

## Performance Evaluation of Trickling Filter and Extended Aeration of Wastewater Treatment Plants

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### ABSTRACT

In recent decades, there has been increasing interest in wastewater treatment because of its direct impact on the environment and public health. Over time, other forms of treatment have been developed and modified, including extended aeration. This process is included in the suspended growth system. In this paper, a comparative study was conducted between the efficiency of the extended aeration plant and that of the trickling filter plant in removal of BOD and COD. The method of comparison was done by knowing the value of the pollutant before and after the treatment and then extract the removal ratio of each pollutant within each plant. The results showed that the percentage of removal of BOD in the trickling filter was 79.5% while in extended aeration was 90.7%. The efficiency of COD removal was 60% in trickling filter and 86% in extended aeration. The study was carried out at the Barrakiyah WWTP in Najaf province in Iraq. As the plant contains these two types of treatment, and the study has been achieved through monthly examinations over a full year.

**Keywords:** extended aeration, trickling filter, performance evaluation.

### تقييم اداء المرشح النقطي والتهوية الممتدة في محطات معالجة مياه الصرف الصحي

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### الخلاصة

خلال العقود الاخيرة اصبح الاهتمام متزايدا بعملية معالجة مياه الصرف الصحي نظرا لما تمثله من تأثير مباشر على البيئة والصحة العامة. بمرور الوقت تم تطوير و تعديل اشكال اخرى للمعالجة ومنها عملية التهوية الممتدة. هذه الوحدة تعتبر ضمن نظام النمو المعلق. في هذه الورقة البحثية تم تقديم دراسة مقارنة بين كفاءة الفلتر وكفاءة التهوية في ازالة BOD و COD. طريقة المقارنة تمت من خلال معرفة قيمة الملوث قبل وبعد المعالجة ومن ثم استخراج نسبة الازالة لكل ملوث داخل كل محطة. حيث اظهرت النتائج ان النسبة المئوية لأزالة BOD في التهوية الممتدة 90.7% بينما في الفلتر كانت 79.5%. أما كفاءة ازالة COD فقد كانت 60% في المرشح المنقط و 86% في التهوية الممتدة. جرت الدراسة في محطة البراكية في

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محافظة النجف في العراق . حيث ان المحطة تحتوي على هذين النوعين من المعالجة و قد تم تحقيق الدراسة من خلال الفحوصات الشهرية على مدى عام كامل .  
الكلمات الرئيسية: التهوية الممتدة، المرشح المقطر، تقييم اداء.

## 1. INTRODUCTION

Over the past years, many experiments and studies have been conducted for the purpose of improving wastewater treatment processes and developing them in a way that meets the requirements of health standards (Khudair and Jasim, 2017). Studies have focused on the development of biological treatment units to increase efficiency, reduce energy consumption and reduce maintenance costs (Alsaqqar, et al., 2014).

The extended aeration represents a modified activated sludge process by prolonging the detention time of the sewage in the aeration tank. This process is one of the suspended growth systems. The trickling filter is the traditional application of attached growth system. It is considered one of the oldest methods of wastewater treatment (Nikmanesh and Eslami, 2018).

(Heidari, et al., 2016) carried out a study to evaluate the performance of extended aeration in the removal of BOD and COD, where the value of influent BOD and COD of about 388 mg/L 643 mg/L, results found that the removal percentage of BOD and COD up to 91.7% and 91.9% and this is a good indicator of the efficiency of this process. (Al-Shammari and Shahalam, 2019) presented a study of the Jahra wastewater treatment plant in Kuwait, which operates the extended aeration system with an actual capacity of 65000 m<sup>3</sup>/day, and the percentage of removal of BOD and COD was about 85% and 81%. Another study was conducted by (Hashimzadeh, et al., 2017) to evaluate performance of full scale extended aeration plant and the efficiency for BOD and COD removal was 85.2% and 82.4%. (Al-Rekaby, et al., 2017) conducted a study to evaluate an intermittent cycle extended aeration and found that the percentage removal of COD is 87%. Alkhdhraa extended aeration plant was evaluated by (Qasim and Al-Obaidi, 2018) and found the efficiency of BOD and COD removal was 83% and 79%, respectively.

