Operation and management of Liaoning waste water treatment plants by STOAT Simulation

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Abstract. Due to the irregular management, the effluent water of some waste water treatment plants (WWPT) of Liaoning province didn't meet the demand of the National Discharge Standard. Meanwhile, excessive of dosage and discharge of sludge made the results of operation costs increasing and environmental pollution during the processes. The use of mathematical models for the simulationof wastewater treatment processes has gained widespread acceptance as a tool to aid the design of newworks and the optimization of existing facilities. STOAT developed by the Water Research Center is the most widely used model for simulating the WWST processes. This paper invited the STOAT as simulation model for the design and optimization of Liaoning waste water treatment plant.

1 Introduction

With the development of industry, the northeast cities of Liaoning province has experienced an economic development at high speed. However, the population growth and industrial scale expansion of Liaoning province have led to an increased waste water discharge, which brought a lot of pressure to the current conventional waste water treatment plants.

At present,there are 160 waste water treatment plants distributed in different cities of Liaoning province, the total daily capacities are 8.467million tons theoretically,but actual treatment water capacities are only 4.67 million tons. Annual treatment water capacities are up to 23.62 billion tons which are amount to the total reservoir capacity of the Dahuofang reservoir.Shenyang is the capital city of Liaoning province, it has 34 waste water treatment plants (WWTP), the daily waste water treatment capacities are 2.508 million tons[1].

The "Discharge standard of pollutants for municipal wastewater treatment plant" (GB18918-2002) of the National Standard has revised in 2006, which has strengthened the effluent water quality of WWTP must meet the National Standard before discharged to the key drainage basins such as Liao River located in Liaoning province. Therefore the Environmental Management Departments have improved the requirements of wastewater treatment plants from large cities to the small towns[2].

Most of the wastewater treatment plants in Liaoning province mainly treat the domestic wastewater and the industrial wastewater.The treatment processes include biological methods, such as AAO, SBR, AO and other classical activated sludge process or the improved process of these classical methods[3].However, due to relaxed construction quality control and insufficient management, large number of small wastewater treatment plants were not meet the demands of National Standard. The running parameters and management methods were different from the original designs demand. Part of the wastewater treatment plant parameters were designed too conservative, which can not work well at full running time. Therefore, such wastewater treatment plants need to be simulated to optimize the running parameters.

Every month,the amount of the wastewater and water quality which need to be dealt are both changed.During the rainy season, the wastewater quantity of WWTP is usually larger than the dry season.Sometimes the amount of water needed to be handled during the rainy season is far greater than that of the design, which is beyond the processing capacity of the wastewater treatment plant.This phenomenon makes a mass of water enter wastewater treatment plant in a short period of time,reduction of hydraulic retention time in the biological reaction tank, a large amount of activated sludge lost ,total active species in the reaction pool decreased,the residual sludge quantity in the two settling basin suddenly increased. Therefore,the system is difficult to work normally.

In general, the small and medium-sized wastewater treatment plant is based on artificial experience to control the technological process,but many times artificial experience cannot meet the water treatment process

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improvement and experience judgment error would reduce the capacity of wastewater treatment plant.A large number of wastewater above the standards were discharged into the river or cannot be recycled, it is easily to cause environmental pollution and economic loss.So the simulation software of wastewater treatment plant is very important in the rapid development of china.[4]
The online real-time monitoring system can provide real-time data for the waste water treatment plants conveniently. The system provided the real time data for the simulation models which can help the waste water treatment plants finding the optimal running parameters. By this system, the waste water treatment plant will reduce the energy consumption when running at full load and treat wastewater under the best condition, in this way, the discharge of WWTP could reach the demand of the National Standard.

2 Select simulation models

Now the mainstream simulation software of wastewater treatment plant are EFOR, GPS-X, STOAT, WEST, Biowin, etc.They are all widely used in developed countries. However, most of these simulation software are not free of charge, which will cost too much for some small wastewater treatment plants.So an economical and practical simulation software is needed to solve the existing problems for small WWTP of Liaoning province[5].
STOAT is the mainstream product of PLC WRc company which can simulate more than 40 kinds of process such as Inline Primary tank ,detention tank,SBR,Chemical P removal,IDEA,CSBR, trickling filter,Chlorination,Acid stripper humus tank,fluidised bed,Thickener,Chemical disinfection ,which basic covers a variety of processes of all the wastewater treatment plants in Liaoning.
STOAT is the only simulation program based on BOD and COD and has been used in many countries such as Britain, Europe, the United States and the Middle East.In order to help the industry better understanding and application of the wastewater treatment model,the British PLC WRc company in 2010 make the STOAT free to use in the world. Any enterprise or individual can go to the PLC WRc company website for free download or obtain STOAT simulation software.This is a good news for Liaoning wastewater treatment plants. For this reason, wastewater treatment plants do not have to consider the cost of the purchase of simulation software problems, also they do not need to solve the use of pirated software problems.

