EFFECTS OF SOIL EROSION ON WATER SOURCES IN THE NORTHEASTERN ENUGU STATE, NIGERIA: A REVIEW

Eze, H. I.
Centre for Environmental Management and Control
University of Nigeria, Nsukka, Enugu Campus
E-mail: hileze@yahoo.com

ABSTRACT

Soil erosion is a grave environmental hazard that has both natural and human causes. This study is a review of the effects of soil erosion on the water sources in the Northeastern Enugu State, Nigeria. Since, water is viewed as an indispensable natural resource for all facets of human development and well being. Its utilities are gradually being destroyed by soil erosion, induced siltation, eutrophication, pollution, water related diseases transmission and channel abrasion. Stringent application of the proffered soil erosion control strategies, outright ban on land use activities at the fringes of the surface water bodies especially in the rainy season, correct water shade management, government subsidization of soil erosion control as well as regular monitoring of these measured by environmental protection extension personnel will stem in the deterioration of water sources in the study area.

***Keywords**: Soil erosion, Water sources, Siltation, Pollution and Control measures.*

INTRODUCTION

Water is very vital for man's existence hence it is refereed to as the blood of the earth. Its role in societal growth is crucial. Presently and even more so in the future the success of such advancements are principally ascribed to water resources. They include storage lakes, hydro-electricity power production, drinking water, rain fed /irrigation agriculture, industry and shipping canals. From its chemical point of view, it is the commonest existing substances that is experienced and used in the solid, liquid and gaseous states. More than 50% of plant and animal body weight consist of water. The entire biomass depends on water.

This very important natural resources legacy has many factors militating against its supply and wholesomeness. They include physical factors such as soil erosion, climatic fluctuation, and drought and soil type, while waste disposal, general land use at the fringes/surface water bodies' devegetation and irrigation are some human factors. Soil erosion ranks highest among the factors that deteriorate water sources in the study area (Eze, 2002). It is geomorphic hazard that wears off the soil with agents such as water, wind, and glacier for final disposition at lower terrains. Water however is the usual agent in this area.

EXTENT OF WATER SOURCES IN ENUGU NORTHEAST

The northeastern part of Enugu State is the area reviewed in this study. It lies between longitude 7^{0}l500 and 7^{0}l570 east and latitude 7^{0}l360 and 7^{0}l41 north. The area occupies a landmass of 1216km^{2}. The population is 259,803 with a density of 206 persons per square kilometer (2006census). The area fall within the tropical wet and dry (AW type) of Koppen's climatic classification. It records 28^{o}C average temperature and 1506mm annual rain fall. Two thirds of the area has the loose sandy ferralitic soil type and a loamy clay type in the rest. The topography is dominated by steeply slopes and prongs of gully channels that terminate in streams. The vegetation is principally the woodland grass derived savannah and the forest type, around the water bodies. The hydrology of the area is mainly dominated by the Ebonyi, Eme, Awra, and Ndene rivers, most of which flow south eastwards. They are fed by some rivulets, steams and brooks. Ponds and ephemeral pools are also found in the loamy clay regions.

Subsistence agriculture is observed by Kowal and Kassam (1978) as the occupation mainstay of the area. Wrong agricultural practices such as non-fallowing of land, bush burning, alignment of farm mounds down slope as well as the sleepy slopes, high rainfall amount and loose soil material make the area susceptible to soil erosion. Sheet erosion removes rich plant nutrients and trace chemical elements from the soil. These are washed into water bodies in the study area causing eutrophication.

The aggregate effects of the three facets of soil erosion (sheet, rill and gully) disrupt the soil structure which aids percolation and purification processes of underground water. Eroded materials deposited in water bodies cause siltation and pollution. Soil erosion exposes and destroys pipe borne water infrastructure in the study area. The study area is greatly endowed with bountiful water sources. Most of the rivers and streams spring from the hilly northeastern areas. They respond to southeastern flows and are fed by brooks and streamlets. These in turn converge within their various basins forming rivers such as Eme, Ebonyi Ngelifi, Olu, Ndene and Awra

