Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 51(1) (2019) 129-142
DOI: 10.22060/ceej.2017.13167.5342

Development of Performance Indicators for Evaluation of Wastewater Treatment Plants Operation

S. Nazif*, M. Gholami Mayani, B. Roghani

School of Civil Engineering, College of Engineering, University of Tehran, Tehran, Iran

ABSTRACT: Typically, management and operation of wastewater treatment plants are based on comparison of the effluent quality with the defined standard values. Under this approach, only after the occurrence of a failure, the problem in system performance is recognized. In the present study, a new methodology is proposed to predict the wastewater treatment plant performance as well as its units, based on the inflow characteristics. For this purpose, first, the wastewater treatment plant simulation model is developed. After that, the relative importance of each inflow characteristic on the performance of the system is evaluated. Then, performance indicators are defined. In the present study, the chemical oxygen demand (COD) and suspended solids (SS) removal efficiency have been used for this purpose. This process reduces the costs and risks of the system failure. The proposed methodology in this study was implemented on a real case study. The selected indices well response to the inflow variables (such as flow and SS). As a result, it is possible to estimate and check the total and unit performance of wastewater treatment plant with acceptable accuracy. Finally, it can be used effectively to adopt preventive policies for improving the performance of wastewater treatment plants and risk management.

Review History:

Received: 19 July 2017
Revised: 17 November 2017
Accepted: 20 November 2017
Available Online: 5 December 2017

Keywords:
Performance Evaluation Indicator
Wastewater Treatment Plant
Treatment Process Simulation
Wastewater Treatment Modeling
Activated Sludge

1- Introduction

Typically, management and operation of wastewater treatment plants (WWTPs)is based on effluent quality and comparing it with allowed values by standards. Under this approach, only after the occurrence of a failure in system performance, operators are informed about having a problem in system operation. As a result, simulation of treatment processes and evaluation of the performance of different treatment units under the inflow conditions or system operation variables is essential. One of the effective factors in the performance of wastewater treatment plants is the characteristics of inflow. The previous studies on WWTPs performance evaluation have mainly focused on the wastewater treatment plants' management and have less dedicated to the effect of inflow characteristics such as flow, chemical oxygen demand (COD) and suspended solids (SS) on the performance of the WWTP. In this research, the focus is on the identification and consideration of effective variables on the performance of WWTPs to evaluate and improve their performance efficiency. Based on the developed performance indicators, the efficiency of the WWTP's units and the whole plant are investigated. Also, according to the developed indicators, a set of rules are developed to predict the system outflow characteristics based on the inflow, which is of great importance in the optimal management and operation of WWTPs.

Corresponding author, E-mail: snazif@ut.ac.ir

2- Methodology

The proposed algorithm in this paper is able to consider the effects of unusual conditions on the system's performance. Unusual conditions refer to those conditions in which the variables affecting the system's performance exceed the usual values and may cause system disruption. The proposed framework consists of three main phases and six steps. The first phase leads to the identification of the WWTP's performance evaluation indicators. In the second phase, by analyzing the WWTP data and examining unusual conditions, a relationship is developed to evaluate the performance evaluation indicators based on the system's effective variables and ultimately, in the final phase, according to the determined indicators, performance of a real WWTP is investigated to show the capability of the proposed methodology to be applied to real cases.

One of the most important requirements in the development of indicators and criteria for performance assessment of wastewater treatment plants is to simulate the performance of these plants under different operating conditions. For this purpose, variety of models has been developed for various wastewater treatment processes. In this study Activated Sludge Model 1 (ASM1) is used. This model is an international standard for activated sludge process modeling

and takes into account the chemical oxygen and nitrogen demand in suspended growth treatment processes, including nitrification and de-nitrification mechanisms. It has been proven that this model has a good description of the activated sludge process. Also in the present study, STOAT software is used to simulate the wastewater treatment processes. The reason is that, in addition to free access, it provides a variety of wastewater treatment plant's units' models.

3- Case study

As a case study, the performance of Karlsruhe wastewater treatment plant in Germany is evaluated. This plant is designed to treat the wastewater of a hundred thousand people and operate at an average inflow of 1000 cubic meters per hour. The treatment process in this plant is activated sludge and consists of screen, grit chamber, primary sedimentation tank, activated sludge, secondary sedimentation tank, filtration, de-watering and sludge digestion.

4- Results and Discussion

Based on the treatment system, removal efficiency of COD and (SS) for the entire treatment plant, as well as the primary settling tank and activated sludge unit can be considered as the objectives (indicators). The reason for choosing these two objectives is their relative comprehensiveness in most of the wastewater effluent quality assessments and also the emphasis of effluent standards is mainly on these parameters [1-3]. It is evident that the objectives can vary according to the operating conditions and the operator's point of view.
Results showed that, in spite of existence of data far beyond usual conditions, the robustness of the WWTP under these conditions is acceptable. Also, the average performance indicator (PI) of COD removal is 0.99, which shows the desirable performance of the system. In addition, the average PI of SS removal is equal to 0.93. Moreover, the weighted average of these performance indicators is equal to 0.96 for the entire WWTP, which indicates a fairly good performance of the plant (e.g. refer to the Figure 1 to determine the PI of COD removal of the whole plant).

Similarly, the values of the average PI of COD removal, SS removal and their weighted average for primary sedimentation tank are 0.44, 0.66 and 0.53respectively, which are relatively inappropriate; and for the activated sludge unit those numbers are 0.78, 0.95 and 0.91 respectively, which seems satisfactory.

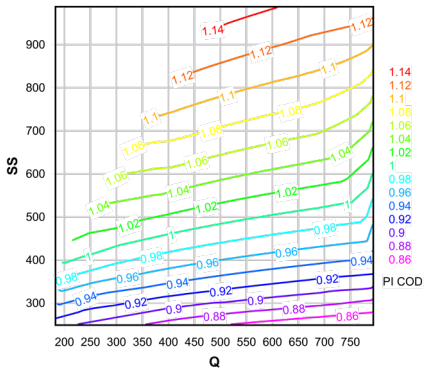

Figure 1. PI of COD removal of the whole plant

5- Conclusion

The proposed methodology reduces the costs and risks of the system's failure. The selected indicators have a good variability in relation to the inflow variables (such as flow and SS), and changes of these variables can easily affect performance indicators. As a result, it is possible to estimate and check the performance of each unit and the whole plant with acceptable accuracy. Finally, it will be possible for the operators to adopt preventive policies to improve the performance of wastewater treatment plants and risk management process.

References

[1] FAO, Environmental quality (industrial effluent) regulations, 2009.

[2] J. Yan, Comprehensive Evaluation of Effective Biomass Resource Utilization and Optimal Environmental Policies, Springer, 2015.

[3] A.F. Martins, D.R. Arsand, C.B. Brenner, L. Minetto, COD Evaluation of Hospital Effluent by Means of UV-Spectral Deconvolution, CLEAN–Soil, Air, Water, 36(10-11) (2008) 875-878.

Please cite this article using:
S. Nazif, M. Gholami Mayani, B. Roghani, Development of performance indicators for evaluation of wastewater treatment plant's units performance, *Amirkabir J. Civil Eng.*, 51(1) (2019) 129-142.
DOI: 10.22060/ceej.2017.13167.5342