Determination of effectiveness of waste water (effluent) treatment process of Kaduna Refinery and Petrochemical Company (KRPC), Nigeria

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Citation

Abstract
This study assesses the effectiveness of wastewater treatment process of KRPC. The scope of the study involves a quality assessment of pre-disposal treatment of an industrial effluent. Wastewater samples were collected for six months from three sampling points within the study site which comprised of the following; effluent sample before treatment (Sample A), effluent sample after treatment (Sample B) and KRPC effluent discharge point (Sample C). Standard methods of wastewater quality assessment were employed in the analyses of the samples collected. Data generated were converted to means of dry and wet seasons (January, February and March) and (June, July and August) respectively. The mean values were subjected to Paired Sample Student t-test and results were presented in tables. Paired sample t-test for pair 1 and 2 for dry and wet seasons revealed a significant difference between A dry season (AD) and B dry season (BD); A wet season (AW) and B wet season (BW). Also, pair 3 and 4 harmoniously, show no significant difference between B dry season (BD) and C dry season (CD); B wet season (BW) and (CW) wet season. Similarly, t-test for Pair 5 and 6 (UNEP-BD), expresses no significant differences between B dry season (BD) and UNEP standard; and B wet season (BW) and UNEP standards. Pair 7 and 8, paradoxically confirmed a significant difference between C dry season (CD) and UNEP standards and no significant differences between C wet season (CW) and UNEP standards. The research confirms the efficiency of effluent treatment by the management of KRPC.

1. Introduction

Kaduna Refinery and Petrochemical Company (KRPC) was established for the purpose of refining crude oil into premium motor spirit and other petrochemical products with the view of providing fuels for automobile engines and other outputs, without threatening environmental safety. Effluent released by crude oil-processing and petrochemical industries are characterized by the presence of large quantities of crude oil products, polycyclic and aromatic hydrocarbons, phenols, metal derivatives, surface-active substances, sulfides, naphthalene acids, oil and grease and other chemicals, due to the ineffectiveness of post-disposal treatment systems or other ambiguities along the line. Wastewaters may become acutely lethal as a result of the
accumulation of persistent organic pollutants and heavy metals in the receiving water bodies [1]; [2]; [3]; [4]; [5]; [6] insisted on standard guidelines which stipulate and recommend the standards for the disposal of effluents from Industries and petro-chemical refineries. These regulations include FEPA (Federal Environmental Protection Agency), UNEP (United Nations Environmental Program), WHO (World Health Organisation) standards among others. These regulating bodies require industrial establishments to treat its effluent properly before disposing them into public drains. Kaduna Refinery which generates large quantities of effluents daily is required by these regulating bodies to treat its effluents before they are discharged into natural water bodies, in this case, Romi River. Thus, the need to evaluate the effectiveness of pre-disposal clean-up of wastewater bodies, in this case, Romi River. Therefore, seek to ascertain the physico-chemical characteristics of the effluent before and after treatment to verify agreement with (UNEP) safety standards for discharge of effluent into surface water.

2. Material and Methods

2.1. Study Area

The study area is KRPC which is located at Chukun Local Government Area of Kaduna State, Nigeria. It lies between latitudes 10° to 11° North and longitudes 7° to 8° east. KRPC Facility lies between latitudes 10° 24’36.18’’ N and longitudes 7° 29’17.37’’E. The Facility occupies approximately 1.8 square Kilometers; about 7% of the total area of the region as shown in Fig.1 in the appendix.

The study area was initially characterized by over 80% agricultural land uses. The location which the refinery occupied is initially considered as a forest reserve in the early 1960’s, before it was later converted to an industrial site with few settlements around. However, because of the petroleum industry, the land use pattern was fast changing; there were also some illegal encroachment of farmlands and settlements on the industrial site.

River Romi is one of the tributaries of River Rigasa, it is the largest river in the study area which adds to drains the region into the Kaduna river system. All streams and rivers within the study area experience flash floods during the rainy season. Runoffs begin soon after the start of rainfall. In valley undersides, the water table is closer to the surface and water logging occurs. Initially the provision of disposing refinery liquid waste into River Romi was one of the reasons why the refinery was located in the Rido region [7] (see figure Fig.1 in appendix).

