Design and fabrication of airlift fluidized bioreactor using marine sponges for treating wastewater

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DESIGN AND FABRICATION OF Airlift FLUIDIZED BIOREACTOR USING MARINE SPONGES FOR TREATING WASTEWATER

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ABSTRACT:

Water-related problems are increasingly recognized as one of the most immediate and serious environmental threats to humankind. Lack of access to a safe water supply and sanitation affects the health of 1.2 billion people annually. Over-pumping of groundwater has also compounded water quality degradation caused by salts, pesticides, naturally occurring arsenic, and other pollutants. Placing sewage water directly into plants can pollute these environments. Many parts of the world are facing changes in climatic conditions, such as rainfall patterns, flood cycles, and droughts, which affect the water cycle. Traditional method of treating sewage water is somehow costly and maintenance problem can be occurred. While treating wastewater in a given situation depends on the availability of additional water resources, a necessity to conserve rather than develop water resources, careful economic considerations, potential uses for the recycled water. In current scenario Airlift fluidized Bioreactor has been designed for treating sewage water by using adsorbent materials (Marine sponges). The main objective of this kind of bioreactor is used to minimize the total cost of treatment process. Among the possible techniques for water treatments, the adsorption process by solid adsorbents shows potential as one of the most efficient methods for the treatment and removal of organic contaminants in wastewater treatment. Adsorption isotherm studies were performing for this sewage water. In recent years, the search for low-cost adsorbents that have pollutant –binding capacities has intensified. The present novel method can be used in this bioreactor to enhance the properties of water and treated can be easily done. Therefore, in future the traditional methods of wastewater treatment may be replaced by this treatment.

Keywords: Marine sponges, water treatment, Airlift fluidized Bioreactor
INTRODUCTION

Water use has more than tripled globally since 1950, and one out of every six persons does not have regular access to safe drinking water. Everyone wants clean water - to drink, for recreation, and just to enjoy looking at. Wastewater may be defined as a combination of liquid or water – carried waste removed from residences, institutions, and commercial and industrial establishments, together with ground water, surface water and storm water. It generally contains a high load of oxygen demanding wastes, pathogenic or disease-causing agents, and organic materials, nutrients that stimulate plant growth, inorganic chemicals, minerals and sediments. It may also contain toxic compounds. For many years the main goal of treating municipal wastewater was simply to reduce its content of suspended solids, oxygen-demanding materials, dissolved inorganic compounds, and harmful bacteria. Placing sewage water directly into plants can pollute these environments. Traditional method of treating sewage water is somehow costly and maintenance problem can be occurred. The latest Global Environment Outlook of the United Nations Environmental Programme (UNEP) reports that about one third of the world’s populations currently live in countries suffering from moderate-to-high water stress, where water consumption is more than 10% of renewable freshwater resources. Whether recycling will be appropriate in a given situation depends on the availability of additional water resources, a desire or necessity to conserve rather than develop water resources, careful economic considerations, potential uses for the recycled water, the strategy of waste discharge and public policies that may override economic and public health considerations or perceptions (Mantovani et al. 2001).

Jin et al. (2002) used an airlift reactor in a comprehensive pilot plant system for starch processing wastewater reclamation. Lazarova et al. (1997) studied experimentally the fluid dynamics and the performance for wastewater treatment of a split-vessel airlift with a rectangular section. Loh and Liu (2001) used an external loop fluidized bed airlift bioreactor for treatment of high strength phenolic wastewater. Pneumatic reactors are grouped according to several criteria, but two main categories are extensively been considered by scientist for various experimental studies and applications: bubble column (BC) and airlift reactor (ALR). They essentially consist in a cylindrical or rectangular vessel with a gas distributor at the inlet, usually without mechanical moving parts (Huang and McDonald, 2009). The only energy input needed is to inject the aeration gas through a simple sparging system (Brenner et al., 1997; Gavrilescu and Roman, 1994; Gavrilescu and Tudose, 1996).
MATERIALS AND METHODS

1. Collection of samples

1.1. Sewage water

The Sewage Water sample were collected from Bannari Amman Institute of Technology-sewage treatment plant, Sathyamangalam of Tamilnadu was collected and transferred to the laboratory in closed Pet bottles bags and carried out for further processing.

Fig.1 (a): wastewater sample

1.2 Marine sponges (Adsorbent material)

The Marine sponges (Adsorbent material) were collected from Colachel beach - coastal region of Kanyakumari district of the Tamilnadu state of India and is an important port on the west coast of that state.

