Treatment of septic tank effluent using sequencing batch reactor along with the incorporation of rice husk and Bael pericarp as a natural adsorbent in reducing BOD and COD

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Abstract. The generation of liquid forms of waste has rapidly shown its hike in the presently expanding world. This quantification hugely includes the day today’s secretion of the human excreta into the septic tanks that are commonly found in every household. Proper treatment and disposal of faecal waste, once the septic tank is full, becomes challenging for every resident and local bodies. The primary contaminants found in the Septic Tank Effluents (STE) include many disease-causing pathogens, faecal coliform bacteria, detergents and toxic gases. The Sequencing Batch Reactor (SBR) takes its position when treating any waste, which contains a high amount of organic content. In this study, the characteristics, namely COD and BOD of STE samples collected from different locations of the semi-urban area at the outskirt of a town were analyzed. The STE samples treated using SBR mainly to reduce COD and BOD concentration found to be in higher concentration beyond the permissible limit. The same samples subjected to contact with adsorbents such as rice husk and powdered form of dried Bael (Aegle marmelos) outer shell. Results showed a good reaction with the adsorbents and found a significant reduction in COD and BOD concentration.

1. Introduction
The drastic increase in population, industrialization and urbanization is inevitable in developing countries like India. Nowadays, it becomes challenging for every resident and local government to identify and pick out the proper treatment and disposal of faecal waste once the septic tank is filled. The improper monitoring and maintenance of these wastes have led to the contamination of various resources, especially India’s water resources mainly in the monsoon season. Most contaminants found in septic tank effluent include pathogens (anything that can produce diseases), faecal coliform bacteria (bacteria from human waste), detergents (including chlorine and bleach) and toxic gases (like methane and hydrogen sulphide). These contaminants have led to the outbreak of severe diseases, including typhoid and cholera. In urban areas, septic tank effluents’ disposal has to be done through well-designed sewer lines and treatment plants. However, in many rural areas, the effluents are disposed of without proper treatment in the nearby railway tracks or lakes. Considering this situation of rural areas, simple and effective treatment plants have to be adopted [1][2][3].
SBR is the best idea for this scenario. SBR is a reactor in which specific steps are carried out sequentially through a fill-and-draw process [4] in which the effluent is put on to a single batch reaction tank, treated for the removal of unwanted components and then released [5][6]. It is a modified system of an Activated Sludge Process (ASP) [7]. The main feature that separates SBR from ASP is that in SBR all the process, including equalization, aeration and clarification, with a controlled time sequence in a single tank. The main advantage of using SBR is that the effluent released from it is low in organic compounds (as it effectively reduces the value of COD and BOD); it also meets effluent discharge standards. SBR can also be used as part of a more extensive system when nutrients such as nitrogen and phosphorus have to be removed [8][9].

Moreover, SBR requires a smaller installation area and the operation time is flexible and feasible [10][11]. Since this system has a small footprint, it is relatively easy to expand this system by adding additional reactors [12]. Importance of protecting the environment is increasing day by day. Therefore, there is a need to develop this SBR technology for the effective disposal of these STEs [13]. Among these modern innovations, adsorption would be an efficient and user-friendly technique for removing substrate present in the STEs [14][15]. Various researchers widely use the adsorption process to remove suspended particles and heavy metals present in the wastewater. The need for economical and readily available adsorption material is essential towards the commercially available activated carbon. In SBR, adsorbents can be added quickly and effortlessly [16][17]. In this study, the characteristics, namely COD and BOD of STE samples collected from different semi-urban areas at the outskirts of a Chengalpattu district in Tamil Nadu, India, were analyzed. Ten samples collected from different places within the district to analyze its common behaviours. Then, STE samples treated using SBR mainly to reduce BOD and COD, which are found to be in higher concentration beyond the permissible limit. The same samples then subjected to contact with adsorbents such as rice husk and powdered form of dried Bael (*Aegle marmelos*) outer shell, which are mainly available in these areas.

