Influence of Using Packing Materials on the UASB Performance

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Abstract
A lot of researchers studied the main factors affecting the performance of using the Up flow Anaerobic Sludge Blanket (UASB) reactors for domestic wastewater treatment. The previous researches and experiments to investigate some parameters which affecting the treatment process using UASB reactors such as Hydraulic retention time, sludge blanket thickness, mode of operation (Continues and feed – feed less), feed less period and internal media inside the reactor.This paper investigate the influence of using pieces of sponge used as an internal media (packing materials) on the UASB performance in treating the municipal wastewater. The main purpose of using the internal media inside the reactor is to allocate large surface area for bacterial community growth.A pilot scale setup was designed and constructed at Zenien wastewater treatment plant (Zenien WWTP) in Giza Governorate, Egypt. It was operated under ambient environmental conditions.The experimental works shows increment at the UASB performance of the main parameters COD, BOD, TSS and VSS.
Keywords: Sewage treatment**,** Packing Materials, UASB

1. Introduction

There is an interest those days toward using the anaerobic wastewaters treatment processes, one of those process is the Up flow Anaerobic Sludge Blanket (UASB) reactor due to its operational simplicity, low bio-solids production, low cost, and the possible biogas production.

The UASB reactor is one of the famous anaerobic processes used for the wastewater treatment that depends on the anaerobic bacteria in the removal and stabilization of dissolved and particulate carbonaceous organic matter found in wastewater.

The main target of this paper is to study the influence of using packing materials on the UASB performance.

2. Review of Literature

The UASB reactor considered as one of the most popular anaerobic wastewater treatment process for both high and low temperature (Dinsdale, et al., 1997). The size and the shape of the UASB reactor depended on many parameters but the organic loading rate and the hydraulic retention time are the most important parameters.

Previous researches investigated the operational parameters which affecting the treatment process using UASB reactors such as Hydraulic retention time, sludge blanket thickness, mode of operation (Continues and feed – feed less), feed less period and internal media inside the reactor.

A. A. Azimi and 2M. Zamanzadeh, published a paper discussed the design criteria for UASB reactors as a wastewater pretreatment system in tropical small communities based on a pilot-scale model consist of 600mm dia. Steel pipe and 3.6m height, using 2,6,8 and 10 (HRT) hydraulic retention time and various (LR) loading rates from 0.95 up to 5.70 kg COD/m3 per day. The paper conclusion is that UASB reactor gives a good result and could be considered as a pretreatment effective alternative for the municipal wastewater tropical locations

S. M. M. Vieira and A. D. Garcia Jr, published a paper discussed the sewage treatment by UASB-reactor, Operation results and recommendations for design and utilization. Based on 5 years experimental works using 120m3 pilot-scale, at room temperature with a 5 to 15 hydraulic retention time. The experimental works showed good results at treatment performance. The paper recommendations to get better result were to follow stringent dimensioning and design, in addition to the importance of reasonable monitoring and operation.

3. Methodology

A pilot-scale UASB setup was designed and constructed in order to simulate the reality in Zenien wastewater treatment plant, Giza, Egypt. The pilot is located between grit removal and primary sedimentation tanks.

3.1 Model Description and Components

The UASB reactor is fabricated using acrylic tube of 0.25 m diameter vertical cylindrical shape with a total volume of 98.13 L. The reactor essentially had an internal effective working volume of 85.86 L and the remaining volume of 12.27L was kept for gas liquid solid (GLS) separation arrangement. The overall height of the reactor was 2 m and effective height being kept as 1.75m. The reactor had one influent port at the bottom, one effluent port and six sampling ports 30 cm apart along the effective height of the reactor equipped with controlling valves; Figure (1) shows the hybrid reactor detail.

