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The Optimum Aeration Time of Wastewater Treatment by Surface Aerators in Suan Sunandha Rajabhat University

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***Abstract*—**This research aimed to study on the efficiency of wastewater treatment by comparing the different aeration times of surface aerators in Suan Sunandha Rajabhat University. In doing so, the operation of surface aerators was divided into 2 groups which included the groups of 8 hours (8-0/opened-closed) and 4 hours (2-2/opened-closed) of aeration time per day. As a result of the study, it was found that the efficiency of wastewater treatment in the forms of DO, BOD, turbidity and NO_2^- by 8 hours (8-0/opened-closed) and 4 hours (2-2/opened-closed) of aeration time per day of surface aerators was not statistically different [Sig. = .644, .488, .716 and .054 > α (.05)] while the efficiency in the forms of NO_3^- and P was significantly different at the statistical level of .01 [Sig. = .001 and .000 < α (.01)].

***Keywords*—**Aeration time, Surface aerator, Wastewater treatment.

I. Introduction

SUAN Sunandha Rajabhat University is located in Dusit district, Bangkok, Thailand on the area of approximately 10 hectares. In 2014, the total number of under graduated and graduated students together with employees and academic staffs is increasing up to 20,000 people [1]. It was reported that, in the past two years, wastewater generated from all buildings in the university was about 1,000 m^3/day mainly by toilets and experimental laboratories in several programs of scientific studies, i.e., biology, biotechnology, microbiology, chemistry, food science, food industry and services and environmental science [2]. Besides, food and beverage center located in the university's area was another important source of wastewater. Because of this situation which had occurred for many years, integrated wastewater treatment project had been created in 2007 in order to treat wastewater before discharging out of the university. This project was designed to collect wastewater from all buildings into the treatment plant which consisted of 2 phases. Phase I was considered to collect the amount of 300 m^3/day of wastewater from 13 buildings on the lower area while Phase II was considered to collect the other 700 m^3/day of wastewater from 16 buildings on the central and upper areas of the university. Both phases of this treatment plant are currently operated by activated sludge system (AS). According to the report during the year 2013, wastewater collected from phase I and II which treated by the AS did not exceed the water quality standard of the country [3].

Not only wastewater treatment by activated sludge system, but also the treatment by surface aerators has been operated as well. This is due to the purpose of wastewater management in natural ponds located in the landscape of the university. At this moment, there are eleven surface aerators working in those ponds as wastewater treatment system. The aeration time of surface aerators are set up at 8 hours per day from 08.00 am to 04.00 pm. Table I shows that water quality in natural ponds of the university is in normal condition when compared to the national water quality standard especially for DO, pH and turbidity [4].

TABLE I
WATER QUALITY IN NATURAL PONDS IN SUAN SUNANDHA RAJABHAT UNIVERSITY, 2013

Month	DO (mg/l)	pH	Turbidity (NTU)
January	3.5	7.2	25.5
February	6.1	6.9	39.0
March	7.4	7.2	28.0
April	6.2	7.0	36.5
May*	-	-	-
June*	-	-	-
July	6.6	7.0	40.7
August	6.7	7.2	46.2
September	5.6	6.7	29.9
October	5.4	7.4	11.4
November	4.7	6.8	14.8
December	6.7	7.0	14.8

Remark: * No data available.

In fact, there are 4 types of wastewater treatment that add oxygen into water bodies such as natural pond. Those are submerged turbine aerator, submersible aerator, jet aerator and surface aerator, respectively [5]. In the case of Saun Sunandha Rajabhat University, surface aerator has been chosen as a tool to improve water quality in natural ponds for many years. By this, electricity needs to be used as an important source of energy. It is, therefore, necessary to be aware of saving energy during the operation of surface aerator. If the aeration time of surface aerator is longer, it means that the electrical cost must be higher as well. Because of this reason, the purposes of this research were to find out the optimum aeration time per day of surface aerators and also to investigate the optimum cost of electricity used in the operation of surface aerators in Suan Sunandha Rajabhat University.

