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EXTENDED ABSTRACT

Performance Evaluation and Comparison of Facultative Ponds in Series and Parallel for Wastewater Treatment (Case study: Delijan WWTP)

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1. Introduction

Waste stabilization pond (WSP) is a conventional and widely applicable wastewater treatment unit globally. This system does not require complicated mechanical operating systems but it should not be classified as a simple process at all. Facultative ponds (FP) are the heart of this system as they use the natural symbiosis of facultative bacteria and algae for organic removal. The performance of FP is very reliant on different parameters such as wastewater influent characteristics or environmental operating conditions. Nonetheless, they are simply designed and operated based on parameters like surface organic loads and hydraulic retention time (Khosravi et al. 2013). Some literatures have recently focused on the optimization of WSP layout for higher performance (Shahsavani et al. 2019; Decostere et al. 2017; Espinosa et al. 2017). For example, a question is that which form of FPs, in series or parallel, have the highest performance or operational reliability? Answering to this question is practically a challenge. There is little chance in full scale to compare the performance of FPs with the layouts in series and parallel for long term, with same source of real wastewater, similar climate and operating conditions. This research primarily evaluates and compares the performance of FPs (2008-2020) in series and parallel layout in Delijan WSP.

2. Methodology

2.1. Study area

This study was carried out in Delijan wastewater treatment plant (WWTP) including two parallel anaerobic ponds (AP1 and AP2), two FPs (FP1 and FP2) and finally a disinfection unit. FPs were initially implemented in series (2008-2017), while they were changed into parallel later (2018-2020). High pollution load is the main problem of this facility as their dissolved oxygen (DO) and oxidation-reduction potential (ORP) reduces below 1mg/L and -150mV, respectively.

2.2. Analysis and tests

The experimental results of Delijan WWTP coupling with water quality data of the inflow and outflow of FPs were compared by statistical methods (Mann-Withney) with 95% confidence interval and Minitab 19 software. Accordingly, the data of water quality parameters such as biochemical oxidation demand (BOD), chemical oxidation demand (COD), total suspended solids (TSS), and fecal coliform (FC) in addition to the

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supplementary sampling data of total kjeldahl nitrogen (TKN) and nitrate were evaluated and compared in different scenarios. Two layouts of FPs (S: series and P: parallel) and two weather conditions (Warm: for spring and summer and Cold: for fall and winter) were considered for detailed comparison.

2.3. Pilot study

Since low DO is an operational problem of FPs, a pilot study is also carried out in this research to control the impacts of limited pre-aeration of the inflow of FP on its performance and operation. For this purpose, FP1 fed by AP1 is pre-aerated temporarily for pilot study in both summer and winter periods, while FP1 remained without pre-aeration.

3. Results and discussion

Overall COD and BOD removal efficiency of Delijan WWTP show that this system has acceptable average performance of 79% in long term. Facultative ponds, in S and P layout, have 65-70% organic removal and 30-40% TKN removal efficiencies.

The statistical comparative results indicated that some parameters like BOD in the effluent of FPs and BOD and COD removal efficiencies (%) have not been changed significantly (P value > 0.05) in P formation in comparison with S layout. However, the concentrations of specific parameters have been increased significantly (P value < 0.05) such as TSS (19%) and TKN (31%) while the ratio of BOD to COD content of effluent was also increased significantly (10%). These considerable variations of aforementioned parameters show that FP with parallel layout has inferior performance and operation in comparison with S layout. In a nutshell, WSP capacity on removing readily biodegradable compounds of wastewater is reduced in P layout. In addition, the possibility of flushing algae out is also increased. It can be concluded that wastewater degradation is more completed in S formation of FPs.

Detailed comparative analysis also shows that the main weakness of FPs in P formation is embedded during cold weather conditions. In S layout, due to elongated hydraulic plug-flow condition, the anaerobic inflow to FPs is gradually improved to aerobic from APs to the FP2. It provides at least a more reliable operation for FP2 in comparison with P layout. This specification strengthens the operation of FPs during cold periods. Therefore, lower DO level of FP1 and FP2 in P layout can reduce the nitrification and readily biodegradable oxidation potential of organic compounds. Consequently, TKN concentration and the ratio of BOD to COD increase in P formation, particularly during cold weather.

