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Model-Based Optimization of a Wastewater Treatment Plant: Hakkari Case Study

Atıksu Arıtma Tesisinin Model Tabanlı Optimizasyonu: Hakkari Örnek Çalışması

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ABSTRACT

Wastewater must be treated in order to reduce the environmental impact of used water and to ensure the efficient use of its resources. Physical, chemical, and biological treatment techniques are used to treat domestic wastewater. It's crucial to either optimize existing processes for domestic wastewater, which has different characteristics in terms of wastewater characterization, or use appropriate treatment technologies, taking into account the conditions in the region where the plant will be built. In this study, the wastewater treatment plant for the Hakkari city centre, where there is no wastewater treatment plant and wastewater is discharged without treatment, was designed and modeled using the GPS-X simulation program.

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ÖZ

Kullanılmış suların çevreye olan zararlarını en aza indirmek ve kaynaklarının verimli kullanılmasını sağlamak için atıksuların arıtılması gerekmektedir. Evsel nitelikli atıksular, fiziksel, kimyasal ve biyolojik arıtma teknikleri kullanılarak arıtılmaktadır. Atıksu karakterizasyonu bakımından farklı özelliğe sahip olan evsel atıksular için mevcut proseslerin optimize edilmesi veya tesisin kurulacağı bölge koşulları dikkate alınarak uygun arıtma teknolojilerinin kullanılması önem arz etmektedir. Bu çalışmada atıksu arıtma tesisi bulunmayan ve atıksuları arıtılmadan deşarj edilen Hakkari kent merkezi için atıksu arıtma tesisinin projelendirilmesi ve GPS-X simülasyon programı kullanılarak modellemesi yapılmıştır.

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1. INTRODUCTION

The need for drinking and potable water is increasing in parallel with the increase in the world population. In a world with a growing population and increasing demand for food and water, current and future generations face a multitude of social, economic, and environmental challenges. According to the United Nations [1], the urban population is estimated to increase by 2.5 billion between 2018 and 2050, reaching approximately 68% of the total world population. This increase brings with it various environmental problems. Domestic wastewater has significant organic (chemical oxygen demand, Biological oxygen demand), inorganic (phosphate-phosphorus, nitrate-nitrogen, nitrite-nitrogen, ammonium-nitrogen), and microbial pollutants (*Escherichia coli*). To overcome these problems, the water used must be treated before being discharged to the receiving environment [2].

While developed countries work to improve WWTP treatment processes or develop new technologies to meet rising water demand, developing countries are still struggling to establish the necessary treatment infrastructure [3]. The activated sludge model (ASM) is a critical treatment process for a variety of wastewaters that is used by more than 90% of wastewater treatment plants (WWTPs) [4]. Under aerobic conditions, the activated sludge process (ASP) primarily uses suspended microorganisms in wastewater to remove biodegradable organic matter and nutrients [5].

Mathematical modeling has become an indispensable tool for simulating complex biochemical processes such as wastewater and sludge properties, process kinetics, and stoichiometry in the activated sludge process [4]. In the existing facilities, the discharge standards and operation problems that must be provided by the legislation are among the biggest problems encountered. To solve these problems encountered during the operation, recently, modeling studies (GPS-X, AQUASIM, BIOWIN, and WEST) in computer environments have been focused on. Among them, the GPS-X showed superiority in facilitating and simplifying model construction, simulation and interpretation of results with an advanced graphical user interface [6]. Therefore, it has been widely applied for WWTPs simulation to improve operational performance [3, 4, 6-10].

Mathematical modeling of activated sludge process; It provides facilities for design, operational assistance, predicting future behavior, and controlling the process [9, 11, 12]. Since the early 1970s, much effort has been devoted to modeling the Activated Sludge Models (ASM). ASM first emerged as a result of the studies carried out by researchers from many countries to mathematically model the biological wastewater treatment design of the International Water Pollution Research and Control Association (IAWPRC), now the International Water Organization (IWA). Today, IWA models consisting of ASM1, ASM2, ASM2d, and ASM3 have proven to be excellent tools for modeling processes of carbon oxidation, nitrification, denitrification, and biological phosphorus removal [9, 12, 13]. However, ASM1, which has become an internationally recognized ASM describing the bio-removal processes of organic matter and nitrogen, including the mechanisms of nitrification and denitrification, is probably the most well-known IWA model [14].

