STATISTICAL ANALYSIS OF PHYSIOCHEMICAL PROPERTIES OF AJALI RIVER STRETCH IN ENUGU, ENUGU STATE NIGERIA

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ABSTRACT

This work studied the physiochemical properties of Ajali River polluted with Industrial effluent at different sampling points from -250m upstream before the pollution to 2250m downstream. Statistical package for Social Science (SPSS) was used for the statistical analysis. Post ANOVA test was used to determine if there is any significant difference between the means and at which distance the difference occurred. A measuring wheel and Global Positioning System (GPS) were used for the exact locations studied. The azide-Winkler method was used for DO determination, while the five-day incubation method was used for BOD. It was observed that there was a significant difference ($p<0.005$) between the means of the properties across the sampling points. Dissolve Oxygen was found to be higher in the rainy season with a range of 3.82±0.47 to 7.70±0.40. Biochemical Oxygen demand was equally higher in the rainy season with a range of 2.05±0.02 to 5.02±0.41. Chemical Oxygen demand was higher in the rainy season with a range of 6.20±0.12 to 15.04±0.03. It was observed that the effect of the pollution decreased along the sampling points away from the point of discharge to the stream suggesting that the river has a natural tendency to purify itself.

Keywords: Ajali river, physiochemical properties, pollution, post-ANOVA, statistical analysis

INTRODUCTION

In prehistoric times, people settled along the banks of rivers, where they found fish to eat and water for domestic purposes. Centuries later, rivers provided routes for trade, exploration, and settlement. When towns and industries developed, the rushing water of rivers was harnessed to supply power to operate machinery. It provides affordable power for millions of homes and businesses. Rivers have been used by a man more than any other ecosystem; they have been obstructed from flowing, fished in, boated on, and discharged into many other activities [1]. Rivers being an open system have been subjected to pollution because of an increase in human and industrial activities thereby affecting their ecological integrity. Industries and cities have historically been located along rivers because the rivers provide transportation and have

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traditionally been convenient places to discharge waste. Domestic and industrial discharges to rivers are one of the causes of river pollution [2].

Flood irrigation is mainly practiced by some agriculturists who use pesticides and fertilizers [3]. This combination leads to the production of non-point source discharges that increase the concentration of these compounds in rivers [4]. These pollutants when discharged into the river bodies render the water unsafe for its intended purposes like domestic use, drinking, recreation, irrigation, food processing, etc. Rivers can be considered polluted when there are undesirable changes in their physicochemical and biological properties which render the water unfit for a particular use [5]. These pollutants tend to reduce the dissolved oxygen (DO) content of the water body on which the aquatic life depends. They also tend to increase the biochemical oxygen demands (BOD) due to the increased amount of organic matter content of the water leading to the death of plants which directly affects the aquatic life too. The dissolved oxygen concentration is the main indicator of the level of organic pollution in a river as it responds to the biological oxygen demands (BOD) load [6]. This level of water pollution has been a serious concern for consumers because it has affected their source of living.

Many types of pollutants which have been discharged into the rivers are removed by purification processes at various speeds. Some heavy metals are removed relatively quickly because suspended clay and organic particles have a slight electric charge and adsorb the metal [7-11]. When the clay or organic particles settle out of the water, they take the metal atoms with them. Unfortunately, some pollutants are very persistent in the water and can accumulate downstream, causing great hazards [12-13]. Suspended solids in a moving body of water will settle out at various points or be carried to a long distance depending on their size and the rate of flow.

Ajali River which spans through Imezi-Owa in Enugu state to Ebenebe in Anambra State of Nigeria is faced with pollution from industries like Ama brewery, Coca-cola, and other bottling companies.

This work, therefore, studied levels and seasonal variations in the physiochemical properties of the Ajali River stretch polluted by effluent from Industries.

MATERIALS AND METHODS

Area of Study

The area of study was Ajali River in Enugu State, it spans across imezi - Owa in Enugu State to Ebenebe in Anambra State of Nigeria.

The sampling points were within Abunuzo and Aguobuowa in Ezeagu Local Government Area. Figure 1 shows the map of the Ajali River indicating the sampling points. Table 1 shows the sampling points and their corresponding

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distances from the point of effluent discharge to the river.

