ความหลากหลายและการกระจายตัวตามฤดูกาลของแพลงก์ตอนพืชในอ่างเก็บน้ำสวนหลวง ร.9 จังหวัดเชียงใหม่

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มหาวิทยาลัยราชภัฏเชียงใหม่ ถ.ช้างเผือก อ.เมือง จ.เชียงใหม่ 50300

บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาความหลากหลายและการกระจายตัวของแพลงก์ตอนพืชในอ่างเก็บน้ำสวนหลวง ร.9 จังหวัดเชียงใหม่ โดยเก็บตัวอย่างในเดือนเมษายน (ฤดูร้อน) สิงหาคม (ฤดูฝน) และธันวาคม (ฤดูหนาว) 2556 พบแพลงก์ตอนพืชทั้งหมด 8 ไฟลัม ซึ่งประกอบไปด้วย 16 อันดับ 19 วงศ์ 23 สกุล 28 สปีชีส์ โดยพบชนิดเด่น คือ *Botryococcus braunii*, *Peridinium* sp., *Pseudanabaena* sp., *Trachelomonas volvocinopsis* และ *Microcystis aeruginosa* ตามลำดับ จากการพิจารณาค่าดัชนีความหลากหลายทางชีวภาพ พบว่ามีค่าสูงสุดในเดือนเมษายน (2.34) และต่ำสุดในเดือนสิงหาคม (2.11) นอกจากนี้ยังพบว่าการกระจายตัวตามฤดูกาลของแพลงก์ตอนพืชมีปริมาณลดลงในฤดูฝน ซึ่งมีความมีความสัมพันธ์กับดัชนีความหลากหลายทางชีวภาพและระดับสารอาหารที่มีค่าต่ำในฤดูเดียวกัน

คำสำคัญ : ดัชนีความหลากหลายทางชีวภาพ / ระดับสารอาหาร / Canonical Correspondence Analysis

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Diversity and Seasonal Distribution of Phytoplankton in the King Rama IX Royal Park Reservoir, Chiang Mai Province

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Abstract

The objective of this research was to study the biodiversity and seasonal distribution of phytoplankton in the King Rama IX Royal Park Reservoir in Chiang Mai Province. Samples were taken during the months of April (summer), August (rainy season) and December (winter) 2013. Eight Phyla, which consisted of 16 Orders, 19 Families, 23 Genera, 28 Species of Phytoplankton were found, of which the most abundance species were, in descending order, *Botryococcus braunii*, *Peridinium* sp., *Pseudanabaena* sp., *Trachelomonas volvocinopsis* and *Microcystis aeruginosa*. The diversity index exhibited the highest values in April (2.34) and the lowest in August (2.11). In addition, the seasonal distribution of phytoplankton were found to be less abundant in the rainy season, which is likely due to the low values recorded in the diversity index and low trophic levels recorded during the same season.

Keywords : Diversity Index / Trophic Level / Canonical Correspondence Analysis

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1. Introduction

The King Rama IX Royal Park is located in Nong Ho, Chang Phueak District, Chiang Mai Province (Figure 1). It was established by the cooperation of the Peace and Order Maintaining Command (POMC) and the people of 17 northern provinces for the purposes of honouring His Majesty the King's 60th birthday anniversary. The estimated area is 67 acres. This park is built to support human activities such as leisure and sport activities, as well as certain ceremonies and rituals. Besides, the highlight of this park is the main reservoir called the "King Rama IX Royal Park Reservoir". Additionally, there are many restaurants in the area. According to the preliminary survey [1], it was found that the continuance of land use surrounding the reservoir has caused adverse effects on the aquatic environment. Particularly, the increase of nutrients in the water had induced the growth of phytoplankton. As a result, the water quality has begun to decline gradually.

2. Materials and Methods

The study sites were set up and samples were collected from 3 sites within the King Rama IX Royal Park Reservoir (Figure 1) during the months of April (summer), August (rainy season) and December (winter) in 2013.

