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Research Article

Performance of Organic overloaded WWTP Comprise Primary followed by Secondary Attached Growth Biological Treatment- Case Study

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Abstract

The Egyptian government faces big challenges to cover rural areas with conventional wastewater treatment systems due to shortage of financial resources. Cascade aerators consist of a series of steps that the water flows over. In all cascade aerators, aeration is accomplished in the splash zones. The aeration action is similar to a flowing stream. Splash areas are created by placing blocks across the incline. The current research aims to examine the performance of a low cost compact sewage treatment unit that employs an integrated aerobic system which is easy to implement and operate and producing effluent wastewater quality complying with Egyptian law 48 for year 82. Initially, Bordain wastewater treatment plant is located in Sharkia governorate, Egypt. It includes UASB unit preceded by screen and grit removal chamber and followed by trickling filter with final clarifier. The main problem of this WWTP is concluded in high level of COD effluent concentration, in addition to zero level of dissolved oxygen. The present research aims to improve COD removal ratio and dissolved oxygen concentration at the effluent samples. A cascade tower was added in the channel between UASB and trickling filter in addition to recirculation submerged pump. Water samples were collected from the influent and effluent of WWTP. Results indicated that, Low COD effluent concentration was achieved. COD removal ratio measured was ranged between 70 - 75%, In comparison with 25 – 30 % at the first and also high level of dissolved oxygen concentration was recorded.

Keywords*: Upgrading treatment, Cascade Tower, Sewage Treatment, Aeration requirements.*

Introduction

The Egyptian government faces big challenges to cover rural areas with conventional wastewater treatment systems due to shortage of financial resources. Initially, Bordain wastewater treatment plant is located in Sharkia governorate, Egypt. It includes UASB unit preceded by screen and grit removal chamber and followed by trickling filter with final clarifier. The main problem of this WWTP is concluded in high level of COD effluent concentration, in addition to zero level of dissolved oxygen.

A wide range of high to low technologies is available for sewage treatment in small communities. Management of sewage in small communities by using conventional high treatment technologies such as activated sludge consumes high energy during the operation and accordingly cost of operation is high. In addition, the conventional treatment systems require regular maintenance and skilled labor for their operation which are normally not available in such remote areas. (Adrianus *et al*, 2004)

To overcome these difficulties, the National organization for potable water and sanitary Drainage (NOPWS) constructed some remote experimental treatment plants based on high efficiency anaerobic primary treatment followed by aerobic Biological treatment. In case they prove to be superior to other technologies, they may be recommended for future works. The presently available limited experience of anaerobic- aerobic treatment indicates that the effluent COD of a combined anaerobic- aerobic system is lower than that of activated sludge process. This can be possibly attributed to the removal of soluble organic material that is biodegradable in an anaerobic environment but not in an aerobic environment. (Soil, 2004)

The current research aims to examine the performance of Bordain wastewater treatment plant, a low cost compact sewage treatment plant that employs an integrated anaerobic/ aerobic system which is easy to implement, operate and producing effluent

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wastewater quality complying with the Egyptian law 48 for year 1982. (Koduri S. *et al*, 2003)

Bordain wastewater treatment plant is located in Bordain village Sharkia governorate, Egypt. It includes UASB unit preceded by screen and grit removal chamber and followed by trickling filter with final clarifier.

The up flow anaerobic sludge blanket (UASB) is one of the promising technologies, zero electric power consumption and high efficiency. Its efficiency may exceed 80% removal of BOD, COD and SS. Also, where sulphides are present in UASB effluent, it will have an immediate oxygen demand at the rate of 29 per 19 of Sulphides. (Sanjib M. *et al*, 2010) This immediate oxygen demand has to be met by aerating the effluent. This reduces to some extent, the economy of UASB system to some extent.

Bordain wastewater treatment plant is presently overloaded. The design influent BOD of raw wastewater was 400- 500 mg/l. Presently the influent wastewater BOD exceeds 800 mg/l resulting in zero dissolved oxygen in the effluent from Biological filters indicating that the reaction is not complete.

The concentration of dissolved oxygen is very important in wastewater whether before or after treatment. It is a prime indicator in determining how satisfactory a biological wastewater treatment is occurring. Aeration is the primary means by which the wastewater replenishes its oxygen content. It is often required in water bodies that suffer from anoxic conditions, such as sewage discharges, agricultural run-off or in wastewater treatment plants.

