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Assessment of Physicochemical Characteristics of Mini-Ezi Stream in Elele-Alimini, Emohua Local Government Area of Rivers State, Nigeria

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ABSTRACT

Mini-Ezi Stream is one major aquatic ecosystem in Elele-Alimini that receives arrays of wastes generated from agricultural farms, residential homes, fecal discharges and other products of anthropogenic activities along the stream course. Samples of water from the stream were collected to assess the physicochemical characteristics during both dry and wet seasons. Thirteen physicochemical parameters were analyzed. pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Temperature and Turbidity were determined in situ, while Bicarbonate, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Hardness (TH), Chloride (Cl^-), Phosphate (PO_4^{3-}), Nitrate (NO_3^-) and Sulphate (SO_4^{2-}) were determined using standard analytical procedures in the laboratory. The result revealed that Temperature, EC, TDS and Bicarbonate levels showed significant differences ($p<0.05$), with the dry season recording higher mean values than the wet season. On the other hand, NO_3^-, PO_4^{3-}, Cl^- and SO_4^{2-} recorded higher mean values in wet season which may be due to runoff from land mass. The result showed that all the physicochemical parameters analyzed in water from Mini-Ezi Stream were within the national and international set standards except for turbidity that was above the set standard. Therefore, this study can serve as baseline information for the periodic monitoring of water quality of the stream.

Keywords: *Assessment, Mini-Ezi Stream, Physicochemical Characteristics, Surface Water, Water Quality*.

1. INTRODUCTION

Water is one of the most valuable and indispensable gifts of nature that has positively affected human life in diverse ways [1].There are various sources of water, which include stream, river, well, borehole, spring, lakes and ocean [2]. One major source of water that provides man with number of services such as water for domestic uses, agricultural, industrial, transportation and recreational purposes is the stream [3].This source of water also serves as recipient of waste, which may contaminate or impair the quality of water [4]. A number of characteristics - chemical, physical, biological and radiological define the quality of water [5]. It is therefore important to evaluate the quality of stream water, since it can be the main pathway for the dissemination of toxic chemicals and pathogenic microorganisms [6].

Mini-Ezi Stream is an important aquatic ecosystem in Elele- Alimini that serves as a source of drinking water particularly for farmers during the farming season. The stream also serves as source of water for washing of clothes, cars for motorists that ply through the Alimini/Okini-Ali road, fishing and other purposes for natives. The strategic location of Mini-Ezi Stream makes the aquatic ecosystem to receive large amount of wastes and runoff from residential, agricultural farm and other arrays of anthropogenic activities within Elele-Alimini and its environs. In spite of all the anthropogenic activities around this stream, there is still paucity of information on the chemical studies of the Mini-Ezi water body. It is therefore pertinent to monitor the surface water of Mini-Ezi Stream in order to ascertain the physicochemical characteristics, as the result obtained will help to know the level, the source and the risk of pollution involved for both human and aquatic organisms. It is against this backdrop that the study on assessment of the physicochemical characteristics of Mini-Ezi Stream in Elele-Alimini was carried out

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2. MATERIALS AND METHODS

2.1 Description of Study Area

The study was carried out in Mini-Ezi Stream in Elele Alimini, Emohua Local Government Area of Rivers State. Mini-Ezi Stream is the major aquatic ecosystem in Alimini, taking its source from Orashi River and connecting to New Calabar River. This river flows down to Ogbodu-Isiokpo where it is joined by a smaller tributary river that rises at Aluu and then empties into some creek and lagoon bordering the Atlantic Ocean. Mini-Ezi Stream is a fresh and non-tidal aquatic ecosystem lying between Latitude $5^{0}45^{1}$N and Longitude $7^{0}60^{1}$E.

