Pilot-scale study of Down-flow hanging sponge reactor at different HRTs for the treatment of Municipal wastewater

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Abstract: In the current era of globalization, rapid urbanization and increasing population has lead to generation of enormous quantity of municipal wastewater. In India conventional treatment options currently employed such as Activated sludge process (ASP) and up-flow anaerobic sludge blanket (UASB) but it often marred with operational difficulties, higher cost and not able to meet the discharge standards. A Down-flow hanging sponge (DHS) is a novel biofilm reactor uses polyurethane sponges as a media to retain biomass. DHS reactor is an attached growth type aerobic biological treatment in which wastewater is entered from the top of the reactor and trickles from the sponge media where it is purified by micro-organisms retain both inside and outside of media. This technology can be a potential solution for achieving discharge standards. The present study will evaluate the performance of DHS reactor at different HRTs for the treatment of municipal wastewater.

Key words: DHS, Hydraulic retention time (HRT), Biological treatment, Municipal wastewater

1. INTRODUCTION:

Recently many developing countries facing the problem of water scarcity and increasing thereafter. i.e. they don't have water which can be used as potable water. Approximately 97% of all the water on the Earth is in the oceans. The other 3% is held as freshwater, including 1.75 – 2.05% frozen in glaciers and icecaps, 0.5–0.75% as fresh groundwater and soil moisture and less than 0.01% of it as surface water in lakes, swamps and rivers [5].

According to the World Water Development Report (WWDR 2006), most of the developing countries in Asia and Africa have less than 2,000 cubic meters of water per capita per year and are considered water stress is illustrated by poor availability of fresh water because earth's supply of fresh water is rapidly diminishing [6]. Water scarcity is regarded by many environmentalists to be the single greatest threat to human health and natural ecosystem [4]. The practice of treatment and reuse of water that has been contaminated by household, industrial and agriculture use can significantly reduced demand on aquifers and decrease the volume of effluent that is discharged into stream, rivers and lakes, contributing to the protection of ecosystem [2].
In India the estimated sewage generation is about 62000 MLD (Approx) which is the biggest source of pollution for water resources. It contributes 70% of pollution load to stream or water bodies of India because of rapid urbanization, industrialization and increasing population growth [3]. Wastewater contains three types of impurities such as dissolved impurities, suspended

impurities and pathogenic microorganisms. It degrades the quality of fresh water and consumption of polluted water has adverse impact on human health and aquatic life. It causes the deadly diseases like cholera, dysentery, diarrhea, tuberculosis, jaundice, etc. and causes the fish killing due to depletion of dissolved oxygen (DO), algal blooms and bacterial contamination respectively in the water bodies. The partially or untreated wastewater is potential pollutant which contaminants the ground, ground water, rivers and natural drainage system causing pollution in downstream areas so managing sewage in proper way is preliminary thing to maintain water resources clean and healthy.

In developing countries most conventional treatment options such as Activated sludge process (ASP) and Up-flow anaerobic sludge blanket (UASB) employed for managing the wastewater. Activated sludge process generates high grade effluent but it requires large space, skilled manpower and also it has operational difficulties like bulking of sludge, rising sludge and nocardia foam. Recently up-flow anaerobic sludge blanket (UASB) reactor has been favored as the most suitable in developing countries because of their low energy use, easy maintenance and cost effectiveness however, when using UASB reactor to treat solely sewage, it is relatively difficult to produce good quality effluent [10]. Therefore the development of suitable and low-cost wastewater treatment technologies for low-income countries evidently needs to be addressed [7].

