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O 34. URBAN WASTEWATER TREATMENT PLANT EFFICIENCY MODELING WITH ARTIFICIAL NEURAL NETWORK: KONYA EXAMPLE

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ABSTRACT: With the climate crisis, the need to use our natural resources effectively and efficiently has begun to be discussed on the world agenda. The reality of drought that we are facing in this process has also brought to the agenda the development of appropriate technologies for the reuse of wastewater. In this context, it is important to control the process management of existing wastewater treatment plants, reduce the potential effects of wastewater treatment plant effluent on the receiving environment and make it reusable. With developing computer technologies, the use of artificial intelligence techniques has increased. Artificial neural networks are also included among these techniques. Studies are being carried out to predict the performance of urban wastewater treatment plants using methods such as artificial neural networks. In our study, it was aimed to estimate the values of Konya Urban Wastewater Treatment Plant effluent parameters using an artificial neural network model. By using the Wastewater Treatment Plant inlet water data, outlet water values can be predicted as a result of Artificial Neural Network modeling, thus predicting sudden changes that occur during the operation of wastewater treatment plants and situations requiring intervention will be important in preventing environmental risks. Additionally, time and cost will be saved. It will set an example for similar processes.

Keywords: Wastewater, Artificial Neural Network, Reuse

1. INTRODUCTION

The effects of global climate change and ecological footprint, which manifest themselves in the world and Turkey, reveal the necessity of sustainable and effective use of natural and renewable resources in the best and most efficient way. Approximately 90% of the population in Turkey and more than half of the world's population lives in cities. This situation has brought urban technical infrastructure facilities to an even more important point than ever before (Üçüncü, 2019).

The production of wastewater beyond what nature can absorb and the pollution of receiving environments brought about by population growth and industrialization are among the problems that directly and indirectly threaten human life today. In order to prevent this situation, which may negatively affect the ecological balance in nature, it has become necessary to treat wastewater before disposal. There is a treatment process that is difficult to manage in wastewater treatment plants established to purify wastewater from these pollutants and discharge it back to the receiving environment.

The long duration of some pollution measurement processes used in wastewater treatment plant (WWTP),process control, their high cost, and the need for urgent evaluation of their results from time to time cause the facility manager to need additional information systems to assist in decision making. Modeling the relationship between historical facility input and output parameters recorded in information systems and estimating possible output parameters for the input control parameter values encountered will support the plant manager in effectively managing the process and regulatory intervention (Öztemel ve Dügenci, 2016).

Many variables (non-linear and time-varying) need to be taken into account in the operation of domestic wastewater treatment plants. Although some of these variables can be measured in situ, some variables need to be measured in laboratories. For these reasons, when a problem is encountered in the operation of these facilities, it is not easy to overcome these problems and tools are needed to help overcome the problem (Çınar ve Yılmaz, 2005).

The concept of pollution, the importance of which was not realized in the past years; It has become very important nowadays. The best way to tackle this situation is to reduce pollution where it occurs, at its source. But as time went by, this situation began to become more complicated. It is obvious that

today's pollution will cause major problems in the future. Based on this, researchers have started to create various models. The purpose of these models is to predict problems that may occur in the future, to reduce or completely prevent pollution, to improve ecosystems, to determine the efficiency of treatment plants without the need for laboratory-scale reactors, etc. (Subaşı, 2010)

Model development is a sophisticated and cost-effective way to control the operation of WWTPs and evaluate their performance (Hassen and Asmare,2019).

Artificial Neural Networks (ANN) are computer software developed by imitating the information processing mechanism of the human brain in order to provide solutions to various problems. Created by simulating a biological neural network such as the human brain, ANNs have the ability to learn, memorize, generalize what they have learned to produce new information, and reveal the relationships between variables. It has been seen that ANN can successfully model the system in wastewater treatment (Erdem, 2021).

ANN analysis; It is an economical and useful method that can be used in the analysis of experimental studies related to environmental engineering, since doing more experimental studies is both costly and time-consuming. In the analysis of data in environmental engineering, input and outputs can be defined with the ANN method and output values can be estimated.

