

UNIDAD DE VIGILANCIA TECNOLÓGICA E INTELIGENCIA COMPETITIVA

Microalgas

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En este boletín se presentan las publicaciones, patentes y noticias de interés del cuarto trimestre del año 2017 que no fueron incluidas en los boletines anteriores por no ajustarse a las categorías definidas pero que, no obstante, pueden resultar de interés.

PUBLICACIONES

Enhanced biohydrogen production from microalgae by diesel engine hazardous emissions fixation

Source: International Journal of Hydrogen Energy

Author(s): D.O. Corrêa, B. Santos, F.G. Dias, J.V.C. Vargas, A.B. Mariano, W. Balmant, M.P. Rosa, D.C. Savi, V. Kava, C. Glienke, J.C. Ordóñez

Microalgae cultivation has gained increased attention from research and industry sectors in recent years, due to the wide variety of applications for the produced biomass, such as biofuels and substances of high economic value. Indirect biophotolysis biohydrogen production from microalgae has been shown recently to be limited by the amount of accumulated biomass during the growth phase. As a result, this study focused on developing a strategy to increase biohydrogen generation via biomass production increase through microalgae cultivation using exhaust gases from diesel engines. In order to achieve that objective, four simultaneous cultures were conducted to compare the growth of microalgae under pure air and emissions injection, in different flow regimes. An indigenous microalgae strain was selected to be robust under different weather conditions and was identified as *Acutodesmus obliquus* through rDNA sequence analysis. The results indicate an increase in biomass production of about 2.8 times for the best case of cultivation with emissions in comparison to a compressed air condition. Besides the growth analyses, the potential for treating the hazardous emissions injected into the system was investigated and the data demonstrated that the CO₂ and NO_x content was substantially reduced, showing that no damage to the microalgae is caused by the diesel engine emissions. Numerical simulation results for the H₂ production indirect biophotolysis demonstrate that there is an optimal rhythm for maximum time averaged H₂ production rate, and that the stoichiometrically limited total H₂ production is augmented by a similar factor to microalgae biomass production increase.



Freshwater microalgae selection for simultaneous wastewater nutrient removal and lipid production

Source: Algal Research, Volume 24, Part B

Author(s): P.D. Álvarez-Díaz, J. Ruiz, Z. Arbib, J. Barragán, M.C. Garrido-Pérez, J.A. Perales

Microalgae are a promising bioenergy source as well as wastewater pollution reducers. This study aims to determine which species better satisfies the double objective of lipid production and wastewater nutrient removal. Seven species were cultured in batch under laboratory conditions in real wastewater and synthetic medium aiming to perform a meaningful comparison among them. Biomass productivity was higher in the wastewater than in the synthetic medium for the strains *Chlorella vulgaris*, *Chlorella kessleri* and *Scenedesmus obliquus*, the latter species yielding the highest biomass concentration (1.4g/L), lipid content (36.75%) and lipid productivity (29.8mg lipids/L•d) while *C. vulgaris* reached the highest biomass productivity (0.107g/L•d). On the other hand, *Neochloris oleoabundans* did not grow in wastewater. Algae were not able to remove nitrogen from wastewater and as they were not nitrogen starved their lipid content was lower than when cultured in synthetic medium. The species that achieved maximum daily nitrogen removal from wastewater was *C. sorokiniana* (6.6mg Total-N/L•d) followed by *S. obliquus* (4.4mg Total-N/L•d). *S. obliquus* was better than *C. sorokiniana* at achieving the double objective of nutrient removal and lipid production in wastewater.

Halophytes: Gourmet food with nutritional health benefits?

Source: Journal of Food Composition and Analysis, Volume 59

Author(s): Luísa Barreira, Eva Resek, Maria João Rodrigues, Maria Isabel Rocha, Hugo Pereira, Narcisa Bandarra, Manuela Moreira da Silva, João Varela, Luísa Custódio

Although little is known about their nutritional composition, *Sarcocornia perennis* subsp. *perennis*, *S. perennis* subsp. *alpini* and *Salicornia ramosissima* (Salicorniaceae) as well as *Arthrocnemum macrostachyum* (Amaranthaceae) are consumed in gourmet cuisine. In spite of belonging to different families, these halophytes share morphological and organoleptic characteristics. This work explored the nutritional properties and the antioxidant potential of these species using five integrative methods. All species had a nutritional profile suitable for human consumption with high levels of protein (5.20–13.2g/100gdw) and n-3 polyunsaturated fatty acids (FA), particularly α -linolenic acid (19.3–25.9% of total FA), and low concentration of toxic metals (below the limits imposed by the European Commission). These halophytes are also a good source of minerals, particularly sodium (64.1–109mg/gdw), and *S. ramosissima* is an excellent source of manganese (204 μ g/gdw). However, due care should be taken not to exceed the legal limits for sodium ingestion. These plants showed also significant antioxidant potential, with high radical scavenging activity (RSA), iron reducing power and total phenolics content (20.5–49.2mgGAE/g). *A. macrostachyum* had the highest RSA (IC50-DPPH =0.84mg/mL; IC50-NO =0.60mg/mL), and



iron reducing potential (IC50 =0.84mg/mL) along with high levels of α - and γ -tocopherol (8.74 and 4.71mg/100gdw, respectively).

