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Assessment of anthropogenic activities impacts on the water quality of Asa river: A case study of Amilengbe area, Ilorin, Kwara state, Nigeria



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A B S T R A C T

The study assessed the impacts of anthropogenic activities on the water quality of the Asa River within the case study area and the probable use of this river for agricultural purposes by estimating the Water Quality Index (WQI). Two sampling points were selected namely; upstream (A) and downstream (B). A total number of sixteen (16) samples were taken for four months (i.e two samples per month per sampling point). Temperatures were measured in-situ while other physicochemical and microbial parameters tests were conducted in the laboratory. The errors arising from environmental conditions were minimized by conducting the tests as soon as the samples were collected and the results were analyzed using both the descriptive and the inferential statistics (Pearson Correlation) on both Statistical Package for the Social Sciences (SPSS) and Microsoft Excel. This study has revealed that the Asa River within the study area is polluted as a result of the impacts of the anthropogenic activities when the results of the analyzed water quality parameters downstream are significantly ($p < 0.05$, at a 95% confidence interval) higher than at the upstream except for pH, DO, BOD, and EC which are relatively higher at the upstream although the study indicated that the results were within the recommendations. This study recommends that the anthropogenic activities within this area be monitored as the urbanizations are rapidly taking place and the effects are polluting the water which is making it harmful not only to the ecosystems but also making unfit for possible drinking at the downstream. Also, the study has concluded that the changes in the Land Use Land Cover (LULC) 2016 – 2020 have no statistically significant effects on the physicochemical and microbial water quality of the Asa River. Therefore, as investigated by estimating the WQI, in its current form, the Asa River is fit for agricultural purposes (irrigation farming). However, this study recommended the treatment of this water before drinking as the water in its present form is unfit for drinking.

1. Introduction

The report of the United Nations 2018 World Water Development projected that by 2050, nearly 6 billion globe population is likely to face acute water scarcity (Nkwanda et al., 2021). Similarly, as estimated in a study by Solihu & Bilewu (Solihu and Bilewu, 2021), only about 62.74% have access to potable water supply in Oyo State, Nigeria, which is greater than 40% estimated in 1990 but still below the projected 70% access as part of the Millennium Development Goals (MDGs) by the end of the year 2015 (MDG 2015). Again, poor funding for water infrastructures has manifested in the inability to meet the MDG on sanitation and water, which now threatens the potential achievement of the SDG6 (Solihu and Bilewu, 2021) in many developing countries.

The human right to sanitation defines sanitation as a process of collecting, transporting, treating, disposing, or reusing human excreta and associated hygiene (United Nations 1997). The percentage of access to basic sanitation increased from 59% (2000) to 68% in 2015 globally (United Nations 2018). Meaning that only 1/10 of the countries below 95% is in sync with SDG 2030. Again, statistics have shown that about 4.5 million people globally are ill-equipped with safely managed sanitation in 2015. The United Nations General Assembly (Human Rights Council) identified access to water and sanitation as human rights that are necessary for maximum comfort in life (United Nations 1997).

Understandably, the quality of any body of surface water such as rivers and streams or groundwater are vital ecosystems that sustain the life of humans and animals (Geda et al., 2020) & (Rajiv et al., 2012) and is a function of either or both natural influences and human activities (Kolawole et al., 2011). Water quality deterioration is one of the critical challenges facing many countries across the globe and this situation is worse in developing countries such as Nigeria and Africa at large where there is a high rate of population growth (Nkwanda et al., 2021), (Biswas and Tortajada, 2019) & (Boretti and Rosa, 2019), thus, surface freshwater pollution has become a major public hazard (Bi et al., 2018). Hence, inadequate water supply and lack of basic sanitation have resulted in grave economic and health consequences (UNICEF 2021) & (Solihu and Bilewu, 2021).

According to Phiri et al. (Phiri et al., 2005), indiscriminate disposal of municipal solid waste in river systems cause an increase in Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), and toxic metals such as Cd, Cr, Ni and Pb, and fecal coliform. Thus, surface waters may be an important disease transmission vehicle due to the exposure of users to pathogenic organisms present in the water bodies (Carla and Maria, 2017). Similarly, as reported in some studies (Sridhar et al., 2020), (WHO 2011) & (WHO 2011), about 10% of the world ravaging diseases can be controlled by the provision of adequate water, sanita-

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tion, and hygiene (WASH) facilities, and the most susceptible people to the consequences are the young people who are deprived access to WASH facilities (Yaya et al., 2011).

Again, Dyer et al., (Dyer et al., 2003) added that the consequence of increased degradative processes is the consumption of DO and production of ammonia from the decomposition of organic nitrogen compounds which have adverse negative effects on health such as many water-borne diseases which include diarrhea, typhoid, cholera, paratyphoid, hepatitis B, enteric fever, dermatitis, the blue baby syndrome can be caused by drinking water that has high nitrates. Benzene, a known component of gasoline, is a human carcinogen (Butt and Iqbal, 2007).

However, Ololade et al., (Ololade et al., 2009) stressed that these pollutants are substances present naturally in the environment but when they are released in a significant amount by humans, become toxic and contribute negatively to the economy of the nation as solid waste and water quality have become major environmental problems in recent years, especially in developing countries (Cointreau, 1982), (Pokhrel and Viraraghavan, 2005), (Markandya, 2006). Meanwhile, according to Oshode et al., (Oshode et al., 2008) the annual generation of municipal solid wastes (MSW) in Nigeria is 29.78×10^9 kg which may increase due to rapid urbanization and population growth rate, and this poses threats to the water quality available for domestic and other purposes.