Dissolved oxygen (DO) is a major contributor to wastewater quality, where aerobic bacteria breathe oxygen to decompose the organic matters. Aeration processes are widely used in the water and wastewater treatment fields, providing services such as removal of undesirable dissolved gases or inorganic substances such as iron or manganese and solids removal.

Four basic types of aeration systems are applicable 1) droplet or thin- film aerators such as spray nozzles cascade and multiple tray aerators. 2) Diffusion or bubble aerators using compressed air. 3) Aspirator type aerators and 4) mechanical aerators.

Cascade and multiple- tray aerators operate on the basic principal of maximizing the exposure of the water to the atmosphere by forcing the water to flow over obstructions.

In wastewater treatment plants where anaerobic primary treatment is followed by activated sludge, the sulphides immediate oxygen demand or excess organic matter demand can be met by increasing the rate of air supply to aeration tanks, the capacity aspirators or mechanical aerators. (Sabry T. 2011)

Wastewater treatment plants where anaerobic primary treatment is followed by attached growth require investigating and adopting one of the following systems to aerate the effluent from the anaerobic biological units.

- Micro- Aeration tank where Air can be supplied using aspirators type aerators, surface mechanical aerators or compressors.
- Increasing the final clarifier effluent recirculation rate to filters.
- Upgrade the rotary distribution arms to be mechanically operated (spray nozzles).
- Use of cascades or multiple tray aerators.

Our main concern is to adopt Cascade aerators in Bordain Wastewater treatment plant to aerate the effluent wastewater from UASB. The improvement in dissolved oxygen concentration will be reported and consequently, the performance or overall efficiency of treatment plant.

The application of this new concept in wastewater can produce effluent quality comparable to that produced by centralized conventional wastewater treatment plant (secondary treatment plant) at a much lower cost (El Gohary F.A, 2003).

This technology is also easy to implement and operate. Therefore, it would be more convenient for the conditions of rural areas in Egypt. The satisfactory performance of USBR in sewage treatment indicates that this system could be used in small scale to serve a household or in a big scale to serve small to medium communities. (Elmitwalli T.A, 2002)

Although many other on-site anaerobic treatment systems were used and tested at different countries as a decentralized sewage treatment, still this system has certain characteristics above the other methods.

According to the journal of American water works association, the inclined cascade aeration (ICA) was effective in removing 10 chlorinated volatile organic chemicals (VOCs) from drinking water at liquid loadings of 5 gpm/ft (1.04 L s^{-1}/m) to 15 gpm/ft (3.1 L s^{-1}/m). Overall mass transfer (or desorption) coefficients (KLav) were an order of magnitude larger (0.08-0.54 s^{-1}) than those reported for packed-tower aeration. A curve fit of the experimental data for all 10 VOCs with the equation KLav = 0.019 + 0.091 (Hp)¼(sinθ)4/3, in which Hp is the Henry's law constant (atm) and θ is the angle of inclination, yielded desorption coefficients within ± 18 percent of experimental values. A cascade angle of 60° was found most efficacious for compounds with Hp values > 300 atm; compounds with H p values < 300 atm were most effectively stripped at yet steeper angles. (American Water Works Association, 1992)

According to Khalil, M. & Seif, H. An empirical correlation predicting the effect of the wind speed, step height and flow rate on the aeration efficiency (E20) was developed. The results indicated that the step height and the flow rate had a significant effect on the aeration efficiency. For low wind speed there is no significant wind effect on the aeration efficiency, while high wind speed improves the aeration efficiency due to higher turbulence. It was noticed that the aeration efficiency is shown to depend on the biochemical oxygen demand. (Khalil M. *et al*, 2014)

Materials & Methods

The Wastewater Treatment Plant of Bordain Governorate was upgraded due to the weak removal efficiency and the high concentration of the previous pre- discussed parameters in the effluent of the plant, which proves the low efficiency of the treatment plant. This low performance leads to the thinking of the addition of the Cascade unit. A constructed treatment unit was designed and constructed at Bordain Wastewater treatment plant in Sharkia Governorate, Egypt. It was operated under ambient environmental conditions. The treatment composed of different treatment phases. A cascade tower was added in the channel between UASB and trickling filter in addition to recirculation submerged pump. Water samples were collected from the influent and effluent of WWTP. The first phase includes up flow Anaerobic Sludge Blanket (UASB) with seven open channels entering to the second phase, which includes aerobic cascade aeration. The setup consists of a submerged pump to the third phase which is the Trickling filter. Figure (1) shows the schematic diagram of the setup. The submerged pump of capacity 8L/s are to sump wastewater coming out from the USAB and pump it to a sewer pipe diameter of 4 inch to a fiber tank on the sides of the channel. Then the wastewater is discharged from the tank in both directions gradually through Cascade steps at a height 3 m. Another pump is used to recycle part of the wastewater.

