EXTENDED AERATION: A COMPARATIVE STUDY BETWEEN PREFABRICATED REINFORCED FIBERGLASS AND CONCRETE CAST IN-SITU PLANTS

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ABSTRACT

The choice of wastewater treatment plants for any application depends on the quality of raw sewage, the required quality of treated water and the economics resources available to pay for both capital cost and operating cost of the treatment plants. The performance of any wastewater treatment plants does not only depend on the construction cost but will also cover the cost and method of operation and maintenance, quality of effluent treated, internal, external and design factors. While potential for identifying a better type of wastewater treatment plant does exist, very modest efforts have been attempted. This study compares and contrasts two of the most commonly used extended aeration systems for small to medium size sewage treatment plants, namely prefabricated reinforced fibreglass and cast in-situ systems. The selected treatment plants are under the jurisdiction of Indah Water Konsortium Sdn. Bhd. (IWK), Terengganu. The flow of raw sewage and the performance of the treatment plants based on effluent quality (i.e. BOD, COD and SS) and electricity cost were assessed. Three treatment plants from both types of systems were studied for a period of five months. It was found that a small to medium size treatment plants suffer high variation in term of flow and organic loading. It seemed obvious that the cast in-situ treatment plants not only built structurally better and ease of operation, but also giving better effluent standard and consumed lower electricity cost.

ABSTRAK

Pemilihan loji pengolahan kumbahan untuk apa jua tujuan adalah bergantung kepada kualiti air kumbahan atau sisa, kehendak kualiti air yang diolah dan kemampuan sumber kewangan untuk membiayai kos pembinaan dan operasi loji kumbahan tersebut. Tahap pencapaian mana-mana loji pengolahan kumbahan bukan sahaja bergantung kepada kos pembinaannya, tetapi juga bergantung kepada kos dan cara ianya beroperasi dan diselenggarakan, kualiti kumbahan yang telah diolah, faktor-faktor dalaman, luaran dan rekabentuk loji pengolahan itu sendiri. Walaupun wujudnya potensi untuk mengenal pasti jenis-jenis loji pengolahan kumbahan yang lebih berdaya saing, namun usaha ke arah ini masih belum lagi dilaksanakan dengan lebih menyeluruh. Kajian ini adalah untuk membuat perbandingan dan mencari perbezaan antara dua loji pengolahan kumbahan jenis pengudaraan lanjutan yang paling popular, iaitu *prefabricated reinforced fiberglass* dan *cast in-situ*. Loji-loji pengolahan yang telah dipilih untuk kajian ini adalah di bawah seliaan Indah Water Konsortium Sdn. Bhd. (IWK), Terengganu. Kuantiti air kumbahan, dan pencapaian loji-loji pengolahan kumbahan dinilai berdasarkan kepada kualiti efluen (seperti BOD, COD dan SS) dan kos penggunaan tenaga elektrik. Tiga loji dari dua jenis sistem pengudaraan lanjutan telah dikaji dalam tempoh lima bulan. Adalah didapati bahawa loji-loji yang bersaiz kecil ke sederhana mengalami gangguan perbezaan influen yang ketara, atau pun perbezaan di antara influen dan beban pencemaran. Dalam kajian ini, loji *cast in-situ* bukan sahaja mempunyai struktur yang lebih baik dan lebih mudah untuk diselenggarakan, tetapi juga menghasilkan tahap efluen yang lebih baik dan penggunaan tenaga elektrik yang lebih rendah.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

The most important goal of the National Sewerage Policy is to ensure that the discarded water after it has been used is properly treated before being discharged in order to protect the receiving environment. The evolution of fully mechanized sewage treatment processes from primitive to primary and continued progress headed to secondary treatment system will help us save our environment from degradation. This trend created new and modern equipments ranging from pumps, screens, aeration systems, sludge process systems and other technological advancement equipments which continuously help us to reduce pollutants entering our water systems.

In 1998, only 4.9% population in Malaysia was served by central sewerage systems (from 3.4% in 1970). Individual septic tanks or communal treatment systems such as oxidation pond, trickling filter, extended aeration and imhoff tank served 34% of the population (up from 17.2 in 1970). Pour flush latrine and other less satisfactory systems served 52.9% of the population while 8.2% have no facilities at all [1].

Based on statistic released by the Department of Environment (DOE), domestic sewage contributed 46% of the total biological oxygen demand (BOD) load into inland waters in 1985 and the figure has increased to 69% in 1988 [2]. It is clearly shown that the domestic sewage is the number one BOD contributor in this country and to remain so if no proper mitigation measures take place.

The declared aim of the Government to promote the involvement of the private sector in the implementation, operation and management of the sewerage infrastructure project, has resulted in 1993, the appearance of Indah Water Konsortium Sdn. Bhd. (IWK) as the national public sewerage systems operator. The main idea of the privatization is to synchronize and harmonize planning, construction, maintenance and operations aspect of this industry under the Ministry of Energy, Water and Telecommunication. Sewerage Service Department (SSD) is the entrusted government agency to coordinates regulation, ordinance and enforcement of the sewerage systems in Malaysia.

The number of sewage treatment plant increase tremendously after the introduction of the National Sewerage Policy in 1994. It was found that in 2005, about 82% of the sewerage treatment plants serving not more than 2,000 PE as shown in Table 1.1 [2]. This increment coupled with technology improvement has taken the sewerage industries to a greater level.