Regarding the trickling filter, a study was conducted by (Zylka, et al., 2018) to determine the performance of the trickling filter to remove the BOD from one of the dairy factories and the result was that the removal percentage was 87% without recirculation and 95% with recirculation. Another study was conducted by (Ewida, et al., 2006) to improve the efficiency of the trickling filter by replacing the old traditional circular nozzles with radial nozzles for the purpose of improving oxygen transfer and increasing the wetting of the media. The results showed an increase in efficiency of BOD removal by 10%.

The aim of this study is an evaluation of the performance of the trickling filter and extended aeration with using the comparison as a tool. The comparison under real conditions through the analysis of the real plant examinations containing the two systems, which is Albarrakiya WWTP in the province of Najaf, Iraq.

## 2. MATERIALS AND METHODS

### 2.1. Case Study Discription

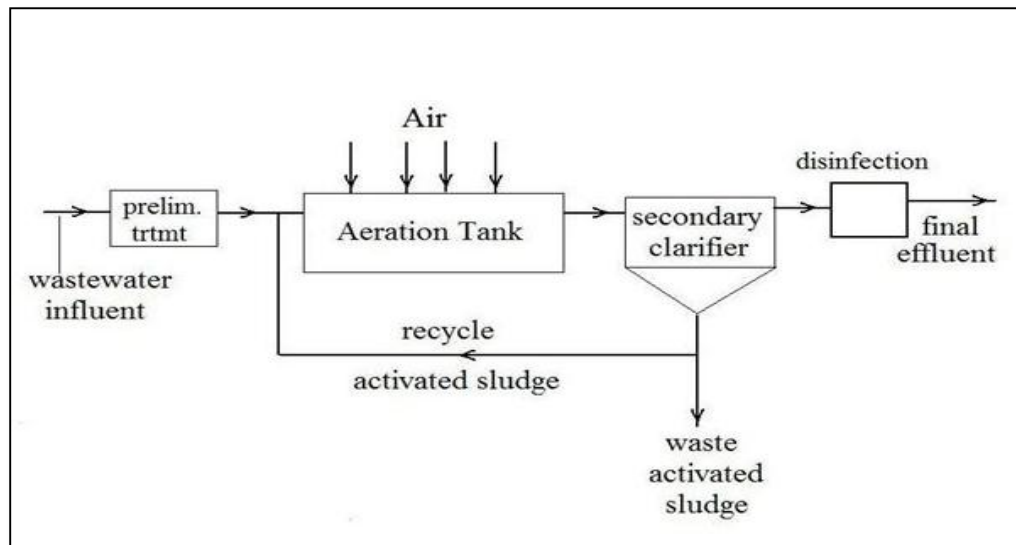
The study was conducted at Albarrakiya WWTP (32° 0' 44" N, 44° 25' 20" E) in the province of Najaf, which lies south of Baghdad, about 175 km.

The extended aeration plant is designed to accommodate and treat the sewage of about 5,000 m<sup>3</sup>/day as shown in Fig. 1. The screens represent the first treatment unit in the plant, which has two types of screens: coarse and fine, and the purpose of it is to protect the other parts of the plant from the floating particles and large particles. These screens are cleaned manually and mechanically. There is a circular tank with a height of 2.5 m and a diameter of 11 m and represents a unit for the removal of grits and oils.

