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ASSESSMENT OF THE IMPACT OF METAL SCRAPS ON THE PHYSICOCHEMICAL PARAMETERS OF WATER AROUND OGIJO, OGUN STATE, NIGERIA

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ABSTRACT

Water resources have been under severe threats from pollutions generated by anthropogenic activities. This study is aimed at evaluating the seasonal variation of physicochemical properties of water around the scrap metal recycling sites at Ogijo, Ogun State, Nigeria. Twelve water samples were collected from different sources and points during wet and dry seasons. The physicochemical parameters were investigated following standard methods. The results of the tests for dry and wet season respectively ranged as: 5.30 to 6.89 and 6.47 to 7.66 (pH); 2.66 to 18.21 µS/cm and 14.50 to 255.5 µS/cm (EC); 8.17 to 22.65 mg/L and 6.98 to 20.01 mg/L (nitrate), 0.001 to 54 mg/L and 0.49 to 47.74 mg/L (sulphate), 0.001 to 4.34 mg/L and 0.17 to 2.39 mg/L (phosphate), 0.002 to 73.00 mg/L and 15 to 59 mg/L (COD), 1.22 to 4.20 mg/L and 0.22 to 1.73 mg/L (BOD), 4.32 to 9.11 mg/L and 3.28 to 4.87 mg/L (DO), 1 to 44 mg/L and 12.40 to 205.7 mg/L (TH), 0.88 to 11.20 mg/L and 19.3 to 171 mg/L (TDS) and 0.62 to 712 NTU and 0.13 to 273.9 NTU (turbidity) with higher values in the dry season and some exceeding the WHO permissible limit for drinking water. About 80% of the water in the area during dry season is suitable for irrigation but treatment is recommended for drinking, entertainment uses and aquatic lives.

Key words: Water assessment, physicochemical parameters, metal scraps, Ogijo

INTRODUCTION

Access to clean and safe water for the entire human consumption was declared a human right by the United Nations General Assembly in July 2016 [1]. The scrap metal recycling companies in Ogijo, Ogun State, discharge diverse types of waste into the water which could lead to alterations in the hydrological cycle and water quality degradation and in turn could have adverse effects on aquatic animals in the area.

Water resources are under severe threats from pollutions that are generated by human interventions and most importantly, inappropriate agricultural drainage from rivers [2]. Other sources of water pollution such as untreated industrial effluents, improperly disposed domestic waste, and agricultural runoff are the major contributors to surface water pollution and water quality deterioration [1, 3]. The increased rate of urbanization, industrialization and other forms of modernization could plague the productive capacities of coastal water bodies in general, thereby threatening their sustainable limits. Seasonal variations in both anthropogenic and natural processes such as temperature and precipitation also affect the quality of river water and as such lead to different attributes for different seasons [4, 5].

Monitoring of the physicochemical water quality parameters plays a pivotal role in assessing the water environment, ecosystem, hydrochemistry, ecology, and restoring water quality [6, 7]. Given that variation in water quality is a continuous process, updated water quality data are necessary for water quality assessment. Therefore, this study was aimed at assessing the impacts of metal scraps on the physicochemical parameters of water around Ogijo, Ogun State, Nigeria.

EXPERIMENTAL

Study area

The study was carried out in Ogijo in Sagamu Local Government Area, Ogun State, located within Southwestern Nigeria. The Local Government has an area of 614 km^2 and its geographical coordinates are 6° 42' 0" North, 3° 31' 0" East. The industries in the study area are mostly for scrap metal recycling. Sagamu region is underlain by major deposits of limestone, which is used in the city's major industry in the production of cement [8].

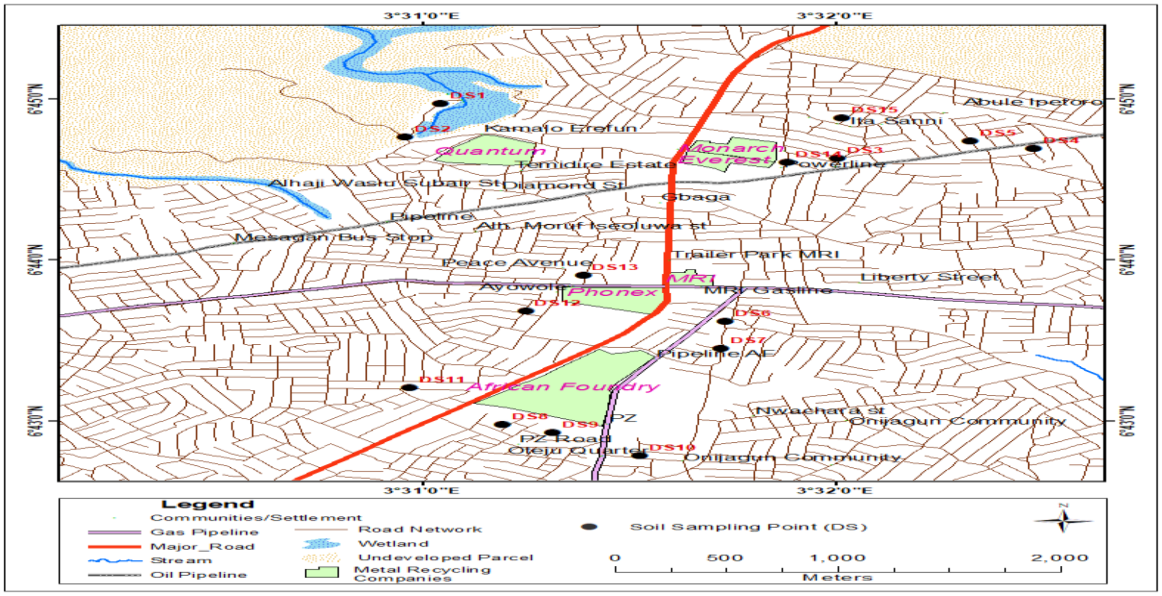

Figure 1: Map of study area and sampling sites in Ogijo, Ogun State, Nigeria

Water Sampling

One well water (W1), one sample each from upper, middle and lower of a stream (W2, W3, W4) and eight borehole water samples (W5, W6, W7, W8, W9, W10, W11, W12) and a borehole water from Ketu in Lagos as control (CW) were collected at different points in Ogijo (Table 1), using a cleaned 2-liter plastic container, soaked overnight in 10% nitric acid solution. The water samples were properly labeled after collection and put in ice-cooled cooler and immediately transported to laboratory where they were refrigerated prior to analyses. A control sample was collected about 12.8 km away from the study area. The samplings were done in wet and dry seasons (between 5th to 7th March and 24th to 25th September, 2020 respectively).

