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Research Paper

Water Quality Index as a Tool for the Assessment of the Health of Usuma Reservoir, in FCT Abuja Nigeria

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This paper assessed the water quality index (WQI) of Usuma reservoir. The samples were collected within an annual hydrological season covering both wet and dry seasons between June 2016 and May 2017. Twelve core water quality parameters which are critical and basic determinants of water conditions were analyzed in 72 water samples. The samples parameters includes: water temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, biochemical oxygen demand, nitrate, phosphate, sulphate, total alkalinity content, total hardness and total iron. Pearson correlation coefficients were calculated to assess the extent of relationship between the electrical conductivity, water temperature, TDS and total iron indicating that as pH increases, these parameters decreased in value. ANOVA showed a significant difference ($p<0.05$) in electrical conductivity, pH, TDS, Total Iron, total alkalinity, total hardness and turbidity in the reservoir. Electrical conductivity (67.3 -150.2 mg/l), pH (6.73 - 8.5), sulphate (0.5 -14 mg/), total dissolved solids (37.75 - 115.5 mg/l), total alkalinity (20 58 mg/l, total hardness (22 80 mg/l) had their maximum values within the WHO range while Biochemical oxygen demand (0.5 - 4.82 mg/l), Dissolved Oxygen (3.89 -12.24 mg/l),Nitrate (0.1 8.35 mg/l), Phosphate (0.11 - 5.28 mg/l), total Iron (0.07- 3.28 mg/l), Turbidity (3.09-69NTU) were out of the WHO range. The WQI for Usuma reservoir was found to be 65.83. This confers the status of 'average' on it based on WQI category.

Keywords: Water quality index; reservoir; physico-chemical variables

INTRODUCTION

Water is the medium around which every living thing revolves. Every human being consumes or uses a certain quantity of water through a life time. An average man (of 53 kg – 63 kg body weight), requires about 3 litres of water in liquid and food daily to keep healthy (Onweluzo and Akazuagbe, 2010). One can survive longer without food than without water. We require it for cooking, washing, sanitation, drinking and for growing his crops and running the factories. Therefore modern man like his primitive ancestors is heavily dependent on water for his sustenance (Etim et al., 2013). Scientist and water quality operators generate huge water quality data daily. These data are in form of physical, chemical and biological variables. Individually, these data do not give us an indication of trends in water quality over time and across geographic areas. A concise, quick way to draw meaning from these numbers is needed. Water quality indices provide a way to distill thousands of records of environmental data into meaningful values that indicate the health of water resources and create a yardstick for measuring and assessing water quality. Water quality index (WQI) enables analysts to make meaningful interpretation out of their experimental observation. It is regarded as one of the most effective ways to communicate water quality (Pradhan et al., 2001; Sinha et al., 2004).The index is a numeric expression used to

transform large number of variables data into a single number, which represents the water quality level (Adriano et al., 2006; Bordalo et al., 2006; Miller et al., 1986; Sánchez et al., 2007). Water quality is assessed on the basis of calculated water quality indices (Sinha et al., 2004; Sinha and Ritesh, 2006). The water quality indices concept is based on the comparison of the water quality parameter with respective regulatory standards (Khan et al., 2003). Indices are based on the values of various physico-chemical and biological parameters in a water sample. The use of indices in monitoring programs to assess ecosystem health has the potential to inform the general public and decision-makers about the state of the ecosystem (Nasirian, 2007; Simoes et al., 2008). This approach can also help to provide a benchmark for evaluating successes and failures of management strategies at improving water quality (Rickwood and Carr, 2009). Parameters are often then weighted according to their perceived importance to overall water quality and the index is calculated as the weighted average of all observations of interest (Liou et al., 2004; Pesce and Wunderlin, 2000; Sargaonkar and Deshpande, 2003; Stambuk-Giljanovic, 1999; Tsegaye et al., 2006). The Water Quality Index uses a scale from 0 to 100 to rate the quality of the water, with 100 being the highest possible score. Once the overall WQI score is known, it can be compared against the following scale to determine how healthy the water is on a given period.
The specific objectives of this paper are:

(i) To examine some physical and chemical parameters of Usuma Reservoir, in FCT Abuja Nigeria.
(ii) To determine the health status of this reservoir using ts water quality index.
(iii) Analysis of some water quality parameters and their trends.