Surface Water Sources: Streams such as Ederi, Odoru and Okpakeke which flow in the northeastern direction feed the Ebonyi River. It flows through communities such as Umuosigide, Obollo Etiti, Obollo Eke, Ikem and Eha-Amufu. The Awo, Nzu and Opu stream as well as the Amanyi rivulet flow into the Ebonyi River near Ikem. These streams flow through communities such as Agu Orba, Obinagu Imilike, Ezimo, Mbu and Ogbodu-Aba. Leke Onueme, Akpochi, Isiagu, Mbu and Akpoga communities have small brooks and streamlets that feed the Eme River. The Awra River with its numerous streams and rivulets flows from the neighbouring Agu Opi in Nsukka Local Government Area (LGA) through the southeastern fringes of the study area. Communities such as Agu Mbu, Agu Neke and Agu Umualo fall within this hydrological network.

The Ayido springs from Obollo Eke in the northern part of the study area. It has few northerly tributaries and distributaries. Ogo-Ndagu Ikem, is the source of the Ndene River which flows through Ikem Nkwo and the Mgbede Local railway station. These hydrological dispositions are in line with the observations of O.U.C.T. (1990) that streams are members of a complicated network of channels which form the unit called drainage basin or catchments. The Olu and Ngelifi Rivers merge with the Ebonyi River

between Ikem and Eha-Amufu. Thereafter the river flows through Umuhali in Isi-Elu L.G.A. Ebonyi State. This Ebonyi River is the major hydrological feature of the study area.

Ponds which are usually integral part of drainage basin form small basins where water supply exceeds loss through evaporation and infiltration in the study area. Some of these ponds where water flows out from are called intermediate while others are terminal ponds. These are the characteristics of ponds in the loamy alluvial and shalyclay areas of Umualo, Agu Neke, Agu Amade, Eha-Amufu and Obollo Eke. Some of them are fed by small streams, while others are suspected to have originated from oxbow lake formations in the meandering stream courses. There are still some that are formed as a result of water accumulation in depression that have imperious clayey floors. The pond levels lower as the dry season progresses. Infact the Nkpo pond in Obollo Eke almost maintains its level throughout the dry season because of the luxuriant forest that shades it and consequently reduces evaporations. Small perennial ponds and pools are abounding in the study area. Some pond levels fluctuate through wide range and each observation of floating sediment marks on their sides during field trips had to be keyed to contemporaneous stages of the ponds.

Underground Water Sources: The shalyclay soil profile with seams of impervious rock material enhances the water aquifer's holding capacity in the study area. At depths of 5m, water can be struck in communities such as Obollo Eke, Ikem, Eha-Amufu, Neke, Mbu, Ogbodu-Aba to name a few. The shalyclay soil inhibits water and the underlying impervious rocks or basal seals keep the water table at appreciable levels. Seasonal ground water recharge which is the process of underground water replenishment is in the wet season. The recharging level is so high that artesian wells sprout sparking water with amazing pressure flows during such periods.

ANTHROPOGENIC FACTORS OF WATER POLLUTION

Water pollution is the introduction of waste material into water such that its natural self-purification processes cannot cope with the situation. Both surface and underground water are polluted by various pollutant agents (solid, effluent and gaseous) in the study area. However, the extent of pollution varies with type of pollutants and other environmental factors such as the

degree of water flow or mobility and the land use factors of the area. The pollutant agents include plant nutrients disease agents, eroded sediments, solid wastes, sewage, other oxygen demanding wastes as well as effluents from local industries and food processing activities.

Plant Nutrients: The use of chemical fertilizers and wastes from food processing generate organic matters that are plant nutrients. These accelerate the growth of weed infestation and the booming of other aquatic plants in surface water bodies causing water pollution. This situation suppresses the growth of planktons and algae which are food for fishes and other water faunae, hence a reduction in fish population. The clustering of water weeds impede normal stream and river flows, puts some streams and ponds out of recreational uses and deteriorates the portability of such stream water.

Eroded Sediments: Human activities such as cultivation, road and building construction as well as devegetation lay the soil bare to erosion. Soil materials are detached from sheet, rilling and gullying activities. They get entrained in runoff water which feed streams. Thereafter, they are conveyed into rivers. Soil erosion is a serious natural hazard in the study area. Nordin (1995) pointed out that rivers convey in their flows, the dissolved and solid products of weathering and erosion from the basin or catchments they drain. These pollute and silt the water bodies causing low water transparency and clogging of certain fluvial channels.

