



OPTIMIZATION OF STABILIZATION POND DESIGN DUE TO EGYPTIAN CONDITIONS

A Thesis

Submitted to the Faculty of Engineering
Ain Shams University for the Fulfillment
of the Requirement of M.Sc. Degree
In Civil Engineering

Prepared by

ENG. AHMED TAREK ABDELMONIEM

B.Sc. in Civil Engineering, June 2004
Faculty of Engineering – Ain Shams University

Supervisors

Prof. Dr. MOHAMED EL HOSSEINY EL NADI,

Professor of Sanitary & Environmental Engineering
Faculty of Engineering, Ain Shams University, Cairo, EGYPT

Prof.Dr. MAHMOUD ABDEL AZIM ,

Professor of Sanitary & Environmental Engineering
Faculty of Engineering, Ain Shams University, Cairo, EGYPT

Dr. NANY ALY HASSAN NASR

Assistant professor of Sanitary & Environmental Engineering
Faculty of Engineering, Ain Shams University, Cairo, EGYPT

2012



OPTIMIZATION OF STABILIZATION POND DESIGN DUE TO EGYPTIAN CONDITIONS

A Thesis For
The M.Sc. Degree in Civil Engineering
(SANITARY ENGINEERING)

by
ENG. AHMED TAREK ABDELMONIEM

B.Sc. in Civil Engineering, June 2004
Faculty of Engineering – Ain Shams University

THESIS APPROVAL

EXAMINERS COMMITTEE

SIGNATURE

Prof. Dr. Mohamed Saeed El Khouly

Professor of Sanitary Engineering

Faculty of Engineering, Ain Shams University

Prof. Dr. Mohamed El Sayed Aly Basiouny

Professor of Sanitary Engineering & Dean of

Faculty of Engineering, Banha University

Prof. Dr. Mohamed El Hosseiny El Nadi

Professor of Sanitary & Environmental Engineering

Faculty of Engineering, Ain Shams University

Date: - ---/--/2012

DEDICATION

I wish to dedicate this work to who suffered to educate, support
and encourage me during the thesis work

TO MY PARENTS,

MY BROTHER

Also, I wish to dedicate my thesis to my professor

PROF. DR. MOHAMED EL HOSSEINY EL NADI

For his encouragement and support to complete this work.

STATEMENT

This dissertation is submitted to Ain Shams University, Faculty of Engineering for the degree of M.Sc. in Civil Engineering.

The work included in this thesis was carried out by the author in the department of Public Works, Faculty of Engineering, Ain Shams University, from November 2010 to May 2012.

No part of the thesis has been submitted for a degree or a qualification at any other University or Institution.

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others

Date: - ---/-- /2012

Signature: - -----

Name: - *AHMED TAREK ABD EL MONIEM*

ACKNOWLEDGMENT

*The candidate is deeply grateful to **Prof. Dr. Mohamed EL Hosseiny EL Nadi**, Professor of Sanitary and Environmental Engineering, Faculty of Engineering, Ain Shams University, for help, encourage, co-operation sponsoring and patient advising during preparation of this work.*

*Also, great thanks to **Prof. Dr. MAHMOUD ABDEL AZIM**, Associate Professor of Sanitary and Environmental Engineering, Ain Shams University, for her help, and co-operation during the preparation of the study.*

*Also, great thanks to **Dr. Nany Ali Hassan Nasr**, Associate Professor of Sanitary and Environmental Engineering, Ain Shams University, for her help, and co-operation during the preparation of the study.*

ABSTRACT

NAME: - AHMED TAREK ABD EL MONIEM

**Title: - “OPTIMIZATION OF STABILIZATION POND
DESIGN DUE TO EGYPTIAN CONDITIONS”**
”

Faculty : - Faculty of Engineering, Ain Shams University.

Specialty: - Civil Eng., Public Works, Sanitary Eng.

Abstract:-

Stabilization ponds are established in various cities and villages in Egypt there are about 38 ponds covering almost all the regions of the country some of these ponds are working with low efficiency some of them are over designed and some are under designed One of the main problems is the plants are not fenced properly which maximize the wind effect and cause disturbance in the pond performance, some ponds are designed to receive a certain flow but actually it receives much less flow which increases the retention time .

In this study, 8 working WSPs in different locations all over Egypt were monitored and their performances were evaluated with respect to ponds retention time and prevailing climate temperature and humidity conditions. The concept of choosing these locations is to cover the different climate conditions (Temperature, wind, humidity) all over Egypt. These locations had covered regions presented in (Al Behera, Fayoum, Wadi Al Gadeed, Luxor, Hurghada, Sharm El Sheikh, Areesh & Abu Rudies) Each location had been visited during season's winter, spring, summer & autumn to obtain the different weather conditions and several samples were collected during the day over three days in each season.