Table 1: Water Codes, Sampling Locations and Description

S/N	Sample Code	Location	Description
1	DW1,WW1	Ipetero extension	Well water
2	DW2 ,WW2	Kamalo Erefun	Upper stream
3	DW3,WW3	Kamalo Erefun	Middle stream
4	DW4,WW4	Kamalo Erefun	lower stream
5	DW5,WW5	PZ road	Borehole
6	DW6,WW6	Ayowole	Community borehole
7	DW7,WW7	Powerline	Borehole
8	DW8, WW8	Peace avenue	Borehole
9	DW9 ,WW9	Erefun	Borehole
10	DW10, WW10	Gbaga	Borehole
11	DW11,WW11	ItaSanni	Borehole
12	DW12 ,WW12	Gasline	Community Borehole
13	CDW,CWW	Ketu	Borehole Water (Control)

Key: DW = Dry season water, WW = Wet season water, C = control water

Determination of water physicochemical parameters

pH (Electrode Method)

An Extech DO700 meter was used to determine the pH of the water samples. The meter was checked and calibrated with buffers 4, 7 and 9 accordingly. Exactly 100 mL of the water sample was accurately measured and the probe of the pH meter immersed into the water sample. The water sample was stirred with the pH meter probe gently and waited until the display on the pH meter stabilized and pH value of the water sample was recorded. The probe was thoroughly rinsed with distilled water after each measurement [9].

Temperature

The temperature of the water sample was determined using a thermometer. The thermometer probe was inserted 100 mL of the water sample and the temperature of the water was recorded. The probe was thoroughly rinsed with distilled water after each measurement [10].

Total Dissolved Solids (TDS) and Conductivity

An Extech DO700 meter was used to determine the total dissolved solids of the water samples. Exactly 100 mL of the water sample was measured and the probe of the meter immersed into the water sample. The water sample was stirred with the meter probe gently and waited until the display on the meter was stabilized and the TDS and conductivity values of the water sample determined and recorded. The probe was thoroughly rinsed with distilled water after each measurement [9, 10].

Turbidity

The turbidity of the water sample was determined using Oakton Turbidimeter (T-100). The equipment was calibrated with four commercially prepared turbidity standards while silicon oil was used to clean the cuvette before use. The turbidity of the water sample was measured on a 10 mL aliquot of the water sample and turbidity determined and recorded [9, 11].

Dissolved Oxygen (DO) (Winkler Colorimetric Method)

Accurately 50 mL of the water sample were measure and transferred into a DO-bottle and 2 drops each of manganese sulphate and alkaline potassium iodide-azide reagents were added. The bottle was capped, mixed and then allowed to stand for the precipitate to settle. Thereafter, 1 g sulphamic acid was added to dissolve the precipitate. The clear (yellow) solution is proportional to DO concentration, and was determined at 428 nm with a colorimeter [9,12].

Chemical Oxygen Demand (COD) (Colorimetric Method)

The chemical oxygen demand was determined by a closed reflux using SM 5220 D colorimeter. Accurately 2 ml of the sample was measured into a digested flask and digested with 10 mL of dichromate and sulfuric acid reagent, in a reactor at 150 ^{o}C for 2 hours. Thereafter, the mixture was allowed to cool and COD content determined colorimetrically at 420 nm. The amount of yellow color remaining after oxidation was proportional to the COD concentration in the water sample [10, 11].

Biochemical Oxygen Demand (5-day BOD Test)

BOD was determined by measuring the dissolved oxygen content of the water sample on the first day (DO initial) and after 5 days (DO final) of incubation of 60 ml water sample in the dark at 20^{o}C. The 5-day BOD determined and calculated.

BOD_5 (mg/L) = ($DO_{initial}$ - DO_{final}) x (dF) [9,13]

Phosphate (Ascorbic Acid Method)

Accurately 10 mL of the water sample was measured and transferred into a sample vial and one phosVer 3 phosphate pillow was added. The resulting mixture was shaken to dissolve the phosphate pillow powder and then allowed to stand for 3 minutes for complete reaction. The phosphate content was determined by measuring the phosphate at 650 nm using SMART 3 colorimeter. The amount of blue color after the reaction was proportional to the phosphate concentration in the water sample [9, 11].

Sulphate (Turbidimetric Method)

Accurately 10 mL of the water sample was measured and transferred into a sample vial. Thereafter, one SulfaVer 4 reagent powder was added and the mixture swirled to mix and allowed to stand 3 minutes for complete reaction. The sulphate content was then determined at 450 nm using a colorimeter [9 – 11, 12].

Total Hardness

Accurately 50 mL of the water sample were measured and transferred into a conical flask and 2 drops of Erichrome black T indicator were added and the resulting mixture titrated with standardized 0.01M EDTA solution to a bluish end point [10, 11].

Nitrate Determination

About 10 ml of the sample was measured and transferred into a reaction tube and placed in a cool water bath. 2 ml NaCl solution, 10 ml H_2SO_4 solution and 0.5 ml brucine-sulphanilic acid were added and the tube swirled and then placed in boiling water bath at temperature 95 °C. After 20 min the tube was removed and immerse in cool water bath and the resulting solution poured into cuvette to read the concentration of sample against the reagent blank at 410 nm. A standard curve of absorbance value against the concentration of NO_3-N of the standard was prepared and then the concentration of NO_3-N in the sample from the known value of absorbance determined [9 - 14].