Local Industrial and Food Processing Wastes: Certain areas of streams and brooks such as Opu and Arikpo in Ezimo, Oshenyi and Egwu near Ogbodu-Aba, Ayido and Ngele-Okpo in ObolloEke and other brooks and rivulets that feed the Ebonyi River near Ikem and Eha-Amufu are used for food processing. The food items include cassava, breadfruit, melon, bitter leaf among others. Local industrial activities such as oil palm extraction and processing, sponge making, cloth dyeing, basket weaving as well as wool spinning generate a great deal of wastes.

Wastes from food processing activities are also directly introduced into the surface water bodies while those from local industrial activities are usually either dumped into these streams or in their catchment areas where they will be latter washed into the streams. Some of these wastes accumulate and float on the water surfaces as scums, blocking off sunlight to water flora

and fauna. The biodegradable items increase Biological Oxygen Demand (BOD), producing foul smelling, gases such as methane CH4, ammonia NH3 and hydrogen sulphide H2S. The water surfaces and the entire surroundings of such streams are degraded.

Irrigation: Dry season farming is practiced at the surroundings of some of these surface water bodies. The crops are usually grown with compost, animal manure or chemical fertilizer. During irrigation, the wash-off water usually flows directly into these streams or indirectly by underground seepages. The constituents of such wash-off water include loose farm soil, decomposed organic manure, trace Nitrogen, Phosphorus and Potassium (N.P.K) which are elements of chemical fertilizer. In situations where pesticides and herbicides are used such as in the Local Government Agricultural Unit Farm Plots and School farms minute quantities of these are also washed down into the surface water bodies causing chemical pollution.

Water contact uses of streams such as swimming and bathing contribute to water pollution in the study area. Adults and children alike swim and swagger for fun in both shallow and fairly deep streams during hot periods. Soap and dirt generated during laundry activities pollute stream water. Human defecation within the catchments areas or directly into the surface water bodies are also sources of water pollution in the area.

EFFECTS OF SOIL EROSION ON WATER SOURCES

Soil erosion has grave impacts on water sources in the study area. Human sustenance by water sources is unspeakable in aspects such as drinking purposes, irrigation agriculture, food processing and cottage industrial activities, horticulture, domestic uses, recreation, fishing and other water related hunting, environmental sustainability among others. These beneficial uses are threatened by soil erosion's degradation of the water sources in the area. Miller (1988) recounts that 34% of China's arable land and 1/3 of USA's rich agricultural top soil has been severely eroded and the resultant siltation of rivers, streams and lakes are now naturally recognized threats. Soil erosion-induced problems on water sources in the study area include the following:

Abrasion of River and Stream Channels: Weathered rock, sharp sand and other loose soil material in the catchments areas or basins find their

way through soil erosion into streams and rivers. In the August and September peaks of the rains in the study area, debris laden runoff water swells the channels of rivers and streams. This optimal soil moisture saturation period, the transporting debris that hit river channel sides as well as the appreciable river channel gradient of certain location give way to river channel abrasion. The downward scouring effects cause the collapsing, slumping and deepening of river and stream channels or bank erosion. The middle courses of the Ebonyi River at Ikem and Isu; the Eme River at Mbu Akpochi and around Neke Onueme and the Ndene River at Ikem Nkwo manifest such features. These river channels posses more variable bank materials than their bed materials. However, their dispositions downstream show more uniformity with sand, silt and clay combinations especially at fully developed flood plain areas.

In areas of cohesive bank material and vegetation whose fibrous root systems reinforce the soil, bank erosion is minimal. Nighton (1994) noted that 5cm root reinforcement affords 20,000 times more protection to erosion than comparable material without vegetation.

Siltation of Surface Water Bodies: The transportation of silting material from land surfaces to the water bodies causes siltation in the study area. This is in line with Startham (1997) who rationalized this phenomenon into three process regimes.

a. Weathering regime - physical and chemical breakdown of rock processes
b. Slope regime - movement of the weathered material by gravity and gradient in mass movement and by slope wash processes.
c. Fluid transfer/deposition regime - where water does the transportation and final deposition of the sediments.

