PHYSICO-CHEMICAL PROPERTIES OF GROUNDWATER QUALITY OF THE EAGLE ISLAND, NIGER DELTA NIGERIA

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Abstract
The study area is located in the Port Harcourt Metropolis. It is bounded by latitudes 4° 44ˈ 30″ and 4° 44ˈ 50″N and longitudes 7° 03ˈ 0″ to 7° 03ˈ 40″E covering an area of about 342 Km^2. It lies on the average altitude of 15m above sea level, and is structurally in low land, typically made up of flat mangroves swamp and devoid of rock outcrops with poor drainage pattern. Five (5) samples of groundwater collected from the study area from both deep (about 60m) and shallow hand-dug wells, following the standard procedure as prescribed by APHA Guidelines. The analysis was achieved using Direct reading Photometer (Hanna model), Titrimetric method, and Flame photometer (FPF9 Jenwy model).The interpretation of groundwater chemistry of the samples suggest that most of the samples analyzed are within the WHO and Nigerian Standards for drinking, while some have concentrations beyond desirable limits. However, the concentrations of some compounds such as nitrate, slightly above permissible limits in the samples analyzed have created a concern over the suitability of the water for drinking and other domestic uses. The assessment of water for irrigation indicates that most of the samples are suitable for irrigational purposes. The result of the laboratory analysis revealed that the selected ions were present in varying concentrations in the study area. The chemical parameters of water samples from the hand-dug wells were plotted using histogram and revealed interaction between the groundwater and aquifer materials, and identified important data trends and groupings.

Keywords: Water quality, analysis, WHO, permissible limits, anion, cation, Eagle Island.

INTRODUCTION

The study area is located in the Port Harcourt Metropolis. It is bounded by latitudes 4° 44ˈ 30″ and 4° 44ˈ 50″N and longitudes 7° 03ˈ 0″ to 7° 03ˈ 40″E covering an area of about 342 Km^2 (Fig. 1). It lies on the average altitude of 15m above sea level, and is structurally in low land, typically made up of flat mangroves swamp and devoid of rock outcrops with poor drainage pattern. Taking the planet earth as a whole, water is one of the most abundant commodities since it occupies 70% of the Earth's surface because of the abundance and it's everyday use, water is usually taking for granted in most part of the world. Water is indispensible for man's activities. It provides means of transportation, provides man with means of recreation and it also serves as ultimate recipient for man's wastes (Etu-Efeotor, 1981; Etu-Efeotor and Akpokodje, 1990; Tahir et al., 2015; Badusha and Santhosh, 2017).

In Nigeria, consumable water sources can be obtained from surface and ground water, such as likely to be polluted with domestic and industrial wastes (Etu-Efeotor, 1981; Etu-Efeotor and Akpokodje, 1990; Tahir et al., 2015; Badusha and Santhosh, 2017). Water can be clear, odorless and tasteless and yet be unsafe to drink groundwater provides more than half the drinking water consumed by the inhabitants of Eagle Island community. The community has of recent witnessed an upsurge in its population with the development of an area called new Eagle Island layout.

Groundwater is water that occurs in permeable geological material or formation known as aquifer. An aquifer is a geological features that stores and permits appreciable amount of water for extraction. The extraction of groundwater for usage in man's activities can be done either by using pipe-borne water pumped via a pumping station, hand drilling well from an underground aquifer prior to which, it has been treated. Good drinking water is one of the most important requirements in life.

The World Health Organization (WHO) considers that drinking water should be suitable for human consumption, therefore all measures pertaining a safe drinking and usage of water should be checked. This study is aim in determining the quality of the ground water in Eagle Island.