2.2. Reconnaissance Survey, Site Selection and Sample Collection

This study started with a reconnaissance survey of which the study area comprising the; Pollution control (Monitoring and Evaluation Unit), Effluent Treatment Plant Unit and Refinery Laboratory. Special consideration was given to the monitoring and evaluation section of the Pollution Control Unit with focus on effluent predisposal treatment.

Raw data of the refinery effluent before and after treatment (Sample A and B) were collected from the refinery Safety And Control Unit for January, February, March, June, July and August, 2010 and Waste Water (Effluent) sample was collected from the refinery effluent discharge point (Sample C). Sample A and B were collected in order to ascertain the difference between effluent before and after treatment and sample C was collected to the exactitude of Sample B treatment by the refinery Management. Sample B was compared with the UNEP safety standard for waste water to ascertain the refinery effluent treatment conformity to safety standard.

The collection of water sample at the refinery effluent discharge point took place in the morning between 8-10am when the temperature was low because high temperature might alter the level of pollutants by enhancing chemical reaction. Sample C was collected using Grab method which according to the UNDP/World Bank 1988 [8] is effective enough for surface water investigation of inland hydrological systems. Grab sampling method involves dipping a sample from one or more points in a stream cross-section. Grab sampling techniques employed by the researcher in this study was consistent throughout the period of sample collection [9].

In situ parameters (temperature, dissolved oxygen, and pH) were taken at the site and the sample was collected in two litre plastic container that was treated with 3-4ml of nitric acid and then rinsed with the water sample to be collected and the container was labeled accordingly. These then was taken to Kaduna Environmental Protection Authority laboratory for analysis within twenty-four hours. The reason was to ensure that the result obtained gave true representation of the parameters in the Effluent at the time of collection.

2.3. Sample Analyses

[16] Suggested that pH, Temperature, Percentage Clarity, Conductivity (EC), Turbidity, COD, BOD, DOD, TDS, Oil and Gas (O&G), Phenolic Compounds, Ammonia (NH$_3$), Phosphate (PH$_4^{2-}$), Total Alkalinity, Magnesium (Mg), Calcium (Ca), Potassium (K), Phosphorous (P), Chloride (Cl$^-$), Sulphate (SO$_4^{2-}$), Copper (Cu), Lead (Pb), Cadmium (Cd), and Zinc (Zn) are crucial while analysing a substance terminated by petrochemical waste, especially as they play a major role in predicting pollution level of surface water. The samples collected were subjected to Laboratory analysis for the parameters above. The pH for each sample was measured using the Mobile Rugged pH Meter at the site of sample collection. Temperatures was measured using a magnified thermometer dipped inside the water at the site of sample
collection. The percentage clarity of the sample was determined photo-electrically, using the Palintest Photometer. The sample was filtered to remove suspended solids before analyses to determine the ‘true colour’ due to dissolved matter. Furthermore, the conductivity was taken with the HI4521 by measuring the ISE ionic strength of each sample. The turbidity throughout the research was determined using the attenuated radiation method (direct reading) with a compliant portable turbidity meter. TSS was measured by taking the difference between total dissolved solids and total solids calculated. Similarly, the most dependable method of TDS testing was used through the use of a portable TDS meter. The dissolved oxygen for the entire research was accessed on site using the HI 9145 Portable D.O. Meters. The BOD Biological Oxygen Demand (BOD) was determined using the Winkler Azide method, but was titrated after five days of incubation. The COD was determined with the closed Microwave digestion method. The test for total alkalinity was carried out by titration method. Magnesium (Mg) was determined with the Palintest Magnecol test which was based on a simple colorimetric procedure; also Potassium (K) was determined with the Palintest Potassium test. Additionally, the Palintest Tube test was used for Ammonia (Indophenol) based on the indophenol blue method and the Palintest Calcium Hardness test with the Calcol indicator reagent method was used to determine calcium. Also the Palintest Tube tests Total Phosphorus/12 test was used for determining Phosphorus. For Phosphate the Palintest Tube tests Phosphate/12P method was used. The Palintest Sulphate test was used for Sulphate determination based on a single tablet reagent containing barium chloride in a slightly acidic formulation and Chloride was determined by the Palintest count method. Phenols were measured with the Phenol test method with a Palintest Photometer. Oil and Grease on the other hand was determined using the separation method and the result was calculated. Copper and Zinc were determined with a Palintest Photometer and Lead and Cadmium were measured using an Atomic absorption Spectrophotometer [4].

