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# Effluent Quality vs Energy Consumption in a Temperature based control strategy for Wastewater Treatment Plants

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**Summary to the submission webpage:** This work presents a the modification of a Temperature Driven Control Strategy (TDCS) designed to improve the eco-efficiency of a wastewater treatment plant to seasonal and abnormal variations of temperature to include the effect of precipitations and populations activities on influent flow and load.

**Keywords**: Process control, Wastewater Treatment, Seasonality.

The goal of the WWTP is to minimize the load of pollutants in the effluent.The sustainable operation of a Wastewater Tratment Plant (WWTPs) implies the consideration of environmental and economic performance objectives which are usually in conflict: emissions to water, environmental impact, and economics. The influence of climate and meteorological conditions into the eco-efficiency aspects of control/operational strategies must be addressed to find sustainable solutions for WWTP operation. The seasonal variations of temperature and precipitations have also a strong influence on WWTP performance. Wastewater temperature determines the kinetics of biological processes used for pollutants removal, but it also affects the energetic efficiency of the plant. The consideration of temperature variations and precipitations of the influent is relevant for the development of efficient control systems, that are able to adapt the operation to Climate Change effects. In Revollar et al. (2025) a Temperature Driven Control Strategy is poposed to adapt the operation to seasonal variations of temperature, improving N-Removal performance at low temperatures and reducing energy consumption at higher temperatures. The strategy is formulated for Benchmark Simulation Model (BSM2) plant (Gernaey et al., 2014) considering a reference period of 30 days where moderated variations of the influent flow and load were observed, then effect of precipitations and droughts have not been addressed. This work presents the adaptation of the Temperature Driven Control Strategy (TDCS) to the full year influent conditions including the effect of precipitations and populations activities together with seasonal variations of temperature.

Some of the main control actions applied in the TDCS are Dissolved Oxygen (DO) control for aerobic zones to desired set-points, variation of carbon dosage to improve nitrification in the presence of excessive amount of DO, and sludge age (SA) timer control. The proposed TDCS increases DO set-point from 2g/m$^3$ to 3.2 g/m$^3$ when strong influent flow disturbances are detected. Temperature based SA is introduced here and triggers of the selected control actions are adjusted to address the influent flow and load disturbances at different temperatures considering the eco-efficiency of the plant.

Fig. 1.1 shows the monthly average values of Effluent Quality Index per m$^3$ of incoming wastewater (EQI/Qin$_{av}$) and electricity consumption per m$^3$ of incoming wastewater $E_{ASP}$/Qin$_{av}$ in a year of operation of BSM2 plant under default control strategy, compared with influent pollution load (IQI/Qin$_{av}$) evolution. In the figure, the profile of EQI/Qin$_{av}$ do not follow the same trend of the IQI/Qin$_{av}$ profile, showing that removal effectiveness is also influenced by temperature and operational strategy. On the other hand, $E_{ASP}$/Qin$_{av}$ annual profile trend suggests that the amount of electricity consumed in the plant is strongly affected by the load of pollutants to be treated. Fig.

2.2 compares the monthly average behaviour of the differen versions of the TDCS formulated in Revollar et al. (2025), there is observed that TDCS improves Effluent quality (EQI) and total Nitrogen indicators in all months and energy consumption only increases in the colder months, which is justified by the increased aeration to improve N-removal. As load and influent flow variations can be detected, the TDCS could attain additional improvements of performance.

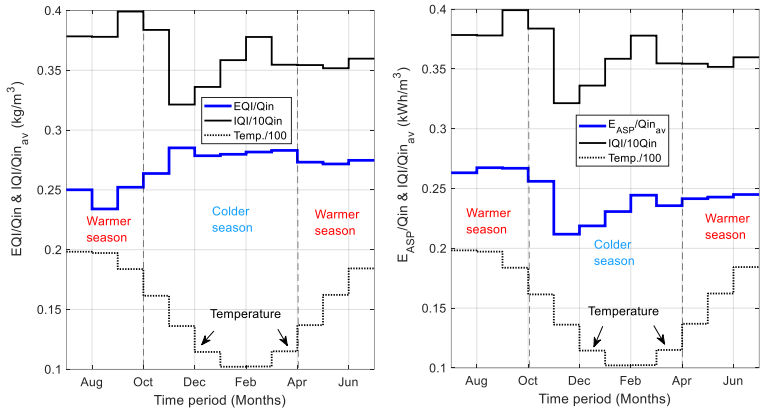


**Figure 1.1** Effluent Quality and Electricity use compared with influent load in BSM2 plant.

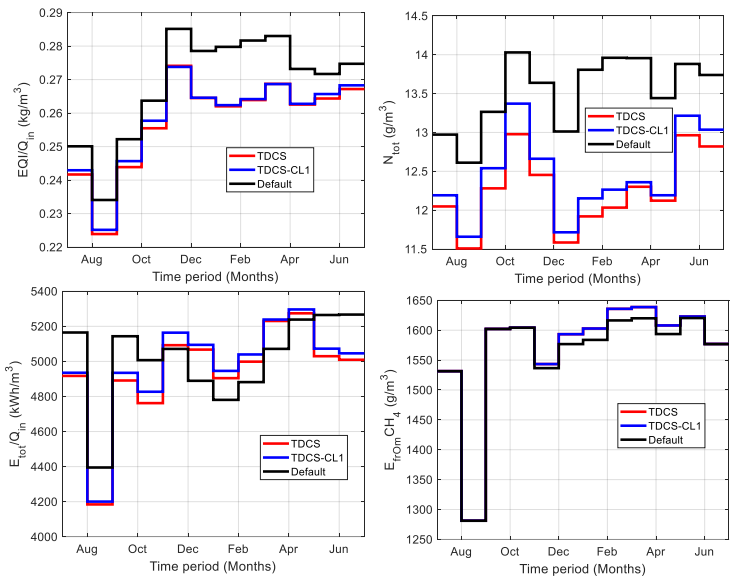


**Figure 1.2** Monthly variations of effluent quality and energy consumption indicators of BSM2 plant. Comparison between default control strategy and TDCSs.

## REFERENCES

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