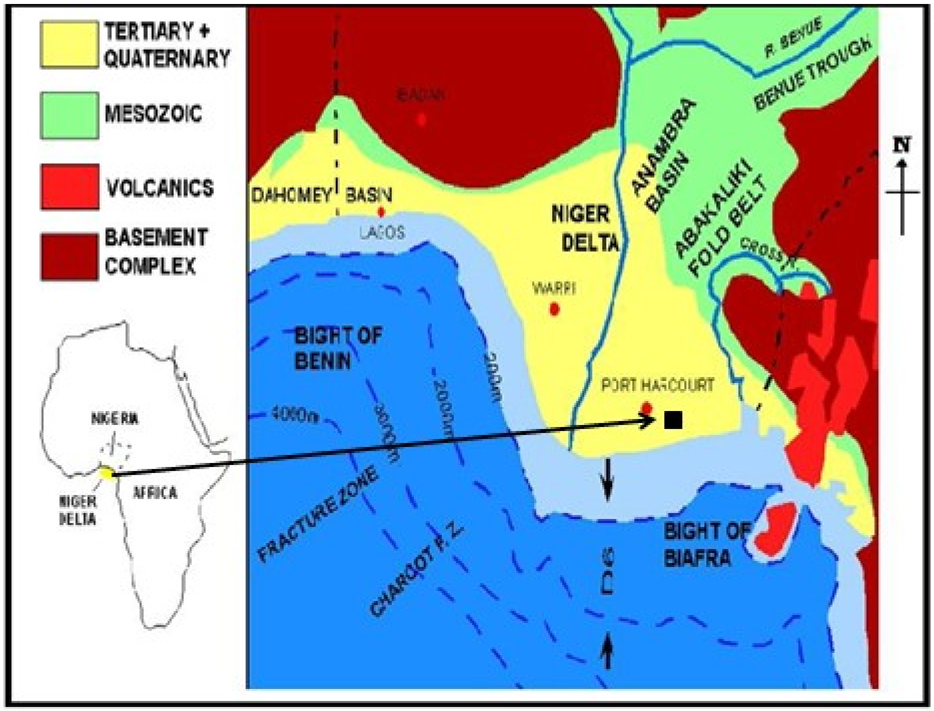

Fig. 1: Map showing location of study area modified (Ocheli et al., 2013).

GEOLOGY OF THE STUDY AREA

The Eagle Island, in Port Harcourt metropolis is mainly found within the Eastern Niger Delta Basin of Nigeria. The studies of the Niger Delta have widely been done mostly by oil companies and academician because of its petroliferous province which is of economic importance. Many authors have investigated and summarized the basic geology, structural setting, depositional environments, production characteristics, and field development strategies among others. Short and Stauble (1967), outlined the regional geology of the Niger Delta. The origin of the Niger Delta were attempted and they established that the Tertiary deltaic fill is represented by a strong diachronous sequence (Eocene- recent), which is divided into three lithofacies units namely; the Akata, Agbada and Benin Formations.

Doust and Omatsola (1990), observed that sands of the Niger Delta are poorly consolidated with porosity as high as 40% in oil bearing reservoir, reservoir sands of more than 15m thick in most places consists of two or more stacked channel. They also observed gradual reduction of porosity with depth and permeability in hydrocarbon bearing reservoirs are commonly in the range of 1-2 Darcy and sands shallower than 3000m have porosity of more than 15%, but below 3000m only a few sands have more than 15% porosity. Bustin (1988) established that the Niger Delta basin is divided into continental, marginal marine and marine facies. He also observed that sediments of the onshore are separately mapped as alluvium in contrast with the offshore sediments, in which the youngest sediments were not investigated because cutting samples could not be collected from the upper hundred feet below sea level.

Akaegbobi and Schmitt (1998), established that heterogeneity of reservoir, and formation evaluation problems can make it difficult to characterize fluid distribution, determine permeability and estimate hydrocarbon in place. They suggested that the approach used in characterizing a reservoir involves a combination of analysis of geological framework of the reservoir, hydrocarbon trapping components (stratigraphic and structural), formation evaluation and calculation of volumetric hydrocarbon in place. Haack et al. (2000) discussed the tertiary petroleum systems of the Niger Delta. He observed the lower cretaceous petroleum system is characterized by lacustrine source rocks which occurs in the north-western part of the delta and might be present in the Benin trough and the upper cretaceous lower Paleocene petroleum system, which is characterized by marine source rocks, is defined for the north-western part of the delta.

Various depositional processes gave rise to the Niger Delta Cenozoic stratigraphy. The studies of Short and Stauble (1967), Frankyl and Cordey (1967) and Avbovbo and Ogbe (1978) provided the initial information on the stratigraphic units distribution of the Niger Delta subsurface. Also, the works of Evamy et al. (1978), Ejedawe et al. (1984), Nwachukwu and Chukwura (1986), Haack et al. (2000), Reijer (1996) among others provided useful information on the stratigraphic units of the region. The Niger Delta subsurface is divided into three major lithostratigraphic units such as the Akata, Agbada and Benin Formations (Reijers, 1996) (Fig. 2). Basin-ward, there is a decrease in age, which reflects the overall regression of the Niger Delta clastic wedge depositional environments. In the south southern Niger Delta, stratigraphic units equivalent to these three formations are exposed, and it reflect a gross coarsening upward progradational clastic wedge (Short and Stauble, 1967), deposited in marine, deltaic and fluvial environments (Weber and Daukoru, 1975; Weber, 1987).