Novel glycosylated mycosporine-like amino acid, 13-O-(β -galactosyl)-porphyra-334, from the edible cyanobacterium *Nostoc sphaericum*-protective activity on human keratinocytes from UV light

Source: Journal of Photochemistry and Photobiology B: Biology, Volume 172

Author(s): Kenji Ishihara, Ryuichi Watanabe, Hajime Uchida, Toshiyuki Suzuki, Michiaki Yamashita, Hiroyuki Takenaka, Ehsan Nazifi, Seiichi Matsugo, Minami Yamaba, Toshio Sakamoto

A UV-absorbing compound was purified and identified as a novel glycosylated mycosporine-like amino acid (MAA), 13-O- β -galactosyl-porphyra-334 (β -Gal-P334) from the edible cyanobacterium *Nostoc sphaericum*, known as “ge xian mi” in China and “cushuro” in Peru. Occurrence of the hexosylated derivative of shinorine (hexosyl-shinorine) was also supported by LC-MS/MS analysis. β -Gal-P334 accounted for about 86.5% of total MAA in *N. sphaericum*, followed by hexosyl-shinorine (13.2%) and porphyra-334 (0.2%). β -Gal-P334 had an absorption maximum at 334nm and molecular absorption coefficient was 46,700 at 334nm. Protection activity of β -Gal-P334 from UVB and UVA+8-methoxypsoralen induced cell damage on human keratinocytes (HaCaT) was assayed in comparison with other MAA (porphyra-334, shinorine, palythine and mycosporine-glycine). The UVB protection activity was highest in mycosporine-glycine, followed by palythine, β -Gal-P334, porphyra-334 and shinorine in order. β -Gal-P334 had highest protection activity from UVA+8-methoxypsoralen induced cell damage followed by porphyra-334, shinorine, mycosporine-glycine and palythine. We also found an antioxidant (radical-scavenging) activity of β -Gal-P334 by colorimetric and ESR methods. From these findings, β -Gal-P334 was suggested to play important roles in stress tolerant mechanisms such as UV and oxidative stress in *N. sphaericum* as a major MAA. We also consider that the newly identified MAA, β -Gal-P334 has a potential for use as an ingredient of cosmetics and toiletries.

Comparison of electrochemical performances and microbial community structures of two photosynthetic microbial fuel cells

Source: Journal of Bioscience and Bioengineering

Author(s): Wei Zheng, Teng Cai, Manhong Huang, Donghui Chen

Microbial fuel cells (MFCs) have attracted intensive interest for their power generation and pollutants removal characteristics. Electrochemical performances and community structures of two algae cathode photosynthetic MFCs were investigated and compared. Microbial consortia of these two MFCs were taken from wetland sediment (named SMFC) and an up-



flow anaerobic wastewater treatment reactor (named UMFC). Maximum power density of the SMFC and UMFC achieved 202.9 ± 18.1 mW/m² and 158.2 ± 15.1 mW/m², respectively. The SMFC displayed higher coulombic efficiency but lower chemical oxygen demand (COD) removal efficiency than that of UMFC. The results also revealed the addition of riboflavin (RF) and neutral red (NR) decreased the redox current of the SMFC but promoted that of UMFC. Community structure analysis showed the SMFC was dominated by photosynthetic genus *Rhodospseudomonas* (61.25%), while bacterial genera in the UMFC were more evenly distributed. The difference of electrochemical activities of the two MFCs was caused by the different roles of exoelectrogens such as *Rhodospseudomonas* spp. and *Citrobacter* spp. in the electron transfer process. Newly developed photosynthetic microbial fuel cells (PMFCs) provide a suitable process to generate power and remove pollutants. The consortia have a significant role in the performance and microbial community of the system.

Biocoatings: A new challenge for environmental biotechnology

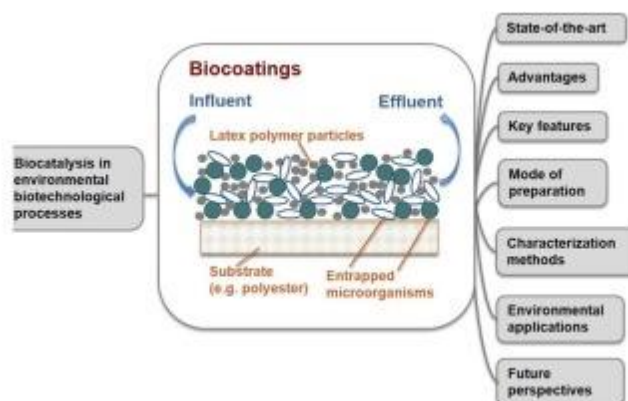
Source: Biochemical Engineering Journal, Volume 121

Author(s): Susana Cortez, Ana Nicolau, Michael C. Flickinger, Manuel Mota

Adhesive biocatalytic coatings (biocoatings) have a nanoporous microstructure generated by partially coalesced waterborne polymer particles that entrap highly concentrated living cells in a dry state stabilized by carbohydrate osmo-protectants. Biocoatings can be deposited by high speed coating technologies, aerosol delivery or ink-jet printed in multilayered, patterned coatings on flexible nonporous or nonwoven substrates, preserving 10¹⁰–10¹² non-growing viable microorganisms per m² in 2–50µm thick layers. Cells are rehydrated to restore their metabolism. The layers reactive half-life following rehydration can be 1000s of hours. The planar structure of biocoatings enable uniform illumination of a high concentration of photo-reactive microorganisms or algae and contact these microbe with thin liquid films for efficient mass transfer. This review highlights recent advances in biocoating technology for pollutants degradation, photo-reactive coatings, stabilization of hyperthermophiles for biocatalysis, environmental biosensors, and biocomposite fuel cells. Engineering cells for desiccation tolerance, unveiling the metabolism of non-growing cells, and engineering the interaction between the cell surface and adhesive polymer binders are fundamental challenges to open the door to vast future applications of biocoatings for environmental sensing and remediation.



