Faculty of Natural and Applied Sciences Journal of Basic and Environmental Research
Print ISSN: 3026-8184
www.fnasjournals.com
Volume 1; Issue 1; March 2024; Page No. 9-16.

Applicability of Water Quality Index in Assessing the Portability of Kaani River in Ogoni Axis of Rivers State, Nigeria

***Anate, S.G., & Edori, O.S.**
Department of Chemistry, Ignatius Ajuru University of Education, Port Harcourt, Nigeria

***Corresponding author email**: anatesumga24@gmail.com

Abstract
Superficial water samples were composed from four locations namely, Maa di Binnise Igbara water side (station 1), mann stream (station 2), woman stream (station 3) and Nwii ke maa kor stream (station 4), along the Ogoni axis of Kaani River and were evaluated for water quality index. Based on several water quality parameters, a water quality index gives a single figure that represents the total water quality at a specific place and time. One of the best ways to inform the public, policymakers, and those involved in water quality management about trends in water quality is through the indices. In contrast to the typical approach of employing physicochemical parameters to evaluate the water quality state of a water body, the weighted arithmetic index method of Ashwani and Anish (2009) was employed in this work for the calculation of the water quality index of the River. The ten most important parameters known to contribute greatly to water quality were considered in the analysis. The observed mean values from the analysis of the physicochemical parameters were; pH 6.56±0.11, EC 158.13±48.25 µS/cm, turbidity 6.08±4.39 NTU, DO 5.29±0.79 mg/l, BOD 5.88±0.78 mg/l, TDS 72.0±20.75 mg/l, TDS 30.88±2.44 mg/l, TA 61.55±4.36 mg/l, TH 49.38±6.73 mg/l and nitrate 0.75±0.35 mg/l respectively. All the tested physicochemical parameters through the locations except turbidity, dissolved oxygen and biochemical oxygen demand fall within the tolerable boundary of WHO (2007). The water quality index value of the Kaani River was 74.038 which indicated that the River has been compromised and is not an excellent source of water suitable for human consumption.

Keywords: Water Quality Index, Physico-Chemical Parameters, Pollution Load, Superficial Water, Kaani River

Introduction

A freshwater body that drains into the Bonny River is the Kaani River, located in the Ogoni axis of Rivers State, Nigeria. The River is bordered to the east by Akwa Ibom State, to the west by Bayelsa State, to the north by the Imo and Abia states, and the south by the Atlantic Ocean. This River is linked by numerous small lakes which may be man-made or natural. These include fish ponds, quarries and streams that flow into it. This expanse is recognized for its enormous freshwater marshlands and temperate rainforest. This river provides the majority of the drinking water for the locals as well as irrigation for plants, animals, and other aquatic life and individuals living in rural areas. Every organism depends on water for survival, but the preservation of water quality and its purity are especially important to the survival of plants animals and humans in particular. Water covers more than 71% of the surface of the earth (Mahananda et al., 2015). As a result, the distribution of water in aquatic settings is unequal. Over 97% of the water in the biosphere is found in the ocean, with the remaining 2% and 1% found in rivers, streams, and creeks beneath the polar ice caps and glaciers, which actively exchange groundwater from waste generated such as agriculture, domestic, industrial and natural sources (Jordan et al., 2018). All these forms are essential in life sequence (Bureau of India Standard, 2005; Casazza et al., 2017)

Surface water contamination may also be ascribed to the natural surroundings of its adjoining water bodies (Casazza et al., 2017). The degree of value water does not exclusively depend on its consumption by humans only, but is relatively, appropriate for other imperative anthropogenic and leisure-based activities (Barakat et al., 2016). The elementary drive for checking the value of water is vital, both as a way to determine its present-day status and as a device for working out good policies for implementation (Kausik et al., 2009). Henceforth, an all-inclusive estimation or analysis of water suggests the consideration of all the mandatory components such as biological, chemical and physical properties of the supposed surficial water in relationship to set criteria, which may perhaps be natural or artificial (man-made) for a definite purpose (Central Public Health Environmental Engineering Organization, 2008).) Straight with a profound perception of the known truth that water adulteration, pollution or impurity is a worldwide pandemic, nonetheless, water pollution differs, subject to the evolving period or phase of the place being investigated. Similarly, nations or provinces with fast rising populaces devoid of proper waste management policies and practices are susceptible to creating more discarded products that will set up irritation within their surroundings when juxtaposed with those countries that have reduced population growth rates and are involved in standard waste management methods and practices (Ihunwo et al., 2018). Accordingly, human-based activities are continuously liable for two things, namely pollution and degradation of the earth's surface. These combined with the coexisting annual rise of flood water traversing the low land, shores of rivers and creeks of the Niger Delta expanse of Nigeria, with the attendant possibility of the region being inclined to drift organisms out of seas, rivers and streams if not properly protected and preserved. Accordingly, these changes present countless jeopardy to streams, creeks rivers and aquatic creatures that live in them. In addition to these is the incessant sand dredging business carried out at Nwii ke ma kor stream and its neighbourhoods that most likely heap up wastes that would in in the short or long run affect these areas. Hence, the necessity to assess the water quality index of the River body to ascertain its integrity and portability to the people of the Kaani community necessitated this work.