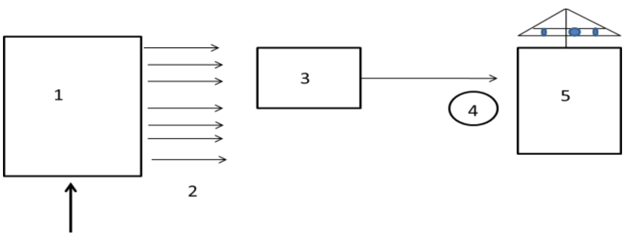

Figure 1 Schematic diagram of the setup

1-UASB, 2-Channel Flow Direction, 3- Cascade Aeration, 4-Submerged pump, 5-Trickling Filter

The channel of flow coming from the UASB has a length of 7.4 m. The dimensions of the cascade aerator are 2m length and each step of aeration is 45 cm * 35 cm. Figure (2) shows an image of the cascade aerator used in the site, where the research took place.

Figure 2 Cascade Aerator

Work Plan

To conduct the desired evaluation a set of factors and analyses to be collected was prepared and results from the different laboratories operated by the governmental operation companies where collected. Analyses for TSS, BOD, COD & DO were collected, certified and reviewed.

Results and Discussion

The study resulted in a relation between the removal ratio and the COD for the samples measured. The analysis was performed before & after the cascade installation. Analyses of influent and effluent wastewater characteristics were carried out at the plants laboratory and results of relevant removal efficiencies are shown in figs (3) to (6).

For Bordain wastewater treatment plant, the results showed low performance of COD was reported. The removal ration didn't exceed 51 % (6- 50 %) of an influent reached 1650 mg/l in Biological filter and the overall efficiency didn't exceed 74%. The influent wastewater COD ranged between 1243- 1651 mg/l. Table (1) shows the wastewater characteristics before the installation of Cascade unit.

