Academia Journal of Environmental Sciences 2(6): 089-102, September 2014
DOI: http://dx.doi.org/10.15413/ajes.2014.0109
ISSN: 2315-778X

Academia Publishing

Research Paper

Assessment of water quality index of some selected boreholes around dump sites in Nigeria

Accepted 7th May, 2014

ABSTRACT

The present work is aimed at assessing the overall water quality employing the water quality index (WQI) approach on some selected boreholes (groundwater) around some specific dump sites in the southern part of Nigeria. A total of nine boreholes comprising of three each at three different locations were selected for this research work. Water samples were collected in air tight polyethylene containers and taken to the laboratory to assess their physico-chemical and biological characteristics. In other to determine the Water Quality Index, the following parameters among others were considered namely; pH, turbidity, conductivity, dissolved oxygen, total hardness, calcium, total dissolved solids, iron, manganese etc. Results obtained was used to develop a water quality data bank that enabled us rank the different water sources in terms of quality, thereafter, appropriate treatment methods were recommended to cater for the pollution problems resulting from human activities that interferes with the quality of ground water. A non-parametric statistical analysis comparing groups using the Mann-Whitney test (U test) was also done, splitting data between the different locations. The central trend measurement chosen to analyze the data was the median, as it is not influenced by extreme series values. Box-plots graphs were utilized to facilitate visualization of the results so that the median and the data distribution trend could be identified. Overall result from the research work has shown the suitability of water quality index modeling and its associated significance in predicting the purity of both surface and ground water. It is recommended that the model be employed to conduct water quality assessment on regular bases as this will help ensure that stake holders in the water business abide by the standard limit before such water is allowed to reach the end user.

Key words: Conductivity, water quality index, ground water quality assessment, water quality parameters, turbidity, and total dissolved solids (tds).

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INTRODUCTION

As water percolates through the sub-soil, the layers of sand that makes up the soil usually act as filters which tend to purify the water as it moves vertically downwards (Brown et al., 1970). As water goes down the aquifer, the qualities of the water tend to increase, but the amount of dissolved minerals may increase in most cases (CCME, 2001). Groundwater especially borehole water has found serious use in both domestic, commercial and industrial water supply in addition to irrigation all over the world (Garg, 2007).

In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization (Gupta and Gupta, 2008).

The activity of man especially as it relates to agricultural development in relation to excessive

application of fertilizers and unsanitary conditions has constantly threatens the quality of water available for use (Ramakrishnaiah et al., 2009).

Rapid urbanization, especially in developing countries like India, has affected the availability and quality of groundwater due to its overexploitation and improper waste disposal, especially in urban areas. According to WHO organization, about 80% of all the diseases in human beings are caused by water. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source. It therefore becomes imperative to regularly monitor the quality of groundwater and to device ways and means to protect it.

One way to monitor the quality of water is to constantly check the concentration of the associated parameters and cross correlates it against water quality standards. Other methods will involve the use of multi-variate statistics to monitor the variability of water quality parameters with time, location and distance and also the water quality index approach that helps to convert the overall quality of water samples into an index that can easily be managed and explained (Raphael et al., 2007).

In this research paper, water quality index method had been employed to investigate the effects of dump site on the quality of selected boreholes around the southern part of Nigeria. In addition, statistical methods including the use of box plots had been employed to explain the variation of individual water quality parameters around the different sampling locations. The main aim of the research is to investigate the suitability of water quality index modeling as a tool to predict and monitor the quality of ground water in addition to studying the effects of source pollutant such as dumpsites, storm water injection, cemetery, point source pollution etc on the overall quality of both surface and ground water source. Some of the major objectives of the research includes; dump site visitation, sample collection, analysis of the sample water, water quality index modeling and finally, statistical analysis of the data including result visualization.

MATERIALS AND METHODS

The methods employed in the sampling and analyses of the borehole water are described as follows:

Sampling and analysis

Nine boreholes from three different locations around selected dump sites were used for these studies. Three samples were collected from each borehole at each location to make a total of twenty seven samples. The sampling was done during the raining season precisely in the month of May, June and July 2012. These periods were chosen so as to study the effects of leachate caused by moving water from the dump site on ground water quality.

The sampling was done at relative distance away from the dump site (10, 50 and 100 m respectively). The samples were stored in clean dried plastic containers, incubated at room temperature and analyzed within 12 – 24 h. The samples were analyzed for various water quality parameters using standard procedures as proposed by standard methods for the examination of water and waste water (2007). The mean value of the water quality test results were designated as A1, A2, A3, B1, B2, B3, C1, C2, C3 where A, B and C represent the different sampling locations. Table 1 defines the methods employed in conducting the Physico-chemical and biological compositions of the sample water:

Evaluation of water quality data

Spatial analysis

The water quality index (WQI), for each water sample was developed to evaluate the water quality index trend along the different dump site location based on the measured water quality data sets. Some of the measured water quality data sets that were investigated include; dissolve oxygen (DO), total suspended solid (TSS), pH, total dissolved solid (TDS), turbidity, concentration of nitrate and nitrite, chloride, phosphate, total coliform count, and several heavy metals including iron, lead, copper, cadmium, and zinc.