Materials and methods

Superficial water samples were composed from Kaani River from four positions namely: Maa di binnise Igbara waterside (station 1), Mann Stream (station 2), Woman Stream (station 3), Nwii ke ma kor stream (station 4) from a distance of 10-15cm under water by glass bottles previously rinsed with dilute nitric acid. The bottles were immediately capped tightly and reserved in a cool box completely filled with ice. The samples were instantaneously relocated to the research laboratory for investigation.

Regular analytical techniques were employed to examine the carefully chosen physical and chemical characteristics of the water. The studied physicochemical considerations were: Total dissolved solids (TDS), total suspended solids (TSS), pH, electrical conductivity (EC), turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), total alkalinity (TA), total hardness (TH), and nitrate. With a portable glass electrode metre, the samples' pH was determined (BIS, 2005). Turbidity and total suspended solids were evaluated using the technique of Uddin and Jeong (2021). A turbidity meter (HACH model 2100An) was applied to determine the level of turbidity. Electrical conductivity was investigated by the use of a conductivity meter. Nitrate values were assessed following the cadmium reduction process [8]. Dissolved oxygen (DO) and biochemical oxygen demand were analyzed by the modified Winkler-azide approach (BIS, 2005). Total dissolved solids (TDS) were measured using the TDS meter (Ashwani & Anish 2009). Total alkalinity and Total hardness were analyzed using titration methods (Irwin, 1997).

Results

Table 1 and Figure 1, respectively, present the findings of the physicochemical parameters of surface water from the Kaani River in the Ogoni axis.

Table 1: Physicochemical characteristics of water samples taken at several sites along the Kaani River.

	Stations					
Parameters	1	2	3	4	Mean±SD	WHO
pH	5.85±0.07	7.0±0.06	6.6±0.21	6.8±0.09	6.56±0.05	8
EC (µS/cm)	140.0±54.0	214.5±41.0	125±50.0	153.0±48.0	158.13±8.03	300
TUR (NTU)	2.63±1.35	4.0±1.9	10.9±3.8	6.8±10.5	6.08±0.89	5
DO (mg/L)	5.15±1.48	5.2±0.54	4.8±1.02	6.0±0.77	5.29±0.79	6
BOD (mg/L)	6.5±1.11	5.5±0.64	5.5±1.01	6.0±0.35	5.88±0.74	5
TDS (mg/L)	72.0±12.0	104.5±23.0	50.0±21.0	61.5±27.0	72.0±6.75	1000
TSS (mg/L)	34.0±2.2	33.0±2.9	30.0±2.25	26.5±2.4	30.88±7.88	500
TA (mg/L)	77.7±4.3	62.0±5.1	52.5±5.43	54.0±2.6	61.55±5.66	100
TH (mg/L)	56.0±7.9	80.0±9.6	36.0±4.4	25.5±5.0	49.38±4.55	100
NO_3^- (mg/L)	0.7±0.15	0.67±0.4	0.71±0.55	0.83±0.3	0.75±0.07	50

Cite this article as:
Anate, S.G., & Edori, O.S. (2024). Applicability of use of the water quality index in assessing the portability of Kaani River in Ogoni axis of Rivers State, Nigeria, *FNAS Journal of Basic and Environmental Research, 1*(1), 9-16.