Activated Sludge Model no.1 (ASM1), defined in 1987, is the first activated sludge model. The basic concepts in the model were derived from the activated sludge model developed by the University of Cape Town. ASM1 was mainly developed to describe the removal of organic compounds and nitrogen with simultaneous consumption of oxygen and nitrate as electron acceptors. The model also aims to give a good description of sludge production. COD (Chemical Oxygen Demand) is considered as a measure of organic matter concentration [15].

In ASM1, organic matter is divided into three: biodegradable, non-degradable, and biomass. The easily biodegradable substrate; is assumed to consist of simple soluble molecules that can be readily absorbed by organisms and metabolized for energy and synthesis. In contrast, the slowly biodegradable substrate consists of relatively complex molecules that require absorption and enzymatic degradation before use. Non-biodegradable organic matter is biologically inert and leaves the system without any change in form. However, biomass is divided into two as heterotroph (XBH) and autotroph (XBA) [16].

Because Hakkari currently lacks a wastewater treatment plant, the province's wastewater is discharged into receiving environments without being treated. The current environmental problems caused by wastewater discharged into the receiving environment without treatment are expected to worsen in the future. In this direction, Iller Bank designed a wastewater treatment plant for Hakkari (Central) province in 2019 to solve the problem, but construction has not yet begun.

In this study, City center, where is located in the southeast of Turkey chosen as a case study. Future population estimates for Hakkari province, facility design, and wastewater characterization were made, and the results were used as input to the model. Then, the wastewater treatment plant planned to be built using GPS-X simulation software was mathematically modeled and model predictions were made.

2. MATERIAL AND METHOD

2.1 Description of Research Area

Hakkari is a province located in the southeast of Turkey, containing 4 districts, 3 towns, and 139 villages. The province is surrounded by the provinces of Iraq in the south, Iran in the east, Van in the north, and Şırnak in the west; The total population is 280,514, with 166,101 in city and district centers and 114,413 in towns and villages. Mountains make up about 88% of the landforms and 86% of the land is suitable for agriculture. However, the share of cultivated area in the province is only 1.4%.

In Hakkari, which has a total area of 9,521 km2, the altitude of the city center is 1,720 m. Hakkari's annual average temperature is higher than many other provinces in Eastern Anatolia. The reason for this is that a part of Hakkari, which is in the southern part of Eastern Anatolia, has been under the influence of the Mediterranean climate. The annual average temperature in the city center is 9.9°C. Hakkari's annual precipitation average is 791.7 mm. This value, which is higher than many provincial centers in Eastern Anatolia, is 384.0 mm in Van, 756.2 mm in Siirt, and 713.4 mm in Mardin, which is one of the neighboring provincial centers. In Hakkari, the most precipitation falls in March and April, while the least precipitation falls in July and August. In the province where the average wind speed is 2.0 m/sec, the prevailing wind direction is south-southeast (qibla - monsoon). It is followed by northwest wind and south-southwest wind The fastest wind in the province is south-southwest wind with a speed of 30 m per second.

Hakkari city center currently lacks a wastewater treatment plant, the province's wastewater is discharged into receiving environments without being treated. The current environmental problems caused by wastewater discharged into the receiving environment without treatment are expected to worsen in the future. By this point of view, Iller Bankasi A.Ş., which has undertaken important duties and responsibilities in the reconstruction and construction of cities and towns of Turkiye, designed a wastewater treatment plant for Hakkari (Central) province in 2019 to solve the problem, but construction has not yet begun.

2.2 Current Water Status in Hakkari Province

Within the scope of the Hakkari province drinking water project, a flow of 358 L/sec will be obtained from Kırkçeşme, Golan 1-2-3-4, Davzıgeyik, Nergiz, Mühürdaroğlu and Katırcılar catchments until 2048. The flow rates of catchments according to the project are given in Table 1 [9].

