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# PERFORMANCE EVALUATION OF UASB FOLLOWED BY DHS REACTOR TREATMENT PROCESS AND ITS COST IN TREATING TEXTILE WASTEWATER

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## ABSTRACT

*This study evaluates the potential of the combination of Up-flow Anaerobic Sludge Blanket (UASB) and Down-flow Hanging Sponge (DHS) in textile wastewater treatment system, especially for developing countries. A pilot scale UASB (446 m$^3$) and DHS was installed in a textile wastewater treatment site and constantly monitored for six months. Capacity of the ETP is 60 m$^3$/hour and design HRT of UASB is 6 hour. Removal efficiency of COD from UASB varied at 53-62 percent, BOD varied at 36-62 percent and color at 40 to 73.33 percent. DHS reactor increased water quality by removing COD (12%-20%), BOD (24%-32%), color (46%-72%), turbidity (64%-82%) and TSS (64%-82%) without any external aeration process. This treatment process has significantly less efficiency in removing TDS and EC. The chemical cost estimated at 1.66 taka/m$^3$, energy consumption 0.75 kw/m$^3$ which represents a very low cost and less energy consumption textile wastewater treatment process. Methane gas was also detected by gas detector from UASB. The sponge medium of DHS reactor was required to remove once in five year operation period of the ETP. The whole treatment process has significantly less biomass yield, sludge removal was required only twice in five year operational period of the ETP.*

**Keywords:** *Up-flow anaerobic sludge blanket reactor, down-flow hanging sponge reactor, biomass yield, removal efficiency.*

## 1.INTRODUCTION

The up-flow anaerobic sludge blanket (UASB) is a high rate anaerobic bioreactor which is a single tank process. Wastewater enters the reactor from the bottom, and flows upward. A suspended sludge blanket filters the treats the wastewater as the wastewater flows through it. The sludge blanket comprised of microbial granules which is small agglomerations of microorganisms that, because of their weight, resist being washed out in the up-flow. The microorganisms in the sludge layer degrade organic compounds. The sludge blanket provides very high concentration of active biomass in the reactor. Thus extremely high SRT could be maintained irrespective of HRT.

After several weeks of use, larger granules of sludge form which, in turn, act as filters for smaller particles as the effluent rises through the cushion of sludge. Because of the up-flow regime, granule-forming organisms are preferentially accumulated as the others are washed out.

The technology is relatively simple to design and build, but developing the granulated sludge may take several months. The reactor UASB has the potential to produce higher quality effluent than Septic Tank, and can do so in a smaller reactor volume. It is a well-established process for large-scale industrial wastewater treatment and high organic loading rates.

The main advantage of anaerobic treatment process are it has less energy consumption as no aeration is required, energy is generated in the form of methane gas, less nutrient requirement, requirement of higher organic loading rate.

The small amount of excess sludge production of anaerobic treatment systems compared to conventional aerobic wastewater treatment system is one of the most significant benefits of anaerobic systems. 0.5 kg of excess biomass yield is obtained from 1 kg aerobic degradation of soluble BOD on the other hand less than 0.1 kg of excess biomass is yielded from 1 kg anaerobic degradation of 1 kg soluble BOD.

A down-flow hanging sponge (DHS) reactor is used for post-treatment of the effluent from an up-flow anaerobic sludge blanket (UASB) reactor and has provided excellent treatment performance. The principle of DHS reactor is similar to trickling filter. In this case sponge medium is used. The advantage of sponge medium is it has high porosity (90% porosity) which increases entrapped biomass. This provides higher solid retention time (SRT). Higher solid retention time provides ample time for autolysis of sludge within the system(Tandukar, 2006). Thus DHS reactor has negligible excess sludge production. No excess sludge withdrawal is required for DHS reactor.  UASB is an anaerobic reactor, so it has less excess biomass yield. As a result the whole treatment.

