PRINT ISSN 1119-8362
Electronic ISSN 1119-8362

Full-text Available Online at
https://www.ajol.info/index.php/jasem
http://ww.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 25 (9) 1671-1675 September 2021

Effect of Ota Industrial Estate Effluents on Surface Water Quality of Oruku River, Ota, South Western Nigeria

***[1]EKUTE, BO; [2]ETIM, EU**

[1]Department of Chemistry, National Open University of Nigeria, Jabi-Abuja, Nigeria*
[2]Department of Chemistry, University Of Ibadan, Ibadan, Nigeria
**Corresponding Author Email: bekute@noun.edu.ng; Tel: +234 7056909001*

ABSTRACT: The effect of industrial effluents on surface water quality of Oruku River was investigated in this study by analyzing selected water quality indicators such as pH, dissolved oxygen (DO) and total dissolved solids (TDS) were examined amongst other physicochemical parameters using standard methods. Results show that, average pH of the surface waters ranged from 5.53±0.31 to 6.23±0.45 with SR3 having the highest value. This indicates that all the water sources were alkaline. The effluents had an average pH range of 5.95 ± 1.12 to 6.40 ± 0.48. A comparison of these average pH values with effluent quality standards indicated that the effluents pH were below limit (6.5-9.5). The average BOD levels in surface water ranged from 1.94 ± 0.95 for SR-4 to 3.78 ± 1.61 for SR-1. DO average values in surface water was found to be higher at SR-1 with a mean value of 5.36 ± 1.55 and lower at SR-2 with a mean value of 3.05 ± 0.68. The mean COD value for surface water ranged from 108.66 ± 73.03mg/L to 232.81 ± 155.46mg/L. SR-3 had the highest COD average value of 232.81 ± 155.46mg/L while there was a reduction at SR-5 to an average value of 108.66±73.03mg/L. The high COD value in the surface water indicates that gross-organic pollution of the water source may be from other sources such as agricultural and urban run-offs.

DOI:https://dx.doi.org/10.4314/jasem.v25i9.19

Dates: Received: 10 May 2021; Revised: 28 June 2021; Accepted: 01 July 2021

Keywords: surface water quality, pollution indicators, industrial effluents, Chemical Oxygen Demand

Surface water is usually rain water that collects in surface water bodies like oceans, lakes or streams. Corrosionpedia (2016) stated that surface water pollution occurs when hazardous substances come into contact and either dissolve or physically mix with the water. Increasing world population has led to urbanization and industrialization. Industrialization makes possible a comfortable living and even creates job opportunities. However, it has brought about a significant change in the environment especially water bodies which has become wastewater receivers. According to EPA (2002), effluent means water sullied or contaminated by any matter in solution or suspension resulting from domestic, industrial or other activities, industrial development manifested due to setting up of new industries or expansion of new industries or expansion of existing industrial establishments. Ogedengbe and Akinbile (2004) identified the most common source of water pollution presently to be industrial wastes. The surface water reservoirs and rivers thus become polluted as a result of the discharge of untreated or partially treated effluents into them. Sangodoyin (1991) mentioned that the effluents of industries gives a great deal of influence on the pollution of water bodies and can alter the physical, chemical and biological nature of the receiving water body. One of such surface water reservoirs is Oruku River in Ota, south-western, Nigeria. It has its originating source at Mopin community and flows through to Iyesi and Ijaba communities. Oruku River receives effluents from Ota industrial estate which houses several industries producing a wide range of goods like pharmaceuticals, beverages, metals and steel. This river is a major source of domestic water supply to the inhabitants of the communities under investigation, hence it is therefore imperative that the level of pollution or contamination be accessed via the analysis of pollution indicators. Therefore, the objective of this paper is to investigate the effect of Ota industrial Estate effluents on surface water quality of Oruku River, Ota, South Western Nigeria.

MATERIALS AND METHODS

Sample collection and Preparation: Grab samples of water were collected at five different locations and labeled SR-1 to SR-5 at four consecutive periods. SR-1 (Oruku source) was taken at about 0.8 km from the effluent discharge point, SR-2 at about 1.0 km and SR-3 at about 1.5km from the discharge point, SR-4 was taken from Iyesi at about 2.5km from the discharge

**Corresponding Author Email: bekute@noun.edu.ng; Tel: +234 7056909001*

point and SR-5 taken from Ijaba community at about 3.2km from the industrial effluent discharge point.