Table 1. Catchment flow rates

BERCELAN PLATEAU WATER RESOURCE MANAGEMENT GROUP	
WATER RESOURCE	MİN. FLOWRATE (L/sn)
Davzıgeyik	150
Nergiz	22
Mühürdaroğlu	32
Katırcılar 1	17.5
Katırcılar 2	10
TOTAL	231,5
GOLAN – KIRKÇEŞMA WATER RESOURCE MANAGEMENT GROUP	
Kırkçeşme Üçgöze	24.5
Golan 1-2-3-4	146
TOTAL	170.5

2.3 Hakkari Province Future Population Forecast

Determining the drinking and utility water need of a settlement and the amount of wastewater accordingly; directly proportional to the population. Therefore, based on the current population of the settlement, both the population data according to the project target years and the determination of the wastewater flow rate are very important for the proper execution of the project. Turkish Statistical Institute (TURKSTAT) population data for Hakkari province between 2007 and 2020 are given in Table 2. Various methods have been developed for population estimations for future years. Many of these are based on mathematical calculations that assume that the population will increase in arithmetic, geometric, exponential, and similar ways, taking into account annual population increases between past censuses. In addition, it would be appropriate to take into account all kinds of social and economic factors that may directly or indirectly affect the population in population estimations. In this section, the census results calculated by the municipality based on the address and since 2007 will be reviewed, the annual population increases will be examined, and the population estimations of the future years will be made since the Wastewater Treatment Plant is designed according to the flow rate of 2052 in a single stage.

Table 2. Population census results by years

YEAR	2007	2008	2009	2010	2011	2012	2012	2014	2015
POPULATION	77926	83423	86631	79576	82423	81549	80498	79335	79562

YEAR	2016	2017	2018	2019	2020
POPULATION	76933	76984	81424	78.672	78516

Although there is a decreasing trend in the population censuses made for Hakkari province, it should be designed according to the population value calculated by the geometric increase method, since it is considered that there may be an increase in the following years (Table 3).

Table 3. Population estimations of Hakkari province according to different methods

YEARS	POPULATION GROWTH COEFFICIENT	METHODS				
		BANK OF PROVİNCES		ARITHMETIC INCREASE	GEOMETRIC INCREASE	COMPOUND INTEREST
		Ç=1	Ç=1,04			
2022	78716	81056	81274	77639	81274	78485
2027	78689	85191	85803	75917	85802	78173
2032	78682	89537	90584	74194	90583	77864
2037	78680	94104	95631	72472	95631	77555
2042	78678	98904	100956	70750	100959	77247
2047	78677	103949	106586	69023	106585	76941
2052	78676	109252	112525	67305	112524	76636

2.4 Hakkari Province Drinking Water and Wastewater Calculations

When the per capita water consumption amount to be used in the calculation of drinking water need during the design of drinking water facilities and the population data are examined according to the "Technical specification for the preparation of drinking water facilities survey, feasibility and projects" prepared by the Bank of Provinces, the per capita water consumption for Hakkari is 140 L/person. calculated in days. The amount of wastewater that will come to the wastewater treatment plant is calculated by assuming that 80% will return to the wastewater treatment plant:

$Q_{2052} = N \times q \times 0.80$

$Q_{2052} = 112000 \times 0.14 \times 0.80$

$Q_{2052} = 12544\ m^3/day$

Note: During the calculations, $Q_{2052} \cong 12000\ m^3/day$ will be taken.

If the amount of wastewater in the wastewater treatment plant and the permeate water originating from the sludge dewatering unit are accepted as 5% of the domestic wastewater amount;

Pollution loads and concentrations for Hakkari province 2052 are given in Table 4.

Where, BOD is biochemical oxygen demand, COD is chemical oxygen demand, MLVSS is mixed liquor volatile suspended solid, MLSS is mixed liquor suspended solid, TOC is total organic carbon, TC is total carbon, TN is total nitrogen, TP is total phosphorous.

