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TITLE: DOWNFLOW HANGING SPONGE

***Miss.Vaishnavi S. Mane[1], Miss.Pooja D. Mote[2], Miss.Arnavi V. Gode[3]*, Prof. A.A. Dhole[4]**

[1]*U.G.Student, Civil Engineering, J.D.I.E.T. Yavatmal , maharashtra, india ,* ***vaishnvmane96@gmail.com***
[2]*U.G.Student, Civil Engineering, J.D.I.E.T. Yavatmal , maharashtra, india ,* ***coolpooja.mote@gmail.com***
[3]*U.G.Student ,Civil Engineering, J.D.I.E.T. Yavatmal , maharashtra, india ,* ***arnavi.gode96@gmail.com***
[4]*Asst.Professor, Department of civil engineering, J.D.I.E.T, Yavatmal, Maharashtra, India,*

ABSTRACT

The sewage treatment plant is a process that excludes the contaminants from the wastewater effectively and make it clean. The down-flow hanging sponge (DHS) reactor, which was developed for post-treatment of seepage from up-flow anaerobic sludge blanket (UASB) process treating sewage, uses polyurethane sponge as media to retain biomass. Wastewater is trickled from the top of the reactor and purified by microorganisms retained both inside and outside of the sponge media as the wastewater flows vertically down through the reactor. Three DHS reactors employing dissimilar sizes of sponge media with the same total sponge size were used for the direct treatment of developed dirt. It was shown that smaller sponge media produced better removal efficiencies. The most realistic explanation for this might be that smaller sponge media allows better oxygen uptake in the stream flowing down through the reactors.

Key words: DHS, Settled sewage, Sponge support media

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1. INTRODUCTION

1.1 General

Recently, up-flow anaerobic sludge blanket (UASB) reactor has been favoured as the most suitable sewage treatment process in developing countries because of their low energy use, easy maintenance, and cost effectiveness. However, UASB reactors used to treat only municipal sewage, it is relatively difficult to produce good quality effluent. Thus installation of an appropriate post treatment process is necessary after UASB treatment .The down-flow hanging sponge (DHS) reactor was developed for post-treatment of effluent from UASB systems treating sewage. The DHS process uses polyurethane sponge as media to retain biomass. Wastewater is trickled from the top of the reactor and purified by microorganisms retained both inside and outside of the sponge media as the wastewater flows vertically down through the reactor. As the sponge media in DHS reactors are not submerged in wastewater but hang freely in the air, oxygen is dissolved into the wastewater. Therefore there is no need for external aeration or any other energy inputs. additionally, in DHS reactors, a large amount of activated sludge grow both inside and outside of the sponge media so that an ecosystem with an extremely long food chain can be established, resulting in minimization of excess sludge production. In combined UASB/DHS systems, the organic substances in the sewage are removed by the first (UASB) step while removal of residual organics, or polishing, is achieved by secondary treatment in the DHS process. Among those available technologies, it is strongly recommended to use DHS system for post-treatment of anaerobic pre-treated sewage.

2. LITRATURE SURVEY

2.1 DHS System

The latest entry to the family of non-submerged biofilm reactors is the Down flow Hanging Sponge (DHS) system. The system was developed by Harada and his research group at Nagaoka University of Technology, Japan, for the treatment of sewage in developing countries. The DHS reactor is composed of several modules, each 2-4 meters vertical length filled with hundreds of series-connected hanging sponge-cubes. The tubular vessel is filled with sponge cubes which are diagonally linked using nylon strings. A large surface area is thus created and this is where the microbial growth takes place in nonsubmerged conditions. Wastewater is supplied at the top end of each module, and trickles down toward the lowest end of the module, (Machdar et al., 1997). As wastewater is trickling downwards through the sponges, the microorganisms take up nutrients from the wastewater. No mechanical air device is used in the DHS system even though the process is aerobic. As the sponges in DHS reactor are not submerged and freely hang in the air, oxygen dissolves into the wastewater as it flows down. This repeated phenomenon maintains dissolved oxygen (DO) concentration in the wastewater at a level which exceeds the need of microorganisms that reside in DHS sludge The DHS system can be operated under anaerobic conditions and provide for the recovery of dissolved methane gas. In 2010, Matsuura et al., investigated a two stage DHS system for the post treatment of UASB effluent in Nagaoka, Japan. Most of the dissolved methane (99%) was recovered by the two stage system, whereas about 76.8% of influent dissolved methane was recovered by the first stage operated at 2 hours hydraulic retention time (HRT). The second DHS reactor was mainly used for oxidation of the residual methane and polishing of the remaining organic carbons. The removal of COD and BOD5 in the first stage was insignificant as there was no air supply; however, high removals were expected in the second stage due to sufficient supply of air, which quickly oxidize the residual dissolve methane in the upper reactor portion before being emitted to the atmosphere as off-gas