Table 1.1: Classification of Sewage Treatment Plant by Size (Malaysia)

PE / Year	Less Than 150	150-2,000	2,001-5,000	5,001-25,000	25,001-50,000	More Than 50,001	Total No of STP
1994	276 (26.4%)	537 (33.7%)	166 (15.9%)	55 (5.3%)	7 (0.7%)	2 (0.2%)	1,043
1997	2,204 (48.6%)	1,706 (37.6%)	416 (9.2%)	191 (4.2%)	11 (0.2%)	10 (0.2%)	4,538
2005	4,163 (47.4%)	3,053 (34.7%)	922 (10.5)	573 (6.5)	42 (0.5)	29 (0.3)	8,782

Source: [2]

In march 2007, out of 8,537 public sewage treatment plants maintained by IWK, 43% are communal septic tanks, 9% are imhoff tanks, 5% are oxidation ponds, 3% are mechanical plants with media and 40% are mechanical plant without media as shown in Table 1.2 [1].

Table 1.2: Treatment plant total by group.

NO	TYPE OF STP	TOTAL	PERCENTAGE	PE
1	Communal Septic Tank	3,637	43%	432,841
2	Imhoff Tank	767	9%	563,967
3	Oxidation Ponds	460	5%	1,892,318
4	Mechanical Plants with Media	247	3%	857,322
5	Mechanical Plant without Media	3,426	40%	11,527,075
	GRAND TOTAL	8,537	100%	15,273,523

Source: [1]

The second most important goal of the National sewerage Policy is to manage the required wastewater treatment plants as cost effective as possible as the cost of the sewerage systems operation is being bore by the tax payer, an effective system is essential as to save money of the tax payer or the public as a whole. With many treatment systems currently available in the market today, proper selection of the systems is crucial and many factors need to be considered which include cost of construction, operation and maintenance, and performance of the systems.

The conversional extended aeration of prefabricated fiber reinforced glass and concrete in-situ are currently considered as the most popular systems particularly for small to medium size treatment plants. Due to the competitive edge on the marketing strategies, the initial capital cost or construction per population equivalent (PE) of these systems is about the same. Typical land area requirements for sitting of small to medium size wastewater treatment plants is also about the same as shown in Table 1.3 [3]. However, no specific study has been conducted to evaluate the performance and the efficiency of these two systems.

Table 1.3: Land Area Requirements for Mechanized Plants

Population Equivalent	Standard A *		Standard B *	
	(ha)	(acre)	(ha)	(acre)
2,000	0.17	0.42	0.17	0.42
3,000	0.22	0.42	0.17	0.55
4,000	0.27	0.66	0.27	0.66
5,000	0.31	0.76	0.31	0.76
10,000	0.78	1.93	0.66	1.63
15,000	1.00	2.47	0.84	2.09
20,000	1.19	2.95	0.99	2.44
25,000	1.37	3.38	1.13	2.79
30,000	1.53	3.79	1.26	3.11
35,000	1.81	4.48	1.65	4.08
40,000	1.97	4.88	1.79	4.43
45,000	2.12	5.25	1.93	4.77
50,000	2.23	5.52	2.03	5.02
55,000	2.37	5.84	2.15	5.31
60,000	2.52	6.22	2.29	5.66
65,000	2.67	6.61	2.43	6.00
70,000	2.93	7.23	2.66	657
75,000	3.27	8.07	2.82	6.96
80,000	3.49	8.61	3.03	7.49
85,000	3.69	9.12	3.23	7.99
90,000	3.89	9.61	3.42	8.46
95,000	4.07	10.06	3.60	8.90
100,000	4.25	10.49	3.77	9.32
110,000	4.57	11.29	4.09	10.10
120,000	4.87	12.02	4.38	10.81
130,000	5.14	12.70	4.64	11.47
140,000	5.39	13.32	4.89	12.08
150,000	5.63	13.90	5.12	12.64
160,000	5.84	14.44	5.33	13.17
170,000	6.05	14.95	5.53	13.67
180,000	6.25	15.43	5.72	14.14
190,000	6.43	15.89	5.90	14.58
200,000	6.60	16.32	6.07	15.00
250,000	7.36	18.20	6.81	16.83
300,000	7.98	19.73	7.41	18.32
450,000	9.36	23.14	8.76	21.65

Source: [3]

The required area does not include any buffer zone surrounding each plant. Appropriate setbacks and access paths within the plant have been included.

1.2 Importance of Study

Presently the Department of Environment (DOE) governs the effluent standards while the Sewerage Service Department (SSD) is an approving authority for any construction of the treatment plants. It appears that no previous study has been conducted to monitor the overall performance efficiency and energy costs to operate any of the treatment plants in Malaysia. As the concessionaire public sewerage systems operator, IWK has to accept all the systems approved by SSD and to fulfill the DOE effluent requirement by baring all the operations and maintenances costs.

It has been proven that operational improvement such as pumping system optimization, flexible tanks release strategies for water distribution, alternative aeration system optimization and use of low cost timer and controls has saved millions of dollars without compromising the effluent standard requirements [4]. Hence, effort should be made to select proper treatments plants, as it will improve the economic of the treatment plants operations.

1.3 Objective and Scope of Study

The main objective of this study was to compare and contrast two most commonly used extended aeration systems for small to medium size sewage treatment plants namely prefabricated reinforced fiberglass and concrete in-situ systems.

This study was limited to the extended aeration systems of prefabricated fiber reinforced glass and cast in-situ plants of the same PE size ranging from 1,000 – 3,500 PE which were currently under the operation of IWK, Terengganu. The comparisons were based on the operational cost of the system, particularly the energy cost, the efficiency of the process and the ease of operation of the systems.