Necessary conditions for the discharge of wastewater to be treated in wastewater treatment plant will be provided by the “Urban Wastewater Treatment Regulation (UWTR)” standards. Discharge limits are given in Table 5.

Table 4. Wastewater project criteria

	Polluting	Unit	Concentration
TOTAL POLLUTION LOAD	COD	kg/day	6300
	BOD	kg/day	3528.2
	MLSS	kg/day	3780
	TN	kg/day	504
	TP	kg/day	88.2
FLOWRATE		m^3/day	12600
CONCENTRATION OF CONTAMINANTS	COD	mg/L	500
	BOD	mg/L	280
	MLSS	mg/L	300
	TN	mg/L	40
	TP	mg/L	7

Table 5. Discharge limits

PARAMETRE	Unit	UWTR (TABLE 2) CONCENTRATİON
BOD_5	mg/L	25
COD	mg/L	125
MLSS	mg/L	35
Total Phosphorous (TP)	mg/L	1
Total Nitrogen (TN)	mg/L	10

2.5 Wastewater Characterization

The characterization of the wastewater has a key role in designing of a wastewater treatment system. The quality of the water used, the population, the existing industries, and their discharge into sewer systems without treatment all influence the characteristics of wastewater [3].

In this study, due to the lack of existing industrial facilities in Hakkari, it is assumed that industrial pollutants do not mix with wastewater. In order to determine the status of the wastewater in Hakkari, samples were taken from the point where it is discharged to ZAP river (Figure 1), and the results of the characterization studies are given in Table 6.

Table 6. Wastewater characterization

Parameters	COD	Nitrate	Nitrite	TC	TOC	MLSS	MLVSS	pH	Turbidity
Value (mg/L)	1041	38.3	*	149.7	72.5	346	285	7.5	41.3 NTU

*Not found

Figure 1. *Wastewater discharge point in Hakkari province*

3. RESULTS AND DISCUSSION

3.1 Modeling Of Wastewater Treatment Plant With GPS-X

Nutrient removal from wastewater is now accomplished using a variety of treatment methods. When deciding on an alternative process, factors such as providing discharge limits, investment, operation, and maintenance costs, climatic conditions, land requirements, and topography all play a role.

Classical activated sludge, stabilization pools, trickling filters, long aeration activated sludge, and advanced biological (A_2O Process, Bardenpho Process, UCT Process) treatment are the most commonly used methods for removing nitrogen and phosphorus from wastewater. The benefits and drawbacks of these methods are evaluated, and the best option is chosen. While modeling, the Sequential Batch Reactor Process used in the wastewater treatment plant project [17] for Hakkari (Center) province in 2019 was selected by Iller Bank.

Wastewater will be taken to treatment plant through the inlet structure, and treatment will begin. Afterward, pre-treatment (Coarse and fine screen and Sand-Oil Trap) will be performed (Figure 2). Solid materials larger than 0.8 m in diameter will be prevented from entering the wastewater treatment plant in the coarse screen. Then, a fine screen (0.03 m) and a sand-oil trap will be arranged to remove the solid wastes that cannot be held in the coarse screen from the process. The dimensioning calculation for the Sequential Batch Reactor design will be made in light of the information given in Table 4.

Hydromantis Environmental Software Solutions, Inc.'s GPS-X software version 7 (Educational license) was applied in this study. This study mainly examines the levels of pH, TSS, alkalinity, COD, TKN, and BOD of the effluent from the secondary treatment. The carbon-nitrogen library is used to model the layout in GPS-X.

