Ponds with facultative stabilisation that differ in DO

[1] Dr. Harish Chand Giri, [2]Ms. Sriya Subnam Mohanty*
[1] Professor, Dept. OF Civil Engineering, NIT BBSR,*
Asst. Professor DEPT. of Civil Engineering, SEARC, BBSR
[1]harishchand@thenalanda.com, sriya002@gmail.com*

Abstract: Stabilisation ponds have recently attracted more attention as a natural wastewater treatment method and are currently being used in almost all developed and developing countries across the globe. The technical, economic, energy saving and operational advantages of such treatment systems have motivated many researchers in these countries to study the improvement of stabilisation ponds in order to increase their efficiency and also to lift the difficulties in their operation. Stabilisation ponds derive their justification as a reliable and easy-to-operate treatment system from the fact that the high oxygen demand by aerobic treatment systems requires costly electromechanical aeration equipment whereas stabilisation ponds do not call for such great investments as the process of photosynthesis in ponds generates an abundance of oxygen supply in excess of the system's requirements. In the present study, two stabilisation ponds operating in Isfahan, Iran, were selected and the variations in their dissolved oxygen levels were measured in the plant effluent at various depths and at different distances between the inlet and outlet points. The results revealed that oxygen generation was far in excess of the oxygen demand by the system.

Keywords: DO variation; stabilisation pond; photosynthesis; wastewater treatment; energy.

1 Introduction

Over the world, a wide range of wastewater treatment techniques are employed, including activated sludge, trickling filters, and waste stabilisation pond (WSP) systems (Hegazi, 2013). These systems, which frequently include anaerobic, facultative, and aerobic ponds, are used due of their low cost and ease of building, operation, and maintenance. These systems' drawbacks include evaporation, large land requirements, and odour discharge (Khusravi et al., 2013).

Municipal or other types of wastewater are held in small or large ponds known as facultative stabilisation ponds. The reduction of the organic matter in the wastewater and its treatment are aided by the settling process, solar energy, rising temperatures, and the significant algal and microorganism growths that follow. In these units, the processes of stabilisation and settlement take place simultaneously.

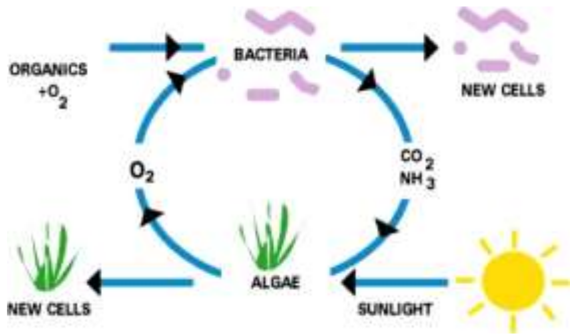
Pond biological processes are more intricate than those found in typical aerobic systems. In stabilisation ponds, bacteria generally degrade the degradable organic debris, absorbing some of it to provide the nutrients needed for algae growths. By the process of photosynthesis, algae then ingest the degraded components and release oxygen into the atmosphere. As a result, the majority of the pond's medium is aerobic, and bacteria use the oxygen that the algae produce to survive. So, with the aid of algae, bacteria, light, and air, the wastewater is treated in a sequence of self-motivated physical, chemical, and biological processes to create a harmless effluent that can be used or discharged into surface waters as necessary.

In facultative ponds, a variety of bacteria are active, resulting in the presence of three separate zones: an aerobic zone on the top, an intermediate zone in the centre, and an anaerobic zone near the bottom.

Although part of the oxygen needed to maintain aerobic conditions in the top zone is drawn from the surface air, the majority of the oxygen is produced by the algae during the process of photosynthesis. If there is an abundance of nutrients and light, algae naturally grows. These algae are what give pools and ponds their green colour.

The bacteria present in these environments consume the oxygen produced by algae to oxidise the organic matter in wastewater. Figure 1 depicts the general view of a facultative stabilisation pond.