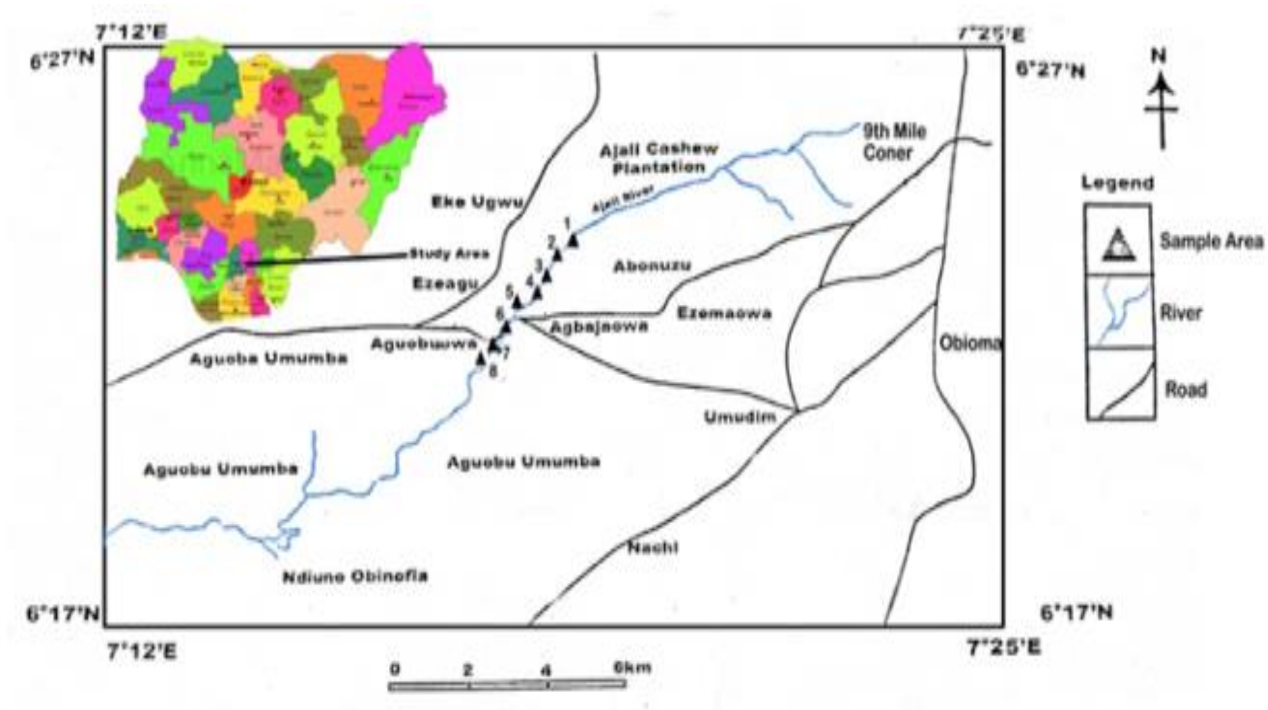

Fig 1. Map of Ajali River indicating the sampling points

Table 1. The sampling points with their corresponding distances.

Sampling points	Distance from the points of discharge (m)
P1	-250m above the discharge point
P2	0 (point of discharge)
P3	250
P4	500
P5	1000
P6	1500
P7	2000

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P8	2250

Sampling methods and preparations

The sampling containers were thoroughly rinsed with distilled water before collection. A small air space was left on the containers after collection to enable proper mixing of the samples at the time of analysis except for those samples that were used for the determination of oxygen resources. For sampling for oxygen resources determination (DO, COD, BOD) the capped container was uncapped inside the water and capped inside the water after filling before removal from the water [14]. This was done to avoid trapping oxygen inside the container. The samples were transported to the laboratory immediately after collection in a cooler with ice cubes -4^{o}C.

Analyses were done in the laboratory immediately while the samples were preserved as stated in Table 2 and were analyzed within 24 hrs. The samples were analyzed in triplicates to check for accuracy and precision.

Table 2 Preservations used for sampling

Analysis	Preservation
General	Refrigerator (4°C)
BOD, COD, DO	Refrigerator (4°C)
Metals	2ml conc. Nitric acid per liter pH < 2
Nitrate	2ml conc. Sulphuric acid per liter, pH < 2

Determination of Oxygen resources

Dissolved Oxygen (DO) was done using Winkler with Azide modification method while biochemical oxygen demand was done using five days incubation method [15].