It was found that reduced pond retention could work perfectly with operating climate conditions in Egyptian circumstances. Conclusions were drawn to suggest usage either minimum retention period or higher limit of volumetric organic loading that will benefit the minimization of area needed for the treatment plant.

SUPERVISORS

Prof. Dr. Mohamed EL Hosseiny EL Nadi,

Prof. Dr. Mahmoud Abdel Azim,

Dr. Nany Ali Hassan Nasr,

TABLE OF CONTENTS

	Page
COVER	i
APPROVAL COMMITTEE	ii
DEDICATION	iii
STATEMENT	iv
ACKNOWLEDGEMENT	v
ABSTRACT	vi
TABLE OF CONTENTS	vii
LIST OF FIGURES	ix
LIST OF TABLES	xiii
 CHAPTER I: INTRODUCTION	
1.1 BACKGROUND	1
1.2 STUDY OBJECTIVE	1
1.3 SCOPE OF WORK	2
1.4 THESIS ORGANIZATION	2
 CHAPTER II: LITERATURE REVIEW	
2.1 WASTEWATER TREATMENT	4
2.1.1 THE NEED FOR WASTEWATER TREATMENT	4
2.1.2 EFFECTS OF WASTEWATER ON WATER QUALITY	5
2.2 BASIC WASTEWATER TREATMENT PROCESSES	5
2.2.1 PHYSICAL WASTEWATER TREATMENT	5
2.2.2 CHEMICAL WASTEWATER TREATMENT	6
2.2.3 BIOLOGICAL WASTEWATER TREATMENT	6
2.3 WASTEWATER TREATMENT STAGES	7
2.3.1 PRIMARY TREATMENT	7
2.3.2 SECONDARY TREATMENT	7
2.4 WASTE STABILIZATION PONDS	7
2.4.1 TYPES OF WSP	7
2.5 TREATMENT PROCESS OF WSP	8
2.5.1 BOD REMOVAL	9
2.5.2 PATHOGEN REMOVAL	10
2.5.3 NUTRIENT REMOVAL	11
2.6 ADVANTAGES OF WSP	11
2.7 FACTORS AFFECTING WSP DESIGN	14
2.7.1 TEMPERATURE	14
2.7.2 NET EVAPORATION	15
2.7.3 HYDRAULIC LOAD	17

2.7.4	ORGANIC LOAD	18
2.7.5	FAECAL COLIFORMS	18
2.7.6	WIND	21
2.7.7	SUN LIGHT	23
2-8	DESIGN EQUATIONS OF W.S.P	24
2-8-1	INTRODUCTION	25
2.8.2	DESIGN PRINCIPLES OF ANAEROBIC PONDS	27
2.8.3	DESIGN PRINCIPLES OF FACULTATIVE PONDS	33
2-8-4	DESIGN PRINCIPLES OF MATURATION PONDS	47

CHAPTER III: MATERIALS & METHODS

3.1	STUDY LOCATION	57
3.1	PROGRAMME OF WORK	57
3.1.1	CHOOSING WORK INTERVALS	57
3.1.2	CHOOSING WORK SITES	58
3.2	SAMPLING	60
3.2.1	FREQUENCY OF SAMPLING	61
3.2.2	LOCATION OF SAMPLING	61
3.3	ANALYSIS AND METHODS OF MEASURES	61
3.3.1	CHEMICAL TESTS	61
3.4	SHAPE OF ANALYSIS PRESENTATION	62
3.5	VISITED SITES AND PLANTS DESCRIPTION	63
3.5.1	STABILIZATION POND IN AL BEHIERA	63
3.5.2	STABILIZATION POND IN FAYOUM	65
3.5.3	STABILIZATION POND IN AL WADI AL GADEED	67
3.5.4	STABILIZATION POND IN LUXOR	69
3.5.5	STABILIZATION POND IN SHARM EL SHEIKH	71
3.5.6	STABILIZATION POND IN AL AREESH, SAINAI	72
3.5.7	STABILIZATION POND IN HURGHADA	73

CHAPTER IV: RESULTS

4.1	GENERAL	75
4.2	FIELD RESULTS	76
4.2.1	FIRST POND (WAKED WSP - AL BEHIERA)	76
4.2.2	SECOND POND (KOTA WSP -AL FAYOUM)	78
4.2.3	THIRD POND (MOUT WSP -NEW VALLEY)	79
4.2.4	FOURTH POND (LUXOR WSP -LUXOR)	81
4.2.5	FIFTH POND (HURGHADA WSP -RED SEA)	83
4.2.6	SIXTH POND (SHARM EL SHEIKH WSP-SHARM EL SHIEKH)	85
4.2.7	SEVENTH POND (ABU RUDAIS WSP- SOUTH SINAI)	87
4.2.8	EIGHTH POND (GARADA WSP - AL ARISH)	90

