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AUTO-PURIFICATION RESPONSE OF ONA RIVER, IBADAN TO INDUSTRIAL AND DOMESTIC EFFLUENT DISCHARGE

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ABSTRACT

This research study investigated the self purification capacity of Ona River due to wastewater effluent discharge from manufacturing industries and households in Oluyole area, Oyo state, Ibadan. Nigeria. Water samples were collected and flow rates measured at a length of 950 m along the river and depth of between 0.6 – 1.2 m. Twenty sampling stations were used (S_1-S_{20}) at 50 m intervals. Physico-chemical parameters (Chemical Oxygen Denab (COD), Dissolved Oxygen (DO), Total Soluble Solids (TSS), Total solids (TS), Exchangeable cations (EC), and pH) were determined using standard procedures. Discharge was measured using current meter and measuring tape. Time of travel of river, de-oxygenation and re-aeration constants per day of river Ona were also calculated. Results showed maximum and minimum discharge of 15.43 and 2.57m^3/s respectively along the stream. Upstream and point of wastewater discharge had BOD and DO values of 33.0, 7.31 and 914.0, 4.21 mg/L respectively. The de-oxygenation constant, re-aeration constant and auto-purification factor of Ona river indicated that the river is a swift stream. A predicted critical DO deficit of 8.01 mg/L was calculated while the measured DO deficit was 3.61 mg/l occurring at the point of discharge (S_7). The river Ona was able to purify comparatively the pollution load discharged into it.

Keywords: *auto-purification, Ona River, wastewater, upstream, downstream and point source.*

INTRODUCTION

Water being an asset with restricted sums has unequaled space circulation. Water is of high significance for human life and is the principal source to satisfy drinking, industrial, commercial and recreational water needs. Wastewater effluent in river is the discharge of natural or artificial water that has already been contaminated due to human activities or industrial activities into the river to cause disruption or change of the natural state river. Wastewater discharge from point and non-point sources without adequate treatment is a common phenomenon in developing countries. Industrial areas in most states in Nigeria are always prone to this menace because of non-enforcement of legislation guiding the standards. Rivers have a tendency of purifying itself as the wastewater goes downstream and the extent of purification is a major factor in determining the usage of the water. The auto-purification capacity also assists water manager in knowing the impact of the pollutants on streams and the maximum allowable waste load permitted to be discharge into the stream.

Longe and Omole (2008), opined that auto-purification capacity of river system is dependent on factors such as stream velocity, stream depth, and water temperature. Tian *et al.,* (2011) defined auto-purification as the self-ability of a wastewater effluent polluted river to purify itself. Nutrients loading in the river greatly affects the level at which the stream nutrients are decomposed by the organism or sediments of the streambed. Nutrient entangled in sediments results in downstream water pollution until flooding or high currents of river dislodges the nutrients (Mccoll, 2016, Omole *et al.,* 2016).

The development of industrial and human activities along river Ona in Oluyole Ibadan has led to increase of sewage and industrial discharge into the river. This has deteriorated the purity of the river and increased health challenges of the citizens in the environment by enhancing breeding space for disease causing agent. This has resulted inillness like typhoid fever, malaria fever cholera. It has also resulted in flooding on the road.

Although all rivers have the tendency to purify themselves after flowing through some distances along its course without any further treatment process; but this has impose a great challenge on some rivers prior to use because of improper analysis andcontrol of waste that is being deposited to the river on a daily basis by the people surrounding the river location(Al-zboon and Al-suhaili, 2009). Pollutants discharged into rivers are most times more than the self-purification capacity of the river, and so the pollutants are likely to impose health challenge and danger to the inhabitants (Tian *et al.,* 2016).

The analysis and extent of auto purification process is usually needful so as to regulate the discharge of any effluent in the river and this can be achieved by studying some organic and inorganic parameters in most rivers. This study therefore investigated some physico-chemical and discharge parameters at various distances along Ona river in Oluyole area of Ibadan, Nigeria for its auto-purification capacity.