3Simulation of Liaoning wastewater treatment plant

3.1 Sanbaotunwastewater treatment plant

Sanbaotun wastewater treatment plant was conducted in Fushun, Liaoning, since 20 years ago to treat wastewater for surrounding cities. This plant served a population of 250000 P.E., the secondary treatment process of this plant used AAO process. And the capacity was 400,000m3/d. The STOAT simulation was used to build a new WWTP and optimize the running parameter. According to the original data of the water influent and the analysis of the online monitoring data to determine the modules used in the simulation framework and the models used in each module.The AAO process of this simulation wastewater treatment process was a multimode AAO technology, also it will be an improved process of traditional AAO.
Multimode is the multiple inlet and multiple return port，which can flexible control between AAO and inverted AAO on the basis of inlet and outlet requirements to achieve the processing requirement.The waste water passes through the thick grid, the fine grid and the micro grid,then adopting the method of subsection inlet makes the wastewater to be treated input in the anaerobic and anoxic zones respectively.Sanbaotun wastewater treatment plant is made up of four AAO reaction tanks,each tank with 161 meters long,102 meters wide and 6 meters effective depth,each anaerobic anoxic zone 19 meters long and 102 meters wide.In the front of the main reaction tank in AAO process is equipped with anaerobic anoxic zone which has the function of removing nitrogen and phosphorus.The back end of the reaction zone is dominated by the aeration zone which has two internal reflux pump to reflux mixed liquid in anoxic zone.Each AAO tank corresponds to two settling basin and each two settling basin's surface area is 1018 square meters and the effective pool depth is 4.5meters.

3.2STOAT model

The STOAT was used to simulate Sanbaotun waste water treatment plant processing. Because the waste water treatment plant was made up of four groups of AAO process, one of the AAO group was chosen for the STOAT simulation.The process was composed of waste water influent and flow divider to shunt waste water.Part of waste water have flowed into anaerobic tank and another part have flowed into anoxic tank.Waste water passes through anaerobic tank and anoxic tank to aerobic tank.After the aeration treatment,part of waste water have returned to anoxic tank and other parts have equally assigned tosecondary sedimentation tank 1 and secondary sedimentation tank 2. After treatment, water and sludge were discharged, part of the return activated sludge after the confluence back to tank Anaerobic

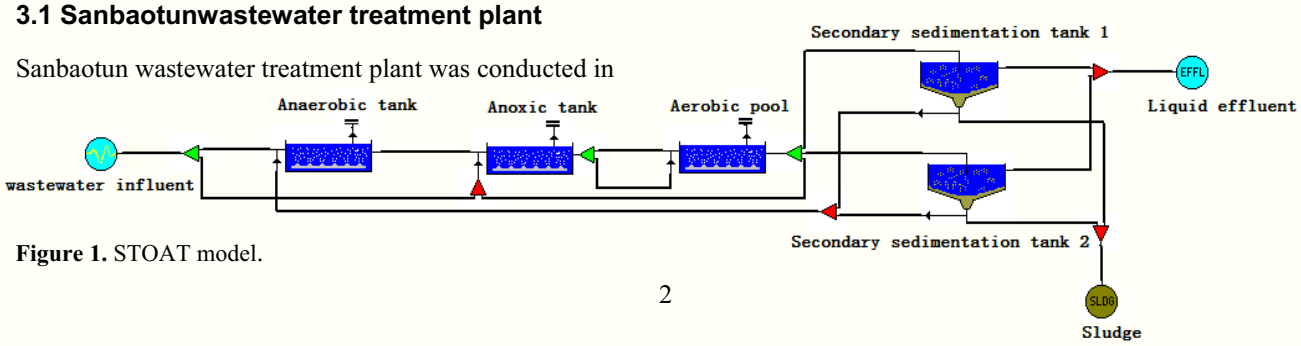

Figure 1. STOAT model.

