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ESTABLISHMENT OF WATER QUALITY CLASSIFICATION SCHEME: A CASE STUDY OF CALABAR RIVER ESTUARY NIGERIA

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ABSTRACT

A water quality classification scheme based on 11 routinely measured physicochemical variables has been developed for the Calabar River Estuary. The variables considered include water temperature, pH. E^h, DO, DO saturation, BOD_5, COD, TSS, turbidity, NH_4-N and electrical conductivity. Classification of water source is performed by reference to mathematically derived Quality index and Quality classification tables. The derivation and application of these models as well as their significance are discussed.

Key Words: Water quality, Calabar River Estuary, Nigeria.

INTRODUCTION

Water quality classification schemes have become a major tool for water quality management in most countries mainly because it allows the overall water quality status to be assessed on a single scale. According to Newman (1988) there are two primary methods for assessment of water quality; the physicochemical and biological methods. Physicochemical method involves measurement of such parameters as suspended solids, biochemical oxygen demand (BOD), dissolved oxygen, ammoniacal nitrogen etc. Biological assessment on the other and, relies on the fact that pollution of a water body will cause changes in the physical and chemical environment of the water and that these changes will disrupt the ecological balance of the system. Thus by measuring the extent of ecological upset, the severity of pollution can be estimated (Hallelwell, 1978).

Although the biological method is more reliable because it gives an overall assessment of the impact of pollutants on the ecosystem, physicochemical method is preferred in terms of precision and discrimination since it gives the actual concentration of pollutants at the time of sampling. The assessment of water quality demands the selection of various quality parameters based mainly on intended water use. Scantaniello (1975) has divided water sources into 5 major end uses, which include (1) public supply, (2) recreation and aesthetic value, (3) preservation of fish and wildlife, (4) agricultural use, and (5) industrial use. For effective computation of water quality status of a river it is advisable to select few parameters to reduce complexities since some parameters may be able to meet the required standard while some may not. Use of few parameters has been found to be more beneficial for administrative management purposes and for communication with the public (Lim and Leong, 1991).

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Water quality studies in the Calabar River Estuary are few and are limited to routine determinations of selected physicochemical parameters over space and time. Such results have limited value to administrators and the public and do not permit easy determination of overall quality trends. Presently, the city of Calabar including the Estuary is being developed as an Export Processing Zone (EPZ). It is certain that this development will lead to increased population and industrial activities and will likely increase pollution loads on the River Estuary. Water quality assessment scheme will be of paramount importance both for administrative purposes and easy communication with the public

METHODOLOGY

Eleven physicochemical parameters representing the most routinely measured in the estuary were selected. The selected parameters: water temperature, dissolved oxygen (DO), dissolved oxygen

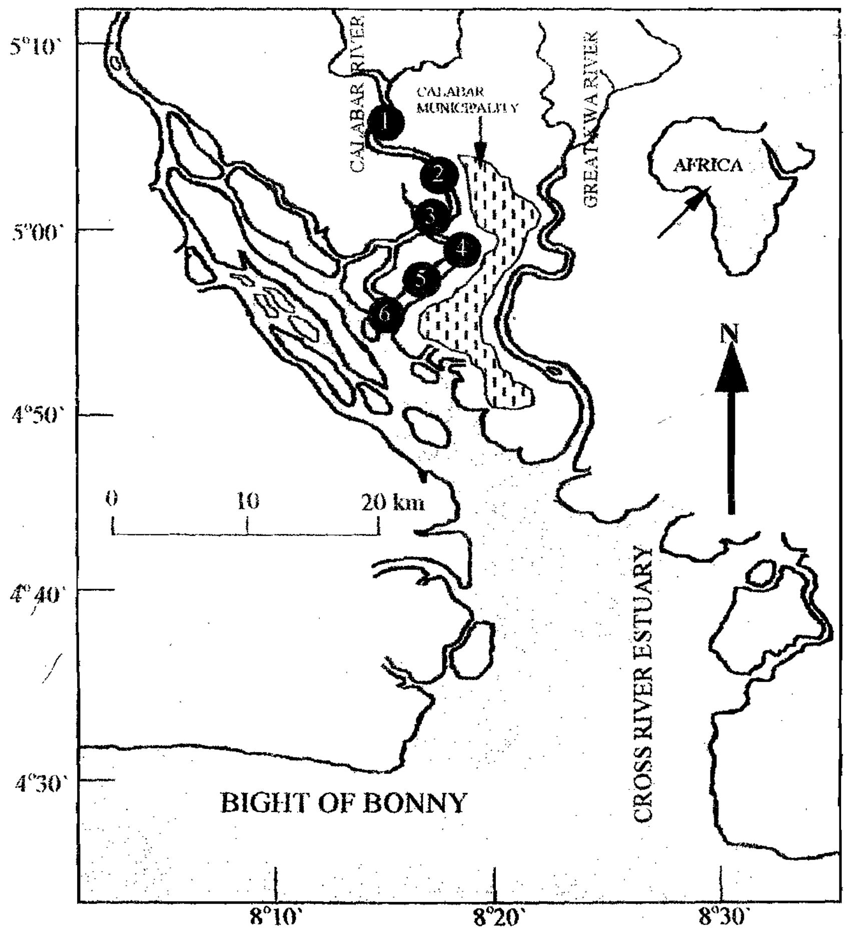

Figure 1: Map of Calabar River Estuary showing sampling stations.