Non parametric analysis

An analysis comparing groups using the Mann-Whitney test (U test) was also accomplished, splitting data between the different locations. The central trend measurement chosen to analyze the data was the median, as it is not influenced by extreme series values. Box-plots graphs were utilized to facilitate visualization of the results so that the median and the data distribution trend could be identified.

RESULTS AND DISCUSSION

The mean of the water quality results for the twenty seven water samples collected at the three different locations are given in Tables 2, 3, and 4.

Water quality index was computed for each of the sample water collected from different point for assessing the suitability of the water for human consumption using eight important physico-chemical parameters namely; pH, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity(EC), alkalinity, concentration of iron (Fe), cadmium (Cd), and copper (Cu). The basic steps for the computation of water quality index used for these studies were taken from (7) as follows:

Table 1. Methods used in the assessment of water quality.

Parameter	Method employed
pH	pH Meter
EC	Water Quality Multi Meter
Temperature	Thermometer
Turbidity	Turbidimeter
TDS	Water Quality Multi Meter
Nitrate	Aqua Multi Test Strips
Nitrite	Aqua Multi Test Strips
Sulphate	Titration Method
Chloride	Chloride Meter
Fluoride	Fluoride Meter
Ammonia	Titration Method
Metals	Atomic Adsorption (AAS)
TSS	Gravimetric Method
Odour	Osmoscope
Colour	Visual Inspection
Hardness	Titration Method
Alkalinity	Titration Method
DO	DO Meter
BOD	Titration Method
COD	COD Analyzer
Phosphate	Atomic Adsorption (AAS)
Manganese	Atomic Adsorption (AAS)
E.coli	Membrane Filtration

Table 2. Mean test results from Dumpsite location A.

Test index	A1 (10 m)	A2 (50 m)	A3 (100 m)
Temperature	29.7	29.7	29.6
Colour	Colourless	Colourless	Colourless
TDS	65.7	43.6	28.9
TSS	0.00	0.00	0.00
Conductivity	99.8	66.1	43.9
Turbidity	0.01	0.00	0.00
pH	5.40	5.42	5.43
Corrosivity	N.C	N.C	N.C
Alkalinity	356	267	178
Hardness	53.4	53.4	53.4
Nitrate	445	178	0
Nitrite	0.00	0.00	0.00
Odour	Odourless	Odourless	Odourless
DO	4.43	4.45	4.47
Phosphate	0.065	0.020	ND
Iron	1.68	1.04	0.67
Lead	ND	ND	ND
Sulphate	1.19	0.94	1.35
Zinc	0.025	0.021	0.010
Copper	0.035	0.023	0.012
Cadmium	0.0014	0.0011	0.001
Chloride	4.50	2.34	2.03
Coliform	0/100	0/100	0/100

Table 3. Mean test results from Dumpsite location B.

Test index	B1(10 m)	B2 (50 m)	B3 (100 m)
Temperature	29.6	29.76	29.6
Colour	Colourless	Colourless	Colourless
TDS	190.1	184	165.1
TSS	0.00	0.00	0.00
Conductivity	288	278	250
Turbidity	0.01	0.00	0.00
pH	5.28	5.29	5.30
Corrosivity	N.C	N.C	N.C
Alkalinity	267	267	267
Hardness	53.4	53.4	53.4
Nitrate	420	380	235
Nitrite	0.00	0.00	0.00
Odour	Odourless	Odourless	Odourless
DO	4.21	4.23	4.51
Phosphate	ND	0.015	0.035
Iron	2.42	1.78	0.89
Lead	ND	ND	ND
Sulphate	1.37	2.18	1.39
Zinc	0.035	0.016	0.011
Copper	0.013	0.013	0.003
Cadmium	0.002	0.002	0.0015
Chloride	26.1	47.4	17.0
Coliform	0/100	0/100	0/100

Table 4. Mean test results from Dumpsite location C.

Test index	C1(10 m)	C2(50 m)	C3(100 m)
Temperature	29.6	29.3	29.6
Colour	Colourless	Colourless	Colourless
TDS	153.8	145.5	136.7
TSS	0.00	0.00	0.00
Conductivity	232.1	220	207.1
Turbidity	0.01	0.00	0.00
pH	5.25	5.25	5.30
Corrosivity	N.C	N.C	N.C
Alkalinity	265	267	269
Hardness	53.4	53.4	53.4
Nitrate	450	445	443
Nitrite	0.00	0.00	0.00
Odour	Odourless	Odourless	Odourless
DO	4.44	4.46	4.478
Phosphate	0.101	0.075	0.043
Iron	1.48	1.24	1.03
Lead	ND	ND	ND
Sulphate	0.61	1.13	0.42
Zinc	0.02	0.02	0.01
Copper	0.03	0.02	0.001
Cadmium	0.001	0.001	ND
Chloride	11.7	12.1	8.76
Coliform	0/100	0/100	0/100