Quality control

Distilled water was used during extraction and preparation of solutions. All glassware were cleaned by soaking in 10% nitric acid overnight and rinsed with deionized water before use. Blank samples were also analyzed to identify for any possible contamination by reagents, distilled water, chemicals and digestion vessels. Replicate analyses of samples were carried out to determine the reproducibility of results.

Statistical analysis

The statistical analysis was performed using the analysis of variance (ANOVA), correlation and t-test to determine the differences between treatments mean at significant level (0.05 and 0.01). Standard errors of mean were estimated. All statistics were run using statistical package for social sciences (SPSS) (25.0) version.

RESULTS AND DISCUSSION

Physicochemical properties for water samples in dry and wet seasons

The physicochemical parameters (pH, EC, temperature, NO_3^-, SO_4^{2-} and PO_4^{3-}) for dry and wet seasons are shown in Tables 2 and 3.COD, BOD, DO, hardness, TDS and turbidity for dry and wet seasons are shown in Tables 4 and 5 respectively.

pH

The pH values of the water samples collected during the dry season were found to range from 5.30 to 6.89, with the lowest pH value found in sample DW9 while the highest pH value was in sample DW1. In the wet season, the pH values ranged from 6.47 to 7.66, with the lowest pH value recorded in sample CWW while the highest value pH was recorded in sample WW10. The results of the pH values of the wet season were found to be within the WHO permissible limit (6.6 to 8.5) of drinking water but most pH the dry season were above the limit [16]. The results show that the pH values of water samples ranged from being slightly acidic to slightly alkaline. Afrin et al. [17] and Ahmed et al. [18] observed in their works that the pH values ranged from 6.98 to 7.93 which were basically in consistent with the results obtained in this study. pH is a measure of acid-base equilibrium achieved by water dissolved compounds as well as extent of flocculation and coagulation process of chemicals [19].

Table 2: Results of Water Physicochemical Parameters during Wet Season

Sample Codes	**pH**	**EC** μScm^{-1}	**Temp** **^{0}C**	**NO$_3$** **mg/L**	**SO$_4$** **mg/L**	**PO$_4$** **mg/L**
WW1	6.74 ± 0.007^{c}	255.50 ± 2.12^{i}	26.00 ± 0.42	11.31 ± 0.41^{cd}	3.08 ± 0.40^{b}	0.64 ± 0.06^{c}
WW2	7.25 ± 0.007^{g}	44.20 ± 0.85^{f}	25.80 ± 0.42	15.07 ± 0.14^{e}	25.34 ± 0.20^{f}	2.39 ± 0.37^{g}
WW3	7.06 ± 0.014^{e}	14.50 ± 0.14^{a}	26.20 ± 0.99	8.21 ± 0.04^{ab}	27.22 ± 0.04^{g}	2.38 ± 0.25^{g}
WW4	7.15 ± 0.014^{f}	51.25 ± 1.48^{g}	25.75 ± 0.49	12.96 ± 0.53^{de}	47.74 ± 0.19^{i}	2.07 ± 0.02^{f}
WW5	6.95 ± 0.00^{d}	34.20 ± 0.57^{cd}	26.35 ± 0.78	20.01 ± 0.41^{f}	8.26 ± 0.19^{d}	1.44 ± 0.13^{e}
WW6	6.63 ± 0.07^{b}	42.90 ± 0.57^{f}	26.30 ± 1.13	18.67 ± 0.16^{f}	6.86 ± 0.19^{c}	1.05 ± 0.02^{d}
WW7	7.04 ± 0.01^{e}	35.75 ± 1.34^{de}	26.20 ± 1.27	6.98 ± 0.06^{a}	17.22 ± 0.20^{e}	0.24 ± 0.06^{a}
WW8	7.54 ± 0.007^{i}	55.45 ± 2.62^{h}	25.85 ± 0.35	14.21 ± 0.41^{de}	3.64 ± 0.39^{b}	0.55 ± 0.11^{bc}
WW9	7.37 ± 0.007^{h}	37.35 ± 1.20^{e}	25.95 ± 0.49	7.53 ± 0.007^{a}	3.06 ± 0.02^{b}	1.64 ± 0.06^{e}
WW10	7.66 ± 0.01^{j}	34.95 ± 0.49^{de}	26.15 ± 0.92	19.14 ± 0.82^{f}	0.87 ± 0.04^{a}	0.35 ± 0.06^{abc}
WW11	7.54 ± 0.007^{i}	30.10 ± 0.28^{b}	26.35 ± 0.92	10.47 ± 0.04^{bc}	0.81 ± 0.00^{a}	0.17 ± 0.007^{a}
WW12	7.32 ± 0.02^{gh}	31.85 ± 0.78^{bc}	25.85 ± 0.35	11.47 ± 0.18^{cd}	0.49 ± 0.01^{a}	0.32 ± 0.03^{abc}
CWW3	$6.47 \pm .0.13^{a}$	33.05 ± 0.49^{cd}	26.05 ± 0.49	14.79 ± 0.51^{e}	34.16 ± 0.79^{h}	0.20 ± 0.007^{a}
P-Value	0	0	0.999	0	0	0
WHO	6.5 – 8.5	500	25	10	250	50
FAO	6.5 – 8.5	3000	-	-	-	-

