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Water Quality Indices of Two Boreholes in Petroleum Training Institute, Effurun Delta State, Nigeria

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Abstract : *Demands for portable water are increasing as population explodes; hence alternative sources to conventional sources of water are constantly being explored. The immediate alternative people resorted to in most growing cities is the drilling of borehole with the hope of getting clean and portable water for domestic and commercial purposes. Before any borehole will be termed clean and portable, a standard water analysis in conformity with world health organization and other reputable international standards need to be conducted. This study was aimed at calculating and comparing the Water Quality Indices (WQI) of water from two separate boreholes located in Petroleum Training Institute Effurun to determine its portability for domestic purposes using the Weighted Arithmetic Water Quality Index (WAWQI), Canadian Council of Ministers of the Environment (CCME) Water Quality Index (CCME WQI) and the National Sanitation Foundation Water Quality Index (NSFWQI). The results revealed AWQI for Borehole 1 (PTI Mosque) 50.66 "Poor Water Quality", NSF WQI of 61 "Medium water Quality" and CCME WQI of 88 "Good Water Quality". Similarly, the AWQI for Borehole 2 (PTI Senior Staff Quarters) was 44.54 "Good Water Quality", CCME WQI of 88 "Good Water Quality" and NSF WQI of 65 "Medium water Quality". It can be concluded that the water from PTI Mosque and the PTI Senior Staff Quarters are of Good Quality, though with minor degree of threat or impairment which could be as a result of contamination due to excessive rainfall. Raising water pH and boiling the water to 100^oC before consumption were recommended.*

Keywords: *Effurun, Index, Portability, Quality, Water*

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I. Introduction

Demands for portable water are increasing as population explodes; hence alternative sources to conventional sources of water are constantly being explored. The immediate alternative people resorted to in most growing cities is the drilling of borehole with the hope of getting clean and portable water for domestic and commercial purposes. Before any borehole will be termed clean and portable, a standard water analysis in conformity with world health organization and other reputable international standards need to be conducted. Water quality index computation can only be possible when the physical, chemical and biological parameters are known. The analyzed values of these parameters in any given sample of water must be within the stated guidelines and limits [1]. As cited in [2], the analyzed samples content of the pollutant, ideal content and standard content for safe use determine this water quality index. Whereas the ideal content and measured one are fixed for a sample, the standard content varies from country to country and from agency to agency. Thus, WQI arrived at by using different standards may vary, if the standard values differ. Presently measured results and standard values of different countries / agencies yield drastically varying WQI in some cases in present measurements. Sources of pathogenic microbial contamination of ground water as it is in surface water are attributed to sewage. Sewage contamination is worsening due to the unsafe method of sewage system construction and the shallow depth of water table [3]

This study was aimed at calculating and comparing the Water Quality Indices (WQI) of water from two separate boreholes located in Petroleum Training Institute Effurun to determine its portability for domestic purposes using the Weighted Arithmetic Water Quality Index (WAWQI), Canadian Council of Ministers of the Environment (CCME) Water Quality Index (CCME WQI) and the National Sanitation Foundation Water Quality Index (NSFWQI).

II. Materials and Methods

A total of six (6) samples were collected from two different boreholes water in the study area. These samples were collected from the PTI mosque borehole, and from the Senior Staff Quarters block 9. The distances from each borehole to the septic tank was 16 meters apart using a measuring tape, These water samples were collected using sterilize containers and they were properly labelled from A to C in each borehole respectively and taken immediately to the laboratory for the analysis of physico-chemical and bacteriological parameters (Electrical conductivity, Total dissolved solid, Sulphate, Nitrate, Calcium, Magnesium, Total alkalinity, Chloride, Dissolved Oxygen, Biochemical Oxygen Demand, Total hardness, Total Suspended Solid, Turbidity and Total coliform Count), pH was measured in situ.

2.1 Physico-Chemical Analysis

The following physico-chemical parameters were analyzed in the sample collected pH, sulphate, nitrate, calcium, magnesium, total alkalinity, chloride, electrical conductivity, dissolved oxygen, biochemical oxygen demand, total hardness, total dissolved solids, turbidity and total suspended solids. All these parameters were analyzed using standard procedure as proposed by standard methods for examination of water and waste water [4].

2.2 Calculation of Water Quality Index

The WQI has been calculated by using standards of drinking water quality recommended by the World Health Organization (WHO) and Indian Council for Medical Research (ICMR). The weighted Arithmetic index method [5, 6, 7], the Canadian Council of Ministers of the Environment (CCME) and National Sanitation Foundation Water Quality Index (NSFWQI) Formulations were used for the calculation of WQI in this study.

