Development of Community Sewage Treatment System Consisting of UASB and the Third Generation DHS (Down Flow Hanging Sponge) Reactor for Developing Countries

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Abstract : *Downflow handing sponge reactor (DHS) is a novel aerobic post treatment system originally developed by our research group in search of appropriate sewage treatment technology for developing countries. The principle of DHS process is similar to that of trickling filter, but suing polyurethane- made sponge material as a medium to support bacterial growth. There is no need of external forced aeration, because the sponge material is exposed to ambient air. This paper presents process performance of the combined system of UASB and DHS G3 and evaluates the potential of the proposed combination of UASB and DHS as a sewage treatment system, especially for developing countries. A third generation Downflow Hanging (DHS) reactor has been developed and proposed as an improved variant of post treatment system of UASB treating waste water. A pilot scale UASB and DHS was installed in a municipal sewage treatment site and constantly monitored for one year. UASB was operated at an HRT of 6h corresponding to an organic load of 2.15kg-COD/m3 per day. Subsequently, the organic load in DHS was 2.35kg-cod/m3 per day, operated at a HRT of 2h. Organic removal by the whole system was satisfactory, accomplishing 96% of unfiltered BOD removal, However, nitrification decreased from 56% during the startup period to 28% afterwards. Investigation on DHS sludge was made by quantifying it and evaluating oxygen uptake rates with various substrates. Average concentration of trapped biomass was 26g-VSS/ L of sponge volume, increasing the SRT of the system to 100-125d. Removal of coliforms obtained was 3-4 log10 with the final count of 103 to 104 MPN/100ml in DHS effluent.*

Keywords : *DHS reactor, Post treatment; sewage treatment; UASB reactor*

I. INTRODUCTION

It is quite obvious that, in most of the developing countries, because of financial and technical scarcity, wastewater treatment system is almost non-existent. They are poured directly into water bodies without any proper treatment which causes pollution and contamination of water, resulting in widespread waterborne diseases. At this verge an effort was put forth in search of a suitable municipal sewage treatment for developing countries. Application of UASB to municipal sewage treatment has been receiving a wide recognition in most of the developing countries (tropical and subtropical regions). Many practical scale and pilot scale operations and experiments have proved that UASB is one of the most suitable alternatives for municipal sewage treatment (Letting et.al, 1993). However treatment of the Municipal sewage by UASB alone cannot meet the discharge standards of most of the developing countries. Usually, organic removal by UASB is not more than 60% and removal of nitrogenous compounds and pathogens is insignificant. Therefore there is a need of appropriate post-treatment to polish up the UASB effluent. UASB can only be applied beneficially if the post treatment unit is efficient, simple inexpensive, and virtually free from maintenance.

In search of such a novel system, a pioneering research was conducted by Harada etc.al. As a result of nearly a decade's endeavor a new system named

"Down-flow Hanging Sponge" (DHS) reactor has emerged (Agrawal L.K. etc.al, 1997: Machdar I.etc.al., 1997 and 2000). Key of this system is the use of simple and easily available polyurethanemade sponge as a medium to retain sludge. Unlike packing materials in Trickling filter, sponge medium has a void space of more than 80% resulting in a significant increase in solid retention time. Sludge is retained both inside and outside the sponge carrier. Air gets dissolved into the wastewater as it slows down the DHS reactor and thus there is no need of external aeration.

The first generation of DHS was made up of small cubes of sponge with the size of 1.5 cm. They are diagonally and vertically stitched along a nylon string. It showed excellent treatment efficiency with BOD removal upto 99% (Machdar I.et.al., 1997). But because of the difficulty in scale up, the second generation DHS was conceptualized. The new DHS was more like a curtain. It was constructed with triangular strips of polyurethane-made sponge, 3 cm x 3 cm x 75 cm in dimension, adhered on both sides of PVC -made sheet film used as a supporting material, as shown in Fig. 1. Gap between consecutive sponge strips was 0.9 cm. When wastewater flows down the DHS reactor, it permeates one sponge strip, comes out of it and enters the next sponge strip. While the wastewater comes out of the sponge, it comes in contact with air. Thus, there is no need of external aeration.

A combination of UASB pre-treatment and aerobic DHS (Down flow Hanging Sponge) posttreatment unit was proposed by H. Harada's research group in the year 1996. The core of the research was the DHS aerobic post -treatment system which doesn't need any external aeration and doesn't produce any excess sludge. Since then third generations of DHS reactor have been realized, improving a little, one after another. This paper presents the development, operation and process evaluation of the Third Generation DHS Reactor. Main emphasis was given on removal of organic substances.

