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Goals and Challenges of International Research Partnerships: Developing Capacity through the SATREPS-COSMOS Program

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Abstract

In addition to addressing global issues, advancing science and promoting international cooperation, the SATREPS collaboration between JST and JICA places a strong emphasis on capacity development. Capacity development in this context is defined as efforts to boost self-reliant research, construct sustainable research infrastructure, develop networks between researchers and train future human resources. It is important to note that any capacity development component of an international research collaboration can be one of the most challenging problems due to the necessity of coordinating not only funding, but also schedules, lives, laws, customs and institutional requirements of respective countries. Since the inception of the COSMOS project in 2015, the Malaysia-Japan partnership has, in addition to obtaining matching-funds from MOHE, diligently made efforts to: (1) develop research-capable infrastructure at three institutions (UPM, UMT and UNISEL), (2) train future science and research leaders, (3) conduct advanced methods workshops, (4) promote career advancement and educational programs and (5) translate the research finding to related industries and communities. The objective of this presentation is to introduce the capacity development goals of the COSMOS project, share our mid-term accomplishments relative to proposed scheduled targets and critically review the challenges and remaining targets towards the second half of the project tenure. Specific examples of private Japanese company internships, multiple human resources exchanges and specialized research workshops will be introduced and reviewed. The goal of this presentation is to highlight the importance of the capacity development component of the SATREPS-COSMOS international research initiatives.

Bioprospecting of High-value Native Microalgae from Malaysia

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Abstract

Microalgae are considered as a promising resource for high-value compounds since they have higher photosynthetic efficiencies than terrestrial plants, and do not compete with conventional agriculture for resources. Microalgal high-value compounds, which include polyunsaturated fatty acids and carotenoids have attracted widespread attention. With only a few microalgal strains having been cultivated on a large scale for commercial production, prospecting for new, robust and fast-growing strains with high-value substances is essential in order to advance research for novel microalgal products. A collaborative team between Universiti Malaysia Terengganu and The University of Tokyo aimed to bioprospect high value microalgae producing useful compounds under the SATREPS-COSMOS project. More than 200 microalgae were isolated from various inland and coastal water bodies in Peninsular Malaysia. Unialgal isolates were screened for the ability to produce high biomass and high-value compounds. These isolates were incubated for 14 days in 48-well plates at 25°C under 150 μmol m^{-2} s^{-1} with a 12:12 h light:dark cycle before examining the optical density at 685 nm and the fluorescence intensity at 575 nm of cells stained with Nile red for lipid/carotenoid concentrations. Results showed that the specific growth rates ranged from 0.14 to 1.0 day^{-1} and the maximum optical densities were 0.08 to 1.16. After eight days of cultivation, two isolates showed higher fluorescence intensity than that of marine diatom *Phaeodactylum tricornutum* which was used as a control for high productivity of lipid/carotenoid. This study illustrated that both isolates have higher productivity of lipid/carotenoid, and further investigations to optimize environmental conditions for growth and high-value substances production could help to improve their viability as candidates for large-scale production.

Survey of Natural Growth-promoting Substances for High-value Indigenous Microalgae

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Abstract

The objective of the SATREPS-COSMOS project Theme 2 is to discover growth-promoting substances from soil extracts for indigenous microalgae culture in Peninsular Malaysia using the plate-culture technique. Chemical characteristics of the growth-enhancing soil extracts were determined by analyzing the distribution of hydrophobic/hydrophilic dissolved organic matter, fluorescence properties and molecular size. Therefore, the three-pronged experimental approach in this theme were "Extraction", "Incubation", and "Fractionation". In "Extraction", soils were collected from different undisturbed locations (National parks and forest reserves) in Peninsular Malaysia. In addition, sludge samples from a shrimp farm in Selangor were also collected. Experimental studies were carried out in laboratories at UNISEL and at NIES. Algal growth tests carried out at NIES on several species with/without addition of soil extracts were examined by the plate culture technique. Soil extracts collected at Puchong and Raja Musa Forest Reserves (hereinafter SE-P and SE-R, respectively) and the one used in NIES Culture Collection (hereinafter SE-N) were used in the experiment (the extraction conditions were the same among SE-P, SE-R, and SE-N). By comparison of optical density (OD) at 680 nm wavelength, SE-R was found to be the most effective soil extract when incubating *Nannochloropsis oculata* under the temperature condition of both 25^{o}C and 30^{o}C. In addition, elemental ratios were different between the natural extraction and that of the autoclave extraction, suggesting that chemical composition of soil extracts can be different depending on soil extraction methods. The microplate technique will be applied to the incubation test of each soil extract fraction (hydrophobic or hydrophilic fraction) to determine which fraction is effective. A fully automatic fractionation system was developed and installed at UNISEL for promoting the efficiency of the fractionation experiment and for obtaining a larger amount of soil fractions. The system was certificated as an employee invention in NIES, and the patent filings are currently under review.