MATERIALS AND METHODS

Sampling stations

Three sampling stations were selected and were conducted fortnightly.
The sampling stations were divided into three.

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Station 1

This is the Usuma reservoir (main dam) situated along the axis of the inflow (inlet of reservoir); characterized by area of slow moving water receiving an enormous impact of human influence, having an inflow of waste with plastics and other floating materials littering entire water body. It has a depth of about 45 m and a surface area of 8 km and a catchment size of 200 km. It has minimal human activity. It also receives inflow from Gurara inter basin transfer.

Station 2

The Ushaffa saddle dam which is about 470 m long and representing an area of moderate flow. It is an area known for enormous fishing and grazing. Other human activities like washing and bathing take place here. It is characterized by a sandy and marshy littoral zone. It has an area of 6 km. The depth is about 25 m. The distance between station 1 and 2 is about 10 km.

Station 3

It is the Usuma outflow representing an area of fast flowing water with rocky substratum. It has a high density of human activities all year round. The anthropogenic activities include farming, bathing, felling and collection of fuel-wood, mining of sand, washing of motorcycles and also serve as grazing ground for animals and herds men. It has an area of 5 km. The depth is about 12 m. It is 4 km from station 1. The station has deforested bank thereby exposing this section of the river to direct sunlight.

METHODOLOGY

Sample Collection, Preservation, and Storage

Plastic containers of 2.5 l were used for this collection and were washed with dilute hydrochloric acid (0.05M) so that substances from the plastic containers and their caps do not leach into the sample. This may alter the chemistry of sample. The containers were later rinsed with distilled water and sun dried. Glass wares used were soaked in 1 M Nitric acid overnight in order to remove residues of previous samples (Onianwa and Ajayi, 2001) and vigorously rinsed with tap water and finally with distilled water,(APHA, 2012). The containers were air-dried. At the collection point, containers were rinsed with the water samples twice and filled with samples and then corked tightly. Samples for total dissolved solids (TDS), dissolved oxygen, total alkalinity, total hardness, free carbon dioxide, colour, sulphate, nitrate, and iron were collected manually during period of stable flow in the pre-cleaned polythene bottles with necessary precautions. All the samples were analyzed in the departments of Biological Sciences and Chemistry of the University of

Abuja and the Federal Capital Territory Water Board Quality Control Laboratory situated at Lower Usuma Dam.

Calculation of WQI

This was carried out using the Horton's method. This is expressed as:

$$WQI = \sum qn\ Wn / \sum Wn \quad (1)$$

Where,

qn = Quality rating of nth water quality parameter.
Wn= Unit weight of nth water quality parameter.

$$\text{Quality rating } (qn) = [(Vn – Vid)/(Sn- Vid)] \times 100 \quad (2)$$

Where,

Vn = Estimated value of nth water quality parameter at a given sample location.
Vid = ideal value for n th parameter in pure water.
(Vid for pH = 7 and 0 for all other parameters)
Sn = Standard permissible value of nth water quality parameter.

Unit weight

The unit weight (Wn) is expressed as:

$$Wn = k/Sn \quad (3)$$

Where,

Sn = Standard permissible value of n th water quality parameter.
k = Constant of proportionality and is given as:
$k = [1 / (\sum 1/ Sn=1,2,..n)]$

The water quality parameters are selected based on its direct involvement in deteriorating water quality for human consumption.

