



Cairo University

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

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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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Table of Contents

ACKNOWLEDGMENTS	I
TABLE OF CONTENTS.....	II
LIST OF TABLES	IV
LIST OF FIGURES	V
NOMENCLATURE	VIII
ABSTRACT	XI
CHAPTER 1 : INTRODUCTION	1
1.1. OVERVIEW	1
1.2. PROBLEM STATEMENT	3
1.3. THESIS OUTLINE	4
CHAPTER 2 : LITERATURE REVIEW	5
2.1. WASTEWATER TREATMENT OVERVIEW	5
2.1.1. Activated Sludge Treatment Process	8
2.1.2. Sludge Treatment and Anaerobic Stabilization	9
2.2. MATHEMATICAL MODELING OF TREATMENT PROCESSES.....	12
2.2.1. Activated Sludge Models	13
2.2.2. Anaerobic Digestion Models	15
2.2.3. Solids – Liquid Separation Models.....	16
2.2.4. Plant Wide Modeling	19
2.2.5. BioWin General Model.....	20
2.2.6. Modeling Protocols of WWTP Processes.....	21
2.3. GOOD MODELING PRACTICE UNIFIED PROTOCOL.....	23
2.3.1. Project Definition.....	24
2.3.2. Data Collection and Reconciliation	25
2.3.3. Plant Model Set-up	26
2.3.4. Calibration and Validation.....	27
2.3.5. Simulation and Result Interpretation	29
2.4. WASTEWATER CHARACTERIZATION	30
2.5. WASTEWATER TREATMENT OPTIMIZATION BY MODELING	33
2.5.1. Energy Efficiency Optimization of Activated Sludge Processes.....	34
2.5.2. Biogas Production Process.....	35
CHAPTER 3 : METHODOLOGY	37
3.1. GAWWTP PROCESS DESCRIPTION.....	37
3.1.1. Wastewater Works Treatment.....	40
3.1.2. Sludge Works Treatment	46
3.2. HISTORICAL WASTEWATER ANALYSIS	50

3.2.1.	Plant performance Assessment	55
3.3.	SAMPLING CAMPAIGN.....	56
3.4.	WASTEWATER CHARACTERIZATION	61
3.5.	BIOWIN MODELS	64
3.6.	MODEL CALIBRATION.....	69
3.7.	MODEL VALIDATION.....	70
3.8.	SCENARIOS SIMULATIONS FOR OPTIMIZATION.....	71
CHAPTER 4 : RESULTS & DISCUSSION		73
4.1.	STOWA PROTOCOL WASTEWATER CHARACTERIZATION	73
4.2.	MODEL CALIBRATION RESULTS.....	74
4.3.	MODEL VALIDATION RESULTS	77
4.4.	ONE YEAR HISTORICAL DATA SIMULATION	92
4.5.	OPTIMIZATION STUDY	98
4.5.1.	Optimization Plan to Achieve Nitrification - Denitrification	104
4.5.2.	Optimization Plan to Achieve Decreased Operational Cost	110
CHAPTER 5 : CONCLUSION & RECOMMENDATION		118
5.1.	CONCLUSION.....	118
5.2.	RECOMMENDATION.....	119
REFERENCES		120