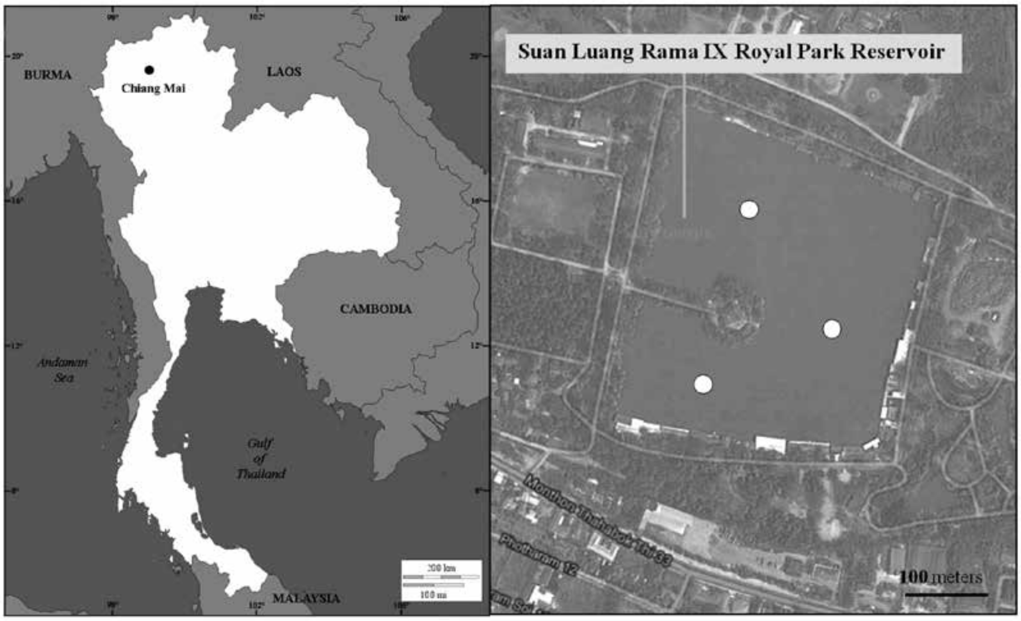

Figure 1 Map of Thailand showing Chiang Mai Province and aerial photograph of the King Rama IX Royal Park Reservoir and sampling sites.

The physical and chemical factors of water including conductivity, DO, BOD_5, nitrate nitrogen and SRP values were measured according to the methods described by APHA, AWWA and WEF [2]. The trophic status of the water was classified using the Applied Algal Research Laboratory-Physical and Chemical Score (AARL-PC Score) [3].

Samples of phytoplankton were collected by filtering 10 liters of water with a 10 µm pore size plankton net in the field, which were then preserved by Lugol's solution. The samples were then brought back to the laboratory for classification and to be taxonomically identified using relevant books and documents [4-9]. Phytoplankton were counted and photographed by an Olympus Normaski light microscope. The number of phytoplankton species found was also counted for the calculation of the diversity index by the Shannon method [10] . Canonical correspondence analysis (CCA) [11] was used to find the relationship between certain physical and chemical factors and the phytoplankton.

3. Results and Discussion

From the study of the biological diversity of phytoplankton in the reservoir, 8 Phyla of phytoplankton were found which consisted of 16 Orders, 19 Families, 23 Genera, 28 Species (Table 1). When the seasonal biodiversity of phytoplankton was analyzed, it was found that in the month of April, 8 Phyla of phytoplankton were discovered which consisted of 14 Orders, 17 Families, 20 Genera, 24 Species. In the month of August, 6 Phyla of phytoplankton were found which consisted of 11 Orders, 12 Families, 14 Genera, 17 Species. And in the month of December, 7 Phyla of phytoplankton were discovered consisting of 14 Orders, 17 Families, 19 Genera, 23 Species. All phytoplankton species found in the reservoir were acknowledged as common species that can be found in standing freshwater throughout Thailand [12].

Table 1 Taxonomic categoriesof phytoplankton in the King Rama IX Royal Park Reservoir.

