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Seasonal Variation in Water Quality: A Study with Reference to Kuwano River, Balrampur, (U.P.) India

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Abstract

Kuwano River is one of the important rivers flowing through the Balrampur District in the Kuwano forest. Rapid development and urbanization in river catchments have recently been seen in the district, putting pressure on the quality of surface water. The current investigation attempted to ascertain how seasonal variations affected the physicochemical properties of river Kuwano water. The study's seventeen parameters like pH, TDS, EC, DO, BOD, COD, total hardness, ammonia, nitrate, nitrite, phosphate, calcium, magnesium, iron, E. coli, fecal coliform, and total coliform—were all taken into consideration. Health issues arise from the greater microbial content of river water. The study demonstrates that river water quality varies seasonally and is only fit for irrigation and bathing.

Keywords: *Kuwano River, seasonal variation, inorganic nitrogen, microbial parameter, water quality*

Introduction

The complex, metabolically active components of rivers' ecosystems are their waters. In the water system, it controls the influx of contaminants and nutrients [1]. In addition to reflecting their surroundings, the river also serves as a collection point for all of humanity's "sins" [2]. Due to poor management and contaminating practices, India is on the verge of a freshwater disaster, notably in the river system [3]. The system's nutrient load eventually changes ecological productivity by causing the inherent food web to collapse. Groundwater is replenished by rivers, but in the interim, these contaminants may seep slowly into the earth and alter the quality of the water below. Either a chronic lack of access to clean water or the pollution of easily available water resources plagues many parts of the world [4]. A recent UNICEF research estimates that 800 million people in Asia and Africa lack access to clean drinking water. As a result, many people now experience a variety of illnesses [5]. Water-borne diseases brought on by fecal contamination of drinking water have wiped out the whole population of cities [6,7,8,9]. Potential markers of water quality include bacteria and bacteriophages [10]. In Uttar Pradesh, there are issues with river water quality. According to the Directorate of Environment's study, the majority of water quality indicators between 2004 and 2008 are unfavorable. Class B (drinking water with treatment) water is present in Kanpur and Varanasi upstream, whereas class D (fishing) water is present downstream. The majority of rivers' downstream water quality surveys reveal a need for improvement [11].

Balrampur is a district in Uttar Pradesh State of India. In this district, there are 3 Tehsils altogether. The district spans 3,349 square kilometers. Its longitude is 82.3018°C and latitude is 27.4308°N. In this district, there are 6 towns and 1,015 villages. 2,986,645 people are anticipated to live in Balrampur in 2023. The Balrampur district receives 326.27 mm of rain on average each year, and there are 88595.63 hm of groundwater that is accessible. The location is in a sub-humid climate zone. The primary rivers in the district's center and southern regions are the Rapti, Kuwano, and Ghaghara. In addition to these rivers, the region is home to a variety of nalas and ponds. The Bahriach District in the U.P. is where the river Kuwano is born. Before entering Basti District close to Chandhokha village in Ramnagar block, it passes through Gonda and Siddharth Nagar districts. In the Basti district, the tributaries Bisuni, Manvar, and Kathinaya feed Kuwano, which runs from northwest to southeast. It flows over a distance of roughly 55 kilometers inside district boundaries before flowing through, close to Banpur in Kudaraha block. It combines in Ghaghara near the village of Shahpur in the Gorakhpur district. The city depends on the river for its survival. Urban sewage, solid waste, and industrial effluents are all mixed into it as it passes through Basti. Small-scale businesses that produce agricultural tools, iron and wood products, brassware, and other things. These businesses, together with one sugar mills, release garbage into the river every day, either directly or indirectly. These untreated effluents contain a number of dangerous substances that can alter the river's water quality and be hazardous to human health.

Studies on the Kuwano River's water quality have not been thoroughly investigated. Due to input trash composition, the river water quality may fluctuate from time to time and site to site [12]. In order to determine if the water from the Kuwano River is suitable for various uses, it is crucial to regularly test its quality.