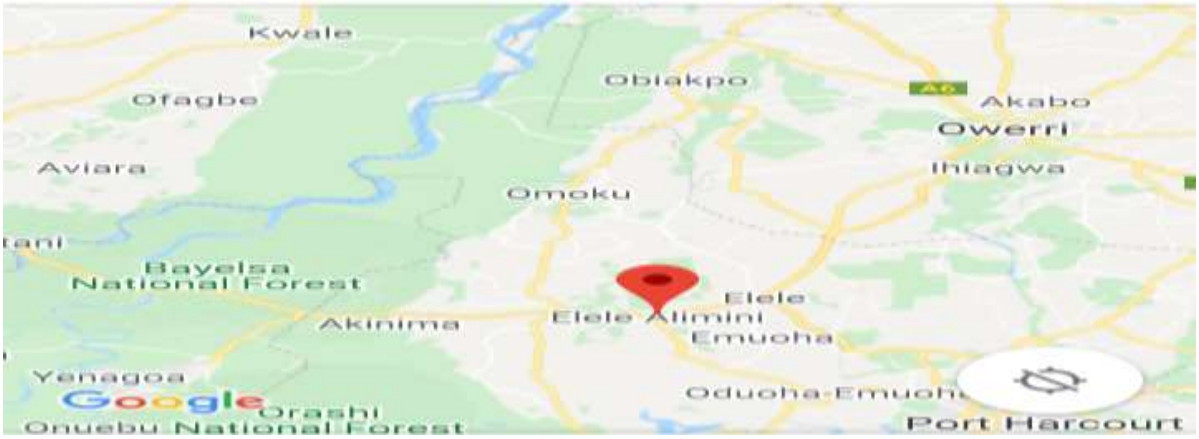

Fig 1: Map of the Study Area Showing Sampling Location (Source: Google Map)

2.2 Sample Collection

Water samples were collected at Mini-Ezi Stream at three different locations, on monthly basis for the period of six months, covering peak of dry (December to February) and peak of wet (June to August) seasons. At each station, water samples were collected for Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) analysis, as well as other physicochemical parameters. *In situ* determination of some parameters was done, while water samples collected for other physiochemical parameters were stored in ice-chest, prior to analysis.

2.3 Sample Analysis

The analysis of physiochemical parameters in water obtained from Mini-Ezi was done using standard analytical procedure. Water pH, temperature, turbidity, TDS and electrical conductivity were measured *in situ*. Water pH was determined with the aid of electric digital pH meter, (Jenway Ltd, model 350. pH meter). Temperature was measured with the aid of liquid-in-glass thermometer, turbidity with the aid of turbidity meter (Turner designs Aquafluor 8000-001) while electrical conductivity and TDS were determined with the aid of conductivity meter (Mettler Toledo M-226 conductivity meter). BOD_5 was fixed *in situ* in amber bottle and determined in the laboratory according to Winkler's method. The determination of total hardness (TH) was done by EDTA Complexometric tritration method using Eriochrome Black-T as indicator, while chloride (Cl^-) was determined by Argentometric titration method. Phosphates were determined by stannous chloride method. Nitrate was determined by Brucine Method while Sulphate was determined by Turbidimetric method.

2.4 Statistical Analysis

All parameters were statistically analyzed using Excel Spreadsheet.

3. RESULTS AND DISCUSSION

The results of physiochemical parameters obtained from analysis and their comparison with national and international standard are shown in Table 1. The table presents the mean, standard deviation and ranges of all the parameters during dry and wet seasons.

Table 1: **Mean of Physiochemical Parameters of Mini-Ezi Stream in both Dry and Wet Seasons.**