The final element of the triumvirate processes which is the deposition or aggradations or siltation takes place as the competence of the streams to transport it decreases below critical level. The lower courses of the Ebonyi, Ngilife and Awra have flood plains with features such as sandbars, ripples and dunes. Back-swamps are areas with deposit of clay and other colloidal materials. They are commonly observed in streams which are tributaries of the Olu, Amanyi and Eme River. Such streams include Isi-Amanyi, Ngele-Okpo and Opu.

Spawning of fishes is disturbed since such favourable places and planktophytes which are food to fishes and their finger lines are destroyed by the accumulating sediments. Siltation of these surface water bodies also cause the decline in number of crabs, tortoise, crocodile, water lilies and other aquatic fauna and flora in the study area. The reducing stream water volume prevents effective irrigation during dry season farming. Spring sapping and trickling points on the channel walls of the Nzu, Awo, Ederi and Odoru streams which are sources of portable water are often times blocked off by silting materials and require a great deal of manual labour to dredge them. Ponds and pools on the shaly clay depressions of Umualo, Neke, Agumade and Mbu often times have inflowing streams which introduce eroded materials into them. This causes siltation of such ponds as their floor levels get raised. Where the ponds are intermediate, the out-flowing streams lower the pond rims through erosion.

Eutrophication: This is an insidious form of water pollution that causes progressive deterioration of surface water sources. Human excrement, dead organic matters, domestic and agricultural wastes, ashes from bush burning, minute elements of agrochemicals are washed by soil erosion into surface water bodies. This over enrichment with nutrients that support aquatic flora results in an overabundance of plant life or eutrophication. Mac - Caull (1994) observed that eutrophication brings about certain drastic changes in the ecology of lakes, streams and ponds. Decomposition of such organic matters cut down the amount of dissolved oxygen in the water which results in the destruction of aquatic animals. Eutrophication also thins down the population of some water plants that do not thrive in overcrowded situations. The recreational and other water-hunting uses of such water bodies are put off.

Water Pollution and Disease Transmission: Solid wastes dumped into gullies, rills, refuse dumps, drains, domestic sewage and other externalities from human activities are washed down into bodies in the stream, causing water pollution. Domestic sewage has a strong composition of pathogenic pollutants (Table 1). The micro-organisms that decompose these biodegradable wastes increase Biological Oxygen Demand (BOD). The water's portability is lost and it turns turbid and putrid. Water samples were collected from the water bodies after rainstorms for laboratory analysis (Table 2).

Table 1: Typical Composition of Domestic Sewage (Values in mg/litre)

Constituents	Strong	Medium	Weak
Solid:			
Total	1000	500	200
Volatile	700	350	120
Fixed	300	150	80
Suspended			
Total	500	300	100
Volatile	400	250	70
Fixed	100	50	30
Dissolved			
Total	500	200	100
Volatile	300	100	50
Fixed	200	100	50
BOD (5 - day 200c)	300	200	100
Oxygen Consumed	150	75	30
Dissolved Oxygen	0	0	0
Nitrogen			
Total	85	50	25
Organic	35	20	10
Free ammonia/inorganic nitrogen	50	30	15
Nitrates NO_2	0.1	0.05	0
Nitrates NO_3	0.4	0.2	0.1
Chlorides	175	100	150
Alkalinity	200	100	50
Fats	40	20	0

Source: Babbit and Baumann (1995)

The stagnant water bodies in the study area such as ponds, pools as well as slow flowing streams which are recipients of pollutants degenerate with time into transmitters of water related diseases. When the water can no longer cope with their natural self purification processes such pollutants form bacterial and viral agents which transmit diseases such as typhoid fever, dysentery, cholera, hepatitis, gastroenteritis among others.

Bilharzias which are a debilitating disease from water snails are sometimes transmitted from stagnant water. Hence water the sustainer and

necessity of life can become a transmitter of disease organisms both organic and inorganic chemical contaminants to man.