Methodology

The water samples from the three selected stations: Upstream at Kuwano river, Midstream at Bhaisahwaghat and Downstream at Lalnagar were collected in replicate (Figure 1). The samples were collected round the year in the Monsoon (September), Winter (January) and summer (May), to obtain data with seasonal variation. The river water samples from different sampling stations were collected in duplicate in two liter capacity polythene containers pre-washed with dilute Hydrochloric acid, detergent, tap water & distilled water. Sampling was carried out manually without adding any preservative, after flushing out at least 2 to 3 minutes. Samples were brought immediately to the laboratory and kept in the refrigerator for further analysis.

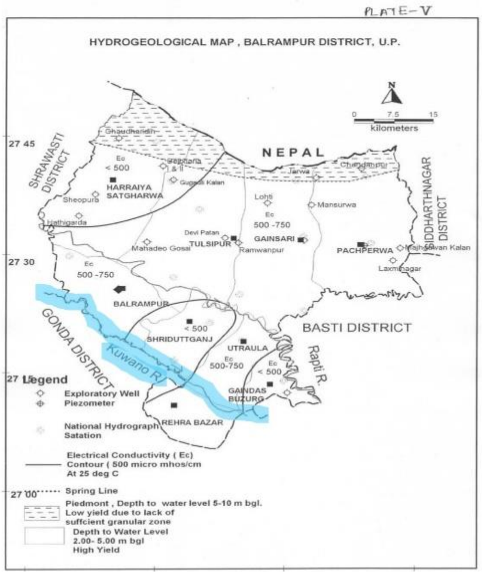

Table 1. Different parameters & assay methods, used in the study.

S.No	Parameters	Unit	Analytical Method
1	pH	-	-
2	TDS	Mg/l	-
3	EC		-
4	DO	Mg/l	Azide Modification
5	BOD	Mg/l	5 Day BOD Test
6	COD	COD	Closed reflux, Calorimeter method
7	Total hardness	-	EDTA titrimetric method
8	Ammonia	NH4-	Calorimeter method
9	Nitrate	N03-	Brucin method
10	Nitrite	NO2-	Sulphanilic acid method
11	Phosphate	PO43-	Ascorbic acid method
12	Calcium	Mg/l	EDTA titrimetric method
13	Magnesium	Mg/l	Calculation method
14	Iron	Mg/l	Phenanthroline method
15	E.coli	MPN	MPN coliform
16	Faecal coliform	MPN	MPN faecal coliform
17	Total coliform	MPN	MPN coliform

+APHA, 2005. [14]. ++Trivedi and Goel, 1984. [13].

The collected water samples were used for analysis of seventeen important parameters. The parameters studied were, pH, TDS, EC, DO, BOD, COD, Total Hardness, Ammonia, Nitrate, Nitrite, Phosphate total, Ca, Mg, Fe, E. Coli, Faecal Coliform and Total Coliform. pH, Temperature, TDS, and EC were analysed on spot by Digital portable meters, the remaining parameters were analysed in the laboratory within twenty-four hours of sample collection (Table 1), following the standard procedure [13,14].

Results and Discussion

pH

The pH is a measure of the acidity of water: the lower the pH, the more acidic is the water. In most natural waters pH values are dependent on carbon dioxide, carbonate, and bicarbonate equilibrium. The pH of water is influenced by geology of the area, buffering capacity of water [15]. The water having pH less < 7 may cause tuberculation and corrosion, while higher the values may produce in crustation, sediment deposit and difficulties in chlorination for disinfection of water [16]. In the study pH in all the sampling locations varied between 7.62 to 7.70 during monsoon, 7.8 to 8.0 during winter and 6.2 to 6.74 during summer (Table 2, Table 3 & Table 4). The fluctuations may be due to variation in water flow and photosynthetic activity of aquatic plants [17].