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	DRY		WET		LIMITS		
PARAMETER (units)	MEAN	RANGE	MEAN	RANGE	WHO	SON	T-TEST VALUE
pH	7.489±0.32	6.9-7.9	7.46±0.21	7.2-7.8	6.5-8.5	6.5-8.5	0.411
Temp. (^oC)	28.06±0.80	26.9-29.1	23.79±0.38	23.1-24.4	<40.0	<40.0	0.000
EC (µs/cm)	267.8±23.57	227-229	185.89±32.6	134-234	1000	1000	0.000
Turb. (NTU)	13.50±7.04	4.3-24.16	20.45±2.10	18.16-24	5.0	5.0	0.014
TDS (mg/L)	145.37±30.4	115-199.3	172.44±26.03	138-200	1000	500	0.030
$HC0_3^-$(mg/L)	2.79±0.55	2.21-3.7	1.27±0.47	0.64-2.1	100	100	0.000
Cl^- (mg/L)	1.79±0.37	1.24-2.37	2.77±1.24	1.94-4.3	250	100	0.003
TH (mg/L)	19.48±1.5	16.7-21.8	15.49±3.26	10.4-20.11	100-500	100	0.001
DO (mg/L)	5.16±0.31	4.8-5.8	5.45±0.40	4.9-5.96	5.0-7.0	7.0	0.061
BOD (mg/L)	2.78±0.36	2.2-3.3	1.77±0.36	1.3-2.4	2.0-5.0	5.0	0.000
NO_3^- (mg/L)	2.0±0.45	1.32-2.8	4.71±2.85	1.77-10.7	50	10	0.015
PO_4^{3-} (mg/L)	0.196±0.12	0.07-0.41	3.44±1.52	1.84-6.2	6.5	5.0	0.000
SO_4^{2-} (mg/L)	1.28±0.23	1.07-1.81	2.58±1.13	1.02-3.82	100	100	0.008

3.1. pH: The test on water pH was done to determine the acidity and alkalinity nature of the river water [7]. The values of pH obtained in this study as shown in Table 1, ranged from 7.20 to 7.80 with a mean value of 7.46 ± 0.21 in wet season and 6.90 to 7.90 with a mean value 7.49 ± 0.32 in dry season. The mean pH showed no significant difference ($p>0.05$) between dry and wet seasons. The stream water was slightly alkaline, which is similar to the report of [8] from River Jibam in Plateau State. This could be attributed to the presence of bicarbonates and biological degradation of waste in the soil which may have been washed into the stream by rainfall [9]. The pH values obtained in this study were within national and international standard of 6.5 to 8.5 [10] [11].The slight alkaline nature observed in Mini-Ezi Stream is common and typical of aquatic ecosystem not badly impacted [12].

3.2. TEMPERATURE: The temperature of stream water is one of the physical properties for dynamics of aquatic environment, because it interferes in the metabolic processes of organisms, influences the reproduction and increases the rate of degradation of organic matter [2]. From Table 1, the values of temperature obtained in Mini-Ezi Stream ranged from 23.10 to 24.40 ^oC with a mean value of 23.79 ± 0.38 in wet season and 26.90 to 29.10 ^oC with a mean value of 28.06 ± 0.80 in dry season. The mean values showed significant difference ($p<0.05$) between dry and wet seasons, with dry season recording higher values than the wet. This observation is typical of most tropical river surface water [13]. The values of water temperature recorded in the study falls within <40 ^oC set standard by World Health Organization [10] and Standard Organization of Nigeria [11].

3.3. ELECTRICAL CONDUCTIVITY: The electrical conductivity (EC) of stream water is a useful indicator of total salt content which could be influenced by sewage discharges and other anthropogenic activities along the river bank [14]. The result obtained from the study revealed that EC values ranged from 134.0 to 234.0 µs/cm, with a mean value of 185.89 ± 32.61 in wet season and 227.0 to 299.0 µs/cm with a mean value of 267.80 ± 23.58 in dry season. There was visible significant difference ($p<0.05$), with the mean values obtained in dry season recording higher EC values than wet season (see Table 1). These are in consonance with the observation of [15] in Elele Alimini stream, but lower than the range of values reported by [5] in Otamiri-Oche River in Etche. The slightly higher conductivity values recorded in this stream could be attributed to discharges from the surrounding land mass and domestic sources along the stream bank, which contain lots of solutes and dissolved compounds ([16]. The EC values are lower in wet season due to dilution and flushing of mineral components but higher in dry season due to evaporation and concentration factor [17]. The mean values were far below 1000 µs/cm permissible limit set by national and international organizations.