Graphical abstract



Nanosecond pulsed electric fields trigger cell differentiation in *Chlamydomonas reinhardtii*

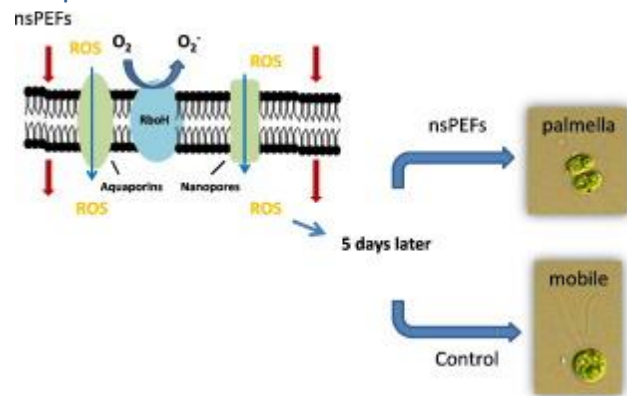
Source: Biochimica et Biophysica Acta (BBA) - Biomembranes, Volume 1859, Issue 5

Author(s): Fan Bai, Christian Gusbeth, Wolfgang Frey, Peter Nick

Nanosecond pulsed electric fields (nsPEFs) have great potential for biotechnological and medical applications. However, the biological mechanisms causing the cellular responses are still far from understood. We used the unicellular green algae *Chlamydomonas reinhardtii* as experimental model to dissect the immediate consequences of electroporation from the developmental cellular responses evoked by nsPEFs. We observe that nsPEFs induce a short-term permeabilization of the membrane, accompanied by swelling and oxidative burst. These responses are transient, but are followed, several days later, by a second wave of oxidative burst, arrested cell division, stimulated cell expansion, and the formation of an immobile palmella stage. This persistent oxidative burst can be suppressed by specific inhibitor diphenyl iodonium (DPI), but not by the unspecific antioxidant ascorbic acid (Asc). Treatment with natural and artificial auxins allows modulation of the cell cycle and cell expansion, and natural auxin can suppress the spontaneous formation of palmella stages. However, when administered prior to the nsPEFs treatment, auxin cannot mitigate the elevated formation of palmella stages induced by nsPEFs. We interpret our findings in terms of a model, where nsPEFs generate a developmental signal that persists, although the other immediate responses remain transient. This signal will initiate, several days later, a developmental programme comprising halted cell cycle, stimulation of cell expansion, a persistent activation of NADPH oxidase activity causing a second wave of oxidative burst, and the irreversible initiation of palmella stages. Thus, a short transient nsPEFs treatment can initiate a stable response of cellular differentiation in *Chlamydomonas reinhardtii*.



Graphical abstract



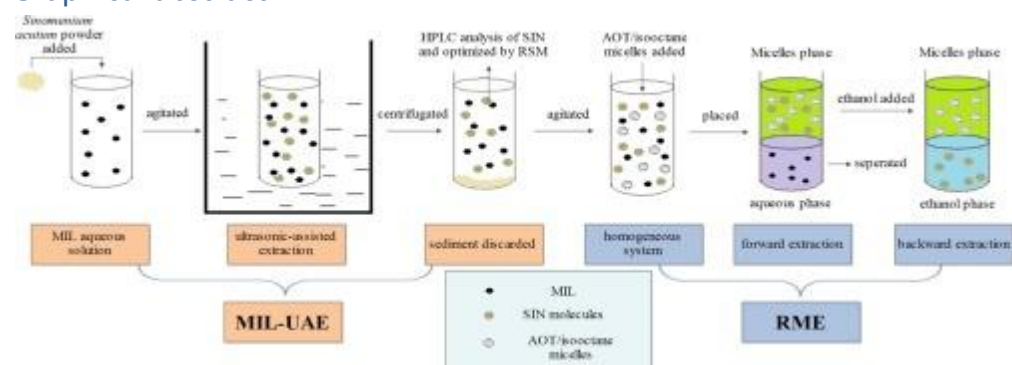
Ultrasonic-assisted extraction of sinomenine from *Sinomenium acutum* using magnetic ionic liquids coupled with further purification by reversed micellar extraction

Source: Process Biochemistry

Author(s): Qiao Li, Shuanggen Wu, Chaoyun Wang, Yongjian Yi, Wanlai Zhou, Hongying Wang, Fenfang Li, Zhijian Tan

Magnetic ionic liquids (MILs) have the same features as conventional ionic liquids (ILs), moreover they possess the potentiality of being recovered under the action of permanent magnetic field. Thus, MILs based on imidazolium cations and iron(III) anions were used for the ultrasonic-assisted extraction (UAE) of sinomenine (SIN) from *Sinomenium acutum* for the first time in this study. The extraction conditions were investigated in the single factor experiments, then the major factors of MIL concentration, liquid/solid ratio, and ultrasonic irradiation time were optimized by response surface methodology (RSM). The extraction yield reached 10.57mg/g under the optimized conditions. The crude MIL extract of SIN was further purified by reversed micellar extraction (RME) using AOT/isooctane system. The recovery and the purity of SIN reached 81.3% and 82.6%, respectively after purification by RME. This hybrid method of MIL-UAE and RME used for the extraction and purification of SIN was effective, rapid, and potential for scale-up.