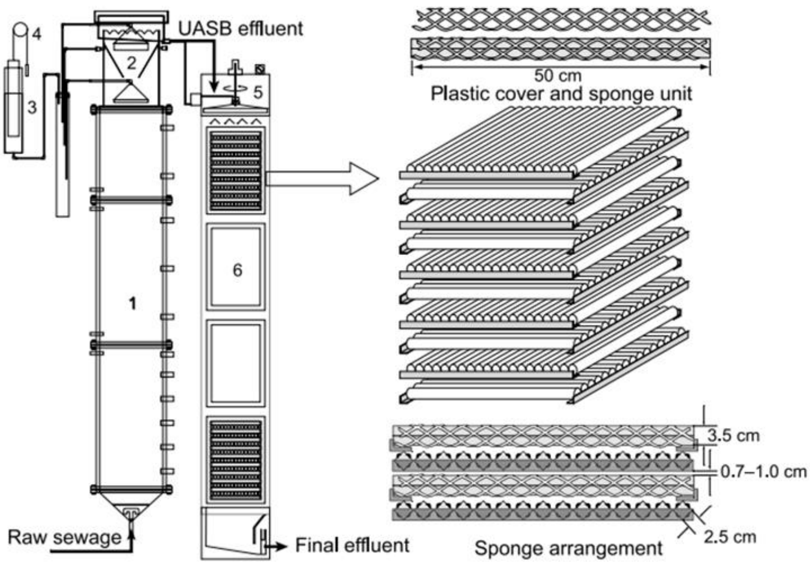



Figure 1: UASB bioreactor combined with DHS reactor

## 2. METHODOLOGY

An effluent treatment plant which has UASB reactor and followed by DHS reactor was monitored for six month. Wastewater sample were collected from each unit of the treatment plant and different pollution parameters were tested (environmental lab, BUET) to assess the performance.  Wastewater sample were collected in the operational period of the industry. Methane gas could also be detected from UASB by gas analyzer. The cost and energy consumption of the ETP was estimated as well.

## 2.1 General information of the textile industry

The industry is situated in Ashulia, Dhaka near TuragRiver. It's a dyeing industry and has a production capacity of 5.5 ton/ day. Its water consumption is 440-550 m3/day and source of water is ground water.

