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Utilization of *Spirulina platensis* for wastewater treatment in fermented rice noodle factory

[1]Sumontip Bunnag, [2]Witaya Pimda, and [2]Sirinapa Pongpera

[1]Applied Taxonomic Research Center (ATRC), Department of Biology, Faculty of Science, Khon Kaen University, Muaeng Khon Kaen, Thailand. [2]Department of Biology, Faculty of Science, Khon Kaen Universiy, Muaeng Khon Kaen, THAILAND.
Corresponding author: S. Bunnag, sumbun@kku.ac.th

Abstract. *Spirulina platensis* is a single-cell blue-green alga which belongs to the family *Oscillatoriaceae*. *S. platensis* can grow in polluted water and it has been widely used to remove excess nitrate-nitrogen and total phosphorus content in wastewater from noodle factories. This study was aimed to investigate the effect of wastewater on growth of *S. platensis* and to examine its potential to reduce nitrate-nitrogen and total phosphorus contents in wastewater from fermented rice noodle factory. Twenty five percent-wastewater mixed Zarrouk's medium gave rise to the highest growth rate of *S. platensis.* Optical density (OD) of *S. platensis* culture increased from 0.07±0.04 to 0.24±0.12. Also, the results exhibited the least value of nitrate-nitrogen and total phosphorus contents when performed in 25 % and 100 % wastewater-mixed Zarrouk's media, respectively.

Key Words: Fermented rice noodle factory, wastewater treatment, nitrate-nitrogen, total phosphorus.

Rezumat. *Spirulina platensis* este o algă unicelulară albastră-verde care aparţine familiei *Oscillatoriaceae*. *S. platensis* poate creşte în ape poluate şi a fost folosită frecvent pentru îndepartarea excesului de nitraţi şi a conţinutului de fosfor din apele reziduale de la fabricile de paste făinoase. Acest studiu şi-a propus investigarea efectului apei reziduale asupra creşterii speciei *S. platensis* şi examinarea potenţialului de reducere a nitraţilor şi a conţinutului de fosfor în apele reziduale provenite de la orezul fermetat din fabricile de paste făinoase. Un procent de 25% de ape reziduale dizolvate în mediul Zarrouk a determinat cea mai ridicată rată de creştere la *S. platensis*. Densitatea optică a culturii de *S. platensis* a crescut de la 0.07±0.04 la 0.24±0.12. De asemenea, s-au obţinut valoari scăzute a nitraţilor şi a conţinutului de fosfor când amestecul de ape reziduale dizolvate în mediul Zarrouk a fost crescut de la 25% la 100%.

Cuvinte cheie: fabrică de paste făinoase din orez fermentat, ape reziduale, nitraţi, fosfor total.

Introduction. Fermented rice noodle is favorable food for Thai people. A process for producing the fermented rice noodle requires a great deal of water, thus resulting in high volume of wastewater. A fermented rice noodle factory is a source of undesirable smell and litter, and directly affects sanitation and low quality of wastewater. In order to exist in the community, the factory must hold wastewater treatment systems before discharge into water resources. Organic-rich wastewater from the factory can be as a nutrient source for microalgae. During photosynthesis, the microalgae utilize nitrogen and phosphorus together with releasing oxygen into water resources. Falmer (1969) and Bunsom (1987) found that *Spirulina* sp. and *Chlorella* sp. can survive in wastewater and help reduce excess nutrients e.g. nitrogen and phosphorus in water resources, thus improving water quality (Phoathongsuk 2000). We, therefore, used *Spirulina* sp. and *Chlorella* sp. to better the quality of wastewater by reducing nitrate-nitrogen and total phosphorus in the fermented rice noodle factory.

Material and Method. Wastewater from the fermented rice noodle factory was evaluated for nitrate-nitrogen, total phosphorus, turbidity, total dissolved solid and conductivity prior to each study.

Experiment I. Growth of microalgae cultured in various concentrations of wastewater

Spirulina platensis was cultured in Zarrouk's medium (Zarrouk 1996) and kept for 20 d at 25°C under light intensity of 2 000 lux with nonstop oxygen flow. Optical density (OD) was measured using spectrophotometer at wavelength of 560 nm. Then, *S. platensis* solution was cultured in wastewater concentrations of 0-100%, 10 ml for each. Each treatment was repeated 4 times.

Experiment II. Nitrate-nitrogen- and total phosphorus-reducing potential of S. platensis

Nitrate-nitrogen was evaluated using the Method 8171, Cadmium Reduction Method while total phosphorus was assessed using the Method 8048, PhosVer3 Ascorbic Acid Method.