Table 3: Results of Water Physicochemical Parameters during Dry Season

Sample Codes	**pH**	**EC** μScm^{-1}	**Temp** **^{0}C**	**NO$_3$** **mg/L**	**SO$_4$** **mg/L**	**PO$_4$** **mg/L**
DW1	6.89 ± 0.12^{f}	18.21 ± 0.09^{i}	32.40 ± 0.06	12.97 ± 0.03^{d}	0.001 ± 0.00^{a}	4.34 ± 0.04^{j}
DW2	6.10 ± 0.06^{cd}	9.62 ± 0.08^{h}	33.60 ± 1.01	17.04 ± 0.16^{g}	27.00 ± 0.90^{f}	1.14 ± 0.001^{c}
DW3	6.20 ± 0.08^{d}	9.44 ± 0.11^{f}	32.50 ± 0.21	8.86 ± 0.09^{b}	30.00 ± 0.13^{g}	1.57 ± 0.001^{d}
DW4	5.60 ± 0.10^{ab}	8.79 ± 0.13^{e}	33.40 ± 0.21	16.80 ± 0.14^{g}	54.00 ± 1.21^{h}	0.41 ± 0.001^{b}
DW5	5.60 ± 0.12^{ab}	3.02 ± 0.08^{b}	34.60 ± 0.14	22.65 ± 0.11^{k}	8.00 ± 0.09^{d}	1.74 ± 0.002^{ef}
DW6	6.10 ± 0.10^{cd}	3.61 ± 0.08^{c}	34.10 ± 0.21	20.00 ± 0.14^{h}	8.00 ± 0.09^{d}	0.41 ± 0.001^{b}
DW7	6.20 ± 0.15^{d}	3.65 ± 0.08^{c}	33.40 ± 1.38	8.17 ± 0.23^{a}	19.00 ± 0.10^{e}	0.001 ± 0.00^{a}
DW8	5.40 ± 0.18^{a}	3.94 ± 0.07^{d}	34.40 ± 1.13	14.62 ± 0.31^{e}	0.001 ± 0.00^{a}	3.23 ± 0.09^{i}
DW9	5.30 ± 0.18^{a}	3.07 ± 0.10^{b}	33.40 ± 1.34	8.51 ± 0.43^{b}	0.001 ± 0.00^{a}	1.85 ± 0.03^{g}
DW10	5.80 ± 0.32^{b}	3.05 ± 0.12^{b}	33.70 ± 0.43	20.98 ± 0.36^{i}	1.00 ± 0.00^{b}	1.12 ± 0.001^{c}
DW11	5.50 ± 0.21^{ab}	2.66 ± 0.10^{a}	34.10 ± 1.65	11.39 ± 0.33^{c}	0.003 ± 0.00^{a}	1.76 ± 0.003^{f}
DW12	5.40 ± 0.33^{a}	2.83 ± 0.13^{a}	33.60 ± 1.78	11.67 ± 1.04^{c}	0.004 ± 0.001^{a}	2.26 ± 0.05^{h}
CDW3	6.54 ± 0.18^{e}	12.54 ± 0.17^{h}	32.50 ± 0.34	16.09 ± 0.19^{f}	7.00 ± 0.12^{c}	1.69 ± 0.06^{e}
P-Value	0	0	0.156	0	0	0
WHO	6.5 – 8.5	500	25	10	250	50
FAO	6.5 – 8.5	3000	-		-	

*Source: Akpan-Idiok*et al*. [15]

Electrical Conductivity (EC)

EC values of the water samples collected during the dry season ranged from 2.66 to18.21 µS/cm, with the lowest EC value recorded in DW11 while the highest EC value recorded in DW1. In the water samples collected during the wet season, the EC values ranged from 14.50 to 255.50 μScm^{-1}, with sample WW3 having the lowest EC value while sample WW1 had the highest EC value. The conductivity values obtained in this study were within the WHO permissible limit (500µS/cm) for quality drinking water. Tahmina *et al*. discovered that the average EC values in two different seasons (wet and dry seasons respectively) were 1568.75 and 1376.25 mS/cm [20]. The high EC values recorded in sample WW1 could be linked to higher concentration of inorganic materials and this could be adduced to the steel foundry in the study area resulting in the discharge of effluents into the environment and subsequently leached down to groundwater.

Temperature

Water temperature in dry season ranged between 32.40 to 33.70 °C, with the least temperature measured at DW1 and the highest measured at DW10 while the water temperature in wet season ranged between 25.75 to 26.35°C, with the least temperature measured at WW4, the highest measured at WW5 (Tables 1 and 2). The temperature values obtained were within the World Health Organization limit acceptable for aquatic life and household activities, including drinking purposes [10]. Afrin et al. reported that the temperature of the Turag River ranged from 23.20 ^{o}C to 31.90 ^{o}C from January to March, which agreed with the findings of this study [17]. Temperature variation of water in this study may not act as a limiting factor for the survival of aquatic populations and the biotic community [6, 18].

Nitrate

The nitrate concentrations in the analysed water samples collected during the dry season ranged from 8.17 to 22.65 mg/L, with the lowest nitrate concentration found in sample DW7 while the highest nitrate concentration was found in sample DW5. In the wet season, the nitrate concentration ranged from 6.98 to 20.01 mg/L, with sample WW7 having the lowest nitrate concentration while sample WW5 had the highest nitrate concentration as observed in Tables 1 and 2. Most of the nitrate values obtained in this study was found to exceed the WHO permissible limit (10 mg/L) of nitrate in quality drinking water. High nitrogen water can be used as a fertilizer early in the season. However, as the nitrogen needs of the crop diminish later in the growing season, the nitrogen applied to the crop must be substantially reduced. High nitrate concentrations in the analysed water samples could indicate pollution from food processing, agriculture and domestic sources and elevated levels in nitrate concentration could result in the delayed reactions to light and sound stimuli, thereby causing methemoglobinemia [21].

Sulphate

The sulphate concentrations in the analysed water samples was found to range from 0.001 to 54 mg/L in the dry season, with the lowest sulphate concentration recorded in samples DW1, DW8 and DW9 while sample DW4 had the highest sulphate concentration. In the wet season, the sulphate concentrations ranged from 0.49 to 47.74 mg/L (with sample WW12 having the lowest sulphate concentration while WW4 had the highest sulphate concentration). The sulphate concentrations obtained in this study were within the WHO permissible limit for sulphate in water (250 mg/L).

Phosphate

Phosphate concentrations in the analysed water samples ranged from 0.001 to 4.34 mg/L while in the wet season, the phosphate concentrations ranged from 0.17 to 2.39 mg/L as observed in Tables 1 and 2. The phosphate concentrations obtained in this study was within the WHO permissible limit (50 mg/l) of phosphate in water. Phosphates are essential nutrients to plants life, but in high concentration, it leads to algae bloom (stimulation of excessive plant growth) and this indicates the pollution of the water body [21].

