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Physiographic Activities: An Assessment of its Impact on the Quality of Streams in Enugu

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ABSTRACT

This investigation is conducted to examine the effects of physiographic elements on the water quality of streams in the Enugu catchment area of southeastern Nigeria and the Enugu urban environment. Samples of stream water and solid waste leachate were collected from 25 sub-catchment areas of the basin and subjected to laboratory analysis of the physio-graphic characteristics. Field investigation of the stream velocity, width, and depth, discharge, and flow variety in the sub-catchment was also conducted Land use, water utilities; waste generation, and management were also examined. The results show that stream water from an urban catchment contains constituents derived from both the natural environment and from the waste products of human activities in the city itself; It was therefore recommended that a redirection of present efforts from water treatments should be made thereby focusing on physio-graphic quality surveillance with a sustainable solid waste disposal practice in the Enugu urban environment to restore and to protect the ambient stream water quality in Enugu catchment area.

Keywords: *Physiographic elements, Water quality, Catchment Area, Streams*

1. Introduction

The physical and chemical water quality characteristics embrace both pollutants which constitute a health hazard and qualities of the water which may lead to its acquiring unfavorable aesthetic characteristics such as unpleasant taste odour, appearance, or other properties likely to discourage its use (Feacham, 1980; APHA, 2000). Investigations conducted in different parts of the world by WHO (1989, 2001) Cairncross and Feachem (1993) Stambuk-Gilfanovic (1999; and Vanleeuwen (2000), Lue Lee and Han (2006) revealed that it is very necessary to ensure that there are no particular chemical pollutants which constitute a health hazard in certain catchment areas because, for untreated water supply, chemical water quality standards are generally poor. For example, Cairncross and Feacham (1993) discovered that some drainage basins in parts of India and Tanzania have fluoride levels in their Water which may cause damage to teeth and bones.

Despite the continuing increase in the extent of major towns and cities in the catchment systems, the concentration of human activities intensifies local competition for all types of resources among the most vital of which is surface water (Powel, 1993; Molden and Defraiture, 2004; 2005, Ezenwaji, 2008). In addition to those uses that are essential for human existence, surface water resource is also widely utilized in urban areas of less developed countries for the disposal of wastes. In its ambient and natural conditions, river water quality is controlled by a complex of meteorological, hydrological, and topographical factors overlain by a multiplicity of geochemical and biochemical processes in its basin (Mountford, 2003; Ekop, 2003; Eze, 2003; IIED, 2004; Adegoke, 2005.

Much work has been done on water quality determination and standards in both urbanized and vegetated catchment systems all over the world particularly in the developed countries where there are adequate research facilities (Cairncross and Feachem, 1993; Eze, 2003; Udotong, 2003; Ekpete, 2004; Etukudo, 2004; WHO, 2004; Lou and Ham, 2006). Although these works show that more stringent control of water contaminants and higher quality standards apply to surface water intended for human consumption than for other utilities, generally, determination of surface water quality standards involves the aesthetic, microbiological, chemical, and physical characteristics of surface water resources (Feachem, 1980; World Bank, 1990; 1992; Ajayi and Umoh, 1998; WHO, 1998; Mendie and Aster, 2003; Ekop, 2004).

Works on the aesthetics aspect of water according to Lou and Ham (2006) center mainly on temperature, color, odour, and taste. WHO (2004) however does not stipulate any standard water temperature for a drinking supply, FEPA (1991) establishes 30^oC as the maximum permissible temperature for drinking water supply in Nigeria. In his work on water pollution in Europe Limentor (1980) revealed that to slake man's taste, drinking water should have a temperature range of 7^oC to 11^oC. Etukudo (2004) worked on the quality characteristics of water in the coastal city of Calabar and discovered that the temperature of the water samples "in-situ" ranged between 26.1 to 26.2^OC. He also observed that the colour values range from 2.0 to 3.0 Hazen units. However, he noted that the range is within the permissible standards stipulated by both the World Health Organization (2004) and Federal Environmental Protection Agency (1991) for domestic water quality requirements.

The fact that few records of water quality of urban streams are maintained in most developing countries today reflects the comparatively limited degree of public and professional concern with the subject. There is therefore little wonder that many scholars observe that there is a lack of scientific interest in investigating the quality changes of stream water in urban catchment areas of developing countries (Ezemonye, 2008). Indeed, this may not be surprising because even in the developed countries, before 1960, very few records of data on water quality of urban environments were kept (Hall, 1984; Salau, 1992; Giordano, 2004). This problem justifies the need to investigate the effects of physiographic elements on the water quality of streams in the Enugu catchment area of southeastern Nigeria.