2.3 The weighted Arithmetic index method

First, the Further, quality rating or sub index was calculated using the following expression.

$$q_n = \frac{100[V_n - V_{io}]}{[S_n - V_{io}]} \quad (1)$$

(Let there be n water quality parameters and quality rating (qn) corresponding to n^{th} parameter is a number reflecting relative value of this parameter in the polluted water with respect to its standard permissible value)
q_n = Quality rating for the n^{th} Water quality parameter
V_n = Estimated value of the n^{th} parameter at a given water sampling station
S_n = Standard permissible value of the n^{th} parameter
V_{io} = Ideal value of n^{th} parameter in pure water (i.e., 0 for all other parameters except the parameters pH and Dissolve oxygen [7.0 and 14.6 mg/l respectively])
The unit weight was calculated by a value inversely proportional to the recommended standard value S_n of the corresponding parameter.

$$W_n = \frac{K}{S_n} \quad (2)$$

Where W_n = unit weight for nth parameter
S_n = standard permissible value for nth parameter
k = proportionality constant and can also be calculated using the following equation:

$$K = \frac{1}{\frac{1}{\sum_i^n S_i}} \quad (3)$$

The overall WQI is calculated by the following equation.

$$WQI = \frac{\sum(W_n \times q_n)}{\sum W_n} \quad (4)$$

The suitability of WQI value for human consumptions

Table I: Water quality index and quality of water [8]

Water quality index level	Water quality status
0 – 25	Excellent water quality
25 – 50	Good water quality
51 – 75	Poor water quality
76 – 100	Very poor water quality
>100	Unsuitable for drinking

2.4 The CCME Water Quality Index Formulation

The index consists of three factors:

F_1 (**Scope**) represents the extent of water quality guideline non-compliance over the time period of interest. It has been adopted directly from the British Columbia Index:

$$F_1 = \left(\frac{\text{Number of failed variables}}{\text{Total number of variables}}\right) \times 100 \quad (5)$$

Where, **variables** indicate those water quality variables with objectives which were tested during the time period for the index calculation.

F_2 (**Frequency**) represents the percentage of individual tests that do not meet objectives ("failed tests"):

$$F_2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}}\right) \times 100 \quad (6)$$

The formulation of this factor is drawn directly from the British Columbia Water Quality Index.

F_3 (**Amplitude**) represents the amount by which failed test values do not meet their objectives. F_3 is calculated in three steps.

(i) The number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective is termed an "excursion" and is expressed as follows. When the test value must not exceed the objective:

$$excursion_i = \left(\frac{\text{Failed Test Value}}{\text{Objective}_j}\right) - 1 \quad (7)$$

For the cases in which the test value must not fall below the objective:

$$excursion_i = \left(\frac{\text{Objective}_j}{\text{Failed Test Value}}\right) - 1 \quad (8)$$

(ii) The collective amount by which individual tests are out of compliance is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives). This variable, referred to as the normalized sum of excursions, or *nse*, is calculated as:

$$nse = \frac{\sum_{i=1}^{n} excursion_i}{\text{Number of Tests}} \quad (9)$$

iii) F_3 is then calculated by an asymptotic function that scales the normalized sum of the excursions from objectives (*nse*) to yield a range between 0 and 100.

$$F_3 = \left(\frac{nse}{0.01nse + 0.01}\right) \quad (10)$$

The CCME WQI is then calculated as:

$$CCME\ WQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}\right) \quad (11)$$

The factor of 1.732 arises because each of the three individual index factors can range as high as 100. This means that the vector length can reach $\sqrt{100^2 + 100^2 + 100^2}$ $=\sqrt{30000}$ =173.20508 as a maximum. Division by 1.732 brings the vector length down to 100 as a maximum.