Tables 4 and 5 show the physicochemical parameters (COD, BOD, DO, hardness, TDS and turbidity) recorded for dry and wet seasons respectively.

Table 4: Results of Water Physicochemical Parameters during Wet Season

Sample Codes	COD mg/L	BOD mg/L	DO mg/L	Hardness (mg/L)	TDS (mg/L)	Turbidity NTU
WW1	29.00 ± 1.41^{ef}	1.17 ± 0.00^{i}	4.87 ± 0.04^{h}	166.0 ± 2.82^{f}	171.0 ± 1.41^{h}	0.13 ± 0.01^{a}
WW2	26.00 ± 0.00^{d}	0.22 ± 0.007^{a}	3.28 ± 0.01^{a}	192.4 ± 0.57^{h}	28.70 ± 0.85^{d}	73.5 ± 0.85^{g}
WW3	18.00 ± 0.00^{b}	0.32 ± 0.02^{b}	4.18 ± 0.01^{g}	205.7 ± 0.98^{i}	68.95 ± 0.21^{g}	11.75 ± 0.21^{f}
WW4	35.00 ± 1.41^{g}	0.47 ± 0.00^{c}	3.29 ± 0.02^{ab}	29.20 ± 1.69^{b}	32.55 ± 0.92^{e}	273.9 ± 1.27^{h}
WW5	25.00 ± 1.41^{d}	1.08 ± 0.00^{h}	3.62 ± 0.13^{e}	190.8 ± 1.69^{h}	21.90 ± 0.71^{b}	0.14 ± 0.02^{a}
WW6	41.00 ± 1.41^{i}	1.02 ± 0.02^{g}	3.56 ± 0.08^{de}	180.6 ± 0.84^{g}	27.45 ± 0.49^{d}	1.21 ± 0.03^{b}
WW7	27.00 ± 1.41^{de}	0.77 ± 0.007^{e}	3.51 ± 0.04^{de}	54.00 ± 2.82^{d}	23.70 ± 0.57^{c}	0.23 ± 0.01^{a}
WW8	30.00 ± 0.00^{f}	1.73 ± 0.007^{k}	3.40 ± 0.01^{bc}	12.40 ± 0.57^{a}	35.45 ± 1.06^{e}	1.72 ± 0.03^{bc}

WW9	21.00 ± 1.41^{c}	0.93 ± 0.00^{f}	3.57 ± 0.05^{de}	13.00 ± 1.41^{a}	23.75 ± 0.78^{c}	4.51 ± 0.14^{d}
WW10	59.00 ± 1.41^{j}	0.34 ± 0.007^{b}	3.47 ± 0.01^{cd}	103.0 ± 1.41^{e}	22.40 ± 0.58^{bc}	2.28 ± 0.08^{c}
WW11	35.00 ± 1.41^{g}	0.71 ± 0.007^{d}	3.76 ± 0.04^{f}	167.4 ± 0.85^{f}	19.30 ± 0.42^{a}	2.36 ± 0.06^{c}
WW12	38.00 ± 0.00^{h}	1.43 ± 0.02^{j}	3.75 ± 0.06^{f}	193.0 ± 1.41^{h}	20.00 ± 0.14^{a}	1.88 ± 0.07^{bc}
CWW3	15.00 ± 1.41^{a}	1.07 ± 0.04^{h}	4.84 ± 0.01^{h}	44.60 ± 0.85^{c}	21.60 ± 0.42^{b}	6.66 ± 0.05^{e}
P-Value	0	0	0	0	0	0
*WHO		6.0	5	500	500	5
*FAO	10	4.5	-	-	2000	35

Table 5: Results of Water Physicochemical Parameters during Dry Season

Sample Codes	COD mg/L	BOD mg/L	DO mg/L	Hardness (mg/L)	TDS (mg/L)	Turbidity NTU
DW1	$.003\pm0.001^{a}$	1.22 ± 0.002^{a}	4.32 ± 0.05^{a}	44.00 ± 1.23^{j}	11.20 ± 0.06^{h}	3.39 ± 0.04^{a}
DW2	11.00 ± 0.13^{b}	2.22 ± 0.001^{d}	5.42 ± 0.03^{b}	12.00 ± 0.11^{e}	5.18 ± 0.04^{e}	2.06 ± 0.003^{a}
DW3	70.00 ± 1.34^{f}	3.88 ± 0.04^{j}	7.28 ± 0.08^{ef}	13.00 ± 0.12^{f}	5.36 ± 0.07^{f}	712 ± 12.96^{d}
DW4	44.00 ± 1.13^{c}	1.63 ± 0.003^{b}	6.03 ± 0.21^{c}	8.00 ± 0.09^{c}	4.93 ± 0.13^{d}	36.40 ± 0.21^{c}
DW5	0.002 ± 0.001^{a}	3.55 ± 0.04^{i}	7.35 ± 0.09^{ef}	1.00 ± 0.00^{a}	1.13 ± 0.003^{b}	1.88 ± 0.002^{a}
DW6	64.00 ± 2.10^{e}	2.38 ± 0.03^{e}	6.28 ± 0.09^{cd}	12.00 ± 0.06^{e}	1.56 ± 0.001^{c}	0.76 ± 0.001^{a}
DW7	73.00 ± 2.19^{g}	2.84 ± 0.06^{f}	7.04 ± 0.08^{ef}	12.50 ± 0.09^{ef}	1.53 ± 0.001^{c}	1.18 ± 0.001^{a}
DW8	68.00 ± 2.34^{f}	2.77 ± 0.09^{f}	6.77 ± 0.24^{de}	15.50 ± 0.34^{g}	1.59 ± 0.02^{c}	0.62 ± 0.05^{a}
DW9	68.00 ± 2.37^{f}	3.24 ± 0.08^{h}	7.44 ± 0.32^{ef}	20.00 ± 0.54^{i}	1.14 ± 0.002^{b}	1.02 ± 0.001^{a}
DW10	60.00 ± 2.21^{d}	3.46 ± 0.08^{i}	7.56 ± 0.10^{f}	18.50 ± 0.18^{h}	1.17 ± 0.001^{b}	0.82 ± 0.002^{a}
DW11	$.003\pm0.001^{a}$	3.04 ± 0.04^{g}	7.64 ± 0.11^{f}	9.00 ± 0.20^{d}	0.88 ± 0.001^{a}	1.02 ± 0.003^{a}
DW12	$.005\pm0.001^{a}$	2.11 ± 0.06^{c}	9.11 ± 1.33^{g}	5.00 ± 0.83^{b}	0.99 ± 0.11^{a}	0.74 ± 0.09^{a}
CDW3	$.006\pm0.001^{a}$	4.20 ± 0.11^{j}	8.50 ± 0.21^{g}	12.00 ± 0.19^{e}	8.40±0.13g	14.22 ± 0.21^{b}
P-Value	0	0	0	0	0	0
WHO		6.0	5	500	500	5
FAO	10	4.5	-	-	2000	35