Physico-chemical parameters

On- site analysis

Parameters like water temperature, pH, Dissolved Oxygen, electrical conductivity and total dissolved solids were done in-situ (Agbogu et al., 2006). They were measured on the spot using digital multi meter (EXTECH Exstik II EC 500) (APHA, 2005) with the exception of Dissolved oxygen which was tested using Jenway DO meter model DO2 9150 (Agbogu et al., 2006). Data on surface water samples were obtained bi-monthly throughout the sampling periods for all the sampling stations. Sampling devices and containers were thoroughly cleaned to prevent carryover from previous samples. Preservation of the samples was done according to test-specific information by HACH (2005). The quality of the analytical data was ensured through careful standardization, blank measurements and triplicate samples. All equipment was duly calibrated according to manufacturer's specification. For the validity of the determination procedure, the standard deviation methodology was used.

Laboratory analysis

Biochemical oxygen demand, nitrate, phosphate, sulphate, total alkalinity content, and total hardness and total iron were analyzed in the laboratory. All chemicals used were AnalaR grade (BDH, England). Biochemical oxygen demand was determined using the 5-day BOD method (APHA, 2012). Nitrate, phosphate, sulphate and total iron were determined with the HACH DR 5000 Spectrophotometer. 10 ml of the replicate samples were prepared by adding the appropriate recommended reagent pillows. The Trimetric method was used to determine total alkalinity content and total hardness (HACH, 2005), (APHA, 2005).

RESULTS AND DISCUSSION

The results of chemical analysis of the reservoir water, analysis of variance and the compliance level with the WHO (2004) are summarized in (Table 3). Normal statistics of water quality parameters of 72 water samples is given in (Table 2).In this study, the WQI is established from important physico-chemical parameters such as pH, water temperature, total iron, total alkalinity, sulphate, phosphate, nitrate, total hardness, electrical conductivity, dissolved oxygen, biochemical oxygen demand, total dissolved solids and turbidity. The results of the physico-chemical parameters of the different samples showed that the concentrations of the respective parameters are within the WHO guidelines for surface water as shown in (Table 1) except for dissolved oxygen with a grand mean that is above the WHO guidelines. The chemical analysis of the reservoir water sample and their relationship with the WHO (2004) guidelines are summarized in (Table 1). Normal statistics of water quality parameters of 72 water samples is also shown in (Table 1).

Table 2 indicates that ANOVA showed a significant difference ($p<0.05$) electrical conductivity, pH, TDS, total iron, total alkalinity, total hardness and turbidity in the reservoir. The pH variable is an important indicator in water

Table 1. Normal statistics of water quality parameters of Usuma reservoir water samples for all stations sampled.

PARAMETERS	STATION 1	STATION 2	STATION 3	GRAND MEAN +SE	WHO STANDARDS
Biochemical oxygen demand	2.90±0.96	2.43±1.15	2.09±1.28	2.47±0.19	3.0 – 6.0
Dissolved oxygen	8.31±1.95	8.04±1.11	7.85±1.50	8.07±0.26	5.0-7.00
Electrical conductivity	96.91±25.2	87.96±11.93	113.5±14.87	99.45±3.42	750
Nitrate	0.88±1.31	1.03±1.91	2.16±2.62	1.36±0.34	< 5.0
Phosphate	0.72±0.85	1.08±1.39	0.99±0.97	0.93±0.18	0.8 -5mg/l
PH	7.62±0.37	7.7±0.43	7.39±0.31	7.57±0.07	6.5-8.5
Sulphate	2.2±1.9	2.36±2.74	5.26±4.31	3.27±0.54	2 – 80
Total dissolved solids	67.89±13.9	65.69±15.73	85.05±16.54	72.88±2.83	600
Water temp	28.44±1.57	28.34±1.62	28.78±2.31	28.52±0.30	29 – 33.0
Total iron	0.20±0.1	0.50±0.80	1.34±0.95	0.68±0.14	1
Total alkalinity	36.42±6.9	34.5±6.8	41.8±6.61	37.57±1.27	100
Total hardness	30.67±7.8	30.25±6.09	36.3±14.54	32.41±1.81	100
Turbidity	7.67±7.7	8.79±10.65	27.65±18.87	14.70±2.62	<25NTU

Table 2. ANOVA table showing WHO standards.