Weightage determination

For water quality index calculation, we first have to know the Weightage of each of the parameters identified. Parameters which have higher permissible limits are less harmful because they cannot change quality of ground water when they are present in high quantity. So Weightage of tested parameters have an inverse relationship with its permissible limits. Therefore:

$$W_n = \frac{K}{S_n} \quad (1)$$

W_n = Unit weight of the parameters tested, S_n = Standard values (WHO Standard)
K = Constant of proportionality.

$$K = \frac{1}{\sum_{i=1}^{s} \frac{1}{S_n}} \quad (2)$$

Calculating quality rating

Rating scale was prepared for range of values of each parameter. The rating varies from 0 to 100 and is divided into five intervals. The rating q_n = 0 implies that the parameter present in water exceeds the standard maximum permissible limits and water is severely polluted. On the other hand q_n = 100 implies that the parameter present in water has the most desirable value. The other ratings fall between these two extremes and are q_n = 40, q_n = 60 and q_n = 80 standing for excessively polluted, moderately polluted and slightly less polluted respectively. This scale is modified version of rating scale and is calculated as follows (Standard Methods, 1995):

$$q_n = \frac{100(V_n - V_{io})}{(S_n - V_{io})} \quad (3)$$

Where: q_n = Quality rating or sun index, V_n = Test result for each parameter tested, S_n = Standard value of each parameter, V_{io} = ideal value of selected parameters tested (in pure water, V_{io} = 0 for all parameters tested except pH and dissolved oxygen which is 7.0 and 14.6 respectively.

The standard values for each parameter for computing the overall water quality index shown in Table 5, were selected in accordance with the World Health Organization Standard for drinking water (WHO standard).

Essentially, a Water Quality Index (WQI) is a compilation of a number of parameters that can be used to determine the overall quality of water sample. The parameters chosen for the Water Quality Index (WQI) compilation are: pH, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity(EC), alkalinity, concentration of iron (Fe), cadmium (Cd), and copper (Cu). The numerical value is then multiplied by a weighting factor that is relative to the significance of the test to water quality. The sum of the resulting values is added together to arrive at an overall water quality index. It is basically a mathematical means of calculating a single value from multiple test results. The WQI result represent the level of water quality in a given water basin such as lake, river or stream.

Table 5. WHO Standard for drinking water.

Factors	WHO Standard
pH	6.5-8.5
EC	400
DO	5
TDS	500
Alkalinity	600
Iron (Fe)	0.3
Cadmium (Cd),	0.003
copper (Cu)	1.0

The following steps were employed in computing the overall water quality.

1. The weightage unit (W_n) for all parameters tested were determined and summed up to obtain $\sum W_n$
2. The quality rating or sub-index for all parameters tested were determined and summed up to obtain $\sum q_n$
3. The index $W_n * q_n$ was calculated for each parameter tested and summed up to obtain $\sum W_n.q_n$
4. Finally, Water Quality Index (WQI) was computed for each ground water source using the mass balance equation:

$$\frac{\sum W_n.q_n}{\sum W_n} \quad (4)$$

In other to fully assess the true status of ground water in the study area, the constituent parameters of the water samples were used as data to compute the overall water quality index. Results of the computed water quality index (WQI) are shown in Tables 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 respectively.

The graphical variation of the water quality index within the different dumpsite locations are shown in the Figure 1.

Evaluation of the plot reveals an upward trend in the quality of ground water as we move away from the dumpsite location. This trend is replicated for the three different sites which justify the fact that the contaminating

Table 6. Water quality index of sample A1.

S/No	Parameter	WHO limits (S_n)	K	Test result (V_n)	Weightage (W_n)	Quality rating (q_n)	[(Wn)(qn)]
1	pH	6.5	0.0030	4.40	0.000461538	520.00000	0.24000
2	Electrical Conductivity (EC)	400	0.0030	99.8	0.0000075	24.95000	0.00019
3	Dissolved Oxygen (DO)	5	0.0030	4.43	0.0006	105.93750	0.06356
4	Total dissolved solids (TDS)	500	0.0030	65.7	0.000006	13.14000	0.00008
5	Alkalinity	600	0.0030	356	0.000005	59.33333	0.00030
6	Iron (Fe)	0.3	0.0030	1.68	0.01	560.00000	5.60000
7	Cadmium (Cd),	0.003	0.0030	0.0014	1	46.66667	46.66667
8	Copper (Cu)	1.0	0.0030	0.035	0.003	3.50000	0.01050
					∑ = 1.01408		∑= 52.581
				WQI = 51.851			

Table 7. Water quality index of sample A2.

S/No	Parameter	WHO limits (S_n)	K	Test result (V_n)	Weightage (W_n)	Quality rating (q_n)	[(Wn)(qn)]
1	pH	6.5	0.0030	4.42	0.000461538	516.00000	0.23815
2	Electrical conductivity (EC)	400	0.0030	66.1	0.0000075	16.52500	0.00012
3	Dissolved oxygen (DO)	5	0.0030	4.45	0.0006	105.72917	0.06344
4	Total dissolved solids (TDS)	500	0.0030	43.6	0.000006	8.72000	0.00005
5	Alkalinity	600	0.0030	267	0.000005	44.50000	0.00022
6	Iron (Fe)	0.3	0.0030	1.04	0.01	346.66667	3.46667
7	Cadmium (Cd),	0.003	0.0030	0.002	1	66.66667	66.66667
8	Copper (Cu)	1.0	0.0030	0.023	0.003	2.30000	0.00690
					∑=1.01408		∑=70.4422
				WQI = 69.464			

Table 8. Water quality index of sample A3.

