PLANT-WIDE MODELING FOR GABAL EL ASFAR WWTP "CONTRACT 19" OPTIMIZATION

By

Mohamed Sherief Shawki Abo-Zaid

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
Civil Engineering - Public Works

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:
Plant-Wide Modeling For Gabal El Asfar Wastewater Treatment Plant "Contract 19" Optimization

Key Words:
Wastewater Treatment; Activated Sludge; Modeling; Treatment Process Optimization; BioWin

Summary:

This master's thesis introduces the Plant Wide modeling of Gabal El Asfar wastewater treatment plant (Contract 19) for process optimization purposes, The modeling equations were based on the BioWin Model and the Good Modeling Practice Protocol has been followed. The results after calibration showed that the BioWin Model can be used to model the whole plant with an accuracy high enough to be used in the treatment processes optimization which leads to better effluent characteristics or operation cost reduction while maintaining high effluent quality.

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Nomenclature

AOB	Ammonia Oxidising Biomass
ARD	Average Relative Deviation
PAOs	Phosphorus Accumulating Organisms
SI	Soluble Inert Organic Matter
STT	Primary sludge thickening Tanks
XI	Particulate Inert Organics
ANAMMOX	Anaerobic Ammonia Oxidizers
CCT	Chlorination Contact Tanks
OHOs	Ordinary Heterotrophic Organisms
Ss	Readily Degradable Organic Matter
Xp	Particulate Inert Organics Derived from Biomass Decay
Xs	Slowly Degradable Organic Matter
ADM	Anaerobic Digestion Model
ASM	Activated Sludge Model
AT	Aeration Tank
BOD	Biological Oxygen Demand
CH4	Methane Gas
CO2	Carbon Dioxide
COD	Chemical Oxygen Demand
DAF	Dissolved Air Flotation
DO	Dissolved Oxygen
DPS	Drainage Pump Station
EBPR	Excess Biological Phosphorous Removal

FCT	Final Clarifier Tank
FRDC	First Receiption Destribution Chamber
FSPS	Floated Sludge Pumping Station:
GAWWTP	Gabal El Asfar Waste Water Treatment Plant
GGRT	Grit & Grease Removal Tanks
GMP	Good Modeling Practice protocol
H2S	Hydrogen Sulphide
IAWPRC	International Association on Water Pollution Research and Control
IPS	Inlet Pumping Station
IWA	International Water Association
IWPS	Inlet Work Pumping Station
MDH	Mechanical Dewatering House
MLSS	Mixed Liqor Suspended Solids
MLSS	Mixed Liquor Suspended Solids
MLVSS	Mixed Liquor Volatile Suspended Solids
N	Nitrogen
ND-EBPR	Nitrification, Denitrification, and Excess Biological Phosphorous Removal
NH4	Ammonia
NO2	Nitrite
NO3	Nitrate
PST	Primary Sedimentation Tank
RAS	Return Activated Sludge
RASPS	Return Activated Sludge Pumping Station
SRT	Sludge retention time
STT	Sludge Thickening Tank
T	Temperature

TKN	Total Keldahl Nitrogen
TSS	Total Suspended Solids
VFA	Volatile Fatty Acids
WASPS	Waste Activated Sludge Pumping Station
WERF	Water Environment Research Foundation
WWTP	Wastewater Treatment Plant

Abstract

Wastewater Treatment plant (WWTP) modeling has been proved to be as very useful tool for understanding, optimizing and upgrading existing wastewater processes; Once a model is calibrated and successfully validated, it allows the operator to model different operation plans, understand the effect of those changes on the process operation and predict the expected results. A validated model can be quiet beneficial in terms of cost saving due to the prediction of the outcome of various operation scenarios without actual operation and can be used to perform optimization studies that can lead to better effluent characteristics.

In general, most wastewater treatment facilities are operated based on previous experience with different processes. Operational change decisions especially for large wastewater treatment plants should be executed with extreme care. Different operational routines have to be deeply investigated and multiple optimization alternatives have to be proposed and sufficiently studied for the purposes of operational cost minimization while maintaining the required effluent quality.

Gabal El Asfar Wastewater Treatment Plant (GAWWTP) in Cairo is considered the largest in Africa and among the few plants that applies anaerobic digestion methods successfully. Currently four projects are operated: Gabal El Asfar stage 1 phase 1 namely Contract 16 with 1 million m^3/day capacity, complemented by Gabal El Asfar stage 1 phase 1 Optimization with a capacity of 300,000 m^3/day and Gabal El Asfar contract 19 (Stage 2 phase 1) with a 500,000 m^3/day capacity and a newly constructed WWTP namely stage 2 phase 2 of 500,000 m3/day capacity. Gabal El Asfar – Contract 19 is an activated sludge WWTP and it is the case study that will be modeled in this research.

Applying the Good Modeling Practice protocol showed clear organized steps for successful modeling of Gabal El Asfar wastewater treatment plant. Historical data and design reports have been collected and various site visits has been made in addition to a sampling campaign to perform important analysis that are not performed in the plant routine analysis for a proper wastewater characterization and a successful model calibration.

Using the BioWin version 5.1 software modeling that has its own general activated sludge-digestion model and contains 50 state variables and 60 process expressions spared us from coupling different models and lessened complexions in the Plant Wide Modeling process, The plan wide model was calibrated and validated.

After the model validation, multiple operation scenarios were investigated using the BioWin Plant Wide model and the results were used to derive operational plans for the activated sludge system for the purposes of aeration cost reduction while maintaining the required effluent quality or applying a nutrient removal operation plan. The BioWin model was successfully used for creating a plant wide model for Gabal El Asfar WWTP with accuracy high enough to perform optimization studies.