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Control of Algae in Swimming Pool by Ozonation

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Abstract

Algae proliferation is an important problem of swimming pool, making it unsightly and ultimately unacceptable to swimmers. Chlorination of the pool seems to inhibit growth of microorganism. However some types of algae can survive the condition and are frequently found (attached on tiles or in suspension). In this study algae samples were collected from a hotel swimming pool and cultured in Bold's Basal medium. Morphological identification by Direct Microscopic Examination of the culture showed that predominating algae were *Oscillatoria, Scenedesmus, Euglena* and *Phagus*. Algae in the culturing bottles were found in 3 zones namely attached on the wall (A), suspended (SS) and settled at the bottom (ST). Ozonation of algae culture with 22.1-141.5 mgO_3/L (5-30 min.ozonation time) was found to remove attached and suspended algae. These then settled down to the bottom resulting in an increase in the settled portion. It was noted that ozone consumption of the suspended portion (1.72 mgO3/mgAlgae at 30 min.) was higher than that of the attached portion (0.47 mgO_3/mgAlgae at 30 min.) indicating that the former was more resistant to ozone than the latter. In terms of algae type, of the 4 predominating spices, *Euglena sp.* was the most resistant.

Keywords : ozonation; algae control; swimming pool

Introduction

Swimming pool is a place where many people gather to swim, for exercise and recreation. Since cleaning before entering the pool is often perfunctorily observed, contamination from the bodies of swimmers, such as cosmetics, oil, and human excretes is common. Without precautionary measures, the swimming pool can be breeding ground for various diseases. Another source of objectionable condition in the pool is the presence of algae. Although most algae does not cause much harm to human health, but its presence makes the pool unsightly. Water quality is thus the point of concern and must be regulated so that it conforms to the standard set by the Ministry of Public Health. One method widely used to control the spread of the diseases is chlorination. It effectively reduces the growth of diseases and algae. However, some types of algae are resistant to this condition and can proliferate in the pool. Use of high chlorine dosage is not feasible due to the formation of carcinogenic trihalomethane (THM) [1]

Algae is a type of microorganism that can be found everywhere, especially in damp places. The distribution depends mainly on the type of

algae and environmental conditions including season, light, moisture, temperature and nutrient. The survey studies on algae proliferation in different area in Thailand reported the presence of Cyanophyta, Chlorophyta and Bacillariophyta. The most frequently found were *Scenedesmus sp.*, *Oscillatoria sp.* and *Euglena sp.* [2-5].

Algae can be controlled by oxidation process through various types of chemicals. In water treatment system, chlorine is a common chemical used. The use of chlorine coupled with oxidizing agent such as $KMnO_4$ and $CuSO_4$ could strengthen the control effect [6].

Ozone, because of its very high oxidizing power, is another candidate for oxidant for algae control. With a short half-life of 20-30 min., it emits O_2 as degradation product [7]. It has been used in food preservation [8] and disinfection purposes in various situations. It has performed better than chlorine and UV in destroying *Escherichia coli*. The destruction caused by oxidation of cell membrane leads to cell lysis [9]. It has been reported that the use of ozone for disinfection of domestic wastewater could reduce Heterotrophic Aerobic Bacteria, Total Coliform, Fecal Coliform and *E.coli* by up to 90% [10]. Algae was also controlled by ozonation, the study on algae from natural reservoir showed that 80% removal was achieved [11].

This study investigated the types of algae surviving in the swimming pool after it has been treated with chlorine and evaluated the efficiency of ozone in controlling algae. Algae morphological identification was achieved by Direct Microscopic Examination. Qzonation was conducted on the algae cultured in Bold's Basal medium. The results of the study should be beneficial as a guideline for algae control in swimming pools.

Materials and Methods

Algae used in the study was collected from a hotel swimming pool. The pool used Trichloro Isocyanuric Acid 90% as disinfectant and had algae proliferation problem. Grab sample was collected by scraping algae attached to the wall of the pool. It was examined under microscope (Direct Microscopic Examination) and identified by morphology according to Bold and Wynne (1978) [12]. To obtain enough population for further study, it was cultured in Bold's Basal medium under natural light with aquarium air pump aiding the mixing. The system setup for ozonation experiment, shown in Figure 1, consisted of a sample bottle (1.5 L) connected with 3 consecutive flasks of 2%KI solution serving as excessive ozone traps. An ozone generator supplied ozone to the sample bottle. The ozone production rate was determined using Wet Chemistry Iodide method [13] in the same ozonation system used for sample but omitting the sample bottle. The ozone production rate was calculated, according to equation 1, from the amount of standard $Na_2S_2O_3$ titrant used in titration with KI traps. The average production rate of 6.97 mgO_3/min was obtained from 10 tests.