3.4. TURBIDITY: This is the measure of disorderliness caused by suspended and fine insoluble particles in water body [18] [17]. The values of turbidity as shown in Table 1, ranged from 18.16 to 24.0 NTU with a mean of 20.45 ± 2.10 in wet season and 4.30 to 24.16 NTU with a mean value of 13.50 ± 7.04 in dry season. The mean values showed significant difference ($p<0.05$), with wet season recording higher mean value than dry season. This could be attributed to runoff carrying sediments from the nearby areas and mixing up with non-living matter like silt and sand at the bottom of the stream during wet season [14]. The mean values were above 5.0 NTU set as standard by WHO and SON.

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3.5. TOTAL DISSOLVED SOLIDS (TDS): It is the measure of inorganic salts and other substances dissolved in aquatic ecosystem [19]. The values of TDS obtained in this study ranged from 138.0 to 200.0 mg/L with a mean value of 172.44 ± 26.03 in wet season and 115.0 to 199.30 mg/L with a mean value of 145.37 ± 30.41 in dry season (see Table 1). The mean values showed significant difference ($p<0.05$), with wet season recording a higher mean value than dry season. This is consistent with the observations of [13] reported to be a common phenomenon in most Nigerian inland waters due to more runoffs and allochthonous materials washed into the river ecosystem during the wet season. The mean values of TDS in this study are lower than the 1000mg/L recommended value by [10] for drinking water and 500 mg/L [11] guideline for water quality in Nigeria.

3.6. BICARBONATE: Bicarbonate is one vital physiochemical parameter of river water that has the ability to enhance conductivity and water alkalinity [20]. From Table 1, the result obtained in this study revealed that the values of bicarbonate ranged from 0.64 to 2.10 mg/L with a mean value of 1.27±0.47 in wet season and 2.21 to 3.70 mg/L with a mean value of 2.79 ± 0.55 in dry season. The mean values showed seasonal significant difference ($p<0.05$) with dry season recording higher mean value. The range of values recorded in this study is consistent with the observation of [21] in water samples from river system in Delta State. The presence of bicarbonates in this river water may be attributed to degradation of domestic and fecal waste discharged to the river, which may have influenced pH and EC concentration [22]. The mean values were far below 100 mg/L permissible limit set by [10] which indicated that the river surface water is soft.

3.7. CHLORIDE (Cl^-): Chloride is an important physiochemical parameter of the aquatic ecosystem that indicates presence of organic waste in water when it is beyond desirable limits in inland water [23]. The values of Cl^- obtained in this study from Table 1, ranged from 1.94 to 4.30 mg/L with a mean value of 2.77 ± 0.81 in wet season and 1.24 to 2.37 mg/L with a mean value of 1.79 ± 0.39 in dry season. The mean values showed significant difference ($p<0.05$) with the mean value in wet season recording higher than that of dry season. This result is in line with the findings of [13] [5]. The values recorded in both wet and dry season were far below 250 mg/L set as [10] and 100mg/L by [11] standard, which is indicative that the stream is completely freshwater in nature.

3.8. TOTAL HARDNESS (TH): Total Hardness is one of the physicochemical parameters of water used to describe the effect of dissolved minerals, particularly Calcium and Magnesium ions (Ca^{2+} and Mg^{2+}) which determine suitability of water for domestic and industrial purposes [24]. From Table 1, the values of TH obtained in Mini-Ezi Stream ranged from 10.40 to 20.11 mg/L with a mean value of 15.49 ± 3.26 in wet season, and 16.70 to 21.80 mg/L with a mean value of 19.48 ± 1.50 in dry season. This is similar to the report of [8] in Jibam River. There was significant difference ($p<0.05$) with dry season recording higher mean value due to concentration factor than the wet season [17]. The values obtained in this study in both seasons were below 100-500 mg/L [10] and 100mg/L [11] permissible limits. The stream water is soft and so is usable for both bathing and washing of clothing.

3.9. DISSOLVED OXYGEN (DO): Dissolved oxygen in water is an important parameter that determines the quality of river water since it is required for aerobic and metabolic process of organisms in aquatic ecosystem as well as decomposition of organic matter [25]. From Table 1, the values of DO obtained in this study ranged from 4.90 to 5.96 mg/L with a mean value of 5.45 ± 0.40 in wet season and 4.80 to 5.80 mg/L with a mean value of 5.16 ± 0.31 in dry season. There was no significant difference ($p>0.05$) between the mean value recorded in wet and dry season, though the values recorded in wet season were higher than dry season. This is in consonance with the report of [17] who reported that higher values of DO in wet season was a general characteristics of tropical waters, since high temperature causes decrease in solubility of dissolved oxygen. The mean DO values recorded in this study is within the national and international standard of 5.0 to 7.0 mg/L.

