Studies on electrical conductivity and total dissolved solids concentration in raw domestic wastewater obtained from an estate in Warri, Nigeria

By

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ABSTRACT

Composite samples of raw domestic wastewater obtained from a sewage treatment plant located in an estate in Warri, Nigeria were analysed for electrical conductivity and total dissolved solids. The essence of this work was to establish an empirical relationship between the two pollution parameters using correlation and regression analysis. Mean values of the electrical conductivity (EC) ranged from 220.6 to 367.0µS/cm while mean values of the total dissolved solids ranged from 100.0 to 206.0mg/l. The correlation coefficient was 0.95. The regression analysis showed a strong significant linear relationship between electrical conductivity and total dissolved solids concentration in the raw domestic wastewater.

Keywords: Electrical Conductivity, Total Dissolved Solids, Domestic wastewater, Pollution, Correlation, Regression.

INTRODUCTION

Electrical conductivity (EC) and total dissolved solids (TDS) are useful parameters for assessing the concentration of solid substances present in any sample of waste water. Electrical Conductivity is also known as specific conductance. It is defined as a measure of the ability of a water sample to convey an electric current (Tchnobanoglous and Kreiti, 2002; Ademoroti, 1996).

The electrical conductivity of industrial wastewaters, treatment plant effluents and polluted water is due to the presence of ionic solutes. Electrical conductivity is a rapid and reasonably precise determination and values are always expressed at a standard temperature of 25°C. The unit of Electrical Conductivity is µS/cm (Csuros, 1997).

The term solid refers to the quantity of matter that remains as residue after evaporation to dryness at 103-108°C. Solids in domestic waste water are usually organic or inorganic in nature. Such solids may be present in dissolved or suspended form. Dissolved solids can be differentiated from suspended solids by filtration (Uwidia and Ademoroti, 2012).

A total dissolved solid is a measure of all dissolved substances in water. It is measured in a laboratory and reported as mg/l. Primary sources for total dissolved solids are agricultural and residential runoff, leaching of soil contamination and point source water pollution discharge from industrial or domestic wastewater treatment plants (Miroslav and Vladimir, 1999).

In this study values of electrical conductivity and total dissolved solids were determined and the values obtained were used to examine the possible relationship between both parameters. It is believed that the result obtained will be useful in wastewater treatment plant operations and environmental laboratories when a quick information on the total dissolved solids or electrical conductivity is required.

OBJECTIVES OF THE STUDY

The objectives of the study are to:

i. Determine the values of electrical conductivity and total dissolved solids present in the raw domestic wastewater.

ii. Study the possible relationship between both parameters mentioned above.

iii. Establish an empirical relationship between them.
MATERIALS AND METHODS

Sampling

Samples were obtained from the estate weekly on different days of the week from Monday to Saturday, beginning at 7.00am and ending at 12.00pm each day. The day for sample collection in the new week was different from that of the preceding week. This was done so that the total exercise might account for the cyclic and intermittent variations occurring at the work site.

Six samples were collected at hourly intervals. During sampling each sample was collected in a clean, well labelled colourless plastic bottle of 1 litre capacity and kept in a refrigerator maintained at 4°C. At this temperature, biodegradation is inhibited. The rate of flow was determined using a flow meter each time the samples were collected.

At the end of the sampling period, a composite sample was made by adding together volumes of the samples proportional to the rates of flow. The samples were collected in wet and dry seasons which are the major seasons in Nigeria so that the results obtained could give a full account of the sewage characteristics in the two seasons.

Analytical Methods

The two parameters such as electrical conductivity and total dissolved solids were analysed as recommended by the Standard Methods for the Examination of Water and Wastewater (APHA, 2005).

The Electrical Conductivity was determined by electrochemical method using the Hach conductivity meter. The total dissolved solids were determined gravimetrically. The mass of solid residue obtained was determined by calculation.

RESULTS AND DISCUSSIONS

Results

The results obtained from the analysis are as shown in Tables 1 – 3 and Figures 1 – 3.

Table 1: EC and TDS determinations for wet season months (April – October).

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Months</th>
<th>EC (µS/cm) Mean±SD</th>
<th>TDS (mg/l) Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>APRIL</td>
<td>348.00±0.94</td>
<td>200.00±0.41</td>
</tr>
<tr>
<td>2</td>
<td>MAY</td>
<td>313.00±2.45</td>
<td>180.00±1.42</td>
</tr>
<tr>
<td>3</td>
<td>JUNE</td>
<td>268.00±6.83</td>
<td>140.00±2.23</td>
</tr>
<tr>
<td>4</td>
<td>JULY</td>
<td>231.33±0.47</td>
<td>132.00±0.27</td>
</tr>
<tr>
<td>5</td>
<td>AUGUST</td>
<td>269.00±3.56</td>
<td>161.33±1.56</td>
</tr>
<tr>
<td>6</td>
<td>SEPTEMBER</td>
<td>367.00±4.67</td>
<td>206.00±1.33</td>
</tr>
<tr>
<td>7</td>
<td>OCTOBER</td>
<td>278.33±2.71</td>
<td>140.00±0.71</td>
</tr>
</tbody>
</table>

Table 2: EC and TDS determinations for dry season months (November – March).

Table 2 below presents the results of EC and TDS obtained during the dry season months from November to March. The essence is also to know the values of both parameters in the raw domestic wastewater from the treatment plant during this season.
Table 3: EC and TDS determinations for the whole year (April – March).