The biological treatment unit in this plant is the aeration tank, which is a diameter of 59 m and height 3.5 m and contains blowers to pump air inside the tank for the purpose of providing the oxygen needed by the microorganisms to complete the treatment and provide the appropriate mixing process within the aeration tank. The period of retention of sewage inside the tank is up to a full day for the purpose of giving bacteria sufficient time to complete the treatment. The process of separating the sludge from the liquid is carried out in the secondary sedimentation tank, where the clarifying process is carried out using the principle of gravity, and the diameter

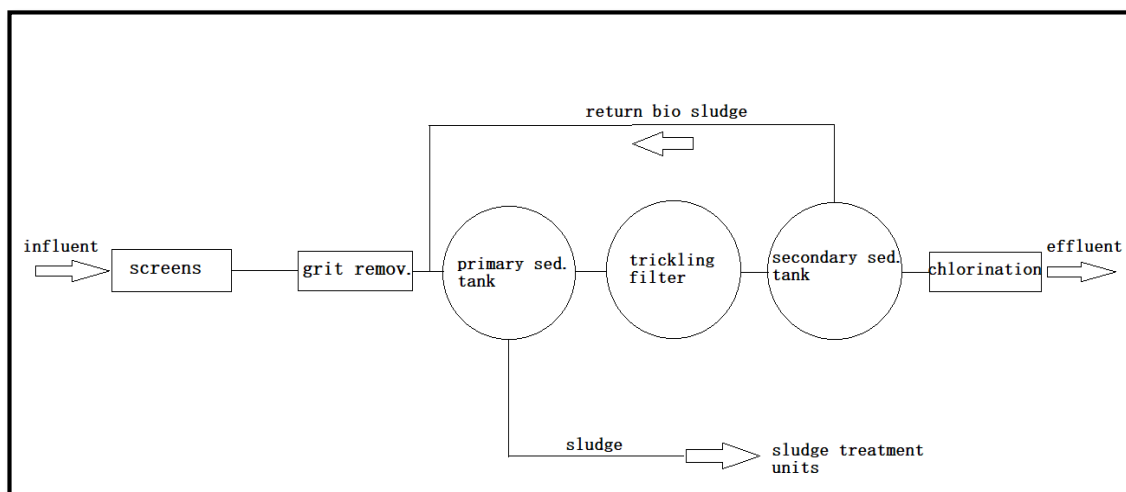
of this tank is about 28 m and its height is 3 m. Part of the sludge is returned to the aeration tank to increase the efficiency of the treatment. The remaining part is transferred to the sludge treatment line, which contains thickener, digester and drying beds.

The second plant is a trickling filter type that serves about 140,000 people with a design capacity 28000 m<sup>3</sup>/day. It consists of the following facilities as shown in **Fig. 2**; screens which are located after the main gate, where there are two channels, each of them contains two types of screens, rough and fine which are designed to prevent large particles from entering the next parts of the plant to protect them from damage and clogging. The next unit is the grit chamber, which was used to remove sand and grit from wastewater by gravity, and its purpose is to protect the subsequent parts of the blockage and reduce the load on the sedimentation basins.



**Figure 1.** Plan of extended aeration plant.

Primary sedimentation tanks (PST) represent the primary treatment stage. In these units, the sludge is deposited and separated from the wastewater and then drawn from these basins to other processing units. Albarrakiya WWTP contains two circular PSTs with maximum hydraulic loading 45 m<sup>3</sup>/m<sup>2</sup>.day and the diameter of each tank 31.6 m.



**Figure 2.** Plan of trickling filter plant.



The first unit of secondary treatment is Biological Trickling Filter (TF). It represents the most important part of the plant and is responsible for the removal of dissolved organic matter by microorganisms that form a biofilm on the surfaces of the packing material in the TF. There are 4 TFs in Albarrakya WWTP with maximum organic loading  $1 \text{ kg BOD/m}^3$ , and the surface area of each filter is  $908 \text{ m}^2$ .

The next unit of secondary treatment is a secondary sedimentation tank (SST). In this unit the activated sludge that resulted from the process of forming the biofilm in TFs is settling. Activated sludge is returned to the primary sedimentation basins to increase the removal efficiency. The plant contains 2 SSTs, and the diameter of each one of them is 31.6 m. In addition, the plant contains a chlorination unit as well as a treatment line for the resulting sludge.