Figure 1 The general view of a facultative pond (see online version for colours)



One of the most important products of bacterial metabolism is carbon dioxide that isconsumed by algae in the process of photosynthesis. The carbon dioxide thus obtained isimportant because the quantity of carbon dioxide obtained from the air does not sufficefor the carbon dioxide demand by the photosynthetic reactions of algae. It is, therefore,the case that bacteria and algae maintain a symbiotic relationships within the ponds. As the process of photosynthesis depends on the amount and intensity of light, DO levels inthe pond undergo variations during day-night cycles. This point will be raised again later.The main requirement for aerobic systems is an adequate supply of oxygen, which calls for considerably large investments on electromechanical equipment. Themaintenance and the power requirements of these systems along with the environmental

impacts of power generation through the use of fossil fuels often lead to unmanageable problems which render artificial aerobic systems both formidable and uneconomical to operate. These considerations have led to o recently increased attention to natural methods of supplying oxygen for aerobic systems while it is expected that this interest is yet to grow in the future. With natural methods of oxygen, supply, not only is no power required but also the fixation of solar energy and the consumption of the nutrients in wastewater and their integration into algae will both treat the wastewater and save on power consumption.

The quantity of oxygen generation in the natural method will depend on such factors as geographical location of the stabilisation pond, light intensity, algal concentration, wastewater quality and the like (Gloyna, 1971). It must he remembered that photosynthesis does not necessarily depend on direct light. There are areas in the world where clear sky is only a rarity but stabilisation ponds in them still retain quite photosynthetic conditions (WHO, 1987). At lower light intensities, the efficiency of light conversion by algae is often linear while a saturation level is reached at higher intensities beyond which photosynthetic and/or efficiency will not increase. An ideal photosynthetic reaction is as follows:

$$CO_2 + 2H_2O \xrightarrow{\text{Plants+light}} (CH_2O)x + O_2 + H_2O$$

CH_2O is the organic matter fixed in plants and the generated O_2 is used in the oxidation of the organic content. The daily oxygen production can be determined from the equation (1) (Gloyna, 1971):

$$O_2 = 0.22\ FI \quad (1)$$

where O_2 is oxygen generated in Kg/day; F is the efficiency of energy conversion whichranges between 0.5 to 0.6; and 1 is light intensity in Cal/cm^2.day.

The quantity of the oxygen generated due to algae can also be determined from theequation (2) (Weseley and Eckenfelder, 1989):

$$YO_2 = 2.8\left(10^{-5}\ FI\right) \quad (2)$$

. where YO_2 is the quantity of oxygen generated by algae in Kg/m^2.day; F is the efficiency of light ranging between 0 to 0.4; and I is the intensity of visible light in Cal/cm^2.day

2 Material and method

The case study pilot was built near north of Isfahan WWTP. At first, the raw wastewater enters to the anaerobic lagoon with about 63.5 m^3 volume. Then it pours to facultative pond with about 300 m^3 volume (26.3*12.3*1.6). Detention time of wastewater in facultative pond is about 13 days and its surface load is 130 kg/ha.d. average temperature is about 25 C° under test condition. The weather humidity is 25%. This study was done inspring and summer.

The average BOD of influent and effluent was measured 300 and 63 mg/l, respectively. Dissolved oxygen was measured in every hour during 48 hour (2 days) and with two methods, chemical and prob.

3 DO variations

The level of dissolved oxygen in wastewater is the best indicator of the satisfactory operation of maturation and facultative ponds. In the afternoon, the surface and the lower layers in facultative ponds normally reach a super-saturation stare (Gloyna, 1971). In most cases, DO concentration may even reach zero with decreased light, foggy air, and at night. During most of the day-night, the DO exists in the upper layers which provide the following advantages:

- Odours from the bottom anaerobic layer are diminished;
- One of the factors effective in the bacterial removal in stabilisation ponds is high DOand pH levels, which forms a major advantage of such systems (Mara et al., 1992).
- Dissolved oxygen plays the major role in the treatment of wastewater and in the stabilisation of pollutants. Supplying adequate DO levels is of utmost importance inall treatment systems. It should be mentioned that in artificial treatment methods, such as the activated sludge system, huge amounts of costs and energy are required to provide no more than a DO level of 2 mg/l.
- Increasing levels of dissolved oxygen in stabilisation ponds causes part of it to bereleased in the surrounding area, making a pleasant atmosphere nearby.