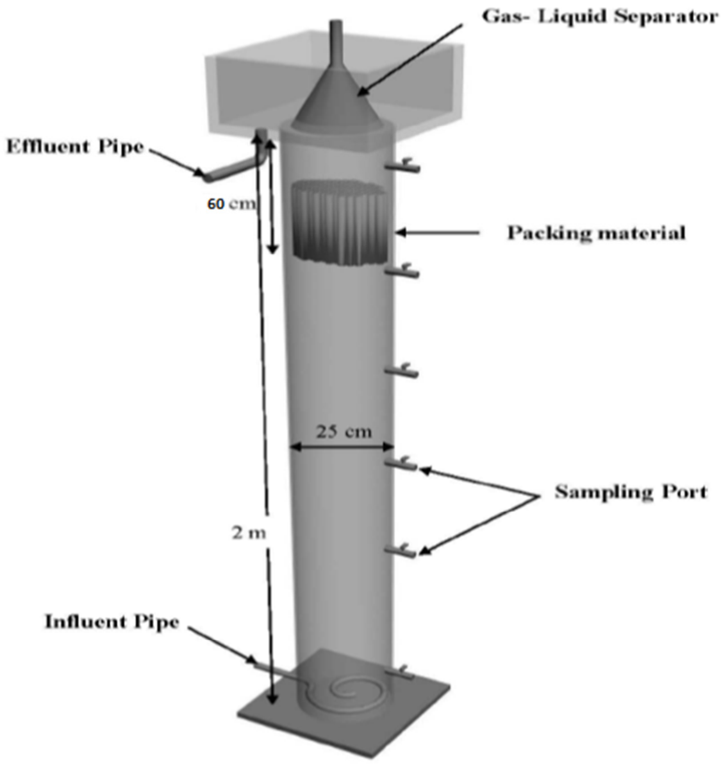

Figure 1. Hybrid Reactor Detail

3.1.1 Sludge Bed
The lower part of the reactor is the sludge bed location with 60cm fixed sludge height.
3.1.2 Packing Material
The importance of the packing material in the reactor is allocate large surface area for bacterial community growth to increase the total hybrid performance by increasing the bacterial action.
Sponge is the used packing material inside the hybrid reactor and has been tested with three thickness heights 20, 40 and 60cm.
3.1.3 Gas Solid Separator
Gas solid separator also known as the (gas-liquid-solids separator) at the top of the reactor, where the water phase is separated from sludge solids and gas (Lettinga, 1995). It's consists of a cone fixed at the top of the reactor.

3.2 Program of Experimental Works
Two parameters have been checked during the experimental work. The first parameter is the retention time and the second parameter is the sponge (packing material) thickness.

- Retention time for continues operation (6 hr., 8 hr. and 10 hr.)
- Sponge thickness (20, 40 and 60cm).

Table (1) shows the schedule of experimental work

Stage No.	Experiment No.	Retention Time (hr.)	Media Thickness (cm)
1	Start-Up	9	_
2	1	6	60
	2	8	60
	3	10	60
3	4	6	40
	5	8	40
	6	10	40
4	7	6	20
	8	8	20
	9	10	20

4 Results*Stage No. (1) (Start-up stage)*

This is a crucial step for the stable operation of the UASB reactor. The reactor reached its stable condition after 37 days. 27 samples have been analyzed to assure that the reactor reached its stability conditions after that the sponge thickness has been increased gradually by adding 20cm each time along 15 days. So the total time consumed at the start up stage was 52 days under 24 °C average temperature, 7.18 average pH, 60 cm sludge bed thickness and 9 hours hydraulic retention time.

Figures (2 – 5) show the COD, BOD, TSS and VSS of influent and effluent wastewater during the start-up stage