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2.3.1 DHS SYSTEM FIRST GENERATION TYPE

Since its inception, the DHS system has been developed through several pilot experimental researches. This was due to the desire to develop a more affordable treatment technology for the developing countries. 7 In 1997, Agrawal developed to a "first generation type" or "cube type" DHS reactor. The reactor used sponge cubes each 1.5cm connected to each other diagonally with a nylon string and arranged in series. (Agrawal et al., 1997; Machdar et al., 2000). The full scale reactor had three segments, each two meters high. Each segment was filled with 120 sponge cubes, which measured 1.5 cm, and were linked diagonally with a nylon string vaccination was done by placing the segments and the cubes into activated sludge for 48 hours. The sponges occupied about 28% of the DHS reactor volume. The reactor was fed by the effluent of a UASB reactor. The reactor was operated at a hydraulic loading rate (HLR) of 0.06 m3/m2d, with a flow of approximately 30 liters per day in winter time and an HLR of 0.11 m3/m2d (flow of 60 L/d) in summer time. The DHS reactor was evaluated for residual organics removal and nitrification under natural air intake only. The influent COD was in the range of 100 – 135 mg/L and the average ammonia concentration was 35mg NH4-N/liter. During the evaluation, it was observed that with post de-nitrification and an external carbon source, 84% in average N (NO3 + NO2) was removed with a hydraulic retention time (HRT) of less than 1 hour, for temperature range of 13 to 30 0C. The effluent contained a negligible amount of SS and total COD was only in the range of 10 to 25 mg/L. The DHS reactor was capable of stabilizing total nitrogen through nitrification, which ranged from 73-78% (Agrawal, et al., 1997)

2.3.2 SECOND GENERATION DHS (CURTAIN) TYPE

Since then, a second generation or "Curtain type" reactor has been developed. The sponge shape changed to triangular strips, 75 cm long and 3cm wide for the second generation reactor. The sponges were tiled on both sides of a plastic sheet with a height of 2 meters. (Machdar et al., 2000). All the other measurements of the cube type DHS reactor remained the same. The influent also came from the effluent of a UASB reactor, as before. The reactor was operated for a total of 550 days. The reactor was operated at a HRT of 2 hour and a temperature of 25o Celsius. The DHS reactor successfully achieved 92% of BOD5 removal, 62% of COD removal, and 79% of TSS removal, and 61% of NH4-N removal As in the first generation type, the complete system neither requires external aeration input nor withdrawal of excess sludge. The final BOD5 effluent concentration was 6 to 9 mg/L. Similarly, FC removal was 3.5 log with a final count of 103 to 104 MPN/100mL in the effluent. Nitrification and de-nitrification in DHS accounted for 72% removal of total nitrogen (effluent concentration of 11 mg N/L) and 60% removal of ammonium nitrogen (effluent NH4-N of 9 mg N/L) over the total operational period. The system was a combined UASB+DHS.

2.3.3 THIRD GENERATION DHS (TRICKLING FILTER) TYPE

A third generation type or "trickling filter type" was developed by Mahmoud et al in 2009. The reactor utilized small sponge pieces encased in a supporting material on the outside. The DHS system had a capacity of 133 liters, consisting four segments connected vertically. Each segment was filled with 6 liters of polyurethane foam(PF), wrapped with perforated polypropylene plastic material, randomly distributed in the whole reactor. The foam occupied 18% of the reactor volume. The reactor was fed with the effluent from an Anaerobic hybrid reactor (AHR). The reactor was operated at an HRT of 2 hours, organic loading rate of 2.1 kg COD/m3.d and a flow of 0.288 m3/day. The system achieved 87% of BOD5 removal, 69 % of COD removal, 66% of TKN removal and 85% of NH4-N removal. The reported results indicated that the third generation DHS reactor is very effective not only for the reduction of chemical oxygen demand (COD), 8 biochemical oxygen demand (BOD5) and ammonia but also for faecal coliform removal.