PARAMETER	MIN	MAX	MEAN	SE	F VALUE	P VALUE	WHO
BOD (mg/l)	0.5	4.82	2.47	0.192894	1.541	0.229	3.0 – 6.0
DO (mg/l)	3.89	12.24	8.02	0.255628	0.439	0.649	5.0-7.00
ELEC COND (µS/cm)	67.3	150.25	99.13	3.4161	5.584	0.008*	750
Nitrate (mg/l)	0.1	8.35	1.26	0.334756	0.822	0.448	< 5.0
Phosphate (mg/l)	0.11	5.28	0.91	0.179118	0.331	0.72	0.8 -5mg/l
pH (pH UNITS)	6.73	8.5	7.54	0.066381	3.696	0.036*	6.5-8.5
Sulphate (mg/l)	0.5	14	3.07	0.54284	2.244	0.122	2 – 80
TDS (mg/l)	37.75	115.5	72.32	2.830353	4.691	0.016*	600
WATER TEMP(°C)	25.5	33.75	28.52	0.303458	0.171	0.843	29 – 33.0
TOT. FE(mg/l	0.07	3.285	0.64	0.136904	6.424	0.004*	1
TOT. ALK(mg/l)	20	58	38	1.26867	5.217	0.011*	100
TOT. HARD(mg/l)	22	80	33.64	1.80954	3.543	0.040*	100
TURBIDITY(NTU)	3.09	69	14.45	2.614593	7.929	0.002*	< 25NTU

quality assessment as it affects many biological and chemical processes within a water body and all processes associated with water supply and treatment (Gray et al., 1999). It also determines the suitability of water for various purposes (Chandaluri et al., 2010). The pH of most natural waters ranges between 6.5 to 8.5 (Table 2), although lower values can occur in dilute waters having higher concentration of dissolved organic substances, and higher values in eutrophic waters. The pH was recorded to be varying from 6.73 (minimum) to 8.5 (maximum) with an average value of 7.57±0.07 from all the sites (Table 2). This shows that the pH range obtained for the reservoir water samples was within the recommended range of 6.50 to 8.50 (WHO, 2004). The value of pH increased from station 1 to station 2 (7.62±0.37-7.7±0.43). ANOVA ($P<0.05$) shows pH is significant between stations ($p=0.036$) (Table 2). Dissolved oxygen values in Usuma reservoir were relatively high. The Dissolved oxygen varied from 3.9 mg/L to 12.24mg/l in the reservoir (Table 2). The mean value was 8.07±0.26mg/l (Table 1) ANOVA showed no significant difference ($P<0.05$) among the stations. Sulphate, phosphate, dissolved Oxygen and biochemical oxygen demand did not vary significantly ($p<0.05$). Iron, pH, total alkalinity, total hardness and turbidity varied significantly ($p<0.05$). These findings are similar to that of Igbinosa and Okoh, (2009). The sharp increase in most parameters like nitrate, sulphate, total iron and turbidity from station 1-3 may be as a result of diffuse sources from settlement and agricultural runoff (Igbinosa and Okoh, 2009). Increase in agricultural runoff from farms upstream and fishing activities may also have contributed to this increase (Izonfuo and Bariweni, 2001).The biochemical oxygen demand (BOD) measures the amount of biodegradable organic material present in a sample of water. Biochemical oxygen demand (BOD) may be used to determine the level of surface water (Etim et al., 2013). The values obtained for BOD in this study are within the biochemical oxygen demand varied from 0.5 mg/l-4.82mg/l. BOD was within the WHO guidelines and showed no significant value ($p=0.649$) (Table 2). Conductivity or specific conductance is a measure of the electric current carrying ability of water and is related to the concentration of dissolved ions Table 4 indicates that the WQI for Usuma reservoir is 65.83. This confers the overall status of medium or average

Table 3. Pearson's correlation coefficient between various water quality parameters.