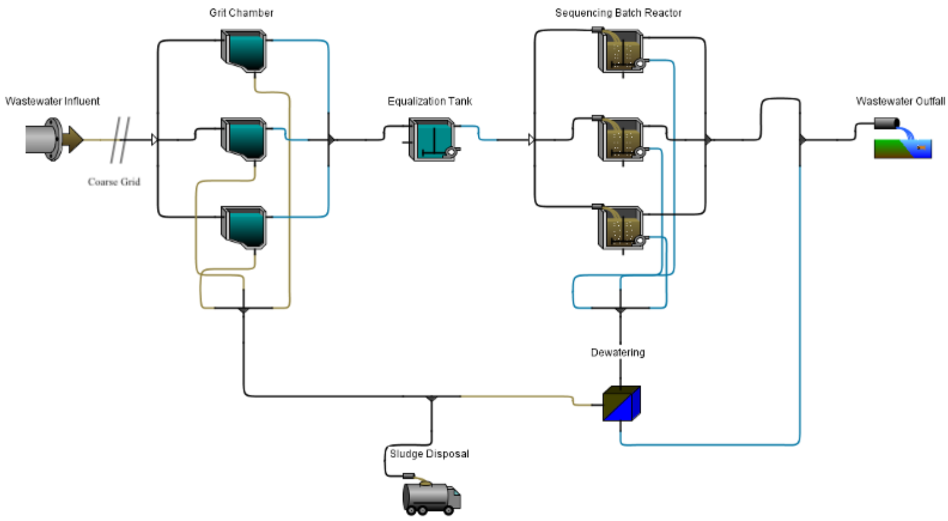

Figure 2. *Wastewater treatment plant general plan*

3.3 Wastewater Treatment Plant Sizing

The wastewater treatment plant was designed according to the wastewater flow rate of 12600 m^3/day and according to the Biological Nitrogen and Phosphorus Removal in Sequential Batch Reactor (SBR) system, which is an activated sludge system [8] designed to provide both biological reactions and solid-liquid separation in the same tank, respectively. designed [9]. The treated wastewater will be discharged into the Serink Stream passing near the facility. In the wastewater treatment plant, physical pre-treatment units, screens, sand-oil trap, and balancing pool units will be applied before the biological treatment, so that the wastewater will be suitable for biological treatment and the pollutant parameters that will affect the biological treatment performance will be eliminated.

3.3.1 Sizing The Grids

The inlet wastewater is first filtered through coarse screens at the facility. As a result, coarse materials that could harm the treatment plant's other units and the treatment process will be retained. Coarse screens will be designed to handle the maximum flow rate while ensuring that no precipitation occurs at the minimum flow rate.

Q_{max} : 1100 m^3/h

Q_{min} : 340.6 m^3/h

Number of coarse grids; 2 main + 1 spare

Q_{max} : 1100/2 = 550 m^3/h = 0,153 m^3/sec

Q_{min} : 340.6/2 = 170.3 m^3/h = 0.047 m^3/sec

Approach channel calculation;

Maximum flow; $K = \frac{Q_{max}\, x\, n}{b^{8/3}\ x\ S^{1/2}} = K = \frac{0.153\ x\ 0.013}{0.8^{8/3} x\ 0.001^{1/2}} = 0.114,\ x = 0.33$

Minimum flow; $K = \frac{Q_{min}\, x\, n}{b^{8/3}\ x\ S^{1/2}}\ K = \frac{0.047\ x\ 0.013}{0.8^{8/3} x\ 0.001^{1/2}} = 0.035$, x=0.14

Duct water height;

h_{max}= 0.33 x 0.8 = 0.26 m

h_{min}= 0.14 x 0.8 = 0.12 m

To prevent precipitation in the channel, the flow rate should be greater than 0.4 m/s.

Maximum flow; $V_K = \frac{Q_{max}}{b\ x\ h} = V_K = \frac{0.153}{0.8\ x\ 0.26} = 0.74\ m/sn$

Minimum flow; $V_K = \frac{Q_{min}}{b\ x\ h} = V_K = \frac{0.047}{0.8\ x\ 0.12} = 0.49\ m/sn$

3.3.2 Sizing The Grit Chamber

Grit removal is used to get rid of inorganic solids (such as sand, gravel, clay, eggshells, coffee grounds, metal filings, seeds, and other similar materials) that can cause excessive mechanical wear. Grit removal is accomplished through a variety of processes or devices, all of which are based on the fact that grit is heavier than organic solids, which must be kept in suspension for treatment in subsequent unit processes. Grit can be removed using grit chambers or by centrifugal separation of biosolids. To separate the solids from the wastewater, processes use gravity/velocity, aeration, or centrifugal force [18, 19]. A pre-treatment unit is considered two main and one spare for sand, oil, and small wastes that cannot be removed from the coarse screen in the facility's inlet wastewater.