Aim and Objectives

The broad aim of this work is to ascertain the impacts in the water quality of streams in the Enugu watershed as a result of human activities in the Enugu urban environment.

2. Literature Review

The Concept of Physiographic Elements

The whole range of water quality problems due to urban (and other human) activities in the drainage basin is being documented in literature at a rapidly increasing rate especially since both the mass media and environmental scientists in every quarter of the globe have seized the catch words of sustainable environmental management, climate change and poverty reduction (Jones, 1997; Peirce and Co-workers,1998; Chukwu, 1999; Broadly speaking, four types of human activities affecting changes in water resources quality of the catchment systems have been recognized by these authors and these may be summarized as:

A. Forest clearance.

B. Urbanization and construction works

C. Irrigation agriculture and fertilizer applications

D. Industrial, commercial and domestic activities.

NEST (1991), Jones (1997), NROP (2001), Adibe *et al* (2005) and DFID (2000; 20001; 2006a; 2006b) have also remarked that urbanization (with its associated industrial and domestic activities) has been responsible for generating most of the problems from surface and atmospheric water pollution. However, Jones (1997) pointed out that in the most recent years, agricultural activity has become an important source of stream water pollution and that efforts to control agricultural sources require basin-wide vigilance. He also revealed that despite recent legislation, the peak in nitrate pollution of surface and ground water resources may lie some years ahead because of the quantities still in ground water.

The current large volumes of pluridisciplinary works dealing generally on the water quality changes brought about by human activities in the drainage basin may be classified under the following headings:

Determination of water quality

I. Stream water quality as a reflection of catchment characteristics.

II. Spatial dimension of surface water quality

III. Effects of industrial and domestic activities on the quality of urban streams.

IV. Sediment yield and surface water quality.

Temperature and Aesthetic Quality of the Stream Water

According to Peirce, Weiner and Vesilind (1998) temperature, colour, odour and taste are actually physical characteristics which give the stream water its aesthetic quality. These parameters vary from one sub catchment to another in the study area depending on the extent and effect of urbanization and geology of the particular sub catchment area.

Temperature is a very important property of surface streams sometimes disregarded by many workers. Some important physical, chemical and biological processes are significantly influenced by the temperature of the water. Temperature is especially important in determining the value of water for cooling requirements, as well as for some other industrial and municipal utilities.

3. Research Methodology

Research Design

Survey research design was adopted in the study. The present research was a survey because the subjects were investigated in their natural settings.

Area of the Study

This study was conducted in Enugu catchment area of Enugu state south-east Nigeria. Enugu urban area, the political and administrative headquarters of Enugu State, is located in the Enugu drainage basin, a humid tropical watershed in the southeastern Nigeria. The study area covers a latitudinal space of $6^0$21' to 6^0 30'N of the equator and longitudinal extent of $7^0$26' to $7^0$37'E of the Greenwich Meridian (see figures 1 and 2). The entire study area covering a spatial entity of about 400sq.km includes the land area under Enugu Town Planning Authority (Chukwu, 2004).

Population for the Study

The population for the study was infinite.

Sample and Sampling Techniques

The population was infinite hence sampling was considered unnecessary since the entire population was used for the study.

Instrument for Data Collection

The main instrument for data collection was a structured likert scale questionnaire structured in four point. The likert scale options included Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD) with scores of 4, 3, 2 and 1 points respectively and were provided to the respondents to place a tick (√) to the response column that best described their level of agreement to each statement in the instrument.

Validation of the Instrument

Face and content validity were established in the research instrument by submitting it to three experts within the field of the study. The experts validated the instrument by making meaningful inputs and corrections which were affected before the final version was reproduced.

Reliability of the Instrument

Cronbach Alpha reliability co-efficient was used to determine the internal consistency of the instrument. The overall reliability coefficient for the instrument was .86. Cronbach Alpha was used because the instrument used was questionnaire and was administered once.

