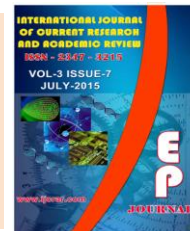




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**Anthropogenic modification of physico-chemistry of the Lower Bonny Estuary, Rivers State, Nigeria**

**S.T. Iderima<sup>1</sup>, K.J. Alagoa<sup>2\*</sup>, B. Ipeteikemoh<sup>3</sup> and Y.B. Eremasi<sup>4</sup>**

<sup>1</sup>Institute of Geosciences and Space Technology, Rivers State University of Science and Technology, Port Harcourt, Rivers State, Nigeria

<sup>2</sup>Department of Agricultural Education, Isaac Jasper Boro College of Education, Sagbama, Bayelsa State, Nigeria

<sup>3</sup>Department of Mathematics, Isaac Jasper Boro College of Education, Sagbama, Bayelsa State, Nigeria

<sup>4</sup>Department of Biological Sciences, Bayelsa State College of Arts and Science, Elebele, Bayelsa State, Nigeria

*\*Corresponding author*

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Anthropogenic, Modification, Bonny Estuary, Physico-Chemistry, Rivers State, Nigeria

**A B S T R A C T**

Select physico-chemical parameters of Bonny Estuary were investigated in order to gauge the obvious threat of human activities along the estuarine catchments on the estuary. This is crucial because of the diverse human activities of crude oil loadings, indiscriminate refusing dumping, residential housing and unrestricted fishing activities going on in the catchment. Samples were collected and investigated from five sampling stations representing fuel depot site, refuse dump, fishing spots, residential quarters and an upstream station far removed from direct human impacts (control). Water samples were collected for six months representing wet and dry seasons. Samples were analyzed for Nitrate (NO<sub>3</sub>), Sulphate (SO<sub>4</sub>), Phosphate (PO<sub>4</sub><sup>3-</sup>) Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Turbidity. Result from the investigation reveal that there were significant seasonal differences in measured parameters (p<0.05). There were no significant differences between sample stations (p>0.05). However, station 5 (control) exhibited relatively lower values in almost all measured parameters compared to other stations, suggesting greater ecological stability in the control station. BOD values were inversely correlated to DO values. Values of Nitrate, sulphate, phosphate and turbidity exceeded recommended safe limit. Based on the findings of this work, it can be concluded that Bonny estuary is under mild threat from land based activities.

## **Introduction**

Bonny River is an important River system east of the Niger. It serves as a major gateway to a number of industrial and commercial activities. Along the shores are located multinational companies that have established oil tank farms, liquefied national gas, flow stations, several pipelines routes, crude oil farm loading bay, condensation plants, office and living quarters for their staff alongside the indigenous populations.

In addition the activities of non-oil industrial sectors such as solid wastes, sewers disposal and agricultural activities contribute immensely to the contaminant load in the water body.

These effluents and solid wastes contain numerous compounds, both of organic and inorganic origins that may slowly degrade under natural condition. Oftentimes these compounds are readily absorbed into particles present in the natural water body which are then deposited on the sediment bottom and ultimately sink or re-suspended into the water column through various physical and chemical processes, where they may interfere and alter the ecological integrity and ecosystem function (Rygg, 1986).

The increased concern about the rapid ecological changes in the natural environment has provided major challenges to the scientific community (Chindah et al, 1999). Changes in the physico-chemistry of any water body greatly affect the dynamics of its biotic populations. As human activities along the estuarine catchments, affects the physico-chemistry of the Bonny Estuary, it is of grave significance to monitor vital water parameters. This study therefore ascertains water quality characteristics of the Bonny estuary as to provide information of

its ecological health status and a direction for action.

## **Materials and Methods**

### **Description of study area**

The lower Bonny River is located southeast of the Niger Delta between longitudes 7<sup>0</sup> 05' E and 7<sup>0</sup>20' E and latitude 4<sup>0</sup> 10' N and 4<sup>0</sup>.40' N. The Bonny River system consists of the main river channel of the Bonny River and large number of associated creeks and creeks-lets.

### **Description of sampling stations**

Five sampling stations were established for purposes of this study. Stations 1 – 4 were located within the impacted area, while station 5 served as the control station.

### **Sampling techniques**

The study covered sampling and the analyses of interstitial water.

Interstitial water samples were collected from a depth of 0 – 25 cm subsurface of the water for physico- chemical analysis.