S/No	Parameter	WHO limits (S_n)	K	Test result (V_n)	Weightage (W_n)	Quality rating (q_n)	[(Wn)(qn)]
1	pH	6.5	0.0030	4.43	0.000461538	514.00000	0.23723
2	Electrical conductivity (EC)	400	0.0030	43.9	0.0000075	10.97500	0.00008
3	Dissolved oxygen (DO)	5	0.0030	4.47	0.0006	105.52083	0.06331
4	Total dissolved solids (TDS)	500	0.0030	28.9	0.000006	5.78000	0.00003
5	Alkalinity	600	0.0030	178	0.000005	29.66667	0.00015
6	Iron (Fe)	0.3	0.0030	0.67	0.01	223.33333	2.23333
7	Cadmium (Cd),	0.003	0.0030	0.0023	1	76.66667	76.66667
8	Copper (Cu)	1.0	0.0030	0.012	0.003	1.20000	0.00360
					∑=1.01408		∑=79.2044
				WQI = 78.105			

Table 9. Water Quality Index of Sample B1.

S/No	Parameter	WHO limits (S_n)	K	Test result (V_n)	Weightage (W_n)	Quality rating (q_n)	[(Wn)(qn)]
1	pH	6.5	0.0030	4.28	0.000461538	544.00000	0.25108
2	Electrical conductivity (EC)	400	0.0030	288	0.0000075	72.00000	0.00054
3	Dissolved oxygen (DO)	5	0.0030	4.21	0.0006	108.22917	0.06494
4	Total dissolved solids (TDS)	500	0.0030	190.1	0.000006	38.02000	0.00023
5	Alkalinity	600	0.0030	267	0.000005	44.50000	0.00022
6	Iron (Fe)	0.3	0.0030	2.42	0.01	806.66667	8.06667
7	Cadmium (Cd),	0.003	0.0030	0.0015	1	50.00000	50.00000
8	Copper (Cu)	1.0	0.0030	0.013	0.003	1.30000	0.00390
					∑=1.01408		∑=58.38757
				WQI = 57.577			

Table 10. Water quality index of sample B2.

S/No	Parameter	WHO limits (S_n)	K	Test result (V_n)	Weightage (W_n)	Quality rating (q_n)	[(Wn)(qn)]
1	pH	6.5	0.0030	4.29	0.000461538	542.00000	0.25015
2	Electrical conductivity (EC)	400	0.0030	278	0.0000075	69.50000	0.00052
3	Dissolved oxygen (DO)	5	0.0030	4.23	0.0006	108.02083	0.06481
4	Total dissolved solids (TDS)	500	0.0030	184	0.000006	36.80000	0.00022
5	Alkalinity	600	0.0030	267	0.000005	44.50000	0.00022
6	Iron (Fe)	0.3	0.0030	1.78	0.01	593.33333	5.93333
7	Cadmium (Cd),	0.003	0.0030	0.0017	1	56.66667	56.66667
8	Copper (Cu)	1.0	0.0030	0.013	0.003	1.30000	0.00390
					∑=1.01408		∑=62.91983
				WQI = 62.046			

Table 11. Water quality index of sample B3.

S/No	Parameter	WHO limits (S_n)	K	Test result (V_n)	Weightage (W_n)	Quality rating (q_n)	[(Wn)(qn)]
1	pH	6.5	0.0030	4.30	0.000461538	540.00000	0.24923
2	Electrical conductivity (EC)	400	0.0030	250	0.0000075	62.50000	0.00047
3	Dissolved oxygen (DO)	5	0.0030	4.51	0.0006	105.10417	0.06306
4	Total dissolved solids (TDS)	500	0.0030	165.1	0.000006	33.02000	0.00020
5	Alkalinity	600	0.0030	267	0.000005	44.50000	0.00022
6	Iron (Fe)	0.3	0.0030	1.29	0.01	430.00000	4.30000
7	Cadmium (Cd),	0.003	0.0030	0.0021	1	70.00000	70.00000
8	Copper (Cu)	1.0	0.0030	0.003	0.003	0.30000	0.00090
					∑=1.01408		∑=74.61408
				WQI = 73.578			

Table 12. Water quality index of sample C1.