$$Q_n = \frac{Q_{max}}{2} = \frac{1100\ m^3}{2} = 550\ m^3$$

Amount of waste;

N_{2052} = 110000 N x 10 l/N.y = 3,01 m^3/day

3.3.3 Sizing The Equalization Tank

The equalization tank is designed to maintain high flow fluctuations while providing consistent inflow to downstream processes. Several processes start when wastewater enters the stabilization pond. Sedimentation, aerobic decomposition, anaerobic decomposition, and photosynthesis are examples of these processes. Solids in the wastewater will sink to the pond's bottom. Solids produced by biological activity, in addition to solids in the wastewater entering the pond, will settle to the bottom [18]. Aeration and mixing are required in balancing ponds to prevent the raw effluent from becoming septic and to keep the solids suspended due to the additional holding time.

$V = Q_{max}$ x t = 1100 m^3/h x 2h = 2200 m^3

if selected $h_{max=}$ 6.2 m ; 2200 m^3 / 6.2 m= 354.84 m^2

x^2= 354.84 m^2 ise x= ~ 19 m

Then, the wastewater will be transferred to 1 equalization tank with a total volume of 2200 m^3 (19m x 19m x 6.2m) to balance the changes in the flow rate and minimize the changes in the polluting parameters. The holding time in the equalization tank is 2 hours.

3.3.4 Sizing the Sequential Batch Reactor (SBR)

Sequential Batch Reactors (SBR) is one of the integrated systems for anaerobic-aerobic bioreactors where wastewater is treated by the fill-and-empty method [20]. SBR is a modified activated sludge process that involves sequentially performing the four basic steps of filling, aeration, settling, and discharge in a batch reactor [13]. While SBR has advantages such as flexibility for variable wastewater characterization, ease of operation, aerobic and anaerobic treatment, oxygen utilization efficiency, high removal, and low energy requirement [21, 22], anaerobic and aerobic cycle times are combined with anaerobic-aerobic microbial group control. As a result, biomass selection and concentration can be considered one of their drawbacks [22, 23].

Total charging time 8 was selected for SBR.

$t_t = t_r + t_d + t_b$ ise t_r = 8-1-1-0.5 = 5.5 hours

here;

t_t: total time

t_r : reaction phase time

t_d : fill time

t_b : discharge time

Denitrification time: 5.5 x 0.209 = 1.15 saat

Nitrification time: 5.5 – 1.15 = 4.35 saat

SBR sludge quantity: 123632,93 kg

SBR sludge concentration: 5 kg/m^3

$$V_{min} = \frac{123632.93}{5x3} = 8242.2\, m^3, V_{max} = \frac{1100\, x\, 8}{3} = 2933.3\, m^3$$

$$V_T = 8242.2\ m^3 + 2933.3\ m^3 = 11175.53\ m^3\ x\ 3 = 33570\ m^3$$

After the equalization tank, the wastewater will be taken into 3 SBRs with a total volume of 33570 m^3 (37.4m x 37.4m x 8m) where biological treatment will take place. In SBR, 1.15 hours for denitrification and 4.35 hours for nitrification are calculated.

3.3.5 Sizing the Sludge Dewatering

Wastewater treatment produces sewage sludge, which is an unavoidable by-product. However, due to rapid industrialization and population growth, as well as more stringent wastewater treatment standards, the amount of sludge produced has increased dramatically in recent decades. This leads to higher sludge handling and transportation costs, which often account for half of the treatment costs at wastewater treatment plants [24].

After thickening, digestion, or conditioning, sludge is frequently dewatered in sludge management systems before being processed further, such as through incineration, composting, or landfilling [25]. Gravity, dissolved-air flotation, belt thickeners, and centrifugation are the most common physical processes used to sludge thickeners [26].