Development of a Novel Closed Photobioreactor for High-Energy-Efficiency Production of Microalgae in the Tropics

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Abstract

In recent years, mass production of photosynthetic microalgae, which have higher photosynthetic efficiencies than terrestrial plants, have received considerable attention as a key technology to produce bio-energy and high-value bio-compounds. Despite the many advances made over several decades, commercialisation of algal biomass remains challenging mainly because of the techno-economic constraints including the cost of photobioreactor, energy expenditure, the nutrients and labour cost. A collaborative research between UPM, Malaysia and Soka University, Japan was initiated through the COSMOS-SATREPS project to solve the main issue of high energy consumption in the algae production process. The project has developed a novel closed photobioreactor, the CRADLE system for high-energy-efficiency production of microalgae. To evaluate the energy efficiency of the production, a continuous culture of *Spirulina platensis* and marine *Chlorella vulgaris* were conducted under high light condition of 1300 μE m^{-2} day^{-1}. The CRADLE system produced high biomass yield of over 2 ton/GJ which was >20 times higher than the conventional race way system for both microalgae species. These results raised the possibility that this new CRADLE system can dramatically reduce the energy consumption in the microalgae production processes. To scale up the system for outdoor microalgae cultivation system in tropical countries, a bench scale reactor using the CRADLE technology has been designed, fabricated and installed in UPM. The test operation using the bench scale has started and the scaled-up system will be designed and installed in the outdoor demonstration site at UPM in 2019. To show the feasibility of the system for commercialisation, the studies on the techno-economic analysis of the scaled-up system will be performed using several indigenous marine and freshwater microalgae species in Malaysia (from Theme 1 & 2). Similar high-efficiency outdoor photobioreactor systems will be applied in aquaculture farms using nutrients recovered from aquaculture pond sediments (Theme 4).

Development of Thermophilic Composting Technique for Enhancing NH_3 Recovery from Shrimp Pond Sludge

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Abstract

Accumulation of sludge at the bottom of the shrimp pond induces the deterioration of the aquatic environment, but effective treatment or utilization method of the sludge is yet to be established. Development of thermophilic composting technique would enable the recovery of "clean nutrients" from sludge in the form of NH_3 gas, since it is free from pathogens and heavy metals. Clean N source could be of potential use in the cultivation of high-value microalgae toward commercial production of medicines, cosmetics, or health supplements. The research objective of our research group (TITECH and UPM; COSMOS Theme 4) is to establish a novel nutrient recovery system from shrimp pond sludge by developing thermophilic composting process. TITECH focuses on the lab-scale research development, while UPM focuses on bench-scale process optimization. Our lab-scale experiments aimed to optimize the composting process by evaluating the effect of sludge type, fermentation temperature, alkaline agent addition on the NH_3 recovery from the sludge. Furthermore, we examined the microbial community structure to explore prospective microorganisms which contribute sludge degradation and/or NH_3 production. Until now, we found that the sludge from integrated shrimp farming systems produced remarkably higher NH_3 yield as compared to that from primitive shrimp farming system. Composting at 60-70℃ conditions was found to be favorable for enhancing the hydrolysis of organic N and NH_3 gas evaporation. Addition of $Ca(OH)_2$ greatly improved the evaporation of NH_4^+ from the compost as NH_3 gas. Geobacillus bacteria dominated in high temperature condition, which is suggested to be a main hydrolyzer of the sludge. All of the above-mentioned results will be further optimized, and will be applied to bench-scale process of UPM, to establish the efficient NH_3 recovery system.