*Ozone production rate (mg O_3/min) = (A+B+C) * N * 24 / T .....(1)*

where A, B, C = mL of $Na_2S_2O_3$ used for titrating trap A, B, C
N = normality of $Na_2S_2O_3$ titrant
T = ozonation time (min)

During experiment, ozone was continuously supplied to a batch of algae culture for 30 min. The treated algae culture was sampled at 10 min.

interval and determined for biomass and cell numbers (Suspended Solids and Natural Unit Count, according to APHA, AWWA and WEF, 2012) [14]. The amount of ozone in KI traps accounted for ozone amount remaining after the reaction. Actual amount used was calculated by subtracting the amount remaining from the amount supplied.

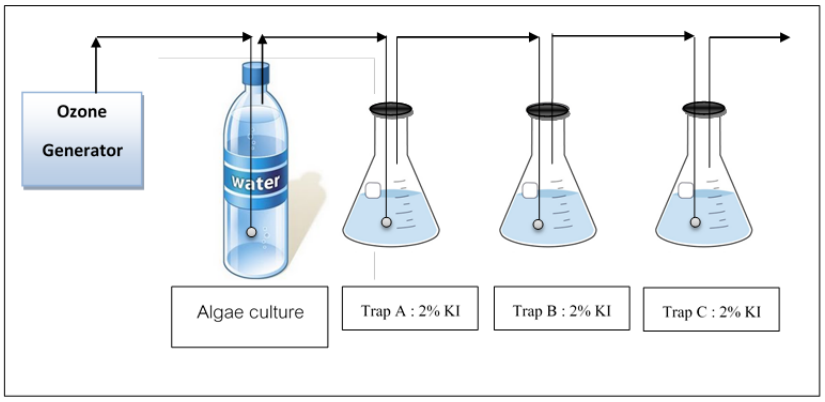

Figure 1 the setup of ozonation system for controlling algae population

Results and Discussion

Identification of algae in the swimming pool

The direct microscopic examination of algae in water sample collected from the swimming pool showed that algae surviving swimming pool condition were in the division Cyanophyta and Chlorophyta. Predominant species of Cyanophyta was *Oscillatoria* sp. (Figure 2). Those in Chlorophyta included *Scenedesmus* sp., *Euglena* sp. and *Phacus* sp. (Figure 3). These species were common species found in natural water bodies in Thailand [2-5].

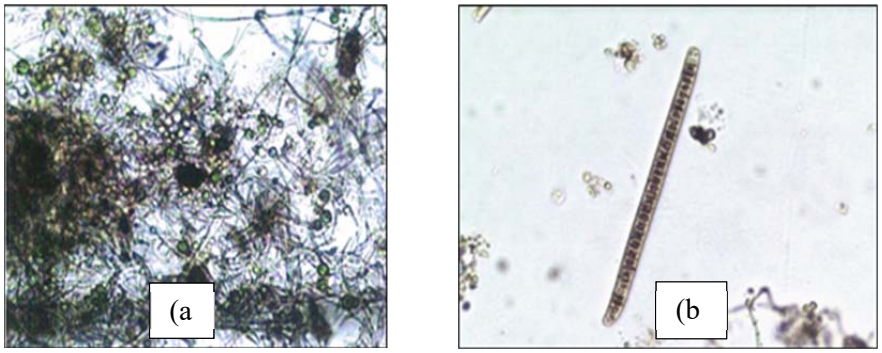

Figure 2 Algae (Division Cyanophyta) found in swimming pool
(a) *Oscillatoria* sp. (10x) (b) *Oscillatoria* sp. (100x)

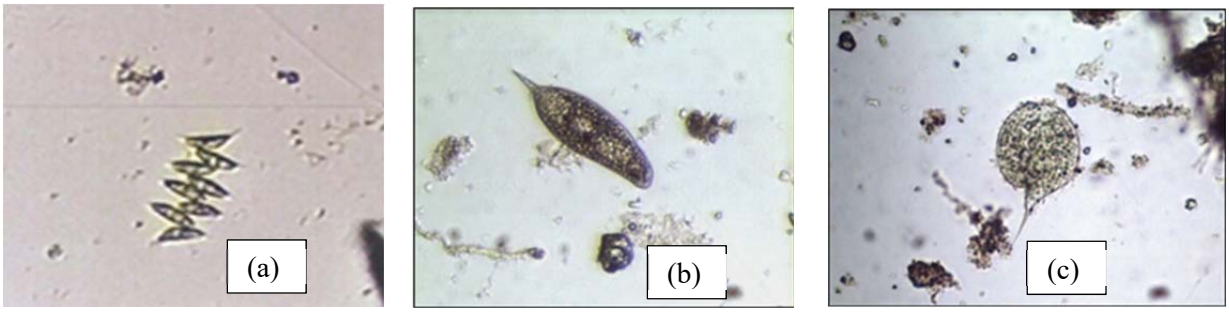

Figure 3 Algae (Division Chlorophyta) found in swimming pool
(a) *Scenedesmus* sp. (100x) (b) *Euglena* sp. (100x) (c) *Phacus* sp. (40x)