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Fig. 1 Operation of Some Surface Aerators in Suan Sunandha Rajabhat University

II. Objectives of the Study

Two objectives of the study on the optimum aeration time of wastewater treatment by surface aerators in Suan Sunandha Rajabhat University were as follows:-

1. To compare the efficiency of wastewater treatment by different aeration times of surface aerators in natural ponds, and
2. To investigate the cost of electricity used as an energy source by different aeration times of those surface aerators.

III. Methodology

A. Methodology for Comparison of the Efficiency of Wastewater Treatment by Different Aeration Times of Surface Aerators

The efficiency of wastewater treatment by surface aerators was compared according to their aeration times. In doing so, the operation of surface aerators was divided into 2 groups which included the groups of 8 hours (8-0/opened-closed) and 4 hours (2-2/opened-closed) of aeration time per day. It means that the working period of surface aerators in the first group were 8 hours per day during 08.00 am to 04.00 pm while the working period of those in the second group were only 4 hours per day during 08.00 to 10.00 am and 12.00 am to 02.00 pm, respectively. In this study, 60 water samples were collected from natural ponds in the university by the period of 30 days. Of these, the number of each 20 samples represented water quality of natural ponds treated by both groups of surface aerators mentioned above and the control group with no operation of surface aerators. All water samples were analyzed for the following parameters; DO, BOD, NO_3^-, NO_2^-, turbidity and P. Thereafter, the efficiency of wastewater treatment by surface aerators was calculated for each parameter by the equation as follow:-

$$\text{Efficiency}(\%) = \frac{A - B}{A} \times 100 \quad (1)$$

Noted that
A =Water quality before treating by surface aerators
B =Water quality after treating by surface aerators

The comparison of the efficiency of wastewater treatment by different aeration times of surface aerators was accomplished by using t-Test as the statistical method at the significant level of 95%.

B. Methodology for Investigation of the Cost of Electricity Used as an Energy Source for Surface Aerators

The electrical cost used as an energy source for surface aerators was investigated by means of a device called "Clamp meter". This device detected the amount of electrical current used by each surface aerator depending on its aeration time. If the aeration time of surface aerator takes longer, the electrical current detected by the clamp meter must be higher, and vice versa. The following equation shows how to calculate the units of electrical power used by different aeration times of all surface aerators in this study.

$$P = \frac{I \times V \times \sqrt{3} \times 0.8}{1,000} \quad (2)$$

Noted that
P =Electrical power (kw)
I =Electrical current (A)
V =Voltage (Volt)

The units of electrical power calculated by this equation was the raw data that leads to calculating the cost of electricity used as an energy source by 2 groups of surface aerators. By this process, the optimum cost of electricity used in the operation of surface aerators in Suan Sunandha Rajabhat University could be figured out.

IV. Results and Discussions

The results of this research can be reported into 2 parts in accordance with objectives of the study.

A. Result of Comparison of the Efficiency of Wastewater Treatment by Different Aeration Times of Surface Aerators

According to the study, water quality of each parameter in natural ponds treated by 2 groups of surface aerators and also water quality with no operation of surface aerator in natural ponds or the control group is illustrated in Table II. The data in this table shows that water quality especially for DO and BOD of Group I with 8 hours of aeration time per day was much better than that of Group II with 4 hours of aeration time per day and Group III with no operation of surface aerators. That is, DO of Group I was 5 mg/l while those of Group II and III were 1.86 and 1.48 mg/l, respectively. On the other hands, BOD of Group I was 3.7 mg/l while those of Group II and III were 5 and 8.15 mg/l, respectively. It is also shown that other parameters of water quality such as NO_3^-, NO_2^- and P among these 3 groups were almost the same except for turbidity in which that of Group I was not better than Group II and III.