Graphical abstract



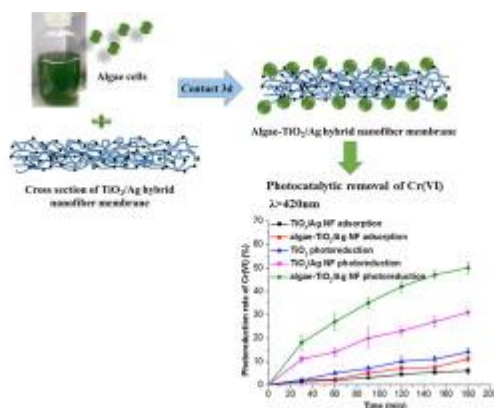
Algae decorated TiO₂/Ag hybrid nanofiber membrane with enhanced photocatalytic activity for Cr(VI) removal under visible light

Source: Chemical Engineering Journal, Volume 314

Author(s): Lei Wang, Changbo Zhang, Feng Gao, Gilles Mailhot, Gang Pan

Algae as an abundant natural biomass, more attention has been paid to explore its potential application in environmental pollutants treatment. This work prepared the algae-TiO₂/Ag bionano hybrid material by loading algae cells on the ultrafine TiO₂/Ag chitosan hybrid nanofiber mat. For the first time, the synergistic photocatalytic effect of fresh algae and TiO₂/Ag nanomaterial was investigated by removal of Cr(VI). The addition of algae significantly improved the photo-removal of Cr(VI) in the system with TiO₂/Ag hybrid nanomaterial under visible light irradiation. Meanwhile, the photocatalytic mechanism was studied. The photogenerated reactive oxygen species were quantified and the addition of algae apparently decreased the yields of OH to 31.0 μM, while improved the yields of 1O₂ and O₂ – in the reaction system with TiO₂/Ag hybrid nanofiber mats. The change of superoxide dismutase activity and malondialdehyde content in algae indicated that TiO₂/Ag could impose oxidative stress and cause lipid peroxidation in algae cells. During the course of irradiation, algae released substances could act as scavenger for holes, thus inhibited the recombination of hole/electron and enhanced the photocatalytic reduction of Cr(VI) by electrons on TiO₂ surface. Algae was simultaneously photodegraded in the system and the resulting O₂ –, organic free radicals could promote the reduction of Cr(VI). This functional hybrid nanofiber mat was easily recovered and maintained a great photocatalytic activity on the five successive cycles. This algae-photocatalyst hybrid material has promising applications potential in heavy metal removal and organic pollutants treatment.

Graphical abstract



Light transfer in agar immobilized microalgae cell cultures

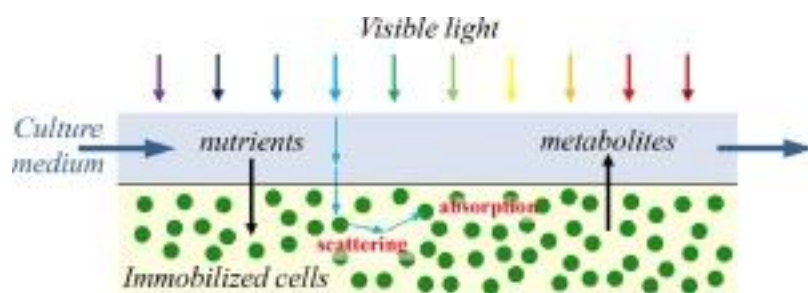
Source: Journal of Quantitative Spectroscopy and Radiative Transfer, Volume 198



Author(s): Razmig Kandilian, Bruno Jesus, Jack Legrand, Laurent Pilon, Jérémy Pruvost

This paper experimentally and theoretically investigates light transfer in agar-immobilized cell cultures. Certain biotechnological applications such as production of metabolites secreted by photosynthetic microorganisms require cells to be immobilized in biopolymers to minimize contamination and to facilitate metabolite recovery. In such applications, light absorption by cells is one of the most important parameters affecting cell growth or metabolite productivity. Modeling light transfer therein can aid design and optimize immobilized-cell reactors. In this study, *Parachlorella kessleri* cells with areal biomass concentrations ranging from 0.36 to 16.9 g/m² were immobilized in 2.6 mm thick agar gels. The average absorption and scattering cross-sections as well as the scattering phase function of *P. kessleri* cells were measured. Then, the absorption and transport scattering coefficients of the agar gel were determined using an inverse method based on the modified two-flux approximation. The forward model was used to predict the normal-hemispherical transmittance and reflectance of the immobilized-cell films accounting for absorption and scattering by both microalgae and the agar gel. Good agreement was found between the measured and predicted normal-hemispherical transmittance and reflectance provided absorption and scattering by agar were taken into account. Moreover, good agreement was found between experimentally measured and predicted mean rate of photon absorption. Finally, optimal areal biomass concentration was determined to achieve complete absorption of the incident radiation.