Once the CCME WQI value has been determined, water quality can be ranked by relating it to one of the following categories [2]:

Table II: Water quality index and quality of water Adopted from [9]

CCME WQI	Quality of Water	Quality Descriptions
95-100	Excellent	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels. These index values can only be obtained if all measurements are within objectives virtually all of the time.
80-94	Good	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
65-79	Fair	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
45-64	Marginal	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
0-44	Poor	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

2.5 National Sanitation Foundation Water Quality Index (NSFWQI)

Nine factors were chosen and some were judged more important than others, so a weighted mean is used to combine the values. Water quality index is a 100 point scale that summarizes results from a total of nine different measurements when complete: Dissolved oxygen, Fecal coliform, pH, Biochemical oxygen demand, Temperature change, Total phosphate, Nitrates, Turbidity and Total solids. So that field measurements could be converted to index values, respondents were asked by questionnaire to graph the level of water quality (0 through 100) corresponding to the field measurements (e.g., pH 2-12). The curves were then averaged and are thought to represent the best professional judgment of the respondents. When test results from fewer than all nine measurements are available, we preserve the relative weights for each factor and scale the total so that the range remains 0 to 100 [10].

Table III: Water Quality Factors and Weights [10]

	Factor	Weight
1	Dissolved oxygen	0.17
2	Fecal coliform	0.16
3	pH	0.11
4	Biochemical oxygen demand	0.11
5	Temperature change	0.10
6	Total phosphate	0.10
7	Nitrates	0.10
8	Turbidity	0.08
9	Total solids	0.07

Table IV: Water Quality Index Legend [10]

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

Results

The results of analysis of water samples collected from two different boreholes were shown in Table V and Table VII.

Table V: Results of Water Analysis for Borehole 1 PTI Mosque

Sn	Parameters	Sample A	Sample B	Sample C	Mean
1	Ph	4.49	4.51	4.46	4.49
2	Total Dissolved Solid	140.1	129.7	132. 50	134.1
3	Electrical Conductivity	211. 60	192.4	200.7	201.57
4	Total Suspended Solid	5	5	5	5
5	Dissolved Oxygen	4.9	5.1	4.8	4.93
6	Biochemical Oxygen Demand	1.3	1.6	1.2	1.37
7	Total Alkalinity	0	0	0	0
8	Chloride	23.03	20.37	21.46	21.62
9	Total Hardness	40	36	37	37.67
10	Calcium	8.8	7.79	7.92	8.17
11	Magnesium	4.39	3.94	4.11	4.15
12	Sulphate	3.18	2.92	3.04	3.05
13	Turbidity	0.29	0.28	0.26	0.27
14	Nitrate	0.73	0.54	0.58	0.62
15	Total Coliform	2.00	2.00	5.00	3.00

Table VI: Water Quality Index Calculation for Borehole 1 PTI Mosque

SN	Parameters	Observed Values	Standard Values (Sn)	Unit Weight (Wn)	Quality Rating (qn)	Wnqn
1	pH	4.49	8.5	0.1053	167.33	17.62
2	Total Dissolved Solid	134.1	500	0.0018	26.82	0.05
3	Electrical Conductivity	201.57	250	0.0036	22.4	0.08

4	Total Suspended Solid	5	10	0.0895	50	4.48
5	Dissolved Oxygen	4.93	5	0.1790	100.73	18.03
6	Biochemical Oxygen Demand	1.37	5	0.1790	27.40	4.90
7	Total Alkalinity	0	120	0.0075	0.00	0.00
8	Chloride	21.62	100	0.0090	21.62	0.19
9	Total Hardness	37.67	500	0.0018	7.53	0.01
10	Calcium	8.17	75	0.0119	10.89	0.13
11	Magnesium	4.15	20	0.0448	20.75	0.93
12	Sulphate	3.05	100	0.0090	3.05	0.03
13	Turbidity	0.27	5	0.1790	5.40	0.97
14	Nitrate	0.62	10	0.0895	6.20	0.55
15	Total Coliform	3.00	10	0.0895	30.00	2.69
K = 0.89500				∑Wn = 1.0000		∑Wnqn = 50.66

Water Quality Index =∑Wnqn/∑Wn = 50.66; hence, QWI = 51 "Poor Water Quality" (See Table I)

Table VII: Results of Analysis of Samples from Borehole 2 PTI Senior Staff Quarters

S/n	Parameter	Sample A	Sample B	Sample C	Mean
1	pH	5.10	5.18	5.20	5.16
2	Total Dissolved Solid	98.80	110.30	100.70	103.27
3	Electrical Conductivity	137.00	158.30	141.60	145.63
4	Total Suspended Solid	2.00	3.00	3.00	2.67
5	Dissolved Oxygen	3.60	3.90	3.60	3.70
6	Biochemical Oxygen Demand	1.20	1.10	1.10	1.13
7	Total Alkalinity	4.00	6.00	6.00	5.33
8	Chloride	17.49	20.08	19.02	18.86
9	Total Hardness	19.50	24.00	21.00	21.50
10	Calcium	4.10	5.54	4.82	4.82
11	Magnesium	2.52	2.57	2.18	2.42
12	Sulphate	1.96	2.16	2.05	2.06
13	Turbidity	0.23	0.23	0.20	0.22
14	Nitrate	0.26	0.43	0.29	0.33
15	Total Coliform	3.00	2.00	4.00	3.00