COD Analysis

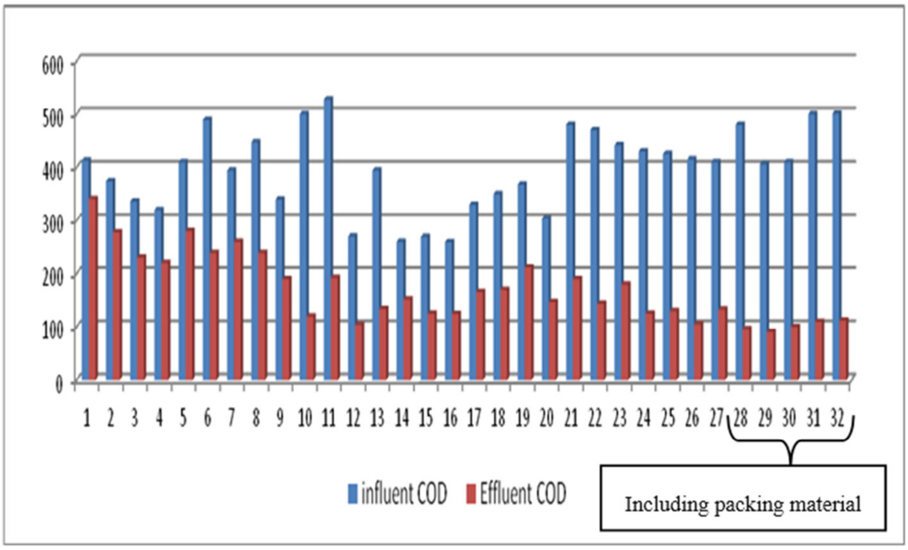

Figure 2. COD removal efficiency for influent and effluent during start-up stage

BOD Analysis

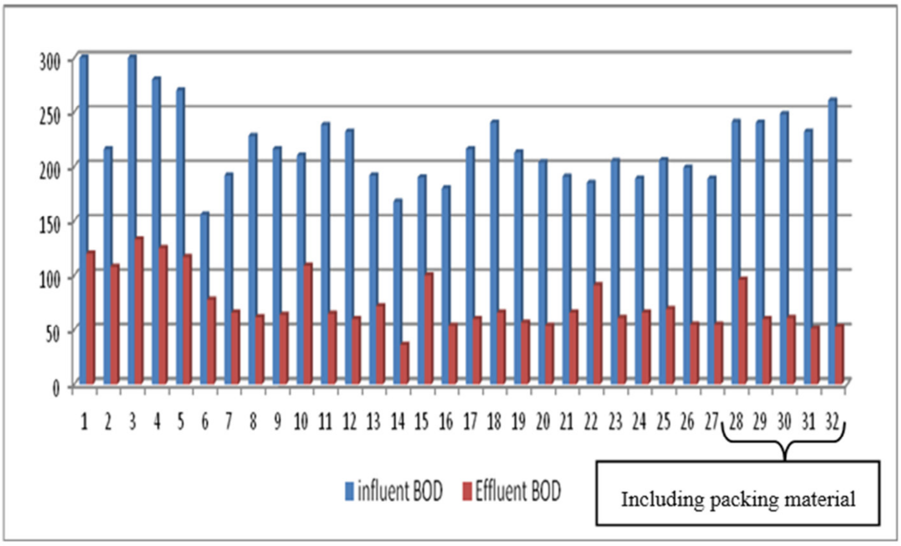

Figure 3. BOD removal efficiency for influent and effluent during start-up stage

TSS Analysis

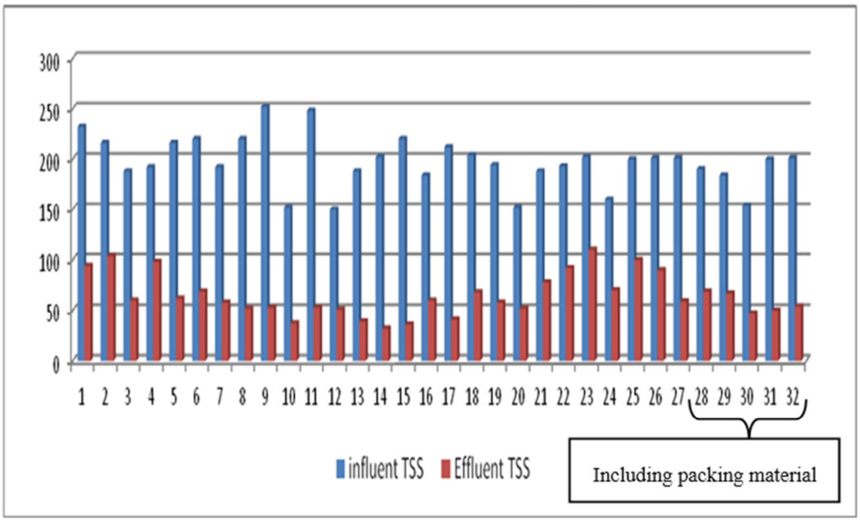

Figure 4. TSS removal efficiency for influent and effluent during start-up stage

VSS Analysis

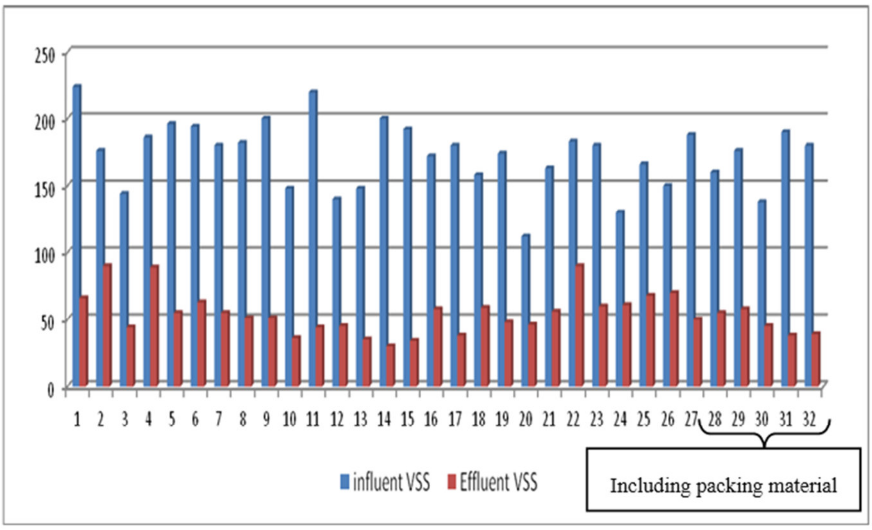

Figure (5): VSS removal efficiency for influent and effluent during start-up stage

4.2 Stage No. (2) (Packing material = 60cm)

After the start-up stage, we got a stable effluent quality and we started stage (2) which divided into 3 experiments (1, 2 & 3), during this stage the average temperature was (26.63)º , average PH was 7.20, three layers of packing material (sponge) each layer 20 cm thickness with total thickness equal 60 cm and sludge bed thickness 60 cm.

The difference between those experiments is the hydraulic retention time, to check the performance and the efficiency of removal under 6,8,10 hrs. Consumed time during this stage was 45 days, with 30 samples taken for the 3 experiments, same tests conducted (BOD, COD, TSS & VSS). The results of these tests mentioned below in details.

Stage no. 2 COD removal efficiency

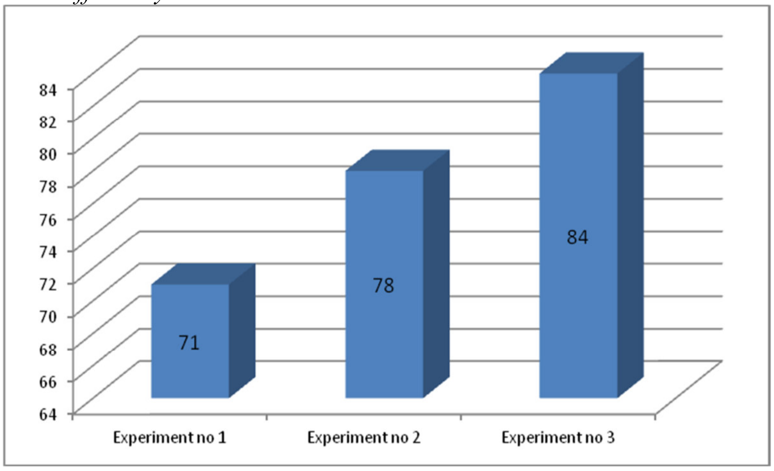

Figure 6. Stage No. 2 COD removal efficiency

As shown in Figure (6), the COD removal efficiency increased by increasing the hydraulic retention time and reached 84% at 10 hrs. hydraulic retention time.