Data Collection

The present investigation in Enugu drainage basin, data collection was based on the following ten aspects: spatial dimension and configuration of the catchment and sub catchment areas, average slope and altitude of the sub catchment areas, drainage composition of the study area, soil types and distribution in the catchment area, pattern of land use types, sources (industrial, commercial and residential) of waste water production and surface stream pollution in the study area, solid waste and leachate production in Enugu catchment area, per capita waste water production in the study area, hydraulic, physical (including aesthetic) and chemical characteristics of the stream water in the catchment area, biological characteristics and oxygen requirements of the surface streams,

Method of Data Collection

Effective methods of Characteristics of Enugu drainage basin, cultural features of Enugu urban environment and physical, qualities of streams in the study area was adopted to source and collect the study data. Also, conventional method of utilizing the topographical water divide to demarcate the boundaries of the sub catchment areas was applied. However, for easy reference and identification of the particular sub catchment area concerned the toponymic system of the sub catchment areas is based on the nomenclature of the pre-existing features in the basin and layouts in the city of Enugu. This means that the nomenclature of the pre-existing layout in Enugu urban area is assigned to the given sub catchment containing greater part of the layout. In order to avoid possible bias, up to twenty-five sub catchment areas (each of which has at least a stream of any given order) are sampled and these form the bases for measurement and water sample collection. Gauging stations for stream flow are also set up in the 25 sub catchment areas. Stream flow data is collected from the natural drainage systems in the watershed. The discharge of the rivers is measured by the Velocity–Area technique. This is based on the fact that discharge, Q, is directly proportional to the product of the average stream velocity, V, and the cross sectional area of the river channel, A, at the point of measurement as represented by Jones (1997) in the relation:

Q = AV ---(1)

Where Q is the stream flow discharge (m^3 /sec); A is the cross –sectional area of the channel (m^2); V is the average stream velocity (m /sec). Each gauging site is carefully selected at such a reach where the river channel is regular without any aquatic vegetation, channel meander or sand deposit to cause obstruction for a length of about 20m to 50m. Floats are improvised to determine the mean velocity of the rivers. The float is made up of a small transparent polythene bag filled with the particular water of the river to be measured. Chukwu (2004) has observed that this is necessary in order to make the float acquire the same hydrodynamic properties with the given river water and also travel at the same speed and turbulence with the water to be gauged. The float is dropped at the starting point up stream of the channel stretch to be measured. A stop watch is used in recording the time it takes the float to travel downstream and arrive at the end of the chosen stream reach where the discharge is calculated. The average velocity of the river at the point of measurement is found by:

$$V = \frac{s}{t} \qquad (2)$$

Where V is the average stream velocity (m/sec); s is distance of the stretch traveled; t is the time taken by the float to make the travel. Three test runs are made to obtain reliable results in each case. The cross-sectional area of the channel at the measuring site is estimated by the product of the measured channel width (bank full discharge) and the mean stream depth and represented by the equation:

A = (□di/n) --- (3)

Where: A is the cross-sectional area of the stream (m^2); n is the number of points where the stream stage or depth is taken; di is the depth of the stream at points i (i = 1, 2, -------, n); w is the width of the stream channel at the measurement point. Stream flow is of course variable with different types of turbulence and, unlike the design peak run off discharge, the critical dissolved oxygen sag curve can be expected to occur when the turbulent flow is the lowest in the river.

4. Data Analysis

The research questions were answered using mean scores with standard deviation. One-Way Analysis of Variance (ANOVA) was, however, used to test the null hypotheses at .05 level of significances. For the determination of the degree of agreement of the respondents to each item, for the purpose of answering the research questions, the upper and lower limits of the mean were used thus:

Table 4.1 The Upper and Lower Limits of Mean Scores Used

Response	Rating	Boundary limits
Strongly Agree	4	3.50 - 4.00
Agree	3	2.50 – 3.49
Disagree	2	1.50 -2.49
Strongly Disagree	1	1.00 -1.49

Decision Rule

The decision rule for the null hypotheses is that if the calculated F-ratio were equal to or greater than the critical (or table) value, the null hypotheses were rejected otherwise it was not rejected

Analysis, Results and Discussions

Table 4.2 Laboratory analysis of aesthetic quality of stream water in Enugu Catchment Area