S/No	Parameter	WHO limits (S_n)	K	Test result (V_n)	Weightage (W_n)	Quality rating (q_n)	[(Wn)(qn)]
1	pH	6.5	0.0030	4.25	0.000461538	550.00000	0.25385
2	Electrical Conductivity (EC)	400	0.0030	232.1	0.0000075	58.02500	0.00044
3	Dissolved oxygen (DO)	5	0.0030	4.44	0.0006	105.83333	0.06350
4	Total dissolved solids (TDS)	500	0.0030	153.8	0.000006	30.76000	0.00018
5	Alkalinity	600	0.0030	267	0.000005	44.50000	0.00022
6	Iron (Fe)	0.3	0.0030	1.48	0.01	493.33333	4.93333
7	Cadmium (Cd),	0.003	0.0030	0.0013	1	43.33333	43.33333
8	Copper (Cu)	1.0	0.0030	0.03	0.003	3.00000	0.00900
					∑=1.01408		∑=48.59386
				WQI =47.919			

Table 13. Water quality index of sample C2.

S/No	Parameter	WHO limits (S_n)	K	Test result (V_n)	Weightage (W_n)	Quality rating (q_n)	[(Wn)(qn)]
1	pH	6.5	0.0030	4.25	0.000461538	550.00000	0.25385
2	Electrical conductivity (EC)	400	0.0030	220	0.0000075	55.00000	0.00041
3	Dissolved oxygen (DO)	5	0.0030	4.46	0.0006	105.62500	0.06338
4	Total dissolved solids (TDS)	500	0.0030	145.5	0.000006	29.10000	0.00017
5	Alkalinity	600	0.0030	267	0.000005	44.50000	0.00022
6	Iron (Fe)	0.3	0.0030	1.24	0.01	413.33333	4.13333
7	Cadmium (Cd),	0.003	0.0030	0.0016	1	53.33333	53.33333
8	Copper (Cu)	1.0	0.0030	0.02	0.003	2.00000	0.00600
					∑=1.01408		∑=57.79070
				WQI = 56.988			

Table 14. Water Quality Index of Sample C3.

S/No	Parameter	WHO limits (S_n)	K	Test result (V_n)	Weightage (W_n)	Quality rating (q_n)	[(Wn)(qn)]
1	pH	6.5	0.0030	4.30	0.000461538	540.00000	0.24923
2	Electrical Conductivity (EC)	400	0.0030	207.1	0.0000075	51.77500	0.00039
3	Dissolved oxygen (DO)	5	0.0030	4.48	0.0006	105.41667	0.06325
4	Total dissolved solids (TDS)	500	0.0030	136.7	0.000006	27.34000	0.00016
5	Alkalinity	600	0.0030	267	0.000005	44.50000	0.00022
6	Iron (Fe)	0.3	0.0030	1.03	0.01	343.33333	3.43333
7	Cadmium (Cd),	0.003	0.0030	0.0019	1	63.33333	63.33333
8	Copper (Cu)	1.0	0.0030	0.001	0.003	0.10000	0.00030
					∑=1.01408		∑=67.08022
				WQI = 66.149			

Table 15. Calculated Water Quality Index of samples.

Mean samples	Distance (m)	WQI
A1	10	51.851
A2	50	69.464
A3	100	78.105
B1	10	57.577
B2	50	62.046
B3	100	73.578
C1	10	47.919
C2	50	56.988
C3	100	66.149

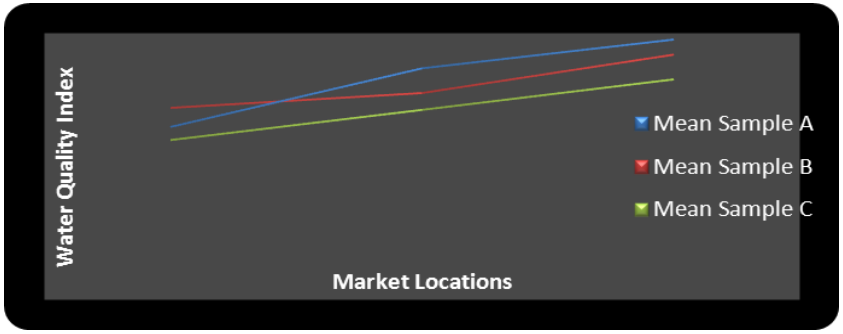

Figure 1. Variation of WQI with sampling locations.

Table 16. Sample groups; A1 and A2: Test statistics.

	pH	Turbidity	Tds	Tss	E.C	Alkalinity	Hardness	Nitrate	Cu	Zn	pb	Cl	Temp.
Mann-Whitney U	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.500
Wilcoxon W	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.500
Z	-1.000	-1.000	-1.000	.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	.000	-1.000	0.000
Asymp. Sig. (2-tailed)	0.317	0.317	0.317	1.000	0.317	0.317	0.317	0.317	0.317	0.317	1.000	0.317	1.000
Exact Sig. [2*(1-tailed Sig.)]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]
a. Not corrected for ties.													
b. Grouping Variable: Dumpsite Location													

Table 17. Sample Groups; A1 and A3: Test statistics.

	pH	Turbidity	Tds	Tss	E.C	Alkalinity	Hardness	Nitrate	Cu	Zn	pb	Cl	Temp.
Mann-Whitney U	0.00	0.00	0.00	.500	0.00	0.00	0.00	0.00	0.00	0.00	.500	0.00	0.00
Wilcoxon W	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000
Z	-1.000	-1.000	-1.000	.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	.000	-1.000	-1.000
Asymp. Sig.(2-tailed)	0.317	0.317	0.317	10.000	0.317	0.317	0.317	0.317	0.317	0.317	10.000	0.317	0.317
Exact Sig. [2*(1-tailed Sig.)]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]	1.000[a]
a. Not corrected for ties.													
b. Grouping Variable: Dumpsite Location													

Table 18. Classification criteria standard, based on NSF.