The samples (twenty in number) were collected in polyethylene bottles that have been previously cleaned by washing in non-ionic detergent, rinsed with tap water, soaked in 10% nitric acid for 24 hours, finally rinsed with distilled water and dried for some physicochemical parameters and heavy metal analysis while those for BOD and DO determination were collected in previously cleaned BOD bottles. Similarly, a total of eight(8) effluent samples were collected same way as the surface water samples, however they were taken at two(2) different locations at distances of 100 meters between the two points and sampled at four different periods.

Sample analysis

pH was determined using a glass electrode pH meter while a TDS meter was used for total dissolved solids. All other parameters were analyzed according to standard methods of analysis stipulated by APHA.

RESULTS AND DISCUSSION

The average levels of examined physicochemical parameters in surface water of Oruku River and the industrial effluents are presented in Table 1. Data revealed that, the pH level is 5.95±1.12, 6.40±0.48, 5.85±0.94, 5.53±0.31, 6.23±0.45, 6.18±0.41 and 6.18±0.41 for sample stations EFF-1, EFF-2, SR-1, SR-2, SR-3, SR-4 and SR-5 respectively. In the same table 1, the mean levels of the other physicochemical parameters such as Alkalinity, Chloride, Total Hardness, Calcium, Magnesium, BOD, COD, DO, TDS, TS, Nitrate, Phosphate, Sulphate are also listed.

Table 1: Average levels of examined physicochemical parameters in surface water of Oruku River and the industrial effluents

Sample ID	EFF-1	EFF-2	SR-1	SR-2	SR-3	SR-4	SR-5
pH	5.95±1.12	6.40±0.48	5.85±0.94	5.53±0.31	6.23±0.45	6.18±0.41	6.18±0.41
Alkalinity	30.01±17.32	29.01±15.09	19.26±11.11	16.44±10.40	24.68±15.22	19.88±11.75	19.32±10.83
Chloride	128.59±110.40	124.20±91.5	32.29±3.58	52.88±13.89	78.42±9.36	62.24±22.86	45.52±15.85
TH	61.21±25.20	51.93±16.92	10.77±2.12	8.61±3.06	14.67±6.06	14.19±6.78	13.86±4.72
Ca	8.46±1.62	7.21±1.29	2.74±1.54	2.07±1.06	3.32±1.41	3.40±1.72	3.27±1.54
Mg	9.81±5.45	8.33±3.91	0.99±0.48	0.86±0.14	1.59±0.91	1.43±0.74	1.42±0.63
BOD	2.56±0.19	2.52±0.17	3.78±1.61	3.63±1.15	2.21±0.75	1.94±0.95	2.51±1.42
COD	247.35±190.98	161.93±129.	205.22±174.40	160.71±104.	232.81±155.46	137.08±94.20	108.66±73.
DO	7.70±0.25	7.58±0.10	5.36±1.55	3.05±0.68	3.94±1.20	4.07±0.70	4.09±0.66
TDS	380±58.88	380±60.00	150±73.48	167±100.51	145±41.23	155±31.17	135±25.17
TS	1211.27±115.9	1167.71±92.	304.94±149.78	414.27±239.	325.05±166.01	332.38±166.58	328.16±151.
Nitrate	16.04±20.09	11.89±12.34	0.18±0.26	1.44±0.90	3.30±2.65	0.10±0.19	0.13±0.19
Phosphate	0.47±0.20	0.36±0.21	0.05±0.09	0.07±0.08	0.06±0.05	0.05±0.06	0.16±0.04
Sulphate	58.90±89.42	47.23±74.29	6.61±10.97	16.23±18.87	11.37±16.18	11.31±16.74	9.90±14.90

(All the results are in mg/L except for total hardness that is in mgCaCO$_3$/L) Values are expressed as mean ± std. deviation, TH = total hardness

The effluents had an average pH range of 5.95 ± 1.12 to 6.40 ± 0.48. A comparison of these average pH values with effluent quality standards (Table 3), indicated that the effluents pH were below limit (6.5-9.5). However, the pH values fall within effluent discharge standards (6.80 – 8.50) for India (2006). The overall average levels of effluent quality characteristics were generally low and below WHO limits and European discharge standards (1994), except for nitrate average level at EFF-1 sampling point (16.04 ± 20.09mg/L) which exceeded the European discharge limit of 15.00mg/L and sulphate at effluent sampling point, EFF-1 of average value, 58.90 ± 89 . 42mg/L which exceeded WHO limit for water quality standard. A contrary result have been reported by Ipeaiyeda *et al.*, (2009) who found that the overall average levels of effluent characteristics were much higher than the available effluent discharge standards.