Table VIII: Arithmetic Water Quality Index Calculations for PTI Senior Staff Quarters

Sn	Parameter	Observed Values	Standard values (sn)	Unit Weight (Wn)	Quality Rating (qn)	Wnqn
1	pH	5.16	8.5	0.105	122.67	12.92
2	Total Dissolved Solid	103.27	500	0.002	20.65	0.04
3	Electrical Conductivity	145.63	250	0.004	58.25	0.21
4	Total Suspended Solid	2.67	10	0.090	26.70	2.39
5	Dissolved Oxygen	3.70	5	0.179	113.54	20.32
6	Biochemical Oxygen Demand	1.13	5	0.179	22.60	4.05
7	Total Alkalinity	5.33	120	0.007	4.44	0.03
8	Chloride	18.86	100	0.009	18.86	0.17
9	Total Hardness	21.50	500	0.002	4.30	0.01
10	Calcium	4.82	75	0.012	6.43	0.08
11	Magnesium	2.42	20	0.045	12.10	0.54
12	Sulphate	2.06	100	0.009	2.06	0.02
13	Turbidity	0.22	5	0.179	4.40	0.79
14	Nitrate	0.33	10	0.090	3.30	0.30
15	Total Coliform	3.00	10	0.090	30.00	2.69
	K = 0.89500			∑Wn = 1.000		∑Wnqn = 44.54

Water Quality Index =∑Wnqn/∑Wn = 44.54; hence, WQI = 45 "Good Water Quality" (See Table I)

Table IX: CCME Water Quality Index Calculations

Location	F_1	F_2	F_3	F_1^2	F_2^2	F_3^2	$F_1^2 + F_2^2 + F_3^2$	$\sqrt{(F_1^2 + F_2^2 + F_3^2)}$	$\sqrt{(F_1^2 + F_2^2 + F_3^2)}/1.732$	WQI
PTI Mosque	14.29	14.29	2.08	204.20	204.20	4.33	412.73	20.32	11.73	88.27
Senior Staff Quarters	14.29	14.29	1.52	204.20	204.20	2.31	410.72	20.27	11.70	88.30

Table X: NSF Calculations using Q-Values (PTI Senior Staff Quarters Borehole)

Factor	Weight (w)	Test Result	Q-Value	W*Q
Dissolved oxygen	0.17	3.70	4	0.68
Fecal coliform	0.16	3.00	86	13.76
pH	0.11	5.16	32	3.52
Biochemical oxygen demand	0.11	1.13	94	10.34
Temperature change				
Total phosphate				
Nitrates	0.10	0.33	97	9.70
Turbidity	0.08	0.22	98	7.84
Total solids	0.07	103.27	83	5.81
	ΣW = 0.80			ΣW *Q = 51.65

$$WQI = \frac{\sum w \times Q}{\sum w} = \frac{51.65}{0.80} = 64.56$$ "Medium Water Quality" (See Table IV)

Table XI: Calculations using Q-Values (PTI Mosque Borehole)

Factor	Weight (w)	Test Result	Q -Value	W*Q
Dissolved oxygen	0.17	4.93	4.00	0.68
Fecal coliform	0.16	3.00	86.00	13.76
pH	0.11	4.49	15.00	1.65
Biochemical oxygen demand	0.11	1.37	91.00	10.01
Temperature change				
Total phosphate				
Nitrates	0.10	0.62	96.00	9.60
Turbidity	0.08	0.27	98.00	7.60
Total solids	0.07	134.10	80.00	5.60
	ΣW = 0.80			ΣW*Q = 49.14

$$WQI = \frac{\sum w \times Q}{\sum w} = \frac{49.14}{0.80} = 61.43$$ "Medium Water Quality" (See Table IV)

Table XII: Comparative Analysis of Arithmetic, CCME and NSF Water Quality Indices

Samples	AWQI		CCME		NSF	
	WQI	Quality Status	WQI	Quality Ranking	WQI	Quality
PTI Mosque	50.66	Poor Water Quality	88	Good Water Quality	61	Medium
Senior Staff Quarters	44.54	Good Water Quality	88	Good Water Quality	65	Medium