Figure 2 The hourly changes of DO and pH in facultative pond in Isfahan, Iran (see onlineversion for colours)

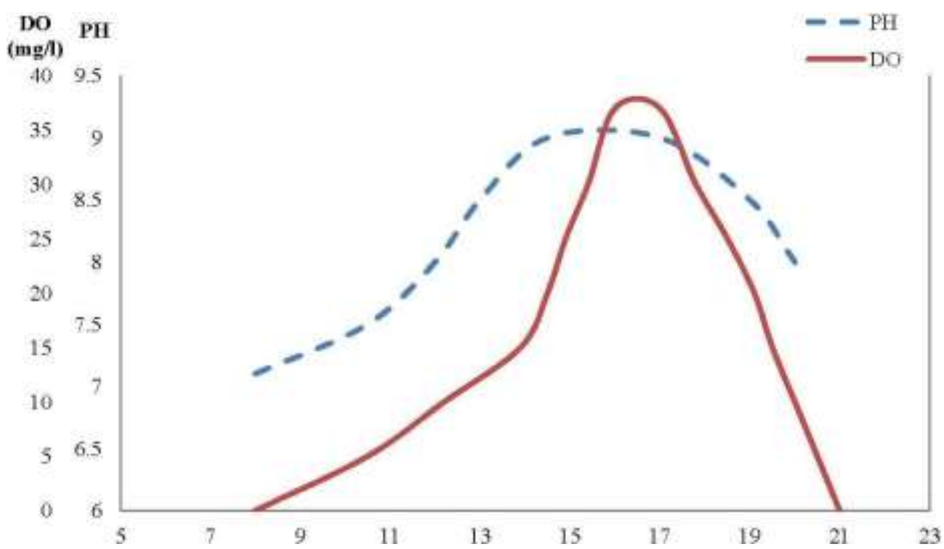


Figure 3 Variation of dissolved oxygen measured at one-hourly intervals over at 24 hour periodin a facultative pond in Brasilia, Brazil (see online version for colours)