## 2.2 General information on the ETP

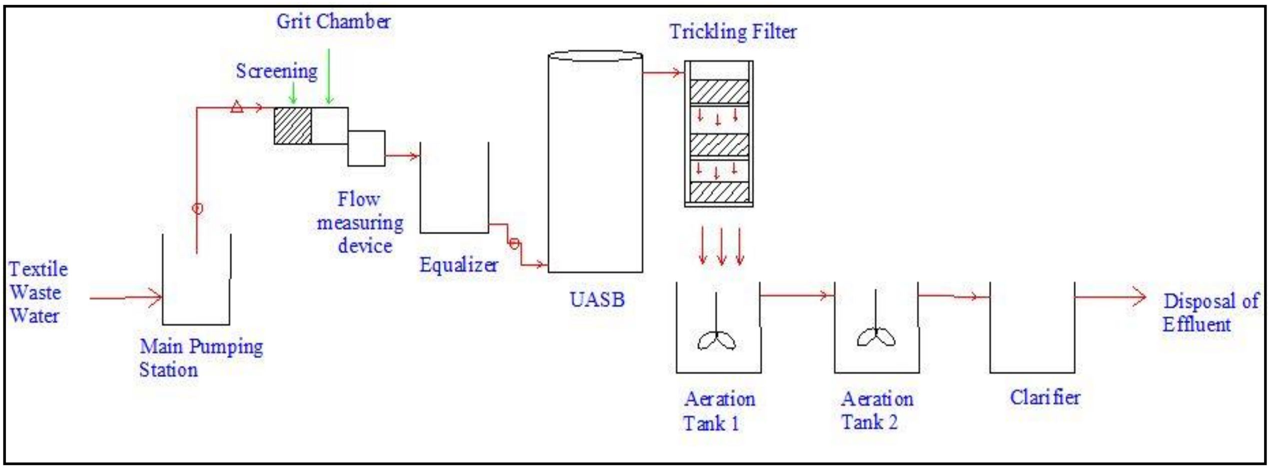


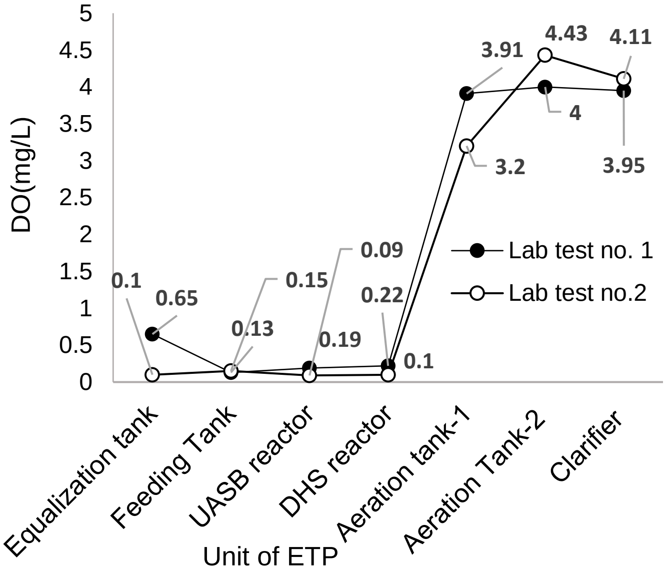

Figure 2: Schematic diagram of the ETP.

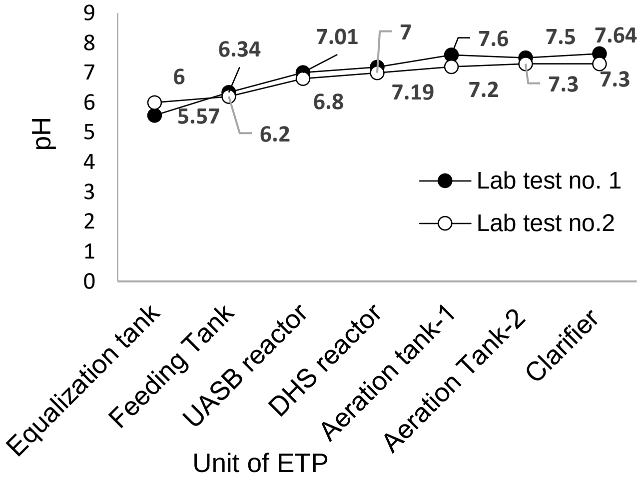
Table 1: Size, hydraulic retention time and capacity of each unit of the ETP

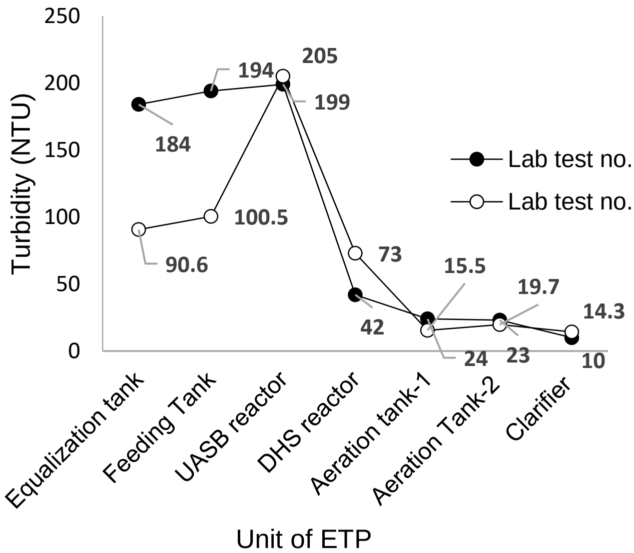
| **Treatment process unit** | **Capacity (m^3)** | **Size(length*width*height) (m*m*m)** | **Theoretical Hydraulic retention time(hour) (HRT)** |
|---|---|---|---|
| Equalization tank | 105 | 4*3.5*7.5 | 1.75 |
| Feeding tank | 75 | 4*2.5*7.5 | 1.25 |
| UASB reactor | 405 | 6*5*13.5 | 6.75 |
| DHS reactor | 94 | 4.5*3*7 | 1.56 |
| Aeration tank-1 | 84 | 4*3*7 | 1.4 |
| Aeration tank-2 | 195 | 6*5*6.5 | 3.25 |
| Clarifier | 102 | 6*3.7*4.5 | 1.7 |