Table 1: Water quality index table based on physicochemical parameters of the Calabar River Estuary.

Parameters	Scores				
	100%	80%	60%	40%	0%
Temperature (°C)		25-30	35-40	41-45	>45
pH	6.5-7.5	7.6-8.4	8.5-9.0	9.1-10.0	>10.0
		6.0-6.4	5.0-5.9	4.0-4.9	<4.0
E^h (mv)	>40	30-39	20-29	10-19	<10
Conductivity (ms/cm)	0.02-3.50	3.60-5.50	5.60-7.50	7.60-9.50	>9.50
DO (mg/l)	4.0-7.5	3.5-3.9	3.0-3.4	2.5-3.0	<2.5/>7.5
DOsat (%)	>55	50-54	45-49	40-44	<40
BOD_5 (mg/l)	0-2.0	2.1-2.5	2.6-3.0	3.1-3.5	>3.5
TSS (mg/l)	5-50	51-60	61-70	71-80	>80
Turbidity (NTU)	5-50	51-60	61-70	71-80	>80
COD (mg/l)	0-2.5	2.6-3.0	3.1-3.5	3.6-4.0	>4.0
NH_4 – N (mg/l)	0.05-1.00	1.10-2.50	2.60-3.50	3.60-4.50	>4.50

Table 2: Water quality classification table for Calabar River Estuary

Quality score	Quality class
91-100	Excellent
71-90	Good
51-70	Moderately polluted
21-50	Poor
0-20	Very poor

saturation (DOsat), hydrogen ion concentration (pH), redox potential (E^h), conductivity, turbidity, total suspended solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD_5) and ammoniacal nitrogen (NH4-N), also represent a summary of routine physicochemical parameters used in the determination of water quality especially in less urbanized environments where municipal sewage is the major source of pollution (Newman, 1988). Temperature was measured using dual temperature/ oxygen meter. Dissolved oxygen was measured with SCHOTT dual oxygen/temperature meter. pH and E^h were measured using single probe pH meter. COD was measured by permanganate method. BOD was measured with dissolved oxygen meter before and after incubation at 20°C for 5 days. Conductivity was measured with WTW LF 90 meter. Total suspended solids and turbidity were measured spectrophotometrically using HACH DR 3000 direct reading spectrophotometer. Ammonium was measured by Nesler's colorimetric method.

The water quality indices were obtained by assigning to each parameter, 5 concentration ranges with score ranging from 0% to 100% based on results of available field investigations in the Calabar River .

The Calabar River takes its rise from the Oban Hills of South eastern Nigeria, meanders southwards and finally discharges into the Cross River Estuary around 4°55' N and 8°15' E (Fig. 1). Results used in this paper are measurements from the lower tidal reaches of the river ranging from stations 1 to 6 from 1987 to 1997. Since the Calabar River drains through the city of Calabar, which is the most densely populated and industrialized area within the Cross River catchment, the development of water quality classification scheme for the Calabar River is also of importance to water quality management in the adjoining Cross River Estuary and associated coastal waters.

The most common and usually encountered range of values for selected parameter (i.e. Mean ± 0.25 x standard deviation) is scored 100%. The other ranges of values are arranged in order of decreasing possibility of natural occurrence and increasing cost of remediation as follows: 80% (Mean ± 0.5 x standard deviation), 60% (Mean ± 0.7 x standard deviation), 40% (Mean ± 1.0 x standard deviation) and 0% (Mean ± > 1.0 x standard deviation).

The water quality classification table was derived from the water quality index table and assigned 5 quality classes represented by Excellent quality (91 – 100% score), Good quality (71 – 90%), Moderately polluted (51 – 70%), Poor quality (21 – 50%) and very poor quality (0 – 20%). The water quality class of a sample is determined by the formula:

$$QC(\%) = \sum_{I=1}^{11} \frac{Q_{si}}{n} \quad \ldots\ldots 1$$

Where QC = Quality class (%)

Q_{si} = Quality score for i[th] parameter (from table 1)

n = Total number of parameter considered

The lower class limits in the quality classification table are obtained by the formula:

$$L = \frac{S_a + S_b}{2} \quad \ldots\ldots 2$$

Where S_a and S_b represent upper limit and adjacent scores (%) respectively on the quality index table.

RESULTS

Table 1 is the water quality index table for the Calabar River Estuary based on the selected physicochemical parameters. Table 2 is the water quality classification table derived from the index table.

DISCUSSION

The use of percentage (%) scale for the water quality index is of much importance to administrators and the public who are already used to such units compared to the multiplicity of scientific units used for individual physicochemical parameters. Results related to such a single scale also allow for better graphical elucidation of temporal and spatial trends and are easily adapted to Geographic information systems. Since a particular water body may be highly contaminated with industrial wastes containing heavy metals, petroleum hydrocarbons, pesticides etc., with little influence on the above oxygen balance parameters, there is need to develop separate quality classification schemes for each group of contaminants. As indicated in this study, this requires baseline studies to elucidate the background levels of the necessary index parameters under all possible temporal and spatial scales.

Apart from the routine physicochemical parameters used in this study, information on others such as heavy metals and petroleum hydrocarbons are very sparse in the Cross River system. These contaminants are also expected to be on the increase both from increased industrial and shipping activities associated with the EPZ. Studies in this direction must begin now if truly representative background levels are to be obtained.

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