Graphical abstract



The role of algae and cyanobacteria in the production and release of odorants in water

Source: Environmental Pollution, Volume 227

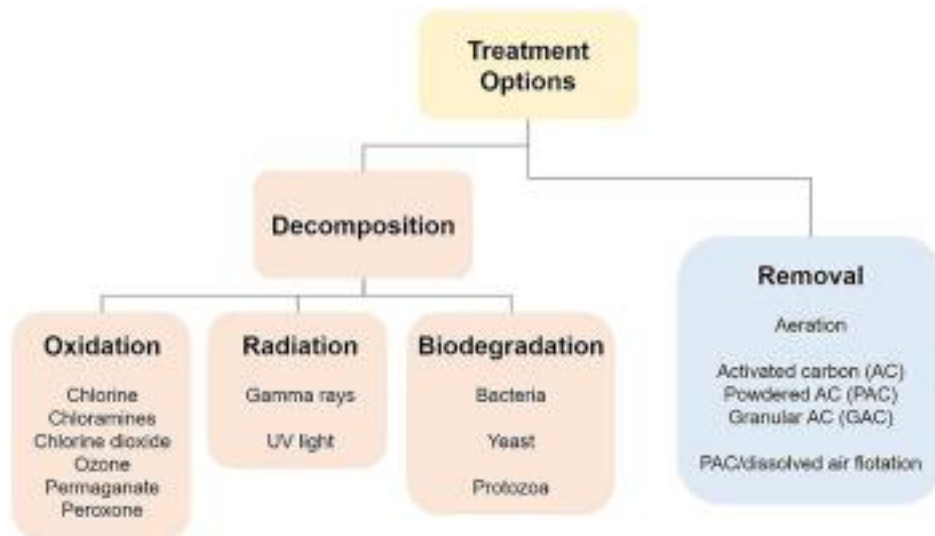
Author(s): Jechan Lee, Prabhat Kumar Rai, Young Jae Jeon, Ki-Hyun Kim, Eilhann E. Kwon



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This review covers literatures pertaining to algal and cyanobacterial odor problems that have been published over the last five decades. Proper evaluation of algal and cyanobacterial odors may help establish removal strategies for hazardous metabolites while enhancing the recyclability of water. A bloom of microalgae is a sign of an anthropogenic disturbance in aquatic systems and can lead to diverse changes in ecosystems along with increased production of odorants. In general, because algal and cyanobacterial odors vary in chemistry and intensity according to blooming pattern, it is necessary to learn more about the related factors and processes (e.g., changes due to differences in taxa). This necessitates systematic and transdisciplinary approaches that require the cooperation of chemists, biologists, engineers, and policy makers.

Graphical abstract



Wirelessly powered submerged-light illuminated photobioreactors for efficient microalgae cultivation

Source: Algal Research, Volume 25

Author(s): Alexandra Marie Murray, Ioannis A. Fotidis, Alex Isenschmid, Karl Rasmus August Haxthausen, Irini Angelidaki

A novel submerged-light photobioreactor (SL-PBR) with free-floating, wireless internal light sources powered by near-field resonant inductive coupling was investigated using a quick (*Chlorella vulgaris*) and a slow (*Haematococcus pluvialis*) growing microalgal species. During testing of the SL-PBR, the yield on photons was 1.18 and 1.15g biomass mol⁻¹ photons for *C. vulgaris* and *H. pluvialis*, respectively. At the same time, a conventional, externally illuminated PBR with the same internal light intensity produced yields of 0.78 and 0.05g biomass mol⁻¹ photons for *C. vulgaris* and *H. pluvialis*, respectively. Thus, the wireless internal light source was proven to be up to fivefold more effective light delivery system compared to the conventional illumination system. Meanwhile, it was discovered that some



of the internal light sources had ceased to function, which might have caused underestimation of the true yield. Interestingly, the SL-PBR provided more uniform light to the culture and had the ability to reduce the presence of dark zones and the effect of self-shading. Thus, the SL-PBR showed potential, if subsequent prototype designs address the technical challenges identified during this study.

Graphical abstract



The effect of microwave pretreatment on chemical looping gasification of microalgae for syngas production

Source: Energy Conversion and Management, Volume 143

Author(s): Zhifeng Hu, Xiaoqian Ma, Enchen Jiang

Chemical-looping gasification (CLG) of *Chlorella vulgaris* was carried out in a quartz tube reactor under different microwave pretreatment. The product fractional yields, conversion efficiency and analysis of performance parameters were analyzed in order to obtain the characterization and optimal conditions of microwave pretreatment for syngas production. The results indicate that microwave pretreatment is conducive to CLG reaction. Furthermore, the higher power or the longer time in the process of microwave pretreatment could not exhibit a better effect on CLG. In addition, 750W and 60s is the optimal microwave pretreatment power and time respectively to obtain a great reducibility of oxygen carrier, high conversion efficiency, high products yield and good LHV. The H₂ yield, LHV, gasification efficiency and gas yield increased obviously from 18.12%, 12.14MJ/Nm³, 59.76% and 1.04Nm³/kg of untreated *Chlorella vulgaris* to 24.55%, 13.13MJ/Nm³, 72.16% and 1.16Nm³/kg of the optimal microwave pretreatment condition, respectively.