NSF-WQI	Descriptor	Category
91 – 100	Excellent	A
71 – 90	Good	B
51 – 70	Medium	C
26 – 50	Bad	D
0 - 25	Very Bad	E

effects of leachate decrease with distance away from the point of pollution.

A non-parametric statistical analysis comparing groups using the Mann-Whitney test (U test) was also done, splitting data between the different locations. The central trend measurement chosen to analyze the data was the median, as it is not influenced by extreme series values. Results of the non-parametric analysis for sample groupings for A1 and A2, A1 and A3 are shown in Tables 16 and 17.

Evaluation of the non-parametric result reveals a significant difference in the water quality parameters within the same locations but different sampling distance for all tested parameters except TSS as depicted by the Mann-Whitney U test statistics.

Box-plots graphs were utilized to facilitate visualization of the results so that the median and the data distribution trend could be identified. The box-plot on the variation of the water quality index with locations is shown in Figure 2, 3, 4, 5, 6, 7, 8, and 9 respectively.

Results of the box plots reveal a significant variation in the water quality data sets. Some of the components analyzed include:

(i) Dissolved oxygen
(ii) pH
(iii) Alkalinity
(iv) Conductivity
(v) Concentration of Iron
(vi) Total dissolved solids
(vii) Concentration of Copper
(viii) Water quality index

On the potential of water quality index model to explain the variability of water quality with distance from point of pollution, it was seen from Figure 10 that the water quality index increases with distance away from the point of pollution.
The high coefficient of correlation as shown in the graph was used to establish the correctness of the model and it suitability for pollution trend assessment as it affects water and wastewater analysis.

Conclusion

In other to fully classify the water quality of the different sampling locations, the classification criteria standard, based on National Sanitation Foundation (NSF) as shown in Table 18 was adopted.

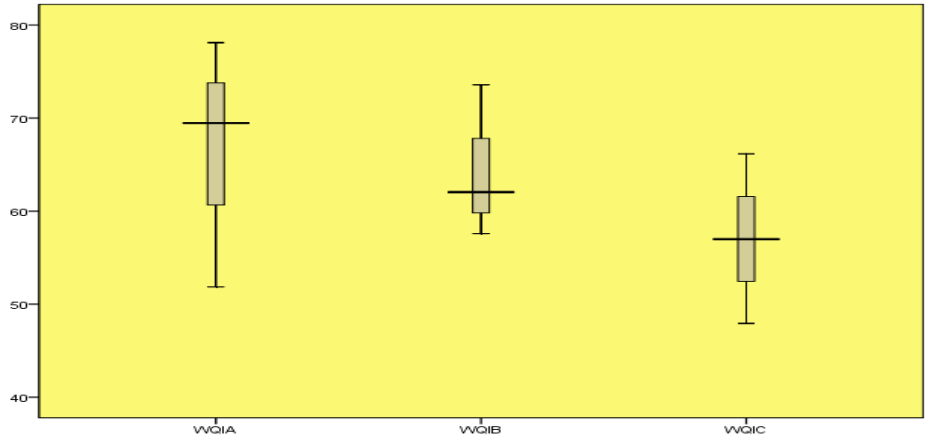

Figure 2. Variation of WQI with sampling locations.

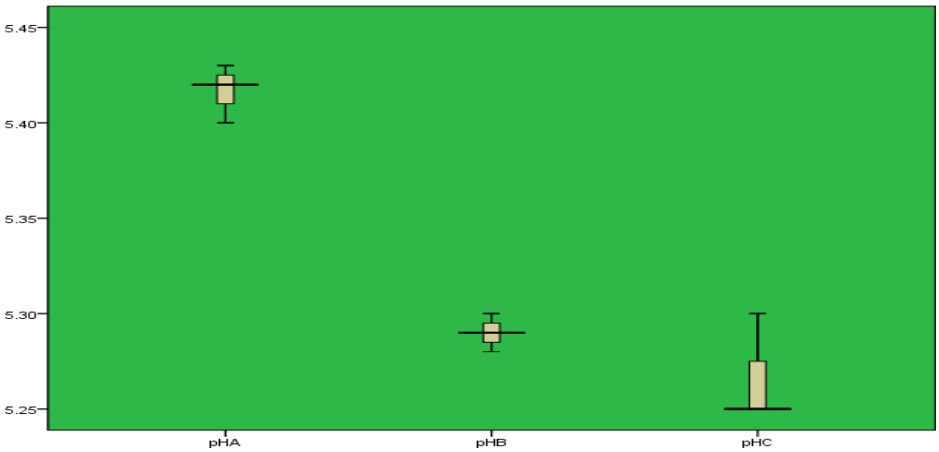

Figure 3. Variation of pH with sampling locations.