3.3 Model comparison

ASAL1： The WRc model comprises a number of differential equations written as a mass balance around a completely mixed reactor. Increasing the number of reactors in series increases the model's approach to plug flow. Twelve tanks in series provide an excellent approximation to a true plug-flow reactor. Each tank contains an identical number of components with a differential equation for each.The model recognised that utilisation of substrate can occur without this consumption being coupled to growth. Thus a more accurate description of the removal of substrate from a wastewater treatment system would include in the mass balance equation a Monod term for the conversion of substrate to new biomass and a Michaelis-Menten term for non-growth substrate removal.

ASAL2：Activated sludge model 1 assumes that all particulate BOD is solubilised immediately. This approximation is acceptable when the sewagewater retention time is long, greater than 4 hours. For shorter sewagewater retention times hydrolysis is incomplete and Model 1 is likely to over-predict the effluent BOD.This model has been evaluated at a UK sewagewater works on storm flows and found to predict the correct effluent BOD. The activated sludge unit at this works had a hydraulic retention time during the storm of less than one hour

ASAL3：This model is equivalent to Model 2 but with all the kinetic and stoichiometric parameters accessible to you and should be restricted to `expert' use especially when treating industrial effluents.

ASAL4：This model will be introduced in a later version of STOAT. It is equivalent to the IAWQ Activated Sludge Model #2 for biological phosphorus removal, modified to work with BOD rather than COD and to include the concept of nonviable bacteria having biological activity.

ASAL5：Activated sludge model 5 is the same as model 1 but includes a simple model of biological P-removal.

The basic model is described here as Model 1 and is intended for normal activated sludge modeling. This model ignores the breakdown of particulate BOD to soluble BOD, and this simplification can affect the predictions of detailed spatial oxygen demand within the aeration basin, and also the effluent BOD under storm conditions. Model 2 therefore includes the effects of solids hydrolysis to soluble products. Although

Model 2 is therefore more accurate than Model 1 it does require that you have some data on solids breakdown; where this is lacking Model 1 should be used. Model 3 gives the user full access to all the kinetic constants within the model. Model 5 is a simple biological phosphorus removal model, based on an extension of Model 1.

3.4Simulationg results

After inputting the data and selecting the model, the practical simulation result of waste water treatment plant will be achieved by adjusting operating parameters in STOAT simulation software according to the practical operating conditions of the wastewater plant. We input the real water quality into the simulation frame to obtain the simulated water quality.

Model parameters need to be revised according to the influent and effluent water quality indexes of aerobic tank, anoxic tank, erobic tank and secondary sedimentation tank. Each parameter adjustment to the reasonable numerical needs a large amount of data and the experiments to verify. Adjusting the parameters to achieve the perfect simulation of a wastewater treatment plant is a very difficult event. But it can simulate the effluent to the waste water treatment plant to the guidance of the proposed process modification.