Standard field sampling kits were used for sample collection. Clean glass bottles was used for surface water (interstitial water quality), 25ml glass container was used for DO and BOD<sub>5</sub>, while plastic container were used for other water quality parameters. Samples were delivered to the laboratory within 24hrs of collection. Water samples for DO were analyzed within 24hrs of collections.

Samples were collected for three months in the wet season and three month in the dry season at each sampling station.

## **Laboratory analysis**

The following water parameters were analyzed in the laboratory.

### **Water quality parameters**

In the laboratory, water samples were analyzed for nitrates phosphate, turbidity, dissolved oxygen and biochemical oxygen demand.

### **Dissolved oxygen**

Winkler filtrations was used for the determination of dissolved oxygen concentration (APHA, 1998). The water sample which was fixed with Winkler 1 and 2 reagents was used for this purpose. In the laboratory, Winkler 3 (concentrated sulphuric acid) was added to the sample. This eventually dissolved the orange - brown gelatinous precipitation, leaving a yellow colour. The solution was mixed by inverting the 70ml reagent bottle several times. 2 millimeter starches indicated were added to 25ml of the sample. The sample turns blue-black. This was titrated using standard sodium thio-sulphate solution (0.025ml) until a colourless solution formed. The final level of sodium thiosulphate indicated the amount of oxygen present in the sample (APHA, 1998).

Dissolved Oxygen = Titre value x factor  
( $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ )

### **Biochemical oxygen demand**

This analysis followed the same procedure for dissolved oxygen determination. At the end of the five-day incubation period, biochemical oxygen demand water sample were fixed with 2ml each of Winkler reagents, followed by Winkler titration as in the determination of dissolved oxygen

concentration (APHA, 1998). The determined biochemical oxygen demand was recorded as the difference between the initial dissolved oxygen value measured in the field and the value of dissolved oxygen determined after five day of incubation. The result shall be recorded as BOD mg/l of water sample.

### **Sulphate**

Sulphate determination was carried out using the turbidimetric procedure described in standard method for the examination of water and waste water (APHA, 1998).

Twenty millimeter of the water sample was measured into 250ml conical flask. One millimeter conditioning reagent was added with mixing and swirling. A quarter spatula full of barium chloride ( $\text{BaCl}_2$ ) was added and swirled for one minute. The colour intensity was measured using a spectrophotometer at 420nm wave length.

$$\text{Sulphate ppm} = (A - B) \times C$$

Where A = Absorbance of sample  
B = Absorbance of blank  
C = 119 – Sulphate in standard taken

### **Phosphate**

Phosphate was determined by the use of stannous chloride procedure (APHA 1998). Twenty five millimeter sample was measured into twenty – five millimeter conical flask, one millimeter ammonium molybdate reagent and 0.2 millimeter stannous chloride were also added. Mixing then turns the colour blue. After 5 minutes the absorbance of the treated sample was read and recorded using spectrophotometer 21D at 690nm.

$MgPO_4^5/Litre = C, X 1100$   
V =Original volume of sample  
C = $A/a$   
A =Measured absorbance of treated simple  
a =Molar Absorptivity  
Cu =Volume of sample taken for analysis

### Nitrate

Nitrate (NO<sub>3</sub>) levels in water samples were determined according to standard procedure using Bacine method (APHA, 1998). This principle of this determination was based on the reaction of nitrate and bacine to produce a yellow colored complex. Two millimeter of the water sample was measured into each of the test tubes and 2ml of 4+1 H<sub>2</sub>S<sub>4</sub> was added into the test tube and placed in a cool bath for 20minutes and 6.2ml of bacine sulphate was also added and sample boiled for 25minutes for colour development. After cooling absorption of the resulting yellow colour is measured in spectrometric 21D at 410nm wavelength

$NO_3mg/ lI = (A-B) \times 1.8678 \times 0.0354$   
A = Absorbance 401nm  
B = Blank

The (total hydrocarbon content) extract of 100ml of the sample was added into a flask (250ml) ass 10ml of toluene, close the tap and shake very well and allow standing for about 5 minutes. Open the tapes to let out pressure and close to back again and attach to restored stand. It is observed that two layer will be formed.

Open tap and allow the lower layer to run-out and collect the supernatant layer put in a test tube and determine its absorbance at 420nm

### Data analysis

The data obtained from the field studies was analyzed and the mean, Correlation and Analysis of variance (ANOVA) at the 95% confidence limit computed using the SPSS statistical software.