Ozonation of algae culture

The effect of ozone on algae population

The experiment on effect of ozone was conducted on swimming pool algae population cultured in Bold's Basal medium. In the culturing bottles, algae was found growing in 3 portions, namely, attached to the bottle surface (A), suspended (SS) and settled at the bottle bottom (ST). Of the 3 portions, biomass of the algae attached to the bottle was the highest. The biomass of the suspended and settled portions were the same. The change in population due to ozonation was investigated, the results are as shown in Figure 4. At the start, the attached biomass was 350 mg/L while the suspended and the settled portion were 85 mg/L. During early period (5-10 min.) of ozonation with 22.1-56.7 mgO_3/L, both the attached and suspended population decreased rapidly. The rate of decrease later slowed down. At the end of the experiment, with 141.5 mgO_3/L, 84% of attached algae was removed (56 mgDW/L remaining from 358 mgDW/L). Suspended population was more sensitive to ozone, 96% was removed (3.3 mgDW/L remaining from 85 mgDW/L) under the same condition. Simultaneous to the decrease in biomass of these 2 populations, the settled population increased. It should be noted that the total dry weight of the 3 portions after ozonation were not much different, in the range of 446-528 mg/L (Table 1). This showed that suspended and attached population settled down due to ozonation. This was confirmed by the appearance of the test bottles in Figure 5. Initially, the green color of attached and suspended algae was very strong and reduced with ozonation, while the amount of the settled portion increased.

Considering ozone consumption for algae removal – mgO_3/mgAlgae (Table 2), both attached and suspended portion showed the increasing trend with an increase in ozone. It was noted that ozone consumption of the suspended portion (1.72 mgO_3/mgAlgae at 30 min.) was higher than those of the attached portion (0.46 mgO_3/mgAlgae at 30 min.) all through the ozonation period, indicating that the former was more resistant to ozone than the latter.

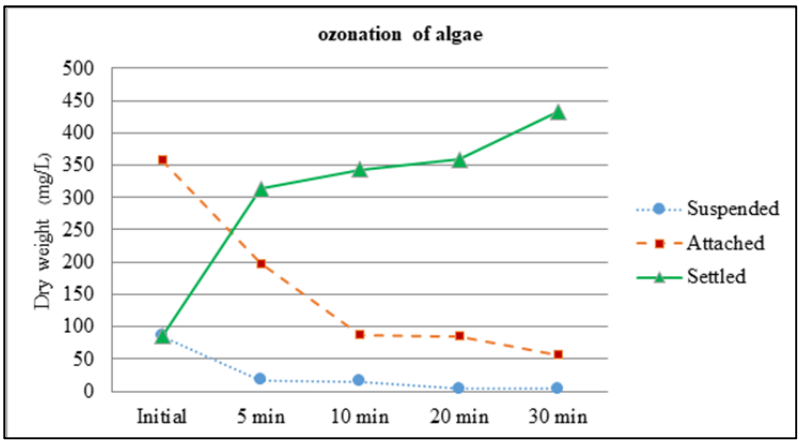

Figure 4 The changes in algae population (dry weight) during ozonation (initial = o min. ozonation time)

Table 1 Algae population (dry weight) during ozonation

Ozonation time	Dosage (mgO_3/L)	Algae population (dry weight, mg/L)			
		Suspended	Attached	Settled	Total
Initial	0	85.1	358	85.1	**528.2**
5 min	22.12	17	198.3	313	**528.3**
10 min	56.71	15.2	87.5	343.3	**446**
20 min	76.07	3.83	85.2	358.7	**447.7**
30 min	141.50	3.3	56	433	**492.3**

Figure 5 The appearance of algae culture at different ozonation times

Table 2 Ozone consumption for algae removal

Ozonation time	Dosage (mgO_3/L)	Ozone consumption (mgO_3/mgAlgae)	
		Suspended	Attached
5 min	22.12	0.32	0.14
10 min	56.71	0.81	0.21
20 min	76.07	0.93	0.27
30 min	141.50	1.72	0.47

The effect of ozone on different groups of algae

This part of the study aimed to investigate the effect of ozone on particular species. The predominating species were enumerated by direct counting before and after ozonation. The result is as shown in Table 3. *Oscillatoria* sp. population was found to be highest with 173,186 cell/L in the test culture. After ozonation, its population decreased to 22 cell/L (>99.99% decrease). *Scenedesmus* sp. and *Phacus* sp. were also very sensitive to ozone, 95 and 100% of the population was decreased, respectively. *Euglena* sp. was more resistant to ozone than the others. Its population was decreased by 68%.