Taxonomic categories	April	August	December
Phylum Chlorophyta			
Order Sphaeropleales			
Family Hydrodictyaceae			
Pediastrum simplex Meyen	*	*	*
Pediastrum tetras (Ehrenberg) Ralfs	*	-	-
Family Scenedesmaceae			
*Coelastrum sphaericum*Nägeli	*	*	*
Coelastrum sp.	*	*	*
Scenedesmus acuminatus(Lagerheim) Chodat	*	*	*
Scenedesmus sp.	*	*	*
Family Selenastraceae			
Monoraphidium contortum(Thuret) Komárková-Legnerová	*	-	*
Order Chlorellales			
Family Chlorellaceae			
Actinastrum sp.	-	-	*
Dictyosphaerium sp.	*	*	-
Order Trebouxiales			
Family Botryococcaceae			
Botryococcus braunii Kützing	***	***	***
Phylum Charophyta			
Order Desmidiales			
Family Desmidiaceae			
Cosmarium sp.	*	*	*
Euastrum sp.	*	-	-
*Staurastrum tetracerum*Ralfs ex Ralfs	*	*	*
*Staurastrum paradoxum*Meyen ex Ralfs	*	*	*
Phylum Dinophyta			
Order Peridiniales			
Family Peridiniaceae			
Peridinium sp.	***	***	***

Table 1 (Continue)

Taxonomic categories	April	August	December
Order Gonyaulacales			
Family Ceratiaceae			
Ceratium sp.	*	-	*
Phylum Euglenophyta			
Order Euglenales			
Family Phacaceae			
Phacus longicauda(Ehrenberg) Dujardin	*	-	*
Family Euglenaceae			
Trachelomonas volvocinopsis Svirenko	***	***	***
Phylum Bacillariophyta			
Order Aulacoseirales			
Family Aulacoseiraceae			
Aulacoseira granulata (Ehrenberg) Simonsen	*	-	-
Order Cocconeidales			
Family Achnanthidiaceae			
Achnanthidium sp.	*	-	-
Phylum Ochrophyta			
Order Mischococcales			
Family Pleurochloridaceae			
Isthmochloron sp.	*	-	*
Order Synurales			
Family Mallomonadaceae			
Mallomonas sp.	-	-	*
Phylum Cyanophyta			
Order Pseudanabaenales			
Family Pseudanabaenaceae			
Pseudanabaena sp.	***	***	***
Order Synechococcales			
Family Merismopediaceae			
Merismopedia sp.	-	*	*
Order Nostocales			
Family Aphanizomenonaceae			
Cylindrospermopsis raciborskii (Woloszynska) Seenayya & Subba Raju	*	*	*
Cylindrospermopsis philippinensis (W.R.Taylor) Komárek	-	-	*
Order Chroococcales			
Family Microcystaceae			
Microcystis aeruginosa (Kützing) Kützing	***	***	*
Phylum Cryptophyta			
Order Cryptomonadales			
Family Cryptomonadaceae			
Cryptomonas sp.	*	*	*

Note: *** = dominant species,* = common species, - = absented

The comparison of the dominant phytoplankton species and the total number of phytoplankton present in each season suggested that the dominant and total number of species were mostly found in December, and were followed by April and August, respectively (Figure 2). This is consistent with the diversity index and the trophic status measurements of the water during each season. The diversity index was found to be highest in April (diversity index 2.34, evenness 0.74) followed by December (diversity index 2.13, evenness 0.68) and August (diversity index 2.11, evenness 0.74), respectively

(Table 2). The trophic status of the water in each season is shown in Table 3 and was classified as mesotrophic status in December and April. Only August was the water classified as being in the oligomesotrophic status. The seasonal distribution of phytoplankton was also found to reveal less abundance in August which was related to the low values reported in the biodiversity index and low trophic levels recorded in the same season.

Table 2 Shannon's diversity index, evenness and the amount ofphytoplankton present in the King Rama IX Royal Park Reservoir.

Shannon's diversity index	April	August	December
Diversity index	2.34	2.11	2.13
Evenness	0.74	0.74	0.68
Number of species	24	17	23

Table 3 Average and Standard Deviation (n=3) of the physico-chemical factors and trophic level in the King Rama IX Royal Park Reservoir.