Chemical Oxygen Demand (COD)

The COD concentrations in the analyzed water samples collected during the dry season ranged from 0.002 to 73.00 mg/L (sample DW5 had the lowest COD value while sample DW7 had the highest COD concentration). During the wet season, the COD concentrations ranged from 15 to 59 mg/L (with a lowest COD concentration recorded in sample CWW while sample WW10 had the highest COD concentration). The COD concentrations were found to exceed the WHO permissible limit (10 mg/L) of COD in water. The Chemical Oxygen Demand is a measure of the oxygen equivalent of that portion of the organic matter in a sample that is susceptible to oxidation by a strong chemical oxidant [22]. High COD concentrations could be due to the industrial and municipal discharge loads into the environment and the water body. In the dry season (summer), the water flow declines, and therefore the growth of microorganisms increases profoundly, providing another potential source of the high COD values [23]. In addition, organic chemical industries, pesticide industries, distilleries and dyeing factories could deteriorate the COD pollution in water body [24].

Biochemical Oxygen Demand (BOD)

The measured BOD values in the analysed water samples collected during the dry season ranged from 1.22 to 4.20 mg/L with sample DW1 having the lowest BOD value while sample CDW had the highest BOD value. In the wet season, the BOD value ranged from 0.22 to 1.73 mg/L, with sample WW2 having the lowest BOD value while WW8 sample had the highest BOD value. The BOD values obtained were within the WHO permissible limit (6 mg/L) of BOD in water. Ahmed *et al*. recorded the highest BOD_5concentration of 31 mg/L at the Tongi Station in the Turag River [18]. Aktar *et al*., recorded a BOD_5 concentration of 13 to 73 mg/L near a major industrial area [26] and Ogundele and Mekuleyi reported BOD as 227.5 ± 14.90 mg/L - 294.10 ± 19.85mg/L for waste water discharged from two industries in Agbara, Lagos State, Nigeria [22]. The findings of this study are found to be in contrast to those of previous studies. The highBOD_5 levels indicates the presence of excessive bacteria/microorganisms in the water, which might come from industrial and domestic wastewater that consumed the dissolved oxygen with increased biochemical oxygen demand in the river water [18,26].

Dissolved Oxygen (DO)

The DO concentration in the analysed water samples collected during the dry season ranged from 4.32 to 9.11 mg/L while the DO concentrations in the water samples collected during the wet season ranged from 3.28 to 4.87 mg/L. The DO values obtained were above the WHO permissible limit (3mg/L) of DO in water. Rahman *et al*. recorded a very low DO value in an urban river of Bangladesh [27]. Okoya and Elufowo obtained much higher DOs values than obtained in this study [28]. Low DO values do not bolster the survival of aquatic life [29]. Dissolved oxygen is required for respiration by most aquatic animals. In addition, it combines with other important elements such as carbon, sulphur, nitrogen and phosphorous to form carbonates, sulphates, nitrates and phosphates, which constitute the required compounds for the survival of aquatic organisms [19]. The diminishment of DO might result from the industrial wastewater discharged as well as the municipal waste loads, which require a higher level of oxygen for chemical oxidation and decomposition [7]. Excess DO in water bodies can cause emphysema (external bubbles), a rare condition that affects the skin and other tissues [28].

Total Hardness (TH)

The TH values obtained in the water samples collected during the dry season ranged from 1 to 44 mg/L with sample DW5 having the lowest TH value while sample DW1 had the highest TH value. However, the TH values recorded in the water samples collected during the wet season ranged from 12.40 to 205.7 mg/L (with the lowest value recorded in sample WW8 while the sample WW12 had the highest TH value). The TH values obtained were within the WHO permissible limit (500 mg/L). Aja *et al.*, classified the river water as soft (<75 mg/L), moderately hard (75 to 150 mg/L), hard (150 to 300 mg/L), and very hard (>300 mg/L) [30]. According to these criteria, the water samples could be regarded as soft in the dry season and hard in the wet. High TH could be an indication that the water is not suitable for different household activities and drinking.

Total Dissolved Solids (TDS)

The TDS values in the analyzed water samples collected during the dry season ranged from 0.88 to 11.20 mg/L while the TDS values in water samples collected during the wet season ranged from 19.3 to 171 mg/. The TDS values obtained were within the WHO permissible limit (500 mg/L) of TDS in drinking water. In a related study carried out by Alexandra *et al.* in Ghana, the study recorded mean TDS concentration in the analyzed water samples to be 172 mg/L[31]. According to Moniruzzaman *et al.*, TDS concentration of the Buriganga River water ranged from 167 to 435 mg/L [32]. This study presented mostly higher TDS during the summer than winter seasons. The dry season's higher TDS readings could be attributed to the high concentration of dissolved solids.