Table 2: Mean heavy metal levels in the effluents and surface water of Oruku River

Sample ID	EFF-1	EFF-2	SR-1	SR-2	SR-3	SR-4	SR-5
Zn(mg/L)	0.136±0.17	0.089±0.12	0.027±0.02	0.039±0.01	0.112±0.17	0.126±0.06	0.016±0.02
Pb(mg/L)	0.149±0.26	0.037±0.04	0.011±0.02	0.018±0.02	0.038±0.04	0.018±0.02	0.045±0.05
Cr(mg/L)	0.179±0.15	0.134±0.10	0.077±0.07	0.079±0.07	0.112±0.08	0.099±0.10	0.041±0.06
Co(mg/L)	0.005±0.00	0.002±0.01	0.004±0.01	0.003±0.01	0.017±0.03	0.002±0.00	0.003±0.01
Cd(mg/L)	0.001±0.01	ND	ND	0.001±0.00	0.002±0.00	ND	ND
Ni(mg/L)	0.017±0.02	0.015±0.01	0.015±0.01	0.017±0.01	0.043±0.05	0.020±0.02	0.014±0.02
Cu(mg/L)	0.024±0.02	0.022±0.02	0.022±0.02	0.022±0.02	0.026±0.02	0.021±0.02	0.020±0.02

Values are expressed as mean±std.deviation

There was a slight variation in pH at each surface water sampling point. The average pH of surface water ranged from 5.53± 0.31 to 6.23 ± 0.4. In water chemistry, the pH that separates alkalinity from acidity is 4.3. Thus, the water source can be considered alkaline. A prior work on this same river reported that the water source was slightly acidic (Etim and Onianwa, 2013). The average alkalinity and chloride levels in surface water ranged from 16.44±10.40 to 24.68±15.22mg/L and 32.29± 3.58 to 78.42 ± 9.36mg/L. Sampling location, SR3 had the highest chloride and alkalinity levels. This is indicative of the effluent impact in comparison with the river source, SR1. Chloride in these water sources could be attributed to effluent discharges containing hydrochloride acid, common salt or other chloride containing compounds used in the production/treatment process. There are no specific limits for alkalinity in water quality standards, however can be checked in water by pH measurement and comparison with standard. Chloride levels in all the water samples were below WHO (1996) standard for water quality (250mg/L) and below optimum value for domestic water supply (750mg/L). Similar results were obtained by Osibanjo *et al*., 2011 with mean chloride levels ranging from 7.59 to 11.78mg/L. The average level of total hardness in surface water was found to be higher at sampling point, SR-3 (14.67±6.06mg C_aCO_3/L) and lower at sampling point, SR-2, (8.61 ± 3.06 mg C_aCO_3/L). Similarly, a higher average level of magnesium (1.59 ± 0.91 mg/L) and lower average (0.86 ± 0.14 mg/L) were recorded at SR-3 and SR-2 respectively. However, SR-4 had the highest average level of calcium (3.40 ±1.72 mg/L) while SR-2 had the lowest (2.07 ± 1.06 mg/L). These variations could be attributed to soil surface run-off in areas of increase. Hardness in waters is an indication of the amount of calcium and magnesium dissolved in them. A correlation analysis of total hardness, calcium and magnesium revealed that total hardness had a very strong positive correlation (r=0.983 and r.0.982) with calcium and magnesium respectively. A comparison of these mean levels with water quality standards by WHO indicates that hardness, calcium and magnesium average levels were below standard (200 mgC_aCO_3/L) for total hardness, though no standard limits for calcium and magnesium were stipulated. Measures of gross organic pollution; BOD, DO and COD varied slightly at each of the surface water sampling points. The average BOD levels in surface water ranged from 1.94 ± 0.95 for SR-4 to 3.78 ± 1.61 for SR-1. The result indicates that the river source, SR-1 has an enormous amount of organic load which is not traceable to the industrial effluent discharge but to other sources such as domestic wastes. The average BOD value obtained from SR-1 was higher than that obtained in ground water (2.58 ± 0.47). This is also indicative of organic pollution by organic matter. DO average values in surface water was found to be higher at SR-1 with a mean value of 5.36 ± 1.55 and lower at SR-2 with a mean value of 3.05 ± 0.68.

Table 3: A comparison of overall average levels of effluent quality characteristics with effluent quality standards.