Physico-chemical factors	April	August	December
Conductivity (μs/cm^{-1})	195.3±3.05	110±1.00	190.3± 5.03
DO (mg/L)	8.80±0.20	9.06±0.31	8.60 ±0.05
BOD_5 (mg/L)	8.3±0.30	6.4±0.20	8.4±0.34
Nitrate nitrogen (mg/L)	0.57±0.23	0.50±0.43	0.50±0.34
Orthophosphates (mg/L)	0.61±0.42	0.10±0.04	0.21±0.05
Trophic level*	Mesotrophic	Oligo-mesotrophic	Mesotrophic

Note: * Trophic level was calculated by 5 factors in Table 2

Subsequently, the seasonal distribution of phytoplankton in the King Rama IX Royal Park Reservoir was compared with several other reservoirs in Thailand. It was found that the biodiversity of phytoplankton was low in the month of August (rainy season) which is similar to the data recorded in the Doi Tao Reservoir (located in Chiang Mai Province) [13], Saluang Campus of Chiang Mai Rajabhat University Reservoir (located in Chiang Mai Province) [14] and Bang Pra Reservoir (located in Chonburi Province) [15]. This contrasts with data obtained from the Banglang Reservoir (located in Yala Province) in Southern Thailand where there was no difference of phytoplankton diversity and abundance found between each season due to the high amount of rain that fell in the area all year round [16, 17]. Thus, this indicates that the amount of rainfall does affect the physical, chemical and biological factors of water including the presence of water catchment areas located at the water bodies as well.

The most abundant phytoplankton species found in the King Rama IX Royal Park Reservoir were *Botryococcus braunii*, *Peridinium* sp., *Pseudanabaena* sp., *Trachelomonas volvocinopsis* and *Microcystis aeruginosa*, respectively (Figure 2). *Botryococcus braunii*, which is regarded as a potential source of renewable fuel due to its ability to produce large amounts of hydrocarbon of up to 75% of algal dry mass [18], was found to be most abundant in all seasons. This data has suggested some essential information on the sampling of this phytoplankton, which can be expanded into the phytoplankton culture for the study of hydrocarbon production in the future. The second most abundant species was *Peridinium* sp., which is a dinoflagellate. Those that live in the sea can cause the 'red tide' phenomenon and produce a neurotoxin called saxitoxin. While those that live in fresh water can only cause red tide when there are enough nutrients for its rapid growth and development, which, as a result, will eventually significantly impact upon the reservoir. However, no data on toxin production of freshwater dinoflagellates has been reported [19-20]. Several studies on *Pseudanabaena* sp. and *Trachelomonas volvocinopsis* have been reported in the United Kingdom, Mexico and Portugal [7, 21, 22] indicating that these two species can be found in high-nutrient water bodies and are tolerant to organic pollution. This suggests that the King Rama IX Royal Park Reservoir tends to contain a high amount of nutrients and this may result in causing Eutrophication in the future. The last dominant species found to be present was *Microcystis aeruginosa*. This specie could produce Microcystins, which are known to be liver tumor promoters [23]. Therefore, this specie should be considered for investigation of species abundance in the long-term.

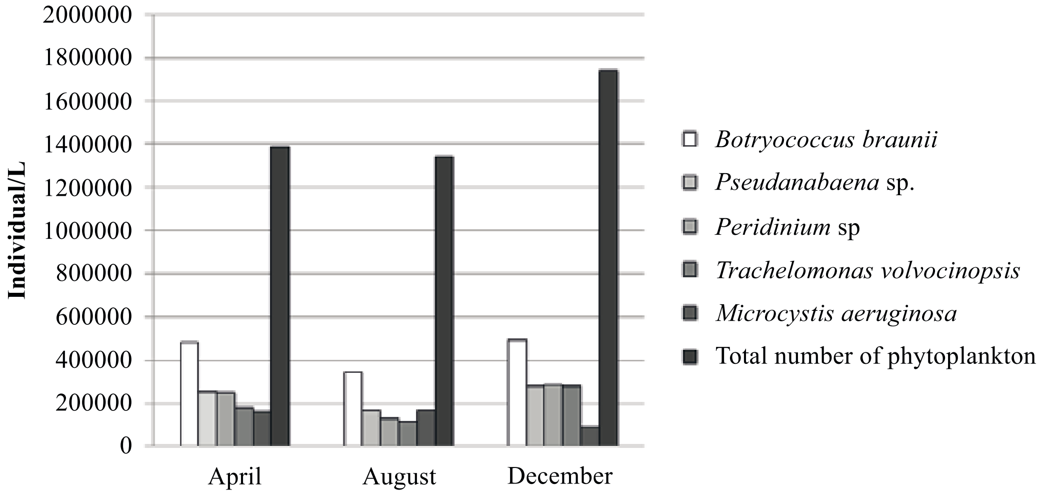

Figure 2 Bar chart of 5 dominant species and total number of phytoplankton during April, August and December 2013.