Efficient results can be achieved by using ANN models in the analysis of the studies. When the relationship between different parameters cannot be expressed with an equation, it would be logical to seek results with a complex system such as ANN. For this, regularly prepared data and accurate measurements are needed (Açıkalın, 2007).

Due to its simplicity and predictive accuracy, the use of machine learning, especially ANN, to model the wastewater treatment process has become a promising alternative that can be realized with the advancement of computing capabilities.

Artificial neural network models use a set of nonlinear equations to determine complex patterns and relationships between input and output and can therefore be used in prediction, simulation and classification (Bekkari ve Zedduri, 2018).

In wastewater treatment plants, the most significant environmental issues during the operational phase are the potential impacts of the treated effluent on the receiving environment. It is important for facility process management to detect system malfunctions in a timely manner and take appropriate measures to ensure that these effects are kept to a minimum. In this study, the optimum algorithm that gives the data closest to the measured outlet water values will be investigated by using the inlet water data of the Konya Province Urban Wastewater Treatment plant through ANN Models.

With this study, it is aimed to estimate the effluent water values of the same parameters by determining the appropriate method from ANN models using the 2021-2022 inlet water parameters (pH, BOD, COD, AKM, TN, TP) of the Konya Urban Wastewater Treatment Plant. The importance of predicting sudden changes and situations requiring intervention that occur during the operation of wastewater treatment facilities in preventing environmental risks was a factor in determining this target.

Currently, WWTP inlet and outlet water analyzes are carried out using measurement and experimental methods. However, this situation causes loss of time and cost problems since the analyzes must be carried out in accordance with the standards. Obtaining results closest to actual measurement data with an appropriate model method will provide the opportunity for early intervention in important problems and will enable increased operating efficiency in facilities that already have high operating costs. It is aimed that the appropriate method obtained after the study can be used in other facilities of similar scale.

2.METHOD

2.1 Konya Urban Wastewater Treatment plant general information

Konya Urban Wastewater Treatment facility is located in Tatlıcak District of Karatay District. Currently, the site has a surface area of 110,000 m^2, with an equivalent population of 1,000,000 people and a wastewater flow rate of 200,000 m^3/day. It is designed for 2030 with an equivalent population of 1,600,000 people and a capacity of 300,000 m^3/day. It works with advanced biological treatment + UV disinfection methods. At the exit of the Wastewater Treatment Plant, the treated water is given to Konya Main Discharge Channel. The facility is constantly monitored by the Ministry of Environment, Urbanization and Climate Change's wastewater monitoring systems.

In addition, electricity and heat energy are produced at the facility by using biogas resulting from the digestion of sludge formed during wastewater treatment. 2500 kWh of electricity is produced.

The stabilized treatment sludge produced in the facility is used in agricultural lands.

Applications are being made in green area irrigation with the 150 m^3/h capacity application project for the reuse of treated wastewater. Thanks to this application, 3,216,000 m^2 of green area irrigation is carried out every year during the irrigation season with approximately 385,000 m^3/season of recycled wastewater produced.

In parallel with the increasing population and urbanization rates, the capacity of the Konya wastewater treatment plant also needs to be increased. A second stage wastewater treatment plant is planned to serve 2,409,592 people and a flow rate of 400,000 m^3/day in 2040. The planned facility also includes the Agricultural Irrigation Water Production Facility Unit from Treated Wastewater.

Figure 1. Konya WWTP general view and photos of the units

2.2 Material and method

With developing computer technologies, the use of artificial intelligence techniques has increased. ANNs are also included among these techniques. ANNs are one of the latest products of people's efforts to research and imitate nature. ANNs are programs designed to simulate the way simple biological neurons work.