### Results and Discussion

The result of the select physico-chemical properties of the Bonny estuary are represented in Tables 1- 6. The measured physico-chemical parameters are Turbidity, Dissolved oxygen, Biochemical Oxygen Demand, Sulphate, Nitrate and Phosphate. The variations of these parameters across seasons and between stations are explained as follows:

The result for all parameters in all stations seem to exhibit a trendless pattern.

However, station 5 showed consistently uniform and low BOD during the entire study period as compared to other study stations (Fig 4). Since BOD is inversely related to DO, it therefore implies that station five had consistently higher DO than other stations (Fig 3). This may be due to the fact that station 5 (control) is located far upstream and has minimal point sources pollutants interfering with its physico-chemistry. The biochemical oxygen demand (BOD) also showed similar seasonal trends as dissolved oxygen. This implies that BOD levels were relatively higher in the wet season than in the dry season. This may be due to the fact that during the dry season, available oxygen is used for biodegradation of waste within the aquatic environment. Hence, very small amounts are left for biochemical (life processes) activities. (Alagoa and Wokoma, 2012).

Also, the high concentration of BOD seem to follow the depth profile theory, implying that water bodies of low depth are more disturbed, resulting in higher BOD concentration (Chindah and Braide, 2003) as most of the stations are located in shallow waters near the shore. The low BOD observed in the study can be explained by assertions of Hynes, (1960).

He reported that BOD values of 1 – 2mg/l or less represents clean water, 4 – 7mg/l represents slightly polluted water and more than 8mg/l represents severely polluted

water. Considering the above, the estuary can be termed slightly polluted. This confirms the assertion that Pollution of water bodies is almost entirely the fault of humans and industrialization.

Turbidity was highest in station 5 (control) as compared to other sampling stations. One reason for the higher turbidity in station 5 may be connected to the fact that station 5 is located deep upstream, where the marine vehicular movement is known to be highest and the water is always unsettled.

**Table.1** Description of sampling stations

Stations	Description
1	Fuel depot
2	House-hold waste refuse dump.
3	Fishing settlement/activities
4	Living quarters/Settlements
5	Up stream of Estuary (Control)

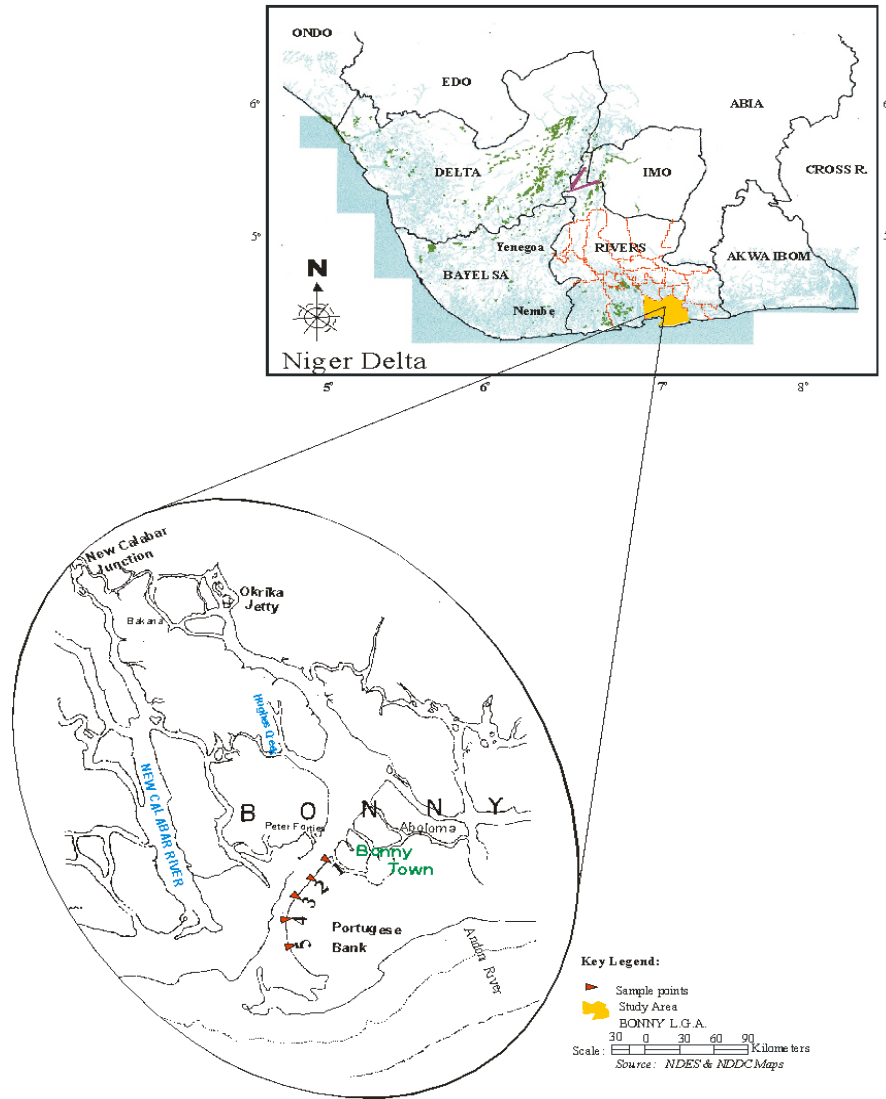
**Table.1** Mean Physico-chemical parameters of water in wet and dry seasons