Experiment III. Changes in turbidity, total dissolved solid, pH and conductivity of wastewater after algal culture

After algal culture, turbidity was evaluated using the Method 8237--Attenuated radiation (DR 2010 Spectrophotometer), total dissolved solid was measured using the Method 8006—Photometric Method (DR 2010 Spectrophotometer), and pH and conductivity were assessed using InoLab® Multi 720.

Results and Discussion. *S. platensis* could grow well in all concentrations of wastewater. However, a significant difference of algal growth was found when varied concentrations were applied. Wastewater concentration of 25% gave rise to the best growth rate. Characteristics of *S. platensis* cultured under different conditions were shown in Figure 1.

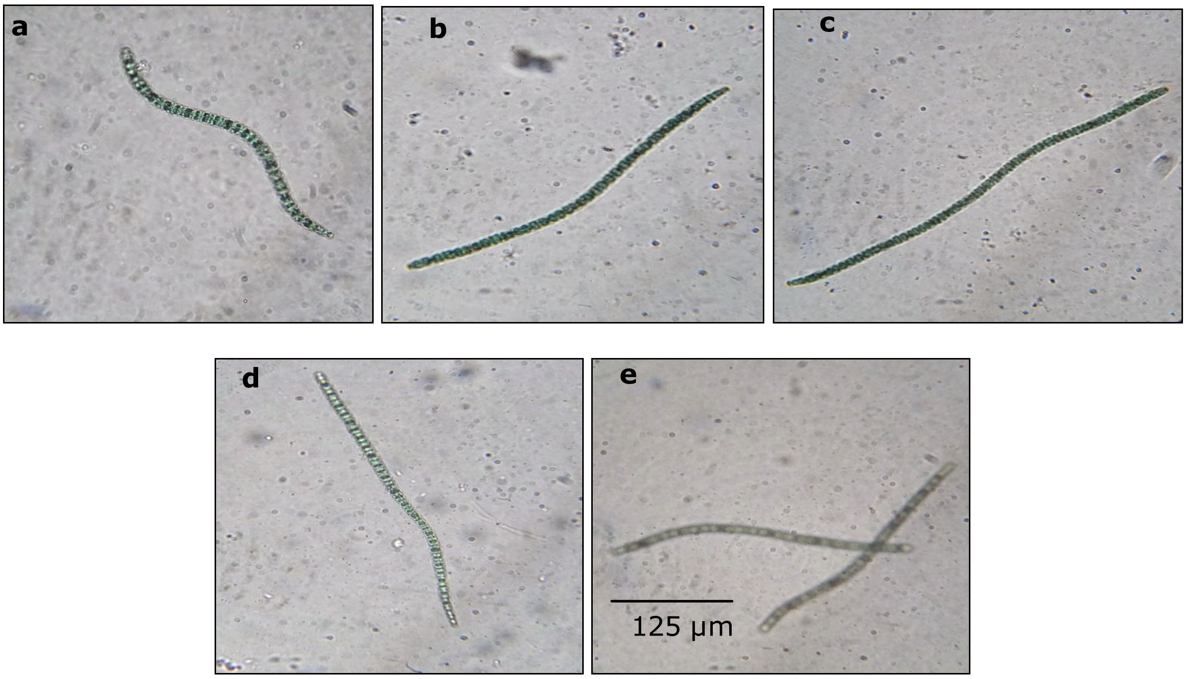

Figure 1. Characteristics of *S. platensis* when cultured in varied concentrations of wastewater: a) 0%, b) 25%, c) 50%, d) 75% and e) 100%.

The OD increased from 0.07±0.01 to 0.24±0.12 and from 0.11±0.03 to 0.41±0.10, respectively (Figure 2). This finding was consistent to Weerapattanapong (1998) reporting that better growth rate was observed when culture time was prolonged. Bacteria play a role in degrading nutrients in wastewater and converted those nutrients into nitrogen compounds and carbon dioxide which were later utilized in metabolic pathway. Gonzalez & Bashan (2000) reported that the bacterium *Azospirillum brasilense* helps improve algal growth. When Batch (close) system was introduced for algal culture, algal growth in the first 5 days was in Lag phase. In this phase, algae adjusted themselves to the surrounding environment so no cell multiplication was initiated. When they enter Exponential phase in the second week, algae initiate cell multiplication which leads to high growth rate exhibiting dark green color during culture (Vorawut 2004).