Table 2: Laboratory Test Results of After Rainstorm Water Samples from the Study Area

	Sample Tests					
	Nzu Stream 1	Odoru Stream 2	Ebonyi River 3	Amanyi River 4	Ndene River 5	Eme River 6
Total solids (mg/l)	760	900	11300	850	820	860
Suspended solids (mg/l)	480	580	700	520	500	540
Dissolved solids (mg/l)	260	320	430	330	320	260
BOD (mg/l)	72	70	63	83	84	73
Colifor (100ml)	38	41	45	47	40	44
PH	6.4	6.7	6.8	6.7	6.9	6.3
Turbidity (JTU)	8	7	9	8	8.4	7.7
Colour (Pt/Co)	14	12	16	12	13	15
Sample Mean,	= 204.0	242.09	300.35	232.09	224.04	218.25

Source: Eze 2002

The laboratory test results on table 2 which gave sample means of 2040, 242.09, 300.35, 232.09, 224.04 and 218.25 were obtained for the Nzu and Odoru streams as well as Ebonyi, Amanyi, Ndene and Eme rivers respectively. The grand means, obtained was 29.62 when these results were subjected to the Analysis of Variance (ANOVA) statistical method. Also in the same order, the sum of squares within, (SSW), of 546984.64, 78678.04, 1238298.34, 680234.04, 621590.05 and 629724.46 were obtained for the streams and rivers. This gave a total of 449951.57. The sum of squares between (SSB) gave 2108006.25. The mean of square within (MSW) obtained was 107131.40 while the mean of square between, MSB gave 421601.25. Hence the ratio of MSW and MSB which is the variance estimate of F-test or Fcal becomes 7.4. With a degree of freedom of 5 (numerator) and 42 (denominator) and at 95% confidence level, the F?, obtained was 2.44 since Fcal > f?. Hence the pollution in the water sample is significant. The values of the magnitude of water pollution from soil erosion as ranked are presented on table 3.

Table 3: Ranked Value of Water Pollution Extent from Soil Erosion in the Study Area

Water Sample	Values of Sum of Squares within SSW	Ranking
Nzu Stream	546984.64	6
Odoru Stream	786769.04	2
Ebony River	1238298.34	1
Amanyi River	680234.04	3
Ndene Rivers	621509.05	5
Eme Rivers	625724.46	4

Effect on Underground Water Sources: Underground water composition is subject to the source of surface water that percolates into it and the interaction of the surface water with the soil and rock materials along its path. The Nzu and Okpakeke streams flow through dolomite and soft talc areas, hence their turbid and low transparency qualities. The streams as well as underground water show chalky sediments in transparent containers.

Gullies in Agu-Ezimo that rip through such soft chalky rocks cause intrusion of such chalky materials into pure underground water held on aquifers below. Artesian well water in such areas shows such sediments mainly in the rainy seasons. In the growing clustered settlement areas such as Obollo Eke, Eha-Amufu, Ogbodu-Aba and Ikem, solid wastes dumped into gullies as well as other eroded materials are washed down the catchment areas until they get to the shale seams where they can infiltrate into the ground and contaminate underground water. Moran, Morgan and Wiersma (1990) observed that soil erosion also lowers the water table in aquifers by agrading eroded materials in the area, and this impedes percolation of water through existing pervious surfaces for final storage as underground water.

CONCLUSION AND RECOMMENDATIONS

This discourse focuses on soil erosion-generated problems on water sources of the study area. Human sustenance will be grossly militated upon in the area if the status of water sources is left to deteriorate. Its importance is buttressed in this Late President John Kennedy's message to the U.S. Congress:

> *From the beginning of civilization, every nation's basic wealth and progress has stemmed in large measures from its natural resources. Our nation has been blessed with a bountiful supply of water; but this blessing we cannot regard with complacency… Pollution of our country's rivers and streams as a result of siltation, rapid population and industrial growth has reached alarming proportions… We must protect our water sources (Nemrow, 1993).*

This gives a global picture of the need for the protection of water resources from deterioration. What applies to the micro environment of our study area does to the macro world. However, this study highlights soil erosion as a factor of water source deterioration. Under this circumstance, it becomes necessary that in water resource management and planning, land from which water comes should be properly managed. Land use management should be given greater considerations. This would guarantee optimal delivery of water from the water shed. Tackling the problem from the source is more rewarding than wasting resources in dredging silted reservoirs streams and rivers. The following recommendations will alleviate the environmental problem.