Stage no. 2 BOD removal efficiency

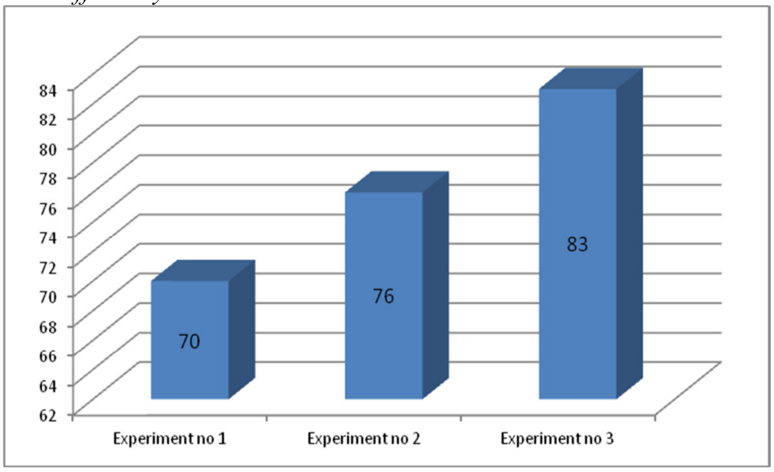

Figure 7. Stage No. 2 BOD removal efficiency

As shown in Figure (7), the BOD removal efficiency increased by increasing the hydraulic retention time and reached 83% at 10 hrs. hydraulic retention time.

Stage no. 2 TSS removal efficiency

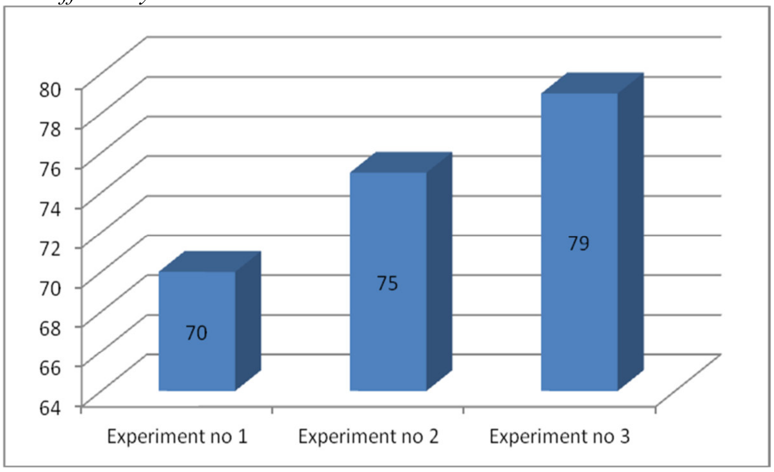

Figure 8. Stage No. 2 TSS removal efficiency

As shown in Figure (8), the TSS removal efficiency increased by increasing the hydraulic retention time and reached 79% at 10 hrs. hydraulic retention time.

Stage no. 2 VSS removal efficiency

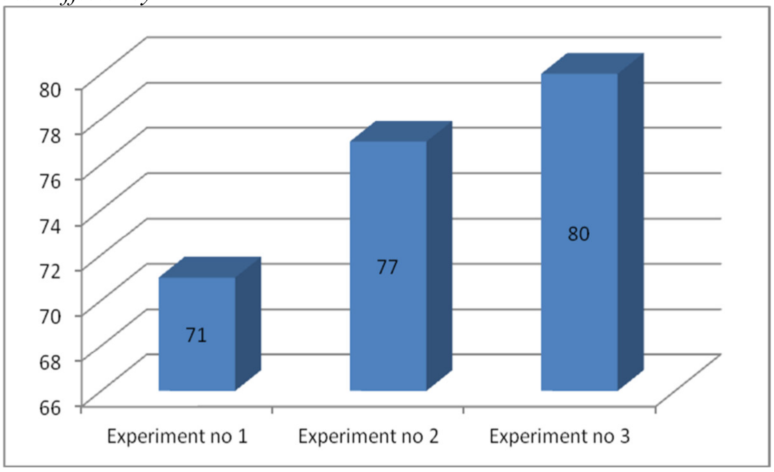

Figure 9. Stage No. 2 VSS removal efficiency

As shown in Figure (9), the VSS removal efficiency increased by increasing the hydraulic retention time and reached 80% at 10 hrs. hydraulic retention time.