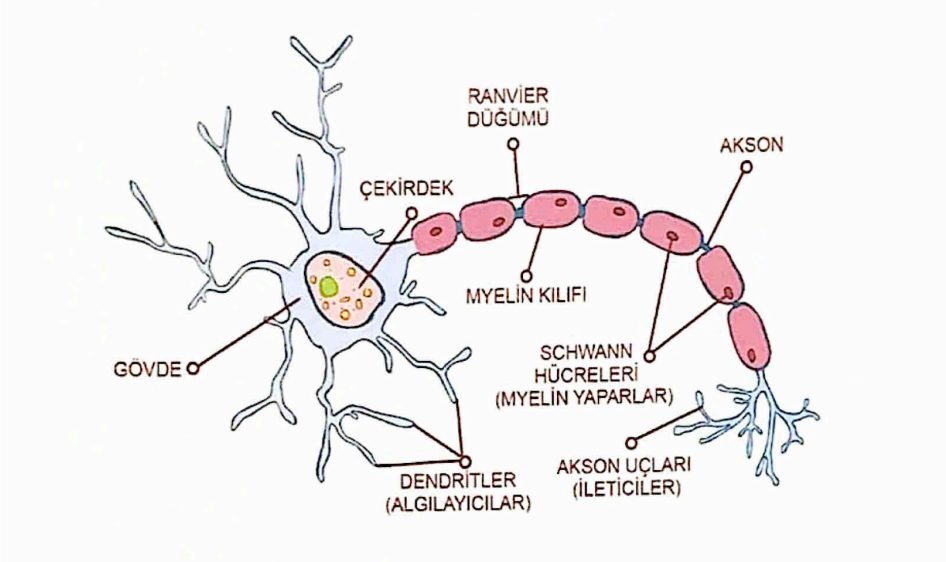

Figure 2. Biological nerve cell

Biological nerve cells communicate with each other through synapses. A nerve cell sends the information it processes to other cells via its axons. Similarly, artificial nerve cells collect external

information with an accumulation function and pass it through the activation function, producing the output and sending it to other cells (process elements) over the connections of the network. It has different collection and activation functions. The values of the connections connecting artificial neural networks to each other are called weight values. Process elements come together in 3 layers parallel to each other and form a network. These; • Input layer • Intermediate layers • Output layer. Information is transmitted to the network from the input layer. They are processed in the intermediate layers and sent to the output layer from there. What is meant by information processing is to convert the information coming to the network into output using the weight values of the network. In order for the network to produce correct outputs for inputs, the weights must have correct values. The process of finding the correct weights is called training the network. These values are initially assigned randomly. Then, when each example is shown to the network during training, the weights are changed according to the learning rule of the network. Then, another sample is presented to the network and the weights are changed again and the most accurate values are tried to be found. These processes are repeated until the network produces correct outputs for all the examples in the training set. Once this is achieved, the samples in the test set are shown to the network. If the network gives correct answers to the examples in the test set, the network is considered trained. (Öztemel,2012).

ANN have the capacity to learn, memorize and reveal the relationship between data. It consists of three basic stages.

1.Education
2.Verification
3.Test

Generally, 80% of the data obtained is used for training and 20% for validation. The accuracy of the model is also tested with data that has not been used before.

