



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم



HANAA ALY



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم



شبكة المعلومات الجامعية التوثيق الإلكتروني والميكروفيلم



HANAA ALY



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات



يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار



HANAA ALY



Cairo University

Use of Continuous-Flow Sequencing Batch Biofilm Reactor (CSBBR) for Improving the Treatment Process in the Wastewater Treatment Plants

By

Ahmed Abdelhalim Sallam

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
GIZA, EGYPT
2020

Use of Continuous-Flow Sequencing Batch Biofilm Reactor (CSBBR) for Improving the Treatment Process in the Wastewater Treatment Plants

By
Ahmed Abdelhalim Sallam

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

Under the Supervision of

Prof. Dr. Hisham Sayed Abdel Halim

Professor of Sanitary and Environmental
Engineering
Public Works Department
Faculty of Engineering ,Cairo University

Dr. Abdelsalam Ahmed Elawwad

Associate Professor of Sanitary and
Environmental Engineering
Public Works Department
Faculty of Engineering ,Cairo University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2020

USE OF CONTINUOUS-FLOW SEQUENCING BATCH BIOFILM REACTOR (CSBBR) FOR IMPROVING THE TREATMENT PROCESS IN THE WASTEWATER TREATMENT PLANTS

By

Ahmed Abdelhalim Sallam

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

Approved by the
Examining Committee

Prof. Dr. Hisham Sayed Abdel Halim

Thesis Main Advisor

Dr. Abdelsalam Ahmed Elawwad

Advisor

Dr. Mona Mohammed Galal El-Din

Internal Examiner

Prof. Dr. Maha Mostafa El Shafei

External Examiner

- Professor of sanitary and environmental engineering,
Housing and Building National Research Center

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2020

Engineer's Name: Ahmed Abdelhallem Sallam Bekhet.
Date of Birth: 31/12/1965
Nationality: Egyptian
E-mail: ahmdsallamsallam@gmail.com
Phone: 01223411972
Registration Date: 01/10/2012
Awarding Date: / /2020
Degree: Master of Science
Department: Civil Engineering – Public Works.



Supervisors:

Prof. Hisham Abdel Halim
Dr. Abdelsalam Elawwad

Examiners:

Prof. Dr. Hisham Sayed Abdel Halim Thesis Main Advisor
Dr. Abdelsalam Ahmed Elawwad Advisor
Dr. Mona Mohammed Galal El-Din Internal Examiner
Prof. Dr. Maha Mostafa El Shafei External Examiner
-Professor of sanitary and environmental engineering,
Housing and Building National Research Center

Title of Thesis:

Use of Continuous-Flow Sequencing Batch Biofilm Reactor (CSBBR) for Improving the Treatment Process in the Wastewater Treatment Plants

Key Words:

Wastewater treatment; CSBBR; Organic Removal; SBR with media; wastewater treatment.

Summary: In this research, a pilot plant was constructed and operated using the continuous-flow sequencing batch biofilm reactor (CSBBR) to study its performance towards wastewater treatment. The experimental work was conducted at Zenien WWTP through different 4 stages using two reactors (R1, R2): The first stage (start-up) carried out in 49 days, the second stage (Low organic load) carried out in 21 days, the third stage (Low organic with added media in R2) carried out in 70 days, and the fourth stage (medium organic load with added media in R2) carried out in 84 days, respectively. Thus, the pilot plant has been operated for 224 continuous days. The temperature was between (16.1 - 33 °C), and pH (6.00 - 7.84). The media used during the third & fourth stages is polyethylene HDPE Bio Pac Media with specific surface area of 600 m²/m³ and have been occupied 30% of the reactor volume. The solid retention time (SRT) was adjusted to be 15 days for all stages, flow rate was (10 L/Hr.), and hydraulic retention time (HRT) was (6 hrs.) for all stages. The removal rates have improved after media addition, and the pilot plant has showed stability for the treatment process with load increases.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Ahmed Abdelhallem Sallam Bekhet

Date: / /2020

Signature:

Acknowledgments

I would like to thank the almighty Allah for the uncountable blessing and mercy that he has bestowed upon me. My sincerest appreciations go to my supervisors Prof. Hisham Sayed Abdel Halim, and Dr. Abdelsalam Elawwad. Thank you so much for your guidance, input throughout the research and thesis writing period. The last and the most important, my mother and my family. All is nothing without your support and pray. Thank you.