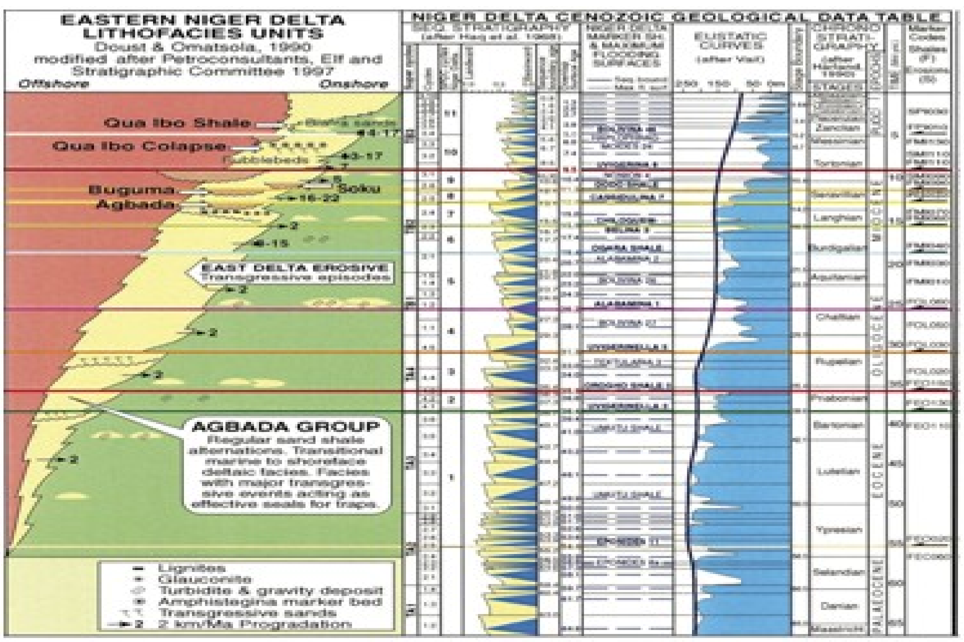

Fig. 2: Stratigraphic Column showing Eastern Niger Delta lithofacies units and Cenozoic Geological Data (Reijers, 1996).

METHODOLOGY

Five (5) water samples from hand-dug wells in the study area were collected, and at each sampling point; PH, Temperature, Total Dissolved Solids (TDS), and Conductivity parameters were measured directly in the field using Mi 806 (4 in 1) combined meter. This allows an initial, rapid assessment of water quality at the site of sampling. This was followed by the acidification of one set of the sample for the cation analysis with some few drops of Nitric acid (HNO_3) to prevent adsorption of ions on the walls of the containers, similarly to prevent bacterial activities. The sample was labeled and stored in container containing ice blocks before taken to the laboratory for Na^+, Ca^{2+}, Mg^{2+}, K^+, $SO4^{2+}$, NO_3, Total Alkalinity, Cl^-, Hardness and Fe^{2+} analysis. The samples were analyzed at the Multi-user laboratory, Department of Geology, University of Port Harcourt, Port Harcourt. The result of the chemical analysis of water samples from the wells were plotted using histogram software developed specifically for graphical and numerical analysis and modeling of water quality data.

RESULTS AND DISCUSSION

Groundwater is a vital resource, with a large fraction of the world's population relying on the resource directly or indirectly for livelihoods (Sanjay, 2010). Much of the groundwater can be said to be meteoric in origin, which is originating from the atmosphere. Also, a small percentage is known to enter the hydrologic cycle from subterranean sources and is described as juvenile water. This water includes water of magmatic and volcanic sources, while connate water is entrapped between the interstices of sedimentary formations.

The aim of evaluating ground water quality is to determine if it meets the requirements for its many different uses. Ground water quality can be affected or degraded as a result of human activities that introduce contaminants into the environment. It can also be affected by natural processes that result in elevated concentrations of certain constituents in the groundwater.