Also, in a research conducted by Akhigbe et al., (Akhigbe et al., 2018) where the surface water samples were tested against their suitability for irrigation purposes by plotting electrical conductivity which is a measure of the salinity hazard in the use of water for irrigation against Sodium adsorption ratio expressed in milliequivalent per liter in water classification diagram for irrigation. The result yielded High salinity water (C3) - Medium sodium water (S2) and Very high salinity water (C4) - High sodium water (S3) suggesting that adequate care is required in the use of the surface water for irrigation. These results are based on the USSL diagram.

While Ololade et al., (Ololade et al., 2009) investigated the impact of indiscriminate dumping of waste, particularly household wastes within a certain locality in Ondo State, Nigeria, on the quality of surface water and underground water (that is, wells with and without rings). The samples were analyzed for some physicochemical parameters and heavy metals using the standard methods. The results revealed that wells without rings are more vulnerable to contaminants than those with rings, and both the surface water and wells without rings recorded threatening values of health concern especially in Pb, Ni, and Cd as almost 100% of the samples analyzed exceeded the WHO and Nigeria Federal Ministry of Environment (FMENV) guidelines.

2. Impacts of consuming untreated water

Water availability is a measure of the nature, quantity, and quality of the readily available water for the general purpose (Solihu and Bilewu, 2021), and the water is needed for replenishment of the fluids lost through normal physiological activities such as respiration, perspiration, and urination (Shalom et al., 2011). Again, according to Solihu & Bilewu, (Solihu and Bilewu, 2021), access to potable water is determined as the percentage of a given population with means of getting a reasonable and adequate quantity of water suitable for drinking and essential household activities (Ishaku et al., 2011). Thus, consumption of unsafe water will not result in more sickness and death but also has economic implications such as higher health costs, lower school enrollment, lower worker productivity, and denial of human rights (GWSSA 2001).

Proper sanitation, according to (Mensah, 2002) is defined as the state of cleanliness of a place, community, or people particularly relating to those aspects of human health including the quality of life determined by physical, biological, social, and psychological factors in the environment. Poor sanitation and consumption of unsafe water, however, are linked to transmission of diseases such as cholera, diarrhea, dysentery, hepatitis, and typhoid killing more than 5000 children and 1000 adults per day (Wolfer, 2014).

Meanwhile, at the global level, water quality deterioration is the primary threat to public health (Rahman et al., 2020). Anthropogenic activities such as improper disposal of municipal, industrialized effluents, and unsystematic use of chemicals in agriculture, are vital aspects causative in the deterioration of water quality resulting in loss of biodiversity, human health and social security issues, and significant economic losses (Kraemer et al., 2001), (Nusrat et al., 2020), (Azizullah et al., 2015), (Iqbal et al., 2020), (Subedi et al., 2019), (Shirani et al., 2018), & (Li et al., 2020).

Asa River is one of the rivers which flows in the study area but has become the major recipient of some anthropogenic activities which majorly include burning of fossil fuels, indiscriminate solid waste disposal, household and industrial wastewater discharge, and agriculture activities. Government intervention through the provision of waste collection bins has not abated the problems. Despite its importance, water is the most poorly managed resource in the world and both water quality and quantity have become prime concerns (Chavan et al., 2014).

Thus, assessing the impact of the anthropogenic activities on this river is the rationale for this study as this will provide useful information for the policymakers at both local and state who need to strategize on improving the framework for solid waste management in the maintenance of river health. In this study area, the impacts of the anthropogenic activities were investigated by comparing the physicochemical and microbial water quality parameters between the upstream, the downstream, and relative to the recommendations in both the National and the International Standards.

3. Materials and methods

3.1. Description of study area

Ilorin is located on latitude $8^\circ\ 24^1\ 0^{11}$ N and $8^\circ\ 33^1\ 0^{11}$ N and longitude $4^\circ\ 30^1\ 0^{11}$ E and $4^\circ\ 36^1\ 0^{11}$ E and it comprises three local government areas which are Ilorin East, Ilorin West, and Ilorin South Local Government Areas. It is situated at a strategic point between the densely populated South Western and the sparsely populated middle belt of Nigeria (Ajadi et al., 2016). The study was carried out along the Asa River segment which spans 6.2 km and flows northwards through the Ilorin Metropolis.

Asa River, being the major water body in Ilorin, enters the southern end of the industrial estate and runs northwards through residential and commercial areas (Kolawole et al., 2011). It thus serves as a recipient of domestic, agricultural, and industrial wastes. Fig. 1 shows the study area location map while Fig. 2 shows the Land Use Land Cover changes between 2016 and 2020 and the Soil Texture Maps of the study area. The sampling site is found within the built-up area as shown in Fig. 2 and Table 1.

From Table 1, the percentages of the land Use Land Cover classes revealed that aside from the built-up area class that increased significantly against the other classes from 2016 to 2020. This is an indication of the likely solid waste generation and indiscriminate disposal into the river system if proper and adequate collection and storage facilities are not provided. This is the case for this study area, and it is evident in the images as shown in Figs. 3 and 4.

3.2. Data collection

There were two sampling points along the river, each located in the southern and northern halves of the town. These locations were selected because there are lots of anthropogenic activities resulting in waste disposal directly into the river daily. Two samples per sampling point per month were collected for four months of low flow and labeled as A1-A8 (upstream samples), and B1-B8 (downstream samples) respectively.