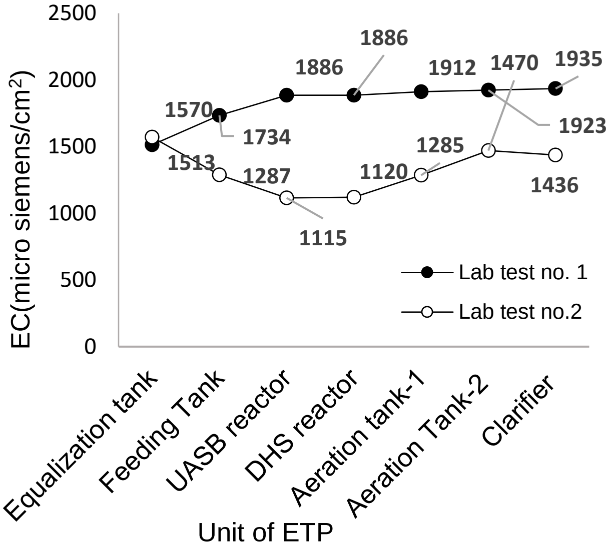
## 3. EXPERIMENTAL RESULTS

### 3.1 Pollution parameter profile of the UASB combined with DHS treatment process



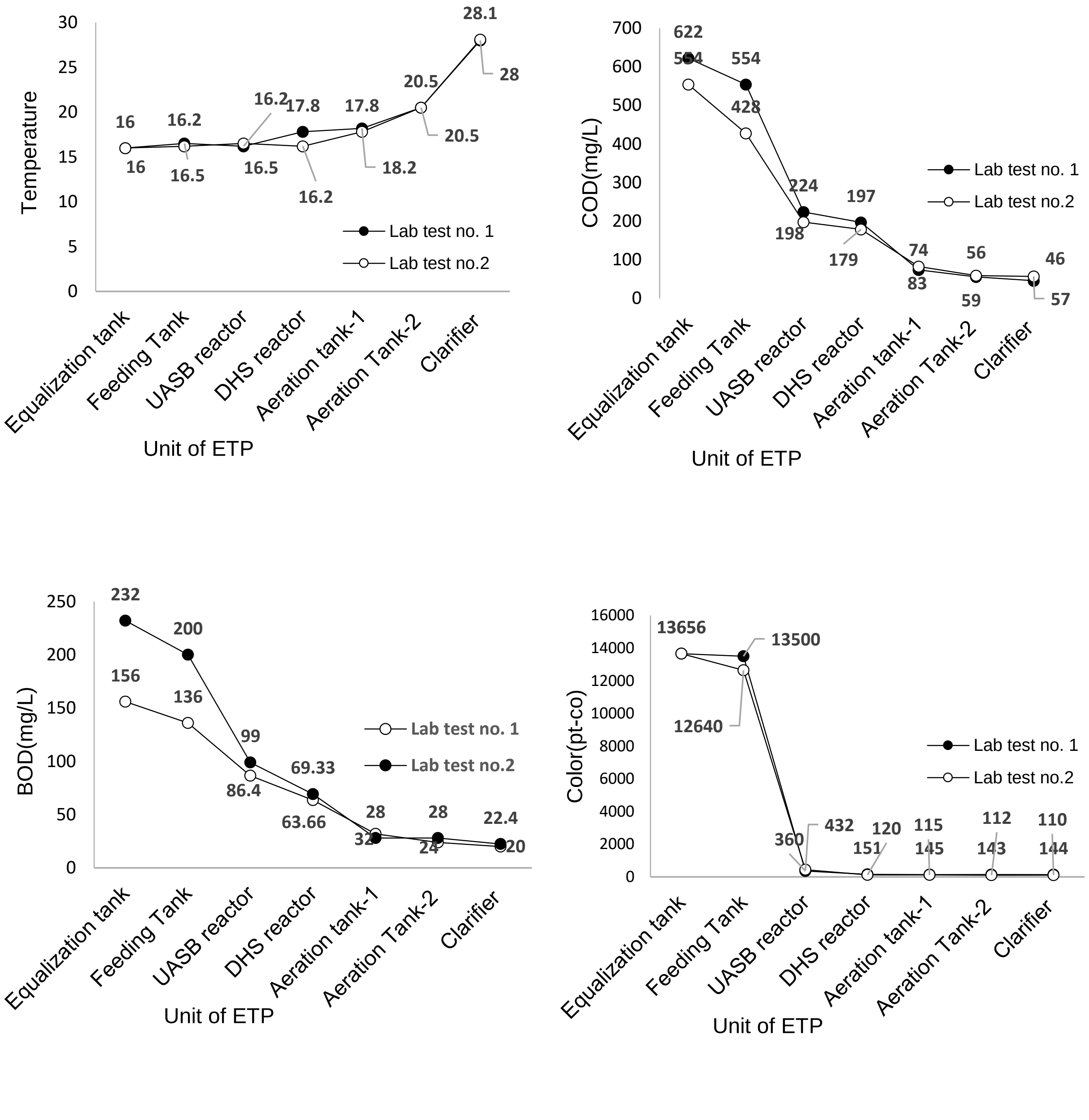
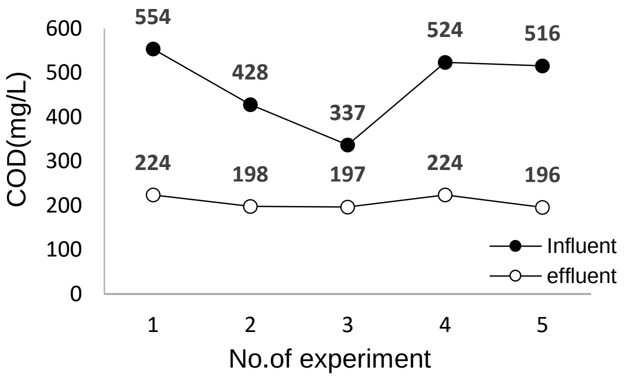
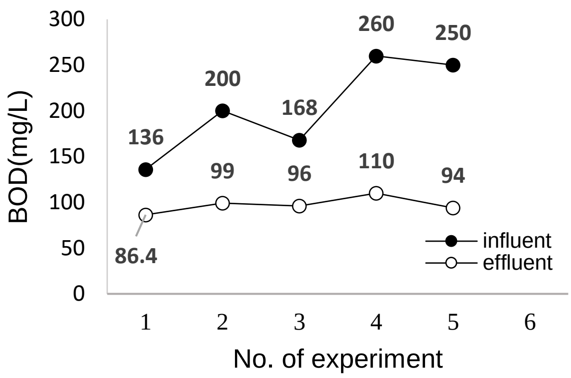



Figure 3: Dissolved oxygenFigyu, pH, turbidity, electric conductivity, temperature, chemical oxygen demand, biological oxygen demand and color profile of UASB combined with DHS treatment process for two laboratory test.

### 3.2 UASB performance assessment



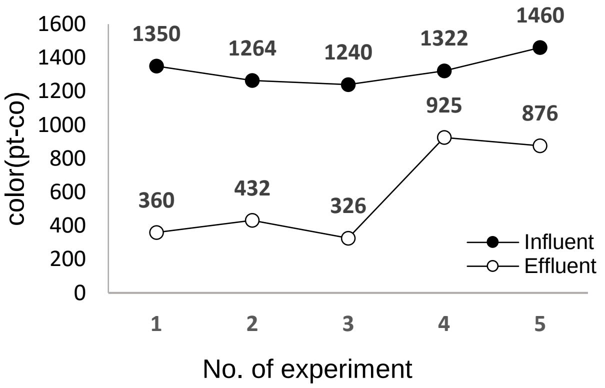




Figure 4: Variation of Chemical oxygen demand, biological oxygen demand and color in the influent and effluent of UASB.