2.4. Statistical Analyses

In carrying out this study, the SPSS Package was used to compute Paired Sample Student t-test, it was computed for pairs of data as follows: Paired Sample Student t-test was computed for mean value of samples A and B for dry and wet season (January, February and March) and (June, July and August) respectively; the same was applied for mean value of samples B and C for the same periods as A and B; mean value of samples B and UNEP standard and mean value of samples C and UNEP standard. The pairs are:

Pair 1: A dry season and B dry as (AD-BD)
Pair 2: A wet season and B wet season as (AW-BW)
Pair 3: B dry season and C dry season as (BD-CD)
Pair 4: B wet season and C wet season as (BW-CW)
Pair 5: UNEP and B dry season as (UNEP-BD)
Pair 6: UNEP and B wet season as (UNEP-BW)
Pair 7: UNEP and C dry season as (UNEP-CD)
Pair 8: UNEP and C wet season as (UNEP-CW). See table 2 in appendix.

3. Results and Discussion

The table 1 shows the mean values for effluent before and after treatment provided by the refinery (A and B), effluent after treatment collected by the researcher at the refinery effluent discharge point and tested (C) all for dry season mean (January, February, March) and wet season mean (June, July and August) 2010 and UNEP safety standard. The raw data on the table 1 (see appendix) therefore, was subjected to the analysis on subsections below;

3.1. Determination of the Variation in Quality between Effluent before and After Treatment (Data Provided by KRPC)

Paired sample student t-test was conducted to ascertain whether there is a difference in quality (i.e. difference in the concentration of the parameters analyzed) between effluent before and after treatment (A and B) which data was provided by KRPC Management, i.e. pair 1 and 2; this was done in order to ascertain the effectiveness of predisposal treatment. The analysis on Table 2 (see appendix) shows that calculated t for all the parameters considered are slightly greater than the significance values. Thus, there is significant difference between the values of tested parameters before and after treatment (tval of 0.726 at 0.475 significance and 0.931 at 0.361 significance for dry and wet season respectively both at P=.05). This therefore, confirms that the treatments of effluent in KRPC for wet and dry (from January to August) 2010 was effective. This corroborates the results of earlier findings by [1]; [11]. However, this research finding is at variance with an earlier study by [12]. This can be attributed to the fact that he only considered physical parameters and that the samples were taken once.

3.2. Validation of Effluent Treatment Data Provided by KRPC

Furthermore, the analysis on Table 2 (see appendix) validates the accuracy of the data for effluent after treatment provided by KRPC (B) as it was compared with effluent after treatment tested by the researcher (C), i.e. pair 3 and 4. The result shows a calculated t value that is less than the significant value. Therefore, there is no difference between the levels of analyzed parameters in effluent after treatment provided by the refinery and effluent after treatment collected at the refinery effluent discharge point and analyzed by the researcher in the laboratory with tcal of -1.843 at 0.078 significant and -0.671 at 0.509 significant for dry and wet season respectively, both at P=.05). This also validates the fact that the treatment of effluents by KRPC for
wet and dry season (from January to August) 2010 was effective and the data provided by KRPC was in line with what was obtained by [13] in his study of the Environmental Regulation of the Oil and Gas Industry in Nigeria in comparison with Alberta’s Experience. His finding indicates that the treatments of Effluent by Alberta’s Oil industries are effective and have minimum impact on the environment [13].

### 3.3. Evaluation of KRPC Wastewater Treatment Acquiescence with UNEP Safety Standard

The data for effluent after treatment provided by KRPC (B) and UNEP safety standard for dry and wet season (Pair 5 and 6) was also subjected to paired sample student t-test to realize variation. The analysis on Table 2 (see appendix) therefore, shows a calculated t that is less than the significant. Therefore, there is no statistical difference between the levels of parameters in effluent after treatment provided by the refinery and UNEP standard \( t_{cal} \) of 1.673 at 1.707 significant and 1.351 at 1.489 significant for dry and wet season respectively at \( P=0.05 \). This in addition authenticates the fact that the treatment of effluent in KRPC in January to August 2010 was effective. This finding agrees with those of [10]; [11]; [3] and disagrees with the findings of [12] probably because his work covers only few of the parameter covered in this work.

