APPLICATION OF LOW-COST ADSORBENT IN THE TREATMENT OF SAMARU STREAM WATER

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Abstract: In this study, low-cost adsorbent was produced and applied in the treatment of Samaru stream water. Treatment of Samaru stream water was carried out in column mode to determine the efficiency of the low-cost adsorbent for improving the quality of Samaru stream water. To achieve this, the stream water samples were collected from three different points (point 1, 2 and 3) and the values of the following parameters were analyzed before and after treatment: pH, Electrical Conductivity (EC), Total Dissolved Solid (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonium, Nitrate, Chloride, Iron (III), Copper (II), Lead (II) and Zinc (II). Results obtained from the study show that highest removal efficiency of 96.18 % was attained for chloride and this was followed by 91.76 %, 90.91 % and 90 % for iron (III), copper (II) and ammonium respectively while the least was 6.33 % (pH). Therefore, the high removal efficiency achieved for some sample parameters in the treatment of Samaru stream water implied that the low-cost adsorbent could be employed in the simultaneous removal of contaminants from a multicomponent system.

Key words: Contaminants, parameters, samples, column, removal efficiency

1. INTRODUCTION

The global world is now characterized with critical issues that have necessitated the increased concern and attention towards environmental management, pollution control and prevention, wastes recycling, reuse, treatment and disposal [1]. The increasing domestic, agricultural and industrial activities consume large volume of water resulting in the generation of contaminated water that eventually gets to the receiving bodies such as streams, rivers, lakes and seas [2]. These receiving bodies become the source of water for mans’ use such as washing, bathing, swimming, cooking and drinking [3] and exposure to contaminated receiving bodies without prior treatment have been reported for resulting adverse effects [4, 5].

Studies on the characterization of raw water from these receiving bodies have shown that it is unsuitable for mans’ use thereby stressing the need for its treatment aimed at quality improvement before use [6-8]. Samaru stream which is the major drain of domestic waste of Samaru village is located in Zaria town, Nigeria. Tanimu et al., [9]
reported that several researchers have noted the poor state of quality of Samaru stream water and according to Agbogu et al., [4], Samaru stream is used by the surrounding communities including Ahmadu Bello University, Zaria, Nigeria for several purposes such as recreation, bathing, herd watering as well as source of raw water treated for drinking. Specifically, Yusuf et al., [5] in their study concluded that Samaru stream could be classified as having doubtful water quality which needs improvement. Therefore the objective of this study is to assess the efficiency of a low-cost adsorbent in improving the quality of raw water collected from Samaru stream.

2. EXPERIMENTAL SET-UP

2.1. Production of low-cost adsorbent
Rice husk was collected from National Cereal Research Institute (NCRI), Badeggi and used in this study for the production of the low-cost adsorbent. Rice husk was washed with distilled water to remove dirt and surface impurity, then oven-dried at 100 °C for 24h. In the thermal pretreatment, rice husk was placed on a ceramic flat surface, charged into a furnace and heated to a temperature of 441.46 °C at a heating rate of 20-25 °C/min and residence time of 1h.

The charred residue was collected and cooled at room temperature. In the chemical pretreatment, the carbonized rice husk (charred residue) was activated with 1M H₃PO₄ for 3h at impregnation ratio of 2:1 (volume mL of acid/mass g of rice husk) and later oven-dried overnight at 200 °C to ensure proper drying. The material was then removed from the oven, cooled for 2h and then washed with distilled water to bring the pH to 7.0 and again oven-dried overnight at 100 °C [10-12].

2.2. Analysis and treatment of raw water from Samaru stream
Raw water was collected at three different sampling points (point 1, 2 and 3) from Samaru stream flowing into Ahmadu Bello University, Zaria. The raw water samples were analyzed for general characterization to determine the values of the following parameters before treatment: pH, Electrical Conductivity, Total Dissolved Solid, Biochemical Oxygen Demand, Chemical Oxygen Demand, Ammonium, Nitrate, Chloride, Iron (III), Copper (II), Lead (II) and Zinc (II). For sample treatment, the column experiment was conducted using a glass column of 12 cm length, 2 cm internal diameter, 3,142 cm² surface area and 37.7 cm³ empty bed volume.

The raw water sample was fed to the column in a downward flow mode at a flow rate of 3 mL/min through a pipe having a valve as the flow regulator. The column was packed with a known quantity of rice husk activated carbon (4 g) to yield a bed depth/height of 6 cm. Glass wool was placed at the bottom as a support and also at the top to prevent flotation of rice husk activated carbon in excess raw water [13] and a liquid head of at least 2 cm was sustained in order to prevent air voids [14]. The effluent raw water was collected from the column outlet for determination of the treated raw water parameters.

2.3. Determination of raw water parameters
The pH of the samples was determined using a digital pH meter. Electrical Conductivity and Total Dissolved Solid were determined using EC/TDS Auto Ranging meter (Hanna Instrument HI 9835). Biochemical Oxygen Demand was determined by Azide modification of the Winker method and Chemical Oxygen Demand was determined by refluxing and both were based on Standard Methods for the Examination of Water and Wastewater [15]. Ammonium was determined using Lovibond 1000 comparator with ammonia disc, nitrate was determined using multiparameter bench photometer (Hanna Instrument HI 83200) and chloride was determined by titration which is based on the standard method for the examination of water and wastewater [15]. Iron (III), copper (II), zinc (II) and lead (II) were determined using Atomic Absorption Spectrometer (Varian AA240FS).