Table 3 below shows a summary of the results for EC and TDS in both wet and dry seasons. Values are also mean of triplicate determinations. The essence of the study is to know the values of both parameters present in the domestic wastewater during both seasons of the year.

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Months</th>
<th>EC (µS/cm) Mean±SD</th>
<th>TDS (mg/l) Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NOVEMBER</td>
<td>220.57±4.45</td>
<td>100.00±1.23</td>
</tr>
<tr>
<td>2</td>
<td>DECEMBER</td>
<td>222.33±2.26</td>
<td>100.00±0.23</td>
</tr>
<tr>
<td>3</td>
<td>JANUARY</td>
<td>241.67±9.17</td>
<td>120.00±1.12</td>
</tr>
<tr>
<td>4</td>
<td>FEBRUARY</td>
<td>260.44±2.59</td>
<td>124.00±0.51</td>
</tr>
<tr>
<td>5</td>
<td>MARCH</td>
<td>285.67±3.23</td>
<td>140.00±1.21</td>
</tr>
</tbody>
</table>

Fig. 1: Linear regression of EC and TDS for wet season.

\[ y = 1.525x + 43.77 \]
\[ R^2 = 0.908 \]
\[ R = 0.95 \]
Fig. 1 shows the linear relationship between EC and TDS during the wet season. The regression equation was $y = 1.525x + 43.77$ and the correlation coefficient was 0.95. This implies that there is a strong relationship between these two parameters.

![Graph showing linear regression between EC and TDS during the wet season.](image)

**Fig. 2:** Linear Regression of EC and TDS for dry season months

Fig. 2 presents the linear regression of EC on TDS for dry season. The regression equation was $y = 1.575x + 62.09$ and the correlation coefficient was 0.98. This also shows strong relationship between EC and TDS during the dry season.

![Graph showing linear regression between EC and TDS for the dry season.](image)

**Fig. 3:** Linear regression of EC and TDS for the whole year.

Fig. 3 presents the linear regression EC on TDS for the whole year. The regression equation was $y = 1.275x + 90.07$ and the correlation coefficient was 0.95. This implies that in the domestic wastewater studied, there is strong relationship between EC and TDS for the whole year.

**DISCUSSION**

The results presented in TABLES 1-3 represent mean values obtained from triplicate determinations. Values obtained as shown in the TABLES were expressed as mean ± standard deviations from the mean. EC values in the wet season months ranged from 231.33µS/cm to 367.00µS/cm and TDS values ranged from 132.00mg/l to 206.00mg/l. Also in the dry season months, EC values ranged from 220.57µS/cm to 285.67µS/cm and TDS ranged from 100mg/l to 140.00mg/l. In the whole year EC values ranged from 220.57 – 285.67µS/cm and TDS values ranged from 100.00 to 206.00mg/l. The results show that EC increased as well as the TDS during wet and dry seasons and in the entire year.
High values of EC shows that inorganic ions such as H\(^+\), Na\(^+\), K\(^+\), Mg\(^{2+}\), Ca\(^{2+}\), Cl\(^-\), SO\(_4^{2-}\), HCO\(_3^{-}\) e.t.c. are present in reasonable concentrations in the wastewater; Such ions have major influence on the conductivity of water. For TDS, high values obtained indicate that reasonable amount of solid matter were present in the wastewater as dissolved substances. During the wet season, organic substances present in the collection chamber due to storm water runoff would have been broken down and dissolved in the water. Substances dissolved in the water often include carbohydrates, proteins, esters, mineral salts etc.

The Linear regression of EC on TDS as shown in Figures 1-3 also indicate that there was positive and proportionate increase in both parameters in the same direction. The EC and TDS gave correlation coefficients, \( r=0.95 \), \( r=0.98 \) and \( r=0.95 \) respectively for the wet and dry seasons and the whole year. Values of correlation coefficient can vary between +1 and -1. A perfect positive correlation is a coefficient of +1. For a positive correlation to exist, both parameters increase in the positive direction (Singer, 1999). This was also true for the graphs obtained in Figures 1-3.

The regression analysis which was carried out to relate both parameters with each other revealed that the electrical conductivity and total dissolved solids gave correlation coefficients close to +1(i.e. \( r=0.95 \), 0.98 and 0.94 respectively). This showed very strong positive correlation. The results show that strong and positive relationship exists between electrical conductivity and total dissolved solids in the raw domestic wastewater. Therefore the results show that electrical conductivity of any water depends on ionic solutes present in it (Adams, 1990).

**CONCLUSION**

EC measures the total concentration of ionic solutes, while TDS measures the total amount of dissolved solids present in the wastewater.

High values of EC indicate high total dissolved solids concentration. This implies that the ability of an electric current to pass through the wastewater is proportional to the concentration of ionic solutes dissolved in the water. It therefore means that values of EC can be used to estimate the values of TDS in the raw domestic wastewater using the regression equation:

\[
y = 1.28x + 89.71
\]

In which \( y \)= EC and \( x \)=TDS.

**RECOMMENDATIONS**

Electrical Conductivity and total dissolved solids in domestic wastewater exhibit strong and positive correlation. Their correlation coefficient for the whole year was \( r=0.95 \). The regression equation obtained was \( y=1.28x+89.71 \).

Therefore, \( \text{TDS} = \frac{\text{EC} - 89.71}{1.28} \)

The regression equation above can be used to determine TDS from EC in the domestic wastewater. Also, results obtained for TDS would be enough to represent EC, thus reducing the time and cost of monitoring both parameters differently.

**REFERENCES**