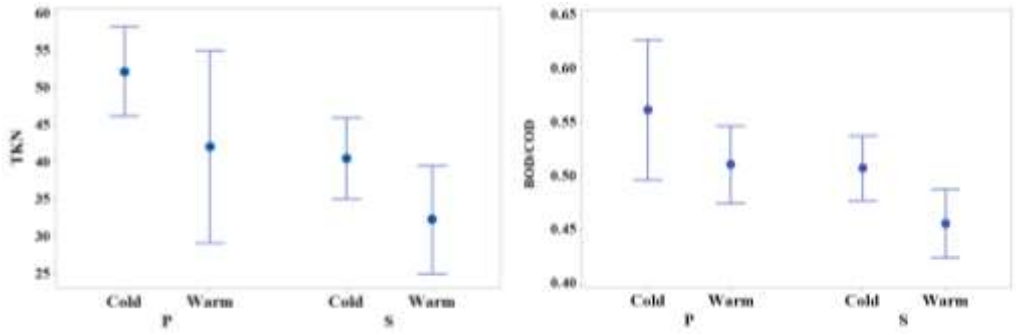

Fig. 1. TKN concentration (left) and BOD/COD ratio (right) in effluent of facultative ponds in series (S) and parallel (P) formation in cold and warm seasons

The results of pilot study show that FPs with P layout can be strengthened in performance and operation, particularly in cold weather which relatively supports the weakness. In other words, temporary pre-aeration of FPs can relatively improve the performance of these treatment units in winter when the aeration potential of algae naturally reduces. This technique may enhance TKN removal efficiency (%) and reduces the ratio of BOD to COD in the treated wastewater (Fig. 2).

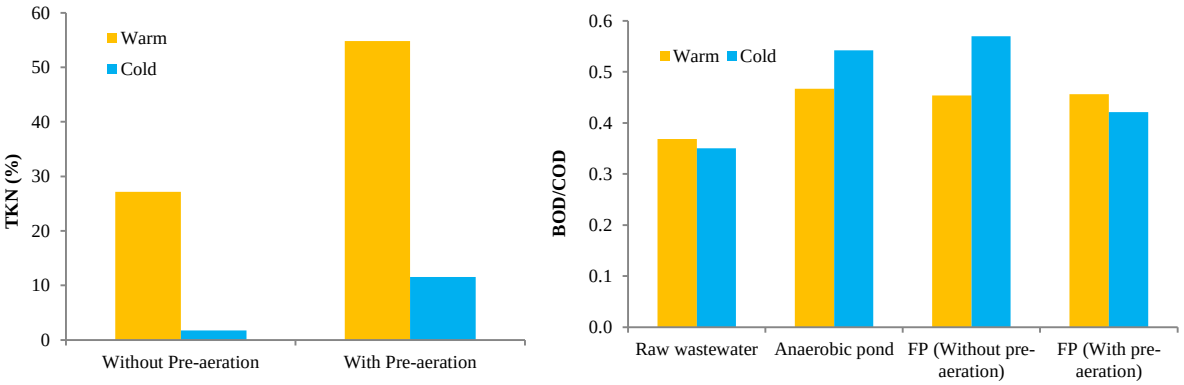

Fig. 2. TKN removal (left) and BOD/COD ratio (right) of Delijan WWTP with parallel facultative ponds (FP) with and without pre-aeration in cold and warm seasons

4. Conclusions

Regarding the statistical and experimental results, it was concluded that FPs with parallel formation is inferior in performance and operation in comparison with S layout. In an overloaded WWTP like Delijan WSP, TKN and readily biodegradable removal of wastewater are adversely influenced significantly. In this condition, S layout has more completed biodegradation potential. In addition, this formation has more reliable performance during colder seasons. However, pre-aeration of parallel FPs can relatively compensate this weakness. It can also be recommended that elaborate evaluation and comparison of FPs should not be limited to ordinary BOD and COD removal efficiencies. TKN, TSS, FC, DO, ORP and BOD/COD ratio are some parameters that may provide an extended perspective for decision-makers and researchers.

5. References

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