Statistical Analysis

Statistical package for Social Science (SPSS) was used for the statistical analysis. Post

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ANOVA test was used to determine if there is any significant difference between the means and at which distance the difference occurred.

RESULTS AND DISCUSSION

The results of the determination of the physicochemical properties of Ajali River studied across various sampling points ranging from P1 to P8 were presented in Tables 3 and 4 for both dry and rainy seasons respectively.

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Table 3. Physiochemical properties of Ajali River at various sampling points for dry season

	P1 (-250)	P2 (0)	P3 (250)	P4 (500)	P5 (1000)	P6 (1500)	P7 (2000)	P8 (2250)	EFFLUENT
Temperature	27.53 ± 0.03^{a}	28.40 ± 0.15^{cd}	28.30 ± 0.12^{bc}	28.37 ± 0.07^{cd}	28.50 ± 0.06^{cd}	28.90 ± 0.06^{d}	28.63 ± 0.09^{cd}	27.77 ± 0.12^{ab}	27.23 ± 0.23^{a}
Conductivity	50.18 ± 0.64^{b}	62.31 ± 0.37^{f}	58.30 ± 0.97^{e}	56.37 ± 0.22^{de}	54.67 ± 1.16^{cd}	52.67 ± 0.35^{bc}	50.30 ± 0.42^{b}	50.16 ± 0.18^{b}	11.08 ± 0.96^{a}
Turbidity	100.34 ± 1.10^{b}	155.37 ± 0.34^{e}	131.56 ± 0.33^{d}	126.17 ± 0.16^{c}	110.56 ± 1.07^{b}	101.74 ± 0.49^{b}	100.58 ± 0.53^{b}	100.97 ± 0.95^{b}	30.70 ± 1.03^{a}
pH	6.40 ± 0.06^{a}	6.87 ± 0.03^{c}	6.73 ± 0.03^{bc}	6.77 ± 0.03^{bc}	6.60 ± 0.06^{ab}	6.70 ± 0.06^{bc}	6.57 ± 0.03^{ab}	6.60 ± 0.06^{ab}	7.60 ± 0.06^{d}
TSS	455.04 ± 0.17^{b}	358.01 ± 176.34^{ab}	523.13 ± 1.29^{b}	343.77 ± 165.70^{ab}	480.20 ± 0.46^{b}	480.20 ± 0.46^{b}	460.37 ± 1.37^{b}	459.13 ± 0.53^{b}	38.06 ± 10.08^{a}
TS	511.49 ± 0.66^{a}	988.52 ± 1.14^{i}	923.53 ± 1.20^{h}	877.24 ± 0.63^{g}	853.95 ± 0.53^{f}	800.76 ± 1.13^{e}	766.78 ± 0.82^{d}	753.55 ± 0.91^{c}	727.39 ± 0.81^{b}
TDS	57.30 ± 0.19^{a}	455.48 ± 1.16^{i}	410.40 ± 1.13^{h}	366.80 ± 1.01^{f}	353.21 ± 0.89^{e}	326.03 ± 0.68^{d}	306.42 ± 0.85^{c}	294.42 ± 0.93^{b}	679.33 ± 0.70^{j}
DO	6.05 ± 0.07^{g}	5.58 ± 0.05^{f}	5.30 ± 0.15^{ef}	5.12 ± 0.07^{de}	4.71 ± 0.06^{c}	4.17 ± 0.09^{b}	5.06 ± 0.02^{cd}	6.07 ± 0.04^{g}	3.21 ± 0.07^{a}
BOD	1.26 ± 0.06^{a}	1.50 ± 0.01^{ab}	2.02 ± 0.11^{bc}	2.50 ± 0.15^{cd}	2.86 ± 0.02^{d}	3.15 ± 0.05^{d}	2.10 ± 0.05^{c}	1.27 ± 0.02^{a}	4.38 ± 0.29^{e}
COD	5.64 ± 0.09^{a}	6.98 ± 0.09^{b}	7.14 ± 0.05^{b}	7.92 ± 0.09^{c}	8.30 ± 0.11^{c}	9.49 ± 0.19^{d}	6.00 ± 0.07^{a}	5.71 ± 0.09^{a}	13.76 ± 0.28^{e}
Sulfate	59.76 ± 0.77^{b}	74.89 ± 0.50^{e}	72.52 ± 0.74^{de}	71.81 ± 0.50^{d}	68.80 ± 0.67^{b}	67.62 ± 0.50^{c}	60.23 ± 0.23^{b}	59.91 ± 0.55^{b}	48.68 ± 0.58^{a}
Nitrate	1.03 ± 0.04^{a}	1.26 ± 0.04^{c}	1.20 ± 0.03^{bc}	1.18 ± 0.02^{bc}	1.13 ± 0.01^{ab}	1.09 ± 0.01^{ab}	1.05 ± 0.01^{a}	1.04 ± 0.00^{a}	2.11 ± 0.01^{d}
Phosphorus	0.11 ± 0.01^{a}	0.16 ± 0.01^{a}	2.15 ± 2.00^{a}	0.15 ± 0.00^{a}	0.14 ± 0.01^{a}	0.13 ± 0.01^{a}	0.11 ± 0.00^{a}	0.11 ± 0.01^{a}	0.13 ± 0.01^{a}
Chloride	21.66 ± 0.52^{a}	37.87 ± 0.58^{d}	36.38 ± 0.58^{d}	36.03 ± 0.39^{cd}	34.61 ± 0.63^{cd}	31.87 ± 0.55^{bc}	29.89 ± 0.59^{b}	28.93 ± 0.04^{b}	49.15 ± 2.20^{e}