### 3.4. Appraisal of the Conformity of Effluent after Treatment Tested by the Researcher (C) and UNEP Safety Standard

Moreover, the data on Table 2 i.e. pair 7 and 8 (see appendix), express that for dry season calculated t value is higher than the significant while in wet season the calculated t is less than the significant. Therefore, there is statistical difference in dry season and no statistical difference in wet season between the levels of analyzed parameters in effluent after treatment collected at the refinery effluent discharge point and analyzed by the researcher in the laboratory and UNEP standard the values are \( t_{cal} \) of 1.617 at 0.119 significant and 1.227 at 1.289 significant for dry and wet season respectively, likewise, at \( P=0.05 \) level). This validates the fact that the treatment of effluent in KRPC from January to August 2010 was effective for wet season both not effective for dry season, although there might be other reasons for the high concentration of the tested parameters in dry season such as high temperature which result to high evaporation in the effluent discharge point since its open and this can result in the high concentration since the water quantity is far less than that of wet season among other things. This study is in tandem with those of [10]; [14] for wet season only.

### 4. Conclusion

The study uses UNEP safety standard for inland waters and wastewaters in order to make the study universal and differ from earlier studies which are mostly based on National standards. The study also agrees with [15] on the efficiency of KRPC effluent treatment and that KRPC effluent is not the chief polluter of Romi-Rido environment and emphasizes on the presence of other source of pollutants aside KRPC within the area. The only vague fact revealed by this study is the significant difference between sample C dry season and UNEP standards and that is not enough reason to disqualify KRPC effluent treatment level.

[15] Affirmed that KRPC effluent treatment attains a moderate universal acceptable limit when compared with UNEP universal safety standards for effluent management. Also that there are other industries beside KRPC in the Romi-Rido environment and these other industries carry out activities that can generate similar of pollutants assessed in this study. Moreover, the level of compliance to environmental safety standard of this other industries has not been investigated.

In view of the major finding revealed by this study, the following recommendations are made to minimize the load of pollutants on Romi River:

1. The activities of other industries in Romi-Rido environment should be investigated;
2. National regulatory agencies associated with industrial activities should introduce a short term review of the Federal Environmental Safety Standards that will always correspond with universal acceptable standards.
3. There is a need for the National bodies entitled with the role of assessing the activities of industries to develop a form of sanctioning against any industry that refuse to adhere to the standard environmental protection legislation.
4. The effort of KRPC should be commended but they must be continually monitored and this kind of study should be carried out on other industries to ensure compliance in order to sustain our fragile environment.

### Acknowledgement

The author acknowledges the co-operation of the management and staff of the Kaduna Refinery and Petrochemical Company, Nigeria for their assistance in the provision of the data for effluent Before and after treatment (sample A and B) and for allowing me to collect effluent sample at the refinery effluent discharge point (sample C). I also appreciate the effort of the staff at Kaduna Environmental Protection Authority where I analyses sample C. I acknowledge the efforts of the anonymous reviewers whose comments and suggestions helped to enrich the content of the manuscript and the contribution of my supervisor and colleague DR. M. M. Alhassan with whom we put head together to ensure a successful completion of my M.Sc. thesis from which this manuscript was extracted.
Appendixes

Table 1. Mean Values for Effluent Samples for Dry and Wet Seasons (January, February, March, June, July and August) 2010