Total Dissolved Solid

TDS measures the total amount of all inorganic and organic compounds, whether they are in molecular, ionized, or micro-granular suspended form, that are present in a liquid. High solids content water has a poor taste and may cause adverse physiological effects in short-term consumers [18]. The TDS in the current investigation varied from 60.3 to 98.3 mg/l (Table 3). Increased values during the monsoon may result from riverfront operations, soil leaching, sewage discharge, etc. Due to the low water volume in the summer, Moniruzzaman et al. [19] found a higher TDS. The TDS value that was actually measured is within the BIS-mandated acceptable range [20]. The primary element that restricts or decides the use of groundwater is often its TDS content.

Conductance

Temperature, ionic concentration, and the types of ions present in the water are all factors that affect electrical conductivity (EC) [22]. The study's water samples have conductivities that range from 110 to 176 S/cm (Table 3), which meets the BIS requirement. During the monsoon, the downstream sampling sites' EC is higher, which is due to increased residential wastewater outflow and runoff from agricultural lands [23]. The Water level rises and electrolytes increase during monsoon season, increasing value. However, summertime readings were lower. In the whole research area, EC values stay within acceptable bounds.

Oxygen (DO, BOD & COD)

Water's general health can be determined by the amount of oxygen present. Higher oxygen levels, then, presumptively indicate that the water is not heavily polluted. In general, more contamination by organic waste is related to lower oxygen levels. According to Table 3 of the study, DO concentrations range from 3.4 to 6.5 mg/l. Oxygen-demanding wastes could be to blame for the variation [23]. The average value demonstrates that the BIS's smear campaign has failed to protect the water body's health. Wintertime high DO is brought on by a drop in temperature, and the amount of time spent in intense sunlight affects the percentage of soluble gases (O2 & CO2).

Levels of Biochemical Oxygen Demand (BOD) can be used to quantify organic load. The BOD in the current investigation ranged from 1.1 to 2.3 mg/l (Table 3), staying within the permitted limits of 3 mg/l [31]. A winter's worth of high BOD readings is associated with more microbial activity and more oxygen available to them. A higher pollution load during the monsoon season is shown by the study's BOD: COD ratio of 0.33, 0.63, and 0.60 in the monsoon, winter, and summer seasons, respectively [24]. BOD and Chemical Oxygen Demand (COD) have a close relationship. The higher COD value indicates that released effluents have a greater capacity to scavenge oxygen and a greater potential to harm aquatic life. The larger inflow of effluents during the monsoon season is correlated with the higher COD/BOD ratio.

Calcium & Magnesium Hardness

The natural hardness of water depends upon the geological nature of the drainage basin and mineral levels in natural water. It is characterized by the content of calcium and magnesium salts. The total hardness ranged between 84 to 89 mg/l in monsoon, 105 to 117 in winter, and 76 to 78 in summer season (Table 2, Table 3 & Table 4). the calcareous bedrock of the city, and domestic sewage could be the possible cause of hardness in winters. The silicate mineral families including Plagioclase, Pyroxene, and Amphibole among igneous and metamorphic rocks, as well as limestone, dolomite, and gypsum among sedimentary rocks, are the main sources of calcium and magnesium in groundwater. The calcium hardness is recorded at 12.7 to 25.9 mg/l (Table 5) within the study area, highest in winter. The lower values of calcium were observed during the monsoon season due to the dilution effect of rainwater. The concentration of magnesium hardness was observed in the range of 14.7 and 20.9 mg/l (Table 5). The seasonal fluctuation revealed that it was higher in the winter season due to the enrichment of metal. In all seasons, the rise in magnesium is somewhat inversely correlated with the rise in calcium.