	BOD	DO	ELEC. COND	NO_3	PO_4	pH	SO_4	TDS	Water temp	Total FE	Total ALK	Total hard	TURB
BOD	1												
DO	0.247	1											
ELEC.COND	0.131	0.022	1										
NO3	0.360*	-0.122	0.007	1									
PO_4	0.194	0.151	0.012	-0.061	1								
pH	0.151	-0.001	-0.261	0.074	-0.01	1							
SO_4	0.359*	-0.159	0.234	0.863**	-0.169	0.102	1						
TDS	0.344*	-0.124	0.636**	0.589**	0.133	-0.212	0.704**	1					
Water Temp	0.135	-0.123	0.009	-0.031	0.142	-0.239	0.009	0.187	1				
Total FE	0.12	-0.236	0.217	0.814**	-0.008	-0.022	.820**	0.718**	-0.053	1			
Total ALK	0.104	-0.028	0.269	0.134	0.281	-0.146	0.135	0.407*	-0.091	0.237	1		
Total hard	0.213	0.105	0.116	0.330*	0.139	-0.077	0.252	0.195	0.049	0.247	0.545**	1	
TURB	0.195	-0.161	0.23	0.686**	-0.057	-0.039	0.748**	0.624**	-0.11	0.793**	0.471**	0.486**	1

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

Table 4. Overall Standard values of water quality parameters and their corresponding ideal values and unit weights for Usuma reservoir.

Parameters	Parameters std values (Sn)	Estimated value of parameter (Vn)	Ideal value of parameter (V-id)	k value	Unit weight (Wn)	qn	1/Sn	qnWn
BOD (mg/l)	5	2.47	0	1.99	0.40	49.4	0.2	19.6
DO (mg/l)	6.5	8.02	14.6	1.99	0.31	81.23	0.15	24.86
Elect. Cond (µS/cm)	70	99.13	0	1.99	0.03	141.6	0.014	4.02
Nitrate (mg/l)	10	1.25	0	1.99	0.20	12.5	0.1	2.49
Phosphate (mg/l)	5	0.91	0	1.99	0.40	18.2	0.2	7.24
pH	7.5	7.54	7	1.99	0.27	108	0.13	28.62
Sulphate	200	3.06	0	1.99	0.001	1.53	0.005	0.002
TDS (mg/l)	500	72.32	0	1.99	0.004	14.46	0.002	0.06
Water Temp (°C)	32.5	28.52	0	1.99	0.06	87.75	0.03	5.35
Total iron (mg/l)	1	0.64	0	1.99	1.99	64	1	127.4
Total hardness	100	33.64	0	1.99	0.02	33.64	0.01	0.67
Turbidity	7.5	11.12	0	1.99	0.27	148.3	0.13	39.29
Total alkalinity	100	38	0	1.99	0.02	38	0.01	0.76
Total					3.96	798.6	1.99	260.4

WQI ($\varepsilon\ q_nW_n/\ \varepsilon\ W_n$) = 65.83
Status = Medium or average water quality.

water quality. This means that this will support less diversity of aquatic organisms and probability of frequent increase in algal growth. Table 5 shows that the WQI for station 1 is 41.65. This confers the status of Fair water quality on it. This means that this will support low diversity of aquatic life, probably experiencing problems with pollution. Table 6 shows that the WQI for station 2 is 58.83. This confers the status of medium or

Table 5. Standard values of water quality parameters and their corresponding ideal values and unit weights for station 1.

Parameters	Parameters std values (Sn)	Estimated value of parameter (Vn)	Ideal value of parameter (V-id)	k value	Unit weight (Wn)	qn	1/Sn	qnWn
BOD (mg/l)	5	2.9	0	1.99	0.40	58.0	0.20	23.08
DO (mg/l)	6.5	8.31	14.6	1.99	0.31	77.7	0.15	23.76
Elect. Cond (µS/cm)	70	96.9	0	1.99	0.03	138.4	0.01	3.93
Nitrate (mg/l)	10	0.9	0	1.99	0.20	9.0	0.10	1.79
Phosphate (mg/l)	5	0.7	0	1.99	0.40	14.0	0.20	5.57
pH	7.5	7.62	7	1.99	0.27	124.0	0.13	32.86
Sulphate	200	2.2	0	1.99	0.00	1.1	0.01	0.00
TDS (mg/l)	500	67.9	0	1.99	0.00	13.6	0.00	0.05
Water Temp (0C)	32.5	28.4	0	1.99	0.06	87.4	0.03	5.33
Total Iron (mg/l)	1	0.2	0	1.99	1.99	20.0	1.00	39.80
Total hardness	100	30.7	0	1.99	0.02	30.7	0.01	0.61
Turbidity	25	7.7	0	1.99	0.26	30.8	0.13	8.01
Total alkalinity	100	36.4	0	1.99	0.02	36.4	0.01	0.73
Total					3.96	712.9	1.99	164.74