CHAPTER V: DISSCUSION	
5.1 INTRODUCTION	92
5.2 APPLICATION OF EL NADI.ABD EL AZIM EQUATION	92
5.3 FIELD RESULTS DISCUSSION	94
5.3.1 WAKED WSP (BEHERA)	94
5.3.2 KOTA WSP (AL FAYOUM)	96
5.3.3 MOUT WSP (NEW VALLEY)	98
5.3.4 LUXOR WSP (LUXOR)	100
5.3.5 HURGADA WSP (RED SEA)	102
5.3.6 SHARM EL SHEIKH WSP (SHARM EL SHEIKH)	104
5.3.7 GARADA WSP (NORTH SAINAI)	106
5.4 MODIFICATION OF NA EQUATION TO BE EGYPTIAN EQUATION	108
 CHAPTER VI: CONCLUSION	
6.1 CONCLUSION	110
6.2 RECOMMENDATIONS	111
 REFERENCES	112

LIST OF FIGURES

Figure	Page
CHAPTER (II) LITERATURE REVIEW	
Figure (2/1) Trickling filter schematic diagram	9
Figure (2/2) Diagram of rotating biological contractor (RBC)	12
Figure (2/3) SBR in Dundee WWTP, Michigan, USA	16
Figure (2/4) Oxidation Ditch	17
Figure (2/5) Waste Stabilization Pond, As-Samra, Jordan	18
Figure (2/6) anaerobic pond, at the Cal Poly, SLO Dairy	19
Figure (2/7) Schematic for Anaerobic pond	20
Figure (2/8) Facultative Pond Process	22
Figure (2/9) Facultative Pond, Korba, Tunisia	22
Figure (2/10) Algal-bacterial metabolism	23
Figure (2/11) Sewage pond Algae	26
Figure (2/12) Maturation Pond, Korba, Tunisia	27
CHAPTER III: MATERIALS & METHODS	
Figure (3/1) Waked WSP, Beheira	65
Figure (3/2) Anaerobic pond Waked WSP, Beheira	66
Figure (3/3) Facultative pond Waked WSP, Beheira	67
Figure (3/4) Maturation pond Waked WSP, Beheira	67
Figure (3/5) Kota WSP, Fayoum	68
Figure (3/6) Anaerobic pond Kota WSP, Fayoum	69
Figure (3/7) Facultative pond Kota WSP, Fayoum	70
Figure (3/8) Maturation pond Kota WSP, fayoum	70
Figure (3/9) Mout WSP, Wadi Al Gadeed	71
Figure (3/10) Luxor WSP, Luxor	73
Figure (3/11) Anaerobic Pond Luxor WSP, Luxor	74
Figure (3/12) Facultative Pond Luxor WSP, Luxor	75
Figure (3/13) Maturation Pond Luxor WSP, Luxor	75
Figure (3/14) Hurghada WSP	76
Figure (3/15) Maturation pond Hurgada WSP	77
Figure (3/16) Sharm El Shiekh WSP, Sinai	78
Figure (3/17) Garada, WSP, Arish, NorthSinai	80
Figure (3/18) Anaerobic pond Garada WSP, North Sinai	81
CHAPTER IV: RESULTS	
Figure (4/1) Locations of the Studied Ponds	82
CHAPTER (V) DISCUSSION	
Figure (5/1) Waked WSP , SLR in different formulas	104

Figure (5/2) Kota WSP , SLR in different formulas	106
Figure (5/3) Mout WSP , SLR in different Formulas	109
Figure (5/4) Luxor , SLR in different formulas	111
Figure (5/5) Hurghada WSP , SLR in different formulas	114
Figure (5/6) Sharm el Shekh WSP , SLR in different formulas	116
Figure (5/7) Garada WSP , SLR in different formulas	119