The sludge taken from the SBR pools will be collected in a storage tank with a total volume of 196 m^3 (7m x 7m x 4m) to prevent precipitation and will be dewatered with the help of a decanter.

3.4 Model Results

The accuracy and reliability of the model results of the wastewater treatment plant are directly related to the design and model parameters of the plant. 13 state variables should be provided as inputs to the ASM1 model. Most of these variables in the model cannot be measured directly. In other words, it is calculated by various analytical techniques. Wastewater treatment plant inlet and outlet concentrations are given in Table 8. It is seen that the model results comply with the standards of "Urban Wastewater Treatment Regulation (UWTR)" (Table 5).

Table 8. Model discharge results

PARAMETERS	UNİT	EFFLUENT
BOD	mgO_2/L	1.6
COD	mgCOD/L	34.84
TN	mgN/L	3.16
TP	mgP/L	0.65
pH	-	7.0
Suspended Solids	mg/L	5.35

To obtain the output concentrations obtained in Table 8, the kinetic and stoichiometric coefficients in the ASM1 model are the model initial parameters and are called "reference parameters". The model operated with reference parameters was optimized to ensure compatibility with target concentrations and it was observed that it complied with the values given in Table 9.

Table 9. Calibrated coefficients

PARAMETERS	EXPLANATION	VALUE	UNIT	REF. [16, 27, 28]
μ_{Hmax}	Maximum specific growth rate for heterotrophic biomass	2.97	1/d	4 - 6
μ_{Omax}	Maximum specific growth rate for otrophic biomass	0.9	1/d	0.8 - 0.88
b_H	Decay rate for heterotrophic biomass	0.62	1/d	0.5 - 0.62
b_O	Decay rate for autotrophic biomass	0.17	1/d	0.13 - 0.18
Y_H	the growth yield coefficient hetetrotrophic biomass	0.66	g Biomass/g Substrate	0,57 - 0.67
Y_O	the growth yield coefficient ototrophic biomass	0.54	g Biomass/g Substrate	0.24
K_S	slowly biodegradable substrate	5	mgS/L	3 - 20
COD/MLSS		1.55	gCOD/gVSS	

4. CONCLUSION

In the study, a wastewater treatment plant with a population capacity of 112000 that provides biological nitrogen phosphorus removal was calibrated and mathematically modeled using the ASM1 model in GPS-X software. It is seen that the discharge standards are met according to the model and facility parameters obtained. Since operational problems and the need for facility improvement are known during facility operation, it is important to create a model of wastewater treatment plants. The results obtained after the modeling are given below.

In the modeling, 97% of MLSS, 93% of COD, 99% of BOD, 92% of TN, and 90% of TP have been removed, thus complying with the discharge limits in secondary treatment according to the Urban Wastewater Treatment Regulation (UWTR).

For the activated sludge process to work properly, the nutrient-microorganism ratio (F/M) must be in balance. Because a high F/M ratio usually results in a weak settling sludge and turbid wastewater in the secondary clarifier, Low F/M causes swelling and growth of filamentous bacteria. As a result of modeling, F/M was calculated as 0.06. This result is in line with the literature values [11].

The specific oxygen consumption rate (OCR), which is one of the effective parameters in nitrogen and phosphorus removal and precipitation problems, was measured as 9.8 mg O_2/l.hour in the study.

It has been observed that the amount of sand removed from the system in the Sand-Oil trap is 84 kg/hour.

In the study, the results were obtained by choosing the sludge age (SRT) 25 days and the retention time (HRT) 8 hours.

VSS/TSS values for the effective removal of both TN and carbonous materials in the wastewater, and the ratio should be maintained above 0.5.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS’ CONTRIBUTIONS

Ertuğrul GÜL: Conceptualization, Validation, Planning and Conducting research activity, Writing-original drafting, Reviewing and Editing, Data collection, Organization and İnterpretation, Analysis. Melek ERDEK: Planning the research activity and supervising project, Data collection, Writing-reviewing and Editing.

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