Station1(Maa di bunnies Igbara water side), station 2 (Mann stream), station 3 (woman stream), station 4 (Nwii ke ma kor stream)

The water pH of the sampled stations at different stations ranged from 5.85±0.07 to 7.0±0.06 with a mean value of 6.56±0.05 was found to fall below the acceptable limit of 8.0 as specified by WHO; the electrical conductivity of the surface water at different stations ranged from 125±50.0 to 214.5±41.0 with a mean concentration value of 158.13±8.03 was found to fall below the acceptable limit of 300 as specified by WHO; the water turbidity ranged from 2.63±1.35 to 10.9±3.8 with a mean value of 6.08±0.89 and found to exceed the WHO acceptable limit of 5; the water dissolved oxygen at different station ranged from 4.8±1.02 to 6.0±0.77 with a mean value of 5.29±0.79 was found to fall below the acceptable limit of 6.0 as specified by WHO; the water biochemical oxygen demand ranged from 5.5±1.01 to 6.5±1.11 with a mean concentration value of 5.88±0.74 was found to exceed the recommended limit of 5.0 as specified by WHO; the total dissolved solids ranged from 50.0±21.0 to 104.5±23.0 with a mean value of 72.0±6.75 was found to fall within the acceptable limit of 1000 as specified by WHO; the water total suspended solids ranged from 26.5±2.4 to 34.0±2.2 with a mean value of 30.88±7.88 was found to fall below the recommended limit of 500 as specified by WHO; the water total alkalinity ranged from 52.5±5.43 to 77.7±4.3 with a mean concentration value of 61.55±5.66 was found to fall below the recommended limit of 100 as given by WHO; the water total hardness ranged from 25.5±5.0 to 80.0±9.6 with a mean value of 49.38±4.55 was found to fall below the acceptable limit of 100 as specified by WHO; The water nitrate had a mean value of 0.75±0.07 and varied from 0.67±0.4 to 0.83±0.3, all of which were below the WHO's recommended limit of 50.

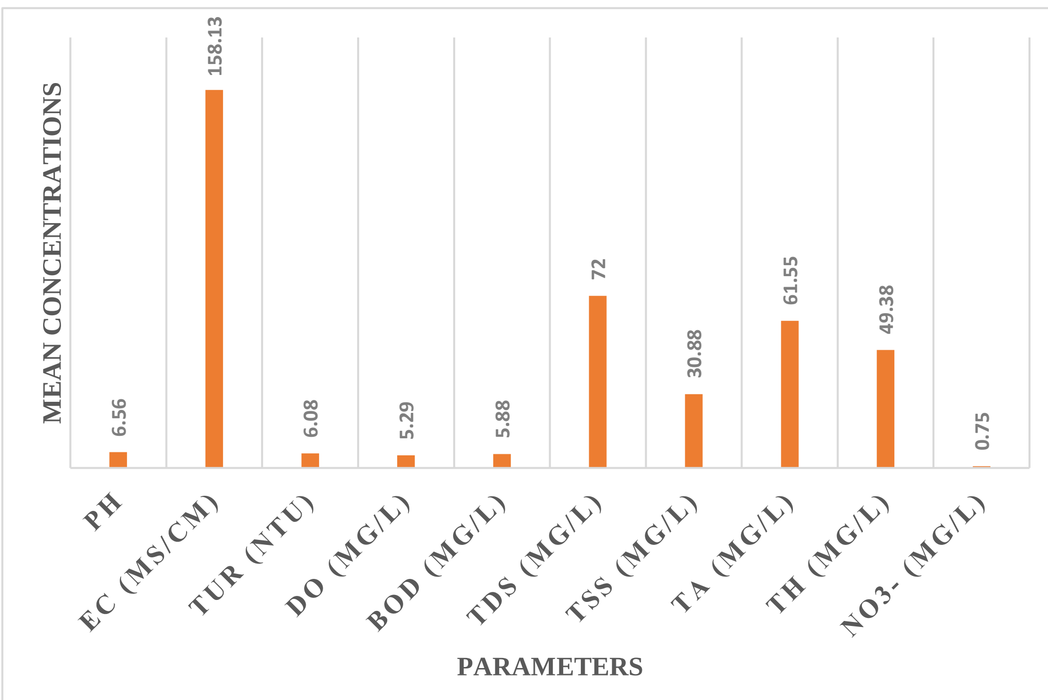

Figure 1: Mean Concentrations of physicochemical parameters of water samples from Kaani River at different stations.