4.3 Stage No. (3) (Packing material = 40cm)

Stage (3) divided into 3 experiments (4, 5 & 6), during this stage the average temperature was (26.83) º , average PH was (7.22), two layers of packing material (sponge) each layer 20 cm thickness with total thickness equal 40 cm and sludge bed thickness equal 60 cm.

Stage no. 3 COD removal efficiency

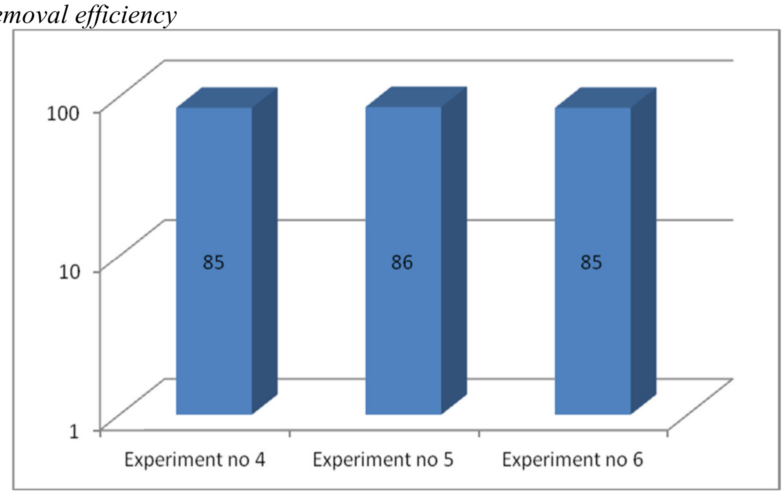

Figure 10. Stage No. 3 COD removal efficiency

As shown in Figure (10), the COD removal efficiency was almost constant regardless the hydraulic retention time with a minor maximum at 8 hrs. hydraulic retention time.

Stage No. 3 BOD removal efficiency

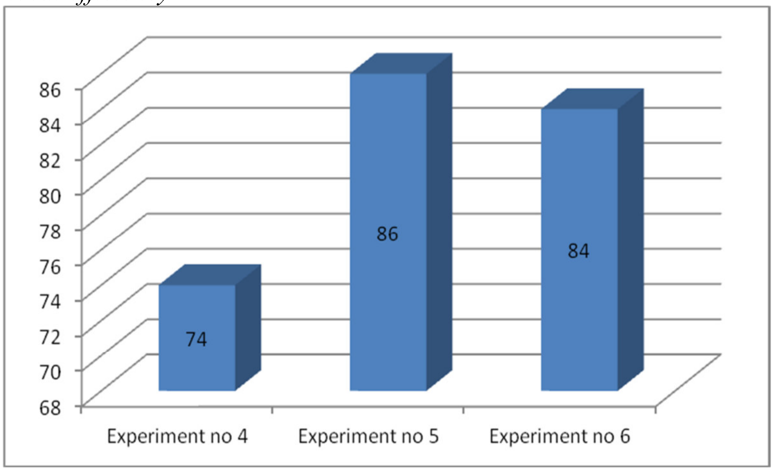

Figure 11. Stage No. 3 BOD removal efficiency

As shown in Figure (11), the reactor reaches its maximum performance in the BOD removal efficiency 86% at 8 hrs. hydraulic retention time.

Stage No. 3 TSS removal efficiency

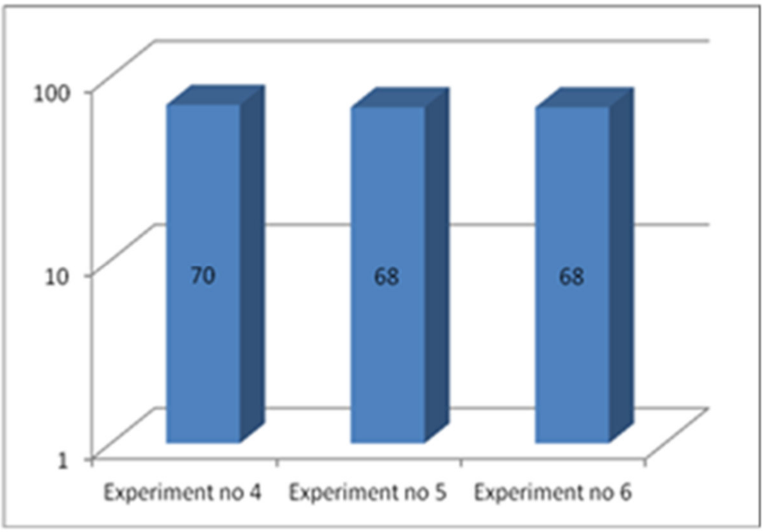

Figure 12. Stage No. 3 TSS removal efficiency

As shown in Figure (12), the TSS removal efficiency was almost constant regardless the hydraulic retention time with a minor maximum at 6 hrs. HRT

