Development of Self-Sustainable Sewage Treatment Syetem consisting of UASB and DHS (down flow hanging sponge) Reactors.

\- Effect of Hydraulic Retention Time (HRT) on the performance -

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Introduction:

An aerobic post treatment system for UASB treating municipal wastewater was proposed and designed by Harada et. al. in early 1990s'. It was then named "Down-flow Hanging Sponge (DHS) Reactor", which employs polyurethane made sponge as a medium for attached growth of bacteria. Since then the design of the system has been upgraded twice resulting in the third generation DHS at present. The first generation of DHS had small cubes of sponge stitched along a nylon string. It showed excellent treatment efficiency with BOD removal upto 99% (Machdar et.el.). But because of the difficulties in scale up, the second generation DHS was conceptualized. The new DHS was more like a curtain in which long strips of prism shaped sponges were pasted on both sides of a polyvinyl sheet. This study compares the performance of the second generation DHS with UASB at an HRT of 5.33 hrs against the previous operational condition of 8 hrs. The UASB was being operated with an HRT of 4 hours. The whole system had been installed in Nagaoka Municipal Sewage Treatment Site, in the year 1996. Since then it had been put into continuous operation with real sewage as an influent. The performance of the combined system, at a total HRT of 8 hours, was continuously evaluated for more than five years. After that the HRT of the system was shortened to 5.33 hrs (4 hrs for UASB and 1.33 hrs for DHS) and was monitored for more than 200 days.

Methodology:

The system consisted of 155 liters-UASB reactor followed by two curtains of DHS in series. Experimental setup is given in the figure. The height of UASB reactor was 4 meters. Height of one curtain of DHS was 2 meters. Volume of sponge in DHS reactor was 51 liters. There were 38 sponge rows on both sides of a PVC sheet. Dimension of each sponge prism was 3cm x 3cm x 75cm. A V-notch type of distribution system was used for the DHS reactor. The total HRT was lowered to 5.33 hrs from 8 hrs. First of all, HRT of UASB was decreased to 4 hrs from 6 hrs, without changing the HRT of DHS. This was an intermediate stage. After confirming the stability of UASB, HRT of DHS was decreased to 1.33 hrs from 2 hrs after approximately five weeks. The process performance was observed for more than 7 months. Sampling was done three days a week for BOD, COD, TKN, nitrogen species, SS, VSS, DO, pH, biogas composition, etc. Gas production was monitored daily. Profiles of the reactors were taken every month. Similarly sludge profile along DHS height was examined arbitrarily. Activity tests were performed for nitrification, denitrification, and oxygen consumption rates.

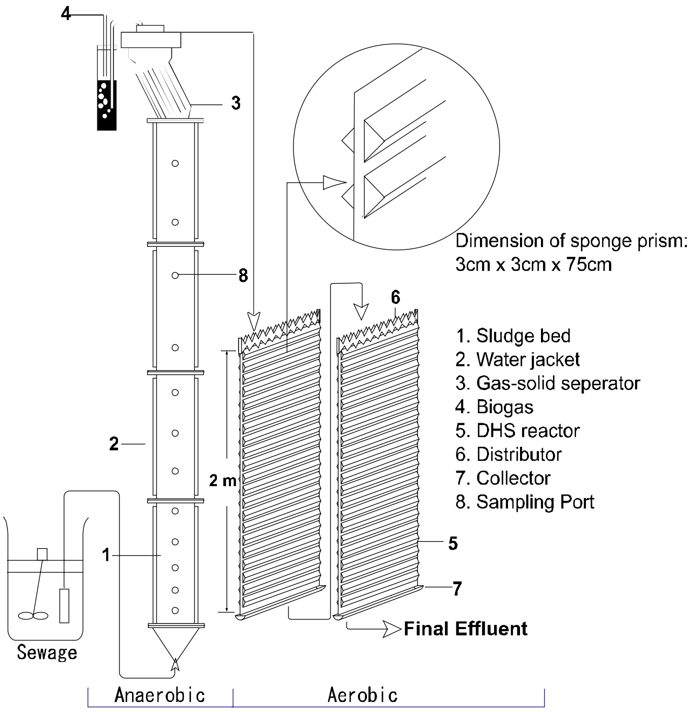

Fig. 1 Experimental setup.