Water Quality Index

The goal of the Water Quality Index calculation was to evaluate the water's suitability for both drinking and biotic communities. In compliance with the Indian Council of Medical Research (ICMR) 2008 guidelines and the World Health Organization (WHO) (2007), 10 significant physicochemical attributes were taken into account. WQI is calculated using 10 key parameters, which are as follows; The following parameters have been chosen: pH, turbidity, electrical conductivity (EC), total hardness (TH), total alkalinity (TA), total suspended solids (TSS), dissolved oxygen (DO), total dissolved solids (TDS), biochemical oxygen demand (BOD), and nitrate. These factors have the biggest impact on the river's quality. The procedures for WQI are as follows:

Weightage/ Rating Scale

Weightage of factor has an inverse association with its allowable boundaries.

Hence;

$$\text{Wi}\,\alpha\, 1/Vi$$

$$\therefore\ \text{Wi} = k/Vi$$

Where K = a constant.

Wi = component weighted factor.

Vi is the maximum tolerable boundary as suggested by the Indian Council of Medical Research (ICMR) in 2008, the World Health Organisation (WHO) in 2007, the National Association for Food, Drug, and Tobacco Administration and Control (NAFDAC) in 2007, the Bureau of Indian Standards (BIS) in 2005, and the Central Public Health Environmental Engineering Organisation (CPHEEO) in 2008.
The importance of k is calculated by;

$$K = \frac{1}{\sum_{i=1}^{10} \frac{1}{Vi}}$$

Where,

$$\sum_{i=1}^{10} \frac{1}{Vi} = \frac{1}{Vi(PH)} + \frac{1}{Vi(TDS)} + \ldots\ldots\ldots\ldots\ldots\ldots + \frac{1}{Vi(n)}$$

Thus;

$$\text{WQI} = \Sigma\ \ \text{Wi x Vr}$$

i.e. Water Quality Index is equivalent to the summation of the product of ranking (Vr) and component weight (Wi) of all the factors under consideration. The values for an interval of interpretation of the water Quality Index, water quality factors, standards (Vi) and the rating scale (Vr) for calculating the water quality index are provided in Tables 2, 3 and 4 respectively.

Table 2: Classification of Water Quality Index.

Range	**Quality**
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Very poor
0-25	Unsuitable for drinking

Adapted from ICMR Standards, (2008)

Table 3: Water Quality Factors: Their, WHO, NAFDAC, BIS, ICMR and CPHEEO Standards

S/n	Water Quality Factors.	Standards (V_i)				
		WHO	NAFDAC	BIS	ICMR	CPHEEO
1	pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	7.0-8.5
2	EC (µS/cm)	300	1000	350	300	>300
3	TUR (NTU)	>5.0	5.0	5.0	5.0	6.5
4	DO (mg/l)	6.0	6.0	5.0	5.0	5.0
5	BOD (mg/l)	5.0	5.0	5.0	5.0	5.0
6	TDS (mg/l)	1000	500	500	1000	<1500
7	TSS (mg/l)	500	500	350	300	350
8	TA (mg/l)	100	100	100	<120	110
9	TH (mg/l)	100	100	300	300	<600
10	NO_3^- (mg/l)	50	10	50	100	50

Adapted from Ashwani and Anish, 2009.

Table 4: Rating Scale for Calculating Water Quality Index (WQI)

Physicochemical Factors	Ranges				
pH	7.0-8.5	8.6-8.7 6.8-6.9	8.8-8.9 6.7-6.8	9.0-9.2 6.5-6.7	>9.2 <6.5
TDS	0-375	375.1-750	750.1-1125	1125.1-1500	>1500
TSS	0-250	251-650	651-950	951-1200	>1200
TH	0-150	150.1-300	300.1-450	450.1-600	>600
NO_3^-	0-20	20.1-40.0	40.1-60.0	60.1-75.0	>75
TB	0-4.5	4.6-15.0	15.1-37.5	37.6-50	>50
BOD	>8.0	5.1-8.0	4.1-5.0	3.1-4.0	<3.0
TA	21-50	50.1-70 15.1-20	70.1-90 10.1-15	90.1-120 6-10	>120 <6
DO	>7.0	5.1-7.0	4.1-5.0	3.1-4.0	<3.0
EC	0-75	75.1-150	150.1-225	225.1-300	>300
Vr	100	80	60	40	0
Extent of pollution	Clean	Slight Pollution	Moderate Pollution	Excess Pollution	Severe Pollution

Adapted from Ashwani and Anish, 2009

Table 5: Water Quality Index (WQI).