2.4. Determination of removal efficiency
Adsorption removal efficiency was determined using the equation [11]:

\[
RE = \left( \frac{C_o - C_f}{C_o} \right) \times 100
\]

where \(C_o\) are initial concentration (mg/L), \(C_f\) - final concentration (mg/L), \(RE\) - removal efficiency (%).
3. RESULTS AND DISCUSSION

3.1 Treatment of raw water from Samaru stream

The values of the raw water parameters collected at the three different sampling points of Samaru stream, their respective values after treatment and percentage removal efficiencies are as presented in Table 1 and Figure 1. It was observed in the Table 1 that pH neutrality of the samples was increased after treatment by 6.3 - 8.97 %. The Electrical Conductivities of the three samples were also observed to be reduced after treatment with sample point 2 having the highest removal efficiency of 47.59 %.

Reduction in TDS was observed in all the three samples after treatment with sample point 2 attaining the highest removal efficiency of 53.61 %. After treatment, the COD of the three samples was also observed to be reduced and highest removal efficiency of 65.38 % was attained in sample point 1. Though BOD of the untreated samples was observed to be very low in all the raw water samples, reduction was achieved in all the three sample points after treatment and the highest removal efficiency of 75 % was attained in sample point 1. According to Jatto et al., [16], water quality is high when there is decrease in oxygen demand after treatment, therefore the decrease in oxygen demand achieved after treatment in this study indicates the potential of the low-cost adsorbent in improvement of water quality.

The concentration of ammonium was also observed to be reduced after treatment in all the sample points and highest percentage removal of 90 % (sample point 2 & 3) was attained. In all the sample points, nitrate concentration was also observed to be reduced after treatment and highest percentage removal of 51.7 % was attained in sample point 2. For the chloride, concentration in the three samples was also observed to be reduced after treatment with sample point 1 showing the highest percentage removal (96.18 %). These observations imply that the low-cost adsorbent could be employed in the improvement of Samaru stream water quality.

Table 1. Raw and Treated Values of Wastewater Parameters collected at different Points (bed depth = 6cm, flow rate = 3 mL/min, time = 300 min).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Point 1</th>
<th>Point 2</th>
<th>Point 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw</td>
<td>Treated</td>
<td>% Removal</td>
</tr>
<tr>
<td>pH</td>
<td>7.8</td>
<td>7.1</td>
<td>8.97</td>
</tr>
<tr>
<td>EC (µS)</td>
<td>3.56</td>
<td>2.9</td>
<td>18.54</td>
</tr>
<tr>
<td>NH₄⁺ (mg/L)</td>
<td>1.2</td>
<td>1.12</td>
<td>6.67</td>
</tr>
<tr>
<td>TDS (mg/L)</td>
<td>1.84</td>
<td>1.46</td>
<td>20.65</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>0.4</td>
<td>0.1</td>
<td>75.00</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>260</td>
<td>90</td>
<td>65.38</td>
</tr>
<tr>
<td>NO₃⁻ (mg/L)</td>
<td>4.8</td>
<td>4.3</td>
<td>10.42</td>
</tr>
<tr>
<td>Cl⁻ (mg/L)</td>
<td>759.76</td>
<td>28.99</td>
<td>96.18</td>
</tr>
<tr>
<td>Fe (mg/L)</td>
<td>24.48</td>
<td>13.38</td>
<td>45.34</td>
</tr>
<tr>
<td>Cu (mg/L)</td>
<td>0.9</td>
<td>0.42</td>
<td>53.33</td>
</tr>
<tr>
<td>Zn (mg/L)</td>
<td>1.044</td>
<td>0.714</td>
<td>31.61</td>
</tr>
<tr>
<td>Pb (mg/L)</td>
<td>3.02</td>
<td>1.931</td>
<td>36.06</td>
</tr>
</tbody>
</table>
For the heavy metals, the concentration of iron (III) was observed to be reduced after treatment in all the samples and considerable percentage removal of 91.76 % was attained in sample point 3. Copper (II) concentration was also observed to be reduced after treatment in all the samples with sample point 3 showing the highest percentage removal of 90.91 %. Concentration of lead (II) was also observed to show highest percentage removal of 52.9 % in sample point 3 and this was followed by 36.06 % in sample point 1. Concentration of zinc (II) was also observed to show highest percentage removal of 31.61 % in sample point 1 and this was followed by 22.36 % in sample point 2. Therefore, concentration of all the heavy metals considered in this study were observed to be reduced after treatment with the exception of zinc (II) in sample point 3 and lead (II) in sample point 2 and this could be attributed to experimental error. This study indicates that among the heavy metals considered, the low cost adsorbent has better adsorption affinity to iron (III) and copper (II) than lead (II) and zinc (II). Similar findings on effective simultaneous removal of contaminants were also reported in the literature [17-21].

4. CONCLUSION

The low cost adsorbent employed in this study was successfully used in the treatment of Samaru stream water leading to improvement in water quality. The high percentage removal efficiencies observed for various sample parameters considered could be attributed to the effectiveness of the low-cost adsorbent. Though low percentage removal efficiencies were observed in some sample parameters which may be as a result of bed saturation, such efficiencies could always be improved by employing higher bed depth or lower flow rates. Therefore, the low-cost adsorbent employed in this study could be used in simultaneous removal of contaminants from multicomponent system.

REFERENCES