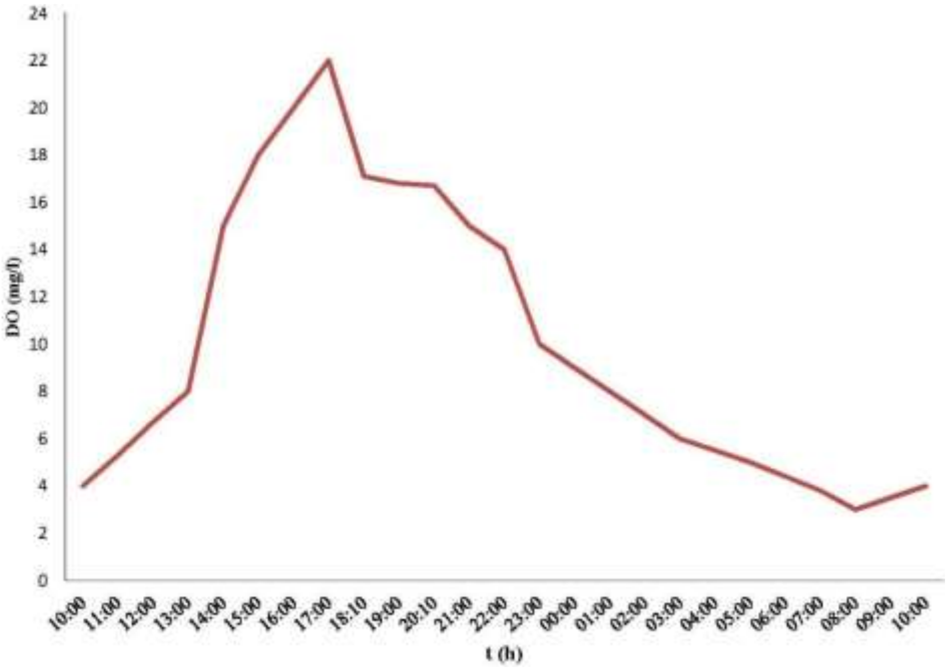
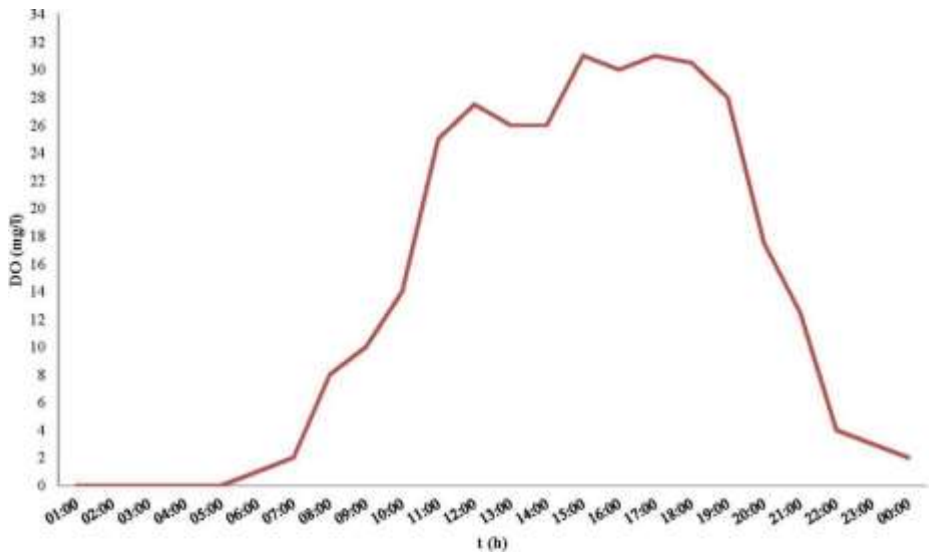


Figure 4 The hourly changes of DO from effluent of facultative stabilisation pond (see onlineversion for colours)



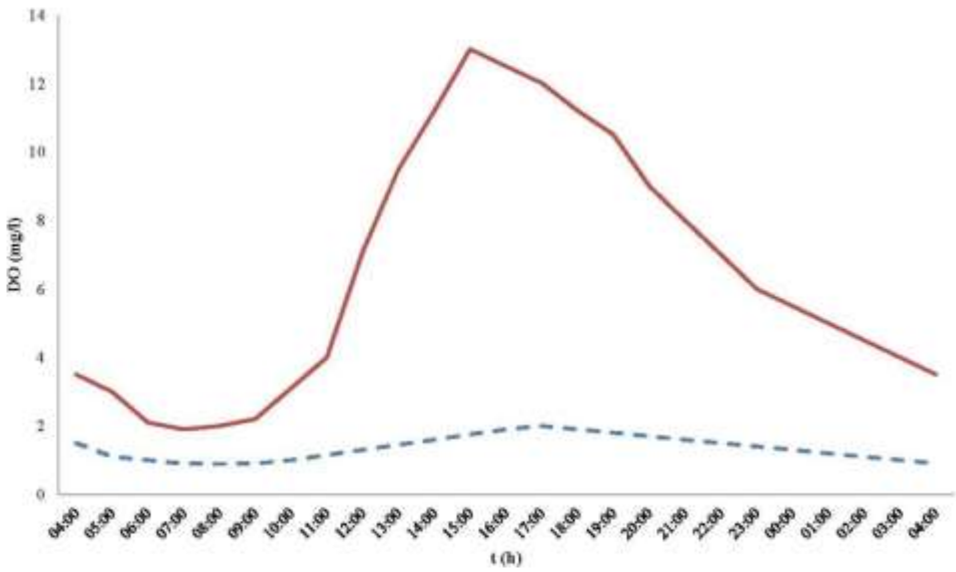
The experience gained from the study in Isfahan shows that with increasing amounts of light from early in the morning, the DO level in the lagoons rises until it reaches its super-saturation state around 3:00 PM which gradually reduces by 5:00 PM in the afternoon and then drops to zero by 10 PM (in the summer) (Gheisari, 1978). Figure 2 shows the hourly changes of DC and pH variations for Isfahan region and Figure 3 showsDO variations in Brazil (WHO, 1987).