Parameters	EFF-1	EFF-2	WHO Discharge Limits	European Discharge Standards (AFTER RIJS, 1994)	Proposed Discharge Standards, 2006
pH	5.95±1.12	6.40±0.48	6.5-9-5	-	6.0-8.5
Alkalinity	30.01±17.32	29.01±15.09	-	-	-
Chloride	128.59±110.40	124.20±91.58	-	-	-
Total Hardness	61.21±25.20	51.93±16.92	-	-	-
Calcium	8.46±1.62	7.21±1.29	-	-	-
Magnesium	9.81±5.45	8.33±3.91	-	-	-
BOD	2.56±0.19	2.52±0.17	50	20	-
COD	247.35±190.98	161.93±129.61	150	125	125
DO	7.70±0.25	7.58±0.10	-	-	-
TDS	380±58.88	380±60.00	1000	-	-
TS	1211.27±115.98	1167.71±92.52	-	-	-
Nitrate	16.04±20.09	11.89±12.34	-	15	-
Phosphate	0.47±0.20	0.36±0.21	-	2	3
Sulphate	58.90±89.42	47.23±74.29	-	-	-
Zn	0.136±0.17	0.089±0.12	-	-	5.0
Pb	0.149±0.26	0.037±0.04	-	-	0.1
Cr	0.179±0.15	0.134±0.10	-	-	2
Co	0.005±0.00	0.002±0.01	-	-	-
Cd	0.001±0.01	ND	-	-	-
Ni	0.017±0.02	0.015±0.01	-	-	1.0
Cu	0.024±0.02	0.022±0.02	-	-	1.0

(All the results are in mg/L except for total hardness that is in mg$CaCO_3$/L)

In surface water, for sustenance of aquatic life, DO levels should be between 5-8mg/L. therefore, surface water at SR-1 can be considered suitable for aquatic life. . Based on classification of surface water quality, SW4 could be considered clean as it falls in the range 1.1 to 1. 9mg/L, however, other surface water sampling points could be considered moderately polluted (2.0 – 2.9mg/L) and polluted (3.0 – 3.9mg/L). The mean COD value for surface water ranged from 108.66 ± 73.03mg/L to 232.81 ± 155.46mg/L. SR-3 had the highest COD average value of 232.81 ± 155.46mg/L while there was a reduction at SR-5 to an average value of 108.66±73.03mg/L. The high COD value in the surface water indicates that gross-organic pollution of the water source may be from other sources such as agricultural and urban run-offs. There are no limits for COD in water quality standards but the surface water values were above the European effluent discharge limit of 125mg/L. Similar results have been obtained by Osibanjo *et al*. (2011). The average TDS and TS values of the surface water ranged from 135±25.17 mg/L to 167 ± 100.51 mg/L and 304.94 ± 149.78 mg/L to 414.27 ± 239.46 mg/L. SR-2 had the highest TDS and TS value of 167 ± 100.51mg/L and 414.27 ± 239.46mg/L while SR-5 had the lowest mean values of 135 ± 25.17 mg/L for TDS and SR-1 had the lowest TS mean value of 304.94 ± 149.78 mg/L. These values were all below the WHO limits (<1200mg/L) and above the USEPA (1999, 2000) limits (500m/L) at some occasions for surface water. Similar results were obtained by Osibanjo *et al*. (2011) with TDS and TS mean values of 120mg/L and 370mg/L respectively. Nitrate, phosphate and sulphate average levels obtained in surface water ranged from 0.01 ± 0.19 mg/L to 3.30 ± 2.65mg/L, 0.05 ± 0.09 to 0.16 ± 0.04 mg/L and 6.61 ± 10.97 to 16.23 ± 18.87 mg/L respectively. Variations in nitrate, phosphate and sulphate levels in surface water at the various sampling points was of the order; nitrate: SR-3 > SR-2 >SR-1 > SR-5 >SR-4, phosphate:SR-5> SR-2> SR-3> SR-4> and SR-1, and sulphate: SR-2> SR-3> SR-4> SR-5> SR-1 respectively. SR-3 recorded highest average nitrate which could be attributed to agricultural run-off from farmlands around the sampling point in which fertilizers may be in use for enhancing crop growth. Similarly, SR-5 recorded highest phosphate average level of 0.16 ± 0.04mg/L while SR-1 and SR-4 had the lowest mean value of 0.05 ±0.09 and 0.05 ± 0.06mg/L respectively. SR-2 had the highest average sulphate value of 16.23 ± 18.87 while SR-1 had the lowest average sulphate level of 6.61 ± 10.97mg/L. sulphate had a very strong positive correlation with TS (r = 0.933, p -0.05) which is an indication of the fact that TS which comprises of TDS and TSS may be affected by increase or decrease in ions in water. A comparison of the results of this study with water quality standards for nitrate, phosphate and sulphate shows that the values were far below standards limits of 50.0mg/L, and 500mg/L for nitrate and sulphate respectively. Similar results were obtained by Osibanjo *et al*,(2011); though higher than the results of this study, with mean values of 6.26mg/L for nitrate, 2.15mg/L for total phosphorus and 6.62mg/L for sulphate. Average heavy metal levels in surface water varied slightly at the various sampling points. Nickel, Cadmium and Cobalt average levels were low and below limits of 0.05mg/L, 0.002mg/L and 0.05mg/L respectively. However, Zn average level at SR-3 (0.126 ± 0.06) was higher than its average level at other sampling points. SR-3 also had higher average Cr level of 0.112 ± 0.08mg/L and recorded average Pb level of 0.038 ± 0.04mg/L. SR-5 recorded the highest level of Pb with average value of 0.045 ± 0.05mg/L. These average values were all above standard limits.