S/N	Sub catchment Unit	Temp (°C)	Colour Pt. Co	Odour (TON)	Taste (THN)
1	Ekulu R at Abakpa 1st Bus Stop	28	55.0	4	6
2	Idaw R. at Achara Layout	30	64.2	6	8
3	Enugu R. at Amagu	27	15.0	2	2
4	Enugu R. at Akwuke	32	52.0	4	6
5	Idaw R. at Amechi Road	31	51.0	4	6
6	Asata R. at Ilukwe Street	26.5	72.0	7	9
7	Idaw R. at Timber Shed	31.7	63.4	6	8
8	Ayo R. at Ayo Station	30	24	1	3
9	Aria R. at Central Business District (CBD)	32.6	57.5	5	7
10	Ekulu R. at Iva Valley	30.0	16.0	4	2
11	Ekulu R. at Abakaliki Rd, Emene	28.3	45.0	3	5
12	Ekulu R. at Oshimili Street	29.0	18.0	2	2
13	Idaw R. at Idaw R. Layout	32.8	57.3	5	6
14	Asata R. at Independence Layout	27.2	24.5	2	3
15	Ekulu R. at Upper Nike Road	33.0	56.4	5	7
16	Ekulu R. at Maryland	29.0	43	3	5
17	Asata R. at New Haven	29.2	51	3	6
18	Ogbete R. At Akwata Police Post	30.6	64	6	8
19	Enugu R. at Enugu-PH Express Rd	30.0	18.2	2	2
20	Asata R. at Kaduna Street	32.7	82.0	8	10
21	Asata R. at O'Connor Bridge	29.8	62.0	6	8
22	Ekulu R. at Trans-Ekulu Flyover	28.7	16	2	2
23	Ekulu R. at Ugbodegwu	28.6	53.0	2	6
24	Idaw R. at Ugwuanji	27.4	24.4	1	3
25	Asata R. at CIA (Coal Camp Industrial Area)	29.7	64.0	4	7
	WHO maximum permissible level	NS[a]	15.0	3*	3*
	FEPA maximum permissible level	30	15	3*	-

Source: Fieldwork, 2008.

Note: NS[a] No specification; 3* Inoffensive, Threshold Odor Number (TON)

Table 4.3 Physical Quality Analyses of Stream Water in Enugu Catchment Area

S/N	Sub catchment Unit	Turbidity (NTU)	Elect. Cond (Micro mhos)	TDS (mg/l)	TSS (Mg/)	TS (Mg/)l
1	Ekulu R at Abakpa 1st Bus Stop	50.0	331	119.0	379	578
2	Idaw R. at Achara Layout	120	32.0	20.0	382.0	622
3	Enugu R. at Amagu	2.0	26.3	16.7	198.3	215.0
4	Enugu R. at Akwuke	24	275	176	384	560
5	Idaw R. at Amechi Road	10	195	125.0	420.0	545.0
6	Asata R. at Ilukwe Street	150	322	206.	424.0	630.0
7	Idaw R. at Timber Shed	115	203	130.0	488.0	618
8	Ayo R. at Ayo Station	4.0	200	125	300.0	425.0
9	Aria R. at Central Business District (CBD)	100	312	200	400.0	600
10	Ekulu R. at Iva Valley	3.0	44	28.0	214.0	322.0
11	Ekulu R. at Abakaliki Rd, Emene	7	259.0	166	372.0	538
12	Ekulu R. at Oshimili Street	3	125	80	320.0	400
13	Idaw R. at Idaw R. Layout	5	192	125	460.0	585.0
14	Asata R. at Independence Layout	70	234	150.0	350	500

15	Ekulu R. at Upper Nike Road	60	188.0	120.0	460.0	580.0
16	Ekulu R. at Maryland	5	313	200.0	310	510
17	Asata R. at New Haven	8	320	200.0	340.0	540
18	Ogbete R. At Akwata Police Post	120	219	139.9	480.10	620
19	Enugu R. at Enugu-PH Express Rd	4	141	90.0	330	420
20	Asata R. at Kaduna Street	200	313	200.5	450.5	651.0
21	Asata R. at O'Connor Bridge	40	267	170.6	466.2	616.8
22	Ekulu R. at Trans-Ekulu Flyover	2.0	290	18	199	217
23	Ekulu R. at Ugbodegwu	30	270	172.6	398.6	571.2
24	Idaw R. at Ugwuanji	4	157	100	350	450
25	Asata R. at CIA (Coal Camp Industrial Area)	40	192	3.5	452.5	575
	WHO Max. Permissible Limit	5	1000	200	300	500

Source: Fieldwork, 2008.

Discussions of Findings

The parameters analyzed here refer to the combined aesthetic, physical, chemical and non-disassociated constituent characteristics of the most abundant compounds in surface stream as well as the physical (hydraulic) characteristics of the streams. Water is vital and essential directly or indirectly to almost all the activities of the inhabitants of Enugu urban environment. Physical and chemical quality analyses are a major factor in assessing the suitability of any water supply from a stream source to meet up with the requirements of those utilities (WHO, 2004; T. I., 2008).