TABLE II
AVERAGES OF WATER QUALITY IN NATURAL PONDS BY DIFFERENT AERATION TIMES OF SURFACE AERATORS IN SUAN SUNANDHA RAJABHAT UNIVERSITY

Parameter	Averages of water quality		
	Group I	Group II	Group III
DO (mg/l)	5.00	1.86	1.48
BOD (mg/l)	3.70	5.00	8.15
Turbidity (NTU)	64.99	48.48	46.20
NO_3^- (mg/l)	0.01	0.02	0.02
NO_2^- (mg/l)	0.05	0.03	0.03
P (mg/l)	0.16	0.17	0.20

Remark: Group I = 8 hours of aeration time per day
Group II = 4 hours of aeration time per day
Group III = no operation of surface aerators (control group)

Table III illustrates the efficiency of wastewater treatment in natural ponds by different aeration times of surface aerators. In this table, it was found that the efficiency of each parameter by average of Group I with 8 hours of aeration time per day was higher than that of Group II with 4 hours of aeration time per day except for turbidity. For example, the efficiency of wastewater treatment in the form of DO between Group I and II were 52.12% and 49.38% and in the form of BOD between Group I and II were 48.17% and 43.62%, respectively.

TABLE III
AVERAGES OF THE EFFICIENCY OF WASTEWATER TREATMENT IN NATURAL PONDS BY DIFFERENT AERATION TIMES OF SURFACE AERATORS IN SUAN SUNANDHA RAJABHAT UNIVERSITY

Parameter	Averages of efficiency (%)		
	Group I	Group II	Group III
DO	52.12	49.38	-
BOD	48.71	43.62	-
Turbidity	24.91	26.08	-
NO_3^-	48.56	23.04	-
NO_2^-	13.21	7.56	-
P	28.77	12.47	-

Remark: Group I = 8 hours of aeration time per day
Group II = 4 hours of aeration time per day
Group III = no operation of surface aerators (control group)

The statistical comparison by t-Test of the efficiency of wastewater treatment in natural ponds by different aeration times of surface aerators is illustrated in Table IV as follow:-

TABLE IV
STATISTICAL COMPARISON OF THE EFFICIENCY OF WASTEWATER TREATMENT IN NATURAL PONDS BY DIFFERENT AERATION TIMES OF SURFACE AERATORS IN SUAN SUNANDHA RAJABHAT UNIVERSITY

Parameter	Aeration time	Mean ($\overline{X}$)	t	Sig.
DO (mg/l)	I	52.1239	0.472	.644
	II	49.3834		
BOD (mg/l)	I	48.7110	0.708	.488
	II	4306222		
Turbidity (NTU)	I	24.9090	-0.372	.716
	II	26.0800		
NO_3^- (mg/l)	I	48.5550	3.968	.001
	II	23.0390		
NO_2^- (mg/l)	I	13.2100	2.087	.054
	II	7.5620		
P (mg/l)	I	28.7700	4.529	.000
	II	12.4730		

Remark: I = 8 hours of aeration time per day
II = 4 hours of aeration time per day

It can be reported by the statistical data shown in Table 4 as the following details;

1) The efficiency of wastewater treatment in the form of DO by 8 hours (8-0/opened-closed) and 4 hours (2-2/opened-closed) of aeration time per day of surface aerators was not statistically different [Sig. = .644 > α (.05)].
2) The efficiency of wastewater treatment in the form of BOD by 8 hours (8-0/opened-closed) and 4 hours (2-2/opened -closed) of aeration time per day of surface aerators was not statistically different [Sig. = .488 > α (.05)].
3) The efficiency of wastewater treatment in the form of turbidity by 8 hours (8-0/opened-closed) and 4 hours (2-2/ opened-closed) of aeration time per day of surface aerators was not statistically different [Sig. = .716 > α (.05)].
4) The efficiency of wastewater treatment in the form of NO_3^- by 8 hours (8-0/opened-closed) and 4 hours (2-2/opened-closed) of aeration time per day of surface aerators was significantly different at the statistical level of .01 [Sig. = .001 < α (.01)].
5) The efficiency of wastewater treatment in the form of NO_2^- by 8 hours (8-0/opened-closed) and 4 hours (2-2/ opened -closed) of aeration time per day of surface aerators was not statistically different [Sig. = .054 > α (.05)].
6) The efficiency of wastewater treatment in the form of P by 8 hours (8-0/opened-closed) and 4 hours (2-2/opened-closed) of aeration time per day of surface aerators was significantly different at the statistical level of .01 [Sig. = .000 < α (.01)].

Because of this result, it is the reason to conclude that the efficiency of wastewater treatment in natural ponds as a whole was not different between the 8 hours (8-0/opened-closed) and 4 hours (2-2/opened-closed) of aeration time per day of surface aerators. Therefore, it is will be better to set up the aeration time per day of surface aerators in natural ponds as 4

hours (2-2/opened-closed) in order to save the electrical power used as an energy source for this purpose.

