DHS(Down-flow Hanging Sponge) Bio-Tower a Sustainable Method for Waste Water Treatment

Rakesh Kumar Bhardwaj*, 1), Hariom Sharma2), and Surender Kumar Bhardwaj3)

1) Department of Chemistry, Dyal Singh College, Karnal – 132001, INDIA
   e-mail: rakesh_bhardwaj2@rediffmail.com

2) PWD Water Supply & Sanitation, Water Testing Laboratory, Karnal – 132001, INDIA

3) Department of Bio-Sciences, Maharshi Dayanand University Rohtak – 124001, INDIA

Abstract

Substantial sustainability integrates social, environmental, economic and institutional aspects, and extends the scope of planning to distant regions and future generations. In spite of unprecedented advancement in technology, globalization and urbanization across the world, a vast number of developing countries are lagging behind in providing basic sanitation and adequate water supply to the people. The present day speedy socio-economic development of humanity has most vigorously stimulated the change in nature. Technological advancement, if on one hand has bettered the life of humans on this planet; on the other hand it has sharply intensified the pollution in environment. The energy and materials needed to sustain the present society are derived primarily from non-renewable fossil resources, which will be depleted at some point. The treatment of waste water generated as sewage has become both an ecological as well as an economic necessity. The investigations over the years have observed that the presence of toxic compound in water has manifested itself in various types of diseases in human-being and adversely affect the plants growth. Discharge of chemicals from various industries causes hazardous effects on humans, animals and environmental balances. The present study summarizes the result of analysis of sewage effluents of Karnal city being drained into Yamuna river, an important tributary of Ganga (our pious GANGA), in the region of eastern Haryana (INDIA). The sewage samples were collected at regular intervals and were analysed for TSS, BOD, COD, ORP and pH. The concentration of toxic metals Pb, Hg, Cd, and As have been determined for the samples. DHS(Down-flow Hanging Sponge) Bio Tower the combination of anaerobic (UASB) with aerobic (DHS) a self-sustainable sewage treatment system shows tremendous decrease in the value of BOD5 - 97% (176mg/kg to 5 mg/kg) and COD - 94% (476 mg/kg to 27mg/kg) in the sewage samples of Karnal.

Keywords: Waste water, Toxic chemicals, Sustainable methods

* Corresponding Author
1. Introduction

The increasing scarcity of water in the world along with rapid population increase in urban areas gives reason for concern and the need for appropriate water management practices. In the closing decades of the 20th century environmental pollution emerged as a major concern for the survival and welfare of mankind throughout the world. Modern civilization, armed with rapidly advancing technology and fast growing economic system is under increasing threat from its own activities causing water pollution, Singh et al. (1989). India is the seventh largest country in the world with a total landmass of 3.29 million sq. km, population over 1 billion, 29% of which live in urban areas spread over 5162 towns. With enormous natural resources and growing economy India is the second largest pool of technical and scientific personnel in the world. Pollution from small size industries (SSIs) puts the Indian regulators in front of a difficult arbitrage between economic development and environmental sustainability. The uncontrolled growth in urban areas has made planning and expansion of water and sewage systems very difficult and expensive, Looker (1998).

The pollution load is characterized by high colour content, suspended solids, nutrients and toxic substances such as heavy metals and chlorinated organic compounds. The discharge of coloured wastewater from textile, leather, printing and other industrial effluents containing toxic compounds viz. Cd(II), Pb(II) and Cr(VI) is currently a major environmental concern in the developing countries because of their poor bio-degradability, carcinogenicity and toxicity, Yadav et al. (1998). Azo-dyes are the most widely used among synthetic dyes, representing almost 70% of the textile dyestuffs produced, Knackmuss (1996). Storm water runoff and discharge of sewage into the water bodies are two common ways by which various nutrients enter the aquatic eco-system, Sudhira et al. (2000); Kansal et al. (2003). The abuse of water
use for diluting human excreta and transporting them out of the settlement is increasingly questioned and being considered unsustainable, van Lier et al. (1998).