S/n	Factors	Mean±SD	V_i	$1/V_i$	Ratings V_r	Weights $W_i=K/V_i$	W_i*V_r
1	pH	6.56±0.05	8.0	0.125	40	0.1694	6.7760
2	EC (µS/cm)	158.13±8.03	300	0.003	60	0.0045	0.2700
3	TUR (NTU)	6.08±0.89	5.0	0.200	80	0.2710	21.6800
4	DO (mg/l)	5.29±0.77	6.0	0.167	80	0.2258	18.0640
5	BOD (mg/l)	5.88±0.74	5.0	0.200	80	0.2710	21.6800
6	TDS (mg/l)	72.0±6.75	1000	0.001	100	0.0014	0.1400
7	TSS (mg/l)	30.88±7.88	500	0.002	100	0.0027	0.2700
8	TA (mg/l)	61.55±5.66	100	0.010	80	0.0136	1.0880
9	TH (mg/l)	49.38±4.55	100	0.010	100	0.0136	1.3600
10	NO_3^- (mg/l)	0.75±0.07	50	0.020	100	0.0271	2.7100
				Σ 0.7380		**Σ**	**74.0380**

V_i is the maximum permissible limits of the factors as recommended by local and international standards (WHO, NAFDAC, BIS, ICMR and CPHEEO), W_i is the calculated unit weights of the factors and V_r is the assigned ratings.

Discussion

The amount of dissolved oxygen in water has a significant impact on WQI readings. The water becomes clearer the higher the DO concentration in it. The levels of BOD, TDS, TSS, and chemical oxygen demand all contribute to the water's quality. BOD is a measurement of how much oxygen is used up by microorganisms throughout breaking down organic matter in water during a set amount of time, often five days. Elevated BOD levels are indicative of elevated organic pollution, which can reduce the amount of dissolved oxygen in water, resulting in the deterioration of aquatic habitats and fish mortality. When evaluating the effectiveness of wastewater treatment facilities and the state of aquatic ecosystems, BOD is a crucial metric (Irwin, 1997).

The amount of oxygen needed to chemically oxidize both organic and inorganic molecules in water is measured by COD. Elevated COD levels are a sign of an abundance of organic contaminants, like sewage or industrial effluent, which can lower the dissolved oxygen content of water bodies (Ihunwo et al.,2018; Iloba & Shomule,2020). Assessing the possibility of water pollution and the efficiency of wastewater treatment methods is made easier with the help of COD monitoring. The Total Suspended Solids (TSS) concentration in water is determined by counting the visible suspended particles, which include silt, clay, and organic materials. Elevated total suspended solids (TSS) can make water seem murky or turbid, which can be visually unpleasant and possibly clog filtration equipment. Because TSS lowers oxygen and light penetration in water bodies, it can have a detrimental effect on aquatic life (Manjare et al.,2010).

The term TDS refers to the overall concentration of dissolved materials in water, which includes trace amounts of organic matter and inorganic salts including calcium, magnesium, sodium, and potassium. Elevated Total dissolved solids (TDS) can have an impact on the colour and flavour of water, as well as signal the presence of impurities or too much mineral content. When determining whether water is suitable for consumption, irrigation, or industrial usage, TDS levels are crucial. On the basis of the WQI, the quality of the water is categorized from very bad to excellent (Ashwani & Anish, 2009). WQI ranges as follows:

Value of WQI Quality of water

90-100 Excellent
70-90 Good
50-70 Medium
25-50 Bad
0-25 Very Bad

The index of water quality for the period of 2022 to 2023 is given in Table 5. The value of WQI (74.0380) demonstrates that the water is clear, which indicated impurity-free water at the sampled locations excluding 2-3 months when the situation values were lower than 70. The obtained values of WQI for the years 2022 and 2023 showed that water was fairly polluted in March, April and May 2023. The variation may be linked to modifications in the way the river operates, which in turn affects the amount of water that is available there. The goal of this paper's application of the water quality index technique to the River Kaani in Ogoni was to offer a straightforward and reliable way to communicate the findings of several criteria to evaluate the water quality. Combining various factors into a single figure makes the index easier to understand, making it a valuable tool for management (Mandaric et al., 2018).