WQI ($\varepsilon\ q_nW_n / \varepsilon\ W_n$) = 41.65
Status = Fair water quality

Table 6. Standard values of water quality parameters and their corresponding ideal values and unit weights for station 2.

Parameters	Parameters std values (Sn)	Estimated value of parameter (Vn)	Ideal value of parameter (V-id)	k value	Unit weight (Wn)	qn	1/Sn	qnWn
BOD (mg/l)	5	2.43	0	1.99	0.40	48.6	0.20	19.34
DO (mg/l)	6.5	8.04	14.6	1.99	0.31	81.0	0.15	24.78
Elect. Cond (µS/cm)	70	87.96	0	1.99	0.03	125.7	0.01	3.57
Nitrate (mg/l)	10	1.03	0	1.99	0.20	10.3	0.10	2.05
Phosphate (mg/l)	5	1.08	0	1.99	0.40	21.6	0.20	8.60
pH	7.5	7.7	7	1.99	0.27	140.0	0.13	37.10
Sulphate	200	2.4	0	1.99	0.00	1.2	0.01	0.00
TDS (mg/l)	500	65.7	0	1.99	0.00	13.1	0.00	0.05
Water Temp (0C)	32.5	28.3	0	1.99	0.06	87.1	0.03	5.31
Total iron (mg/l)	1	0.5	0	1.99	1.99	50.0	1.00	99.50
Total hardness	100	30.3	0	1.99	0.02	30.3	0.01	0.61
Turbidity	25	8.8	0	1.99	0.08	35.2	0.13	2.80
Total alkalinity	100	34.5	0	1.99	0.02	34.5	0.01	0.69
Total					7.74	1439.3	3.97	437.09

WQI ($\varepsilon\ q_nW_n / \varepsilon\ W_n$) = 56.47
Status = Medium or average water quality.

Table 7. Standard values of water quality parameters and their corresponding ideal values and unit weights for station 3.

Parameters	Parameters std values (Sn)	Estimated value of parameter (Vn)	Ideal value of parameter (V-id)	k value	Unit weight (Wn)	qn	1/Sn	qnWn
BOD (mg/l)	5	2.09	0	1.99	0.40	41.60	0.20	16.64
DO (mg/l)	6.5	7.9	14.6	1.99	0.31	82.72	0.15	25.64
Elect.Cond (µS/cm)	70	113.5	0	1.99	0.03	161.4	0.01	4.84
Nitrate (mg/l)	10	2.16	0	1.99	0.20	21.6	0.10	4.32
Phosphate (mg/l)	5	0.99	0	1.99	0.40	19.8	0.20	7.92
pH	7.5	7.39	7	1.99	0.27	78	0.13	21.06
Sulphate	200	5.26	0	1.99	0.00	2.63	0.01	0.00
TDS (mg/l)	500	85.1	0	1.99	0.00	17.02	0.00	0.00
Water Temp (°C)	32.5	28.8	0	1.99	0.06	88.62	0.03	5.32
Total Iron (mg/l)	1	1.34	0	1.99	1.99	134.0	1.00	266.7
Total hardness	100	36.3	0	1.99	0.02	36.30	0.01	0.73
Turbidity	25	27.7	0	1.99	0.08	110.8	0.13	8.86
Total alkalinity	100	41.8	0	1.99	0.02	41.8	0.01	0.84
Total					3.78	941.71	1.99	362.87

WQI ($\varepsilon\ q_nW_n / \varepsilon\ W_n$) = 96
Status = Excellent water quality.