The research has shown that stream water from an urban catchment contains constituents derived from both the natural environment and from the waste products of human activities in the city itself. The result of the laboratory examination of the stream water samples from Enugu catchment area is only a guide to the overall evaluation of surface water quality in the study area. In this investigation therefore, it is not feasible to consider all the individual and combined effects of the 2000 substances present in surface streams due to the prohibitive cost and inadequate laboratory research facilities. Another point is that heavy metals and pesticides are particularly expensive to analyze in the laboratory. Hall (1988) and DIFD (2002) in support of this have warned researchers and water resource managers against the tendency of including water quality parameters that are not immediately relevant to the purposes of the investigation or monitoring programme. They have also pointed out that a number of properties have little or no effect on water quality. This chapter therefore follows the recommended standard parameters of stream water quality analysis as specified by American Public Health Association (1975), Hall (1988), DFID (2002), WHO (2004b). These include:

A. Temperature and aesthetic quality assessment

B. Hydraulic characteristics

C. Physical quality examination

D. Chemical quality analysis

E. Non-dissociated constituents' analysis

Color in Stream Water

Color in surface streams of Enugu catchment area is usually caused by a variety of organic waste matter and humid compounds from human activities in the city environment as noted earlier in chapter three. In spite of this, if water looks colored, people instinctively avoid making use of it even though it might be perfectly safe from the public health view point. Some metallic substances such as iron also impact color in surface water.

The color values of streams in only nine sub catchments are generally 50 Pt. Co units or less, a limit which is an acceptable standard in some developing countries like Tanzania to mention but one. These sub catchment areas include Enugu River at Amagu (15 Pt. Co), Ayo River at Ayo (24 Pt. Co), Ekulu River at Iva Valley (16 Pt. Co), Ekulu River at Abakaliki Road (45 Pt. Co), Ekulu River at Oshimili St. (18.0 Pt. Co), Asata River at Independence Layout (24.5 Pt. Co), Ekulu R. at Maryland (42 Pt. Co), Enugu River at Enugu PH Express Road (18.2 Pt. Co), Ekulu River at Trans-

Ekulu Flyover, (16.0 Pt. Co) and Ekulu River at Ugwuanji (24.4 Pt. Co). This parameter indicates that the surface streams in Enugu urban environment are highly polluted beyond the WHO and FEPA maximum permissible limit.

Taste and Odor in Surface Stream Water

These two parameters are examined together here, although some nonvolatile substances can cause tastes without odours. Taste and odour in surface streams of Enugu urban environment are caused by waste materials and leachate in solution with stream water. Inorganic colored compounds found in industrial wastes from Tinker (Coal Camp industrial area) in the Asata River sub catchment at CIA also produce odour. Odor is measured by successive dilution of the stream water sample with odour free water until the odour is no longer detectable. This test is obviously subjective and depends upon entirely the olfactory lobe tissues and sensitive areas in the nostrils of the tester (Peirce*et al*, 1998). In this work, the testing program utilized a group of ten persons to conduct the test. In this test, a unit of 3 is taken as a standard threshold number (maximum permissible limit) for inoffensive odour.

These streams are actually the most affected by domestic and industrial waste discharge from Enugu urban environment especially Idaw River at Achara Layout, Asata River at Ilukwe St., Idaw River at Timber shed, Aria River at CBD, Idaw River at Idaw River Layout, Ekulu River at Upper Nike Road, Ogbete River at Akwata Police Post, Asata River at Kaduna St., and Asata River at O'Connor bridge.). Only 11 sub catchment areas have streams whose water odour is within the maximum permissible limit of inoffensive odour.

Taste is also measured in the laboratory in terms of threshold concentrations, which indicate the lowest concentrations that produce a perceptible taste. Taste values in surface streams of the study area are also high especially in the main city environment. The taste value in Asata River at Kaduna St. is as high as 10 units of THN while the least (2 units) is observed in five subcatchment areas of Enugu River at Amagu, Ekulu River at Iva Valley, Ekulu River at Oshimili St., Enugu River at Enugu–PH express road and Ekulu River at Trans-Ekulu Flyover. Thus, taste values in surface streams of 16 subcatchment areas are well beyond (3 units of THN) the maximum permissible limit of inoffensive odour. The average taste value in the surface steams of the study area is 6 units of THN which is very high indeed and as a consequence of both solid and liquid waste generated by Enugu urban inhabitants.