## 2.2. Data Collection

The data used in this research was obtained from the field laboratory of Najaf Sewage Project Management / Ministry of Municipalities and Public Works of Iraq. It includes monthly examinations for one year from January 2018 to December 2018. The laboratory examines the parameters of the wastewater influent and effluent the plant. The comparison with the Iraqi standards, which sets a higher limit for each parameter, should not be exceeded. In terms of this study, BOD and COD was used as parameters for comparison.

## 3. EXTENDED AERATION AND TRICKLING FILTER CONCEPTS

Extended aeration is one of the modifications to the conventional activated sludge that removes biologically degradable organic pollutants from wastewater. This system is used for small communities and differs from the conventional system by not having a primary sedimentation basin. Air can be provided either mechanically or by pumping inside the tank to maintain the aerobic conditions of the process. Microorganisms must remain in continuous contact with dissolved organic matter through continuous blending by aeration. For better efficiency of this process, the pH must be controlled, as well as the essential nutrients that must be available to ensure biological growth, (Al-Shammari and Shahalam, 2019).

A trickling filter is one of the aerobic technologies used to treat sewage, and through which microorganisms attached to the surfaces of the packing media are used to remove organic matter from sewage. This system is common in a number of other treatment techniques such as, bio towers and rotating biological contactors. These systems are common as attached growth processes. On the other hand, systems in which microorganisms are suspended in a liquid are known as suspended growth processes (Zylka, et al., 2018).

## 4. RESULTS AND DISCUSSION

### 4.1. Raw Sewage Assessment

The characteristics of the influent raw sewage of the two plants are the same as the sewage is collected in the main pump station, and then it distributed between the two plants according to the capacity of each plant. Fig. 3 shows the average monthly values of the COD and BOD where the annual average of each of them was  $146 \text{ mg/L}$  and  $311 \text{ mg/L}$  respectively. The maximum value of influent BOD was  $190 \text{ mg/L}$  in August and September, and the minimum value was  $100 \text{ mg/L}$  in October and November. The maximum value of influent COD was  $373 \text{ mg/L}$  in August while the minimum value was  $278$  in October.

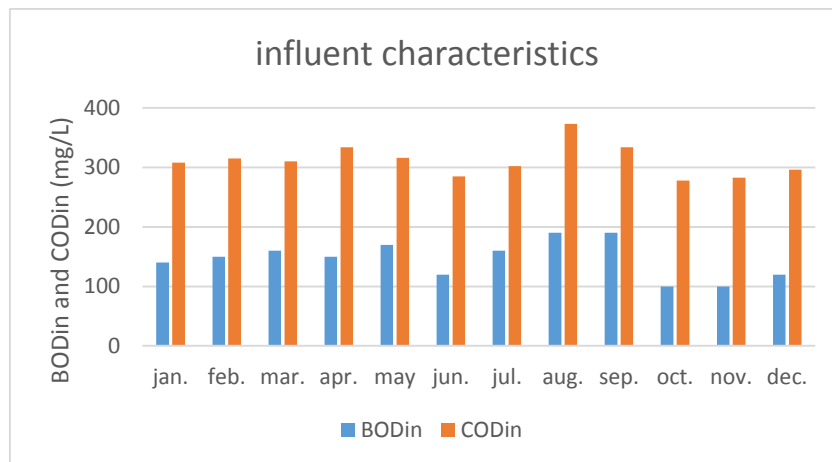


Figure 3. Influent variation BOD and COD with study period.

#### 4.2. Assessment for effluent BOD

Fig. 4 represents the values of effluent BOD from the two plants during the year of study. The annual average value of effluent BOD was 29 mg/L from trickling filter (TF) while it was 12 mg/L from extended aeration (EA). The maximum value in TF was 51 mg/L in January and the minimum value was 15 mg/L in October and November. The maximum value in extended aeration was 20 mg/L in November, while the minimum value was 10 mg/L over seven months of year of study.