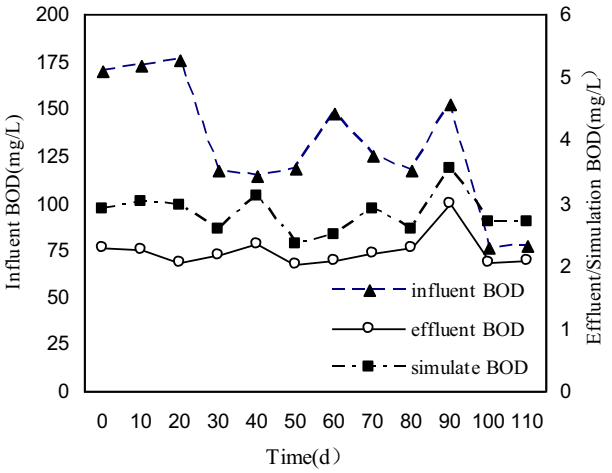

Figure 2. Influent / Effluent / Simulate BOD data

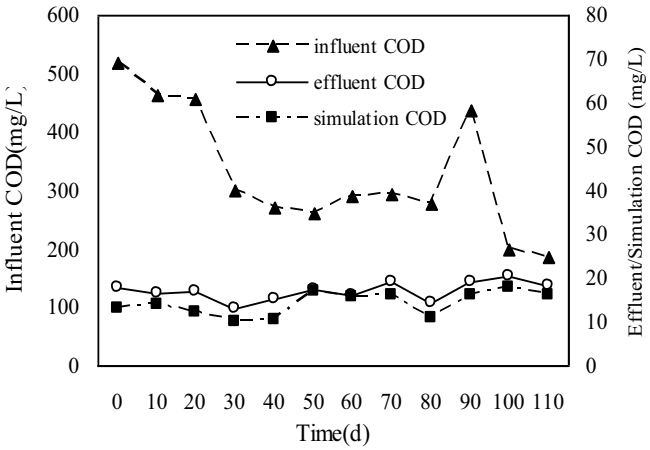

Figure 3. Influent / Effluent / Simulate COD data

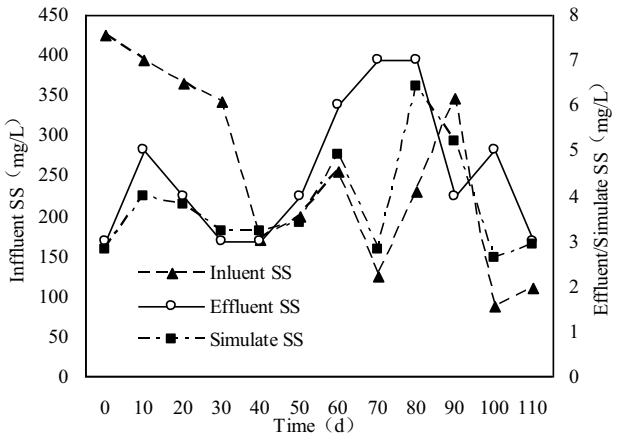

Figure 4. Influent / Effluent / Simulate SS data

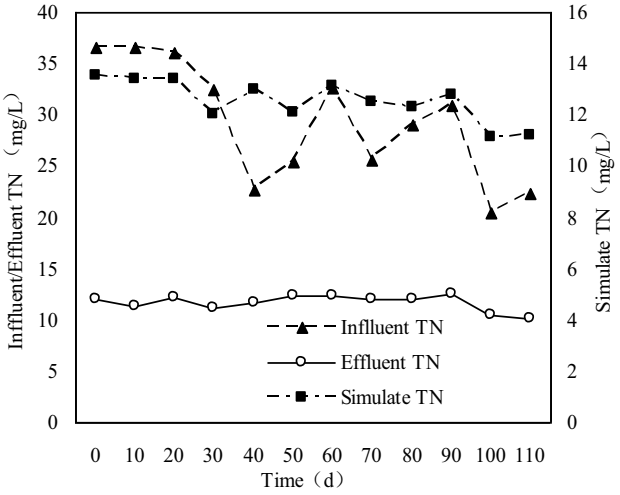

Figure 5. Influent / Effluent / Simulate TN data

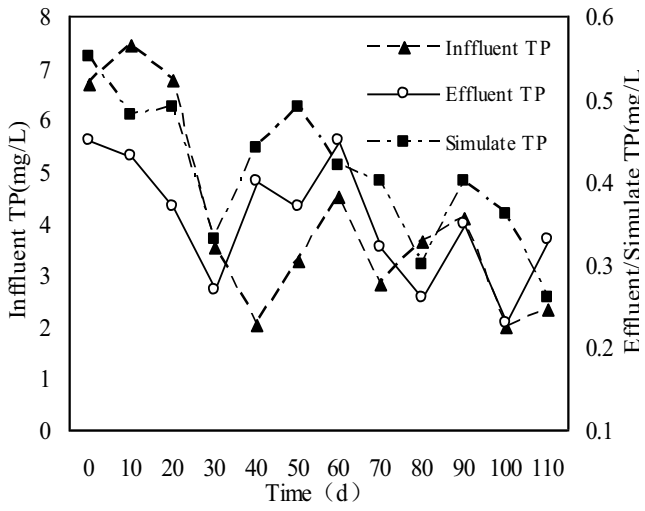

Figure 6. Influent / Effluent / Simulate TP data

4Conclusion

After comparing the real water quality index with the simulated water quality index, the quality of the waste water treatment plant can be simulated by the STOAT software. By this way, the simulation process of the wastewater treatment plant can be simulated by adjusting the reflux ratio and the amount of aeration according to the simulation software. The discharge of wastewater and the amount of aeration can be reduced as far as possible. The operation energy consumption of wastewater treatment plant will be reduced either, and the effluent water quality of wastewater treatment plant will meet the national standard.

Acknowledgments

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