LIST OF TABLES

Table	Page
CHAPTER II LITERATURE REVIEW	
Table (2/1) Design values of permissible volumetric BOD loading rate	40
Table (2/2) Design of percentage BOD removal in anaerobic ponds at various temperatures	41
Table (2/3) Variation of the plug-flow reaction rate (KBODp20) with surface organic loading rate	47
CHAPTER IV RESULTS	
Table (4/1) Waked, Wastewater Analysis	83
Table (4/2) Waked, Weather Analysis Results	84
Table (4/3) Kota, Wastewater Analysis	85
Table (4/4) Kota, Weather Analysis Results	86
Table (4/5) Mout, Wastewater Analysis	87
Table (4/6) Mout, Weather Analysis Results	88
Table (4/7) Luxor, Wastewater Analysis	89
Table (4/8) Luxor, Weather Analysis Results	90
Table (4/9) Hurghada, Wastewater Analysis	91
Table (4/10) Hurghada, Weather Analysis Results	92
Table (4/11) Sharm, Wastewater Analysis	93
Table (4/12) Sharm, Weather Analysis Results	94
Table (4/13) Abu Rudais Wastewater Analysis	95
Table (4/14) Abu Rudais, Weather Analysis Results	96
Table (4/15) Garada, Wastewater Analysis	97
Table (4/16) Garada, Weather Analysis Results	98
CHAPTER V: DISSCUSSION	
Table(5/1) Actual and design parameters for Waked WSP	102
Table (5/2) Actual and design parameters for Kota WSP	105
Table (5/3) Actual and design parameters for Mout WSP	108
Table (5/4) Actual and design parameters for Luxor WSP	110
Table (5/5) Actual and design parameters for Hurghada WSP	112
Table (5/6) Actual and design parameters for Sharm El Sheikh WSP	115
Table (5/7) Actual and design parameters for Garada WSP	118

CHAPTER I

INTRODUCTION

1-1 BACKGROUND

Stabilization ponds treatment plants are widely used in hot climates and developing countries, due to simplicity, low cost and high efficiency. Several treatment plants were constructed and operated properly in Egypt in last few years.

All present equations concerning the stabilization ponds design depends mainly on the site conditions as climate, type of wastewater and land topography. With the applications of such type of treatment in Egypt, some notifications appeared due to design overload that increases the need for specific Egyptian design equation.

With these increasing interests, it was essential to monitor and evaluate these plants performance for any possible future modifications or suggestions towards more stable technical and financial recommendations, and to allow defining suggested possible design criteria.

1-2 STUDY OBJECTIVES

The main target from this study is to determine an optimum design equation for stabilization ponds that suits the Egyptian conditions.

1-3 SCOPE OF WORK

The study had been done on by conducting site visits to several stabilization ponds in Egypt

The study work included the following:

1. Theoretical work which include data collection about the selected plants and its wastewater characteristics and other parameters affecting plants' performance. This data collection divided to literature review and site visits.
2. Practical work includes field investigation to fulfill different cases of study of WSP plants in Egyptian regions
3. Analysis of field results of influent and effluent wastewater characteristics as pH, BOD, COD and TSS.

That was measured and monitored as the indicating parameters of the performance of the treatment.

1-4 THESIS ORGANIZATION

The thesis will include the following chapters:

1-4-1 CHAPTER I: INTRODUCTION

This chapter includes background about the Stabilization ponds, then study the objective of this study, then scope of the study work which it divided to theoretical work and practical work and finally thesis organization to cover all work done and its conclusions.

1-4-2 CHAPTER II: LITERATURE REVIEW

This chapter includes introduction about stabilization ponds, worldwide applications, and applications in Egypt, in addition to the present equations concerning the stabilization ponds design and parameters affecting design, the notifications appeared due to design overload that affects plant's performance.

1-4-3 CHAPTER III: MATERIALS & METHODS

This chapter represents the practical work done, as it presents the collected data for the selected plants and its wastewater characteristics in addition to the other parameters affecting plants' performance. It includes the required measured parameters illustrating the site locations, and work intervals. It also highlights the sampling collection methodology and the sampling intervals

1-4-4 CHAPTER IV: RESULTS

This chapter includes presentation for the raw wastewater results for the measured parameters for different WSPs that were taken in our study. All results for each treatment plant during the study period and the results were attached with charts to illustrate the results. The samples were collected from different plants all over Egypt in order to cover and take into account the different climate conditions.

1-4-5 CHAPTER V: DISCUSSION

This chapter includes discussion of the results for each stabilization plant and the aim of this chapter is to study the current situation of the stabilization pond and evaluate the field results with regards to the desirable expected removal efficiency based on the actual condition. After that, the normal design criteria shall be applied to the current plant with respect to SLR and pond dimensions to check plant's efficiency. Accordingly, the actual factor (Coefficient) that has impacts on the temperature to provide the optimum removal efficiency, shall be determined.

1-4-6 CHAPTER VI: CONCLUSION

This chapter includes conclusion for all the study work, and recommendations for applying the new design equation to get the optimum efficiency according to the new equation.