<table>
<thead>
<tr>
<th>Parameters</th>
<th>A Dry Season</th>
<th>A Wet Season</th>
<th>B Dry Season</th>
<th>B Wet Season</th>
<th>C Dry Season</th>
<th>C Wet Season</th>
<th>UNEP Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>31</td>
<td>30.3</td>
<td>29.97</td>
<td>27.83</td>
<td>30.54</td>
<td>27.20</td>
<td>30°C</td>
</tr>
<tr>
<td>%CLARITY</td>
<td>7</td>
<td>9</td>
<td>4</td>
<td>5</td>
<td>8.00</td>
<td>8.00</td>
<td>1 (Colorless)</td>
</tr>
<tr>
<td>EC (ms/cm)</td>
<td>315.3</td>
<td>305.3</td>
<td>303.67</td>
<td>302.33</td>
<td>360.67</td>
<td>262.33</td>
<td>380ms/cm</td>
</tr>
<tr>
<td>TURBIDITY (mg/l)</td>
<td>1960.43</td>
<td>1960.43</td>
<td>199.00</td>
<td>599.33</td>
<td>469.67</td>
<td>515.00</td>
<td>600mg/l</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>50.00</td>
<td>50.00</td>
<td>121.83</td>
<td>77.17</td>
<td>76.37</td>
<td>136.53</td>
<td>200mg/l</td>
</tr>
<tr>
<td>BOD (mg/l)</td>
<td>10.10</td>
<td>10.10</td>
<td>18.93</td>
<td>20.27</td>
<td>18.86</td>
<td>18.49</td>
<td>25mg/l</td>
</tr>
<tr>
<td>DOD (mg/l)</td>
<td>0.30</td>
<td>0.30</td>
<td>12.40</td>
<td>7.47</td>
<td>9.16</td>
<td>8.87</td>
<td>&gt;10mg/l</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>1.56</td>
<td>1.56</td>
<td>501.91</td>
<td>96.98</td>
<td>1237.83</td>
<td>1081.19</td>
<td>2000mg/l</td>
</tr>
<tr>
<td>TSS (mg/l)</td>
<td>72.00</td>
<td>72.00</td>
<td>32.85</td>
<td>16.07</td>
<td>217.47</td>
<td>173.87</td>
<td>30mg/l</td>
</tr>
<tr>
<td>Oil and grease (O&amp;G) (mg/l)</td>
<td>13.34</td>
<td>11.57</td>
<td>10.11</td>
<td>10.00</td>
<td>111.35</td>
<td>9.78</td>
<td>10mg/l</td>
</tr>
<tr>
<td>Ph</td>
<td>10.94</td>
<td>10.94</td>
<td>8.78</td>
<td>8.44</td>
<td>8.61</td>
<td>8.65</td>
<td>6.0-9.50</td>
</tr>
<tr>
<td>Phenolic compounds (mg/l)</td>
<td>16.57</td>
<td>16.57</td>
<td>0.31</td>
<td>0.95</td>
<td>9.40</td>
<td>8.63</td>
<td>11mg/l</td>
</tr>
<tr>
<td>Ammonia (NH3) (mg/l)</td>
<td>11.69</td>
<td>11.69</td>
<td>0.93</td>
<td>0.49</td>
<td>2.07</td>
<td>1.34</td>
<td>11mg/l</td>
</tr>
<tr>
<td>Total alkalinity (mg/l)</td>
<td>46.15</td>
<td>46.15</td>
<td>39.33</td>
<td>40.00</td>
<td>1.48</td>
<td>0.78</td>
<td>20-60mg/l</td>
</tr>
<tr>
<td>Mg (mg/l)</td>
<td>10.17</td>
<td>10.17</td>
<td>1.32</td>
<td>4.58</td>
<td>33.33</td>
<td>51.00</td>
<td>20mg/l</td>
</tr>
<tr>
<td>Pb (mg/l)</td>
<td>150.00</td>
<td>150.00</td>
<td>5.30</td>
<td>2.13</td>
<td>9.78</td>
<td>16.41</td>
<td>20mg/l</td>
</tr>
<tr>
<td>Ca (mg/l)</td>
<td>17.10</td>
<td>150.00</td>
<td>5.66</td>
<td>7.79</td>
<td>25.12</td>
<td>20.58</td>
<td>30mg/l</td>
</tr>
<tr>
<td>Km (mg/l)</td>
<td>1.03</td>
<td>17.10</td>
<td>35.47</td>
<td>26.18</td>
<td>16.11</td>
<td>19.04</td>
<td>30mg/l</td>
</tr>
<tr>
<td>Phosphate (PP/M)</td>
<td>1.06</td>
<td>1.03</td>
<td>9.16</td>
<td>2.82</td>
<td>1.63</td>
<td>0.46</td>
<td>5PPM</td>
</tr>
<tr>
<td>Sulphate (mg/l)</td>
<td>0.06</td>
<td>1.06</td>
<td>31.00</td>
<td>164.00</td>
<td>5.64</td>
<td>2.56</td>
<td>500mg/l</td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>0.00</td>
<td>0.06</td>
<td>6.32</td>
<td>6.41</td>
<td>133.67</td>
<td>122.67</td>
<td>20mg/l</td>
</tr>
<tr>
<td>Cu (mg/l)</td>
<td>0.2</td>
<td>0.04</td>
<td>ND</td>
<td>ND</td>
<td>19.48</td>
<td>26.81</td>
<td>0.01mg/l</td>
</tr>
<tr>
<td>Pb (mg/l)</td>
<td>0.05</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>ND</td>
<td>ND</td>
<td>0.2mg/l</td>
</tr>
<tr>
<td>Cd (mg/l)</td>
<td>0.02</td>
<td>0.01</td>
<td>0.00</td>
<td>ND</td>
<td>0.00</td>
<td>ND</td>
<td>0.1mg/l</td>
</tr>
<tr>
<td>Zn (mg/l)</td>
<td>0.19</td>
<td>0.15</td>
<td>0.13</td>
<td>0.08</td>
<td>30.54</td>
<td>27.20</td>
<td>0.5mg/l</td>
</tr>
</tbody>
</table>