Table 3 Effect of ozone on predominant algae in the swimming pool (141.5 mgO_3/L)

Division	Genus	Population number (Cell/L)		%decrease
		Initial	Ozonated	
Cyanophyta	*Oscillatoria* sp.	173,186	22	>99.99
Chlorophyta	*Scenedesmus* sp.	100	5	95
	Euglena sp.	50	16	68
	Phacus sp.	88	ND*	100

*ND = Not Detected

Conclusion

Algae found to survive swimming pool after disinfection by chlorination were in the genus Cyanophyta (*Oscillatoria sp.*) and genus Chlorophyta (*Scenedesmus sp., Euglena sp.* and *Phacus* sp. Ozone was an interesting choice for algae control in the swimming pool. By ozonation with 141.5 mgO_3/L, 84% of algae on the wall and 96% of algae suspended in the medium were removed and settled down. Among the 4 predominating species, *Euglena* sp. was the most resistant to ozone, only 68% of the population was removed while 95-100% removal could be achieved in other species.

Acknowledgement

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References

[1] Trusell, R.R. and Umphres, M.D. 1978. The formation of trihalomethanes. Journal of the American Water Works Association. 70(11): 604-612.

[2] Mahakhant, A., Chalermsiri, W., Kunyalung, W., Tungtananuwat, M. and Arunpairojana V. 2001. Survey and collection of freshwater microalgae strain in Bangkok and Vicinity. Microbiological Resources Centre (MIRCEN), Thailand Institute of Scientific and Technological Research (TISTR).

[3] Wongrat, L., Wongrat, P., Ruangsomboon, S. 2001. Diversity of freshwater phytoplankton in Thailand (Chlorophyta and Chromophyta). Department of Fishery Biology. Faculty of Fisheries, Kasetsart University, Bangkok.

[4] Lueangthuwapranit, C., Sampantarak, U. and Wongsai, S. 2011. Distribution and abundance of phytoplankton: Influence of salinity and turbidity gradients in the Na Thap River, Songkhla province, Thailand. Journal of Coastal Research 2011; 27(3): 585-594.

[5] Suwanvitaya, P., Suwan, S. Predominant algae in Bang Phra Reservoir: morphological and molecular identification. In: the 9th International Symposium on Lowland Technology, Saga University, Japan, 2014; 646-651.

[6] Shen, Q., Zhu, J., Chen, L., Zhang, J., Zhang, Z. and Xu, X. 2011. Enhanced algae removal by drinking water treatment of chlorination coupled with coagulation. Desalination. 27(1): 236-240.

[7] Kim, J.G., Yousef, A.E. and Khadre, M.A. 2003. Ozone and its current and future application in the food industry. Advances in Food and Nutrition Research; 45: 167-218.

[8] Pandiselvam, R., Shajahan, S., Ramarathinam, M., Kothakota, A. and Hebbar, K. 2017. Application and kinetics of ozone in food preservation. Ozone Science and Engineering. 39(2): 115-126.

[9] Cho, M., Kim, J., Kim, J.Y., Yoon, J. and Kim, J.H. 2010. Mechanisms of Escherichia coli inactivation by several disinfectants. Water Research; 44: 3410-3418.

[10] Kaewdam, J. and Suwanvitaya, P. Ozone disinfection of domestic wastewater. In: the 15th National Conference on Environmental Engineering, Environmental Engineering Association of Thailand, 2016; 57-58.

[11] Suwanvitaya, P. and Singhaphen, S. 2018. Ozonation as Cyanophyta Control Method for Water Treatment. Engineering and Applied Science Research. 45(3): 235-239.

[12] Bold, H.C. and Wynne, M.J. 1978. Introduction to the Algae. Prentice-Hall of India, New Delhi.

[13] Rakness, K., Gordon, G., Langlais, B., Masschelein, W.M. et al. 1996. Guideline for measurement of ozone concentration in the process gas from an ozone generator. Ozone Science and Engineering. 18: 209-229.

[14] APHA, AWWA and WEF. 2012. Standard Methods for Examination of Water and Wastewater**.** American Public Health Association. Washington, D.C.