Inorganic Nitrogen

For the growth and feeding of plants and animals, nitrogen and phosphorus are necessary, but an excess of some elements in water can have detrimental consequences on human health and the environment. Nitrogen is a nutrient required for plant growth and can be found in the forms of nitrate, nitrite, or ammonium. Because nitrate-containing fertilizers can flow off into water, nitrate can enter the water immediately. Sewage effluent and runoff from land that has had manure applied can both introduce ammonia and organic nitrogen into the water [25]. Shallow aquifers are more susceptible to nitrogen intrusion. There are three main environmental issues caused by inorganic nitrogen pollution in aquatic ecosystems: (1) it has a limited capacity to neutralize acid, increasing the concentration of hydrogen ions in freshwater environments, which causes those systems to become acidified; (2) it can promote or increase the growth, maintenance, and proliferation of primary producers; and (3) it can reach hazardous levels that limit aquatic species' capacity for survival, growth, and reproduction [26]. Numerous nitrogen molecules, including ammonia (0.3-0.04 mg/l), nitrate (0.4-0.9 mg/l), and nitrite (0.3-0.7 mg/l), were detected in the study to have concentrations below the allowable limit.

Table 2. Variation in Physico-chemical and biological parameters of the Kuwano river water in Monsoon season

S.No,	Parameters	Upstream	Midstream	Downstream	Mean
1	pH	7.70	7.65	7.62	7.66
2	Temperature	28.1	28.2	28.5	28.27
3	TDS	88	95	112	98.33
4	EC	171	171	186	176
5	DO	3.8	4.2	4.0	4
6	BOD	0.80	1.2	1.2	1.07
7	COD	3.0	3.4	3.4	3.27
8	TH	84	88	89	87
9	Ammonia	0.05	0.05	0.04	0.05
10	Nitrate	0.22	0.48	0.64	0.45
11	Nitrite	0.21	0.22	0.58	0.34
12	Phosphate	0.30	0.36	0.32	0.33
13	Ca	12.6	12.8	12.8	12.73
14	Mg	17.42	18.34	18.59	18.12
15	Fe	1.22	1.65	1.60	1.49
16	E.coli	62	230	113	135
17	Fecal coliform	220	384	438	347.33
18	Total coliform	340	384	468	397.33