Conclusion: The physicochemical characteristics and heavy metal levels in Ota industrial estate effluents were analyzed to ascertain its quality and its impact on the surface water quality of Oruku River. This study observed that the effluents were treated to a reasonable extent before discharge as opposed to earlier reports on this same river. This is evident in the results obtained from the analysis of same characteristics in the surface water. The results revealed that the pollution of the surface waters though to a relatively moderate degree is due mainly to agricultural wastes (run-offs), urban run-offs and domestic wastes. A comparison of the values obtained from this study with WHO, USEPA, CQC and FEPA guidelines for drinking water quality, irrigation quality and industrial use indicates that the surface water is suitable for irrigation purposes, recreation and industrial use but not suitable for drinking.

REFERENCES

APHA, (1992). Standard methods for the examination of Water and Wastewater, 16th edition. Washington, DC.

Canadian Council of Ministers of Environment. (1999). *Canadian Environmental quality guidelines* (CQC). Winnipeg, MB.

Environmental Protection Agency, (EPA), (2002). Acid rains, Retrieved Jan. 11th, 2001 from http://www/epa.god/acidrain/index.htm

Etim, EU; Onianwa, PC (2013). Impact of Effluent of an Industrial Estate on Oruku River in

Southwestern Nigeria. *World Appl. Sci. J.* 21(7): 1075-1083.

Federal Environmental Protection Agency, (1991). *Guideline and Standard for Environmental Pollution Control in Nigeria*. FG Press pp. 238.
https://www.corrosionpedia.com/definition/1059/surface-water

Ipeaiyada AR; Onianwa PC (2009). Impact of brewery effluent on water quality in Olosun River in Ibadan, Nigeria. *Chem. Ecol.* 25:189-204.

Ogedengbe, K; Akinbile, CO (2004). Impact of Industrial Pollutants on Quality of Ground and Surface Waters at Oluyole Industrial Estate, Ibadan, Nigeria. *Nigerian J. Tech. Develop.* 4(2) 139 – 144.

Osibanjo, O; Adegbenro, PD; Adewole, MG (2011). The impact of industries on surface water quality of River Ona and River Alaro in Oluyole Industrial Estate, Ibadan; Nigeria. *Afr. J. Biotech*. 10(4). 696 – 702.

Rijs, GBJ (1994). *Het, toepassen van helofytenfiltres bij de zuivering van kleinschage afvalwaterlozingen, Let einde. Studiedag Individuele Behandeling van Afvalwater*. Vanq Hall Instimuit, Leewarden. Pp 1-8.

Sangodoyin AY (1991). Groundwater and Surface Water Pollution by Open Refuse Dump in Ibadan, Nigeria. *J. Discov. Innov*. 3(1) 24 – 31.

United State Environmental Protection Agency (USEPA), (1999). *National Recommendation Water Quality Criteria-Correction* EPA 822/Z-99-001. USEPA, Washington DC

United States Environmental Protection Agency (USEPA), (2000). National Water Quality Inventory. Retrieved August 6, 2003 from *(http://www.epa.gov/305b)* 2000 report.

World health Organization (WHO) (1996). *Guideline for Drinking Water Quality Recommendations 2.* World Health Organization, Geneva.