2. Materials and methods

2.1. Sample Collection

The septic tank effluent samples collected in a 5-litre jar for SBR treatment. The jar cleaned with water and naturally dried in the sunlight. Ten samples each of 20 litres collected and stored in these sun-dried airtight containers. Figure 1 shows the collection of samples from the septic tank. The samples were collected from different Chengalpattu district locations, as shown in Figure 2, whose latitude and longitude are given in Table 1.
Table 1. Characteristics of STE samples

| Sample designation | Latitude (°) | Longitude (°) |
|--------------------|--------------|---------------|
| STE 1              | 12.816       | 80.037        |
| STE 2              | 12.816       | 80.039        |
| STE 3              | 12.83        | 80.041        |
| STE 4              | 12.836       | 80.056        |
| STE 5              | 12.86        | 80.082        |
| STE 6              | 12.902       | 80.1          |
| STE 7              | 12.893       | 80.11         |
| STE 8              | 12.92        | 80.14         |
| STE 9              | 12.907       | 80.128        |
| STE 10             | 12.896       | 80.086        |

2.2. Preparation of absorbent Rice husk

Rice husk is profusely accessible waste material, extensively produced as a by-product from the rice mills and available in excess all around significant rice-producing countries [18][19]. This material’s primary content was carbon, about 30 – 60% of the total constituents [20]. The rice husk is collected from the rice mill as a raw form, as shown in Figure 3 (a). These collected rice husks are then sun-dried and ground into fine form, as shown in Figure 3 (b). The powdered form was used as the adsorbent in this study. The subtle form will accelerate the boost up the reaction rate compared to concrete rice husk due to increase in the adsorbing particles, thus increasing the area of contact of the adsorbent with the suspended particles present in the effluent to be treated.
Bael (Aegle marmelos)
The fruit of *Aegle marmelos* is mainly available in the selected study areas and is collected from its vicinity and dried under the sun for 4 to 5 days. After drying, the inner pulpy part removed and the outer shell crushed into smaller fragments, as shown in Figure 4 (a). This follows oven drying of those fragments after cleaning with water at 50°C. The crushed outer shells are subjected to grinding to make it a semi-fine powder, as shown in Figure 4 (b), used for the study. The same concept of increasing the area of contact to accelerate the treatment process in the SBR was used, which paved the way to grind the Bael pericarp into powdery form and utilize it.

2.3. Experimental setup
The SBR consists of a holding tank in which the collected sample retained reaction tank where all the treatment performed. An outflow pipe attached to the main tank for collecting the treated effluent. Two air diffusers attached to the main tank to induce the aeration process. The mixing is done using a mechanical stirrer. Valves provided in the tanks to adjust the flow of the septic tank effluent. A schematic diagram showing the SBR design and its components shown in Figure 5.
The SBR specification and design include:

**STE holding tank – specifications**

Holding tank has a full capacity of 15.75 L with a dimension of 35 x 15 x 30 cm. It has a working volume of 13 L.

**Reaction tank – specifications**

The tank’s total capacity is 24 L with a working capacity of 20 L having a dimension of 40 x 30 x 20 cm.

**Operating conditions**

The reactor is operated for 8-hour cycle for about three days (filling - 30 minutes, mixing - 30 minutes, aeration - 120 minutes, settling - 120 minutes, drawing - 30 minutes and idle - 150 minutes).

2.4. **SBR treatment process**

The treatment of SBR occurs mainly in five different phases performed in order to achieve higher efficiency. The following sections will elaborately discuss each phase.

2.4.1 **Phase 1 – Filling and Mixing.** The septic tank effluent poured into the effluent holding tank according to its volume. The valve opened and effluent filled into the main vessel for treatment process under gravity. This gravity dropping helps settle the heavier particles in the bottom and leave only the rarer particles in suspension with the water. The filling process is shown in Figure 6, and it follows by mixing process, as shown in Figure 7. The mixing is done mechanically using a **stirring machine**. This phase took about 30 minutes, and the SBR operated in static fill phase.