S. platensis was capable of best reducing nitrate-nitrogen when cultured in 25% wastewater (Figure 3a). Nitrate-nitrogen content dropped from 16.00±4.30 mg/l to 5.50±1.50 mg/l. Reduction of nitrate-nitrogen was resulted from the fact that nitrogen is essential nutrients for algal growth. When culture time was extended, algae require nitrogen for growth. Due to the fact that *S. platensis* cannot fix atmospheric nitrogen, abundant nitrogen source in wastewater is alternatively utilized in both organic and inorganic forms. Consequently, extended culture time resulted in reduction of nitrate-nitrogen (Thongtong 1986).

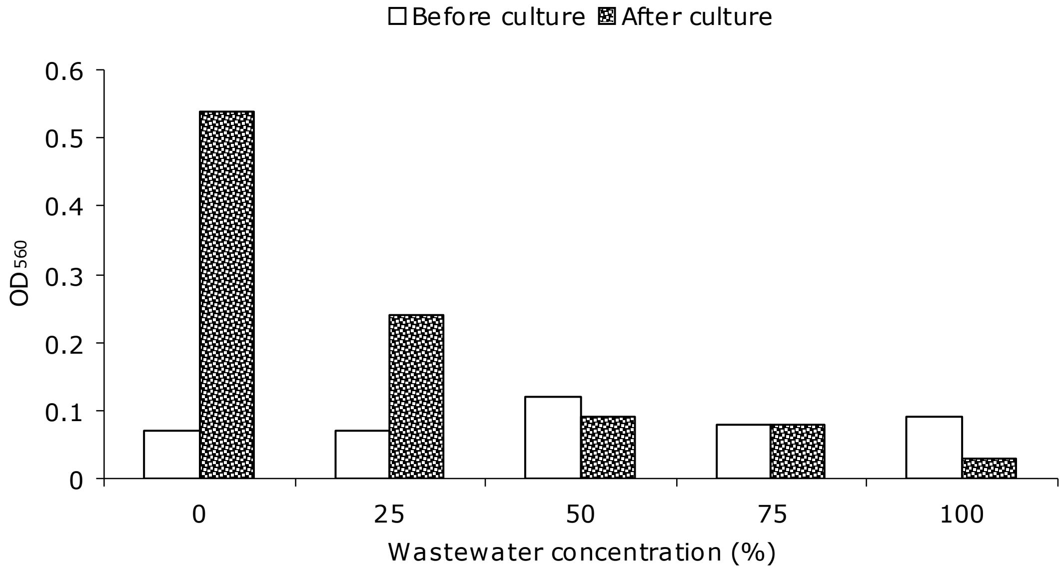

Figure 2. Growth rate of *S. platensis* when cultured in varied concentrations of wastewater

Total phosphorus-degrading potential of *S. platensis* was significantly different in varied concentrations of wastewater (Figure 3b). *S. platensis* could best reduce total phosphorus in 100% wastewater. Total phosphorus content dropped from 19.50±2.77 mg/l to 5.8±0.64 mg/l. This finding was consistent to Tam & Wong (1989) reporting that *Spirulina* sp. could reduce total phosphorus when culture time was increased.

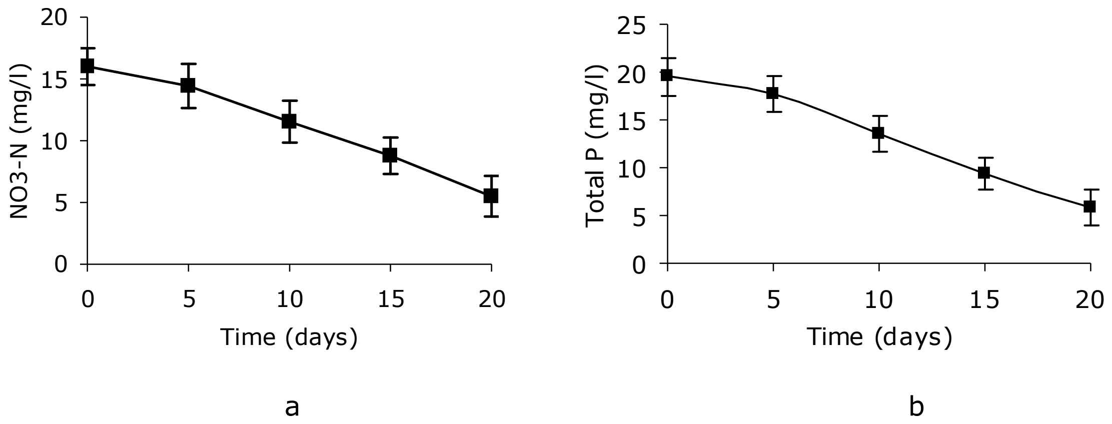

Figure 3. Nitrate-nitrogen (a) and total phosphorus (b) in wastewater-mixture medium

Values of turbidity, total dissolved solid, pH and conductivity in wastewater which are acceptable for discharge into water resources were found in 25% wastewater-mixture medium.