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	P1 (-250)	P2 (0)	P3 (250)	P4 (500)	P5 (1000)	P6 (1500)	P7 (2000)	P8 (2250)	EFFLUENT
Ag	0.01 ± 0.0025^{a}	0.054 ± 0.0050^{de}	0.047 ± 0.0024^{cd}	0.04 ± 0.0009^{bc}	0.04 ± 0.0006^{bc}	0.04 ± 0.0009^{bc}	0.04 ± 0.0006^{b}	0.03 ± 0.0007^{b}	0.06 ± 0.0015^{e}
Na	4.91 ± 0.082^{b}	12.09 ± 0.088^{g}	10.04 ± 0.102^{f}	8.11 ± 0.171^{e}	6.69 ± 0.104^{d}	5.86 ± 0.095^{c}	4.10 ± 0.155	3.18 ± 0.140^{a}	7.79 ± 0.166^{e}
K	4.45 ± 0.293^{c}	14.77 ± 0.259^{f}	9.24 ± 0.072^{e}	6.92 ± 0.252^{d}	4.78 ± 0.142^{c}	3.06 ± 0.200^{b}	2.21 ± 0.116^{ab}	1.67 ± 0.172^{a}	26.94 ± 0.255^{g}
Pb	0.01 ± 0.0006^{a}	0.05 ± 0.0006^{b}	0.05 ± 0.0003^{b}	0.04 ± 0.0012^{b}	0.03 ± 0.0033^{ab}	0.02 ± 0.0006^{ab}	0.02 ± 0.0012^{ab}	0.02 ± 0.0087^{ab}	0.04 ± 0.0183^{b}
Mg	0.46 ± 0.056^{a}	1.14 ± 0.070^{d}	0.86 ± 0.062^{c}	0.73 ± 0.036^{bc}	0.68 ± 0.018^{bc}	0.59 ± 0.015^{ab}	0.47 ± 0.016^{a}	0.46 ± 0.002^{a}	1.13 ± 0.009^{d}
Mn	0.009 ± 0.0006^{a}	0.04 ± 0.0012^{e}	0.0340 ± 0.0015^{d}	0.0297 ± 0.0015^{d}	0.0247 ± 0.0007^{c}	0.0140 ± 0.0006^{b}	0.012 ± 0.0006^{ab}	0.009 ± 0.0006^{a}	0.07 ± 0.0012^{f}
Zn	0.04 ± 0.0202^{a}	0.03 ± 0.0009^{a}	0.03 ± 0.0009^{a}	0.03 ± 0.0003^{a}	0.03 ± 0.0006^{a}	0.02 ± 0.0009^{a}	0.02 ± 0.0003^{a}	0.02 ± 0.0003^{a}	0.03 ± 0.0009^{a}
Cu	0.0030 ± 0.001^{a}	0.0323 ± 0.001^{ef}	0.0280 ± 0.001^{de}	0.0257 ± 0.001^{d}	0.023 ± 0.002^{cd}	0.0193 ± 0.001^{c}	0.0127 ± 0.001^{b}	0.008 ± 0.002^{ab}	0.038 ± 0.001^{f}
Ni	0.22 ± 0.001^{a}	0.35 ± 0.008^{c}	0.34 ± 0.004^{c}	0.32 ± 0.009^{c}	0.29 ± 0.007^{b}	0.23 ± 0.005^{a}	0.22 ± 0.004^{a}	0.22 ± 0.001^{a}	0.43 ± 0.009^{d}
Cr	0.19 ± 0.002^{a}	0.62 ± 0.007^{g}	0.55 ± 0.006^{f}	0.49 ± 0.004^{e}	0.42 ± 0.001^{d}	0.41 ± 0.004^{cd}	0.39 ± 0.006^{c}	0.36 ± 0.002^{b}	0.65 ± 0.003^{h}
Ca	2.96 ± 0.058^{b}	10.06 ± 0.261^{g}	7.95 ± 0.203^{f}	6.71 ± 0.145^{e}	4.28 ± 0.192^{d}	3.17 ± 0.299^{c}	2.16 ± 0.291^{ab}b	1.65 ± 0.176^{a}	13.87 ± 0.145^{h}
Fe	0.31 ± 0.006^{b}	0.81 ± 0.006^{f}	0.71 ± 0.003^{e}	0.68 ± 0.005^{d}	0.65 ± 0.004^{d}	0.44 ± 0.009^{c}	0.31 ± 0.006^{b}	0.27 ± 0.002^{a}	1.00 ± 0.012^{g}
Cd	0.02 ± 0.0035^{a}	0.033 ± 0.0012^{de}	0.0293 ± 0.0007^{cd}	0.025 ± 0.0006^{bc}	0.0213 ± 0.0009^{b}	0.019 ± 0.0006^{ab}	0.019 ± 0.0006^{ab}	0.019 ± 0.0003^{ab}	0.039 ± 0.0007^{e}