Stations	PARAMETERS					
	DO(mg/l)	BOD(mg/l)	SO <sub>4</sub> (mg/l)	NO <sub>3</sub> (mg/l)	PO <sub>4</sub> (mg/l)	TURB.(NTU)
1W	1.47 <sup>a</sup>	6.36 <sup>a</sup>	876 <sup>a</sup>	0.31 <sup>a</sup>	0.05 <sup>a</sup>	12.0 <sup>a</sup>
D	4.54 <sup>b</sup>	4.48 <sup>b</sup>	989 <sup>b</sup>	0.05 <sup>b</sup>	0.11 <sup>b</sup>	72 <sup>b</sup>
2 W	2.78 <sup>d</sup>	5.56 <sup>a</sup>	914 <sup>d</sup>	0.47 <sup>a</sup>	0.05 <sup>a</sup>	2.61 <sup>c</sup>
D	8.58 <sup>c</sup>	4.77 <sup>b</sup>	663.7 <sup>c</sup>	0.23 <sup>c</sup>	0.16 <sup>b</sup>	25.5 <sup>d</sup>
3 W	3.03 <sup>f</sup>	6.23 <sup>e</sup>	1002 <sup>d</sup>	0.46 <sup>a</sup>	0.08 <sup>a</sup>	45.75 <sup>d</sup>
D	8.55 <sup>c</sup>	2.52 <sup>f</sup>	1884 <sup>e</sup>	0.05 <sup>b</sup>	0.26 <sup>c</sup>	19.5 <sup>a</sup>
4 W	2.46 <sup>d</sup>	5.20 <sup>c</sup>	675 <sup>c</sup>	0.35 <sup>a</sup>	0.05 <sup>a</sup>	146 <sup>f</sup>
D	1.58 <sup>a</sup>	7.01 <sup>e</sup>	826 <sup>a</sup>	0.05 <sup>b</sup>	0.57 <sup>b</sup>	32.5 <sup>d</sup>
5 W	3.14 <sup>f</sup>	5.19 <sup>c</sup>	669 <sup>c</sup>	0.38 <sup>a</sup>	0.05 <sup>a</sup>	74 <sup>b</sup>
D	6.86 <sup>e</sup>	3.55 <sup>fb</sup>	268.45 <sup>f</sup>	0.05 <sup>b</sup>	0.57 <sup>b</sup>	294 <sup>e</sup>

W – Wet season. D – Dry season.

\*Means with the same letter superscripts between and within rows are not significantly different