Recently, groundwater quality has become a matter of concern due to discharge of industrial and domestic effluents directly into both surface and underground, the use of agricultural chemicals, land use and cover changes. Thus water quality is influenced by many factors, including atmospheric chemistry, the underlying geology, climate change and anthropogenic activities. The quality of water should satisfy the requirements or standards set for specific uses, such as drinking, domestic, agricultural, industrial and recreational purposes.

Table 1: Showing the parameters, sampled well and WHO standard.

Parameter	Number of hand-dug wells from the region					W.H.O
	1	2	3	4	5	Standard
P^H	4.73	5.90	6.04	5.30	3.67	6.7-8.5
Turbidity (NTU)	20.00	23.00	102.00	41.00	20.00	5.00
TDS (mg/l)	54.20	49.20	410.00	76.80	81.60	1000.00
Conductivity (LIs/m)	87.00	82.00	683.00	12.00	316.00	–
Total Hardness (mg/l)	19.40	33.00	210.00	11.60	21.30	100.00
Chloride (mg/l)	11.40	<100	45.70	8.15	11.40	250.00
Total Alkalinity (mg/l)	<100	34.80	116.00	11.60	<1	–
Nitrate (mg/l)	4.72	1.28	10.90	3.27	5.50	10.00
Sulphate (mg/l)	0.46	0.27	1.49	0.26	0.53	30.00
Potassium (mg/l)	1.77	1.14	14.70	5.59	0.89	–
Sodium (mg/l)	8.75	1.70	36.10	11.50	8.65	200.00
Total Iron (mg/l)	0.05	1.02	<0.05	0.21	0.05	0.30

The evaluation of the physical and chemical test results on the groundwater from the study area involved a comparison of the results with the World Health Organization (W.H.O) Standards (Hems, 1970). Some points to note include spatial variations in concentration, since comparisons have to be made to distinguish between natural and man-made contamination in relation to background concentration values on the results. The results gotten from the analyses of the five wells were compared to W.H.O standard (1996) as presented in Table 1.

Physical Properties

The P^H results in the five wells range from 3.67 in well 5 to 6.4 in well 3. This range falls within the W.H.O standard and the general trend is that the water is acidic. This is due to the presence of organic matter in the soil or the peculation of rainwater underground releasing CO_2, a process that reduces the waters. This is favorable to the growth of iron bacteria which cause incrustation of pipes. The required treatment is by the addition of hydrated lime after exposure to the air The Turbidity results from the wells range from 20 NTU in well 1 and 5 to 102 NTU in well 3 all being above the W.H.O standard (Table 1, Fig. 4). The general trend from the results indicates

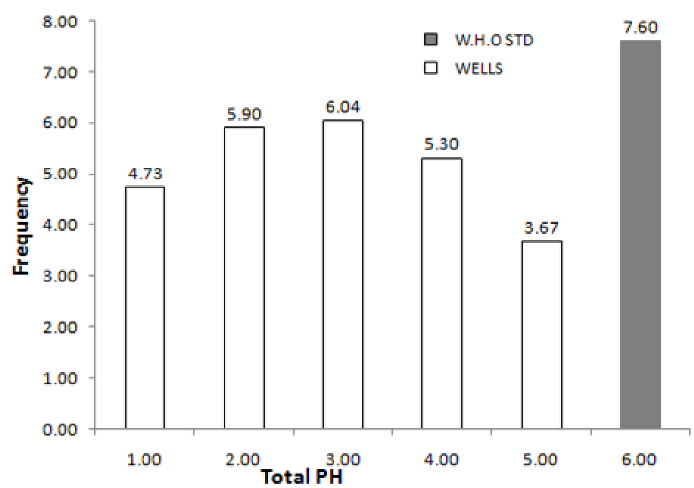

Fig. 3: Showing the pH values of the five wells as compared to W.H.O

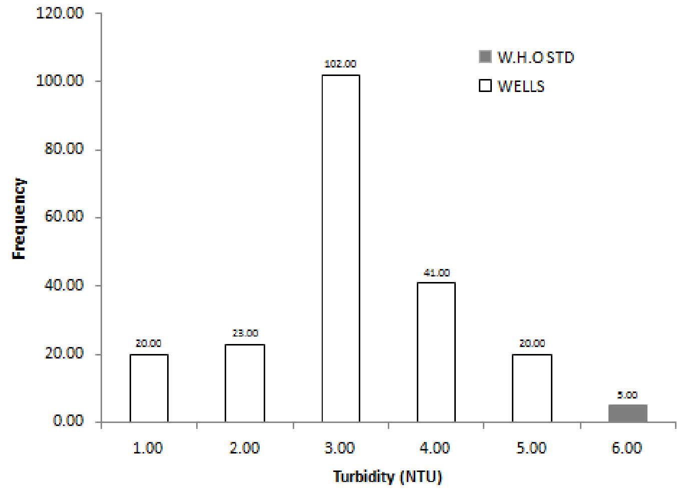

Fig. 4: Showing the turbidity values of the five wells as compared to W.H.O.