A down-flow hanging sponge (DHS) reactor is a novel, aerobic, bio-film reactor that is used to polish effluent received from an up-flow anaerobic sludge blanket (UASB) reactor for treating municipal sewage [9]. The DHS process is similar to the mechanism of the trickling filter, but uses sponges as a site for growth and attachment of active biomass [1]. In DHS system wastewater is trickled from the top of the reactor and purified by microorganisms retained both inside and outside of sponge media as the wastewater flows vertically down through the reactor. As the sponge media in DHS reactors are not submerged in wastewater But hanging freely in the air so oxygen can dissolve easily into the wastewater. Therefore there is no need for external aeration or any other energy inputs. Furthermore, in DHS reactor, a large amount of activated sludge growth both inside and outside of sponge media so that an ecosystem with an extremely long food chain can be established, resulting in minimization of excess sludge production [10]. Overall the main merits of DHS system can be summarized as follows [7]: Simplicity, low space requirement and no sludge separation requirement for effective operation (advantages over AS process); No need for periodic backwashing (advantages over fixed bed bio-film reactors / bio-filters or trickling filters); High amount of active biomass retained in the sponge of DHS system and corresponding longer sludge residence time (SRT) ensures high degree of treatment at minimum operational conditions.

In this study our aim is to develop an economically sound, low-tech and easy maintainable treatment system namely down-flow hanging sponge (DHS) reactor that would allow direct treatment to municipal wastewater. With these conditions in mind, this study is conducting to test the potential for use of DHS as an alone system for treatment of municipal wastewater at different hydraulic retention time (HRTS) with objective to evaluate the performance potential of DHS reactor as an alone unit at different HRTs and determine the optimum HRT for maximum removal efficiency.

2. MATERIALS & METHODS:

2.1 Characterization of municipal wastewater

The wastewater for study was obtained from partial flume (existing STP unit). Analysis of the pollution parameters of raw influent wastewater during study period which indicates great fluctuations in its strength. The characterization of municipal wastewater was carried out in this study are presented in table no1.

Parameters	Unit	Range
pH	-- ---	7.0 – 7.5
Turbidity	NTU	60 - 70
Total suspended solids (TSS)	mg/l	305 – 350
Biochemical oxygen demand (BOD)	mg/l	300 - 410
Chemical oxygen demand (COD)	mg/l	450 – 600

Table 1 characterization of sewage

2.2 Reactor configuration

A pilot scale DHS reactor was installed at 180 MLD sewage treatment plant, pirana, Ahmedabad. Conventional activated sludge process based existing sewage treatment plant capacity is 180,000 m^3 per day. The capacity of pilot scale DHS reactor was 1500L. The DHS reactor composed of 02 segments in which polyurethane sponge media is filled into each segment of reactor, each with height of 1000 mm and a diameter of 1000 mm. Total working height of DHS system was 2000 mm. At the end of the treatment sedimentation provided to achieve settling purpose with a volume of 390L installed at the bottom of the reactor. A schematic diagram and actual pilot plant of DHS reactor is shown in following figure 1 and Figure 2.