**Fig.1** Map of Niger Delta showing Bonny in Bonny LGA



**Fig.2** Temporal / seasonal Variation of Turbidity at different station

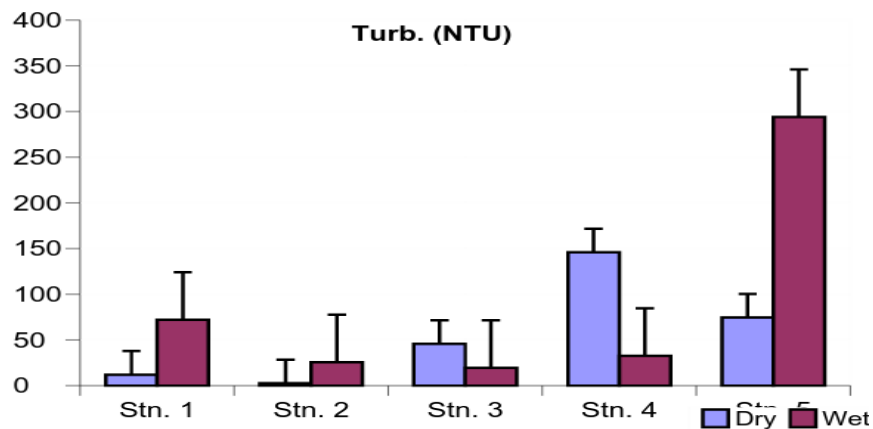


Fig.3 Temporal / seasonal variation of dissolved oxygen at different stations

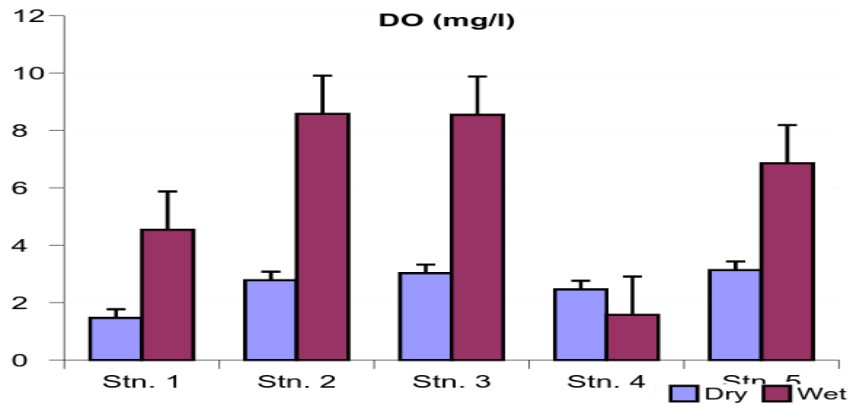


Fig.4 Temporal Variation of BOD at different stations

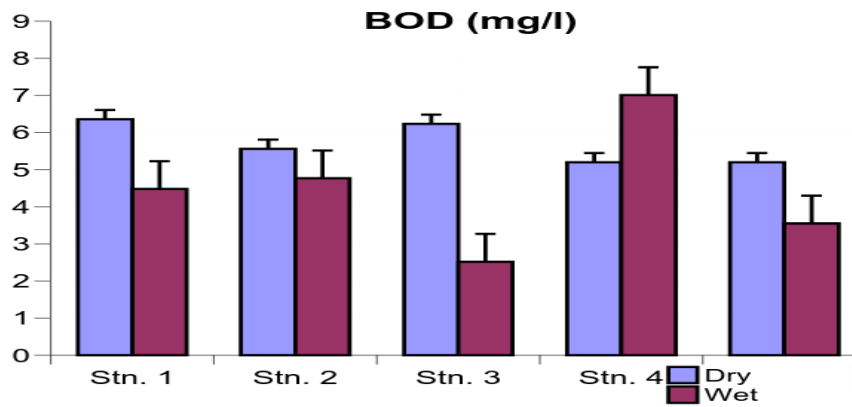


Fig.5 Temporal Variation of Sulphate at different stations

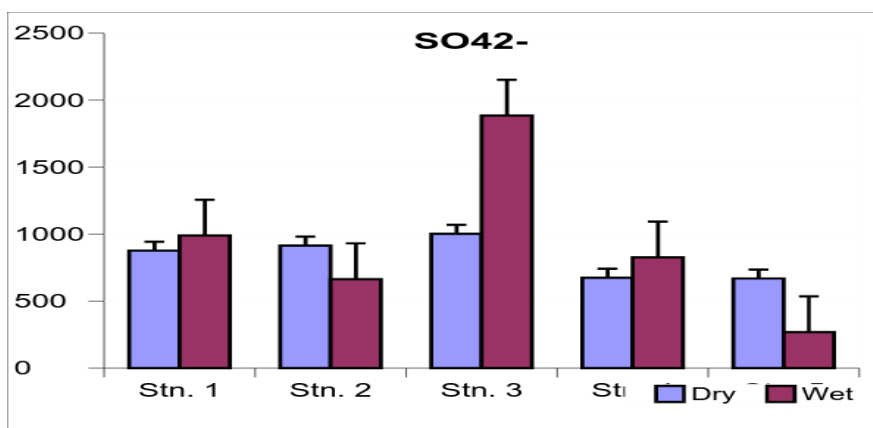


Fig.6 Temporal Variation of Nitrate at different stations

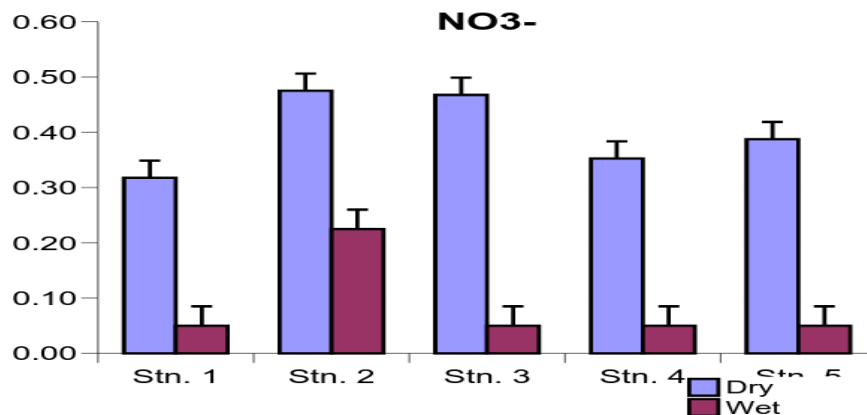
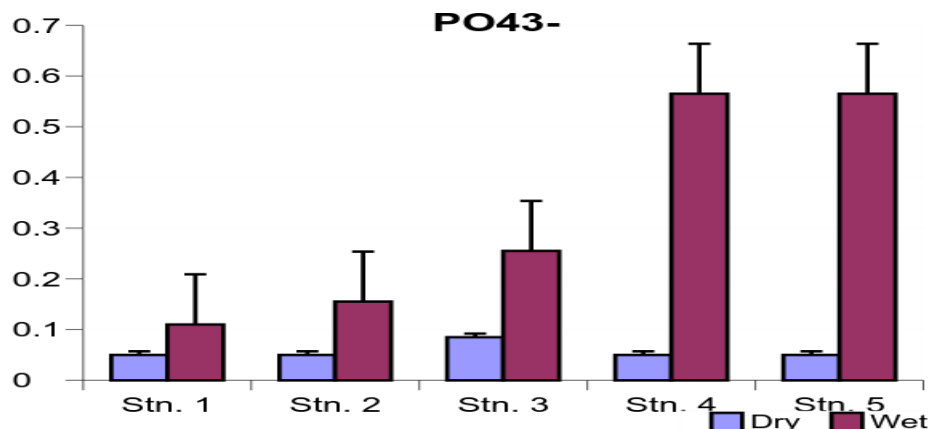


Fig.7 Temporal Variation of Phosphate at different stations



Except for sulphate (SO<sub>4</sub>), the nutrient parameters of phosphate (PO<sub>4</sub>) and nitrate (NO<sub>3</sub>) were generally low. Low nutrient levels of this nature have been reported for the Niger Delta region by other researchers (Chindah and Pudo, 1991; Chindah et al, 1999). This low nutrient level in the water column can be attributed to high activity rate of organisms and their ability to quickly use up the nutrient in the water column as soon as it is released, and the poor nutrient status of the substratum.

However, PO<sub>4</sub> and NO<sub>3</sub> levels in water were higher in other stations than in station 5 (control). Sources of phosphates include septic tanks, runoff from feedlots, and runoff from agriculture and waste water

treatment plants. In addition, detergents with phosphates were a prime source before manufacturers developed phosphate-free alternatives. Phosphates can also enter waterways from human and animal waste, phosphorus rich bedrock, laundry, cleaning, industrial effluents, and fertilizer runoff. These phosphates become detrimental when they over fertilize aquatic plants and cause stepped up eutrophication. The siting of sampling stations in areas of waste dumps, residential quarters, and fuel depots may be responsible for the rise above that of the control station. Eutrophication brings with it high amounts of phosphates and nitrates and is a main cause in the destruction of lake ecosystems around the world. (Ansar & Khad, 2005) Also NO<sub>3</sub> rise in these stations



above that of the control may be due to its usual association with PO<sub>4</sub>.

Phosphates and nitrates always occur together in small amounts in all aquatic environments and are required to maintain the growth and metabolism of plants and animals. However, in excess amounts, these minerals can prove to be quite harmful. Through the process of eutrophication, dissolved minerals and nutrients flow into streams, lakes, and other bodies of water. A good portion of these dissolve minerals consist of phosphates and nitrates. Levels of phosphates and nitrates that are intolerable to local organisms have been known to deplete dissolved oxygen levels by causing algae blooms.

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