Table 2: Summary table of UASB removal efficiency.

**UASB performance evaluation**

| **Parameter** | **Removal efficiency(%) range** |
|---|---|
| COD (mg/L) | 53-62 |
| BOD(mg/L) | 36-62 |
| Color(mg/L) | 40-73 |

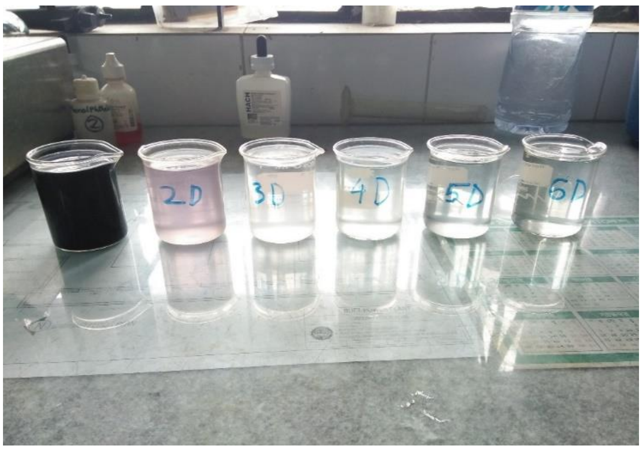



Figure 5: Wastewater sample of each unit of ETP

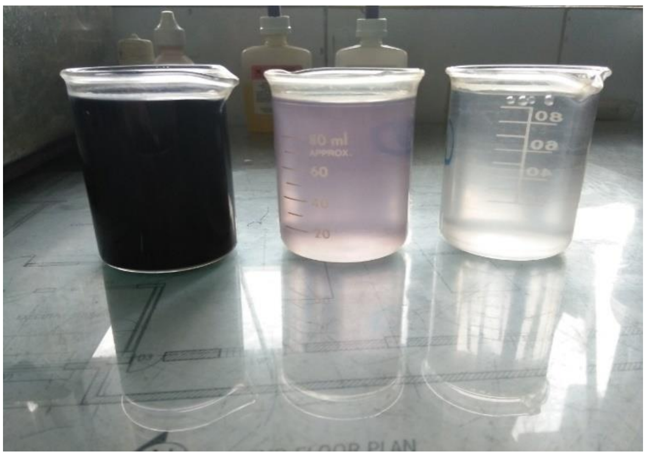
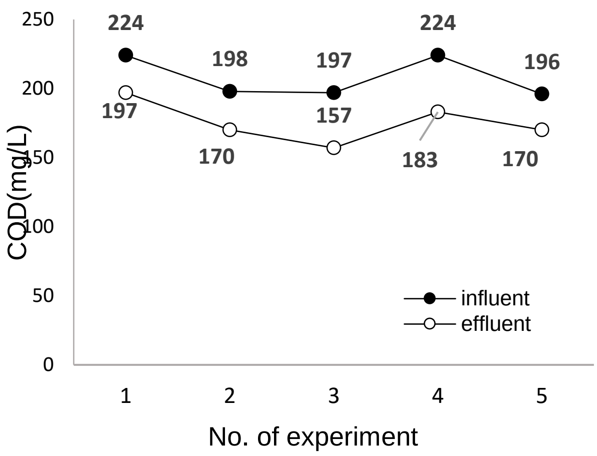
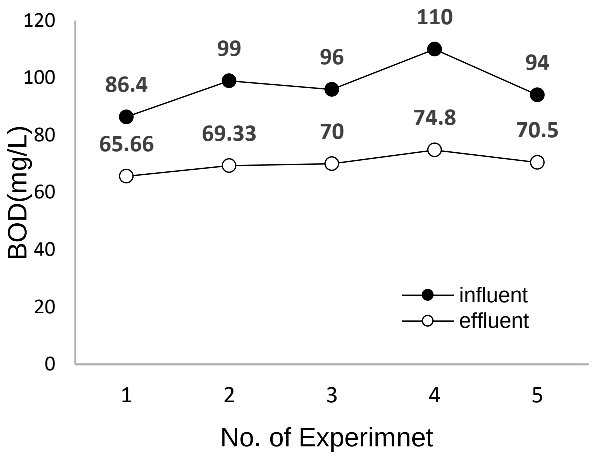
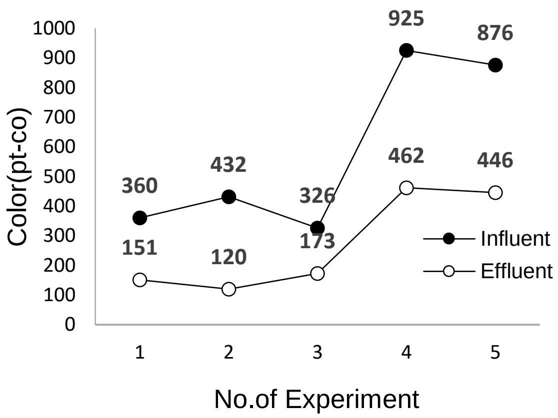