Conclusion

A comparison of the WQI for the twelve months from July 2022 to June 2023 revealed that, except for two or three months, the water was nearly pure for the entire period the samples were taken. A high WQI value is beneficial to aquatic plants and animals. The computation reveals that the parameter with the least favourable value offers the index a high statistical value. Out of the ten factors, dissolved oxygen was determined to be the most significant since it had the biggest impact on the WQI computation. To sum up, as crucial markers of water quality, TDS, TSS, COD, and BOD reveal information on the existence of impurities, organic pollutants, and the general well-being of aquatic ecosystems. By keeping an eye on these factors, we can make sure that water is safe to use for drinking, farming, and maintaining ecosystems.

Recommendations

1. Implement routine monitoring of DO levels in the River Kaani to detect changes that could indicate pollution or stress on aquatic life. Implement management strategies to maintain healthy DO levels.
2. Establish a monitoring network and collaborate across disciplines to make informed decisions and improve water quality in the River Kaani.

References

Ashwani, K., & Anish, D. (2009). Water quality index for assessment of water quality of River Ravi at Madhopur, India. *Global Journal of Environmental Sciences*, *8*(1), 49-57.

Barakat, A., Baghdadi, M. E., Rais, J., Aghezzaf, B., & Slassi, M. (2016). Assessment of spatial and seasonal water quality variation of Oum Er Rbia River (Morocco) using multivariate statistical techniques, *International Soil Water Conservation Research*, *4*(4), 284-292.

Bureau of India Standard (BIS) (2005). Drinking water specification, IS 10500: 2012 Bharti N and Katyal.D. *International Journal of Environmental Science*, *2011*(2), 1-2.

Casazza, M., Maraga, F., Liu, G. Y., Lega, M., Turconi, L., & Ulgiati, S. (2017). River water quality and its relation with air quality: a long-term case study in a remote and pristine NW Italian headwater catchment. *Journal of Environmental Accounting and Management*, 34, 535–547.

Central Public Health Environmental Engineering Organization (CPHEEO) (2008). Manual of water supply and treatment, Ministry of Urban Development, New Delhi.

Ihunwo, O., Chisom, E., Okon, M., Isaiah, O., Obunwo, C., & Mmom, C. (2018). Effect of urban effluent on river water quality in the Niger Delta. *F4 Frontiers Environmental Microbiology*, *4*(3), 110–114.

Iloba k. I., & Shomule, O. S. (2020). Assessment of the physicochemical-water quality parameters of a tropical River in Aragba, Delta State, Nigeria *IOSR Journal of Agriculture and Veterinary Science 13*(6), 10-20.

Indian Council of Medical Research (ICMR) (2008). Manual of standards of quality for drinking water supplies. *Indian Council of Medical Research*, *44*(8), 27-37.

Irwin, R. J. (1997). Environmental contaminants encyclopedia, PAHs Entry. National Park Service, Water Resources Division, Water Operations Branch, Colorado State University. http://www.nature.nps.gov/hazardssafety/toxic/benzobfl.pdf.

Jordan, T. E., Weller, D. E., & Pelc, C. E. (2018). Effects of local watershed land use on water quality in mid- atlantic coastal bays and sub estuaries of the Chesapeake Bay. *Estuaries Coasts*, 4138–4153.

Kausik, A., Ankur, K., Santosh, M., Shiv, K., & Kaushik, C. P. (2009). *Journal Hazard Material, 164* (7), 265-270.

Mahananda, H. B., Mahananda, M. R., & Mohantu, B. P. (2015). Studies on the physicochemical and Biological Parameters of a Freshwater pond Ecosystem as an indicator of water pollution. *Ecological, Environmental and Conservation*, *11*(3-4), 537-541.

Mandaric, L., Mor, J., Sabater, S., & Petrovic, M. (2018). Impact of urban chemical pollution on water quality in small, rural and effluent dominated Mediterranean streams and rivers. *Science and Total Environment*, *6*(5), 613–614, 763–772.

Manjare, S. A., Vhanalakar, S. A., & Muley, D. V. (2010). Analysis of water Quality using Physico-Chemical parameters Tamdalge Tank in Kolhapur District, Maharashtra, *International Journal of Advanced Biotechnology and Research*, *1*(2), 115-119.

National Association for Food, Drug, Tobacco Administration and Control (NAFDAC) (2007). Standard Regulation for Drinking Water.

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), 107-113.

World Health Organization (WHO) (2007). The International Network to Promote Household Water Treatment and Safe Storage.