turbidity levels to be very high and this is due to the oxidation of dissolved ferrous iron to produce insoluble residue. As a result, the turbidity levels in the study area are unacceptable, because well 1-5 is higher than the WHO standard. In drinking water, the higher the turbidity level, the higher the risk that people may develop gastrointestinal diseases, therefore causing lots health problems to the people through contaminants like viruses, bacteria can become attached to the suspended solids (source: Water quality standard for surface water of the state of Washington, 1997).

Throughout, the groundwater show relatively low amounts of TDS with well 3 having the highest amount 410mg/l and the lowest value 49.2mg/l in well 2 (Fig.5). All values are within the W.H.O standard.

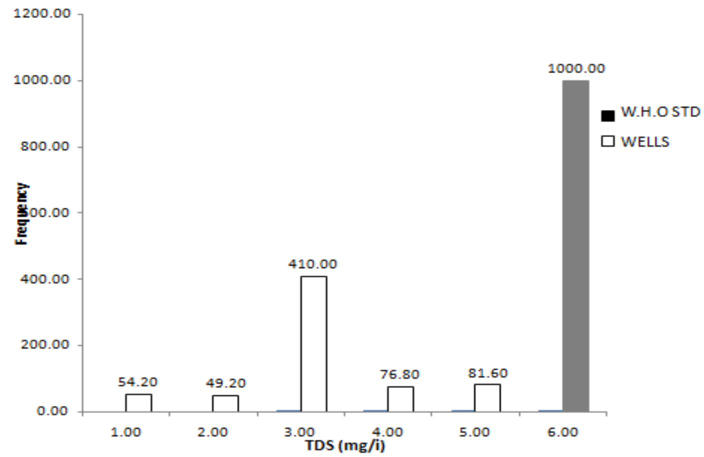

Fig. 5: Showing the TDS values compared to W.H.O.

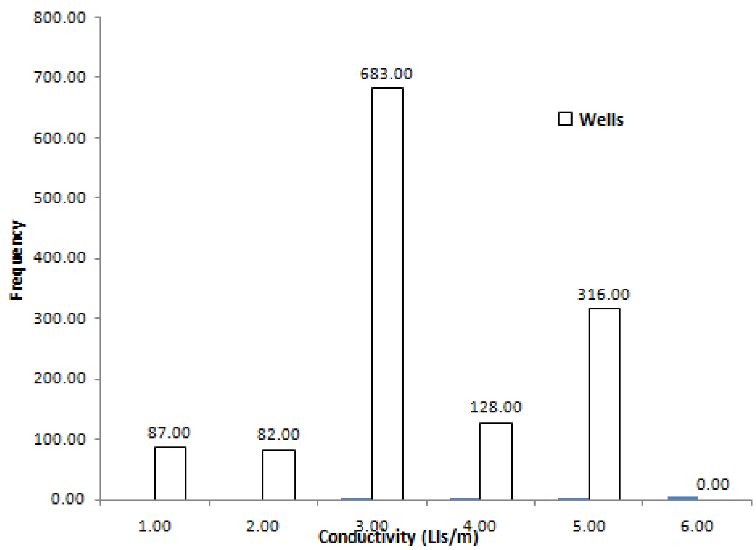

Fig. 6: Showing the values of conductivity levels.