3.10. BIOCHEMICAL OXYGEN DEMAND (BOD): Biochemical oxygen demand is known as the oxygen required for microorganism to breakdown organic matter in the waste under aerobic conditions [26]. A low value of BOD in water is an indicator of good water quality [27]. The values of BOD obtained in this study ranged from 1.30 to 2.40 mg/L with a mean value of 1.77 ± 0.36 in wet season, and 2.20 to 3.30 mg/L with a mean value of 2.78 ± 0.36 in dry season (see Table 1). There was significant difference ($p<0.05$) with dry season recording higher mean value than wet season. This finding is similar to the observation of [15] in Elele-Alimini stream. The higher value of BOD in dry season could be attributed to the effect of higher temperature and putrefaction of substances deposited in the stream from surrounding environment [17]. The mean values obtained in both dry and wet season were within the 2.0 to 5.0 mg/L WHO standard for surface water.

3.11. NITRATE (NO_3^-): Nitrate in water is a product of anthropogenic activities such as runoff from agricultural lands and discharge of household wastes, which indicates the presence of fully oxidized organic matter [24]. From Table 1, the values of nitrate in surface water of Mini-Ezi Stream ranged from 1.77 to 10.70 mg/L with a mean value of 4.71 ± 2.88 in wet season and 1.32 to 2.80 mg/L with a mean value of 2.00 ± 0.45 in dry season. There was significant difference ($p<0.05$) with wet season

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recording higher mean value than dry season. This could be attributed to runoff from waste and human defecation around the stream course [28]. The values recorded in this study are within 50 mg/L [10] and 10 mg/L [11] standard. Higher nitrate in water is indicative of pollution, which causes blue baby syndrome disease in human [23].

3.12. PHOSPHATE (PO_4^{3-}): Phosphate is an essential nutrient that serves as an indicator of anthropogenic biological pollution, responsible for eutrophic condition in aquatic ecosystem [12]. The result of this study revealed in Table 1, that the values of phosphate ranged from 1.84 to 6.20 mg/L with a mean value of 3.44 ± 1.52 in wet season and 0.07 to 0.41 mg/L with a mean value of 0.196 ± 0.12 in dry season. The mean values showed significant difference ($p<0.05$), with higher values observed in wet season. The observation in this study conforms to the report of [29] in Mini-Weja stream. The values recorded in both wet and dry season were below 5mg/L guideline by [11] and 6.5 mg/L permissible limit for surface water by [10].The low values of phosphate in this aquatic ecosystem is a common feature of tropical freshwater bodies [16] [30].

3.13. SULPHATE (SO_4^{2-}): Sulphate ions occur in natural water and in higher concentration, contributes to permanent hardness of water [31]. From Table 1, the values of sulphate in Mini-Ezi Stream ranged from 1.02 to 3.82 mg/L with a mean value of 2.58 ± 1.13 in wet season and 1.07 to 1.80 mg/L with a mean value of 1.28 ± 0.23 in dry season. The mean values showed significant difference ($p<0.05$), with the wet season recording higher mean values. This finding is in conformity with the observation of [12]. The result of sulphate in this study is far below 100 mg/L recommended for surface water by [10] and do not show any characteristics of eutrophication, thereby confirming the reports by [15] that sulphate, phosphate and nitrate levels control algal growth and eutrophication in river ecosystem.

4. CONCLUSION

The results obtained in the assessment of physiochemical characteristics of Mini-Ezi Stream reveal that apart from turbidity, all other parameters were within the set standards by national and international organizations. This shows that the stream water is still fit for domestic use. Therefore, this result can serve as baseline information for the periodic monitoring of Mini-Ezi Stream.

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