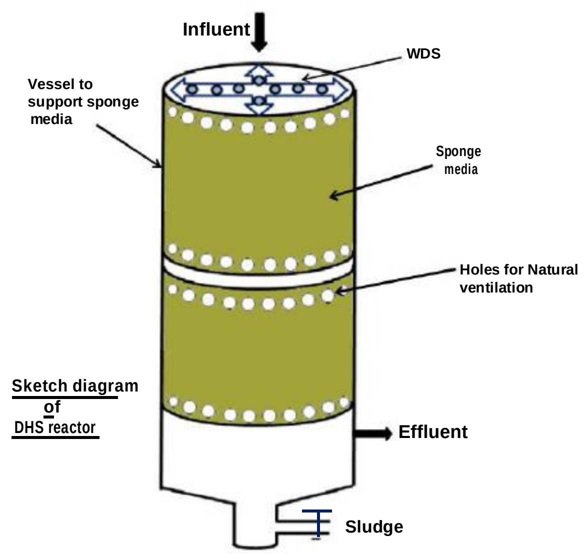

Figure 1 schematic diagram of DHS reactor

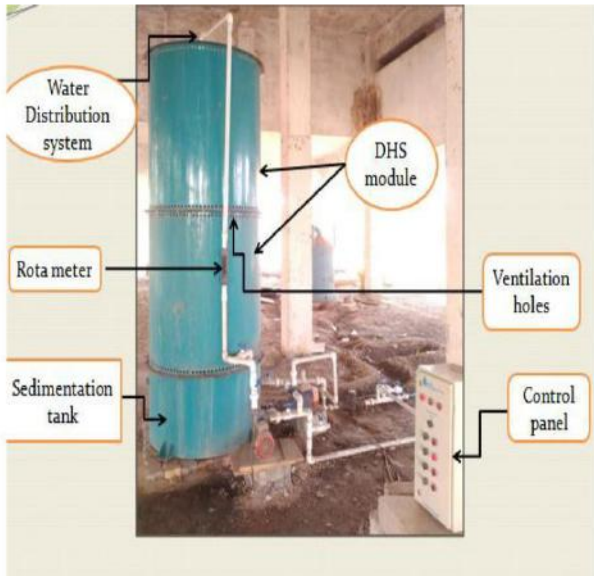

Figure 2 Actual pilot plant of DHS reactor

2.3 Sponge configuration

In this study polyurethane material cylindrical type sponge media was used. The sponge media randomly filled in DHS reactor with support of plastic mesh. The total sponge media volume in the reactor is 1000L, giving a material occupancy ratio of 55 % (based on reactor volume). Sponge criteria are given in following table no 2.

Properties	Specification
Length	50 mm
Diameter	25 mm
Density	32 ± 2 kg/ m^3
Void ratio	0.96
Porosity per inch (PPI)	70 ± 10

Table 2 criteria of sponge media

2.4 Experiment setup and operating conditions

The DHS reactor were designed and manufactured from mild steel material. The system was continuously operated with different HRT at ambient temperature. Before starting of actual run of pilot plant, system was seeded with additional bacteria for acclimatization. After the acclimatization phase DHS reactor is operated at flow rate of 100L/H, 150L/H and 200L/H with respect to 10hrs, 6.6 hrs and 5 hrs Hydraulic retention time.

2.5 Sampling and analytical method

Performance of the system was monitored by analyzing grab samples of raw sewage (after the grit chamber, corresponding to the PST influent), the DHS effluent. Three times in a week at sewage treatment plant, Ahmedabad in between 9:00 AM and 10:00 AM in duration of study. Routine monitoring was conducted to measure chemical oxygen demand (COD), biochemical oxygen demand (BOD) and Ammonical nitrogen. All parameters were analyzed as per “Standard Methods for Examination of Water and Wastewater” (APHA, 2005).

3. RESULTS & DISCUSSION:

Performance of DHS reactor for treatment of sewage at different HRT 10hrs, 6.6hrs and 5hrs. DHS reactor first operated for 10hrs and some time period interval it was operated at 6.6hrs and 5hrs. below charts indicate the removal efficiency of DHS reactor at different HRT.

