the weighed dish and dried in an oven and later weighed. The difference in weight gives the weight of the total dissolved solids of the samples. The Total Suspended Solids (TSS) was determined by the filtration method. Water samples were filtered by the use of filter paper. The filter paper and residue were dried in an oven. The difference in weight of filter paper before and after drying gives the Total Suspended Solids (TSS). The tablet count method was adopted for Hardness test using Palin test sample counter and hardness tablets. The hardness was calculated $in\ mg/l$ $CaCO_3$

$$(N \times 20) - 1 \quad (1)$$

Where N is the no of tablets used.
The turbidity test was carried out using a portable microprocessor turbidity meter.
The color match method and Palin test comparator were used for the tests for Iron. For Chloride Tests, the tablet count method using Palin test Chloride tablets. The number of tablets was noted and the result was calculated from the formula

$$(N - 1) \times 5 \quad (2)$$

The chloride ion concentration was converted in terms of sodium chloride.
Pathological test was carried out to determine the presence of pathogens. The number of calories in sample which is the plate count was computed thus:

$$X^1/_1 \times Dilution\ Factor \quad (3)$$

The BOD was determined using Wincklers solutions, starch indicator, concentrated hydrochloric acid and sodium trioxosulphate solution. The BOD_5

$$(DO - DO_5)P \quad (4)$$

Where DO = Dissolved Oxygen concentration at zero time
DO_5 = Dissolved Oxygen Concentration after 5 days incubation period
P = Dilution Factor

The pollution index of the sample was computed using the formula developed by Horton (1965)[10] using multiple items of water qualities and permissible levels of the respective items. From the formula, Pollution index P_{ij} may be expressed as a function of the relative values of (c_i/L_{ij}).Each value of (c_i/L_{ij}) shows the relative pollution contributed by a single item, The overall pollution index was computed using equation 5.

$$P_{ij} = \sqrt{\frac{\left(\max {}^{c_i}/_{L_{ij}}\right)^2 + \left(\text{mean} {}^{c_i}/_{L_{ij}}\right)^2}{2}} \qquad (5)$$

$$Thus, \qquad P_{ij} = F\left\{{}^{c_1}/_{L_{1j}}, {}^{c_2}/_{L_{2j}}, {}^{c_3}/_{L_{3j}}, \ldots\ldots, {}^{c_i}/_{L_{ij}}\right\} \qquad (6)$$

Where c_i's are the multiple item of water quality and the permissible items of water and L_{ij}'s are the permissible levels of the respective items. i is the number of the i_{th} item of the water quality and j is the number of the j_{th} water use. The items of water quality considered include Iron Hardness, Chloride, Ph, BOD, TSS and TDS.

3. RESULTS AND ANALYSIS

Tables 1 presents the test results for samples A and B alongside WHO permissible values [11] for computation of the pollution index (P_{ij} for the two samples). The percentage differences in the values are also presented. The results showed marked fluctuation in quality between samples from location A and B. Measured values of Ph, hardness, Iron, chloride, BOD, TSS and TDS indicated 30.8%, 88.9%, 50%, 60% , 176%, 94.5% and 84.4% differences respectively. Recent studies (Lacey, 1982)[12] confirm that increasing hardness in water is correlated with decreasing cardio-vascular mortality in males. It is important to note that Iron content for both samples are above maximum permissible levels. Iron has a lot of corrosive property which imparts to surface water as Iron (iii) hydroxide. The corrosive nature of this compound can cause harm to humans if the WHO permissible limit is exceeded (Egereonu and Ozuzu, 2005)[13].

It is important to note that there was absence of Pathogens in Sample A while Sample B contained 1.0 col of pathogens. This could lead to gastro-intestinal infections when the water is consumed. Tables 2 and 3 present computed values of ${}^{C_i}/_{L_{ij}}$ for the two samples.

For sample 'A' using equation 5

$$P_{ij} = \sqrt{\frac{(1.667)^2 + (.45)^2}{2}}$$
$$= 1.22$$

Similarly, for Sample 'B',

$$P_{ij} = \sqrt{\frac{(3.33)^2 + (0.88)^2}{2}}$$
$$= 2.43$$

A value of 1.0 is a critical value. Though the values of Pij obtained for samples A and B indicate pollution (greater than 1), the value for sample B is twice higher than the value for sample A. This indicates much higher level of pollution of pollution of the water sample collected near the gully discharge points relative to the one collected near a location of no sediment inflow.