Turbidity

The turbidity of the water samples collected during dry season ranged from 0.62 to 712 NTU while the turbidity value in the water samples during the wet season ranged from 0.13 to 273.9 NTU. The turbidity values obtained in the analysed water samples were within the WHO permissible limit for quality water. Bhuiyan *et al*. found that the highest mean turbidity of the Bangladesh River water was 27.41 NTU [26]. The present study showed higher values. Musa *et al.*, reported that turbidity describes the cloudiness of water caused by suspended particles such as clay and silts, chemical precipitates such as manganese and iron, and organic particles such as plant debris and organisms [33]. Turbidity affects water hardness when the source of turbidity is inorganic particles released from weathering of rocks, soils and clays [16].

Table 6: Correlation among all Water Quality Parameters

	pH	EC	Temp	Nitrate	Sulphate	Phosphate	COD	BOD	DO	Hardness	TDS	Turbidity
pH	1	-0.296	-0.201	-0.125	-0.378	-0.033	0.461	-0.138	-.618(*)	-0.146	-0.323	0.035
EC		1	-0.175	-0.072	-0.193	-0.137	-0.006	0.25	.532(*)	0.093	.918(**)	-0.04
Temp			1	0.173	-0.328	-0.263	0.074	-0.104	0.148	0.386	-0.09	-.531(*)
Nitrate				1	-0.082	-0.036	0.451	0.046	-0.17	0.218	-0.21	0.008
Sulphate					1	.505(*)	-0.4	-0.458	0.053	-0.23	-0.086	.736(**)
Phosphate						1	-0.328	-.527(*)	-0.277	0.192	0.051	.502(*)
COD							1	-0.119	-0.417	0.105	-0.144	0.061
BOD								1	0.212	-0.202	0.1	-0.386
DO									1	0.144	.626(*)	-0.331
Hardness										1	0.229	-0.27
TDS											1	-0.073
Turbidity												1

*Correlation is significant at the 0.05 level (1-tailed), **Correlation is significant at the 0.01 level (1-tailed).

Table 6 shows the correlation coefficients (r) of all studied parameters at p = 0.05 and 0.01. Water temperature had a negative correlation with turbidity (r = -0.531). Temperature did not show any noticeable relationship with other studied parameters. pH has strong negative correlation with DO (r = -0.146) and pH did not significantly correlate with other parameters except COD and Turbidity. DO showed negative correlation with most of the parameters except EC, temperature, sulphate and BOD. TDS showed a very strong correlation with EC with correlation value of 0.918. Turbidity showed a strong correlation with sulphate (r = 0.736) and phosphate (r = 0.502). Sulphate was averagely correlated with phosphate with correlation value of 0.505. TDS showed a good correlation with DO (r = 0.626).High correlations of some of these physicochemical parameters values could mean that they could come from the same sources, mainly from anthropogenic sources [34].

CONCLUSION

The seasonal variations of the assessment of the physicochemical parameters revealed that the water quality parameters showed significant ($p \leq 0.05$) variations among the different sources, except for the temperature. The temperature, nitrate, and DO were the only physicochemical parameters of the sources that were over the WHO and FAO guidelines for drinking and irrigation water usage (dry season). It might be concluded that anthropogenic activity, in this case metalworking around the examined location, may be the primary cause of the water pollution (high COD values).According to the findings, the overall contamination level for some of the physicochemical characteristics was below the allowable limit for drinking water. However, compared to the wet season results, the physicochemical parameters were higher in the dry season. The results of the physicochemical parameters indicated that the water samples under study were not significantly polluted, indicating that the pollution levels of the water samples were likely to alter owing to seasonal variations. The study found that while the water is appropriate for irrigation, it should be treated before being used for drinking, entertainment, or aquatic life.

REFERENCES

1. United Nations (UN) (2016). Sustainable Development Goals; Goal 6: Ensure access to water and Sanitation for all. UN News Centre.
2. Jin, G.Q., Xu, J., Mo, Y.M., Tang, H.W., Wei, T., Wang, Y.G. & Li, L. (2020). Response of sediments and phosphorus to catchment characteristics and human activities under different rainfall patterns with Bayesian Networks. *J. Hydrol.*, 584. https://doi.org/10.1016/j.jhydrol.2020.124695
3. Uddin, M.J. & Jeong, Y.K. (2021). Urban river pollution in Bangladesh during last 40 years: Potential public health and ecological risk, present policy, and future prospects toward smart water management. *Heliyon*, 7(2), e06107. https://doi.org/10.1016/j.heliyon.2021.e06107

4. Vega, M., Pardo, R., Barrado, E. & Deban, L. (1998). Assessment of seasonal and polluting effects on the quality of river water by exploratory data analysis. *Water Res*., 32(12), 3581e3592. https://doi.org/10.1016/S0043-1354(98)00138-9.
5. Islam, J.B., Akter, S., Bhowmick, A.C., Uddin, M.N. & Sarkar, M. (2018). Hydro-environmental pollution of Turag River in Bangladesh. *Bangladesh J. Sci. Ind. Res*., 53(3), 161-168.
6. Islam, M.S., Afroz, R. & Bodruddoza, M. (2019). Investigation of surface water quality of the Buriganga River Bangladesh: Laboratory and spatial analysis approaches. *Dhaka Univ. J. Biol. Sci*., 28(2), 147-158.
7. Whitehead, P.G., Bussi, G., Hossain, M.A., Dolk, M., Das, P., Comber, S., Peters, R., Charles, K.J., Hope, R. & Hossain, S. (2018). Restoring water quality in the polluted Turag-Tongi-Balu river system, Dhaka: Modelling nutrient and total coliform intervention strategies. *Sci. Total Environ*., 631e632, 223-232.
8. Ogiji Map/ Nigeria Satellite Maps - Maplandia(http://wikiedit.org/Nigeria/Ogijo/2421820/retrieved June, 2021).
9. American Public Health Association (APHA) (2017) (Jointly Published by American Water Works Association (AWWA) and Water Environment Federation (WEF).Standard Methods for the Examination of Water and Wastewater, 23rd Edition
10. Boyd, C. E. (1981).Water Quality in Warm Water Fish Ponds. Alabama Agricultural Experimental Station, Auburn University, Alabama, 358.
11. APHA (2005) Standard Methods for the Examination of Water and Wastewater, 21st edition .Amr. Pub. Health Assoc. Washington DC, 1368p.
12. American Public Health Association (APHA). (2012). Standard methods for the examination of water and wastewater.20th edn, American Public Health Association, Washington DC,
13. Norgate, T., Jahanshahi, S. & Rankin, W. (2006). Assessing the environmental impact of metal production processes”. *Journal of Cleaner Production,* 15(8-9). 838-848.
14. Ademoroti C.M.A (1996). *Environmental Chemistry and Toxicology*, Foludex Press Limited, Ibadan, 44-47.

15. Akpan-Idiok, A.U., Ibrahim, A. & Udo I.A. (2012). Water Quality Assessment of Okpauku River for Drinking and Irrigation Uses in Yala, Cross River State, Nigeria. *Research Journal of Environmental Sciences, 6: 210-221.* **DOI:** 10.3923/rjes.2012.210.221
16. WHO, (2017). Guidelines for Drinking Water Quality, Fourth Edition, incorporating the First Addendum, Geneva, World Health Organization.
17. Afrin, R., Mia, M.Y., Ahsan, M.A., Akbor, M.A. & Akter, S. (2015). Status of water pollution in respect of physicochemical parameters and anions in the Turag River of Bangladesh. *Bangladesh J. Environ. Sci*., 28, 113-118.
18. Whitehead, P.G.,Wilby, R.L., Battarbee, R.W., Kernan, M. & Wade, A.J. (2009). A review of the potential impacts of climate change on surface water quality. *Hydrol. Sci. J*., 54(1), 101-123.
19. Ahmed, K., Rahman, A., Sarkar, M., Islam, J., Jahan, I., Moniruzzaman, M. & Bhoumik, N. (2016). Assessment on the level of contamination of Turag River at Tongi area in Dhaka. *Bangladesh J. Sci. Ind. Res*., 51(3), 193e202.
20. Jenyo-Oni, A. & Oladele A. H. (2016). Heavy Metals Assessment in Water, Sediments and Selected Aquatic Organisms in Lake Asejire, Nigeria. *European Scientific Journal*, 12(24): 339 – 351.
21. Tahmina, B., Sujan, D., Karabi, R., Hena, M.K.A., Amin, K.R. & Sharmin, S. (2018). Assessment of surface water quality of the Turag River in Bangladesh. *Res. J. Chem. Environ*., 22(2), 49-56.
22. Kuforiji, T.S., & Ayandiran, T.A. (2013). Study of heavy metals pollution and physico-chemical assessment of water quality of River Owo, Agbara, Nigeria. *Int. J. Water Res. Environ. Eng*., 5(7):434-341.
23. Ogundele1 O. & Mekuleyi, G. O. (2018). Physico-chemical properties and heavy metals concentration in waste water discharged from two industries in Agbara, Lagos State, Nigeria. *International Research Journal of Public and Environmental Health,* .5 (3),. 32-37
24. Sarkar, M., Islam, J.B. & Akhter, S. (2016). Pollution and ecological risk assessment for the environmentally impacted Turag River. Bangladesh. *J. Mater. Environ. Sci*., 7(7), 2295-2304.

25. Sharma, B.K. (2003). Environmental Chemistry. GOEL Publishing House, Meerut.
26. Aktar, P., Moonajilin, M.S., & Sabrina, M. (2017). Assessment of water quality status of Turag River due to industrial effluent. *Int. J. Eng. Inform. Syst.*, 1(6), 105-118.
27. Hasan, M.K., Shahriar, A. & Jim, K.U. (2019). Water pollution in Bangladesh and its impact on public health. *Heliyon*, 5(8), e02145. https://doi.org/10.1016/j.heliyon.2019.e02145.
28. Rahman, A., Jahanara, I.& Jolly, Y.N. (2021). Assessment of physicochemical properties of water and their seasonal variation in an urban river in Bangladesh. *Water Science and Engineering*, 14(2), 139-148.
29. Okoya, A. A & Elufowoju, M. A. (2020). Seasonal assessment of the physicochemical of grondwater in some villages around an iron and steel recycling industries Southwestern Nigeria. *American Journal of Water Resources*, 8 (4), 164 - 172
30. Uddin, M.J. & Jeong, Y.K. (2021). Urban river pollution in Bangladesh during last 40 years: Potential public health and ecological risk, present policy, and future prospects toward smart water management. *Heliyon*, 7(2), e06107. https://doi.org/10.1016/j.heliyon.2021.e06107
31. Ajai, A I., Jacob, J O., Ndamitso, M M. & Abdulgafar, J. (2011). Physicochemical Characteristics and Trace Metal Levels of Locally Dug Wells in Tunga Area of Minna, Nigeria. *J. Appl. Sci. Environ. Manage*, 15 (2), 247 – 250
32. Alexandra K., Jeanine D.D, Kenneth, C. & Karen K. (2017). Physicochemical Parameters Affecting the Perception of Borehole Water Quality in Ghana. *International Journal of Hygiene and Environmental Health*, 220 (6), DOI: 10.1016/i.jheh.2017.05.008
33. Moniruzzaman, M., Elahi, S.F. & Jahangir, M.A.A. (2009). Study on temporal variation of physicochemical parameters of Buriganga River water through GIS (Geographical Information System) technology. *Bangladesh J. Sci. Ind. Res.*, 44(3), 327e334.
34. Bhuiyan, M.A.H., Rakib, M.A., Dampare, S.B., Ganyaglo, S. & Suzuki, S. (2011). Surface water quality assessment in the central part of Bangladesh using multivariate analysis. *KSCE J. Civ. Eng.*, 15(6), 995-1003.
35. Musa D. M., Garba, Y.I., Yusuf, M.S. & Ishaq, A. (2018). Assessment of Water Quality for Selected Boreholes and Sachets Water in Maigatari Town, Jigawa State, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 11(2),122 – 127.