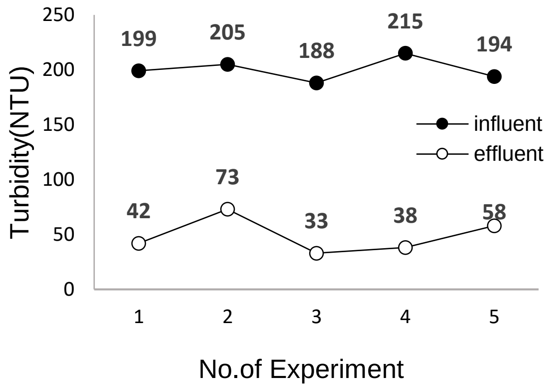
Figure 6: Color variation of wastewater sample of equalization tank, UASB reactor and DHS reactor.




### 3.3 DHS performance assessment



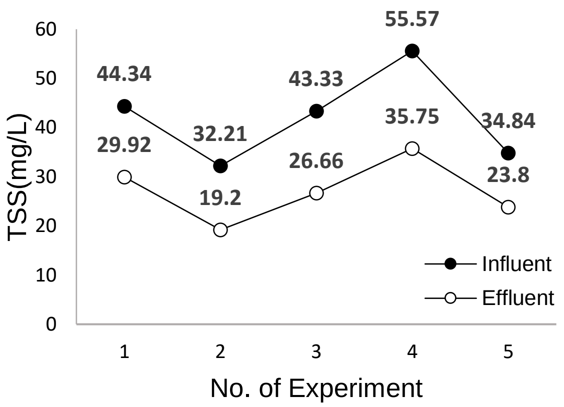




Figure 7: Variation of COD, $BOD_5$, color, turbidity and TSS in influent of DHS reactor and effluent of DHS reactor

Table 3**:** Summary table of DHS reactor removal efficiency.

**DHS performance evaluation**

| **Parameter** | **Removal efficiency(%) range** |
|---|---|
| COD (mg/L) | 12-20 |
| BOD(mg/L) | 24-32 |
| Color(mg/L) | 49-72.22 |
| TSS(mg/L) | 64-82 |
| Turbidity (NTU) | 64.39-82.44 |

### 3.4 Performance assessment of the UASB combined with DHS treatment process

Table 4: Inlet and outlet wastewater sample laboratory test result.