Soil Conservation: The fundamental tenet of soil conservation with a view to arresting soil loss into water bodies are that soil surfaces be maintained in a receptive condition for the infiltration of rainfall. Also, surplus runoffs are to be channeled along gentle gradients such as permanent grass covered areas and circumvent obstruction. There should be an agreement on how the drainage routes should transit boundaries of individual land or properties and serve the catchment area as an entity. The optimal application of these measures requires the co-operation of all rural dwellers. Extension officers from the state ministry of environment should oversee these arrangements. These must be strict adherence to cultivation on the contours, planting of grassed water routes and construction of drains to cut off water from higher terraces. Where cultivation is done on sleepy slopes the ridges and mounds should be aligned across slopes and terracing should be practiced. The cost of these structures should be subsidized by government. There should be belts of fallowing and tree planted plots between farm plots to boost infiltration of water. These measures will stem soil loss and inflow of debris into surface water bodies in the study area.

Watershed Protection: The highest points or rims of catchments are the peaks where precipitation gets into the ground. It is from there that water percolates to the lower base of the basin from where springs sprout and latter flow as streams and rivers. Such points or watershed should be protected with forest reservations to enhance the conservation of water and steady flows from the springs.

Reservation of Land Strips Close to Water Bodies: There should be reservation and outright ban to cultivation on the lowest third portion of land in all catchment areas towards surface water bodies. Such undisturbed soil and vegetation rich areas would enhance infiltration of rain water, prevent the generation of runoff water and its associated soil erosion and purify percolating rain water. To maximize land use in this face of growing population and food insecurity, small patches of such reserved areas can be put into dry season irrigation farming. The precautionary measure in this instance is strictly regulated irrigation such as to prevent back flow or wash off sediments into the water bodies.

Livestick Fencing: In already established gullies, livestick fencing methods are to be applied to hold further deposition of sediments into the water bodies. It involves staking of livesticks across gully channels from the points where the scouring activities starts receding. Palm fronds and other fast establishing wattles are tied across the lowest portion of the staked livesticks such as Indian Bamboo Bambus vulgaris. This is repeated at distances of 100-150m down the gully channels. They hold the transported sediments, thereby reducing siltation of the receiving streams. Indian bamboos Bambus vulgaris and other live sticks will spring into luxuriant vegetation strips across the gullies and this will in the long run, aid gully stability.

Monitoring: Local government environmental protection officials should monitor these management measures and not to leave it to the care of the rural farmers. This is because the marginal economic situation of the subsistent farmers of the study area does not incline them to see with these long-term but rewarding control measures.

REFERENCES

Babbit, H. E. and **Baumann, E. R.** (1995). *Sewerage and Sewage Treatment.* New York: John Wiley and Sons Inc.

Eze, H. I. (2002). Impact of Soil Erosion on Biophysical and Socio-Economic Resources in the Upper Ebonyi River Basin, Enugu State, Nigeria. Unpublished Ph. D Thesis, submitted to Environmental Management Programme, Geo and Met Department, Enugu State University of Science and Technology, Enugu.

Kowal, J. M. and **Kassam, A. H.** (1978). *Agricultural Ecology of the Savannah: A Study of West Africa.* Oxford: University Press.

Mac Caull, J. (1994). Water Pollution. United States of America: Institute of Water Research Publication.

Miller, G. T. (1988). *Living in the Environment: An Introduction of Environmental Sciences.* Belmont Cal: Wadsworth Publication Co..

Moran, J. M., Morgan M. D. and **Wiersma J. H** (1990). *Introduction to Environmental Science.* San Francisco: Freeman Publisher.

Nemerow, N. L. (1993). *Theories and Practice of Industrial Waste Treatment.* USA: Addison-Wesley Publication Reading Mass.

Nighton, D. (1994). *Fluvial Forms and Process.* London: Arnold Publication.

Nordin, C. F. (1995). *Sediment Loads of Rivers. In J.C. Rodda (ed) Facets of Hydrology Vol. II 183-488*. New York: John Wiley and Sons

Open University Course Team (O.U.C.T.) (1990). *The Environment: Rivers and Lakes.* Bucks: Open University Press.

Startham, I. (1997). *Earth Surface Sediment Transport.* Oxford: Clarendon Press.