Results and discussion:

After decreasing the HRT to 5.33 hrs from 8 hrs, BOD loading rate increased by 53% in UASB and 52% in DHS. But the removal rate also doubled for both reactors. BOD removal efficiency increased to 96% from 94% irrespective of the increase in loading rate. Likewise COD and NH_4 were removed by 89% and 73% respectively (Fig 2). The average gas production from UASB was 32.6 liters per day, out of which 71% was methane. But the amount of gas production per kg of COD removal slightly decreased which was 0.15 m^3/kg of COD removed compared to previous 0.16 m^3/kg of COD removed. From another study it was found that as the flow rate became high the amount of soluble methane flowing away from UASB increased as a result, the amount of biogas collected decreased. Outstanding feature of the DHS post treatment lies in the fact that there is no requirement of any external forced aeration there is no excess sludge production. Dissolved oxygen in the final effluent was around 7 mg/l in average. The reason for the negligible amount of excess sludge production in DHS unit was that SRT is long and that the rate of bacterial growth balances the rate of autodecay. Profile of DHS reactor demonstrates that heterotrophs were found mostly active along the first half of the reactor where as autotrophs were found more active along the later half of the reactor. COD or BOD can be seen to decrease more in upper part, where as TKN can be seen to decrease more in the lower part of the reactor. Nitrification activity in the lower part of the reactor was 45 gmNH_4-N/kg VSS/day. It was approximately 25% lower than that of previous operational condition. But the increased removal of the NH_4 species can be attributed to increased amount of retained sludge inside the sponge. In 7 months there was approximately 36% increase in the sludge inside the sponge.

Key words: Sewage, DHS, UASB, HRT

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Table 1: Comparative overview of system at two different HRTs.

HRT / Parameters	8 hrs (UASB 6 hrs & DHS 2 hrs)				5.33 hrs (UASB 4 hrs and DHS 1.33 hrs)			
	Sewage	UASB eff.	DHS eff.	% removal	Sewage	UASB eff.	DHS eff.	% removal
Total BOD (mg/l)	162 (37)	54 (18)	8 (6)	94	209 (37)	68 (23)	8 (3)	96
Sol. BOD (mg/l)	78 (19)	19 (5)	2 (1)	97	102 (22)	27 (11)	3 (2)	97
Total COD (mg/l)	373 (83)	165 (62)	60 (28)	83	408 (96)	173 (50)	43 (16)	89
Sol. COD (mg/l)	168 (38)	57 (14)	22 (8)	97	178 (33)	59 (15)	24 (9)	87
NH_4-N (mg-N/l)	33 (6)	40 (7)	12 (7)	71	22 (4)	25 (4)	6 (3)	75
NO_2-N (mg-N/l)	ND	ND	1 (1)	-	ND	ND	2 (2)	-
NO_3-N (mg-N/l)	ND	ND	17 (5)	-	ND	ND	9 (2)	-
Total-N (mg-N/l)	61 (11)	61 (11)	37 (8)	40	43 (6)	45 (6)	21 (5)	51
SS (mg/l)	134 (48)	70 (37)	43 (30)	67	155 (65)	71 (38)	29 (12)	78
VSS (mg/l)	114 (40)	57 (30)	30 (19)	73	133 (54)	57 (30)	19 (7)	83
DO (mg/l)	0 - 1.9	0	5 - 7	-	0 - 0.8	0	5 - 7	-
Gas production (l)	-	20.5	-	-	-	32.6	-	-

Fig. 3 shows the sludge retainment in the interstices of sponge material. The system was also found to possess high potential for the high removal of coli-form bacteria. The removal efficiency for the coli-form bacteria was found to be more than 99.75%. The removal was supposed to be done by the predation by protozoan and by adsorption.

Table 1 shows a comparative outlook of the performance of the system at two different HRTs.