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Table 4: Physiochemical Properties of Ajali River at various sampling points for Rainy Season.

	P1 (-250)	P2 (0)	P3 (250)	P4 (500)	P5 (1000)	P6 (1500)	P7 (2000)	P8 (2250)	EFFLUENT
Temperature	26.30 ± 0.52[a]	26.70 ± 0.35[a]	26.60 ± 0.46[a]	26.40 ± 0.23[a]	26.60 ± 0.30[a]	27.00 ± 0.40[a]	27.00 ± 0.64[a]	26.80 ± 0.26[a]	26.70 ± 0.46[a]
Conductivity	35.70 ± 0.98[a]	47.00 ± 0.40[b]	46.63 ± 0.69[b]	46.20 ± 0.22[b]	44.90 ± 1.10[b]	43.93 ± 1.11[b]	44.57 ± 0.18[b]	44.13 ± 0.65[b]	60.17 ± 0.42[d]
Turbidity	65.00 ± 0.38[b]	108.11 ± 0.64[h]	100.42 ± 0.45[g]	91.78 ± 0.91[f]	87.80 ± 0.47[e]	81.13 ± 0.08[d]	70.00 ± 0.06[c]	79.53 ± 0.87[d]	22.65 ± 0.51[a]
pH	6.50 ± 0.17[a]	7.20 ± 0.40[a]	6.80 ± 0.35[a]	6.90 ± 0.06[a]	6.80 ± 0.12[a]	6.90 ± 0.23[a]	6.80 ± 0.35[a]	6.80 ± 0.31[a]	7.60 ± 0.40[a]
TSS	257.69 ± 0.18[h]	248.70 ± 0.87[g]	231.11 ± 0.64[f]	211.10 ± 0.52[e]	201.10 ± 0.75[d]	182.60 ± 0.35[b]	193.11 ± 0.46[c]	180.13 ± 0.67[b]	54.40 ± 0.35[a]
TS	280.00 ± 0.29[a]	530.05 ± 0.08[g]	494.45 ± 0.26[g]	463.00 ± 0.36[f]	444.00 ± 0.44[e]	417.01 ± 0.05[b]	433.70 ± 0.05[d]	425.95 ± 0.15[c]	692.95 ± 2.94[i]
TDS	22.31 ± 0.28[a]	281.35 ± 0.13[h]	262.91 ± 0.53[g]	251.57 ± 0.20[f]	242.06 ± 0.48[d]	234.41 ± 0.12[b]	240.29 ± 0.17[c]	245.49 ± 0.25[e]	635.61 ± 0.35[i]
DO	7.60 ± 0.35[a]	7.05 ± 0.47[a]	6.81 ± 0.47[a]	6.31 ± 0.05[a]	5.21 ± 0.38[a]	6.50 ± 0.29[a]	7.6 ± 2.65[a]	7.70 ± 0.40[a]	7.82 ± 0.47[a]
BOD	2.31 ± 0.18[a]	2.71 ± 0.40[ab]	3.12 ± 0.07[ab]	3.41 ± 0.21[ab]	4.01 ± 0.33[bc]	3.30 ± 0.39[ab]	2.20 ± 0.44[a]	2.05 ± 0.02[a]	5.02 ± 0.41[c]
COD	6.80 ± 0.46[a]	8.13 ± 0.06[b]	9.31 ± 0.18[bc]	10.21 ± 0.12[c]	12.10 ± 0.02[d]	9.90 ± 0.51[c]	6.51 ± 0.29[a]	6.20 ± 0.12[a]	15.04 ± 0.03[e]
Sulfate	51.53 ± 0.06[g]	39.17 ± 0.09[e]	33.65 ± 0.37[d]	32.88 ± 0.45[d]	27.39 ± 0.36[b]	25.16 ± 0.10[a]	28.61 ± 0.37[b]	30.61 ± 0.79[c]	47.91 ± 0.13[f]
Nitrate	1.29 ± 0.12[a]	1.54 ± 0.30[a]	1.52 ± 0.25[a]	1.46 ± 0.15[a]	1.33 ± 0.25[a]	1.39 ± 0.23[a]	1.41 ± 0.26[a]	1.39 ± 0.23[a]	2.14 ± 0.19[a]
Phosphorus	0.16 ± 0.06[a]	0.19 ± 0.08[a]	0.19 ± 0.07[a]	0.18 ± 0.05[a]	0.16 ± 0.02[a]	0.15 ± 0.01[a]	0.18 ± 0.04[a]	0.17 ± 0.05[a]	0.09 ± 0.03[a]
Chloride	163.30 ± 0.17[d]	227.21 ± 0.35[e]	149.11 ± 0.24[c]	142.33 ± 0.20[b]	134.91 ± 0.49[a]	142.18 ± 0.17[b]	149.15 ± 0.31[c]	152.60 ± 0.08[c]	482.48 ± 0.17[f]