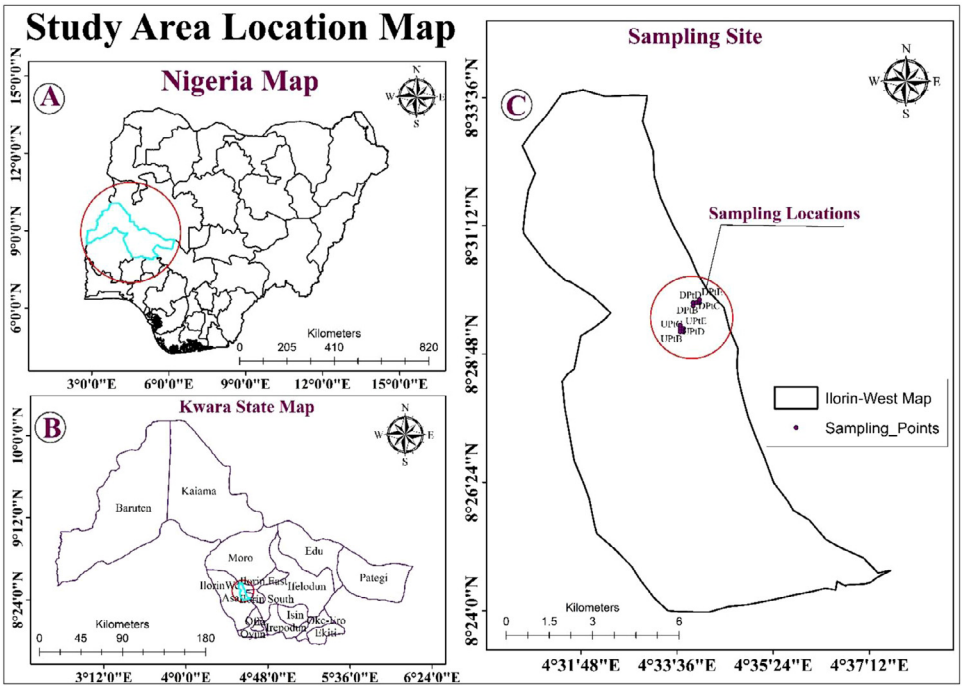


Fig. 1. Map of Study Area showing the Sampling points (Source: Author).

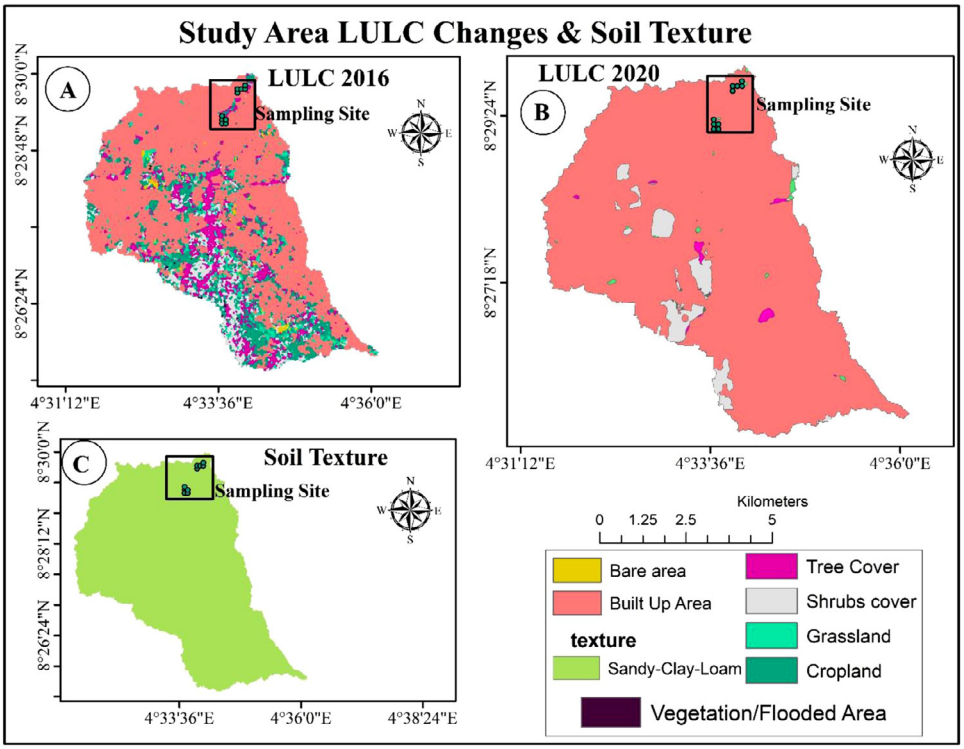


Fig. 2. Study Area Land Use and Soil Texture Maps (Developed by the Author in ArcGIS version 10.4 from LandSat 10).

Table 1
LandUse LandCover Changes of the Study Area Classification.

Description	Area_2016 (ha)	Percentage (%)	Area_2020 (ha)	Percentage (%)	Changes (%)
Bare areas	28.02	0.73	0.00	0.00	-0.73
Built up area	2464.80	64.12	3529.18	94.42	30.30
Croplands	509.65	13.26	2.42	0.07	-13.20
Grasslands	193.19	5.03	13.54	0.36	-4.67
Shrubs cover areas	254.43	6.62	170.88	4.57	-2.05
Tree cover areas	387.57	10.08	21.78	0.58	-9.50
Vegetation or regularly flooded areas	6.19	0.16	0.00	0.00	-0.16
Water	0.00	0.00	0.16	0.00	0.00



Fig. 3. Asa River Longitudinal Section within the Study Area (Pictures captured by the Author).