B. Result of Investigation of the Cost of Electricity Used as an Energy Source for Surface Aerators

Since the efficiency of wastewater treatment by 8 hours (8-0/opened-closed) and 4 hours (2-2/opened-closed) of aeration time per day of surface aerators as mentioned earlier was not different. That means the operation of surface aerators by 4 hours (2-2/opened-closed) of aeration time per day should be considered by the reason of saving more energy than the other one. In Table V, the total electrical power and total electrical cost are shown to support this reason. When compared between Group I and II of surface aerators, it can be found that Group II with 4 hours of aeration time per day used less electrical power than Group I with 8 hours of aeration time per day. In the same manner, the electrical cost caused by Group II was also less than that of Group I. That is, the total electrical cost of Group II was only 340.47 baht per day while the cost of Group I was higher at 674.96 baht per day.

In addition to Table V, Table VI shows the difference of total electrical cost caused by these 2 groups of surface aerators in more details. The total electrical cost in this case is compared by different periods of time as 1 day, 1 month, 1 year, and 10 years, respectively.

TABLE V
TOTAL ELECTRICAL POWER AND TOTAL ELECTRICAL COST CAUSED BY GROUP I AND GROUP II OF SURFACE AERATORS IN SUAN SUNANDHA RAJABHAT UNIVERSITY

Items	Surface aerator		
	Group I	Group II	Group III
Electrical power (w)*	25.96	26.19	-
Aeration time (hr)	8.00	4.00	-
Total electrical power (w/hr)	207.68	104.76	-
Electrical cost (baht/unit)**	3.25	3.25	-
Total electrical cost (baht/day)	674.96	340.47	-

* Data derived from the calculation by equation (2)
**Data derived from Office of the Central Division, SSRU [6].
Remark: Group I = 8 hours of aeration time per day
Group II = 4 hours of aeration time per day
Group III = no operation of surface aerators (control group)

The data shown in Table VI reveals that the difference of total electrical cost between these 2 groups of surface aerators is continuously increasing in accordance with the period of time. In one day, the operation of surface aerators in Group II with 4 hours of aeration time per day can save 334.49 baht of electrical cost. When the periods of time are longer to 1month, 1 year, and 10 years, the saving of electrical costs are much higher up to 10,034.70, 122,088.85 and 1,220,888.50 baht as well.

TABLE VI
THE DIFFERENCE OF TOTAL ELECTRICAL COST USED BY GROUP I AND II OF SURFACE AERATORS IN DIFFERENT PERIODS OF TIME IN SUAN SUNANDHA RAJABHAT UNIVERSITY

Surface aerator	Total electrical cost (baht)			
	Per day (1 day)	Per month (30 days)	Per year (365 days)	Per 10 years (3,650 days)
Group I	674.96	20,248.80	246,360.40	2,463,604.00
Group II	340.47	10,214.10	124,271.55	1,242,715.50
Group III	-	-	-	-
Difference (+/-)	334.49	10,034.70	122,088.85	1,220,888.50

Remark: Group I = 8 hours of aeration time per day
Group II = 4 hours of aeration time per day
Group III = no operation of surface aerators (control group)

V. CONCLUSION

The study on the optimum aeration time of wastewater treatment by surface aerators in Suan Sunandha Rajabhat University was conducted during the year 2012 to 2013. The expected outcome of this study is to help authorized members make decision on improving the operation of surface aerators in natural ponds located in the landscape of the university. As a result of the study, it is recommended that the pattern of 4 hours (2-2/opened-closed) of aeration time per day of surface aerators should be implemented instead of having the pattern of 8 hours (8-0/opened-closed) of aeration time per day. This is due to the fact that the efficiency of wastewater treatment in natural ponds as a whole by these 2 patterns is not statistically different. More importantly, the electrical cost caused by the operation of 4 hours (2-2/opened-closed) of aeration time per day of surface aerators is cheaper when compared to the other one. The more advantage derived from this conclusion is to save electrical power used as an energy source of the operation of surface aerators.

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