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Paper Authors:
Khaitova Aziza Ruzimamatovna

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Intellectual methods of technological materials and methods in the treatment of industrial wastewater

Khaitova Aziza Ruzimamatovna

Research assistant at the Karimov Tashkent State Technical University Uzbekistan, Tashkent city.

E-mail: *xaitovaaziza45@gmail.com*

Abstract: The article discusses the state of intellectual methods of technological materials and methods of industrial wastewater treatment. The purpose of biological treatment of wastewater is to provide information about the system for the elimination of contaminants present in the water, and this article provides information on the use of various microorganisms to decompose organic matter in water in a bioreactor.

Keywords: biological treatment, bioreactor, microorganism, chemical oxygen, oxidation tank

Introduction

Model Design COD is one of the most important variables in the process of a biological treatment since experts can make decisions based on the measurements of this variable. The objective of biological wastewater treatment is to perform a system to remove the pollutants present in water. Thus, this treatment is used overall because it is compelling and more efficient than numerous mechanical or compound procedures. In the bioreactor at this stage, a variety of microorganisms are used to break down organic matter in the water. However, the microorganisms are susceptible to change, depending on all the conditions in the tank. For this reason, the present work proposes to use predictive analysis on COD to make decisions, knowing how contaminated the water will be in the tank. For studying how COD dynamics in the process are, a dataset was received from a WWTP from the Nantong, China plant with a daily data frequency for a total of 847 samples at different stages of the process, where a total of 22 variables were collected from 01/12/2017 to 24/05/2020. The COD dynamic can be observed in Figure 1.

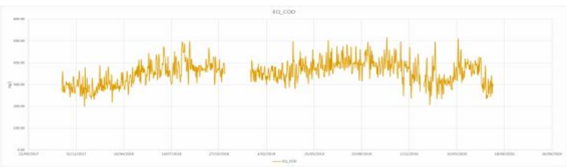

Figure 1. Chemical oxygen demand behavior.

Figure 2 shows the biological stages of the process in which the organic load of water is removed. Some important variables for the project that describe the WWTP process are represented as circles in blue and green. The blue circle is the output variable COD for the forecasting analysis, while green circles are input variables to design the intelligent system.

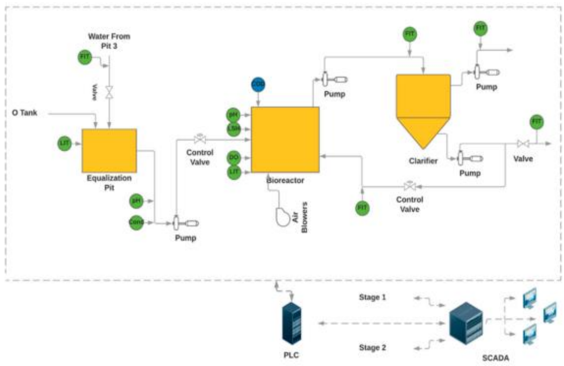

Figure 2. Biological WWTP process diagram.

For the development of the system, the selected technology was an ANN because of the state-of-the-art review supported by the complexity of the WWTP process. Figure 3 presents the flowchart that synthesizes the design process of the intelligent systems proposed, which started with the data collection and the use of different strategies for variable selection. Within the dataset, the main variables of the process were:

- Flow

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• COD of influent water
• Suspended solids in influent water (SS)
• Mixed liquor suspended solids (MLSS)
• Mixed liquor volatile suspended solids (MLVSS)
• Nitrogen (N)
• pH
• Mixed liquor dissolved oxygen (DO)
• Food to microorganism (F/M)

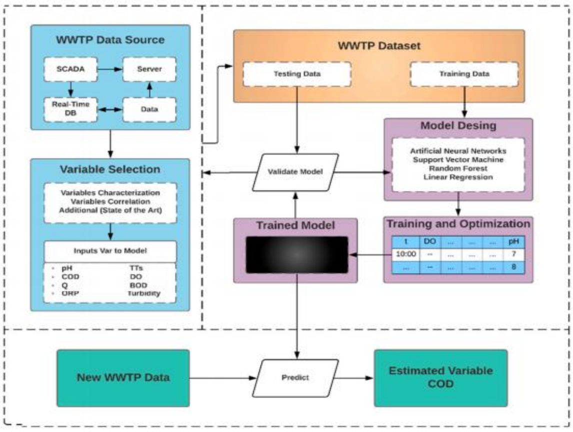

Figure 3. Model structure diagram.

Each characteristic can be repeated in one or more stages that are listed as below:

• EQ = Equalizer
• BIO = Bioreactor
• BT_N = Bioreactor Pit N
• BT_C = Bioreactor Pit C
• Clari = Clarifier
• OxT = Oxidation Tank
• D = Discharge Pit

After variable selection, the dataset is split into training, validation and test sets. However, in this case, the data was split into training and test sets since the number of samples was small in comparison with the amount of data used to train an ANN. It is important to note that a computational technique must be selected. Once the model was selected, the model was trained and brought into operating condition to estimate COD. An error measure is necessary to support the performance of the model. Therefore, the MAPE), defined as shown in Equation (1), was chosen to quantify the ANN error. In this equation, y_i represents the actual point, which is intended to be predicted, $\tilde{y}_i$ represents the predicted values of that observed point and N is the number of observed values that are intended to be predicted.

$$MAPE = \frac{100}{N}\sum_{i=1}^{N}\left|\frac{y_i-\tilde{y}_i}{y_i}\right| \quad , \tag{1}$$

Figure 4 shows in more detail how the model is conceived and how the COD forecasting is achieved. First, the objective variable taken from the dataset is studied using a time-series decomposition technique that transforms the variable into three additive components: trend, seasonality and residual. Leveraging an autocorrelation study over the components, the first two are estimated using their past values. On the other hand, the residual component is estimated using an ANN, which received exogenous variables selected from a correlation study and a past value of the same component. Finally, the addition of the three components provides the COD prediction

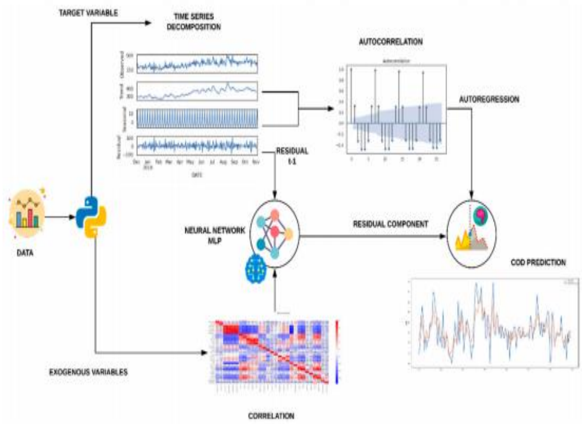

Figure 4. Model block diagram

A web platform was designed to visualize all the variables of the WWTP dynamically, monitor the COD prediction provided by the forecast model and consult the historical measurements of the variables. The technology that performed the view in the platform was ReactJS, responsible for rendering the visual content to interact with the user and make requests (frontend). ReactJS related to the master and brain of the platform, NodeJS, which controlled the logic responsible for managing all functions and methods that made the platform work (backend). Parallelly with

NodeJS, TensorFlow.JS deployed the trained forecast model, which was developed to predict the COD at the beginning of the bioreactor. Besides, all the data and the information important to be the cog in this system were stored in a database schema settled in PostgreSQL. The interaction between those technologies allowed for reaching the objectives mentioned

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