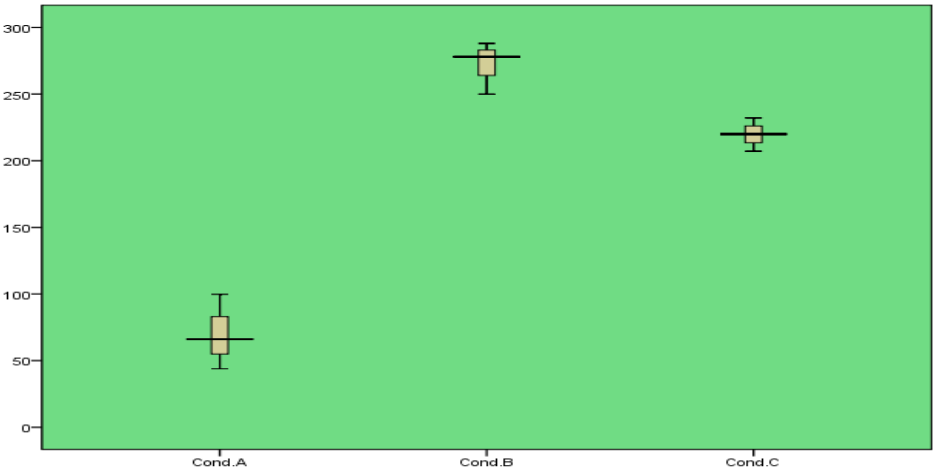

Figure 4. Variation of conductivity with sampling locations.

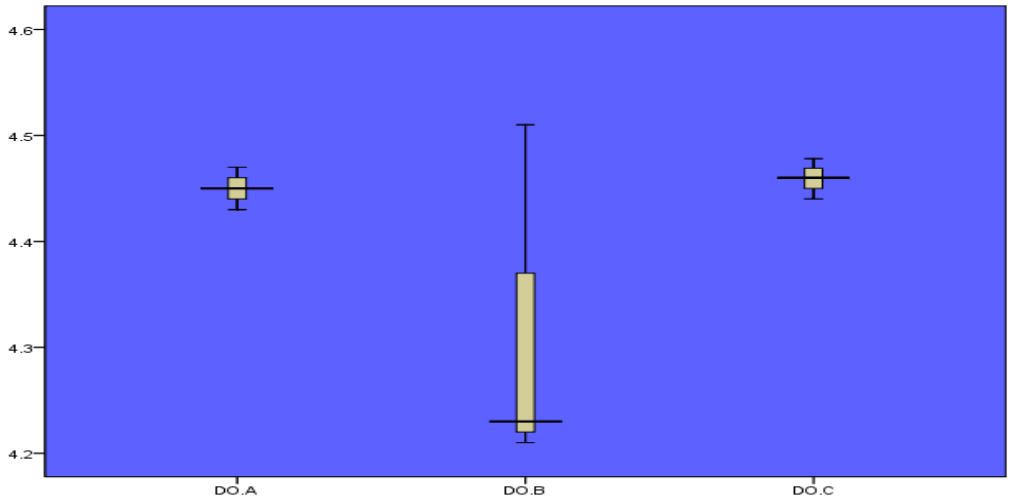

Figure 5. Variation of dissolved oxygen with sampling locations.

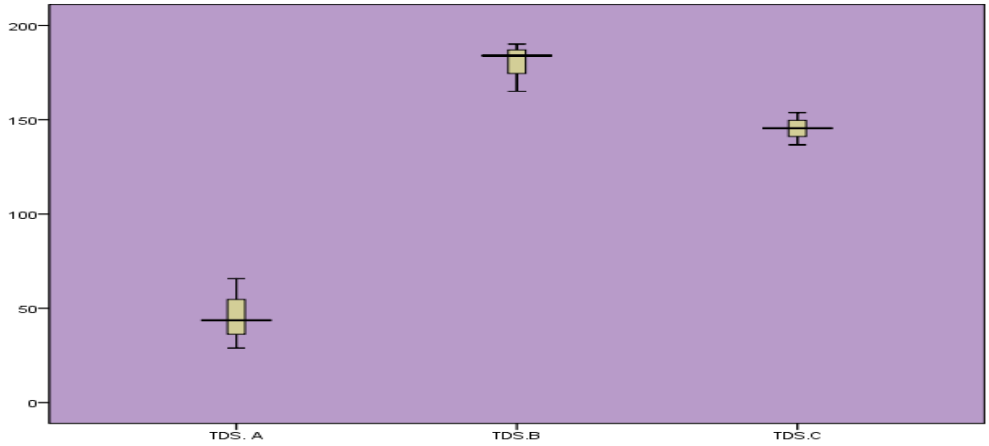

Figure 6. Variation of TDS with sampling locations.

Figure 7. Variation of Alkalinity with sampling locations.