Fig.1 (b): Marine sponges

2. Analysis of the properties of sample before treatment

   Physical Separation

2.1. Total Dissolved solids (TDS)

   Total dissolve solids is a measure of the combined content of all inorganic and organic substances. To determine the TDS of given water sample with stipulations as per Bureau of Indian Standard (BIS).
2.2. **Total Suspended Solids (TSS)**
Total suspended solids is a water quality measurement. To determine the TSS of given water with the stipulations as per Bureau of Indian Standard (BIS).

2.3. **Turbidity**
The measurement of turbidity is a key test of water quality. To determine the turbidity of given water sample with stipulations as per Bureau of Indian Standard (BIS).

**Chemical Examination**

2.4. **pH**
Initial pH of sewage water sample and after the treatment has to measure. 5ml of sample was taken and placed in a pH meter before and after treatment. To determine pH in the given water sample with stipulations as per Bureau of Indian Standard (BIS).

2.5. **Total Alkalinity test**
To determine the alkalinity of given water sample with the stipulations as per Bureau of Indian Standard (BIS). It is primarily a way of measuring the acid neutralizing capacity of water.

2.6. **Total Hardness as CaCO₃**
To determine total hardness in the given water sample with stipulations as per Bureau of Indian Standard (BIS).

2.7. **Chloride Test**
Chlorides are widely distributed as salts of calcium, sodium and potassium in sewage water. To determine the chlorides of given water sample with the stipulations as per Bureau of Indian Standard (BIS).

2.8. **Chemical Oxygen Demand (COD)**
Chemical Oxygen Demand (COD) determine the amount of organic pollutants found in surface water or wastewater making. COD a useful measure of water quality. To determine COD in the given water sample with stipulations as per Bureau of Indian Standard (BIS).

2.9. **Calcium as Ca**
Calcium is an important determinant of water hardness, and it also functions as a pH stabilizer, because of its buffering qualities. To determine the Calcium of given water sample with the stipulations as per Bureau of Indian Standard (BIS).

2.10. **Magnesium as Mg**
Magnesium in wastewater is the pH control and neutralization of acid. To determine the Magnesium of given water sample with the stipulations as per Bureau of Indian Standard (BIS).
2.11. Iron Total as Fe
To determine the Iron of given water sample with the stipulations as per Bureau of Indian Standard (BIS).

2.12. Manganese as Mn
Manganese does not present a danger to human health, nor for the environment but it is unpleasant. To determine the Manganese of given water sample with the stipulations as per Bureau of Indian Standard (BIS).

2.13. Free Ammonia as NH₃
Ammonia is a prevalent problem in the wastewater of many industries. To determine the free ammonia of given water sample with the stipulations as per Bureau of Indian Standard (BIS).

2.14. Nitrite as NO₂
To determine the Nitrite of given water sample with the stipulations as per Bureau of Indian Standards (BIS).

2.15. Nitrate as NO₃
To determine the Nitrate of given water sample with the stipulations as per Bureau of Indian Standard (BIS).

2.16. Fluoride as F
Fluoride can be found in our daily lives, most commonly in our drinking water. To determine the Fluoride of given water sample with the stipulations as per Bureau of Indian Standard (BIS).

2.17. Sulphate as SO₄
Sulphate is needed as growth nutrient so in high rate bioreactors it is not a trace element. To determine the Sulphate of given water sample with the stipulations as per Bureau of Indian Standard (BIS).

2.18. Phosphate as PO₄
The removal of phosphate is achieved largely by chemical precipitation which is expensive and causes an increase of sludge Volume by up to 40%. To determine the Phosphate of given water sample with the stipulations as per Bureau of Indian Standard (BIS).
3. Design & Fabrication of Airlift Fluidized Bioreactor- Laboratory set up