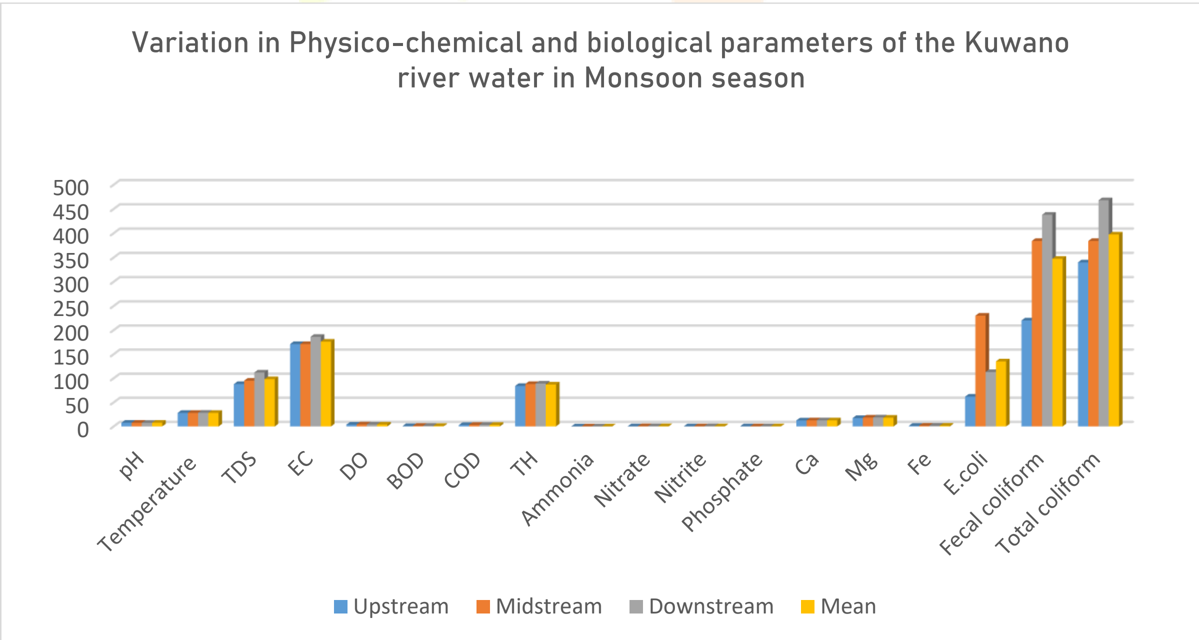

Table 3. Variation in Physico-chemical and biological parameters of the Kuwano river water in Winter season

S.No,	Parameters	Upstream	Midstream	Downstream	Mean
1	pH	7.8	7.8	8.0	7.87
2	Temperature	16	15.5	15.3	15.60
3	TDS	82	88	85	85
4	EC	145	136	122	134.33
5	DO	6.6	6.5	6.5	6.53
6	BOD	2.1	2.4	2.3	2.27
7	COD	3.4	3.5	3.8	3.57
8	TH	105	117	114	112
9	Ammonia	0.34	0.35	0.35	0.35
10	Nitrate	0.82	0.90	1.04	0.92
11	Nitrite	0.64	0.68	0.81	0.71
12	Phosphate	0.36	0.38	0.38	0.37
13	Ca	27.2	25.6	25	25.93
14	Mg	18.9	22.2	21.6	20.90
15	Fe	0.81	0.88	0.95	0.88
16	E.coli	112	117	114	114.33
17	Fecal coliform	204	215	216	211.67
18	Total coliform	302	312	322	312

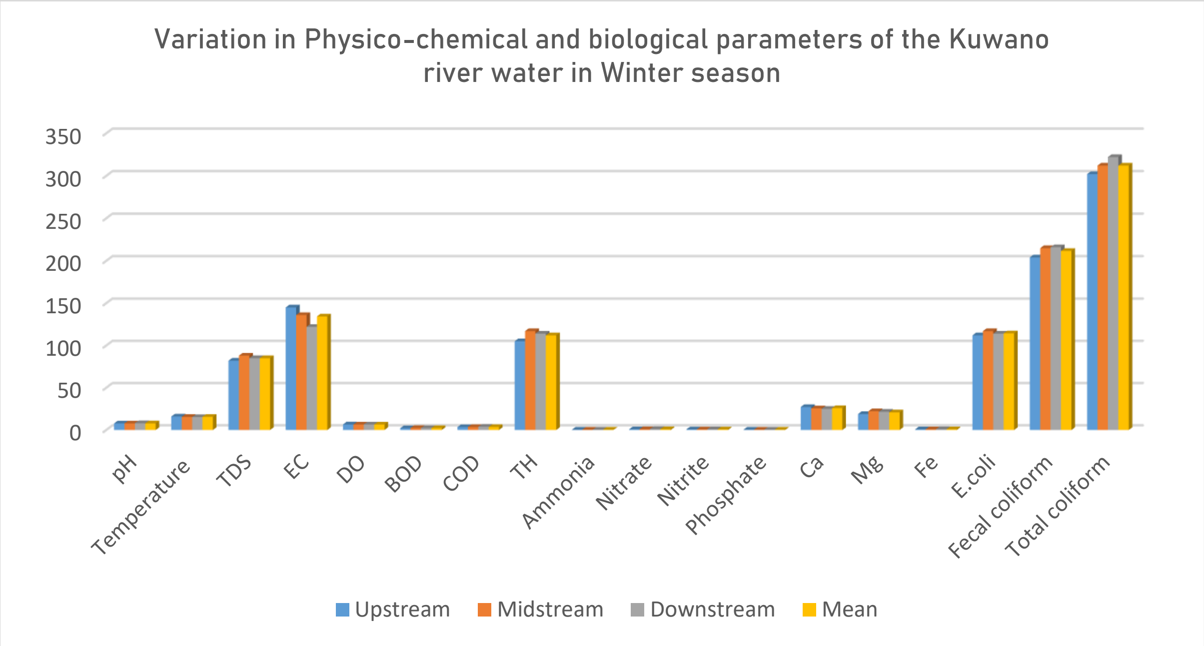

Table 4. Variation in Physico-chemical and biological parameters of the Kuwano river water in summer season