![Figure 6. Phase 1 – Fill](image1)

![Figure 7. Phase 1 – Mixing](image2)
2.4.2 Phase 2 – Adding Natural Adsorbent and Aeration. The second phase is the addition of natural adsorbent, followed by aeration. In this phase, crushed rice husk and powdered form of dried Bael (Aegle marmelos) add to the effluent and a porous air diffuser immersed into the reactor tank to induce aeration. This aeration and the added natural adsorbent will help in the decomposition of organic matter present inside the reactor. The aeration phase was done for about 150 minutes. The process of aeration, along with the added adsorbent shown in Figure 8.

![Figure 8. Phase 2 - Aeration using air diffusers](image1)

Figure 8. Phase 2 - Aeration using air diffusers

![Figure 9. Phase 3 - Sludge settled in the main tank](image2)

Figure 9. Phase 3 - Sludge settled in the main tank

2.4.3 Phase 3 – Settling. In this phase, effluent neither added nor removed and SBR kept undisturbed for the microbial reaction and the natural adsorbent present. The microbe will exploit the remaining substrate present in the tank, and when these substrates decrease, the microbe starts to die due to lack of food. The perished microbes along with the added substrate, settle down as sludge inside the reactor. Simultaneously natural adsorbent present in the tank will absorb the remaining substrates and settle as sludge after its potential. This phase took about 120 minutes to complete. The sludge settled in the main tank after this phase is shown in Figure 9.

2.4.4 Phase 4 – Drawing. The settling phase followed by a drawing phase where the treated effluent removed from the reactor. During this phase, the reactor kept undisturbed so that the settled sludge did not mix up.

2.4.5 Phase 5 – Idle. The idle phase was the last stage in the treatment of effluent using SBR. The reactor kept undisturbed for 150 minutes by not withdrawing or adding any effluent in the idle phase. This phase is not mandatory in all SBR operating conditions if the sludge completely separates.

3. Results and discussion
The STE characteristics were analyzed based on various parameters. A total of 25 parameters taken to understand the typical behaviour of STE samples. Characteristics of STE samples are as shown in Table 2.

| Parameter (units)       | STE1 | STE2 | STE3 | STE4 | STE5 | STE6 | STE7 | STE8 | STE9 | STE10 |
|-------------------------|------|------|------|------|------|------|------|------|------|-------|
| pH                      | 7.28 | 6.92 | 7.02 | 7.51 | 6.98 | 7.16 | 6.88 | 7.35 | 7.10 | 7.24  |
| Turbidity (NTU)         | 149  | 258  | 154  | 195  | 165  | 208  | 269  | 165  | 186  | 164   |
| Electrical conductivity | 3.1  | 2.4  | 3.6  | 2.8  | 3.1  | 2.6  | 2.4  | 3.0  | 2.8  | 2.9   |
| Parameter                  | Values           |
|----------------------------|------------------|
| (µs/cm) TSS ×10³ (mg/L)   | 10.3 20.8 11.5 16.2 12.03 16.8 21.1 11.9 15.2 11.9 |
| TDS (mg/L)                 | 3.6 2.4 3.54 3.0 3.4 2.9 2.3 3.3 3.0 3.4 |
| Ammonium (mg/L)            | 109.3 133.9 110.6 124.2 113.2 128.3 135.5 115.7 121.0 114.1 |
| BOD (mg/L)                 | 22 44 24 35 27 40 49 35 29 31 |
| COD (mg/L)                 | 80 224 86 156 113 172 232 105 210 96 |
| Lead (mg/L) LOQ-0.1        | BLQ 0.53 BLQ 0.1 BLQ 0.28 0.51 BLQ BLQ BLQ |
| Copper (mg/L) LOQ-0.05     | BLQ 0.06 BLQ BLQ BLQ BLQ 0.07 BLQ BLQ BLQ |
| Zinc (mg/L) LOQ-0.01       | BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ |
| Nickel (mg/L) LOQ-0.1      | BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ |
| Boron (mg/L) LOQ-0.1       | BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ |
| Arsenic (mg/L) LOQ-0.005   | BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ |
| Mercury (mg/L) LOQ-0.01    | BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ |
| Cadmium (mg/L) LOQ-0.01    | BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ |
| Selenium (mg/L) LOQ-0.005  | BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ |
| Cyanide (mg/L) LOQ-0.01    | BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ BLQ |
| Total phosphorous (mg/L)   | 10.95 37.8 20.75 31.3 15.59 26.7 38.6 20.6 127 10.29 |
| Potassium (mg/L)           | 9.0 5.0 2.0 10.2 5.6 4.8 7.8 5.0 9.2 2.8 |
| Total Nitrogen (mg/L)      | 198.3 206 168.4 192 175.2 216 159 135 178 196.23 |
| Nitrates (mg/L)            | 22.35 31.2 28.64 29.5 33.26 24.0 16.5 29.7 19.1 23.56 |
| E coli (Mpn/100ml)         | 1600 1600 1600 1700 1700 1600 1500 1400 1400 1600 |
| Total coliform (Mpn/100ml) | 1600 1600 1500 1500 1700 1600 1400 1400 1400 1600 |
| Bacterial count ×10⁵ (CFU/ml) | 2 1.8 2 2 1.8 1.9 2 1.8 1.8 1.8 |
It was found that some parameters were higher than the prescribed standards as given IS code provisions. For this study, reduction in BOD and COD took for analysis. The concentration of BOD before and after treatment with both the adsorbent shown in Figure 10. The dosage for the addition of adsorbent fixed for both the adsorbent and dosage is 20 g/L.