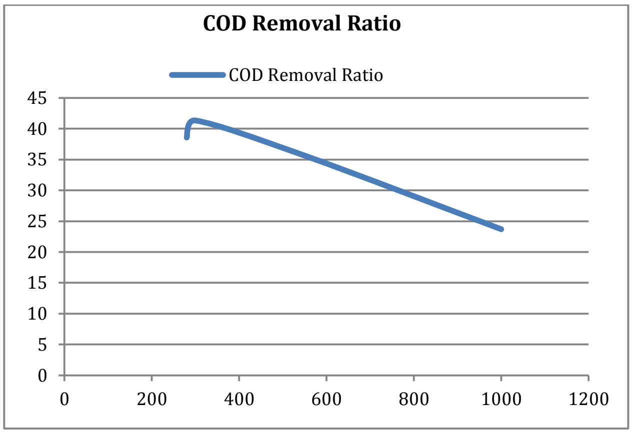

Figure 3 COD removal efficiency before Cascade Installation

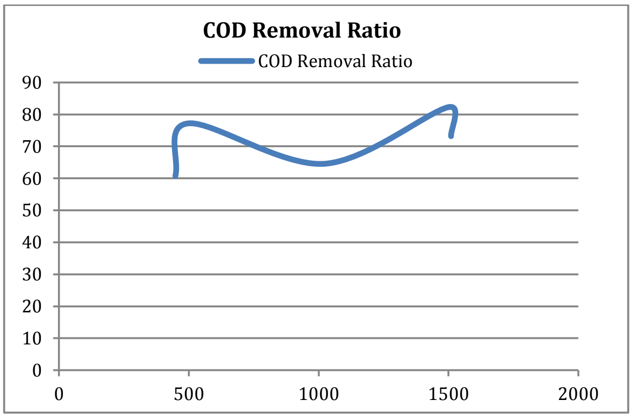

Figure 4 COD removal efficiency after Cascade Installation

Table 1 Wastewater Characteristics before the installation of Cascade Unit

Samples No	Characteristics	Source of Samples		
		Raw Wastewater	Effluent from UASB	Final Effluent
1	• Total Suspended solids TSS mg/l	560	256	236
	• Chemical Oxygen Demand COD mg/l	1243	439	413
	• Biochemical Oxygen Demand mg/l	760	275	217
	• Sulfides S mg/l	16	16	6.8
2	• Total Suspended solids TSS mg/l	675	286	236
	• Chemical Oxygen Demand COD mg/l	1397	475	412
	• Biochemical Oxygen Demand mg/l	810	309	226
	• Sulfides S mg/l	16	24	8
3	• Total Suspended solids TSS mg/l	530	512	265
	• Chemical Oxygen Demand COD mg/l	1651	891	428
	• Biochemical Oxygen Demand mg/l	790	361	220
	• Sulfides S mg/l	16	20	6
4	• Total Suspended solids TSS mg/l	420	359	265
	• Chemical Oxygen Demand COD mg/l	1581	601	415
	• Biochemical Oxygen Demand mg/l	791	315	219
	• Sulfides S mg/l	16	20	6

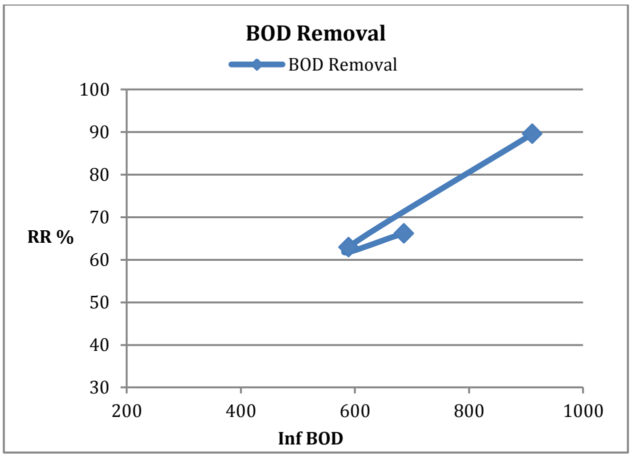

Figure 5 BOD removal efficiency after Cascade Installation

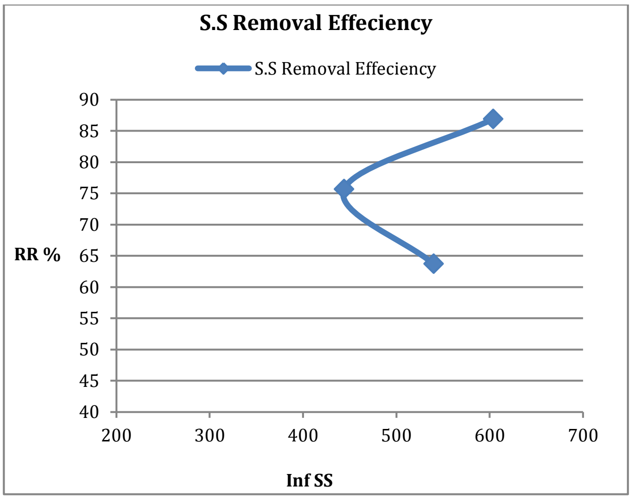

Figure 6 S.S removal efficiency after Cascade Installation

After the installation of the cascade unit, the removal ratio showed noticed improvement in the results. The removal ratio reached 85 % compared to 45% before the installation of the cascade. The removal ratio of BOD reached 90%, while for TSS it reached 87%.

Conclusion and Recommendation

Based on the previous discussions and results, the following points were concluded:

- The cascade aeration process proved excellent quality of treatment up to a concentration of 405 mg/l COD in the effluent compared to 763 mg/l before the installation of the cascade aeration.
- The removal efficiency of COD reached 85 % compared to 45% before the installation.
- The removal efficiency of BOD reached 90% which shows high percentage of removal.
- The removal efficiency of TSS reached87%, which shows the high performance of Cascade in the removal of TSS.
- The Cascade aeration has proven to be of a higher efficiency with better space utilization and low cost financially other treatment systems, it is highly recommended to expand the use of Cascade aerators.

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