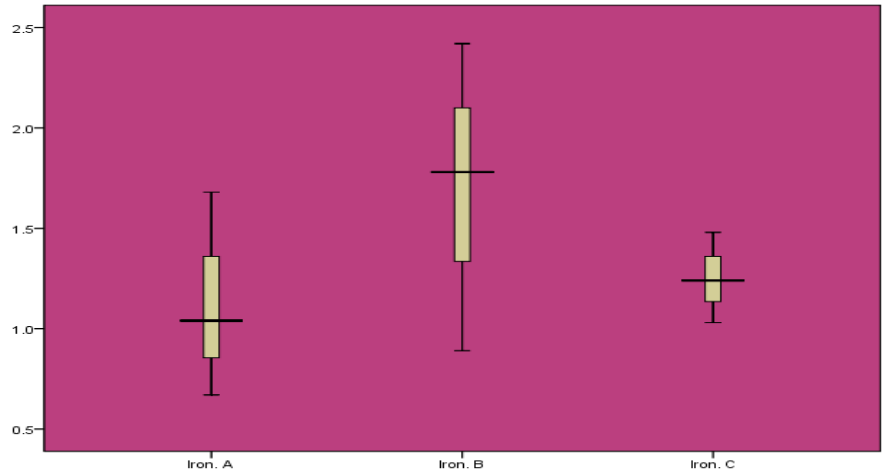

Figure 8. Variation of Iron with sampling locations.

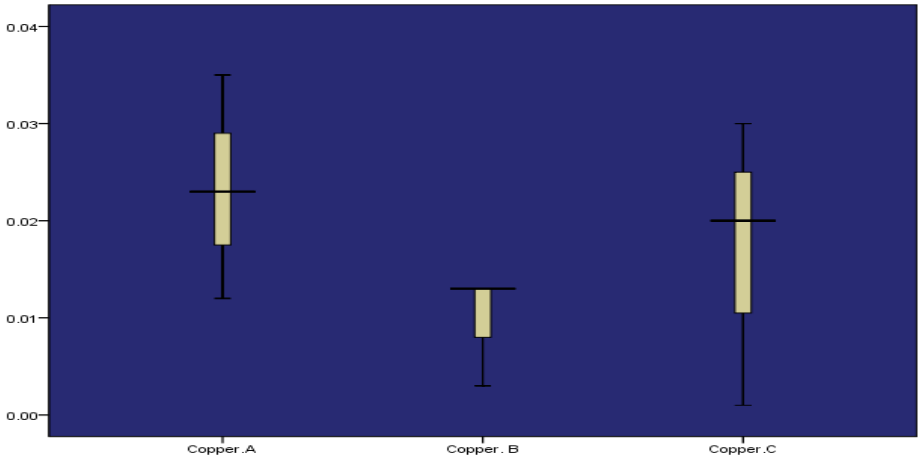

Figure 9. Variation of Copper with sampling locations.

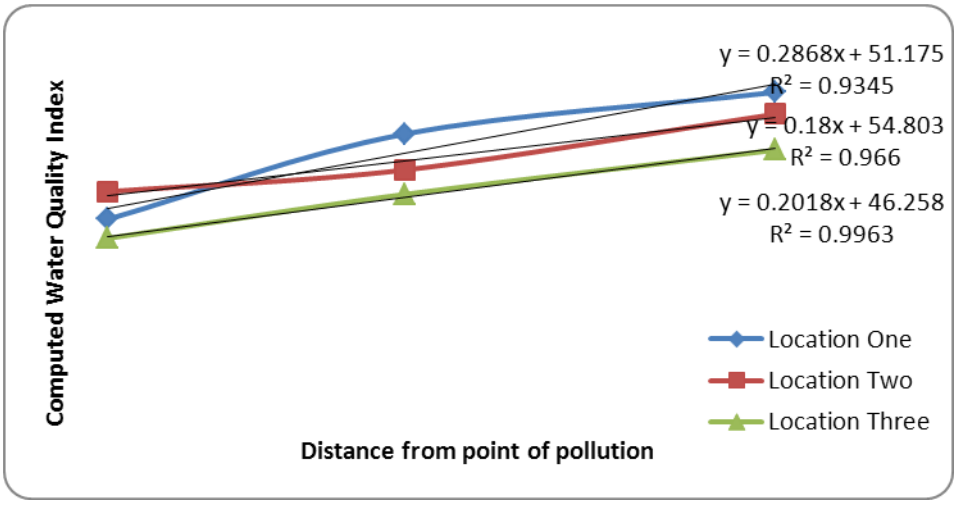

Figure 10. Water quality index trend.

It could be concluded based on the criteria, that the water quality index of location A moved from medium to good as one goes away from the point of pollution, the same trend also applied to location B. For location C, the index moved from Bad to medium indication a strong generation of leachate from location C as compared to A and B.

On the whole, the model proved effective in evaluation water quality status and also to assess the pollution trend on the overall quality of water.

It is recommended that the water be passed through a fixed bed adsorption column having activated carbon in the reaction zone to deal with the relatively high concentration of iron present in the water samples.

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Cite this article as:

Ilaboya IR, Oti EO, Ekoh GO, Umukoro LO (2014). Assessment of water quality index of some selected boreholes around dump sites in Nigeria. Acad. J. Environ. Sci. 2(6): 089-102.

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