In addition, the results of the CCA are shown in a CCA plot (Figure 3). It was found that *Botryococcus braunii* (Botrbru) had a positive correlation with conductivity and BOD_5. *Pseudanabaena* sp. (Pseudsp) had a positive correlation with nitrate nitrogen and SRP. *Peridinium* sp. (Perisp) had a negative correlation with conductivity and BOD_5 and *Trachelomonas volvocinopsis* (Trachvo) had a negative correlation with DO.

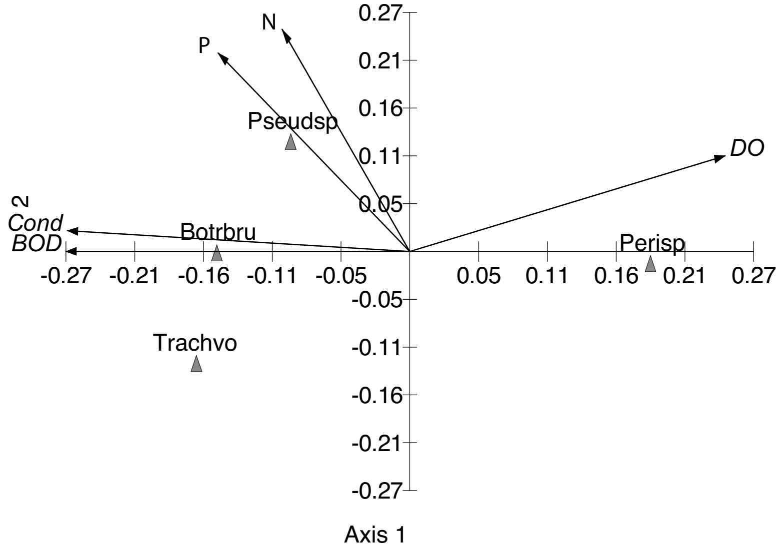

Figure 3 Canonical Correspondence Analysis (CCA) of the Physico-chemical parameters and phytoplankton of water properties showing the correlation between these physico-chemical parameters and the dominant species of phytoplankton in the King Rama IX Royal Park Reservoir (Eigenvalues percentage of axis 1 = 80.68, axis 2 = 19.32).

4. Conclusion

Eight Phyla of phytoplankton, which consisted of 16 Orders, 19 Families 23, Genera 28 Species, were found in the King Rama IX Royal Park Reservoir. These species are commonly found in still water throughout Thailand. The seasonal distribution, diversity index and trophic levels were all found to be low in August (rainy season). In addition, the some dominant species were indicative of high-nutrient content and toxin production. Therefore, the distribution of phytoplankton and the nutrient levels in the water should be assessed regularly for effective Eutrophication monitoring.

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6. References

1. Sompong, U., 1998, Water quality, Phytoplankton and Coliform Bacteria Distribution in the Reservior of Ratchamangkla Park, Chiang Mai Province, Independent study for Graduate, Department of Biology, Faculty of Science, Chiang Mai University. Chiang Mai.

2. APHA, AWWA and WEF, 2005, Standard Methods for the Examination of Water and Wastewater, 21st edition, American Public Health Association (APHA), Washington DC.

3. Peerapornpisal, Y., Chaubol, C., Pekkoh, J., Kraibut, H., Chorum, M., Wannathong, P., Ngearnpat, N., Jusakul, K., Thammathiwat, A., Chuanunta, J. and Inthasotti, T., 2004, "Monitoring of Water

Quality in Ang Kaew Reservoir of Chiang Mai University Using Phytoplankton as Bioindicater from 1995-2002", *Chiang Mai Journal of Science*, 31(1), pp. 85-94.

4. Peerapornpisal, Y., 2006, *Phycology*, Chotana Print CO.,LTD, Chiang Mai.

5. Peerapornpisal, Y., 2013, Freshwater Algae in Thailand, Chotana Print CO., LTD, Chiang Mai.

6. Lee, R.E., 1999, Phycology, Cambridge University Press, Cambridge.

7. John, D.M., Whitton, B.A. and Brook, A.J. 2011, The Freshwater Algae Flora of the British Isles, 2nd edtion, Cambridge Press, Cambridge.