Turbidity was resulted from total amounts of suspension in water which hinder the journey of light toward water body to reach the bottom of the water resources by reflecting or absorbing light. It was found that turbidity was increased after algal culture. This could be simply explained by the theory of absorption and scattering of light. Light is reflected and absorbed when light travels through algae because algae are microorganisms, thus acting as small particles suspending in water. This resulted in an increase in water turbidity. Figure 4 represented the augumentation of water turbidity in algal culture for 20 days. It was clear that, among all treatments except control, 25% wastewater gave rise to very little increase in water turbidity.

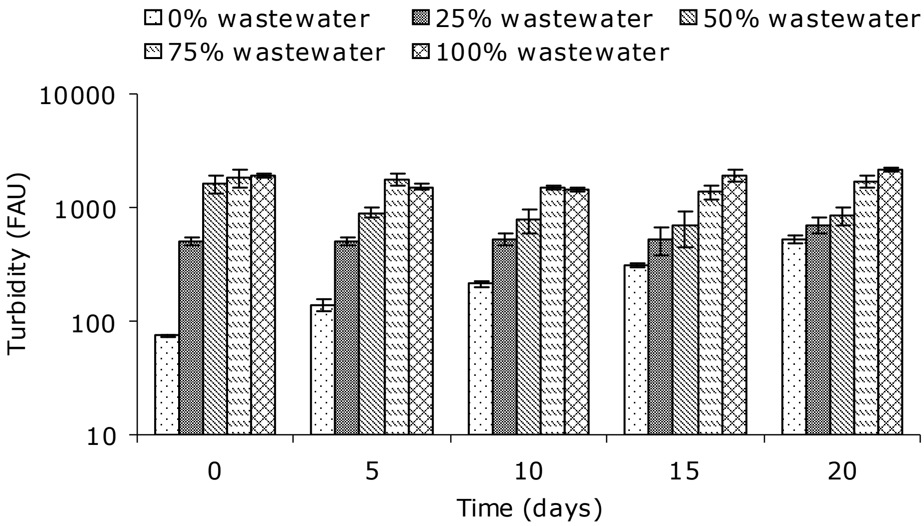

Figure 4. Turbidity of wastewater after algal culture for 20 days

Total dissolved solids meased in the form of total suspended solids (TSS) also hindered the journey of light toward water body, thus resulting in low photosynthetic capacity of aquatic plants. This phenomenon adversely lowered amounts of dissolved oxyen in water resources. It was certain that 25% wastewater caused little increment of total dissolved solids (Figure 5).

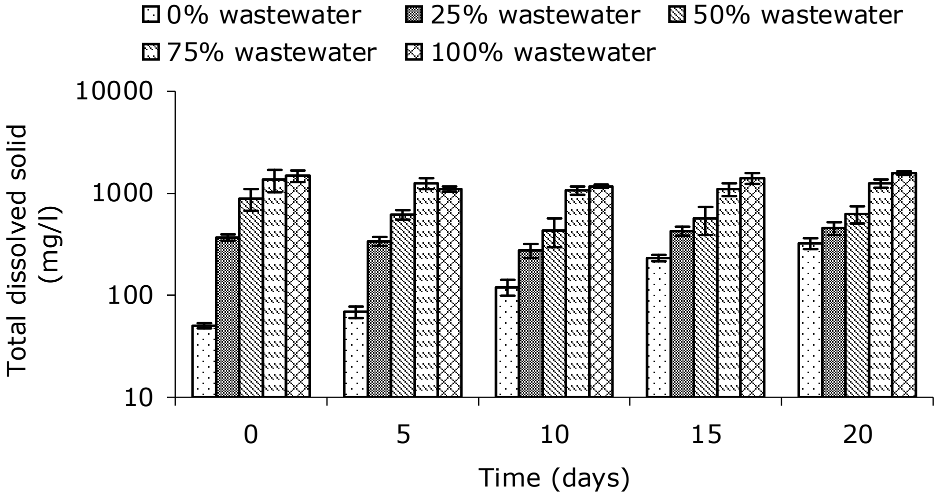

Figure 5. Total dissolved solid of wastewater after algal culture for 20 days

In general, many kinds of algae inhabit in different pH environmenrs. Wastewater should have optimum pH for not harming aquatic lives. The pH of surface water that is safe for the enviroments ranges from 5 to 9 ratified by the Office of the National Environment Board, Thailand (1994). The results showed that *S. platensis* could grow under wastewater concentrations of 0-75%, pH of 5-9 (Figure 6). The pH values were in in the benchmark of natural water quality (Office of the National Environmental Board, Thailand 1994).