List of Tables

Table 3-1: Inlet IWPS Average Monthly Historical Analysis.....	52
Table 3-2: PST Effluent Average Monthly Historical Analysis	53
Table 3-3: Treated Effluent To Gabal Drain Historical Analysis	54
Table 3-4: Raw Water Influent to Primary Sedimentation Tank Sampling Campaign Statistical Analysis Results.....	57
Table 3-5: Settled Water Effluent from the Primary Sedimentation Tank Sampling Campaign Statistical Analysis Results	58
Table 3-6: Effluent from Aeration Tanks Sampling Campaign Statistical Analysis Results	58
Table 3-7: Effluent from Final Sedimentation Tanks Sampling Campaign Statistical Analysis Results	59
Table 3-8: Supernatant from Mechanical Dewatering House to Primary Sedimentation Tank Sampling Campaign Statistical Analysis Results.....	59
Table 3-9: DAF Under Flow to the Aeration Tanks Sampling Campaign Statistical Analysis Results	60
Table 3-10: Thickener Supernatant to Primary Sedimentation Tank Sampling Campaign Statistical Analysis Results.....	60
Table 3-11: Effluent from the Secondary Digester to the Mechanical Dewatering House Sampling Campaign Statistical Analysis Results.....	60
Table 3-12: Produced Sludge from the Mechanical Dewatering Sludge Sampling Campaign Statistical Analysis Results	61
Table 3-13: Raw wastewater Default charecterization parameters	63
Table 3-14: Settled wastewater Default charecterization parameters	64
Table 4-1: Characterization parameters used in the BioWin plant wide model.....	73
Table 4-2: Actual Measured WWTP Effluent Values and The Calibrated Model Results.	74
Table 4-3: Actual and Simulated Aeration Tanks MLSS & MLVSS Results.	75
Table 4-4: Actual and Simulated Anaerobic Digester and Sludge Production Results. ..	75
Table 4-5: calibrated stoichiometric and kinetic parameters.....	76
Table 4-6: Anaerobic Digester and Sludge Production Results:	92
Table 4-7: Multiple Operational Configurations:.....	99
Table 4-8: Optimization Plan Results for Nitrification - Denitrification	104
Table 4-9: Optimization Plan Results for Decreased Aeration	110
Table 4-10: Aeartion Electrical requirments From BioWin Results:.....	112

List of Figures

Figure 1.1: GAWWTP Effluent Water path to El Manzala Lake (Arabic Development Bank, 2007)	2
Figure 1.2: Gabal El Asfar WWTP (Adopted from Google Earth).....	4
Figure 2.1: Basic concept of the activated sludge process (Govoreanu, 2004).....	8
Figure 2.2: Anaerobic Digester simplified figure (Tchobanoglous, Burton, & Stensel, 2003).....	9
Figure 2.3: Basic Diagram of Anaerobic Digestion Processes (Verma, 2002).....	10
Figure 2.4: Simplified process schematic of a typical large WWTP (Raymond, 2012) ..	11
Figure 2.5: Different representations of the same clarifier (Jeppsson U. , 1996).....	18
Figure 2.6: Simplified representation of HSG protocol, STOWA protocol and BIOMATH protocol (Vanrolleghem, et al., 2003) (Hulsbeek, J. Kruit, & Loosdrecht, 2002) (Langergraber, et al., 2004).....	22
Figure 2.7: GMP Project Definition Flowchart (Rieger, Shaw, Gillot, & Takács, 2012)	25
Figure 2.8: GMP Data Collection Flowchart (Rieger, Shaw, Gillot, & Takács, 2012) ...	26
Figure 2.9: GMP Model Setup Flowchart (Rieger, Shaw, Gillot, & Takács, 2012)	27
Figure 2.10: GMP Calibration and Validation Flowchart (Rieger, Shaw, Gillot, & Takács, 2012)	28
Figure 2.11: STOWA Protocol Calibration Parameters (Hulsbeek, J. Kruit, & Loosdrecht, 2002).....	29
Figure 2.12: GMP Simulation and Results Interpretation Flowchart (Rieger, Shaw, Gillot, & Takács, 2012)	30
Figure 2.13: Wastewater Characterization for Carbonaceous Components (Jeppsson U. , 1996).....	30
Figure 2.14: The Biological Decomposition Chain (Jeppsson U. , 1996).....	31
Figure 2.15: Wastewater Characterization for Nitrogenous Components (Jeppsson U. , 1996).....	32
Figure 3.1: GAWWTP Contract 19 Satellite image (Adopted from Google Earth)	37
Figure 3.2: Process Flow Diagram of GAWWTP Contract 19	38
Figure 3.3: General Layout of GAWWTP Contract 19 (Degremont, 2001a).....	39
Figure 3.4: Preliminary Treatment Units in GAWWPT contract 19 (Adopted from Google Earth)	41
Figure 3.5: 6 Primary Sedimentation Tanks in GAWWPT contract 19 (Adopted from Google Earth)	42
Figure 3.6: GAWWTP contract 19, 8 Three Zoned Aeration Tanks (Adopted from Google Earth)	42
Figure 3.7: Schematic DWG of the Current Aeration Plan of the 8 Aeration Tanks in GAWWTP Contract 19	44
Figure 3.8: 8 Final Clarifiers in GAWWTP Contract 19 (Adopted from Google Earth). 44	
Figure 3.9: Gravity Thickening Tanks in GAWWTP Contract 19 (Adopted from Google Earth)	46
Figure 3.10: Dissolved Air Floatation Units in GAWWTP Contract 19 (Adopted from Google Earth)	48
Figure 3.11: Two Digestion Blocks in GAWWTP Contract 19 (Adopted from Google Earth)	49
Figure 3.12: STOWA protocol characterization equations (Roeleveld & Loosdrecht, 2002).....	62