S.No.	Parameters	Upstream	Midstream	Downstream	Mean
1	pH	6.2	6.74	6.7	6.55
2	Temperature	28.8	28.7	28.8	28.77
3	TDS	60	55	66	60.33
4	EC	112	108	110	110
5	DO	3.1	3.2	4.0	3.43
6	BOD	1.8	1.6	1.8	1.73
7	COD	2.8	2.5	3.2	2.83
8	TH	78	76	77	77
9	Ammonia	0.40	0.32	0.32	0.35
10	Nitrate	0.45	0.58	0.70	0.58
11	Nitrite	0.34	0.48	0.65	0.49
12	Phosphate	0.24	0.27	0.26	0.26
13	Ca	17.2	16.12	16.9	16.74
14	Mg	14.8	14.6	14.6	14.67
15	Fe	0.43	0.32	0.26	0.34
16	E.coli	70	136	128	111.33
17	Fecal coliform	240	260	324	274.6
18	Total coliform	260	377	390	342.33

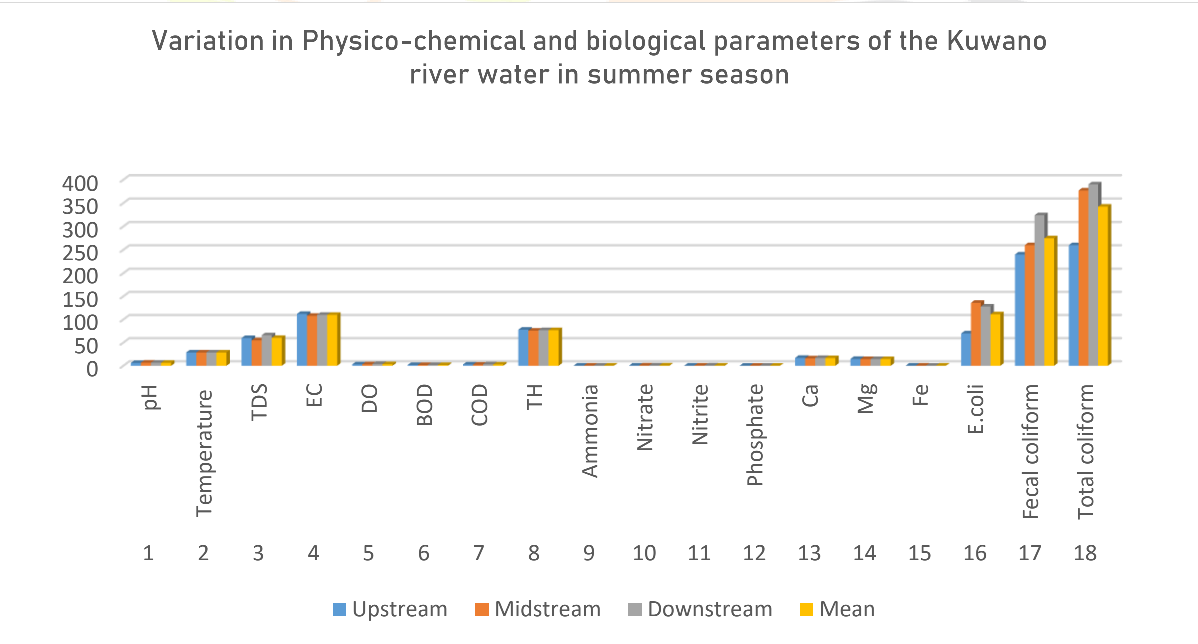

Table 5. Mean ±SD of physicochemical and bacteriological parameters of Kuwano river in seasons