2.3.4 FOURTH GENERATION DHS (RANDOM) TYPE

A fourth generation DHS reactor (Tandukar et al., 2006), had box modules with long sponge strips, placed inside a net-like cylindrical plastic cover. This provided rigidity to the sponges. The strips measured 2.5cm x 2.5cm x 50cm. The system was developed to increase the dissolution of air into the wastewater and to avert the possible blockage of the reactor. The DHS reactor had a volume of 375 liters and consisted of four modules put one above the other with a gap in between, giving a total height of 4 meters. The sponges were put within a net-like cylindrical plastic coat to provide inflexibility. Fifteen such sponge units were arranged in a row, and were then stacked one above another but in directions 90o to each other to make 20 rows. Gaps between consecutive rows were maintained at 0.7 –1.0 cm. Three hundred sponges, in total were put inside the module and this represented 39% of the reactor volume. The reactor was fed with the effluent from a UASB reactor using a peristaltic master-flex pump. The reactor was operated at a HRT of 2 hours with a temperature range of 20o C – 25o C. to simulate an annual average ambient temperature of most of the developing countries in tropical and subtropical regions. The DHS system was started with clean sponge saturated with water without the use of inoculation. The start-up period was less than two weeks. The DHS system achieved 90% of BOD5 removal, 76 % of COD removal, 30% of TKN removal and 28% of NH4-N removal. study on DHS sludge was ready by quantifying it and evaluating oxygen uptake rates with various substrates. Average concentration of trapped biomass was 26 g-VSS/L of sponge volume, increasing the SRT of the system to 100-125 days. Removal of coliforms obtained was 3-4 log10 with the final count of 10(3) to 10(4) MPN/100 ml in DHS effluent

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2.3.5 FIFTH GENERATION DHS REACTOR

The fifth generation reactor (Tandukar et al., 2007) made improvements to the sponge arrangement for the second generation reactor by lining up several sponge sheets. The reactor had total volume of 480 L, based on the sponge volume. Polyurethane sponge with pore size of 0.63 mm was used for the construction of DHS. Void ratio of sponge was more than 90%, The DHS reactor was filled with sponges arranged in a curtain, constructed by adhering the sponge with undulating surface on both sides of a thin plastic sheet. The reactor was fed with effluent from a UASB reactor, without any pretreatment. The flow from the UASB reactor was by gravity. The HRT for the DHS reactor was 2.5 hours, and was operated for 300 days. DHS system was comparable to that of activated sludge process (ASP). Unfiltered BOD5 removal was more than 90%. COD removal of over 70%, TKN removal of over 60% and a 3 log removal of Fecal Coliforms.

2.3.6 SIXTH GENERATION DHS REACTOR

The sixth generation reactor has the basic design similar to the third generation reactor but utilizes rigid sponge media which is manufactured by copolymerizing polyurethane with epoxy resins. (Onodera et al., 2014). The reactor consisted of four segments, each segment being 76.5 cm tall and 24 cm in diameter separated by 15 cm connecting segments. The total volume of the reactor was 136 liters and the sponges occupied 33.8% of the volume. The connecting segments had removable windows to allow the reactor to be ventilated and wastewater samples to be collected. It had a rotary distributor at the top of the reactor. The reactor was operated at a hydraulic retention time (HRT) of 2 hours, calculated on the sponge volume. Fed with effluent from a UASB reactor, it was started without any inoculation. The system gave reasonable organic and nitrogen removal efficiencies. The reactor achieved a BOD5 removal efficiency of 96 % TKN removal efficiency of 43%. The nitrification performance was good, this being attributed to the rigid sponge media. There was a high concentration of dissolved oxygen under natural ventilation.

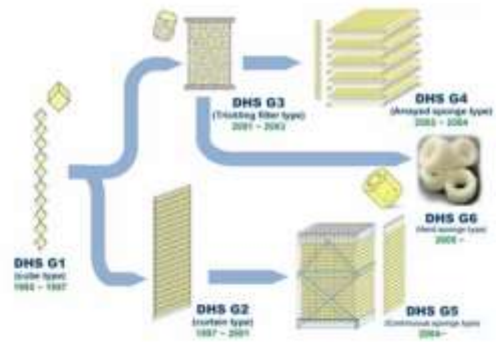

Fig- 1: Evolution of DHS.