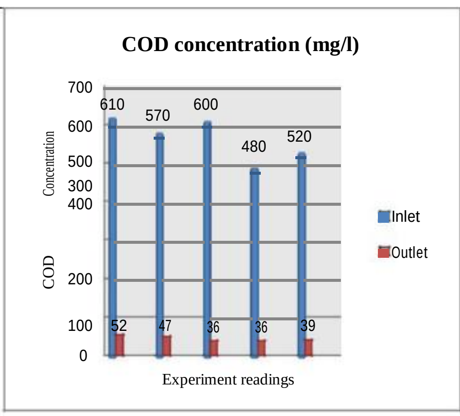

Figure 3 COD removal during 10hrs HRT

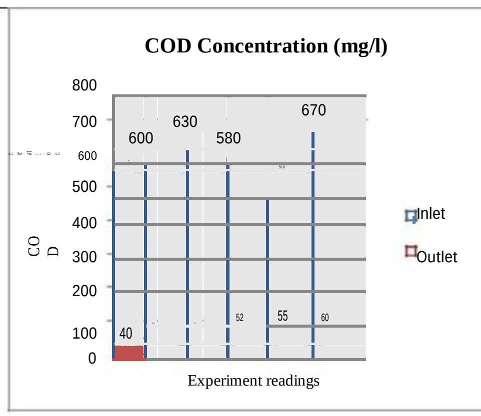

Figure **4** COD removal during 6.6hr**s** HRT

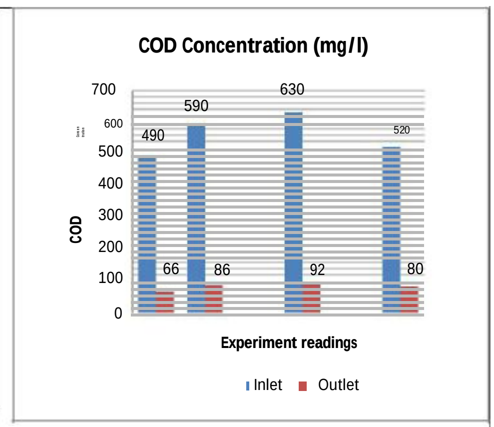

Figure 5 COD removal during 5hrs HRT

Fig. 3, 4 and 5 shows COD profile during 10hrs, 6.6hrs and 5hrs HRT of DHS operation. The average COD removal efficiency during 10hrs HRT was 90±2%, during 6.6hrs HRT was 92±2% and at 5hr HRT was 85±2%.

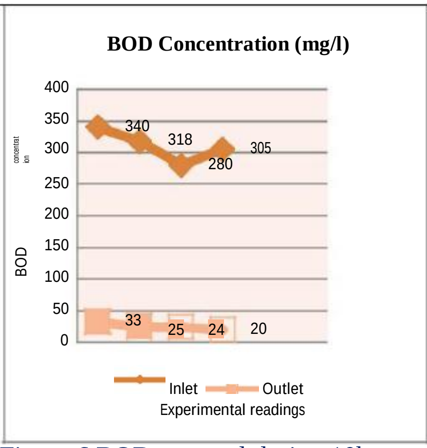

Figure 6 BOD removal during 10hrs HRT

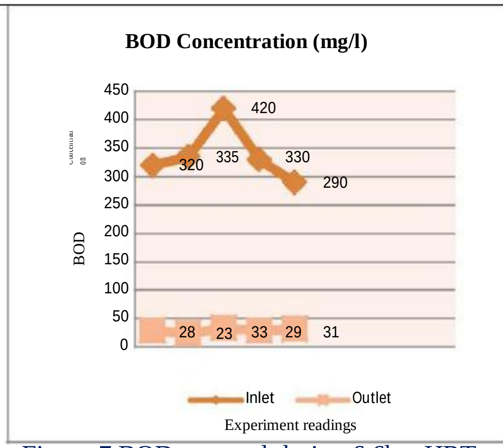

Figure 7 BOD removal during 6.6hrs HRT

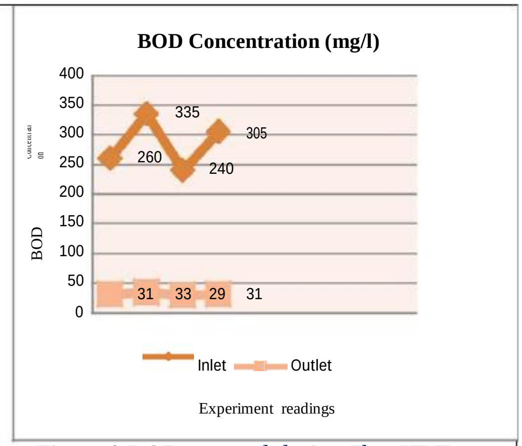

Figure 8 BOD removal during 5hrs HRT

Fig. 6,7 and 8 shows BOD profile during 10hrs, 6.6hrs and 5hrs HRT OF DHS operation. The average BOD removal efficiency during 10hrs HRT, 6.6hrs HRT and 5hrs HRT was 91±1%, 92±2% and 88±1% respectively.