In another study carried out in Isfahan on an operating facultative pond, the hourly variations in DO levels were measured at regular intervals (Gheisari, 1998). As shown in Figure 4, the maximum DO level in the plant effluent reaches over 30 mg/l which is threetimes.

This maximum is reached with high intensities of light leading to increased algal activity and concentration. Under such conditions, pH levels also reach a maximum. The generation of oxygen in such cases is so high that the gas emissions produce a milky pond surface and also that the oxygen emissions are easily observed. The milky colour of the pond surface lasts for a short time and then turns into green.

In this study, DO concentrations were also measured at various depths along the stabilisation pond at several points from the inflow to the outflow points. The results revealed that DO concentration increased toward the outlet point which is due to the gradual reduction in organic content and the increase in algal activities. At increased depths, DO level sharply dropped and reached zero level. This is accounted for by the fact than increased algal concentration at higher depths prevents the penetration of light, thus reducing oxygen levels. Figure 5 shows the DO variations against time at two different depths (0.2 and 0.8 m from wastewater surface).

Figure 5 DO variations against time at two different depth (see online version for colours)



Note: 0.2 and 0.8 m from wastewater surface.

It should also be mentioned than the variations in oxygen level at different depths of the stabilisation pond reflects the ‘dominant plug flow hydraulic regime rather than the complete mix’.

4 Conclusions

Considering the fact that the artificial aerobic treatment of wastewater is accomplished through dissolved oxygen and that supplying the oxygen demand requires heavy investments on electromechanical equipment, increased maintenance costs, dependence on skilled human power and on fossil fuel for power generation, it follows that the aerobic systems may not be feasible in all countries and in fact in some cases it may not be even practical. On both economic and technical grounds, it is therefore recommended that the natural and simpler methods of supplying energy for aerobic systems be applied in wastewater treatment. Stabilisation ponds have the potential to satisfy all these objectives. The process does not depend on power, in the first place. Rather, the solar energy is fixed in plants and wastewater nutrients are integrated into algal cells which can also be considered as a food source in view of the shortage of food in the present century. On the other hand, another advantage of this natural treatment process is that the DO level is mostly at saturation level and at times also at super-saturation level.

References

Gheisari, A. (l978) *Algae Removal from Effluent of Waste Stabilization Ponds*, MS thesis, Schoolof Public Health, Tehran University.

Gheisari, A. (l998) *Effect of Rock Filters on the Efficiency of Stabilization Ponds*, PhD thesis,School of Public Health, Tehran University.

Gloyna, E.F. (l971) *Waste Stabilization Ponds*, WHO, Geneva.

Hegazi, B. (2013) 'Evaluation of waste stabilization ponds performance in Egypt', *Journal of Applied Science Research*, Vol. 9, No. 1, pp.638–642.

Khusravi, R., Khodadadi, M. and Gholizadeh, A. (2013) 'BOD removal kinetics and wastewater flow pattern of stabilization pond system in Birjand', *European Journal of Experimental Biology*, Vol. 3, No. 2, pp.430–436.

Mara, D.D., Alabaster, G.P., Pearson, H.W. and Mills, S.W. (l992) *Waste Stabilization Ponds*, Lagoon Technology International, Leeds, UK.

Weseley, W. and Eckenfelder, J. (l989) *Industrial Water Pollution Control*, McGraw-Hill, Singapore.

WHO (l987) *Waste Stabilization Ponds*, EmroTechnical Publication, No. 10, Alexandria, Egypt.