2. Methods and Materials

The same sampling protocol was employed for each measurement. Routine sampling was employed during dry weather to characterise water quality under ‘normal’ operating conditions, and opportunistic sampling was undertaken during rainfall. As the physical and chemical characteristics of sewage vary from top to bottom of the sewage depth as well as with time from morning to evening so the grab samples were collected at regular interval and were mixed together. The samples were filtered in the field immediately after sampling and subsequently collected in clean polyethylene bottles. The water samples were collected from the selected area of Karnal and Panipat (an industrial town) in a routine manner for 30 weeks in continuation covering seasons of year 2007-2008. Simultaneously the samples were also collected from the Down-flow hanging sponge (DHS) reactor Bio-Tower, installed at a sewage treatment plant Karnal. The pH was measured using the Systonic pH meter-324. The samples were analysed for the BOD and COD as per the manufactures manuals for calibrations of the apparatus and operations. For the measurements of BOD, the BOD bottles of capacity 300 ml and the incubator was provided with a temperature control of ± 0.5°C. The estimation of suspended solids was carried out by measuring the weight of residue retained on the glass fiber filter (Whatman Grade 934 AH) in the known volume of the samples. For toxic metals analysis, samples were collected from Panipat in 100 ml polyethylene bottles and acidified with 0.5 ml of Conc. HNO₃ to pH 2 and few drops of HgCl₂ were also added to stop the microbiological activity. The pre-treated samples were taken into the polarographic cell with appropriate supporting electrolyte. Currents were measured at peak potential of concentrated ion after making blank corrections. Dropping
mercury electrode was used as the working electrode. All the mass measurements were performed on an electronic balance (Citizen). The experiments were carried out at 25 ± 1°C. The samples were stored in refrigerator before analysing and the reagents used in the estimation were of AR grade.

3. Result and Discussion

Sewage is the wastewater released by residence and industries in a community. It consists of more than 99 % water with only less than 1 % of dissolved and suspended solid material. The experimental results of our measurements in the samples of sewage for the BOD, COD, ORP TSS, VSS and pH, are reported in Table 1 and are graphically represented in Figure 1-3. Quantitation in all observations was made by standard addition method, Willard et al. (1974).