Source: Field work, 2010

Key
Clarity, 1: Colourless 2: Clear with very small precipitate, 4: Pale brown, 5: Greenish with suspended particles, 7: Fairly Turbid, 8: Light brown, 9: Light reddish brown.

Sample Site Location: A: Before Treatment, C: Refinery Waste Water Discharge Point, B: After Treatment,
Table 2. Paired sample t-test

<table>
<thead>
<tr>
<th>PAIRS</th>
<th>Mean</th>
<th>Std</th>
<th>Std. EM</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 (AD-BD)</td>
<td>5.39152E1</td>
<td>371.43946</td>
<td>74.28789</td>
<td>-99.40747 - 207.23787</td>
<td>.726</td>
<td>24</td>
<td>.475</td>
<td>S</td>
</tr>
<tr>
<td>Pair 2 (AW-BW)</td>
<td>5.16312E1</td>
<td>277.37570</td>
<td>55.47514</td>
<td>-62.86386 - 166.12626</td>
<td>.931</td>
<td>24</td>
<td>.361</td>
<td>S</td>
</tr>
<tr>
<td>Pair 3 (BD-CD)</td>
<td>-5.83360E1</td>
<td>158.24252</td>
<td>31.64850</td>
<td>-123.65530 - 6.98330</td>
<td>-1.843</td>
<td>24</td>
<td>.078</td>
<td>NS</td>
</tr>
<tr>
<td>Pair 4 (BW-CW)</td>
<td>5.32828E1</td>
<td>225.64651</td>
<td>45.12930</td>
<td>-123.42510 - 62.85950</td>
<td>-6.71</td>
<td>24</td>
<td>.509</td>
<td>NS</td>
</tr>
<tr>
<td>Pair 5 (UNEP-BD)</td>
<td>1.04997E2</td>
<td>313.81107</td>
<td>62.76221</td>
<td>-24.53765 - 234.53205</td>
<td>1.673</td>
<td>24</td>
<td>1.707</td>
<td>NS</td>
</tr>
<tr>
<td>Pair 6 (UNEP-BW)</td>
<td>1.03080E2</td>
<td>381.44337</td>
<td>76.28867</td>
<td>-54.37248 - 260.53168</td>
<td>1.351</td>
<td>24</td>
<td>1.489</td>
<td>NS</td>
</tr>
<tr>
<td>Pair 7 (UNEP-CD)</td>
<td>7.27968E1</td>
<td>225.11397</td>
<td>45.02279</td>
<td>-20.12568 - 165.71928</td>
<td>.617</td>
<td>24</td>
<td>.119</td>
<td>S</td>
</tr>
<tr>
<td>Pair 8 (UNEP-CW)</td>
<td>4.66612E1</td>
<td>190.09121</td>
<td>38.01824</td>
<td>-31.80459 - 125.12699</td>
<td>1.227</td>
<td>24</td>
<td>1.289</td>
<td>NS</td>
</tr>
</tbody>
</table>

Source: Fieldwork 2010

KEY:
S= There was significant difference
NS= There was no significant difference
Std= Standard Error of The Mean
Std= Standard Deviation
AD= After treatment dry season
AW = After treatment wet season
BD = Before Treatment dry season
BW= Before Treatment wet season
CD = effluent sample from facility’s effluent discharge point Dry season
CW = effluent sample from facility’s effluent discharge point Wet season

References