Toxicity of TiO₂, in nanoparticle or bulk form to freshwater and marine microalgae under visible light and UV-A radiation

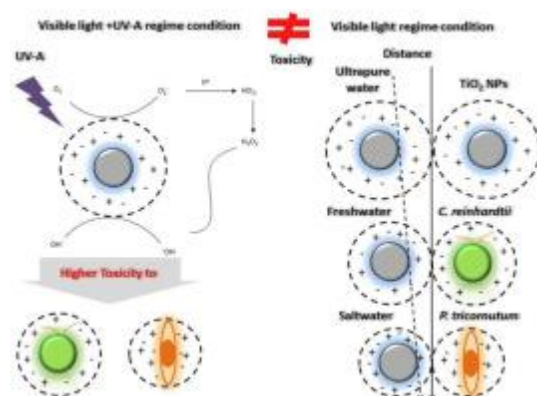


Source: Environmental Pollution, Volume 227

Author(s): M. Sendra, I. Moreno-Garrido, M.P. Yeste, J.M. Gatica, J. Blasco

Use of titanium dioxide nanoparticles (TiO₂ NPs) has become a part of our daily life and the high environmental concentrations predicted to accumulate in aquatic ecosystems are cause for concern. Although TiO₂ has only limited reactivity, at the nanoscale level its physico-chemical properties and toxicity are different compared with bulk material. Phytoplankton is a key trophic level in fresh and marine ecosystems, and the toxicity provoked by these nanoparticles can affect the structure and functioning of ecosystems. Two microalgae species, one freshwater (*Chlamydomonas reinhardtii*) and the other marine (*Phaeodactylum tricornutum*), have been selected for testing the toxicity of TiO₂ in NP and conventional bulk form and, given its photo-catalytic properties, the effect of UV-A was also checked. Growth inhibition, quantum yield reduction, increase of intracellular ROS production, membrane cell damage and production of exo-polymeric substances (EPS) were selected as variables to measure. TiO₂ NPs and bulk TiO₂ show a relationship between the size of agglomerates and time in freshwater and saltwater, but not in ultrapure water. Under two treatments, UV-A (6 h per day) and no UV-A exposure, NPs triggered stronger cytotoxic responses than bulk material. TiO₂ NPs were also associated with greater production of reactive oxygen species and damage to membrane. However, microalgae exposed to TiO₂ NPs and bulk TiO₂ under UV-A were found to be more sensitive than in the visible light condition. The marine species (*P. tricornutum*) was more sensitive than the freshwater species, and higher Ti internalization was measured. Exopolymeric substances (EPS) were released from microalgae in the culture media, in the presence of TiO₂ in both forms. This may be a possible defense mechanism by these cells, which would enhance processes of homoagglomeration and settling, and thus reduce bioavailability.

Graphical abstract



Large scale cultivation of genetically modified microalgae: A new era for environmental risk assessment

Source: Algal Research, Volume 25

Author(s): Tracey A. Beacham, Jeremy B. Sweet, Michael J. Allen



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The genetic modification of microalgal strains for enhanced or modified metabolic activity shows great promise for biotechnological exploitation. However, of key concern for many is the safety of genetic modification technology and genetically modified organisms with regard to both the environment and human health, and how these concerns are met will play a key role in ensuring how successful commercialisation of genetically modified (GM) algae is achieved. Commercialisation opportunities for GM microalgae will inevitably require translation from laboratory to industrial settings, on scales beyond those typically associated with the current biotechnology sector. Here we provide an overview of the current situation with regards to genetic modification techniques and legislation, and the implications of large-scale cultivation with regards to developing a safe and effective risk assessment system for contained and uncontained activities. We discuss the rationale and options for modification and the implications for risks associated with scale up to human health and the environment, current grey areas in political/technical legislation, the use of contained/uncontained production systems, deliberate release and monitoring strategies. We conclude that while existing procedures are not entirely sufficient for accurate and exhaustive risk assessment, there exists a substantial knowledge base and expertise within the existing aquaculture, fermentation and (algal) biotechnology industries that can be combined and applied to ensure safe use in the future.

Oil and gas produced water as a growth medium for microalgae cultivation: A review and feasibility analysis

Source: Algal Research, Volume 24, Part B

Author(s): Enid J. Sullivan Graham, Cynthia A. Dean, Thomas M. Yoshida, Scott N. Twary, Munehiro Teshima, Mark A. Alvarez, Tawanda Zidenga, Jeffrey M. Heikoop, George B. Perkins, Thom A. Rahn, Gregory L. Wagner, Paul M. Laur

Scale-up of microalgal biotechnology to provide large quantities of biofuel, lipids, and coproducts is not fully developed because of the large needs for nutrients, water, land, solar insolation, and CO₂/carbon supplies. Wastewaters, including oil and gas produced water (PW), may supply a portion of these needs in regions with insufficient fresh water resources. PW is a challenging water resource for this use because of variable salinity, geochemical complexity, and the presence of biologically toxic components. In this paper we review PW volumes, quality, and use in media for microalgae production in the southwestern US, Australia, and Oman. We also include data from the southwestern US, referencing previously unpublished results from the National Alliance for Biofuels and Bioproducts (NAABB) consortium research project. We include a Supplementary Information section that explores cultivation of multiple microalgae species in PW and examines the carbon utilization process, all work performed in support of the NAABB field program. Strains of algae tested in the reviewed papers include *Nannochloropsis*, *Dunaliella*, *Scenedesmus*, and several mixed or unknown cultures. We conclude that the use of PW in algae cultivation is feasible, if the additional complexity of the water resource is accounted for in developing media formulations and in understanding metals uptake by the algae. We recommend additional work to standardize growth testing in PW, better and more thorough chemical



analysis, and geochemical modeling of the PW used in media. Expanded strain testing in PW media will identify improved strains tolerant of PW in algae cultivation.