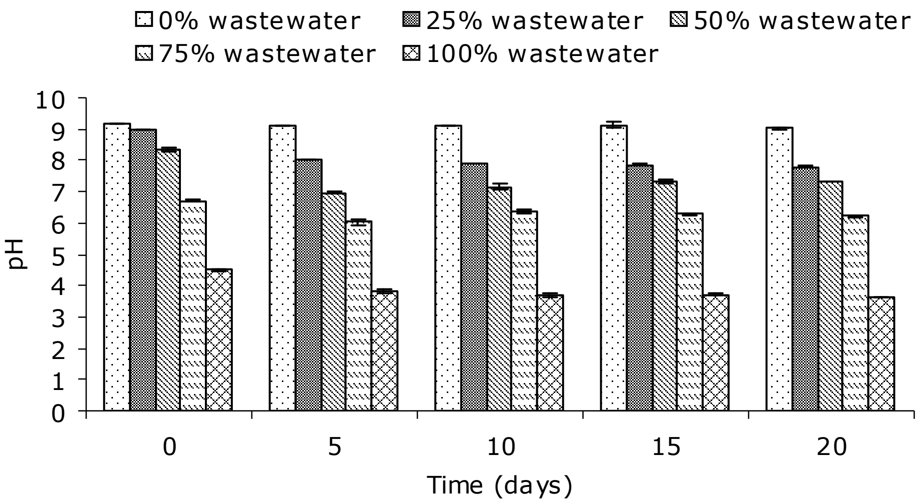

Figure 6. pH of wastewater after algal culture for 20 days

High conductivity value implied that water was of high salinity. Many kinds of algae could not toterate salt stress except hypersaline algae. Conductivity value represented amounts of nutrient concentrations or total dissolved solids (TDS). Natural water resources should exhibit not exceed 5 mS/cm. Here, the results showed that water conductivity remained stable (Figure 7). *S. platensis* grew well under high salinity as it could stand hypersaline environments. According to OD_{560} value, 25% wastewater was considered suitable for *S. platensis* culture as it exhibited the conductivity in the benchmark of natural water quality (Office of the National Environmental Board, Thailand 1994).

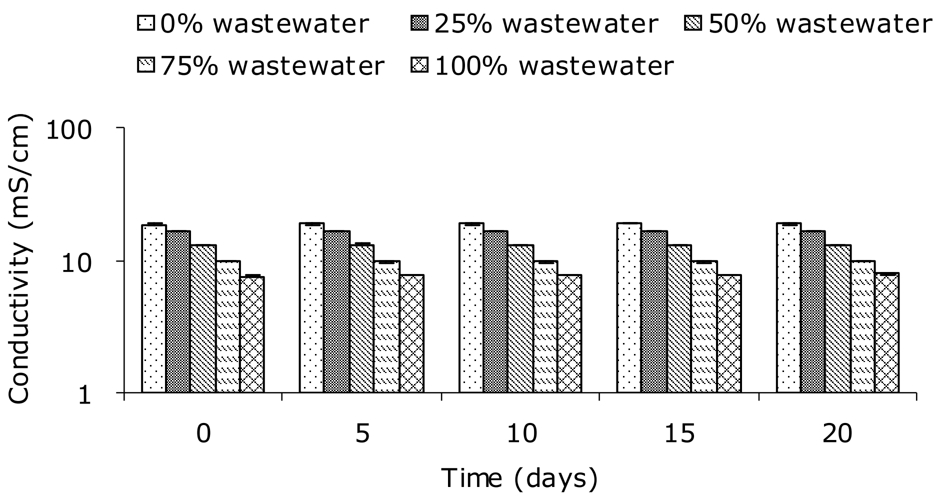

Figure 7. Conductivity of wastewater after algal culture for 20 days

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Authors:
Sumontip Bunnag, Khon Kaen University, Applied Taxonomic Research Center, Department of Biology, Thailand, Khonkaen, Friendship Highway, 123/2001, 40002, e-mail: sumbun@kku.ac.th
Witaya Pimda, Khon Kaen University, Department of Biology, Thailand, Khonkaen, Friendship Highway, 123/2001, 40002, e-mail: wp_sc29th@hotmail.com
Sirinapa Pongpera, Khon Kaen University, Department of Biology, Thailand, Khonkaen, Friendship Highway, 123/2001, 40002, e-mail: biofunny@hotmail.com

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