Fig. 4. Some Open Waste Disposal Points within the Study Area (Pictures captured by the Author).

Temperatures of these samples were measured in-situ while water samples were taken to the laboratory for analysis of water quality parameters. The analyzed water quality parameters include the physical, chemical, and microbial parameters. Error arising from environmental conditions were minimized by proper storage and conducting the tests as soon as the samples were collected. Physical, chemical, and microbial parameter tests were carried out according to Standard Methods.

3.3. Data analysis

The test results were analyzed using both the descriptive and *t*-test methods. The variables analyzed were water quality parameters upstream and downstream with the recommendations in WHO, EPA, and NSDWQ, 2007 standards. For the paired *t*-test part, rejection of the null hypothesis indicates a statistically significant difference while a non-rejection signifies that there is no statistically significant difference between these variables at a level of significance. The significance level was set at 0.05, indicating a 95% confidence interval. Analyses were computed with the Statistical Packages for the Social Sciences (IBM SPSS) Statistics software version 25.0 and Microsoft Excel version 2016 for windows 10.

3.4. Overall water quality determination

The water quality of the Asa section within the case study area was quantified by estimating the Water Quality Index (WQI). The WQI provides a more comprehensive image of surface water quality (Sahu and Sikdar, 2008), (Nusrat et al., 2020). As reviewed in several studies (Nusrat et al., 2020), (Ravikumar et al., 2013), (Rokbani et al., 2011), (Asadi et al., 2007), the calculation of WQI involves three major steps:

Marking of the water quality chemical parameters with a weight (w_i): This was done following their relative importance in water quality and/or impacts on public health.

Table 2
Water Quality Index and their Respective Water Type (source: (Nusrat et al., 2020)).

WQI range	Water Type
< 50	Excellent
50 - 100	Good water
100 - 200	Poor water
200 - 300	Very Poor Water
> 300	Unfit for use

Determination of the relative weight (W_i) of each parameter: This study used Eq. 1

$$Wri = wi / \sum_{i=1}^{n} wi \quad (1)$$

Where W_{ri} = relative weight of each parameter; n = no. of parameters; w_i = weight of each parameter

Computation of quality rating scale: This is estimated using Eq. 2

$$qi = \frac{Ci}{Si} * 100 \quad (2)$$

Where q_i = quality rating; C_i = concentration of each parameter in each water sample (mg/L); S_i = WHO recommendation of each chemical parameter (mg/L) except electrical conductivity and pH.

$$SIi = Wri * qi \quad (3)$$

$$WQI = \sum_{i=1}^{n} SIi \quad (4)$$

Therefore, the sub-index of the ith parameter was estimated using Eq. 3 while Eq. 4 was used to determine the actual WQI for each sampling point and the overall WQI for upstream and downstream were determined by estimating the average WQI for all the sampling locations. Again, the calculated water quality index values are categorized in five (5) classes viz-a-viz; excellent, good, weak, inferior, and unfit to use respectively (Nusrat et al., 2020), (Sahu and Sikdar, 2008), (Ravikumar et al., 2013). The WQI range for each water type is, therefore, presented in Table 2.

4. Results and discussion

4.1. Results

The results are divided into two major sections. The first is the comparison between the results of the analyzed water quality at the upstream and the downstream while the second section shows the comparison of the analyzed water quality parameters with the selected standards (WHO, EPA, and NSDWQ, 2007).

The analyzed water quality parameters at the upstream and the downstream were compared using bar charts as shown in Figs. 5, 6, 7, 8, and their statistically significant differences were determined using the Paired-Samples T-Test. The results are presented in Table 2.

From Tables 3 – 6, it is seen that the values of the analyzed water quality parameters downstream are relatively higher than the results upstream except for the pH, DO, BOD, and EC which appeared higher at the upstream relative to the downstream. Therefore, their statistically significant differences are presented in Table 3.

From Table 3, of all the water quality parameters analyzed only the total coliform count is statistically significant ($p>0.05$), therefore, the null hypothesis of no statistically significant difference between the upstream and the downstream total coliform count is failed to be rejected at a 95% confidence interval. However, the results of other parameters are statistically insignificant (p-values < 0.05 at a 95% confidence interval), indicating that there were statistically significant differences

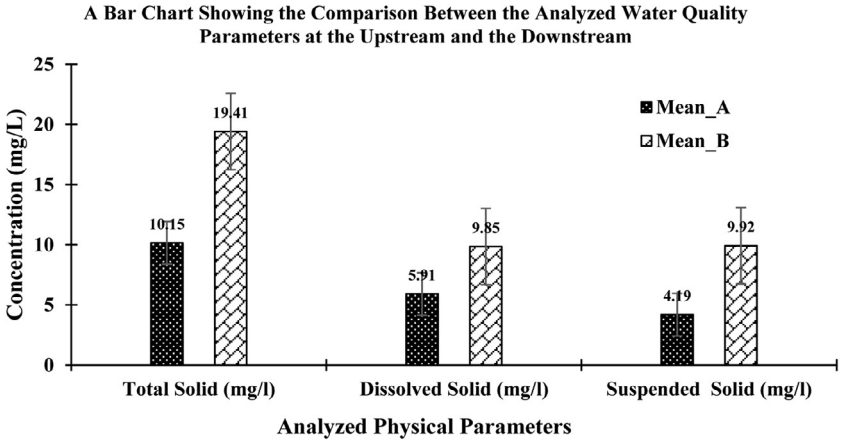


Fig. 5. Comparisons between the upstream and the downstream analyzed physical water quality parameters.