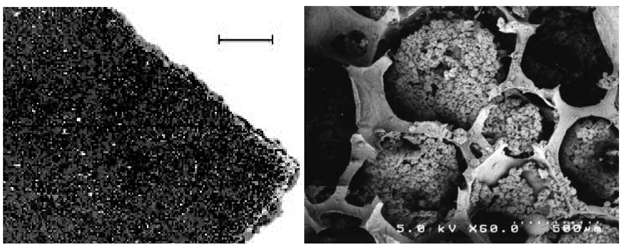

Fig 3 Retained sludge inside the sponge.

Summary:

From the present study, it has been verified that this combined system can also work at an HRT as short as 5.33 hrs with satisfactory performance. The system has a great potential to treat municipal sewage and is a viable option over other conventional treatment facilities. The construction of DHS reactor is very simple and inexpensive with minimal maintenance cost. It does not require any external energy and there is no excess sludge production.

Demonstration scale plant of DHS is planned to be operated soon in Niger of Africa and of India as a post treatment system for UASB effluent.

Reference:

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2. Machdar I., ., Sekiguchi Y., Sumino H., Ohashi A. and Harada H. (2000) Combination of a UASB Reactor and a Curtain Type DHS (Down Flow Hanging Sponge) Reactor as a Cost effective Sewage Treatment System for Developing Countries. *Wat. Sci. Tech*., 42, (3-4), 83-88.

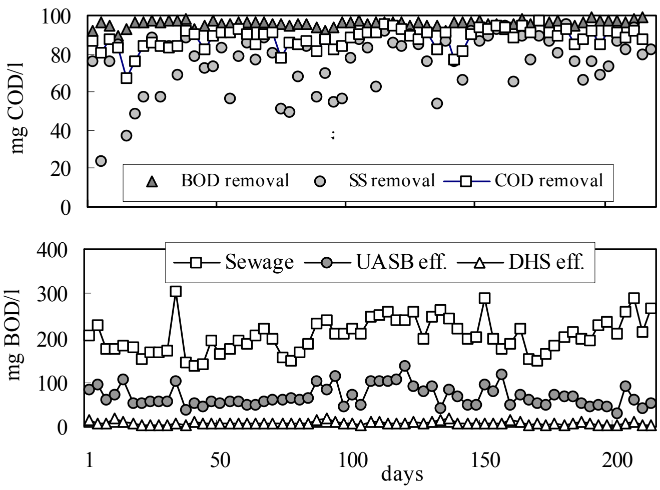

Fig. 1 BOD along time and Removal efficiencies.

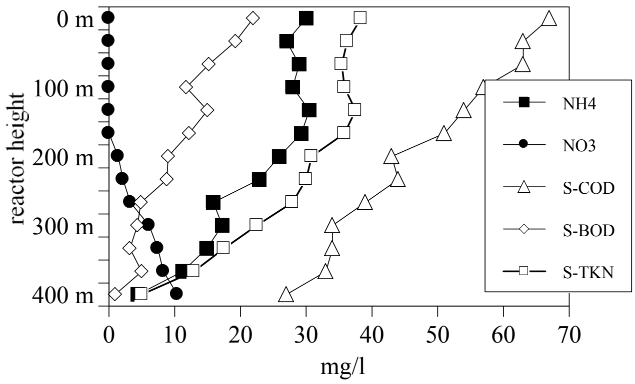

Fig 4 Profile of DHS reactor.

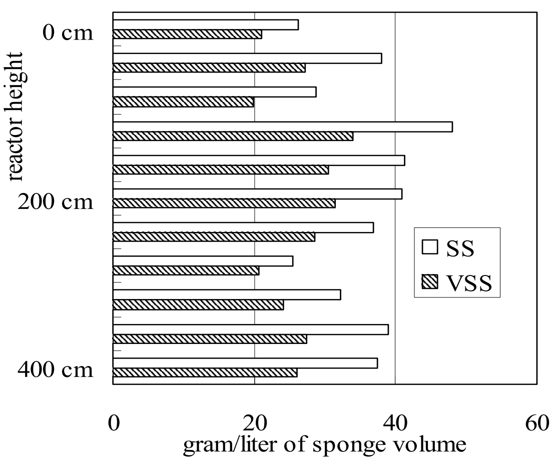

Fig 5 Profile of Sludge inside DHS reactor