S.No	Parameter	Rainy Season (Mean±SD)	Winter Season (Mean±SD)	Dry Season (Mean±SD)
1	pH	7.7±0.04	7.9±0.09	6.5±0.30
2	Temperature	28.3±0.21	15.6±0.29	28.8±0.06
3	TDS	98.3±12.34	85.0±2.45	60.3±5.51
4	EC	176.0±8.66	134.3±9.46	110.0±2.00
5	DO	4.0±0.20	6.5±0.05	3.4±0.49
6	BOD	1.1±0.23	2.3±0.12	1.7±0.12
7	COD	3.3±0.23	3.6±0.17	2.8±0.35
8	TH	87.0±2.65	112.0±5.10	77.0±1.00
9	Ammonia	0.04±0.01	0.3±0.00	0.3±0.05
10	Nitrate	0.4±0.21	0.9±0.09	0.6±0.13
11	Nitrite	0.3±0.21	0.7±0.07	0.5±0.16
12	Phosphate	0.3±0.03	0.4±0.01	0.3±0.02
13	Ca	12.7±0.12	25.9±0.93	16.7±0.56
14	Mg	18.1±0.62	20.9±1.44	14.7±0.12
15	Fe	1.5±0.24	0.9±0.06	0.3±0.09
16	E.coli	135.0±86.13	123.7±8.50	111.3±36.02
17	Fecal coliform	335.3±113.55	230.0±22.23	277.0±40.88
18	Total coliform	397.3±65.03	312.7±15.17	340.3±72.30

Phosphorus

Fertilizers, agricultural effluents, detergents, and sewage are the main sources of anthropogenic phosphorus [27,28]. Pollution is indicated by an increase in the PO4 concentration. The study's phosphate concentrations, which ranged from 0.3 to 0.4 mg/L at each site, are similarly quite low (Table 5). Because phosphate is adsorbed or fixed as calcium phosphate in alkaline or neutral soils or as aluminium or iron phosphate in acidic soils [29], the concentration of phosphate in surface water is often low.

Iron

Both physicochemical and microbiological factors influence the amount of iron in natural water. The primary sources of iron in groundwater are typically thought to be the weathering of rocks and the discharge of waste effluents on land. The types of aqueous iron species that are present in the water are influenced by its conductance, pH, and dissolved carbon dioxide [29]. Acidic waters, or fluids with a low pH, can contain higher concentrations of iron. Higher quantities typically provide an astringent, bitter, and inky flavour. It can also stain clothing, plumbing fixtures, and pipes by causing scaling. A high concentration could encourage bacterial growth in pipes and service mains, giving the water an unpleasant odour and the red-rod illness. Aeration of fluids containing ferrous iron, however, can result in a decrease in iron content. In the current study, the iron concentration (0.3 - 1.5 mg/l) was within the desired range in all seasons (Tables 5).

Microbial Parameter

Water that contains coliforms has likely been contaminated by human or animal waste. The presence of coliform further raises the probability that other dangerous microbes are present, and it also raises the possibility that sewage has gotten into the water supply [30]. The samples revealed seasonal changes in the concentrations of faecal coliform (278.0 to 335.3) and E. coli (111.3 to 135.0). The total count also demonstrates seasonal variation, with the wintertime minimum (312.7) and summertime maximum (397.3). This may be explained by a larger discharge of contaminants into the city's shallow aquifers from sources such as surface runoff, residential sewage, and septic tanks. This suggests that the river water is polluted and that other contaminants may be present.

Conclusion

The study finds correlation in seasonal variation and Kuwano river water quality. The water quality is not suitable for drinking but qualifies for outdoor bathing (organised), Propagation of wildlife and Fisheries, and irrigation purpose [31].

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