Stage No. 3 VSS removal efficiency

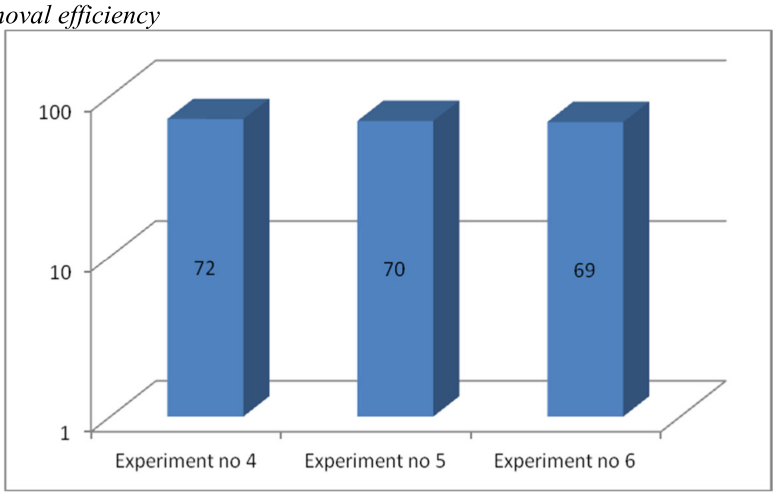

Figure 13. Stage No. 3 VSS removal efficiency

As shown in Figure (13), the VSS removal efficiency slightly decreased by increasing the hydraulic retention time and reached 72% at 6 hrs.

4.4 Stage No. (4) (Packing material = 20cm)

Stage (4) divided into 3 experiments (7, 8 & 9), during this stage the average temperature was (26.58)º , average PH was (7.25), One layers of packing material (sponge) as a one layer 20 cm thickness and sludge bed thickness equal 60 cm.

Stage No. 4 COD removal efficiency

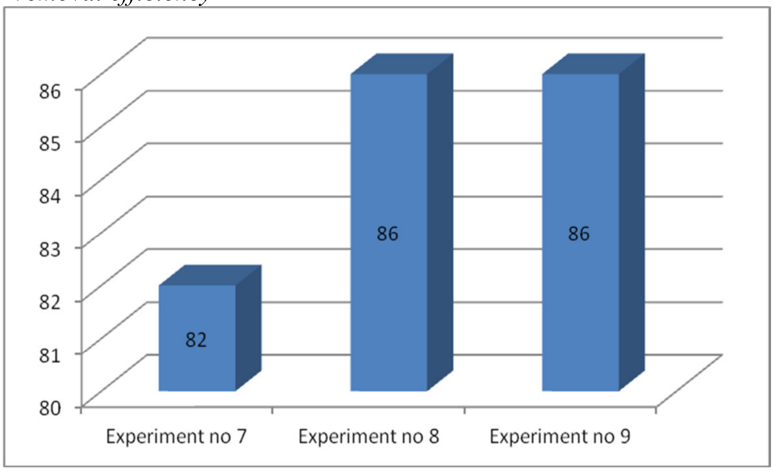

Figure 14. Stage No. 4 COD removal efficiency

As shown in Figure (14), the reactor reaches its maximum performance in the COD removal efficiency 86% at 8 hrs. hydraulic retention time.

Stage No. 4 BOD removal efficiency

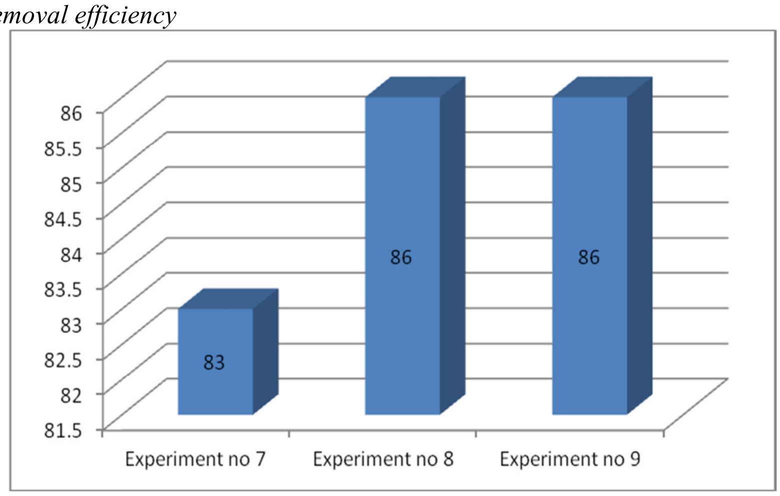

Figure 15. Stage No. 4 BOD removal efficiency

As shown in Figure (15), the reactor reaches its maximum performance in the BOD removal efficiency 86% at 8 hrs. hydraulic retention time.

Stage No. 4 TSS removal efficiency

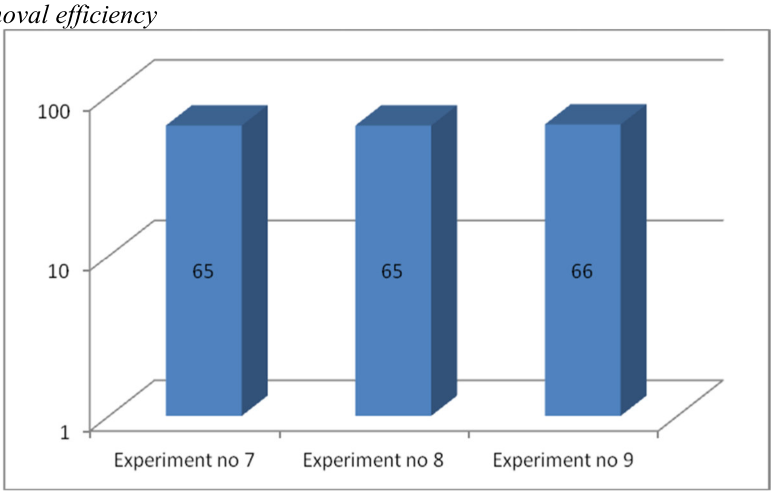

Figure 16. Stage No. 4 TSS removal efficiency

As shown in Figure (16), the TSS removal efficiency was almost constant regardless the hydraulic retention time with a minor maximum at 10 hrs. hydraulic retention time.