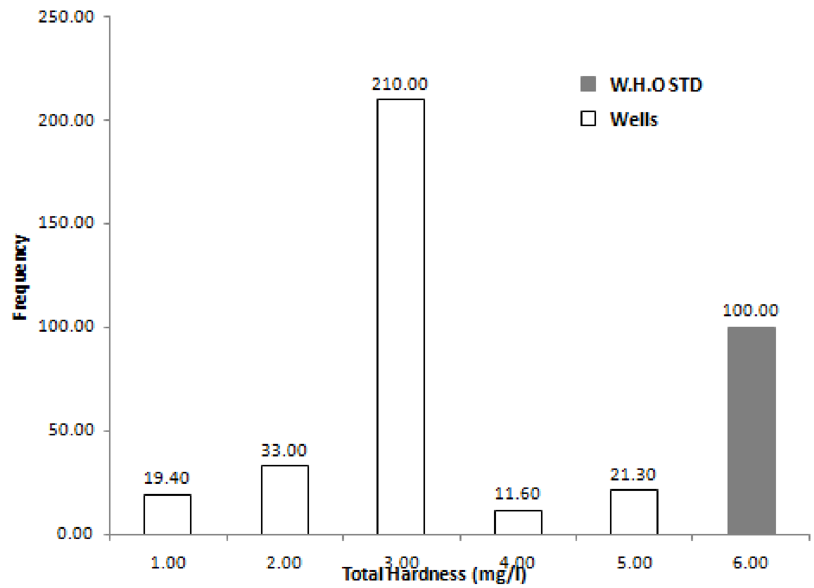

Fig. 7: Showing the values of total hardness

The Conductivity levels ranges from 82LIs/m in well 2 to 683LIm/s in well 3. The high conductivity value in the groundwater in well 3 is suspected to be due to the high amount of soluble salts which a general trend in the study area (Fig. 6). There is no W.H.O standard.

The Total hardness ranges from 11.6mg/l in well 4 to as high as 210mg/l in well 3. By W.H.O water standard, all the wells house potable water except well 3. This level of Hardness is attributed to presence of bicarbonates and hydroxide (i.e. contaminants). Water described as “hard” is high in dissolved minerals such as calcium and magnesium. Hard water is not a health risk, but a nuisance because of mineral buildup on fixtures and poor soup and/or detergent performance (Mary Ann et al.1998).

Chemical Properties

The Chloride values for all wells fell within the W.H.O Standard with the lowest being well 2 values of 0<1.00mg/l and the highest being 45.7mg/l in well 3. There is therefore no chloride problems associated with the groundwater.

The Total Alkalinity values range from <1.00mg/l in well 1 and 5 to 116mg/l in well 3. The high amount of Total Alkalinity is probably due to presence of bicarbonate and hydroxide hence well 3 is not suitable. But there is no W.H.O Standard. The Nitrates values for all wells fell within the W.H.O standard except well 3 with values of 10.9mg/l while low values of 1.28mg/l for well 2.

The Sulphate values for all the wells fall within the W.H.O standard with the lowest value being 9.44mg/l in well5 and the highest being 73.1mg/l in well 3. This high concentration level in well 3 could be attributed to the presence of improper disposal of wastes, sulphur in chemical reagents from the flowing river.

The Calcium values for all the wells fall within the W.H.O standard with the highest value being in well 3 and the lowest values being in well 5. The high Calcium value could be attributed to a high concentration of CO_2 in the soil water. The groundwater therefore remained potable with Calcium.

The Concentration values of Magnesium ranges from 0.26mg/l in well 4 to 1.49mg/l in well 3. All the values fall within the acceptable standard limit but well 3 showed a slightly higher reading which can be explained by the presence of carbon dioxide and it is supported by the fact that magnesium share a similar geochemistry to calcium. The Potassium values for all the wells are relatively small but well 3show a high spike of 14.7mg/l. There is however no W.H.O standard. The Sodium values ranging from 0.89mg/] in well 5 to 14.7mg/l in well 3 fell within the W.H.O standard. 3.25 The high value in well 3 may be due to dissolution of clay minerals in the soil. The Iron values for all the wells except well 2 fell within the W.H.O standard with the highest value of l.Q2rng/l in well2. Making well 2 unacceptable for domestic use since it would stain laundry.

CONCLUSION

The present study on the physico-chemical quality of river water reveals that the total alkalinity and nitrate values are within the water quality standards prescribed by WHO and the concentration of all other parameters especially in well 3 are slightly above the limit set by WHO. From this study it is revealed that degradation of water quality is very high at the well 3 stretches of the area. This is due to high anthropogenic disturbances associated with the location and the cumulative effect of all pollutants from region. Wild use of chemical fertilizers and pesticides, devious dumping of domestic wastes are also the major causes of rapid fall in water quality. The quality of water is depleting also with the change in climate and other natural processes. Under this context, it is discovered that surface water pollution is comparatively high during the dry season. Apart from the lowering of water quality, these factors may adversely impact biodiversity of the riverine ecosystem. So this study indicates the need for control measures for a broader perspective to regulate these problems in Eagle Island.

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