Table of Contents

<u>LIST OF TABLES</u>	vi
<u>LIST OF FIGURES</u>	vii
<u>NOMENCLATURE</u>	xi
<u>ABSTRACT</u>	xii
<u>CHAPTER 1: INTRODUCTION</u>	1
1.1. Background.....	1
1.2. Problem statement.....	2
Research objectives.....	2
<u>CHAPTER 2: LITERATURE REVIEW</u>	3
2.1. Introduction.....	3
2.2. Impact of regulations on wastewater engineering.....	3
2.3. Process of treatment.....	4
2.3.1. Preliminary/Primary Treatment.....	6
2.3.2. Screening Influent Wastewater.....	6
2.3.3. Grit Removal.....	7
2.3.4. Influent-Flow Equalization.....	7
2.4. Advanced wastewater treatment.....	8
2.5. Sequencing batch reactor (SBRs).....	9
2.5.1. SBR Characteristics.....	10
2.5.2. Basic Treatment Process.....	10
2.5.2.1. Fill.....	10
2.5.2.2. React.....	12
2.5.2.3. Settle.....	12
2.5.2.4. Decant.....	12
2.5.2.5. Idle.....	13
2.5.3. Continuous-Flow Systems.....	13
2.6. Design guidelines.....	13
2.6.1. Basin Design	13
2.7. Flow-Paced Batch Operation	14
2.8. Lessons from the Field	14
2.9. Blower Design	15

2.10. Variable Frequency Drives – VFDs.....	15
2.11. Decanting.....	16
2.12. Bottom Slope.....	16
2.13. Maintenance.....	16
2.14. Post Basin.....	16
2.15. Operational suggestions.....	17
2.15.1. Parameters to be monitored by the SCADA system.....	17
2.16. Cold-Climate Adjustments.....	18
2.17. Sampling.....	19
2.17.1. Proper Sampling Points.....	19
2.18. Parameters to Monitor.....	19
2.18.1. Solids Retention Time – SRT.....	19
2.18.2. Sludge Wasting.....	19
2.19. Alkalinity	20
<u>CHAPTER 3: MATERIALS AND METHODS.....</u>	21
3.1. Plan of Work.....	21
3.2. Description of Zenein WWTP.....	22
3.3. Pilot plant setup.....	24
3.4. The media.....	29
3.5. Chemicals used for increasing the organic load.....	30
3.6. Wastewater samples collection	31
3.6.1. Sampling program.....	32
3.7. Analytical methods.....	33
3.7.1. Chemical oxygen demand (COD).....	33
3.7.2. Biological oxygen demand (BOD).....	33
3.7.3. Total kjeldahl nitrogen (TKN).....	33
3.7.4. Ammonium nitrogen.....	34
3.7.5. Nitrite nitrogen.....	34
3.7.6. Nitrate nitrogen.....	35
3.7.7. Total nitrogen.....	35
3.7.8. Phosphorus.....	35
3.7.9. Total suspended solids (TSS).....	36

3.7.10. Volatile suspended solids (VSS).....	36
3.7.11. Alkalinity.....	36
3.7.12. Sludge volume index (SVI).....	36
<u>CHAPTER 4: RESULTS AND DISCUSSION.....</u>	38
4.1. Introduction.....	38
4.2. Starting up period (Run I).....	38
4.3. Second stage period (RUN II).....	48
4.4. Third stage period (RUN III).....	58
4.5. Fourth stage period (RUN IV).....	68
4.6. Assessment of influent and effluent wastewater quality.....	78
4.6.1. BOD results.....	78
4.6.2. COD results.....	81
4.6.3. VSS results.....	84
4.6.4. TSS results.....	87
4.6.5. MLSS & MLVSS results.....	90
4.6.6. NO ₂ &NO ₃ results.....	92
4.6.7. NH ₄ results.....	94
4.6.8. pH value.....	96
4.6.9. Temperature measurements.....	97
4.6.10. DO measurements	97
4.7. Batch Reactors.....	98
4.7.1. Run 1. Carbon removal.....	98
4.7.2. Run 2. Denitrification.....	100
4.7.3. Run 3. Nitrification.....	103
<u>CHAPTER 5: CONCLUSIONS AND RECOMEDATIONS.....</u>	105
5.1. Conclusions.....	105
5.2. Recommendations.....	107
<u>REFERENCES.....</u>	108
<u>APPENDIXES.....</u>	118

LIST OF TABLES

Table 3.1 Plan of work and operating conditions.....	22
Table 3.2 Specification of the media	30
Table 3.3 Chemical added to increase organic load.....	31
Table 4.1 Operation condition of startup period	39
Table 4.2 Results summery of startup period.....	39
Table 4.3 Operation condition of second period	49
Table 4.4 Results summery of second period	49
Table 4.5 Operation condition of third period	58
Table 4.6 Results summery of third period	59
Table 4.7 Operation condition of fourth period	68
Table 4.8 Results summery of fourth period	69
Table 4.9 BOD concentrations and its removal efficiency % by R1 in all stages....	79
Table 4.10 BOD concentrations and its removal efficiency % by R2 in all stages..	81
Table 4.11 COD concentrations and its removal efficiency % by R1 in all stages..	82
Table 4.12 COD concentrations and its removal efficiency % by R2 in all stages..	84
Table 4.13 VSS concentrations and its removal efficiency % by R1 in all stages ..	86
Table 4.14 VSS concentrations and its removal efficiency % by R2 in all stages ..	87
Table 4.15 TSS concentrations and its removal efficiency % by R1 in all stages ...	89
Table 4.16 TSS concentrations and its removal efficiency % by R2 in all stages ...	90
Table 4.17 pH values for R1, R2.....	96
Table 4.18 Atmospheric temperature values on-site.....	97
Table 4.19 DO values of the R1, R2.....	98
Table 4.20 Chemicals added to the batches.....	98