Stage No. 4 VSS removal efficiency

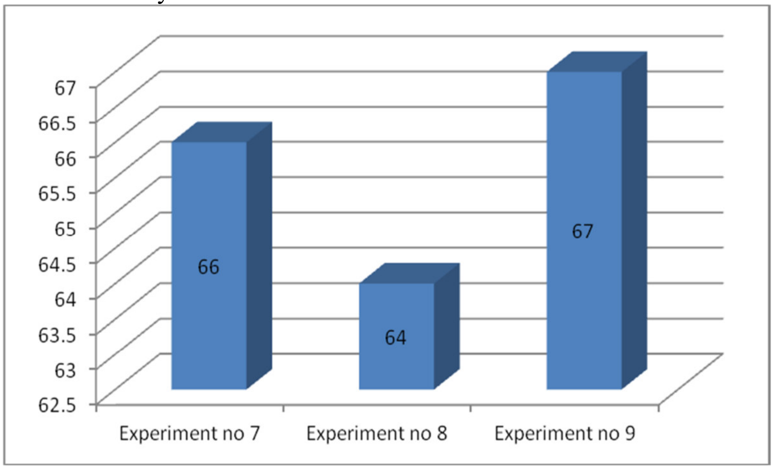

Figure 17. Stage No. 4 VSS removal efficiency

As shown in Figure (17), the TSS removal efficiency was almost constant regardless the hydraulic retention time with a minor maximum at 10 hrs.

5. Discussions

From the above results we can summarize the effect of the hydraulic retention time and the effect of the packing material (Sponge) thickness for the following parameters as follow:

COD Results

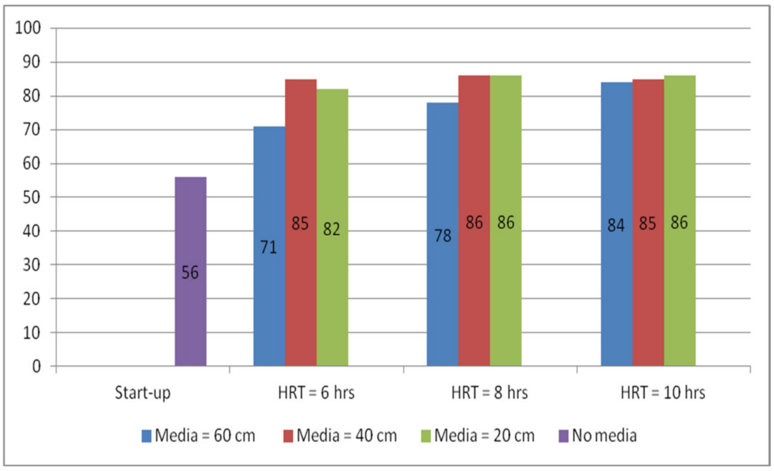

Figure 18. COD removal efficiency along the four stages

Figure (18) shows that during the different stages we can find that changing the hydraulic retention time gives us few changes in the removal efficiency for the COD results except for the usage of sponge with 60cm thickness that increasing the hydraulic retention time gives a reasonable increase in the removal efficiency. This is due to the fact that adding the sponge increases the surface area for different bacterial community growth that capable to biodegrade the low biodegradable COD.

We can consider that 6 hrs. and 20cm sponge thickness is the optimum operational parameter for COD removal of about 86%.

BOD Results

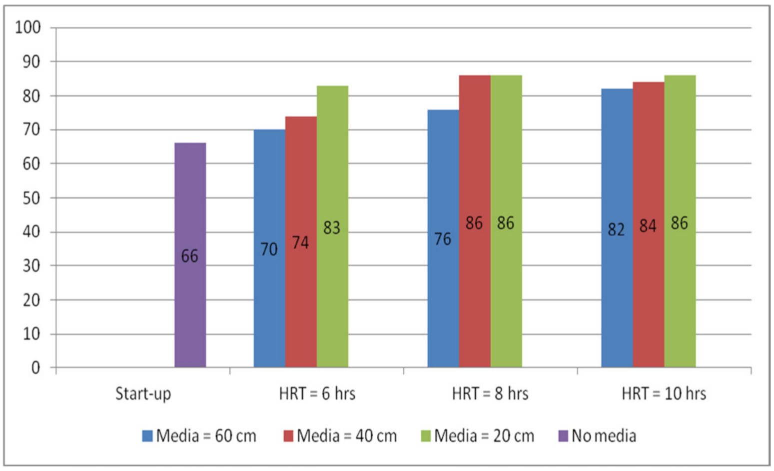

Figure 19. BOD removal efficiency along the four stages

Figure (19) shows that during the different stages we can find that changing the hydraulic retention time gives us few changes in the removal efficiency for the BOD results except for the usage of sponge with 60cm thickness that increasing the hydraulic retention time gives a reasonable increase in the removal efficiency. This is due to the fact that adding the sponge increases the surface area for different bacterial community growth that capable to biodegrade the low biodegradable BOD.