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	P1 (-250)	**P2 (0)**	**P3 (250)**	**P4 (500)**	**P5 (1000)**	**P6 (1500)**	**P7 (2000)**	**P8 (2250)**	**EFFLUENT**
Ag	0.016 ± 0.0122^{a}	0.040 ± 0.0087^{ab}	0.039 ± 0.0075^{ab}	0.033 ± 0.0029^{ab}	0.029 ± 0.0064^{ab}	0.020 ± 0.0023^{a}	0.018 ± 0.0017^{a}	0.015 ± 0.0012^{a}	0.057 ± 0.0058^{b}
Na	2.762 ± 0.0831^{b}	7.298 ± 0.0820^{f}	6.003 ± 0.0092^{e}	4.893 ± 0.0098^{d}	3.893 ± 0.0722^{c}	2.686 ± 0.0355^{b}	1.536 ± 0.0398^{a}	1.269 ± 0.0456^{a}	7.369 ± 0.0675^{f}
K	2.785 ± 0.0935^{c}	8.431 ± 0.0895^{f}	6.518 ± 0.1397^{e}	4.328 ± 0.0912^{d}	2.243 ± 0.0323^{b}	1.935 ± 0.0306^{b}	0.886 ± 0.0040^{a}	0.539 ± 0.0237^{a}	21.348 ± 0.0699^{g}
Pb	0.011 ± 0.0041^{a}	0.048 ± 0.0110^{bc}	0.028 ± 0.0046^{abc}	0.020 ± 0.0058^{ab}	0.018 ± 0.0029^{ab}	0.012 ± 0.0017^{a}	0.010 ± 0.0006^{a}	0.008 ± 0.0035^{a}	0.052 ± 0.0121^{c}
Mg	0.372 ± 0.0173^{bc}	1.008 ± 0.1305^{ef}	0.739 ± 0.0531^{de}	0.558 ± 0.0485^{cd}	0.378 ± 0.0144^{bc}	0.213 ± 0.0300^{ab}	0.139 ± 0.0306^{ab}	0.086 ± 0.0167^{a}	1.115 ± 0.0525^{f}
Mn	0.015 ± 0.0035^{a}	0.052 ± 0.0150^{ab}	0.049 ± 0.0156^{ab}	0.040 ± 0.0064^{ab}	0.032 ± 0.0040^{ab}	0.029 ± 0.0029^{ab}	0.020 ± 0.0058^{ab}	0.014 ± 0.0058^{a}	0.065 ± 0.0127^{b}
Zn	0.009 ± 0.0023^{a}	0.023 ± 0.0075^{a}	0.020 ± 0.0052^{a}	0.019 ± 0.0012^{a}	0.018 ± 0.0023^{a}	0.016 ± 0.0046^{a}	0.014 ± 0.0040^{a}	0.020 ± 0.0028^{a}	0.027 ± 0.0009^{a}
Cu	0.000 ± 0.0000^{a}	0.025 ± 0.0015^{bc}	0.014 ± 0.0020^{ab}	0.006 ± 0.0006^{a}`	0.000 ± 0.0000^{a}	0.000 ± 0.0000^{a}	0.000 ± 0.0000^{a}	0.000 ± 0.0000^{a}	0.032 ± 0.0092^{c}
Ni	0.205 ± 0.0826^{ab}	0.308 ± 0.0589^{ab}	0.250 ± 0.0167^{ab}	0.201 ± 0.0814^{ab}	0.177 ± 0.0404^{ab}	0.146 ± 0.0583^{a}	0.119 ± 0.0098^{a}	0.067 ± 0.0338^{a}	0.410 ± 0.0254^{b}
Cr	0.167 ± 0.0629^{a}	0.506 ± 0.0167^{cd}	0.392 ± 0.0410^{bc}	0.212 ± 0.0144^{ab}	0.191 ± 0.0566^{ab}	0.093 ± 0.0271^{a}	0.079 ± 0.0167^{a}	0.052 ± 0.0237^{a}	0.667 ± 0.0664^{d}
Ca	1.333 ± 0.0548^{a}	6.000 ± 0.0999^{d}	5.312 ± 0.1466^{c}	3.896 ± 0.0739^{b}	2.000 ± 0.1542^{a}	1.936 ± 0.2702^{a}	1.839 ± 0.1103^{a}	1.532 ± 0.0878^{a}	12.667 ± 0.1045^{e}
Fe	0.201 ± 0.0837^{ab}	0.734 ± 0.0970^{cd}	0.669 ± 0.0416^{c}	0.500 ± 0.0473^{bc}	0.367 ± 0.0312^{ab}	0.236 ± 0.0242^{ab}	0.197 ± 0.0075^{a}	0.156 ± 0.0583^{a}	0.978 ± 0.0872^{d}
Cd	0.019 ± 0.0069^{a}	0.323 ± 0.3000^{a}	0.020 ± 0.0064^{a}	0.015 ± 0.0012^{a}	0.009 ± 0.0017^{a}	0.008 ± 0.0023^{a}	0.006 ± 0.0029^{a}	0.004 ± 0.0006^{a}	0.035 ± 0.0046^{a}