LIST OF FIGURES

Figure 2.1 Schematic diagrams of a wastewater plant. (Azadi et al., 2015).....	5
Figure 2.2 Schematic diagrams of SBR wastewater plant.....	11
Figure 3.1 General Layout of Zenein WWTP	23
Figure 3.2 Schematic diagram of the pilot plant.....	25
Figure 3.3 Details of the reactor and components.....	26
Figure 3.4 Air diffusers at the bottom of the reactors	27
Figure 3.5 Feeding tank 500 L	27
Figure 3.6 The reactors and decant pumps.....	28
Figure 3.7 Influent pipe of the reactors.....	28
Figure 3.8 Pilot Plant after construction.....	29
Figure 3.9 Sample of media.....	29
Figure 3.10 The sampling bottles	32
Figure 4.1 Influent and effluent BOD concentrations in R1 at start-up stage	40
Figure 4.2 BOD removal percentage in R1 at start-up stage	40
Figure 4.3 Influent and effluent COD concentrations in R1 at start-up stage	41
Figure 4.4 COD removal percentage in R1 at start-up stage	41
Figure 4.5 BOD & COD loads in R1 and R2 at start-up stage	42
Figure 4.6 Influent and effluent of VSS concentration in R1 at start-up stage	42
Figure 4.7 VSS removal percentage in R1 at start-up stage	43
Figure 4.8 Influent and effluent of TSS concentration in R1 at start-up stage	43
Figure 4.9 TSS removal percentage in R1 at start-up stage.....	44
Figure 4.10 Influent and effluent of BOD concentration in R2 at start-up stage	44
Figure 4.11 BOD removal percentage in R2 at start-up stage	45
Figure 4.12 Influent and effluent of COD concentration in R2 at start-up stage	45
Figure 4.13 COD removal percentage in R2 at start-up stage	46
Figure 4.14 Influent and effluent of VSS concentration in R2 at start-up stage	46
Figure 4.15 VSS removal percentage in R2 at start-up stage	47
Figure 4.16 Influent and effluent of TSS concentration in R2 at start-up stage	47
Figure 4.17 TSS removal percentage in R2 at start-up stage	48
Figure 4.18 Influent and effluent of BOD concentration in R1 at second period stage	50

Figure 4.19 BOD removal percentage in R1 at second period stage	50
Figure 4.20 Influent and effluent of COD concentration in R1 at second period stage	51
Figure 4.21 COD removal percentage in R1 at second period stage	51
Figure 4.22 BOD & COD loads in R1 and R2 at second period stage	52
Figure 4.23 Influent and effluent of VSS concentration in R1 at second period stage	52
Figure 4.24 VSS removal percentage in R1 at second period stage	53
Figure 4.25 Influent and effluent of TSS concentration in R1 at second period stage	53
Figure 4.26 TSS removal percentage in R1 at second period stage	54
Figure 4.27 Influent and effluent of BOD concentration in R2 at second period stage	54
Figure 4.28 BOD removal percentage in R2 at second period stage	55
Figure 4.29 Influent and effluent of COD concentration in R2 at second period stage	55
Figure 4.30 COD removal percentage in R2 at second period stage	56
Figure 4.31 Influent and effluent of VSS concentration in R2 at second period stage	56
Figure 4.32 VSS removal percentage in R2 at second period stage	57
Figure 4.33 Influent and effluent of TSS concentration in R2 at second period stage	57
Figure 4.34 TSS removal percentage in R2 at second period stage	58
Figure 4.35 Influent and effluent of BOD concentration in R1 at third period stage	59
Figure 4.36 BOD removal percentage in R1 at third period stage	60
Figure 4.37 Influent and effluent of COD concentration in R1 at third period stage	60
Figure 4.38 COD removal percentage in R1 at third period stage	61
Figure 4.39 BOD & COD loads in R1 and R2 at third period stage	61
Figure 4.40 Influent and effluent of VSS concentration in R1 at third period stage	62
Figure 4.41 VSS removal percentage in R1 at third period stage	62
Figure 4.42 Influent and effluent of TSS concentration in R1 at third period stage	63
Figure 4.43 TSS removal percentage in R1 at third period stage	63