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



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

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## 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 viz: 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 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.

## Keywords

Conductivity, Water Quality Index, Ground Water Quality Assessment, Water Quality Parameters, Turbidity, and Total Dissolved Solids (TDS)

## 1. 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 (1). 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 (2). Groundwater especially borehole water has found serious use in both domestic, commercial and industrial water supply in addition to irrigation all over the world (3).

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 (4).

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 (5).

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. (6)

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.

## 2. Materials and Methods

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

### 2.1. 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 meters respectively). The samples were stored in clean dried plastic containers, incubated at room temperature and analyzed within 12 – 24 hours. 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:

***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 |

### 2.2. Evaluation of Water Quality Data

#### 2.2.1. 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.

#### 2.2.2. 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.

## 3. Results and Discussions

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

***Table 2.*** *Mean test results from Dumpsite location A*

| Test Index | A1 (10m) | A2 (50m) | A3 (100m) |
|---|---|---|---|
| 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(10m) | B2 (50m) | B3 (100m) |
|---|---|---|---|
| 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 |

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 4.*** *Mean test results from Dumpsite location C*

| Test Index | C1(10m) | C2(50m) | C3(100m) |
|---|---|---|---|
| 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 |

### 3.1. 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

$$W_n = \frac{K}{S_n} \tag{1}$$

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

$$K = \frac{1}{\sum_{i=1}^{s} \frac{1}{S_n}} \tag{2}$$

### 3.2. 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 (8):

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

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).

***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 |

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.

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:

$$\frac{\sum W_n.q_n}{\sum W_n} \tag{4}$$

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 the tables: 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 respectively.

***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 |

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


***Figure 1.*** *Variation of WQI with sampling locations*

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 table 16 and 17:

***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 | .000 | .000 | .000 | .500 | .000 | .000 | .000 | .000 | .000 | .000 | .500 | .000 | .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 | .000 |
| Asymp. Sig. (2-tailed) | .317 | .317 | .317 | 1.000 | .317 | .317 | .317 | .317 | .317 | .317 | 1.000 | .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 | .000 | .000 | .000 | .500 | .000 | .000 | .000 | .000 | .000 | .000 | .500 | .000 | .000 |
| 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) | .317 | .317 | .317 | 1.000 | .317 | .317 | .317 | .317 | .317 | .317 | 1.000 | .317 | .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

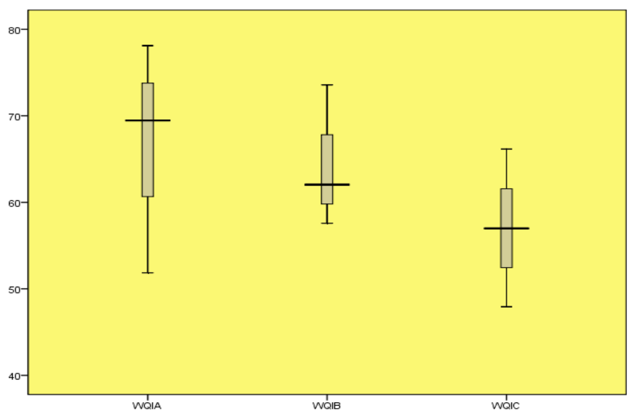


***Figure 2.*** *Variation of WQI with sampling locations*

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.