Table XIII: Calculation of Pearsons Correlation Coefficient for the Two Boreholes

Sn	Parameter	BH1	BH2	$X - M_x$	$Y - M_y$	$(X - M_x)^2$	$(Y - M_y)^2$	$(X - M_x)(Y - M_y)$
1	pH	4.49	5.16	-24.177	-16.18	584.543	261.792	391.189
2	Total Dissolved Solid	134.10	103.27	105.433	81.93	11116.047	6712.525	8638.098
3	Electrical Conductivity	201.57	145.63	172.903	124.29	29895.332	15448.004	21490.072
4	Total Suspended Solid	5.00	2.67	-23.667	-18.67	560.143	348.569	441.869
5	Dissolved Oxygen	4.93	3.70	-23.737	-17.64	563.461	311.17	418.727
6	Biological Oxygen Demand	1.37	1.13	-27.297	-20.21	745.144	408.444	551.679
7	Total Alkalinity	0.00	5.33	-28.667	-16.01	821.816	256.32	458.964
8	Chloride	21.62	18.86	-7.047	-2.48	49.665	6.15	17.477
9	Total Hardness	37.67	21.50	9.003	0.16	81.048	0.026	1.44
10	Calcium	8.17	4.82	-20.497	-16.52	420.141	272.91	338.616

11	Magnesium	4.15	2.42	-24.517	-18.92	601.1	357.966	463.868
12	Sulphate	3.05	2.06	-25.617	-19.28	656.248	371.718	493.902
13	Turbidity	0.27	0.22	-28.397	-21.12	806.409	446.054	599.752
14	Nitrate	0.62	0.33	-28.047	-21.01	786.653	441.42	589.274
15	Total Coliform	3.00	3.00	-25.667	-18.34	658.812	336.356	470.739

BH1 = Borehole 1 (PTI Mosque), BH2 = Borehole 2 (PTI Senior Staff Quarters)

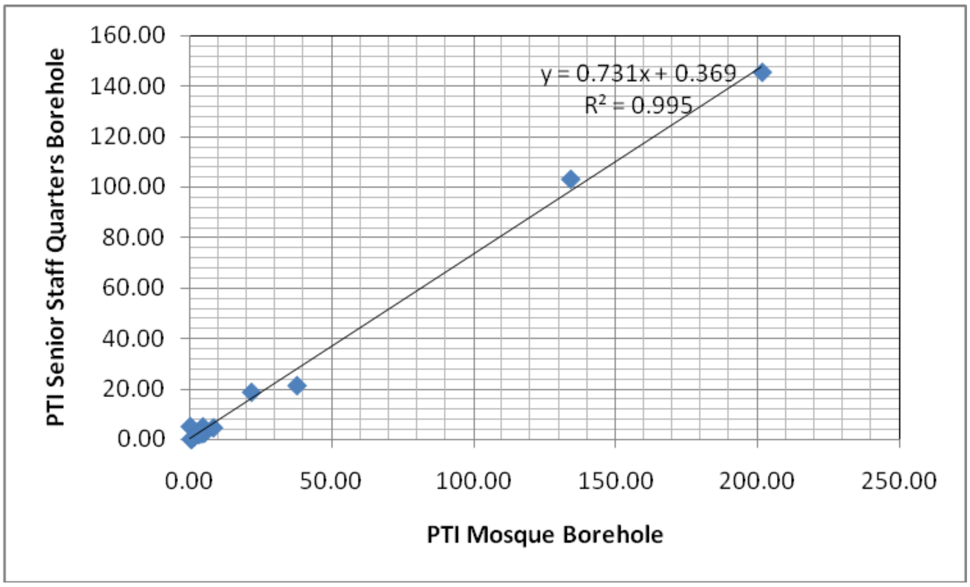

Figure I: Correlation of the Observed Results from the Two Boreholes

Pearson Correlation Coefficient Calculations [11]
X Values
$\sum X = 430.01$
Mean = 28.667
$\sum(X - M_x)^2 = SS_x = 48346.561$