MATERIALS AND METHODS

The area studied was Ona river, at Oluyole industrial estate, Oluyole Local Government Area of the south western part of Ibadan, Oyo state in Nigeria (Fig. 1). The river is on Latitude 7° 22′ 4.81″ N and Longitude $3^0$50′ 09.84″ E, it is 10 km long (Andem *et al.,* 2012). It flows in a north south direction with its source from Asejire dam at Ido local government area in Ibadan and flows through Apata, Ibadan south local government area to Oluyole local government area. Some industries discharge there wastewater effluent through a well-designed drainage that is channeled into the river. Domestic wastes from household around the estate are also deposited into the River. The waste discharged into the river decreases the channel width and flow rate thereby causing flooding around the estate whenever there is heavy rainfall.

Samples were collected from twenty different stations (S1-S20) 50 m apart in a 750 ml container at 4^0C according to standard procedure (APHA, 2005). The physico-chemical parameters analyzed included DO, BOD, TSS, TS, COD, pH, EC, odour and temperature. Stations S_3 and S_7 represent points of discharge from soap and biscuit manufacturing industries respectively; domestic wastewater was discharged from point S_{10}. Samples were analyzed at the Lagos state wastewater treatment plant laboratory, Ikeja, Lagos state. Stream information was also collected at each of the sampling stations using the current meter and measuring tape (Plate 1) Trapezoidal method of area computation was adopted to obtain thecross-sectional area of each of the sampling point. Time of travel, de-oxygenation and re-aeration constants of the river per day were also calculated using:

$$k_2 = \frac{(\log D_o - \log D)}{t} \quad \text{........... (i)}$$

$$f = \frac{k_2}{k_1} \quad \text{............ (ii)}$$

$$t = \frac{V}{Q} \times \frac{1}{86{,}400} \quad \text{------------ (iii)}$$

Where t = time of travel (days); V = stream reach volume (m^3); Q = average stream flow in the segment (m^3/s); k_1 = de-oxygenation constant (per day); k_2 = re-aeration constant (per day); D_o = initial DO deficit at point of pollution at the upstream; D = DO deficit at any point downstream of the point of pollution; and f is the auto-purification factor of the river

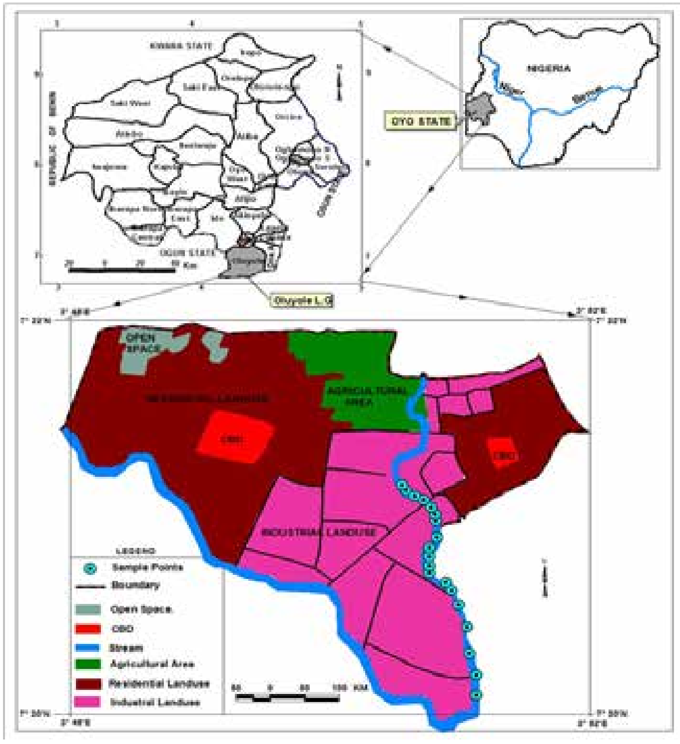

Fig. 1: Ona river, Oluyole local government, Ibadan, Oyo State

Plate 1: Cross-sectional area determination using measuring tape and bamboo

RESULTS AND DISCUSSION

The discharge data obtained along the studied stretch of river Ona is shown in Table 1. The river was on the high flow during the sampling period which led to high precipitation and low infiltration of water in the base soil of the river. The range of depth varied from 0.36 m to 1.85 m at the deepest part. The highest values of discharge occurred at station 17 and 18 upstream of the effluent discharge. The profile along river Ona reveals that the velocity of the river is inversely proportional to the depth of the river.