Figure 3.13: STOWA protocol characterization Influent Composition fractions (Roeleveld & Loosdrecht, 2002)	62
Figure 3.14: BioWin model Layout for the secondary treatment in GAWWTP contract 19	66
Figure 3.15: BioWin model Layout for the primary and secondary treatment in GAWWTP contract 19	67
Figure 3.16: Plant wide BioWin model Layout for GAWWTP contract 19	68
Figure 3.17: Order of Steps during the Calibration Process (Hulsbeek, J. Kruit, & Loosdrecht, 2002).....	69
Figure 3.18: The values of S_{ij} for the most sensitive parameters of the Calibrated BioWin AS model (Liwarska-Bizukojc & Biernacki, 2010).	70
Figure 3.19: Aeration tanks DO control panel in GAWWTP contract 19	71
Figure 4.1: November 2016 Effluent Validation Curves for COD	78
Figure 4.2: November 2016 Effluent Validation Curves for BOD	78
Figure 4.3: November 2016 Effluent Validation Curves for TSS.....	79
Figure 4.4: November 2016 Effluent Validation Curves for NH_4	79
Figure 4.5: November 2016 Effluent Validation Curves for TKN	80
Figure 4.6: November 2016 Effluent Validation Curves for MLSS	80
Figure 4.7: November 2016 Effluent Validation Curves for MLVSS	81
Figure 4.8: September 2016 Effluent Validation Curves for COD	83
Figure 4.9: September 2016 Effluent Validation Curves for BOD	83
Figure 4.10: September 2016 Effluent Validation Curves for TSS.....	84
Figure 4.11: September 2016 Effluent Validation Curves for NH_4	84
Figure 4.12: September 2016 Effluent Validation Curves for TKN	85
Figure 4.13: September 2016 Effluent Validation Curves for MLSS	85
Figure 4.14: September 2016 Effluent Validation Curves for MLVSS	86
Figure 4.15: June 2016 Effluent Validation Curves for COD.....	88
Figure 4.16: June 2016 Effluent Validation Curves for BOD.....	88
Figure 4.17: June 2016 Effluent Validation Curves for TSS	89
Figure 4.18: June 2016 Effluent Validation Curves for NH_4	89
Figure 4.19: June 2016 Effluent Validation Curves for TKN	90
Figure 4.20: June 2016 Effluent Validation Curves for MLSS.....	90
Figure 4.21: June 2016 Effluent Validation Curves for MLVSS	91
Figure 4.22: Validated Model Effluent Simulation Results from June 2015 to May 2016 Effluent for BOD	94
Figure 4.23: Validated Model Effluent Simulation Results from June 2015 to May 2016 Effluent for COD	94
Figure 4.24: Validated Model Effluent Simulation Results from June 2015 to May 2016 Effluent for TSS	95
Figure 4.25: Validated Model Effluent Simulation Results from June 2015 to May 2016 Effluent for TKN	95
Figure 4.26: Validated Model Effluent Simulation Results from June 2015 to May 2016 Effluent for NH_4 ,	96
Figure 4.27: Validated Model Effluent Simulation Results from June 2015 to May 2016 Effluent for MLSS	96
Figure 4.28: Validated Model Effluent Simulation Results from June 2015 to May 2016 Effluent for MLVSS	97
Figure 4.29: Schematic DWG of the Aeration Tank External Part Aeration Configuration for Scenario 11	101