Ταβλε 1: Θυαλιτψ Τεστ Ρεσυλτσ

Parameters	Sample A	Sample B	Permissible WHO Level	% Difference
Pathogens	-	1.0	0	100
pH	6.0	6.5	8.5	30.8
Hardness	90	170	500	88.9
Iron	0.5	1.0	0.3	50
Chloride	25	40	250	60
BOD	10.32	28.48	30	176
TSS	63.5	124	500	95.4

TDS	24.4	45	1000	84.4

Ταβλε 2: Χομπυτατιον οφ C_i/L_{ij} φορ Σαμπλε A

Parameters	Quality (c_i)	Permissible WHO Level (L_{ij})	c_i/L_{ij}
pH	6.0	8.5	0.706
Hardness	90	500	0.18
Iron	0.5	0.3	1.667
Chloride	25	250	0.1
BOD	10.32	30	0.344
TSS	63.5	500	0.127
TDS	24.4	1000	0.0244
Total (c_i/L_{ij})			**3.148**

Ταβλε 3: Χομπυτατιον οφ P_j φορ Σαμπλε B

Parameters	Quality (c_i)	Permissible WHO Level (L_{ij})	c_i/L_{ij}
Ph	6.5	8.5	0.76
Hardness	170	500	0.34
Iron	1.0	0.3	3.33
Chloride	40	250	0.16
BOD	28.48	30	0.95
TSS	124	500	0.25
TDS	45	1000	0.045
Total (c_i/L_{ij})			**6.165**

4. CONCLUSION

From the results, it is observed that sediment inflow from gully erosion into the river imparts negatively on the river quality. A higher value of pollution index for the sample collected near a gully discharge point relative to the sample collected at a location upstream where there are no discharge points confirms that the river is polluted by sediments inflow. Though the general level of pollution is moderate, the presence of Pathogens in Sample B and high Iron content should be a source of concern. Otamiri River serves as a major source of water to many communities along its course. Its pollution will impart negatively on public health. The implications on the health of rural dwellers that use the water should be a source of concern to the Government and Non- governmental organisations.

Since virtually all gullies in discharge into water courses, the pollution effect is bound to increase with increasing menace of gully erosion in South Eastern Nigeria. It is therefore necessary that a proactive and multidisciplinary approach should be adopted in solving the problems of Erosion. Beyond the primary effects such as loss of land and property, the secondary effects like sediments inflow into Rivers and the resultant effect on surface water quality should not be neglected. The cost of water treatment is bound to increase with depreciation of water quality.

5. REFERENCES

[1]. Hundson, N.W. Instrumentation for Studies of the Erosive Power of Rainfall. *Proceedings of International Symposium on Erosion and Sediment Transport Measurement, Italy.* June 1981.

[2]. Penitel, D., Howey, C., Resosidarmo, P., Sinclair, K., Kurz, D., Crist, S., Shipiritz L., Fitton, L. and Blair, R. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. *www.com /shows/results/16* .1975.

[3]. Bettis, E.A.. Gully Erosion, *Iowa Geology* No 8. Iowa Department of Natural Resources. 1983

[4]. Eze-Uzoamaka, O.J.. Hydraulic Soil Erosion And its Management in Rural Development. *Proc. Engineering for Accelerated Rural Development, Faculty of Engineering, University of Nigeria, Nsukka.*1991

[5].McDowell, D.M. A General formula for estimation of the rate of transport of the rate of Transport of Bed load by Water. J. Hydraulic Resources (27(3) 355-61. 1989.

[6]. MCWG . Effects of Sediments on Water Quality. Mill Creek Watershed Group Constitution. www.milcreek.20m.com 2013

[7].Anyanwu F.C. A Comparative Evaluation of early Rains Phytoplankton productivity of Nworie and Otamiri Rivers, AICE, Owerri. 2009

[8].Onweremadu, E.U. Soil Mecury Distribution in Forest Savana Mosaic in Relation to Soil fertility. J of Environmental Toxicology vol 1 (4). P158-166. 2007.

[9]. Acholonu, A.D. Water Quality Studies of Nworie River in Owerri Nigeria. Missisipi Academy of Sciences. 2008.

[10]Horton R.K.. An index number system for Rating Water Quality. Poll, Control Fed. 37(3). 1965

[11]. World Health Organisation. International Standard for Drinking Water, WHO, Geneva. 1984.

[12].Lacey, W.F. Changes in Water Hardness and Cardiovascular Environment of the Benin Formation, Nig.j. Min. Geology 17, P147-151. 1982.

[13].Egereonu U.U. and Ozuzu C.I. (2005). Physiochemical Analysis of River Niger at Onitsha Bank, Nigeria. J. Chemical Society of Nigeria, vol 30, p. 197