Modelling growth and CO₂ fixation by *Scenedesmus vacuolatus* in continuous culture

Source: Algal Research, Volume 24, Part A

Author(s): Rafael García-Cubero, José Moreno-Fernández, Mercedes García-González

A promising approach to CO₂ abatement is the use of photosynthetic microorganisms. Different microalgae (*Chlorococcum* sp., *Porphyridium purpureum*, *Scenedesmus vacuolatus*) and cyanobacteria (*Anabaena* PCC7119, *Anabaena* PCC7120, *Anabaena* PCC 7937, *Nostoc* PCC 9202, *Nostoc punctiforme*) were cultivated in photobioreactors operated as chemostat, simulating light conditions analogous to those prevailing outdoors and compared on their ability to fix CO₂ efficiently. Due to its high biomass productivity and CO₂ fixation rate, *Scenedesmus vacuolatus* was selected and the effect of different culture parameters (i.e. dilution rate, temperature, pH and impinging irradiance on surface's photobioreactor) on its biomass productivity and CO₂ fixation was further investigated. In optimal culture conditions, *S. vacuolatus* rendered 0.63g biomass L⁻¹ d⁻¹, resulting 1.15 gCO₂ assimilated L⁻¹ d⁻¹. Based on the data obtained in this study, a mathematical model was developed to describe growth and CO₂ bio-fixation by *S. vacuolatus*. Finally, the potential of this microalga for carbon capture was further tested using synthetic flue gases as the source of CO₂.

Evaluation of phenotype stability and ecological risk of a genetically engineered alga in open pond production

Source: Algal Research, Volume 24, Part A

Author(s): Shawn J. Szyjka, Shovon Mandal, Nathan G. Schoepp, Briana M. Tyler, Christopher B. Yohn, Yan S. Poon, Steven Villareal, Michael D. Burkart, Jonathan B. Shurin, Stephen P. Mayfield

Genetically engineered (GE) algae offer the promise of producing food, fuel, and other valuable products with reduced requirements for land and fresh water. While the gains in productivity measured in GE terrestrial crops are predicted to be mirrored in GE algae, the stability of phenotypes and ecological risks posed by GE algae in large-scale outdoor cultivation remain unknown. Here, we describe the first US Environmental Protection Agency (EPA)-sanctioned experiment aimed at understanding how GE algae perform in outdoor cultivation. *Acutodesmus dimorphus* was genetically engineered by the addition of two genes, one for enhanced fatty acid biosynthesis, and one for recombinant green fluorescence protein (GFP) expression; both the genes and their associated phenotypes were maintained during fifty days of outdoor cultivation. We also observed that while the GE algae dispersed from the cultivation ponds, colonization of the trap ponds by the GE



strain declined rapidly with increasing distance from the source cultivation ponds. In contrast, many species of indigenous algae were found in every trap pond within a few days of starting the experiment. When inoculated in water from five local lakes, the GE algae's effect on biodiversity, species composition, and biomass of native algae was indiscernible from those of the wild-type (wt) progenitor algae, and neither the GE nor wt algae were able to outcompete native strains. We conclude that GE algae can be successfully cultivated outdoors while maintaining GE traits, and that for the specific GE algal strain tested here they did not outcompete or adversely impact native algae populations when grown in water taken from local lakes. This study provides an initial evaluation of GE algae in outdoor cultivation and a framework to evaluate GE algae risks associated with outdoor GE algae production.

A study of photosynthetic biogas upgrading based on a high rate algal pond under alkaline conditions: Influence of the illumination regime

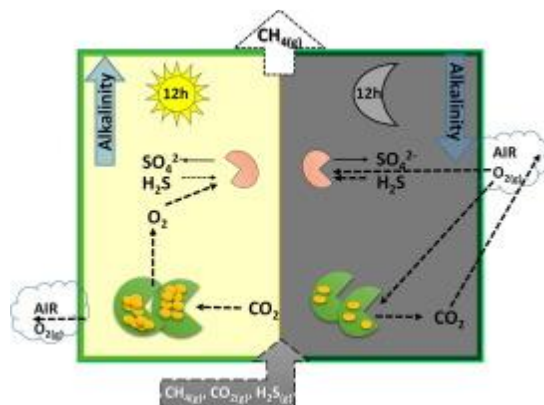
Source: Science of The Total Environment, Volume 592

Author(s): Mariana Franco-Morgado, Cynthia Alcántara, Adalberto Noyola, Raúl Muñoz, Armando González-Sánchez