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Data were presented by means ± Standard error while significant means were separated using Tukey's HDS post hoc test

Tables 3 and 4 show the physicochemical properties of the Ajali River stretch under study at various sampling points for dry and rainy seasons. It was observed that the temperature ranged from 27.23 to 28.90ºC across the sampling point for the dry season. Effluent recorded the least temperature which was significantly different ($P<0.05$) from other points except for P1 and P8. P6 had the highest temperature of 28.90± 0.06 which was not significantly different from P2, P4, P5, and P7. So many factors can affect the temperature of the water such as seasons, latitude, sea level attitude, air circulation, cloud shade, depth, and water flow [16-18]. The temperature change can as well affect the overall processes in the river body [19-22].

It was observed that those points that recorded the lowest temperature (P1 and P8) did not experience heavy effluent infiltration. P1 was not directly exposed to sunlight; the area was covered with trees and a thick forest. P2 which recorded high temperature was the point of mixing of the effluent with the river. P6 which recorded the highest temperature had the highest exposure to sunlight due to the openness of the sample point compared to others. Effluent recorded the highest conductivity with an average of 71.08 ± 0.96 which was not significantly different from P2. P2 was the point of effluent discharge and received the highest concentration of waste. P1 with an average of 50.18 ± 0.64 recorded the lowest conductivity and was significantly different from other points except for P6, P7, and P8. P1 was the upstream that had no effluent discharged on it. P6, P7 and P8 having conductivity values closer to P1 suggested that conductivity decreases with an increase in distance. It showed that dissolved salt contents were reduced from the source of pollution.