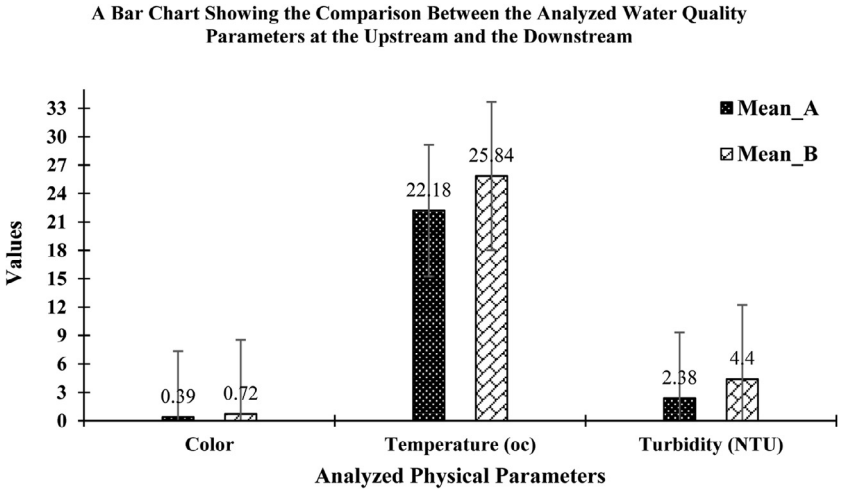


Fig. 6. Comparisons between the upstream and the downstream analyzed physical water quality parameters.

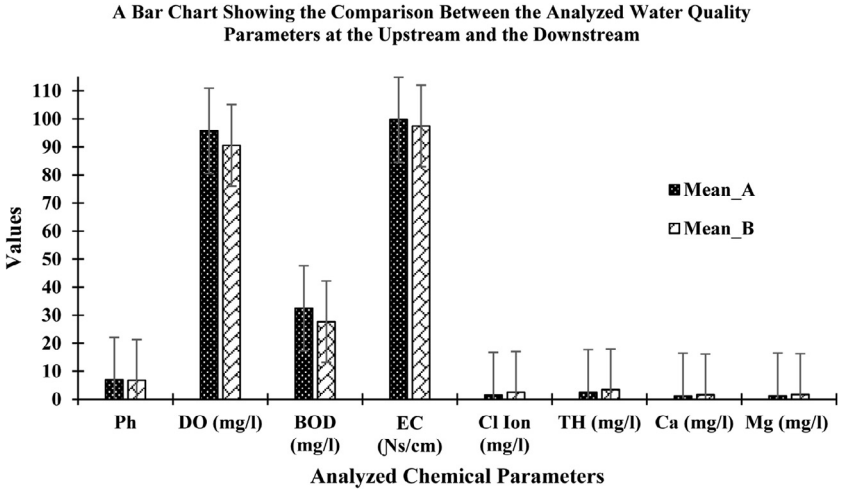


Fig. 7. Comparisons between the upstream and the downstream analyzed chemical water quality parameters.

between the upstream and the downstream analyzed water quality parameters. Therefore, indicating an impact of the anthropogenic activities in the study area.

Also, a comparison was made between the analyzed water quality parameters both upstream and downstream with the recommended values in the selected standards. The results are presented in Table 4.

As shown in Table 4, the results have revealed that the chemical quality of the water is within the recommended values in the standards. Also, the microbial properties of the water are higher than the recommended values in both WHO and NSDQW, 2007 while only temperature and turbidity values are higher than the recommended values only in EPA and WHO; other physical parameters are found to be within the recommended values in the three standards.

4.1.1. Relationship between water quality parameters and LULC

Also, the study assessed the correlations between the analyzed water quality parameters and the changes in the LULC (2016 and 2020) using Pearson Correlation Method in SPSS. The results are thus, presented in

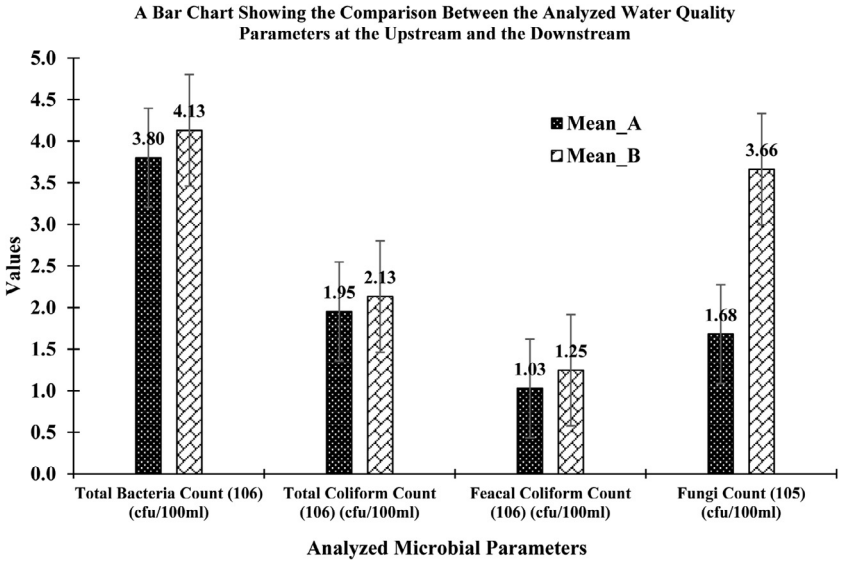


Fig. 8. Comparisons between the upstream and the downstream analyzed microbial water quality parameters.