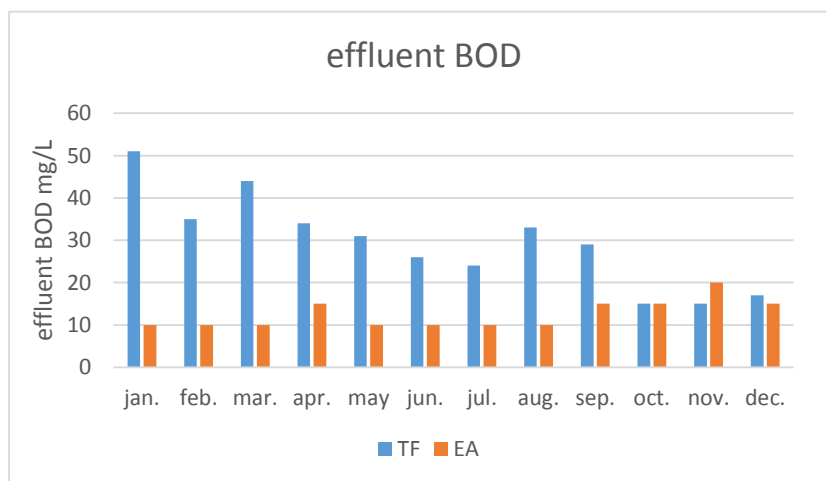
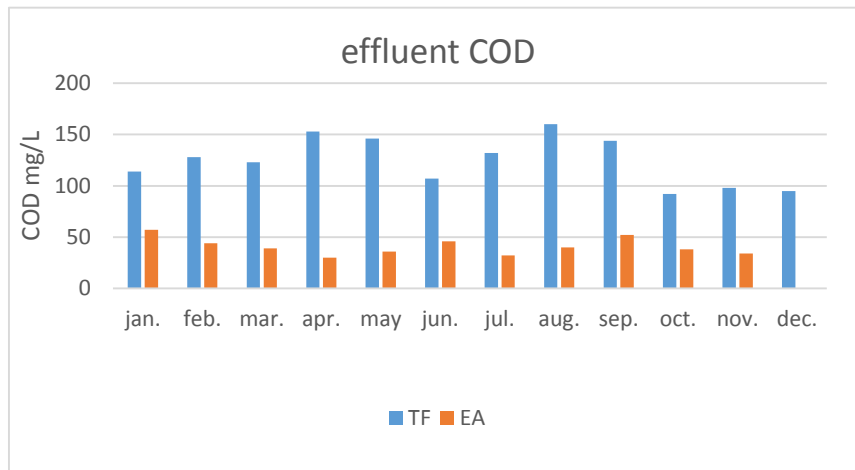


Figure 4. Effluent variation BOD with study period.

#### 4.3. Assessment for Effluent COD

Fig. 5 represents the values of effluent COD from the two plants during the year of study. The annual average value of effluent COD was 124 mg/L from trickling filter (TF), while it was 41 mg/L from extended aeration (EA). The maximum value in TF was 160 mg/L in August, and the minimum value was 92 mg/L in October. The maximum value in extended aeration was 57 mg/L in January, while the minimum value was 30 mg/L in April.



**Figure 5.** Effluent variation BOD with study period.

The annual percentage removal average of BOD from TF was 80%, while EA was 91%. The same average for COD removal was 60% from TF and 86% from EA.

## 5. CONCLUSIONS

- In general, the efficiency of the extended aeration plant is higher than the trickling filter. The efficiency of BOD removal from TF was 80% while EA was 91%, and efficiency for COD removal was 60% from TF and 86% from EA.
- The trickling filter meets the Iraqi standards for effluent BOD (40 mg/L) so that the effluent BOD was 29 mg/L, but it is out of standards for effluent COD due to operational conditions and insufficient instrument used, so that the value of effluent COD was 124 mg/L ( the standard is 100 mg/L).
- The extended aeration meets the Iraqi standards for both effluent BOD and COD.
- The trickling filter plant needs continuous maintenance and requires high efficiency in the initial treatment process to avoid blockage of the media or coating with fats and oils.
- Both systems can be used for small or medium-sized communities wherein the case of large communities they require large areas and high costs for construction and maintenance



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