Y Values
$\sum Y = 320.1$
Mean = 21.34
$\sum(Y - M_y)^2 = SS_y = 25979.425$

X and Y Combined
N = 15
$\sum(X - M_x)(Y - M_y) = 35365.668$

R Calculation
$r = \sum((X - M_y)(Y - M_x)) / \sqrt{((SS_x)(SS_y))}$

$r = 35365.668 / \sqrt{((48346.561)(25979.425))} = 0.9979$

Key:
X: X Values (Borehole 1 PTI MOSQUE)
Y: Y Values (Borehole 2 PTI SENIOR STAFF QUARTERS)
M_x: Mean of X Values
M_y: Mean of Y Values
$X - M_x$ & $Y - M_y$: Deviation scores
$(X - M_x)^2$ & $(Y - M_y)^2$: Deviation Squared
$(X - M_x)(Y - M_y)$: Product of Deviation Scores

The value of R is 0.9979. This is a strong positive correlation, which means that high X variable scores go with high Y variable scores (and vice versa).
The value of R^2, the coefficient of determination, is 0.9958.

Discussions

The water quality indices are summarized in table XII. The AWQI calculated for Borehole 1 (PTI Mosque) was 50.66 corresponding to “Poor Water Quality” (see table I), looking critically at the value it can be seen that the water quality just slightly drifted into the “Poor Quality” by a small margin. This observation is corroborated by the NSF calculations which revealed WQI of 61 “Medium water Quality” (Table IV). But the CCME calculations revealed WQI of 88 “Good Water Quality” (Table II) for the same borehole. Combining the three calculations, the water from borehole 1 can be termed as “Medium Quality”. Similarly, the AWQI calculated for Borehole 2 (PTI Senior Staff Quarters) was 44.54 corresponding to “Good Water Quality” (Table I). This observation is corroborated by the CCME calculations revealed WQI of 88 “Good Water Quality” (Table II) for the same borehole which implies Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels [9]. But the NSF calculations revealed WQI of 65 “Medium water Quality”, which is closer to being “Good Water Quality” looking critically at the classification legend (Table IV).

The three different methods used for calculating WQI for Borehole 1 (PTI Mosque) revealed “Poor, Good and Medium” water quality. And same methods revealed “Good, Good and Medium” water quality. However, the correlation coefficient results indicated that the two boreholes have water of similar quality.

Conclusion

It can be concluded that the water from PTI Mosque and the PTI Senior Staff Quarters are of **Good Quality**, though with minor degree of threat or impairment which could be as a result of contamination due to excessive rainfall.

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References

[1]. Shweta T., Bhavtosh S., Prashant S., and Rajendra D. “Water Quality Assessment in Terms of Water Quality Index.” *American Journal of Water Resources* 1, no. 3 (2013): 34-38. doi: 10.12691/ajwr-1-3-3.

[2]. Farouq A.U. “Comparative Water Quality Indices of Hand-Dug Wells Near Septic Tanks In Effurun, Delta State, Nigeria." IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) 12.5 (2018): 82-86.

[3]. Abdel-Lah A.K., and Shamrukh M. “*Impact of Septic System on Groundwater Quality in a Nile Valley Village, Egypt”, Sixth International Water Technology Conference, IWTC 2001, Alexandria, Egypt 237-245*

[4]. APHA (2007). American public health association, Standard Method of the Examination of Water and Wastewater.18th edition, Washington D. C

[5]. Brown, R.M, McCleil and N.J., Deniger, R.A. and O. Connor, M.F.A, (1972). Water quality index – crossing the physical barrier (Jenkis, S.H. ed) proceedings in international conference on water pollution Research Jerusalem 6. 787-797

[6]. Chowdhurry, R.M, Muntasi, S.Y and Hossain M.M, (2012). Water quality index of water bodies along Faridpur-Barisal road in Bangladesh, Glob Eng. Tech Rev 2(3) 1-8.

[7]. Chauhan, A. and Signh S., (2010). Evaluation of Ganga water for drinking purpose by water quality index at Rishikesh, Uttarakham, India, Report Opinion 2(a). 53-61.

[8]. Chatterjee C. and M. Raziuddin, Determination of water quality index of a degraded river in Asanol Industrial area, Raniganj, Burdwan, West Bengal, *Nature, Environment and Pollution Technology,* 1 (2), 2002, pp 181-189.

[9]. CCME (2001): Canadian Water Quality Guidelines for the Protection of Aquatic Life, CCME WATER QUALITY INDEX 1.0 Technical Report in Canadian Environmental Quality Guidelines Canadian Council of Ministers of the Environment, 2001

[10]. Brown, R.M., McClelland, N.I., Deininger, R.A. and Tozer, R.G., “Water quality index-do we dare?”, *Water Sewage Works*, 117(10). 339-343. 1970.

[11]. www.socscistatistics.com

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