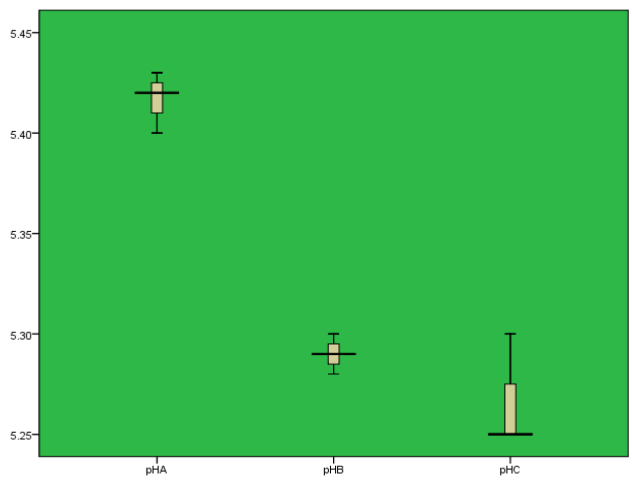


***Figure 3.*** *Variation of pH with sampling locations*

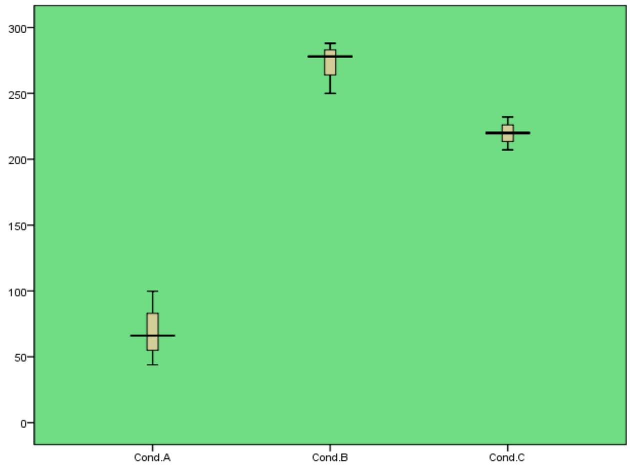


***Figure 4.*** *Variation of Conductivity with sampling locations*

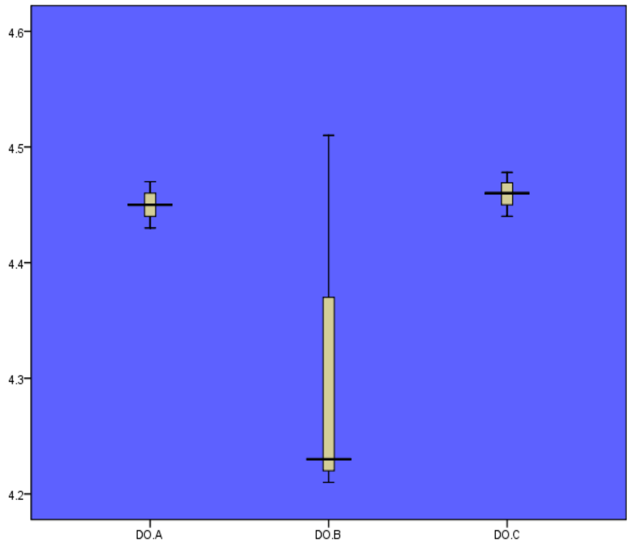


***Figure 5.*** *Variation of dissolved oxygen with sampling locations*

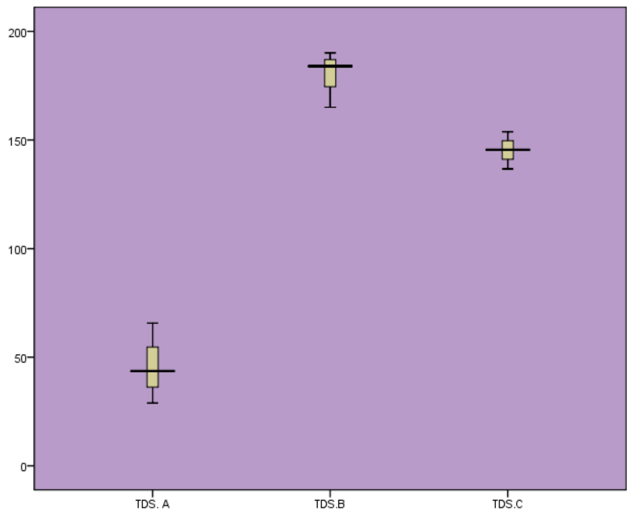


***Figure 6.*** *Variation of TDS with sampling locations*

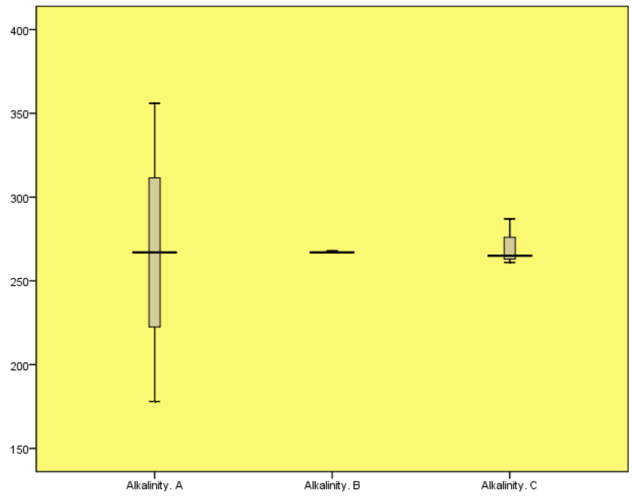


***Figure 7.*** *Variation of Alkalinity with sampling locations*

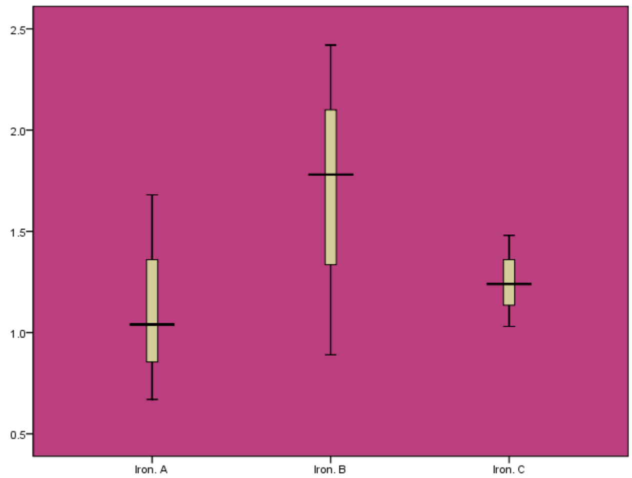


***Figure 8.*** *Variation of Iron with sampling locations*

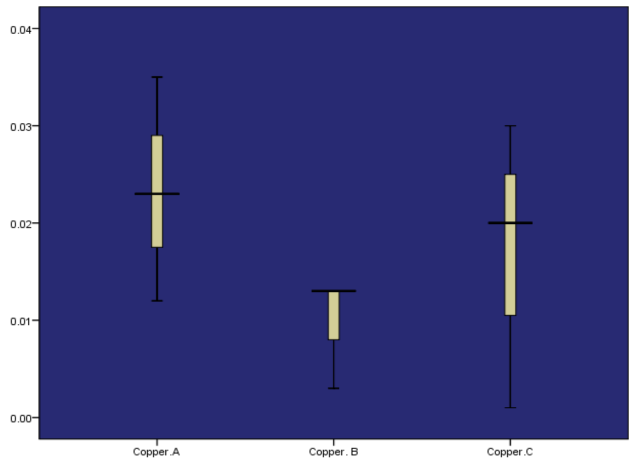


***Figure 9.*** *Variation of Copper with sampling locations*

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

- Dissolved oxygen

- pH
- Alkalinity
- Conductivity
- Concentration of Iron
- Total Dissolved Solids
- Concentration of Copper
- 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.

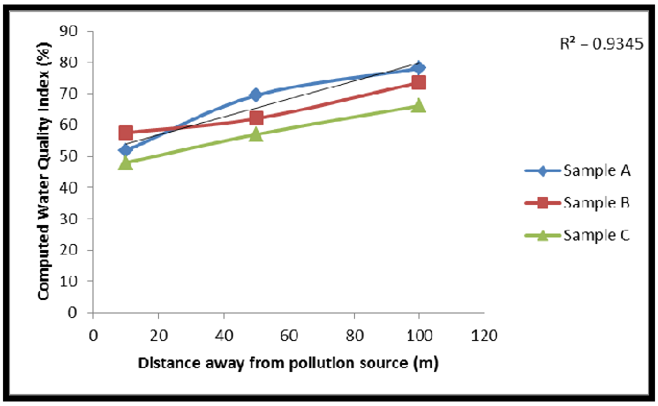


***Figure 10.*** *Water quality index trend*

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.

## 4. 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.

***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 |

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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