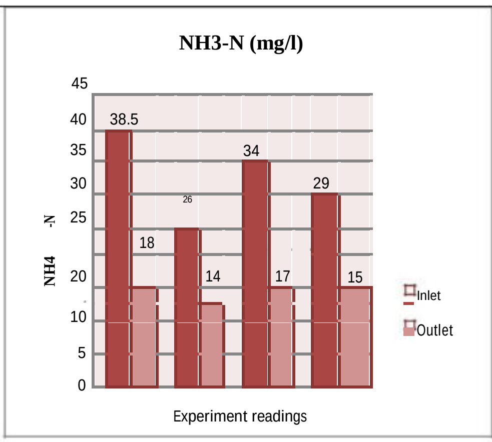

Figure 4 NH3 – N removal during 10hrs HRT

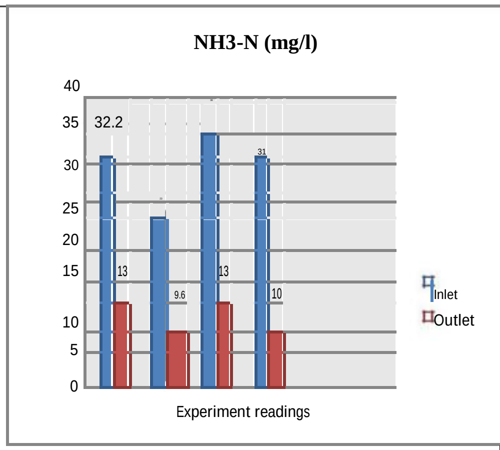

Figure 5 NH3 – N removal during 6.6hrs HRT

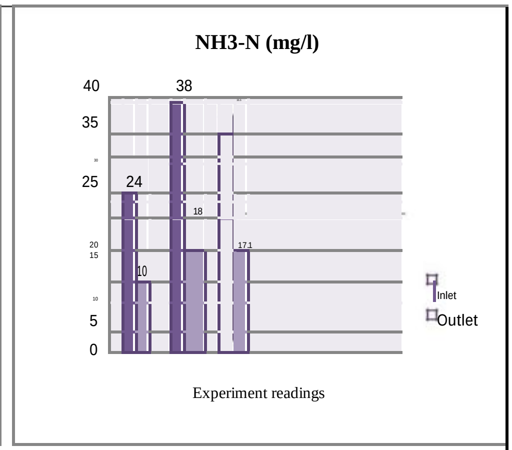

Figure **11** NH3 – N removal during 5.00hrs HRT

Fig. 9,10 and 11 show NH3 – N profile during 10hrs, 6.6hrs and 5hr HRT OF DHS operation. The average NH3 – N removal efficiency during 10hr HRT, 6.6hrs HRT and 5hrs HRT was 50±2 %, 64±3% and 55±3 % respectively.

4. CONCLUSION:

Decreasing HRT of DHS reactor from 10hrs to 6.6hrs performance of DHS reactor not major but positively affected, the removal efficiency of COD, BOD, NH_3-N increased from 90±2%, 91±1%, 50±2%, to 92±2%, 92±2%, 64±3%

Decreasing HRT of DHS reactor from 6.6hrs to 5hrs performance of DHS reactor positively affected, the removal efficiency of COD, BOD, NH_3-N dropped down from 92±2%, 92±2%, 64±3% to 85±2%, 88±1%, 55±3%

However the removal efficiency of DHS reactor increasing with decreasing HRT from 10hr to 6.6hrs so it recommended to operate such system at HRT not exceeding 6.6hrs.

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