<table>
<thead>
<tr>
<th>Time /Week</th>
<th>pH</th>
<th>ORP (v)</th>
<th>BOD (mg/kg)</th>
<th>COD (mg/kg)</th>
<th>TSS (ppm)</th>
<th>VSS (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sewage</td>
<td>Sewage</td>
<td>Sewage</td>
<td>UASB</td>
<td>UASB + DHS</td>
<td>Sewage</td>
</tr>
<tr>
<td>1</td>
<td>7.19</td>
<td>-281</td>
<td>151</td>
<td>28</td>
<td>2</td>
<td>356</td>
</tr>
<tr>
<td>2</td>
<td>7.12</td>
<td>-278</td>
<td>167</td>
<td>66</td>
<td>5</td>
<td>578</td>
</tr>
<tr>
<td>3</td>
<td>7.13</td>
<td>-266</td>
<td>169</td>
<td>70</td>
<td>5</td>
<td>560</td>
</tr>
<tr>
<td>4</td>
<td>7.05</td>
<td>-278</td>
<td>186</td>
<td>65</td>
<td>6</td>
<td>460</td>
</tr>
<tr>
<td>5</td>
<td>7.21</td>
<td>-249</td>
<td>144</td>
<td>60</td>
<td>9</td>
<td>385</td>
</tr>
<tr>
<td>6</td>
<td>7.16</td>
<td>-258</td>
<td>160</td>
<td>52</td>
<td>1</td>
<td>516</td>
</tr>
<tr>
<td>7</td>
<td>7.13</td>
<td>-252</td>
<td>172</td>
<td>55</td>
<td>4</td>
<td>420</td>
</tr>
<tr>
<td>8</td>
<td>7.21</td>
<td>-240</td>
<td>201</td>
<td>58</td>
<td>3</td>
<td>556</td>
</tr>
<tr>
<td>9</td>
<td>7.21</td>
<td>-215</td>
<td>228</td>
<td>50</td>
<td>6</td>
<td>600</td>
</tr>
<tr>
<td>10</td>
<td>7.28</td>
<td>-231</td>
<td>214</td>
<td>67</td>
<td>2</td>
<td>533</td>
</tr>
<tr>
<td>11</td>
<td>7.13</td>
<td>-231</td>
<td>199</td>
<td>52</td>
<td>3</td>
<td>584</td>
</tr>
<tr>
<td>12</td>
<td>7.14</td>
<td>-251</td>
<td>192</td>
<td>60</td>
<td>7</td>
<td>566</td>
</tr>
<tr>
<td>13</td>
<td>7.29</td>
<td>-220</td>
<td>180</td>
<td>42</td>
<td>5</td>
<td>496</td>
</tr>
<tr>
<td>14</td>
<td>7.22</td>
<td>-245</td>
<td>177</td>
<td>54</td>
<td>5</td>
<td>463</td>
</tr>
<tr>
<td>15</td>
<td>7.30</td>
<td>-152</td>
<td>182</td>
<td>70</td>
<td>6</td>
<td>462</td>
</tr>
</tbody>
</table>
Table 1 revealed that the composition of wastewater varies significantly with session as a result of the release of untreated domestic and industrial inorganic and organic toxicants. Figure 1 shows that the variation of studied parameters over the study period is not regular but at random, the studied parameter as a whole increases with alarming rate. The BOD$_5$ measures the amount of oxygen microorganisms required in five days to break down sewage. The amount of BOD varies from 144 mg/kg to 228 mg/kg averaged 176.0 (mg/kg); while COD 335 mg/kg to 611 mg/kg averaged 476 (mg/kg) and pH 7.05 to 7.33 averaged as 7.20. The cloudiness of sewage is caused by suspended particles. The TSS ranges from 155 to 348 ppm while the VSS is averaged as 150 ppm. The ORP (oxidation reduction potential) is a measure of energy potential. Table 1 indicates the values of ORP various from -152 V to -281 V averaged as -242.5 V An ORP in the negative range indicates reaction taking place is anaerobic, while the positive value of ORP indicates that the reaction is aerobic or there is presence of oxygen.
**Figure 1** Variation of BOD, COD, TSS, VSS and ORP in waste water with Time (in week)

**Figure 2** Variation of BOD with Time (in weeks)
Heavy metals from waste-water are partitioned into sewage sludge and the effluent and are returned to the environment where they may contaminate soil, water and eventually also the food chain. While some metal compounds are essential to animals and humans, others are known to be toxic and the environmental impact of many of them has to be elucidated.

Many industrial plants discharged *heavy metals* and *volatile organic chemicals* (VOCs) directly into streams or inject them into the subsurface. The chemicals used in the dyeing factoriesviz sodium nitrate, aluminum sulphate, caustic soda and soda ash may be responsible for high value of the studied parameters. Similar results were also reported by Somashekar et al. (1984). The measured concentration of toxic metals Cr, Pb, As, and Hg in the sewage samples of Panipat town along with standard deviation have been summarized in Table 2. It can be seen from the tabulated values that the level of toxic metals in the waste water is much higher.
The main components of domestic wastewater are proteins, carbohydrates, detergents, tannins, lignin, fulvic acid, and many other dissolved organic compounds, Rebhun et al. (1971). Pathogens or disease-causing organisms are present in sewage. Coliform bacteria are used as an indicator of disease-causing organisms, Kansal et al. (2003).

A number of conventional treatment technologies have been considered for treatment of wastewater contaminated with organic substances. Commercial activated carbon is regarded as the most effective material for controlling the organic load. However due to its high cost and about 10-15 % loss during regeneration, unconventional adsorbents like fly ash, peat, lignite, wood, saw dust etc. have been used for the removal of refractory materials, Pandey et al. (1985) for varying degree of success. Ionic liquids holds promise to provide better alternative to the toxic solvents, Sheldon et al. (2001).

The removal of organic material by adsorption has recently become the subject of interest of several workers, Nelson et al. (1969); Eye et al. (1970); Johnson et al.(1965); Deb et al.(1966); Gupta et al.(1978,1990); Mott et al. (1992); Viraraghavan et al.(1994). They have

---

**Table -2 Concentrations of toxic metal and standard deviation \( \sigma \) in wastewater**

<table>
<thead>
<tr>
<th>Metal ion</th>
<th>Supporting Electrolyte</th>
<th>Peak Potential(v)</th>
<th>Concentration (mg/kg)</th>
<th>( \sigma ) ±</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>0.1M KCl</td>
<td>-0.44</td>
<td>139</td>
<td>52</td>
</tr>
<tr>
<td>Chromium</td>
<td>1 M NaOH</td>
<td>-0.80</td>
<td>112</td>
<td>69</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.5M HCl + 0.5M H(_2)SO(_4)</td>
<td>+0.19</td>
<td>28</td>
<td>11</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Oxalate Buffer (pH 4.0)</td>
<td>-1.15</td>
<td>17</td>
<td>6</td>
</tr>
</tbody>
</table>
explored the use of fly ash as an adsorbent for treatment of wastewater to remove toxic compounds and colour. Pandey et al.(1985), has proposed a method for removal of copper from wastewater by taking fly ash as an adsorbent. The use of active filtration through alkaline media for the removal of phosphorus from domestic wastewater has been proposed by Johansson et al.(1998); and Drizo et al. (2006). Ozone is a very good oxidizing agent due to its high instability (reduction potential 2.07 V) when compared to chlorine (1.36 V) and \( \text{H}_2\text{O}_2 \) (1.78V). It has potential to degrade large number of pollutants like phenols, pesticides and aromatic hydrocarbons and is used since the early 1970s in wastewater treatment (Robinson et al. 2001, Özbek et al. 2002, Pera-Titus et al. 2004). The major drawback of the use of this method is, ozone has short half-life, it decomposes in 20 minutes so require continuous ozonation and making this method expensive to apply, Slokar et al. 1998, Robinson et al. 2001).

Anaerobic wastewater treatment is a biological wastewater treatment without the use of air or elemental oxygen. Applications are directed towards the removal of organic pollutants in wastewater, slurries and sludge. Complete replacement of aerobic with anaerobic technology is not yet possible as the effluent quality of anaerobic treatment systems is not up to par. The anaerobic treatment is considered as a pre-treatment technique and has been applied in Colombia, Brazil, and India, replacing the more costly activated sludge processes. There are different types of digesters available, some have been proven effective over time, and others are still being tested. One of the most suitable digesters for tropical conditions is the UASB (Up flow Anaerobic Sludge Blanket).

Harada et al. (2007, 2006, 2005, and 2002) has proposed a self-sustainable sewage treatment system with the combination of UASB as pretreatment unit and an aerobic reactor Down-flow Hanging Sponge (DHS) reactor as a post treatment unit shown in Figure 4. The
proposed anaerobic-aerobic biocoenoses of UASB and DHS fulfills the need for a simplified treatment system for developing countries because of its low cost, and operational simplicity, along with sustainability of the system as a whole. The results in Table 1 and Figure 2 & 3 show a tremendous decrease of 97% in BOD$_5$ (176mg/kg to 5mg/kg) and 94% in COD (476mg/kg to 27mg/kg in the samples collected from DHS Bio Tower reactor at Karnal.

![Schematic diagram of anaerobic (UASB) with aerobic (DHS) sewage treatment.](image)

**Figure 4** Schematic diagram of anaerobic (UASB) with aerobic (DHS) sewage treatment.

4. Conclusions

An increasing proportion of the human population is concentrated in towns, which is associated with the production of large volumes of waste-water that must be treated before discharge in to a recipient. To achieve ecological wastewater treatment, a closed-loop treatment system is the need of hour. Now a day’s most of the systems under operation are “disposal-based linear system”. These traditional linear treatment systems must be transformed into the cyclical treatment to promote the conservation of water and nutrient resources. It can be concluded from this study that combination of anaerobic (UASB) with aerobic (DHS) a self-sustainable sewage treatment is a good alternative to other conventional treatment system.
5. References


EP&RC Foundation, Wageningen (The Netherlands), Sub-Department of Environmental Technology, Agricultural University.