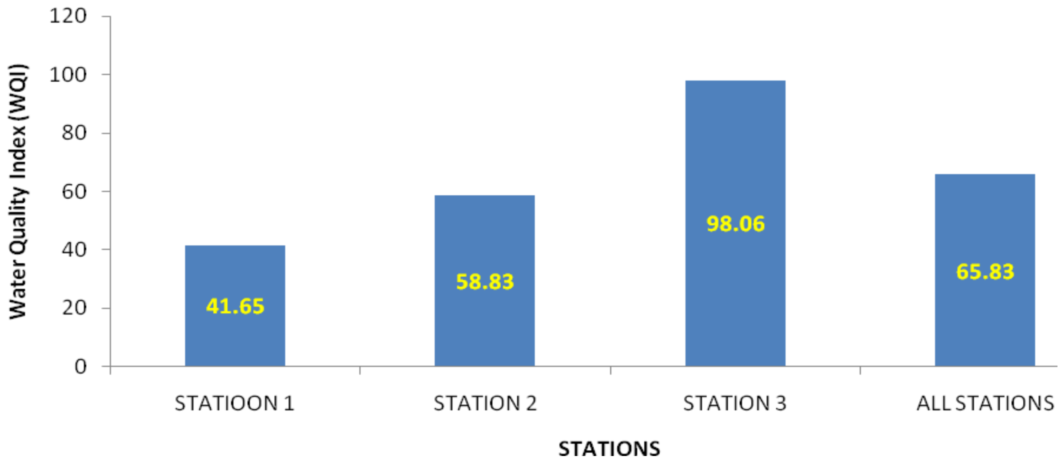

Figure 1. WQI by stations.

Table 8. WQI table of interpretation.

WQI	Status	Indications
91-100	Excellent water quality	Support high diversity of aquatic life, suitable for all forms of recreation
71-90	Good water quality	Support high diversity of aquatic life, suitable for all forms of recreation
51-70	Medium or average water quality	Less diversity of aquatic organisms, probability of frequent increase in algal growth, Conventional treatment required
26-50	Fair water quality	Low diversity of aquatic life, probably experiencing problems with pollution
0-25	Poor water quality	Support limited number of aquatic life, significant quality issues

Source: Tyagi *et al.* (2013).

average water quality on it. This means that this will support less diversity of aquatic organisms and probability of frequent increase in algal growth. Table 7 shows that the WQI for station 3 is 98.06. This confers the status of excellent water quality water quality on it. This means that this will support high diversity of aquatic life, suitable for all forms of recreation.

Conclusion

The WQI for Usuma reservoir was found to be 65.83. This confers the status of average on it based on WQI category. This means that there will be less diversity of aquatic organisms and associated probability of frequent increase in algal growth. This translates that enormous cost will be incurred in treatment. This assessment shows that some of the physico-chemical parameters of Usuma reservoir were within the permissible limit prescribed by WHO. These include Electrical conductivity, pH, sulphate, total dissolved solids, total alkalinity, and total hardness. Biochemical oxygen demand, dissolved oxygen, nitrate, phosphate, total iron, turbidity was out of the WHO range. pH bore significant negative correlation with dissolved oxygen, electrical conductivity, water temperature, TDS and total Iron indicating that as pH increases, these parameters decrease in value. From the results of present study we can also conclude that the water of Usuma reservoir falls within the medium or average category of water quality class based on water quality index values and may be susceptible to imminent pollution problems in the future if deterioration is not abated. The reservoir could be free or level of pollution reduced if proper measures are put in place to discourage the users from polluting the water in order to bring about improved health especially around the river Usuma and its catchments.

Recommendation

Adequate and consistent monitoring of the reservoir and source water should be of utmost priority in order to detect early warning signs and forestall further deleterious deterioration of its WQI.

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