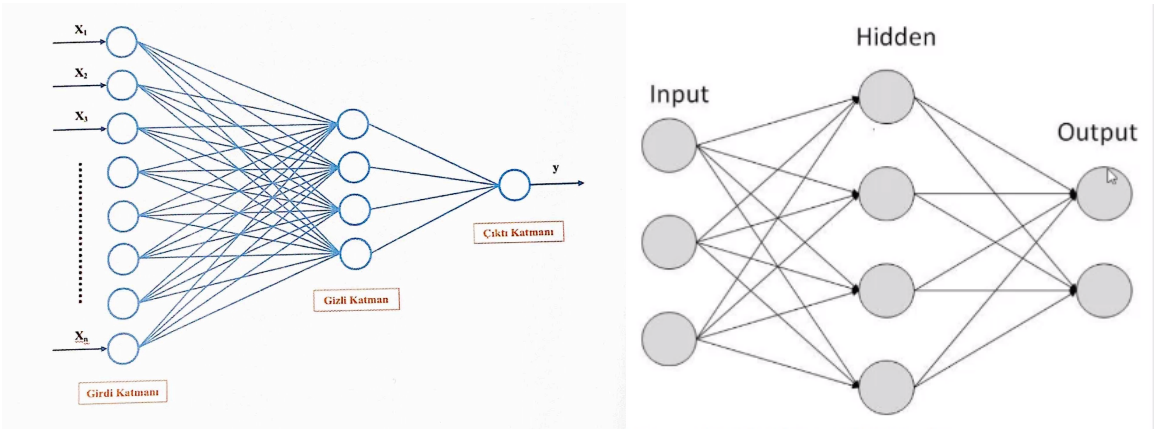

Figure 3. Artificial neural networks layers

An ANN cell consists of five basic components: input, weight, summation function, activation function and output.

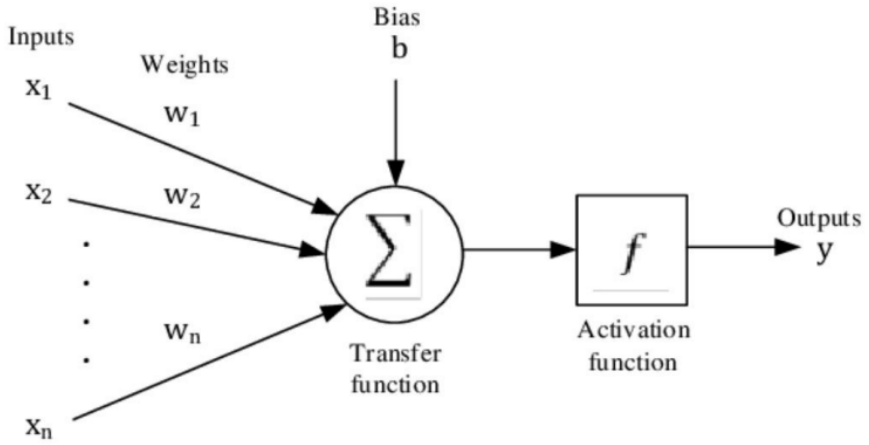

Figure 4. Structure of Artificial Nerve Cell

Some Advantages of Artificial Neural Networks

1. Artificial neural networks consist of many cells, and these cells work simultaneously and perform complex operations.

2. Certain types of non-linear subunits distributed on the structure make it possible to solve non-linear problems.

3. ANNs can perform machine learning. By learning about events, one can make logical decisions in the face of similar events.

4. They can make predictions faster than traditional methods and more successfully than the literature.

5. They can produce information about previously unseen samples. ANNs derive generalizations from the examples given to them during their training and can produce information about new examples with these generalizations.

6. There is error tolerance.

Nowadays, it is widely used in many areas such as classification, modeling and prediction applications. It is suitable for use in almost every field where machine learning algorithms are applied. It is also widely used in the field of engineering.

In the field of Environmental Engineering, studies are carried out to predict the performance of urban wastewater treatment plants using methods such as artificial neural networks. In this study, it was aimed to estimate the values of Konya Urban WWTP effluent parameters using an artificial neural network model.

Using the 2021-2022 WWTP inlet water values obtained from KOSKİ General Directorate, outlet water values will be estimated with the computer program of the appropriate ANN model.

In addition, the parameters for which data cannot be obtained from time to time in the WWTP inlet water values will be included in the process after determining the approximate values using appropriate methods.

Due to the difficulties encountered in estimating using classical methods or complex models and the dependence of performance on many parameters, this method was preferred because the appropriate ANN model facilitates the monitoring of the performances of wastewater treatment plants.

3. RESULSTS

It is thought that this study will contribute to the literature on how determining the process controls and performances of Urban Wastewater Treatment Facilities can be done more practically with artificial intelligence methods such as artificial neural networks.

At the same time, it is envisaged that it will set an example for similar processes in that, with timely intervention in the facilities, possible problems that may occur in the facility units and the effects on the receiving environment can be reduced. In this way, time and cost will be saved.

We also believe that it will contribute to science at national and international levels and will serve as a preliminary study for all wastewater treatment facilities of similar structure.

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