



## Improving novel extreme learning machine using PCA algorithms for multi-parametric modeling of the municipal wastewater treatment plant

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### ABSTRACT

In order to develop a tool for modeling the efficiency of municipal wastewater treatment plants (MWWTP), a reliable prediction tool is essential. In this research, two scenarios (I and II) were investigated for modeling the performance of Nicosia MWWTP. The extreme learning machine (ELM), which is a newly developed black-box model, combined with principal component analysis was developed in scenario I and two principal components (PCs) variables were generated, while in scenario II, traditional multi-layer perceptron (MLP) neural network and multiple linear regression (MLR) models were established for comparison. The daily measured data obtained from new Nicosia MWWTP includes ( $\text{pH}_{\text{inf}}$ ,  $\text{Conductivity}_{\text{inf}}$ ,  $\text{BOD}_{\text{inf}}$ ,  $\text{COD}_{\text{inf}}$ ,  $\text{Total-N}_{\text{inf}}$ ,  $\text{Total-P}_{\text{inf}}$ ,  $\text{NH}_4\text{-N}_{\text{inf}}$ ,  $\text{SS}_{\text{inf}}$  and  $\text{TSS}_{\text{inf}}$ ) as the input variables and ( $\text{BOD}_{\text{eff}}$ ,  $\text{COD}_{\text{eff}}$ ,  $\text{Total-N}_{\text{eff}}$ ,  $\text{Total-P}_{\text{eff}}$ ) as the corresponding outputs. Taylor diagrams, box and whisker were also utilized to examine the similarities and comparisons between the observed and predicted values for both the ELM and PCs-ELM in scenario I. The obtained results based on the performance indices showed that the PCs-ELM model has higher performance accuracy than the novel ELM model. The results also showed increases of the PCs-ELM of about 12%, 2%, 20% and 6% for  $\text{BOD}_{\text{eff}}$ ,  $\text{COD}_{\text{eff}}$ ,  $\text{TN}_{\text{eff}}$  (total nitrogen) and  $\text{TP}_{\text{eff}}$  (total phosphorite) with regard to the ELM model. Also, the comparison results demonstrated that ELM and MLP revealed higher prediction accuracy than the MLR model, and the ELM model comparably outperformed the MLP model. The overall results indicated that both the PCs-ELM and two scenarios could be alternative reliable tools for modeling the performance of Nicosia MWWTP.

**Keywords:** Wastewater treatment plant; Extreme learning machine; Principal component analysis; Multi-layer perceptron neural network; Nicosia-Cyprus

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