Fig. 2(a): Airlift bioreactor with motor

Fig. 2(b): Thermometer attached with Bioreactor

Schematic Representation of Airlift Fluidized Bioreactor

Fig. 2(c): Airlift Fluidized Bioreactor –Full Overview

4. RESULTS AND DISCUSSION

4.1 Treatment of sewage water in Airlift Fluidized Bioreactor

Jin et al. (2002) used an airlift reactor in a comprehensive pilot plant system for starch
Processing wastewater reclamation. Airlift fluidized bioreactor are solid-liquid contacting device which are of particular importance in biotechnology industries. Loh and Liu (2001) used an external loop fluidized bed airlift bioreactor for treatment of high strength phenolic wastewater. Fluidized-bed refers here to all beds in which the particles are not in continuous contact with each other due to the flow of a fluid up through them. From this Bioreactor, Marine sponges were used as adsorbent materials to adsorb impurities of water. The Bioreactor consisting of 2 litre pet bottle with a hole punched on the bottom of cap. The inverted pet bottle is kept on tristand and attached with burette. A thermometer is placed from top of the pet bottle which measure the temperature range of water sample (Fig 2 c). A desired amount of sample poured inside the reactor and marine sponges were placed inside the reactor. Lazarova et al. (1997) studied experimentally the fluid dynamics and the performance for wastewater treatment of a split-vessel airlift with a rectangular section. The Bioreactor was made to run continuously for about three days. Finally treated sample were filtrated and collected from the reactor for further analysis.

4.2 Analysis the properties of sample after treatment

After treating the sample in bioreactor, sample has been collected and transferred into beaker. Filtrate the collected sample by using filter paper. Marine sponges have different kind of physical, chemical and mechanical properties which changed sample properties which kept for treatment. To further confirm the properties of water sample, has been analysed and performed by above mentioned procedure and stipulations.

Properties of wastewater has been analysed in TAMILNADU WATER SUPPLY AND DRAINAGE BOARD (TWAD)-Erode. George Z. Kyzas(2013) showed that various combination between adsorbent materials were tested in order to obtain an effective materials for wastewater treatment. Amuda et al (2006) and Ibrahim et al (2006) showed that coconut shell-based activated carbon was found to effectively adsorb organic matter. From this result, values obtained before and after treatment of sewage water using sponges has changed. Using Fluorescent Microscope, before and after the treatment of sewage water were photographed (Fig 3). From Table 1, Parameter values shows positive and in effective manner. The present novel method can be used in this bioreactor to enhance the properties of sewage water sample.
Table 1: Changing of water sample properties before and after treatment

<table>
<thead>
<tr>
<th>S.NO</th>
<th>PARAMETER</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before treatment</td>
</tr>
<tr>
<td>1.</td>
<td>Turbidity NT Units</td>
<td>12</td>
</tr>
<tr>
<td>2.</td>
<td>Total dissolved solids</td>
<td>1033.0 mg/L</td>
</tr>
<tr>
<td>3.</td>
<td>Total suspended solids</td>
<td>10.0 mg/L</td>
</tr>
<tr>
<td>4.</td>
<td>pH</td>
<td>7.49</td>
</tr>
<tr>
<td>5.</td>
<td>Chloride as Cl</td>
<td>34.0 mg/L</td>
</tr>
<tr>
<td>6.</td>
<td>COD</td>
<td>240.0 mg/L</td>
</tr>
<tr>
<td>7.</td>
<td>Total hardness as CaCO₃</td>
<td>460.0 mg/L</td>
</tr>
<tr>
<td>8.</td>
<td>Calcium as Ca</td>
<td>88.0 mg/L</td>
</tr>
<tr>
<td>9.</td>
<td>Total Alkalinity as CaCO₃</td>
<td>416.0 mg/L</td>
</tr>
<tr>
<td>10.</td>
<td>Calcium as Ca</td>
<td>88.0 mg/L</td>
</tr>
<tr>
<td>11.</td>
<td>Magnesium as Mg</td>
<td>58.0 mg/L</td>
</tr>
<tr>
<td>12.</td>
<td>Iron total as Fe</td>
<td>1.20 mg/L</td>
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<tr>
<td>13.</td>
<td>Manganese as Mn</td>
<td>0.0 mg/L</td>
</tr>
<tr>
<td>14.</td>
<td>Free Ammonia as NH₃</td>
<td>31.08 mg/L</td>
</tr>
<tr>
<td>15.</td>
<td>Nitrite as NO₂</td>
<td>0.08 mg/L</td>
</tr>
<tr>
<td>16.</td>
<td>Nitrate as NO₃</td>
<td>2.0 mg/L</td>
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<td>17.</td>
<td>Fluoride as F</td>
<td>0.50 mg/L</td>
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<tr>
<td>18.</td>
<td>Sulphate as SO₄</td>
<td>97.0 mg/L</td>
</tr>
<tr>
<td>19.</td>
<td>Phosphate as PO₄</td>
<td>10.91 mg/L</td>
</tr>
</tbody>
</table>

Fig.3: Microscopic view of Adsorbent materials (Marine sponges)

Fig.3 (a): Before treatment Fig.3 (b): After treatment
Acknowledgement:

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References:


