Modified biosand - water treatment plant
Unnat Bharat Abhiyaan
National Institute of Technology Manipur
Langol Lamphel-795001

Coordinator: Dr. P. Albino Kumar
Head, Departmental of Civil Engineering

The National Institute of Technology (NIT) Manipur has adopted 5 (five) villages at Nambol, Bishnupur District of Manipur, namely- (i) NambolMakha, (ii) Kongkhamawang, (iii) Maibam Chingmang, (iv) Nambol Bazar & (v) Koriphaba with due consent from District Collector. The team of UBA-NIT Manipur had carried out Participatory rural appraisal (PRA) of these villages in 2015 and identified the most priority issue - "Clean & Safe water for drinking". The main sources of water for these villages are the neighbouring ponds. However the degrees of safeness of these ponds water are the main concerns. During the pond water assessment survey from 25th March till 17th April 2015, the following data were obtained (Table 1.) suggesting high Turbidity, Hardness, Solids, Dissolved oxygen and MPN etc (Fig. 1).

Table 1. Assessment of Pond water parameter:

<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Location of collection</th>
<th>Turbidity (NTU)</th>
<th>Conductivity (μS)</th>
<th>Dissolved Solids(mg/L)</th>
<th>pH</th>
<th>Dissolved Oxygen (mg/L)</th>
<th>MPN (in 100 mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nambol River near Nambol Bazar</td>
<td>155</td>
<td>68.2</td>
<td>33.8</td>
<td>7.43</td>
<td>5.4</td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>Lainingthou Khoriphaba pond</td>
<td>1.27</td>
<td>126.3</td>
<td>62.64</td>
<td>7.23</td>
<td>5.63</td>
<td>185</td>
</tr>
<tr>
<td>3</td>
<td>Nambol Sabal Leikai pond</td>
<td>3.51</td>
<td>157.7</td>
<td>78.35</td>
<td>7.24</td>
<td>6.8</td>
<td>210</td>
</tr>
<tr>
<td>4</td>
<td>Nambol maibam Chingmang pond near Club</td>
<td>6.23</td>
<td>215.1</td>
<td>105.9</td>
<td>8.24</td>
<td>7.64</td>
<td>320</td>
</tr>
<tr>
<td>5</td>
<td>Nambol Maibam near Tiddim road</td>
<td>4.07</td>
<td>190.6</td>
<td>93.88</td>
<td>7.93</td>
<td>6.84</td>
<td>296</td>
</tr>
<tr>
<td>6.</td>
<td>Keinoumamang Leikai Pukhri Achouba</td>
<td>9</td>
<td>115.8</td>
<td>75.2</td>
<td>7.2</td>
<td>6.62</td>
<td>310</td>
</tr>
</tbody>
</table>
In Manipur, few other villages have Water treatment Plant based on Slow sand filter along with coagulation (alum dosing). In slow sand filter, automatic formation of Smutzdecke layer (dirty skin) on top surface of the filter is required for effective water treatment against solids and pathogens and this can be achieved by *continuous* water feeding to the plant reactor for treatment. However, intermittent feeding is practised in these filters and the development of smutzdecke layer is not proper and results ineffective pathogen removal. For intermittent supply of water, many researcher studied bio-sand filter (maximum 30 cm diameter) for household purposes and development of large scale reactor is not much reported. Therefore, NIT Manipur studied and designed a prototype reactor to enhance the reactor size using biosand filter concept with intermittent feeding. The media used are sand and gravels from local markets after optimizing their effective size through sieve analysis study.

Thus, a lab-scale and a pilot plant filtration unit has been set at NIT Manipur, and studied for designing of large scale plant to be implemented at the village site. The treatment plant was based on indigenous techniques (combination of Roughing Filter and Slow Sand Filter), low cost and easily available materials. The designed plants was approached and conducted for both household and community based requirements (Fig. 2).

**Design Details:** Shown in Fig. 3(a, b & c).
1. For the plant
   - Length = 530 cm
   - Breadth = 320 cm
   - Depth = 163 cm
   - Thickness of the wall = 12 cm
   - Slope = 1:8
   - Standing Water depth = 5 cm
   - Free board = 10 cm
   - Sand Depth = 70 cm
   - Finer Gravel Depth = 25 cm
   - Coarser Gravel Depth = 25 cm

2. For reactor:
   - No. of reactor = 8 nos.
   - Length = 126 cm
   - Breath = 150 cm
   - Depth = 163 cm

Source of Water:
The source of water for the treatment is identified as the local pond at Nambol Makha. During the survey, it was observed that the turbidity of pond is 7 - 15 NTU during last 2 years and further increased to 15 - 20 NTU during monsoon season. The surface runoff and other human activities including washing, bathing and cattle add to more pollution during monsoon. But after the construction of plant, awareness was given to the local villager regarding pollution & such activities and suggested to fence & protect the pond. During present 2017 rainy season (March Mid till date), the turbidity were observed less with 6.4 NTU (max.) due to dilution of rain water and absence of pollution activity due to awareness by the club.
Feeding to Reactor:
Water is fed from the pond using generator cum water pump in every alternate day for an hour and filled the 9000 litre capacity reactor. The pump also run twice or thrice a day if sudden water demand arises in the village due to occasions (Fig 4a). For operational cost regarding fuel of the generator, its arranged by the Gram panchayat. In order to prevent rupture of Smutzdecke layer during feeding of the reactor, the diffuser is introduced in household biosand reactors. For the same purpose, a sprinkler feeding mechanism is designed by blocking the end of pipe through tightening the end pipe and introducing several holes on all sides of pipes (Fig. 4b). The treated water is then collected at the bottom of the reactor through common outlet for Reactor 1&2, Reactor 3&4, Reactor 5&6 and Reactor 7&8 as shown in Fig. 3(c). The Smutzdecke layer is preserved by maintaining standing water height through raising the outlet pipe for a minimum hydraulic head just before discharging to the disinfection reservoir. Also disinfection (chlorination) is done in the reservoir inlet as shown in Fig 4(c) and baffles were provided in the reservoir to increase the contact period of disinfection.

Mechanism:
The high water level pushes the water through the diffuser and filter (also called the hydraulic head. The water level in the reservoir goes down as it flows evenly through the sand. The flow rate will slow down over time due to less pressure to force the water through the filter. The inlet water contains dissolved oxygen, nutrients and contaminants and provides the oxygen required by the microorganisms in the biolayer. Larger suspended particles and pathogens are trapped in the top of the sand and they partially plugged the pore spaces between the sand grains. This also causes the flow rate to slow down.

Results:
After completion of the construction, the biosand filter was inaugurated on 28th August 2017, in august presence of Dr. Birendra Singh, NIT Manipur Director and L. Biramani, local Head. The inauguration was attended by more than 200 local peoples and awareness & demonstration lecturer were delivered by Dr. P. Albino Kumar, UBA Coordinator, NIT Manipur with emphasis on the following points (Fig. 5 a,b,c)

- Protection of Pond against cattle and human intervention to preserve the quality of pond water.
- The mechanism of the reactor
- Dos & Donts on the reactor (wasting of treated water by kids for bathing- a common sight always)
- Design of house hold filters with easily available low cost material.

**Monitoring & survey:**

The assessment of water parameters were evaluated on site & lab (Fig. 6) and is shown in Table 2 and showed that all the treated effluent were within the permissible limit.

**Table 2: Water parameters of the untreated and treated during last 8 months**

<table>
<thead>
<tr>
<th>Months</th>
<th>Untreated</th>
<th></th>
<th>Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Solids (ppm)</td>
<td>Turbidity (NTU)</td>
<td>pH</td>
</tr>
<tr>
<td>September</td>
<td>102.9</td>
<td>9</td>
<td>6.7</td>
</tr>
<tr>
<td>October</td>
<td>101.5</td>
<td>10</td>
<td>6.6</td>
</tr>
<tr>
<td>November</td>
<td>99.2</td>
<td>8.5</td>
<td>6.9</td>
</tr>
<tr>
<td>December</td>
<td>100.4</td>
<td>8.0</td>
<td>6.7</td>
</tr>
<tr>
<td>January</td>
<td>100.8</td>
<td>8.2</td>
<td>6.7</td>
</tr>
<tr>
<td>February</td>
<td>105.1</td>
<td>8.2</td>
<td>6.7</td>
</tr>
<tr>
<td>March</td>
<td>102.3</td>
<td>7.5</td>
<td>6.8</td>
</tr>
</tbody>
</table>
During the survey with the villagers, the following conclusions were also drawn.

- Monitoring of the biosand filter plant & survey of the water consumption has been carried out since inauguration and the following observations are made.
- No of people depending on this biosand filter: more than 2000 nos
- Farthest distance of villagers collecting water from the filter: 2-3 km
- Mode of conveyance for collection: Trolleys, cycles. (Fig. 7)
- Frequency of pumping for feeding: 1-2 hours every alternate day
- Decrease in output flowrate: Insignificant (suggesting higher capacity of filtration)
- Smell or colour in water: Nil
- Any health effects due to this treated water: Nil