| **Parameters** | **Inlet** | **Outlet** | | **ECR'97** | | | **Minimum Detection Limit (MDL)** |
|---|---|---|---|---|---|---|---|
| | | | **Removal Efficiency (%)** | **Inland surface water** | **Public sewerage system connected to treatment at 2nd stage** | **Irrigated Land** | |
| pH | 6.0 | 7.3 | | 6.0-9.0 | 6.0-9.0 | 6.0-9.0 | 0 |
| Color (Pt-Co) | 1365 | 110 | 91.94 | - | - | - | 0.01 |
| Turbidity (NTU) | 90.6 | 14.3 | 84.21 | - | - | - | 0.01 |
| DO (mg/L) | 0.1 | 4.11 | | 4.5-8.0 | 4.5-8.0 | 4.5-8.0 | 0.1 |
| BOD5(mg/L) | 232 | 22.4 | 90.4 | ≤ 50 (at 20°C) | ≤ 250 (at 20°C) | ≤ 1000 (at 20°C) | 0.2 |
| COD(mg/L) | 554 | 57 | 89.7 | ≤ 200 | ≤ 400 | ≤ 400 | 0.2 |
| EC(µS/cm) | 1570 | 1436 | | ≤ 1200 | ≤ 1200 | ≤ 1200 | 0.1 |
| TDS (mg/L) | 1285 | 982 | | ≤ 2100 | ≤ 2100 | ≤ 2100 | 5 |
| TSS (mg/L) | 85 | 18 | 78.8 | ≤ 150 | ≤ 500 | ≤ 200 | 5 |

### 3.5 Cost estimation of The ETP

Chemical Cost

Textile wastewater is highly alkaline. Acetic Acid is used to control pH. Acetic Acid is used 40 kg/ day. Acetic Acid costs 60 taka/kg.

Total cost = (40*30*60) taka/month
= 72,000 taka/month

Mechanical Cost

Wastewater enters UASB bioreactor from bottom and flows upward. To maintain the upward velocity of fluid from equalization tank to UASB reactor three 5.5 kw/hour pump is used. Three 2.2 kw/hour pump is used to flow the waste water from equalization tank to Feeding tank and 22 kw blower is used for aeration process.

Energy consumption=3*5.5*24+3*2.2*24+22*24
= 1082.4 kw/day

Table 5: Summary of different type of cost of the treatment process.

Table 5: Summary of cost

| **Type of cost** | **Cost (taka/m$^3$)** | **Remark** |
|---|---|---|
| Chemical cost | 1.66 tk/m$^3$ | Acetic acid is used to control pH |
| Mechanical cost | 0.75 kw/m$^3$ | 3, 5.5 kw/hr pump<br>3, 2.2 kw/hr pump<br>2, 22 kw blower |
| Operational cost | 1 staff/shift | Three shift |

## 4. CONCLUSIONS

Results indicate that COD, $BOD_5$, TSS and turbidity removal efficiency of the DHS combined with UASB reactor treatment process are 89%, 90%, 78% and 84%. 91 percent color removal is achieved from this treatment process without any addition of de-coloring agent. The effluent water quality of this treatment indicates a potentiality of reuse in the industry itself and irrigation purpose.

UASB reactor removal efficiency of COD, BOD and color in treating textile wastewater is 53-62, 36-62, and 40-73.33. UASB reactor and DHS reactor has no contribution in decreasing or increasing turbidity, TDS and EC.
DHS is generally an aerobic reactor without any external aeration system but our lab test shows that dissolved oxygen level of DHS is 0.19 mg/l and 0.09 mg/l which indicates that DHS is in anaerobic condition and this might be the reason why it has color removal (46-72) efficiency. DHS has high turbidity (64-82) and TSS (64-82) removal efficiency. DHS has less efficiency in removing COD (12-20), BOD (24-32) in case of textile wastewater compared to municipal wastewater. Unlike sand bed filtration medium DHS reactor doesn't require regular backwashing or other maintenance. Sponge medium is removed once in 5 year of operation of the ETP.

EC and TDS profile has tend to increase as the treatment process proceeds. The average temperature of the ETP $19^0$C is which is good for UASB reactor. Performance of UASB usually decreases when temperature falls and during heavy rainfall. Methane could be detected from UASB reactor.

The whole treatment process has significantly less biomass yield. Sludge removal is required only once in 2 years of operation. The UASB combined with DHS treatment process has higher pollution load removal efficiency with less biomass yield and less chemical consumption.

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