There was an equal decrease in sulfate concentration with an increase in distance with P2 recording the highest concentration (74.89±0.5) though not significantly different from P3. More so, the effluent recorded the least sulfate concentration and was significantly ($P<0.05$) different from all other sampling points.

Dissolve Oxygen (DO) content ranged from 3.21 ± 0.07 to 6.07 ± 0.04. The lowest concentration was recorded by the effluent and was significantly different ($P<0.005$) from other points. P8 recorded the highest DO of 6.07 ± 0.04 which was not significantly different from P1, the upstream though significantly different from others. Dissolve oxygen content is used to check the pollution load of a river [23]. This confirmed effluent as having a high pollution load. At P8 the river has recovered from the pollution load through self-purification which was evident from the high dissolved oxygen content (6.07±0.04) recorded. P1 had high dissolved oxygen content because there was no infiltration of effluent at that point.

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Effluent recorded the highest value of Biochemical oxygen demand (BOD) with a value of 4.38±0.29 which was significantly different from every other point. P1 recorded the lowest BOD of 1.26±0.06 and was significantly different from other points except for P8. Effluent which recorded high BOD showed that it contained a high amount of organic material that requires high microbial reactions for biodegradation [24-26].

Silver had a concentration ranging from 0.01±0.0025 to 0.06 ± 0.0015. Effluent had the highest value of 0.06 ± 0.0015 which was significantly different from other points except for P2, the point of mixing. P1 recorded the least value of 0.01±0.0025 which was significantly different from other points. Zinc had a concentration ranging from 0.02±0.0009 to 0.04±0.0202 with P1 having the highest value and the values were not significantly different from each other.

Cadmium recorded values in the range of 0.02±0.0035 to 0.039±0.0007. Effluent had the highest value of 0.039±0.0007 and was significantly different from other points except for P2. P6 had the lowest concentration of 0.019±0.0006 which was significantly different from other points except for P7 and P8. It was discovered that effluent recorded the highest concentration of all the metals except zinc.

Table 4 shows the physiochemical properties of the River during the rainy season. The temperature ranged from 26.30±0.52 to 27.00±0.64. P1 recorded the lowest temperature of 26.30± 0.52 while P7 recorded the highest temperature of 27.00±0.64. The temperature values were not significantly different from different sampling points.

Effluent had the highest conductivity of 60.17±0.42 and the lowest concentration was recorded at P1. Effluent had a concentration that was significantly different from the rest though there was no significant difference between the values recorded at P2 to P8.

Dissolve oxygen recorded values that were not significantly different from each other though the highest occurred at P8 with a value of 7.70±0.40 and lowest at P5 with a value of 5.21±0.38. There was no significant difference in the values of Nitrate and phosphorus recorded across all the points. Effluent recorded the highest concentration of BOD with a value of 5.02±0.41 which was significantly different from others except for P5. The lowest BOD value was recorded at P1 with a value of 2.31±0.18 and was significantly different from P5 and effluent.

There was no significant difference in the pH values recorded at different points though the highest concentration, high alkalinity was recorded by the effluent followed by P2. pH concentration in the river did not show a fluctuating pattern.

Silver had a concentration ranging from 0.057± 0.0058 to 0.015±0.0012. Effluent recorded the

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highest concentration of 0.057±0.0058 and was significantly different from other points except for P2, P3, P4, and P5. P1 recorded the lowest concentration and was not significantly different from other points except effluent.

Lead has its highest concentration on the effluent with a value of 0.052±0.0121 which was significantly different from others except for P2 and P3. P1 recorded the lowest concentration with a value of 0.011±0.0041 and was significantly different from other points except for P3 to P8. Zinc and cadmium were seen not to exhibit any significant difference across the sampling points.

CONCLUSION

The physicochemical properties of the Ajali river polluted with industrial effluent studied showed that the effluent had a tremendous effect on the properties studied. The effect was observed to decrease along the sampling point away from the discharge point which shows that it has a natural tendency to purify itself. There was a significant difference between the physicochemical properties studied across the sampling points for both rainy and dry seasons. There was a significant difference between the dry and rainy seasons' physiochemical properties studied except few metals like zinc, manganese, lead, phosphorus, and nitrate.

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