Table 3
Results of Statistically Significant Difference between the Upstream and the Downstream Water Quality.

Nature	Parameter	n	$Mean_1$	$Mean_2$	SE_1	SE_2	df	P-Value
Physical	Color	8	0.389	0.719	0.005	0.015	6	0.000
	Temperature (˚c)	8	22.181	25.843	0.403	0.197	6	0.000
	Turbidity (NTU)	8	2.383	4.400	0.011	0.082	6	0.000
	Total Solid (mg/l)	8	10.150	19.409	0.012	0.066	6	0.000
	Dissolved Solid (mg/l)	8	5.913	9.846	0.006	0.051	6	0.000
	Suspended Solid (mg/l)	8	4.187	9.917	0.032	0.120	6	0.000
Chemical	pH	8	6.917	6.729	0.011	0.126	6	0.001
	Dissolved Oxygen (mg/l)	8	95.756	90.551	0.403	0.197	6	0.000
	BOD (mg/l)	8	32.480	27.669	0.034	0.154	6	0.000
	Electrical Conductivity (Ns/cm)	8	99.697	97.453	0.021	0.018	6	0.000
	Chloride Ion (mg/l)	8	1.511	2.490	0.003	0.009	6	0.000
	Total Hardness (mg/l)	8	2.493	3.387	0.013	0.030	6	0.000
	Calcium (mg/l)	8	1.219	1.609	0.005	0.012	6	0.000
	Magnesium (mg/l)	8	1.256	1.726	0.006	0.007	6	0.000
Microbial	Total Bacteria Count (10^6) (cfu/100 ml)	8	3.801	4.131	0.129	0.125	6	0.034
	Total Coliform Count (10^6) (cfu/100 ml)	8	1.951	2.131	0.044	0.086	6	0.080*
	Feacal Coliform Count (10^6) (cfu/100 ml)	8	1.029	1.247	0.017	0.050	6	0.012
	Fungi Count (10^5) (cfu/100 ml)	8	1.680	3.663	0.140	0.760	6	0.048

*statistically significant at a 95% confidence interval

Table 4
Analyzed Water Quality Parameters and the Recommendations in Standards.

Nature	Parameter	$Mean_1$	$Mean_2$	(W.H.O, 1993)	EPA (MLV)	NSDWQ, 2007
Physical	Color	0.389	0.719	2	20	2
	Temperature (˚C)	22.181	25.843[b]	28	25	NS
	Turbidity (NTU)	2.383[a]	4.400[b]	5	1	5
	Total Solid (mg/l)	10.15	19.409	500	NS	NS
	Dissolved Solid (mg/l)	5.913	9.846	600	NS	500
	Suspended Solid (mg/l)	4.187	9.917	500	50	500
Chemical	pH	6.917	9.729	8.5	8.5	8.5
	Dissolved Oxygen (mg/l)	95.756	90.551	6	NS	NS
	BOD (mg/l)	32.48	27.669	10	5	NS
	Electrical Conductivity (Ns/cm)	99.697	97.453	1000	1000	1000
	Chloride Ion (mg/l)	1.511	2.49	250	250	250
	Total Hardness (mg/l)	2.493	3.387	100	NS	150
	Calcium (mg/l)	1.219	1.609	150	NS	150
	Magnesium (mg/l)	1.256	1.726	30	NS	0.2
Microbial	Total Bacteria Count (10^6) (cfu/100 ml)	3.801[a,c]	4.131[a,c]	0	NS	0
	Total Coliform Count (10^6) (cfu/100 ml)	1.951[a]	2.131[a]	0	5000	10
	Feacal Coliform Count (10^6) (cfu/100 ml)	1.029[a,c]	1.247[a,c]	0	1000	0
	Fungi Count (10^5) (cfu/100 ml)	1.68[a]	3.663[a]	0	NS	NS

[a] : indicated the value is higher than the WHO recommended value
[b] : indicated the value is higher than the EPA MLV recommended value
[c] : indicated the value is higher than the NSDWQ, 2007 recommended value

Table 5
Description of the Variables for Correlation Test.

Descriptive Statistics					
Variable	Mean	Std. Deviation	Variable	Mean	Std. Deviation
LULC for the Year 2016	12.500	21.409	Total Hardness (mg/l)	2.940	0.468
LULC for the Year 2020	12.500	33.135	Chloride ion (mg/l)	2.001	0.508
pH value	6.823	0.114	Electrical Conductivity	98.575	1.166
Turbidity(NTU)	3.391	1.057	Calcium ion (mg/l)	1.414	0.204
Temperature degree C	24.012	2.106	color (tcu)	0.554	0.174
Total Solids(mg/l)	14.779	4.806	Magnesium ion	1.491	0.244
Dissolved Solid(mg)	7.879	2.043	Total Bacteria Counts	3.966	0.366
Suspended Solid(mg)	7.052	2.982	Total Coliform Counts	2.041	0.197
Dissolved Oxygen	93.154	2.710	fecal coliform counts	1.138	0.147
Biological Oxygen Demand	30.074	2.512	FC (fu/10)	2.671	1.728

Table 6
Correlations of the LULC Changes with the Physical Parameters.

