Gradient Boosting Machine for Phosphorus Removal Prediction in Multi-Soil-Layering (MSL) system operated in a rural area

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Introduction

Simulating the efficiency of wastewater treatment plants is critical in the management of its effluents

Challenge :

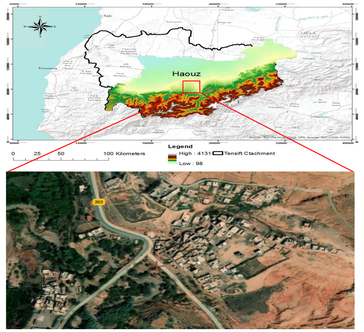
- Linear models that use a high dimensional dataset may be unable to build accurate and interpretable models.

To address this complexity :

- Multiple linear regression (MLR) # Gradient boosting machine algorithm (GBM)

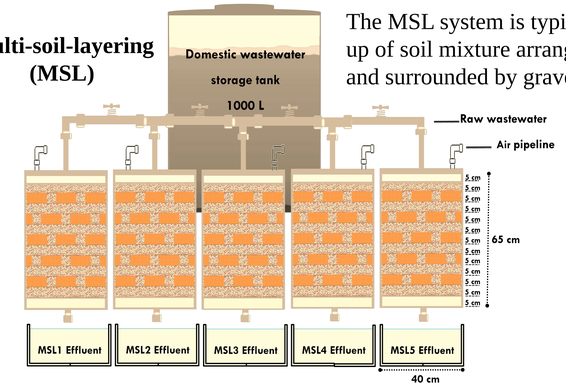
MATERIAL AND METHODS

Study area and WWTP



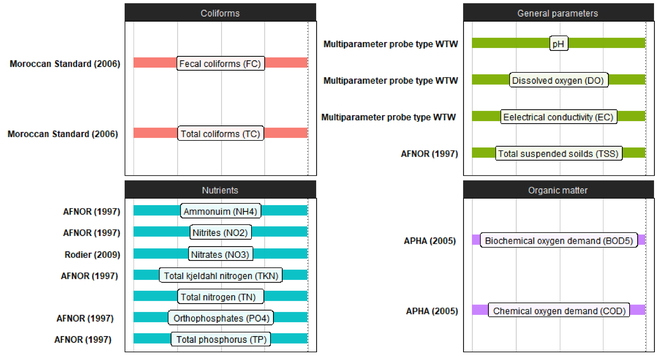
Talat Marghen village in Al-Haouz Province, Morocco

Multi-soil-layering (MSL)

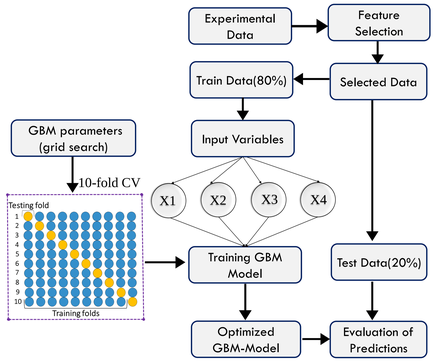


The MSL system is typically made up of soil mixture arranged in bricks and surrounded by gravel particles

… Water quality indicators



Methodology



MODELING

Pseudo-code of the GBM algorithm

1- $F_0(x) = \underset{\gamma}{\arg\min} \sum_{i=1}^{N} = L(y_i, \gamma)$

2- From the first tree (m=1) to the last tree (m=M)

3- For $i = 1, 2, \ldots, N$ compute

4- $\tilde{n}_{im} = -\left[\frac{\partial L(y_i, F(x_i))}{\partial F(x_i)}\right]_{F(x)=F_{m-1}(x)}$

5- R_{jm}, For $j = 1, 2, \ldots . J_m$

6- For $j = 1, 2, \ldots . J_m$ compute

7- $\gamma_{jm} = \underset{\gamma}{\arg\min} \sum_{x_i \in R_{ij}} L(y_i, F_{m-1}(x_i) + \gamma)$

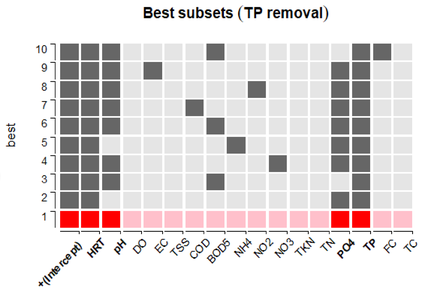
Friedman (2002): Boosting learning and editing error of decision trees is used to develop the GBM algorithm

Feature Selection

Bayesian information criterion (BIC)

Relevant predictors :

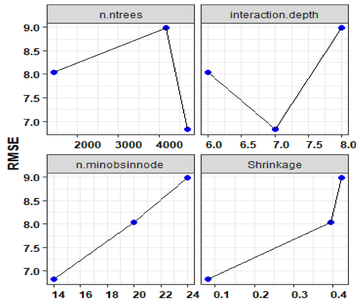
- Hydraulic retention time (HRT)
- Orthophosphates (PO_4–P)
- pH
- Total phosphorus (TP)



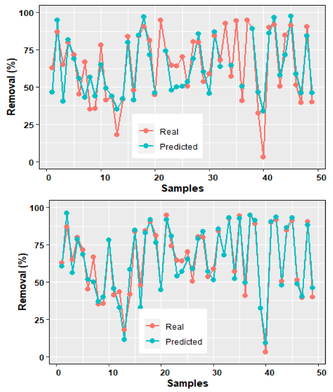
TUNING RESULTS

- n.ntrees = 4685,
- interaction.depth = 7,
- shrinkage (λ= 0.082)
- n.minobsinnode = 14

have a significant effect on reducing the training error (RMSE= 6.64 %) of the GBM model for TP removal



RESULTS of VALIDATION



MLR model

GBM model

CONCLUSION

The selected input variables have been shown to have significantly ($p < 0.05$) impact the removal of TP in the MSL system. In comparison, the GBM model has proved to be more accurate than the linear model (R^2 for the output variable exceeded 0.93). Thus, the GBM model is capable of investigating the nonlinear relationship between the removal of TP and the affecting parameters.

ACKNOWLEDGEMENT

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