3.FINDINGS OF STUDY

3.1MATERIALS & METHODS

Three identical DHS reactors, 2000 mm in working height and 20 mm in width, were used. The reactors are shown in Fig. 1 along with a sketch of the three different sizes of polyurethane sponge media (Maruei Co. Ltd., MSC-E16, void volume=98.4%) which were adhered onto a polyacrylamide-made plastic plate (2000 mm in height x 70 mm in width). The largest sponge medium is the same size as that used in previous pilot and demonstration studies of curtain type DHS units. The reactors, tiled with the small, medium, and large size sponge media were designated reactors No. 1, No. 2, and No. 3, respectively. Although the sizes of the three sponge media were different, the total sponge volume in each reactor was set at 240 cm3. The reactors were seeded with activated sludge taken from a municipal sewage treatment site in Kisarazu, Chiba, Japan just before start-up. The activated sludge was concentrated by sedimentation to 3.2 g/L of MLSS. To seed the sludge into the sponge media, the sponges were forcibly soaked with the concentrated activated sludge.

Routine monitoring of ammonium nitrogen, nitrate, nitrite, COD and F. coli in the wastewater and the effluent of each reactor was conducted. The number of F. coli was determined by the membrane filter method with mFC medium following the “Standard Methods for the Examination of Water and Wastewater” (APHA, 2005). The COD, ammonium nitrogen, nitrate and nitrite were analyzed using a HACH water quality analyzer (HACH DR-890, USA) as in a previous study . To conclude the dissolved oxygen (DO) in the river flowing through the DHS reactors, Clerktype DO microelectrodes were used as in another previous study. All other analytical procedures were carried out according to “Standard Methods for the ssssExamination of Water and Wastewater” (APHA, 2005).

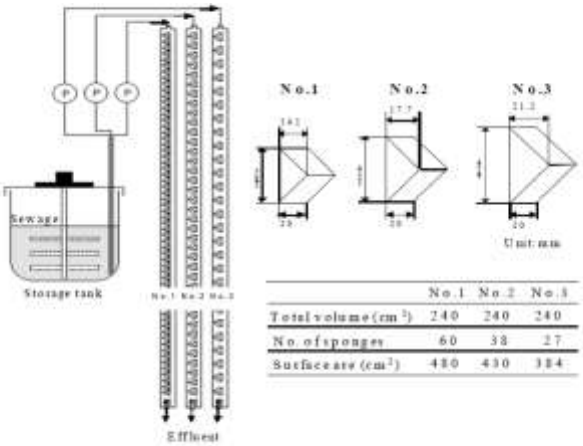

Fig- 2: DHS reactors and Sponge size

CONCLUSION OF LITRATRE

This study showed that the smaller the sponge media sizes of the DHS reactors are, the better the removal efficiencies of COD, ammonium nitrogen, and F. coli. This phenomenon could occur for the following reasons:
1) Smaller sponge media allows better oxygen uptake in the stream flowing down through the reactors.
2) With smaller sponge media, contact between the sludge and the wastewater is better.

ADVANTAGES

1) Lower energy consumption.

2) Lower biomass production.

3) Aerobic, no external aeration is required

DISADVANTAGES

1)Requires a large area of land may produce undesirable odour.

2)Require skill labours.

3)Initial cost is high.

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CONCLUSION

In this study, three identical DHS reactors employing different sizes of sponge media with the same total sponge volume were used for the direct treatment of settled sewage. All three DHS reactors performed satisfactorily in removal of COD, ammonium nitrogen, and F. coli at a fixed hydraulic retention time of 2.0 h based on the sponge volume. This study showed that the smaller the sponge media sizes of the DHS reactors are, the better the removal efficiencies for all the parameters above. The most reasonable explanation for this might be as follows;

1) Smaller sponge media allows better oxygen uptake in the stream flowing down through the reactors.

2) With smaller sponge media, contact between the sludge and the wastewater is better. It was suggested that the removal efficiencies

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