Figure 4.30: Schematic DWG of the Aeration Tank External Part Aeration Configuration for Scenario 12	102
Figure 4.31: Schematic DWG of the Aeration Tank External Part Aeration Configuration for Scenario 13	102
Figure 4.32: Schematic DWG of the Proposed Aeration Plan of the 8 Aeration Tanks in GAWWTP Contract 19 to Achieve Nitrification - Denitrification	105
Figure 4.33: The Effluent Comparison While applying the Nitrification – Denitrification Optimization Plan & Before Applying the Optimization Plan for the BOD.....	106
Figure 4.34: The Effluent Comparison While applying the Nitrification – Denitrification Optimization Plan & Before Applying the Optimization Plan for the COD.....	106
Figure 4.35: The Effluent Comparison While applying the Nitrification – Denitrification Optimization Plan & Before Applying the Optimization Plan for the TSS.	107
Figure 4.36: The Effluent Comparison While applying the Nitrification – Denitrification Optimization Plan & Before Applying the Optimization Plan for the TKN.....	107
Figure 4.37: The Effluent Comparison While applying the Nitrification – Denitrification Optimization Plan & Before Applying the Optimization Plan for the NH ₄	108
Figure 4.38: The Effluent Comparison While applying the Nitrification – Denitrification Optimization Plan & Before Applying the Optimization Plan for the MLSS.....	108
Figure 4.39: The Effluent Comparison While applying the Nitrification – Denitrification Optimization Plan & Before Applying the Optimization Plan for the MLVSS.....	109
Figure 4.40: Schematic DWG of the Proposed Aeration Plan of the 8 Aeration Tanks in GAWWTP Contract 19 to Decreased Aeration.....	111
Figure 4.41: The Effluent Comparison While applying the Decreased Aeration Optimization plan & Before Applying the Optimization Plan for the BOD	113
Figure 4.42: The Effluent Comparison While applying the Decreased Aeration Optimization plan & Before Applying the Optimization Plan for the COD.....	113
Figure 4.43: The Effluent Comparison While applying the Decreased Aeration Optimization plan & Before Applying the Optimization Plan for the TSS	114
Figure 4.44: The Effluent Comparison While applying the Decreased Aeration Optimization plan & Before Applying the Optimization Plan for the TKN	114
Figure 4.45: The Effluent Comparison While applying the Decreased Aeration Optimization plan & Before Applying the Optimization Plan for the NH ₄	115
Figure 4.46: The Effluent Comparison While applying the Decreased Aeration Optimization plan & Before Applying the Optimization Plan for MLSS.....	115
Figure 4.47: The Effluent Comparison While applying the Decreased Aeration Optimization plan & Before Applying the Optimization Plan for the MLVSS	116

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
CH ₄	Methane Gas
CO ₂	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 Reception Distribution Chamber
FSPS	Floated Sludge Pumping Station:
GAWWTP	Gabal El Asfar Waste Water Treatment Plant
GGRT	Grit & Grease Removal Tanks
GMP	Good Modeling Practice protocol
H ₂ S	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 Liquor Suspended Solids
MLSS	Mixed Liquor Suspended Solids
MLVSS	Mixed Liquor Volatile Suspended Solids
N	Nitrogen
ND-EBPR	Nitrification, Denitrification, and Excess Biological Phosphorous Removal
NH ₄	Ammonia
NO ₂	Nitrite
NO ₃	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 quite 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 m³/day capacity, complemented by Gabal El Asfar stage 1 phase 1 Optimization with a capacity of 300,000 m³/day and Gabal El Asfar contract 19 (Stage 2 phase 1) with a 500,000 m³/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.