Hydraulic Characteristics of Streams in Enugu Catchment Area

A river's hydraulic characteristics include the average stage (or mean stream depth), the width of the bank full discharge (i.e. the width covered by the water course), the cross-sectional area of the stream, the mean stream turbulence, the average velocity and the catchment yield (or discharge) (Porteous *et al*, 2000). Nutrients and dissolved oxygen are essential to aquatic life but these hydraulic–conditions must also be satisfactory because they in turn affect the physical-chemical and biological characteristics of the stream water (Porteous *et al*, 2000).

Mean Depth, Velocity and Turbulence

To get nutrients and dissolved oxygen supply to the entire depth of the surface stream water, good mixing is essential and this is a function of the stream turbulence and velocity.As velocity, depth or bank full discharge increases, a given condition of laminar stream flow reaches a critical condition and becomes a turbulent flow variety.

There are two kinds of turbulent flow, in our study area namely: streaming (tranquil) and shooting flow and these are determined by the Froude number (F_r), a dimensionless parameter given by the formula:

$$F_r = \frac{V}{\sqrt{gD}} \qquad (15)$$

Where: V is the mean stream velocity; g is force due to gravity; D is the depth of the stream water.

Reynolds' number is another commonly utilized dimensionless parameter in predicting the type of stream flow but Froude number (Fr) is preferred in this work because it incorporates the effects of stream flow depth, velocity and the force of gravity in turbulent mixing of water constituents and oxygen supply in natural open channels of a catchment system (Roberts & Snyder, 1993).

The purely natural physical characteristics affecting stream water quality of the 25 sub catchment areas include their spatial size, configuration, average slope and altitude, drainage composition and soil types. Four micro relief regions are discovered in the basin. The first region comprises five sub catchments in the western part of the basin where average altitudes are generally well over 240m asl. And average slope ranges from 10.2^{O} to 40^{O}. In the second and third relief regions, mean altitudes and average slope are moderate, ranging from 225 to 239m asl and 5.6^{O} – 7.80^{O} respectively. It was discovered that the average slope does not vary in regular fashion with average height in the second and third micro relief regions. The mean altitude in the fourth region is 225m asl or less while average slope varies from 3.8^{O} to about 6.6^{O}. The relief features affect mainly the sediment and total solid contents of the stream water. Generally, the mean stream frequency in Enugu drainage basin is about 1.3 streams per square kilometer but this varies from 3 to about 0.4 streams/sq. km. The particle size of coarse sand ranges from 0.5 to 1.0mm and it has the highest particle size distribution among the various classes of soil in the study area. The least is observed for the clay soil in Idaw R. at Idaw R. Layout (0.002 – 0.004mm). Both the stream frequency and particle size of soil affect the quantity and quality of solids and pollutants.

5. Conclusion and Recommendations

Municipal sewage treatment work is therefore strongly recommended to prevent water pollution caused by sewage constituents. Since some of the streams such as Ogbete, Asata, Ekulu and Enugu rivers serve as both drainage channels and sources of domestic water supply to the local inhabitants, the treatment of sewage is necessary to minimize the pollutant load of the surface stream on the treatment plant. As a nuisance, sewage in the urbanized catchment area of the watershed constitutes an eye-sore with its pungent irritating odour like rotten egg. It is important to emphasize that the protection of natural recreational facilities, such as swimming pools, the prevention of surface water pollution, the maintenance and restoration of ambient conditions and ecological integrity of the urban streams and the exercise of common decency offer tangible and intrinsic justifications for the treatment of sewage in the urbanized part of Enugu catchment area and be properly adhered to. This study recommends an environmental education model which is focused towards a wide-scale participation in environmental stewardship education. This is a departure from the old traditional model that has largely been aimed at awareness creation only for surface water pollution impacts. In our proposed model, the aim will be to show how participatory approaches to environmental education can inculcate the necessary skills that will enable us take active participation in environmental stewardship and actions to protect our surface water resources and control water pollution in the city. This will also engage students in water pollution control projects as a goal of participatory environmental education which UNESCO in collaboration with UNEP has declared a global concern and assignment. There is hence the urgent need to proceed beyond this level and direct more energies on socio-political processes that are capable of bringing about, positive changes in the surface water pollution problem and also adopt pluridisciplinary attack to develop critical thinking and the required skills by playing an active role in the participatory educational process.

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