Table 1: Discharge of Ona river at selected locations

Sampling station	Distance(m)	Width (m)	Mean depth (m)	Cross-sectional area (m^2)	Velocity (m/s)	Discharge (m^3/s)
1	0	13.4	0.6	9.00	0.4	3.60
2	50	11.00	0.9	10.63	0.6	6.38
3	100	11.60	0.8	10.24	0.5	5.12
4	150	11.00	0.7	8.58	0.3	2.57
5	200	10.36	0.9	10.18	0.6	6.11
6	250	18.90	0.5	10.71	0.6	6.43
7	287.8	11.30	0.9	11.92	0.5	5.96
8	337.8	12.20	0.8	9.72	0.8	7.78
9	387.8	12.20	0.9	10.88	0.4	4.35
10	437.8	12.20	0.5	7.06	0.5	3.53
11	487.8	12.20	0.8	11.26	0.7	7.88
12	537.8	11.60	1.2	14.94	0.4	5.98
13	587.8	13.10	0.8	10.79	0.5	5.40
14	637.8	10.36	0.7	8.34	0.7	5.84
15	687.8	9.10	1.2	12.01	0.5	6.00
16	737.8	12.80	1.2	17.26	0.7	12.09
17	787.8	13.70	0.9	15.76	0.8	12.61
18	837.8	15.50	1.5	25.72	0.6	15.43
19	887.8	11.00	1.6	23.28	0.4	9.31
20	937.8	10.40	0.7	8.49	0.6	5.09

The lowest stream velocity of 0.3 m/s was measured at station 4 with a corresponding discharge and DO of 2.56 m^3/s and 7.55 mg/L respectively. Results also revealed thatthe width of the river sections increases as it goes downstream. The stream velocity also decreased as the depth increased.

Table 2 shows the results of physico-chemical parameters at all the sampling stations. The highest BOD occurred at the point of wastewater discharge S_7 with the lowest upstream at S_2. The DO was inversely proportional to the BOD; the microbes consumed the available oxygen thereby causing increase in BOD. This is also shown on the DO deficit curve (Fig. 3). The high velocity of the flowing river enhances high re-aeration rates and increase in discharge rate resulted in fast dilution and neutralization of the discharged effluents into the water body (Longe, 2008).

The de-oxygenation constant and re-aeration constant were calculated to be 20.08 and 55.38per day respectively, while the auto-purification factor was calculated to be 2.76 using equation (i), (ii) and (iii). The auto-purification factor indicates the nature of the stream according to Fair et al., (1971) and Omole, (2010). The stream can be classified according to the value of auto¬-purification factor as a swift stream whose value is between 2.0 and 3.0.