II. MATERIAL AND METHOD

A pilot scale Fourth Generation DHS posttreatment unit was combined with UASB reactor (1.15 m3) and a continuous experiment was carried out with the use of raw sewage in municipal sewage treatment center. Presently the system is being operated at Total HRT of 8 h (6h for UASB and 2 h for DHS). Design of generation-3 DHS was based on the concept of trickling filter. Small pieces of sponge kept inside plastic net like support are the unit of G3. These units are used as a packing material in place of gravel. Stones, plastics, etc.

Sponge units were randomly packed in a cylindrical column. There is no continuous gap between the sponge units in one column. This resulted in plugging of the reactor by the sludge accumulation after 8-9 months of operation.

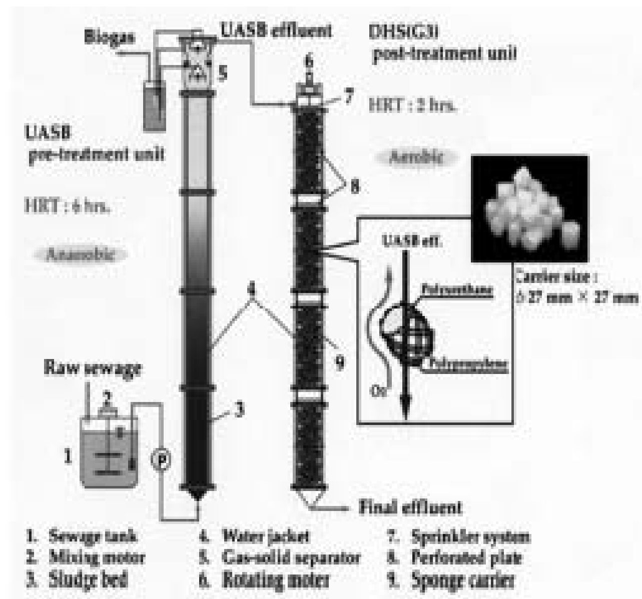

Fig. 1: Schematic representation of the whole system

III. RESULTS AND CONCLUSION

During the experimental period, the whole system exhibited an excellent performance in removing organic particulates. The average unfiltered BOD removal was 93-96% and the average unfiltered COD removal was 88- 91%. Graph shows unfiltered BOD in sewage, UASB effluent and final effluent against time. Performance of DHS post-treatment system was more consistent than that of UASB pre-treatment unit. The average unfiltered BOD and filtered BOD in the raw sewage were 180 mg/1 (SD ± 37 mg/1) and 80 mg/1 (SD ± 24 mg/1), respectively.

Unfiltered and filtered BOD in UASB effluent were 89 mg/1 (SD ± 31 mg/1) and 71 mg/1 (SD ± 15 mg/1), respectively. After filtered BOD of 12 mg/1 (SD ± 2.5 mg/1) and 8 mg/1 (SD ± 1.8 mg/1), respectively. Similarly SS removal was 91-95%. Since DHS reactor is in operation only for last three months, there is not yet full development of sludge inside the sponge, especially in the lower part. Higher efficiency in organic removal is expected in future after the development of

Table 1 : Performance chart of DHS with Raw Sewage and UASB Reactor

H RT 8	hrs (UASB 6 hrs & DHS 2 hrs)			
Parameters	Sewage	UASB eff.	DHS eff.	% removal
Total BOD (mg/1)	180(37)	89(31)	12(2.5)	96
Sol. BOD (mg/1)	80(24)	71(15)	8(1.8)	97
Total COD(mg/1)	408(96)	173(50)	43(16)	89
Sol COD(mg/1)	178(33)	59(15)	24(9)	87
NH4-(mg-N/1)	22(4)	25(4)	6(3)	75
NO2-(mg-N/1)	ND	ND	2(2)	-
NO3-(mg-N/1)	ND	ND	9(2)	-
Total -N(mg-N/1)	43(6)	45(6)	21(5)	51
SS (mg/1)	155(65)	71(38)	29(12)	95
VSS (mg/1)	133(54)	57(30)	19(7)	83