		LULC 2016	lulc 2020	color (tcu)	Turbidity (NTU)	Temperature degree C	TS (mg/l)	DS (mg)	SS (mg)
LULC for Year 2016	Pearson Correlation	1.000	.975**	-0.246	-0.248	-0.121	-0.241	-0.238	-0.228
	Sig. (2-tailed)		0.000	0.556	0.553	0.776	0.565	0.571	0.587
	n	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
LULC for Year 2020	Pearson Correlation	.975**	1.000	-0.189	-0.171	-0.056	-0.158	-0.156	-0.148
	Sig. (2-tailed)	0.000		0.654	0.686	0.896	0.708	0.712	0.727
	N	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 7
Correlations of the LULC Changes with the Chemical Parameters .

		LULC 2016	LULC 2020	pH value	DO	BOD	TH (mg/l)	Cl^- (mg/l)	EC	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)
LULC 2016	Pearson Correlation	1.000	.975**	-0.508	0.241	0.235	-0.267	-0.241	0.259	-0.251	-0.206
	Sig. (2-tailed)		0.000	0.199	0.565	0.576	0.522	0.565	0.536	0.549	0.625
	N	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
LULC 2020	Pearson Correlation	.975**	1.000	-0.452	0.159	0.158	-0.198	-0.155	0.185	-0.176	-0.117
	Sig. (2-tailed)	0.000		0.261	0.706	0.709	0.638	0.715	0.662	0.677	0.783
	N	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 8
Correlations of the LULC Changes with the Microbial Parameters.

		LULC 2016	LULC 2020	Total Bacteria Counts	total coliform counts	fecal coliform counts	FC (fu/10)
LULC 2016	Pearson cor.	1.000	.975**	0.370	-0.614	0.138	-0.162
	Sig. (2-tailed)		0.000	0.367	0.105	0.744	0.702
	N	8.000	8.000	8.000	8.000	8.000	8.000
LULC 2020	Pearson cor.	.975**	1.000	0.259	-0.546	0.233	-0.112
	Sig. (2-tailed)	0.000		0.536	0.162	0.579	0.791
	N	8.000	8.000	8.000	8.000	8.000	8.000

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Tables 5, 6, 7, 8 for the descriptive statistics; correlations of the LULC changes with the physical parameters; correlations of the LULC changes with the chemical parameters, and correlations of the LULC changes with the microbial parameters respectively.

4.1.2. Overall water quality

Water quality for the study area was quantified using the Water Quality Index (WQI). Following the procedure in Section 5.3, the results are presented as in Tables 9 and 10 considering WHO and NSDWQ, 2007 respectively.

4.2. Discussions

The results above show both the descriptive and inferential statistics for the upstream and the downstream water samples from the study area along with the Asa River systems. The results of the descriptive statistics were represented in both tables and figures which represented the

Table 9
Water Quality Index Results Using WHO Standard of each Chemical Parameter.

WQ	A	B	WHO	Standard	w_i	W_R	qi_A	qi_B	SIi_A	SIi_B
pH	6.91	6.70	8.50	WHO	3	0.12	81.29	78.82	9.76	9.46
Turbidity(NTU)	2.43	4.42	5.00	WHO	3	0.12	48.60	88.40	5.83	10.61
DS(mg)	5.94	9.68	1000.00	WHO	5	0.2	0.59	0.97	0.12	0.19
SS(mg	4.23	9.75	500.00	WHO	2	0.08	0.85	1.95	0.07	0.16
Cl(mg/l)	1.55	2.47	250.00	WHO	3	0.12	0.62	0.99	0.07	0.12
EC	99.73	97.42	1000.00	WHO	3	0.12	9.97	9.74	1.20	1.17
Ca(mg/l)	1.22	1.61	150.00	WHO	2	0.08	0.81	1.07	0.07	0.09
Mg	1.27	1.72	30.00	WHO	2	0.08	4.23	5.73	0.34	0.46
TH(mg/l)	2.48	3.33	100.00	WHO	2	0.08	2.48	3.33	0.20	0.27
					25	**0.92**	**WQI =**		**6.70**	**11.89**
			Sum(wi) =							

Table 10
Water Quality Index Results Using NSDWQ, 2007 Standard of each Chemical Parameter.

WQ	A	B	NSDWQ	Standard	w_i	W_R	qi_A	qi_B	SIi_B	SIi_B
pH	6.91	6.70	8.5	WHO	3	0.12	81.29	78.82	9.76	9.46
Turbidity(NTU)	2.43	4.42	5.0	WHO	3	0.12	48.60	88.40	5.83	10.61
DS(mg)	5.94	9.68	500.0	WHO	5	0.2	1.19	1.94	0.24	0.39
SS(mg	4.23	9.75	500.0	WHO	2	0.08	0.85	1.95	0.07	0.16
Cl(mg/l)	1.55	2.47	250.0	WHO	3	0.12	0.62	0.99	0.07	0.12
EC	99.73	97.42	1000.0	WHO	3	0.12	9.97	9.74	1.20	1.17
Ca(mg/l)	1.22	1.61	150.0	WHO	2	0.08	0.81	1.07	0.07	0.09
Mg	1.27	1.72	0.2	WHO	2	0.08	635.00	860.00	50.80	68.80
TH(mg/l)	2.48	3.33	150.0	WHO	2	0.08	1.65	2.22	0.13	0.18
					25	**0.92**	**WQI =**		**57.21**	**80.33**
			Sum(wi) =							

comparisons between the upstream and downstream for both physicochemical and microbial water quality parameters. The results of the comparison between the upstream and downstream physical parameters revealed that the river has been polluted with anthropogenic activities along the river section.