Table 2: Results of physico-chemical parameters along Ona river

Sample station	TEMP ^{0}C	pH	Ec (µs)	TDS (ppm)	TSS (ppm)	Turb (FTU)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	NH□-N (ppm)	NO□-N (ppm)	NO□ (ppm)
S1	26.3	7.27	268	180	8	11	7.35	952.3	38	0.17	5.02	22.1
S2	26	7.47	262	180	8	11	7.31	1429	33	0.16	6.07	26.7
S3	25.7	7.52	263	180	11	13	7.80	1905	78	0.14	7	30.8
S4	25.8	7.54	264	180	11	12	7.55	952-3	68	0.16	7.32	32.2
S5	26.3	7.55	261	180	14	13	7.65	952.3	84	0.14	8.43	37.1
S6	25.6	7.56	260	170	14	13	7.50	952.3	81	0.18	8.84	38.9
S7	25.9	7.23	332	230	15	18	4.21	1905	914	2.52	8.05	35.4
S8	25.1	7.35	258	180	7	9	6.89	952.3	195	0.18	9.27	40.8
S9	25.6	7.43	256	170	9	11	6.57	1429	96	0.19	9.7	42.7
S10	25.3	7.53	260	170	6	9	6.73	952.3	161	0.21	10.18	44.8
S11	25.3	7.54	260	180	16	19	6.81	1429	138	0.13	10.7	46.9
S12	25.8	7.55	258	180	24	26	6.66	1905	100	0.14	11.18	49.2
S13	25.4	7.56	256	180	20	23	6.78	1905	110	0.13	12.3	54.1
S14	26	7.57	267	180	18	18	7.00	1905	137	0.22	11.73	51.6
S15	25.2	7.58	262	180	16	16	7.05	1667	155	0.15	11.73	51.6
S16	25.5	7.59	262	180	14	15	6.91	1429	135	0.15	9.27	40.8
S17	24.6	7.61	262	180	17	15	7.08	1425	188	0.18	14.14	62.2
S18	24.6	7.62	265	170	18	17	7.38	1905	177	0.16	12.86	56.6
S19	25.9	7.63	266	180	15	18	7.31	238	180	0.09	13.43	59.1
S20	25.7	7.62	265	170	19	17	7.87	238	111	0.16	14.14	62.2

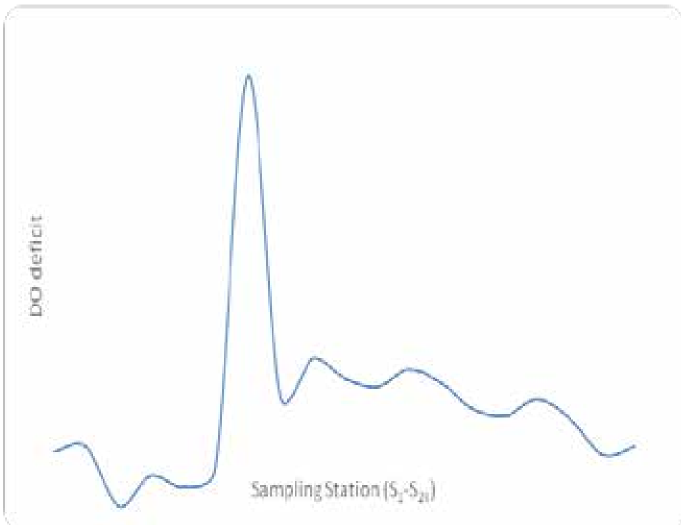

Figure 3: DO deficit along the sampled station of the river

There was an increase in the BOD and the COD as a result of the wastewater effluent discharged from the soap manufacturing industry at station 3. The inorganic effluent significantly affected the value of the COD, increasing it from 1429 mg/L at S2 to 1905 mg/L.

A sharp increase in BOD was observed at station 7 with effluent from a biscuit manufacturing company from 81 to 914 mg/ L which resulted in a DO deficit. The high velocity (0.8 m/s) 50 m away from the station (S8) resulted in high re-aeration and the DO value increased from 4.21 to 6.89 mg/L with a BOD value of 195 mg/L. Domestic discharge at S10 led to an increase in the BOD from 96 to 161 mg/L. Whenever there is a reduction in the velocity of flow the suspended solids settle down, hence the TSS becomes low and the water less turbid.

CONCLUSION

From the results obtained, it was discovered that Ona river was not seriously endangered by the source of pollution but the major source of pollution were the industries. The river also shows the ability to purify itself since a large reduction was noticed downstream from the point of effluent discharge. It was also noticed that the effluent discharged into the river had high value of BOD, pH, DO deficit but the availability of dissolved oxygen in the river aided the treatment process by reducing the DO deficit and the BOD value after discharge of the effluent at various stations. Also the calculated DO deficit and the auto-purification factor also suggested that the the river is a swift flow.

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