

**EFFECT OF SLUDGE PRETREATMENT ON  
SLUDGE REDUCTION POTENTIAL OF AAO  
REACTOR AND RECOVERY OF PHOSPHATE  
FROM PRETREATED SLUDGE**

**A THESIS**

*Submitted by*

**ESAKKI RAJ S**

*in partial fulfillment of the requirements for the degree of*

**DOCTOR OF PHILOSOPHY**



**FACULTY OF SCIENCE AND HUMANITIES**

**ANNA UNIVERSITY**

**CHENNAI 600 025**

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ANNA UNIVERSITY, CHENNAI - 600 025  
CENTRE FOR RESEARCH



CERTIFICATE

1. This is to certify that no corrections/suggestions were pointed out by the Indian/Foreign Examiner(s) in the Thesis titled " EFFECT OF SLUDGE PRETREATMENT ON SLUDGE REDUCTION POTENTIAL OF AAO REACTOR AND RECOVERY OF PHOSPHATE FROM PRETREATED SLUDGE " submitted by Mr./Ms. ESAKKI RAJ.S

OR

2. This is to certify that all corrections and suggestions pointed out by the Indian /Foreign Examiner(s) are incorporated in the Thesis titled " EFFECT OF SLUDGE PRETREATMENT ON SLUDGE REDUCTION POTENTIAL OF AAO REACTOR AND RECOVERY OF PHOSPHATE FROM PRETREATED SLUDGE " submitted by Mr./Ms. ESAKKI RAJ.S

*-NA-*  
Signature of the Joint Supervisor  
(if applicable)

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**Assistant Professor**  
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**Regional Centre of Anna University**  
**Tirunelveli - 627 007**

Place : *Tirunelveli*  
Date : *14/7/2015*





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Proceedings of the Ph.D. Viva-Voce Examination of Mr./Ms. ESAKKI RAJ.S held at 10:30 AM on 03.07.2015 in Department of Civil Engineering Regional Center of Anna University Tirunelveli 627007

The Ph.D. Viva-Voce Examination of Mr./Ms. ESAKKI RAJ.S (Reg. No. 2011110114) on his/her Ph.D. Thesis Entitled "EFFECT OF SLUDGE PRETREATMENT ON SLUDGE REDUCTION POTENTIAL OF AAO REACTOR AND RECOVERY OF PHOSPHATE FROM PRETREATED SLUDGE " was conducted on 03.07.2015 at 10:30 AM in the Department of Civil Engineering Regional Center of Anna University Tirunelveli 627007.

The following Members of the Oral Examination Board were present:

- |                                                                                                                                                                                    |                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| 1. Dr. K N Yogalakshmi, Assistant Professor, Centre for Environmental Science & Technology, School of Earth & Environmental Sciences, Central University of Punjab Bathinda 151001 | Indian Examiner       |
| 2. Dr. Kurian Joseph, Professor, Centre for Environmental Studies, Anna University, Chennai 25                                                                                     | Subject Expert        |
| 3. Dr. Rajesh banu. J, Assistant Professor, Regional Centre of Anna University, Tirunelveli                                                                                        | Supervisor & Convenor |

The research scholar, Mr./Ms. ESAKKI RAJ.S presented the salient features of his/her Ph.D. work. This was followed by questions from the board members. The questions raised by the Foreign and Indian Examiners were also put to the scholar. The scholar answered the questions to the full satisfaction of the board members.

The corrections suggested by the Indian/Foreign examiner have been carried out and incorporated in the Thesis before the Oral examination.

Based on the scholars research work, his/her presentation and also the clarifications and answers by the scholar to the questions, the board recommends that Mr./Ms. ESAKKI RAJ.S be awarded Ph.D. degree in the Faculty of Science and Humanities.

1. Dr. Yogalakshmi K.N.

Indian Examiner

2. Dr. Kurian Joseph

Subject Expert

3. Dr. J. RAJESH BANU

Supervisor & Convenor

4. —

Joint Supervisor (If any) NA



**ANNA UNIVERSITY**  
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**CERTIFICATE**

The research work embodied in the present Thesis entitled **“EFFECT OF SLUDGE PRETREATMENT ON SLUDGE REDUCTION POTENTIAL OF AAO REACTOR AND RECOVERY OF PHOSPHATE FROM PRETREATED SLUDGE”** has been carried out in the Department of Civil Engineering, Regional Centre of Anna University, Tirunelveli. The work reported herein is original and does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion or to any other scholar.

I understand the University’s policy on plagiarism and declare that the thesis and publications are my own work, except where specifically acknowledged and has not been copied from other sources or been previously submitted for award or assessment.

**ESAKKI RAJ S**  
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## **ABSTRACT**

Introduction of sludge reduction practices in Enhanced Biological Phosphate Removal (EBPR) often leads to a decrease in phosphorous (P) removal efficiency of the system. In the present study an attempt has been made to recover phosphorus in the presence of poly P and to disintegrate sludge through combinative treatment. Primarily the sludge was treated by thermal method at a temperature range of 40 to 90<sup>0</sup>C. During thermal treatment, EBPR (Enhanced Biological Phosphorous Removal) sludge releases poly P and is found to be maximum at 60<sup>0</sup>C for 3 hrs. Increase in temperature over 60<sup>0</sup>C causes degradation of the released poly P. The COD solubilisation and release for 60<sup>0</sup>C were found to be 12.4% and 1020 mg/L. Secondary release of phosphorous was done by subjecting thermally treated sludge samples to anaerobic conditions for 8 hrs. During anaerobic treatment, TP release and solubilisation were found to be higher at temperature 60<sup>0</sup>C and was found to be 58 mg/L and 24.1% respectively. Anaerobic treatment didn't affect the thermally released poly P. TP recovery was carried out using a coagulant lime. A coagulant dosage of 1.2:1 mole ratio was used to recover 90% of P selectively for the temperature 40 to 60<sup>0</sup>C. Temperature in excess 60<sup>0</sup>C demands more coagulant dosage and was not selective in precipitating phosphorous.

In continuation to combinative treatment, an attempt has been made to develop a sustainable P removal in an anaerobic/anoxic/oxic (AAO) system, integrated with sludge reduction, by incorporating side stream P recovery. Two AAO reactors, one acting as control (CAAO) and the other as experimental system (EAAO), were used in our experiment for 225 days. The average P solubilisation efficiency and its recovery from thermally pre-treated

sludge were found to be 28% and 99%, respectively. P recovery process prevented the biomass in EAAO system from reaching its threshold level and resulted in sustainable P removal throughout the study period. Thermochemical pre-treatment at the rate of 1.5% Q in EAAO reactor was responsible for 28% sludge reduction. The  $Y_{obs}$  for the system with and without pre-treatment was found to be 0.28 and 0.22 kg MLSS/kg COD. Initial 50 days (Phase 1) of reactor operations were utilized for system stabilization and the total nitrogen removal during Phase 2, 51<sup>th</sup> day to 225<sup>th</sup> day (76–80%) was slightly higher than that in Phase 1 (68–75%). The MLSS/MLVSS ratio of the both systems was identical, and was between 78% and 83% for CAAO and for EAAO. The effluent COD concentration was not significantly affected by the proposed method of treatment as it varied in the range of 1950–2600 mg L<sup>-1</sup> for the CAAO and 2100–2650 mg L<sup>-1</sup> for the EAAO. From the present study, it is concluded that the proposed model of treatment system was capable of sustainable removal of P and controlling the excess sludge production.