8. Wehr, J.D. and Sheath, R.G. 2003, *Freshwater Algae of North America: Ecology and Classification*. Academic Press, San Diego.

9. Guiry, M.D. and Guiry, G.M., AlgaeBase, Available : http:// www. algae base.org. Accessed August, 17 2015.

10. Odum, E.P. 1971, Fundamental of Ecology, 3rd edtion, Saunders, W.B. Philadelphia.

11. Varis, O., 1991, "Associations Between Lake Phytoplankton Community and Growth Factors — a Canonical Correlation Analysis", *Hydrobiologia*, 210 (3), pp. 209-216.

12. Pollution Control Department, 2010, Survey, Collection and Analysis of Water Samples and Living Organisms in the Standing Water, Final report, Vol. 2, Ministry of Natural Resources and Environment, Bangkok.

13. Khuantrairong, T. and Traichaiyaporn, S., 2008, "Diversity and Seasonal Succession of the Phytoplankton Community in Doi Tao Lake, Chiang-Mai Province, Northern Thailand", *The Natural History Journal of Chulalongkorn University*, 8 (2), pp. 143-156.

14. Leelahakriengkrai, P. and Kunpradid, T., 2014, "Water Quality and Biodiversity of Phytoplankton and Benthos in the Reservoirs at Saluang Campus Chiang Mai Rajabhat University", *Rajabhat Journal of Science, Humanities & Social Sciences*, 15(1), pp. 87-97.

15. Chaichana, R., Arunlertaree, C., Srichareondham, B. and Veeravaitaya, N., 2003, "Quantity and Distribution of Plant Nutrients on Eutrophication in Bang Pra Reservoir, Chonburi Province", *Kasetsart Journal : Natural Science*, 37, pp. 90-100.

16. Ariyadej, C., Tansakul, R., Tansakul, P. and Angsupanich, S., 2004, "Phytoplankton Diversity and its Relationships to the Physico-chemical Environment in the Banglang Reservoir, Yala Province", S*ongklanakarin Journal of Science and Technology*, 26(5), pp. 595-607.

17. Ariyadej, C., Tansakul, P. and Tansakul, R., 2008, "Variation of Phytoplankton Biomass as Chlorophyll a in Banglang Reservoir, Yala Province", *Songklanakarin Journal of Science and Technology*, 30(2), pp. 159-166.

18. Banerjee, A., Sharma, R., Chisti, Y. and Banerjee, U.C., 2002, "*Botryococcus braunii*: A Renewable Source of Hydrocarbons and Other Chemicals", *Critical Reviews in Biotechnology*, 22(3), pp. 245–279.

19. Rengefors, K. and Legrand, C., 2001, "Toxicity in *Peridinium aciculiferum*—an Adaptive Strategy to Outcompete other Winter Phytoplankton?", *Limnology and Oceanography*, 46(8), pp. 1990–1997.

20. Lee, J.J., Chang, S.H., Lee, J.H. and Lee, J.H., 2006, "Morphology and Ecology of *Peridinium bipes* var. *occultatum* Lindem. (Dinophyceae) Forming Freshwater Red Tides in Korean Dam Reservoirs", *Algae*, 21(4), pp. 433-443.

21. Xavier, L., Vale, M. and Vasconcelos, V.M., 2007, "Eutrophication, Phytoplankton Dynamics and Nutrient Removal in Two Man-made Urban

Lakes (Palácio de Cristal and Serralves), Porto, Portugal", *Lakes & Reservoirs: Research and Management*, 12, pp. 209–214.

22. Solórzano, G., Martinez, M., Vazquez, A., Garfias, M., Zuniga, R. and Conforti, V., 2011, "*Trachelomonas* (Euglenophyta) from a Eutrophic Reservoir in Central Mexico", *Journal of Environmental Biology*, 32, pp. 463-471.

23. Thangavelu, B. and Jang-Seu, K., 2014, "Impact of Environmental Factors on the Regulation of Cyanotoxin Production", *Toxins*, 6, pp. 1951-1978.