It is seen that the reduction of the concentration of BOD is more in case of powdered rice husk with a maximum reduction of 50% than the powdered Bael fruit with a maximum reduction of 48%. This may be due to the higher amount of Silicon present in the rice husk with the content being approximately 96.34%, which act as a medium in accelerating the rate of adsorption, based on the XRD analysis done by various researchers [21] [22] [23] [24]. The concentration of COD before and after treatment with both the adsorbent shown in Figure 11.

![Figure 10. Graphical representation of the concentration of BOD](image1)

From Figure 11, the same pattern observed as that of Figure 10. SBR effectively reduces COD concentration when subjected to rice husk with a maximum reduction in the percentage of 87.25%
than that of powder outer shell of Bael fruit, which has a maximum reduction percentage of 84%. One reason for reducing COD and BOD may be due to the accelerated aeration process given to the effluent through SBR [25], and the other may be due to the Oxygen content available in the adsorbents. Many studies based on XRF analysis reveal that the amount of oxygen present in the rice husk and Bael are about 25.982% and 20% respectively [26] [27], which diminishes both the oxygen demands that are found in the

4. Conclusion
The septic tank effluent has been collected from different places of Chengalpattu district, Tamil Nadu and its essential characteristics were analyzed. From the analysis of the septic tank effluent, it was found that the samples have a high content of COD, BOD, and bacterial Coliforms. From the observation, metals like lead, zinc, nickel, copper, boron, arsenic, mercury, cadmium, selenium and cyanide are below the limit of qualifications as per IS 3025. Hence, the paper’s main aim was curated to reduce COD and the BOD contents from the septic tank waste. The treatment was carried out with the help of SBR. The natural adsorbents were added to the SBR after grinding it into fine form. The adsorbent which included rice husk powder and powdered outer shell of Bael fruit, are added with a dosage of 20 mg/L. The effluent has been subjected to a physical and chemical process to reduce BOD and COD concentration, high in concentration. The results revealed that COD and BOD’s removal efficiency was between 73 -87% and 27 - 50% respectively in rice husk and 65 – 87% and 25 – 50% when subjected with powdered Bael shell as the adsorbent. It was observed that SBR was adequate for the treatment of septic tank effluent for the reduction of COD as well as BOD with the help of added adsorbent and proving rice husk to be slightly effective than the powdered outer shell of Bael fruit in reducing the different oxygen demands.

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