We can consider that 6 hrs. and 20cm sponge thickness is the optimum operational parameter for BOD removal of about 86%.

TSS Results

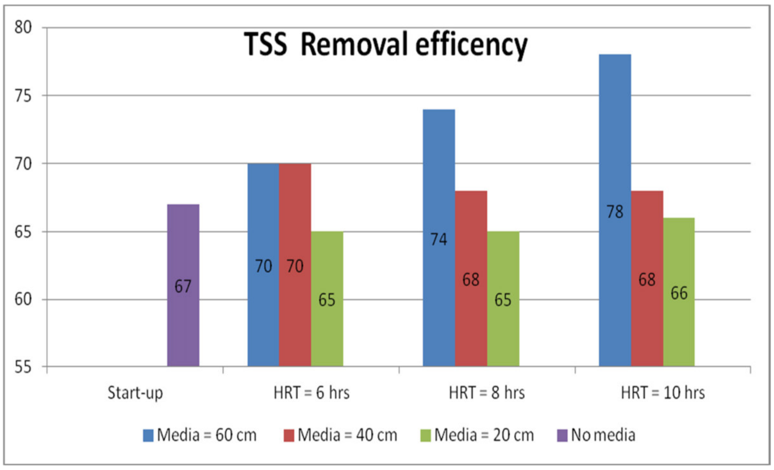

Figure 20. TSS removal efficiency along the four stages

Figure (20) shows that during the different stages we can find that changing the hydraulic retention time gives us few changes in the removal efficiency for the TSS results except for the usage of sponge with 60cm thickness that increasing the hydraulic retention time gives a reasonable increase in the removal efficiency. This is due to the fact that adding the sponge increases the possibility of retaining the solids in the sponge and accordingly decreasing the TSS in the effluent.

We can consider that 6 hrs. and 40cm sponge thickness is the optimum operational parameter for TSS removal of about 70%.

VSS Results

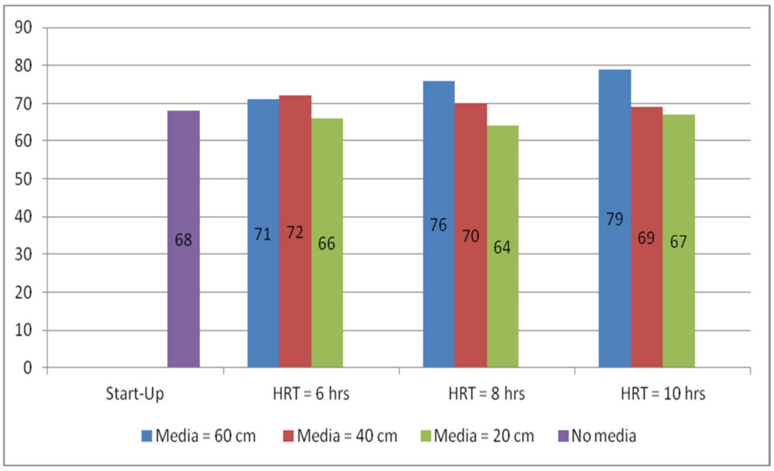

Figure 21. VSS removal efficiency along the four stages

Figure (21) shows that during the different stages we can find that changing the hydraulic retention time gives us few changes in the removal efficiency for the VSS results except for the usage of sponge with 60cm thickness that increasing the hydraulic retention time gives a reasonable increase in the removal efficiency.

This is due to the fact that adding the sponge increases the possibility of retaining the solids in the sponge and accordingly decreasing the VSS in the effluent.

We can consider that 6 hrs. and 40cm sponge thickness is the optimum operational parameter for TSS removal of about 72%.

4. CONCLUSION

Using backing material (Sponge) increases the COD, BOD, TSS and VSS removal efficiencies and enhances the performance of the UASB reactor.

Increasing the hydraulic retention time results in increasing the removal efficiency of COD, BOD, TSS and VSS specially, in the existence of backing material with higher thickness.

The rate of increase in removal efficiency of COD, BOD, TSS and VSS with the hydraulic retention time increase decreases for hydraulic retention time more than 8hrs.

The effect of increasing the hydraulic retention time in case of using backing material is more noticeable for the higher thicknesses.

Increasing the backing material thickness gives better removal efficiency for the TSS and VSS, however, it gives worst removal efficiency for the COD and BOD.

The optimum hydraulic retention time is 6 hrs for COD, BOD, TSS and VSS removal efficiencies.

The optimum backing material thickness is 20cm for COD, BOD removal efficiency and 40cm for TSS and VSS removal efficiency.

The recommended backing material thickness should be determined according the permissible limit for the COD, BOD, TSS and VSS in the treated effluent.

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