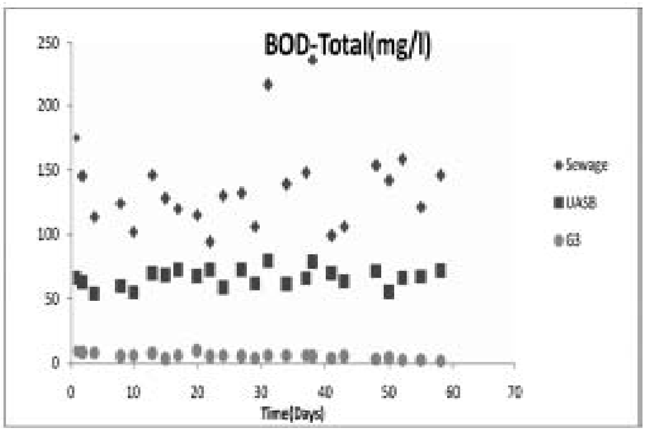

Fig. 2: A Trend of T-BOD in Sewage, UASB and DHS G3 along the time

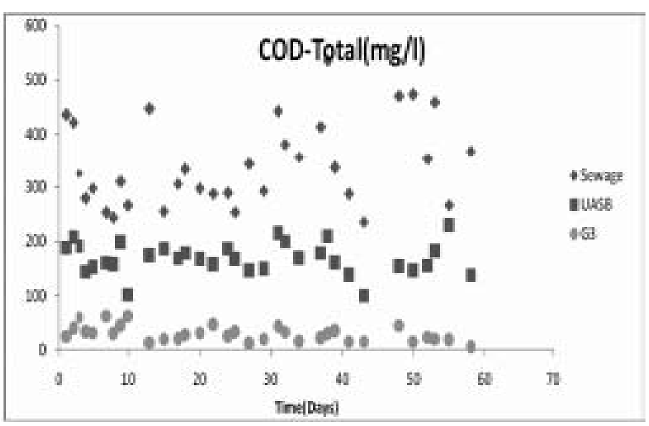

Fig. 3: A Trend of T-COD in Sewage, UASB and DHS G3 along the time

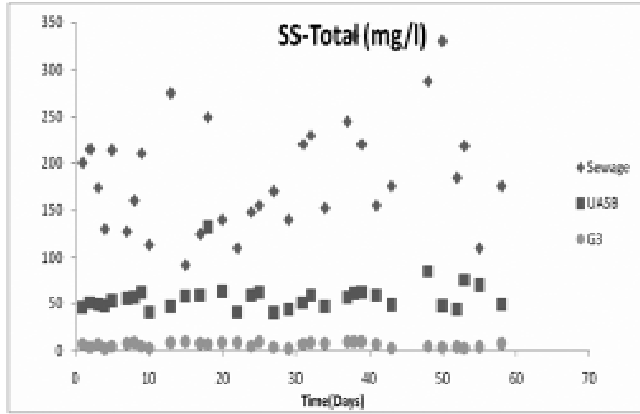

Fig. 4 : A Trend of T-COD in Sewage, UASB and DHS G3 along the time

more sludge inside the sponge. Long term experiment will be carried out to further evaluate its process performance.

References

1. Agrawal, L.K.Ohashi, Y., Mochida, E., Okui, Y.,Harada, H., Ohashi, A., (1997) Treatment of raw sewage in a temperate climate using a UASB and the Hanging Sponge Cubes process. Wat. Sci. Tech. Vol. 36, pp. 433-440.

2. Araki N. Ohashi A., Machdar I. and Harada H., (1999) Behaviors of Nitrifiers in a Novel Biofilm Reactor Employing Hanging Sponge- Cube as Attachment Site. Wat. Sci. Tech. 39, (7), 23-31.

3. Machdar I., Harada H., Ohashi A., Sekiguchi Y., Okui H. and Ueki K. (1997) A Novel and Cost Effective Sewage Treatment System Consisting of UASB Pretreatment and Aerobic Post-treatment Units for Developing Countries. Wat. Sci. Tech., 36, (12), 189-197.

4. Machdar I., Sekiguchi Y., Sumino H., Ohashi A., and Harada H. (2000) Combination of a U A S B R e a c to r a n d a C u rta in -ty p e D H S (Down flow Hanging Sponge) Reactor as a Cost-effective Sewage Treatm ent System for Developing Countries. Wat. Sci. Tech. 42, (3-4), 83-88.

5. Sekiguchi Y., Harada H., and Ohashi A.(1996) A simple and Cost Effective Anaerobic Sewage Treatment System for Developing Countries. In; Advances Technology in the Environment Field, M.H.Hamza (ed.) Gold Coast, Australia, pp. 92-159.

6. Uemura S., Takahasi K., Takahashi A., Harada H., Phashi A. and Machdar I. (2000) Behavior of Coliforms and Coliphages in a Novel Sewage Treatment System consisting of UASB and DHS Units. J. of Japan Soc. On Water Env., 22, (2), 152-159.

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