Also, the results have revealed that physio-chemical and microbial parameters were statistically insignificant ($p < 0.05$, at a 95% confidence interval). However, when these results were compared with the recommendations in the WHO, EPA, and NSDWQ, 2007, the results revealed that the chemical quality of the water is within the recommended values in the standards. Although the microbial properties of the water are higher than the recommended values in both WHO and NSDQW, 2007 but only temperature and turbidity values are higher than the recommended values both in EPA and WHO; other physical parameters are found to be within the recommended values in the three standards.

In addition, the results of the correlation between the LULC changes and the physicochemical and microbial water quality parameters revealed that the correlations are statistically insignificant both at 95% and 99% confidence intervals ($p>0.05$ and $p>0.01$) for the physicochemical and microbial water quality parameters as shown in Tables 6, 7, and 8 respectively. This implies that the changes in the LULC have no statistically significant effects on the physicochemical and microbial water quality of the Asa River.

As shown in Tables 9 and 10 which are WQIs using the WHO and NSDWQ, 2007 standards respectively, the results for the upstream and the downstream water quality showed a WQI of about 6.70 and 11.89 and 57.21 and 80.33 using WHO and NSDWQ, 2007 respectively. These results when compared with the recommended WQI ranges according to (Nusrat et al., 2020) revealed that both the water quality at the upstream and the downstream are suitable for agricultural purposes (irrigation) which is one of the Land Use activities downstream. However, the river has been polluted due to anthropogenic activities such as improper and indiscriminate disposal of waste into the river system along the study area which makes it unsuitable for drinking without prior treatment.

In a similar study by Mustapha (Mustapha, 2008) that investigated the variations in the selected physicochemical factors for two years to determine the water quality of Oyun Reservoir, Offa, Nigeria for drinking and fish production, three monitoring points were chosen on the reservoir to reflect the effect of human activities, lacustrine and lotic habitats. The study confirmed that the ranges of these factors were comparable to those reported for other African reservoirs except for nitrogen and phosphate which were found in higher concentrations above freshwater limits and were attributed to the Agricultural wastes within the catchment. However, concluded that Oyun reservoir has excellent water quality, high ecological status, and passes chemical status.

Similarly, a study by Oluwaseyi and Israel (Oluwaseyi and Israel, 2020) aimed at investigating the impact of effluent discharge from a medium-scale aquaculture fish farm on the water quality of a nearby receiving stream, Odo-Owa stream, near Ijebu-Ode in Ogun State, Southwest Nigeria. The results indicated that the parameters such as NH_4, true & apparent colors, depth, alkalinity, HCO_3^-, SO_4^{2-}, pH, Ca2+, Na+, K+, Cl-, and PO_4^{3-} were significantly higher along with the downstream than the upstream sections of the receiving stream likewise the analyzed heavy metals (Fe^{2+}, Mn^{2+}, Zn^{2+}, and Cu^{2+}) except for Hg^{2+}. Thus, the study revealed that the receiving stream is polluted and the water quality indices 26.88 and 32.42 respectively showed that the Odo-Owa stream is very bad in both dry and rainy seasons.

Again, Raghumani and Mithra (Raghumani and Mithra, 2014) investigated in a study entitled “surface water quality concerning municipal solid waste disposal within the Imphal municipality area, Manipur”, the impact of unscientific disposal of municipal solid wastes from different sources on the surface water quality. The parameters taken for the analysis using the standard methods were air temperature, water temperature, transparency, conductivity, pH, TDS, alkalinity, hardness, Ca^{2+}, Mg^{2+}, Cl^-, DO, and BOD for 24 months. From the study, it was concluded that solid waste disposal in the water bodies leads to pollution of water quality and that there are differences in the values of the parameter between the waste disposal and non-disposal areas.

Also, in a study by Islam et al., (Islam et al., 2012) where the water samples from the selected points at the upstream and downstream were analyzed for the physicochemical parameters including color, odor, pH, EC, TDS, DO, BOD, Cu, Cd, Fe, Pb, and Zn concentrations, the results revealed that continuous dumping of waste materials resulted in a marked

increase in the concentration of metals in the river water varied in the order of Fe > Zn > Pb > Cu > Cd. The researchers opined that the downstream water in the river section was almost polluted and unsuitable for human consumption and aquaculture purposes.

5. Conclusions

It is concluded that the section of the Asa River within the study area is polluted as a result of the impacts of the anthropogenic activities when the results of the analyzed water quality parameters downstream are significantly higher than at the upstream except for pH, DO, BOD, and EC which are relatively higher at the upstream. The results are within the recommendations in the selected standards, which, notwithstanding, this study recommends that the anthropogenic activities within this area be monitored as the urbanizations are rapidly taking place and the effects are polluting the water which is making it harmful not only to the ecosystems but also making unfit for possible drinking at the downstream.

Also, from the results, the study concludes that the changes in the LULC (2016 – 2020) have no statistically significant effects on the physicochemical and microbial water quality of the Asa River. The study, therefore, investigated the suitability of the Asa River for agricultural purposes (irrigation farming) by estimating the WQI. The results have revealed that the Asa River is suitable for Agricultural purposes since the WQIs are within the range of “good water”. However, this research recommends treatment of this water before drinking as the water in its present form is unfit for drinking.

Declaration of Competing Interest

The authors declared no conflict of interest in this research paper.

Data Availability

The datasets analyzed during the current study are available from the corresponding author upon reasonable request

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