Microalgal-bacterial processes have emerged as environmental friendly systems for the cost-effective treatment of anaerobic effluents such as biogas and nutrients-laden digestates. Environmental parameters such as temperature, irradiation, nutrient concentration and pH effect the performance of the systems. In this paper, the potential of a microalgal-bacterial photobioreactor operated under high pH (≈ 9.5) and high alkalinity to convert biogas into biomethane was evaluated. The influence of the illumination regime (continuous light supply vs 12h/12h light/dark cycles) on the synthetic biogas upgrading efficiency, biomass productivity and nutrient removal efficiency was assessed in a High-Rate Algal Pond interconnected to a biogas absorption bubble column. No significant differences in the removal efficiency of CO₂ and H₂S ($91.5\pm 2\%$ and 99.5 ± 0.5 , respectively) were recorded regardless of the illumination regime. The high fluctuations of the dissolved oxygen concentration during operation under light/dark cycles allowed to evaluate the specific growth rate and the specific partial degradation rate of the microalgae biomass by photosynthesis and respiration, respectively. The respiration reduced the net microalgae biomass productivity under light/dark cycles compared with process operation under the continuous light supply.

Graphical abstract





A new biofilm based microalgal cultivation approach on shifting sand surface for desert cyanobacterium *Microcoleus vaginatus*

Source: Bioresource Technology, Volume 238

Author(s): Shubin Lan, Li Wu, Haijian Yang, Delu Zhang, Chunxiang Hu

Biofilm based microalgal cultivation has recently received great attention because of its low water requirement and harvesting cost. However, the contradiction between microalgal attachment and harvesting still hinders the development of this technology. Therefore, in this study the most readily available and inexpensive shifting sand was used as attached substrate for microalgal (*Microcoleus vaginatus*) biofilm cultivation under different water conditions. After the inoculation, a stable and easily peeled microalgal biofilm formed through filamentous binding and exopolysaccharide cementing. In general, microalgal biomass, photosynthetic activity and exopolysaccharide accumulation were all significantly affected by the cultivation time, water content and their interaction ($P < 0.001$). According to the maximal photosynthetic activity and microalgal productivity, cultivation time of microalgal biofilm on sand surface should be controlled around 15–25 days, with water content at 10%. Based on the biofilm cultivation system, microalgal biomass yield reached up to 11 gm⁻² eventually on the sand surface.

Mutation of *Spirulina* sp. by nuclear irradiation to improve growth rate under 15% carbon dioxide in flue gas

Source: Bioresource Technology, Volume 238

Author(s): Jun Cheng, Hongxiang Lu, Xin He, Weijuan Yang, Junhu Zhou, Kefa Cen

Spirulina sp. was mutated by γ -rays from ⁶⁰Co nuclear irradiation to improve growth and CO₂ fixation rate under 15 vol.% CO₂ (in flue gas from a power plant). Mutants with enhanced growth phenotype were obtained, with the best strain exhibiting 310% increment in biomass yield on day 4. The mutant was then domesticated with elevated CO₂ concentration, and the biomass yield increased by 500% after domestication under 15 vol.%



CO₂, with stable inheritance. Ultrastructure of *Spirulina* sp. shows that the fractal dimension of *Spirulina* cells decreased by 23% after mutation. Pore size in the cell wall of *Spirulina* mutant increased by 33% after 15vol.% CO₂ domestication. This characteristic facilitated the direct penetration of CO₂ into cells, thus improving CO₂ biofixation rate.

Influence of preoperative food and temperature conditions on pearl biogenesis in *Pinctada margaritifera*

Source: Aquaculture, Volume 479

Author(s): Oihana Latchere, Gilles Le Moullac, Nabila Gaertner-Mazouni, Julie Fievet, Kevin Magré, Denis Saulnier

Trophic conditions and water temperature strongly influence bivalve physiological processes and metabolism. In black-lip pearl oyster *Pinctada margaritifera*, these parameters have been shown to affect shell biomineralization. The present study investigated the effect of preoperative food level (i.e., microalgal concentration) and temperature on pearl biomineralization. Donor and recipient oysters were conditioned at different levels of food and temperature during the preoperative phase to evaluate the influence of these factors on 1) pearl retention rate (grafting success), 2) expression of genes involved in biomineralization in the mantle and pearl sac and 3) pearl quality traits. Our study confirmed the influence of both microalgal concentration and temperature on shell growth. Food level of donor oysters was decisive for pearl biomineralization, with donors that had been fed at a high microalgal concentration producing pearl sacs with significantly higher biomineralization capabilities and faster nacre establishment during early stages of pearl formation. However, food level showed no effects on quality traits of the pearls harvested 12months postgrafting, while preoperative temperature only influenced the relative expression of two genes in pearl sacs at 12months postgrafting. No significant effects of the preoperative conditioning of recipient oysters were detected in either experiment considering gene expression measurements and pearl quality traits. However, mortality was significantly lower in grafted recipient oysters fed at an intermediate trophic level. Finally, pearl weight was shown to be positively correlated with recipient oyster growth.

Investigation of nanotoxicological effects of nanostructured hydroxyapatite to microalgae *Pseudokirchneriella subcapitata*

Source: Ecotoxicology and Environmental Safety, Volume 144

Author(s): Flávia F. Pereira, Elaine C. Paris, Joana D. Bresolin, Milene M. Foschini, Marcos D. Ferreira, Daniel S. Corrêa

The advance of nanotechnology has enabled the development of materials with optimized properties for applications in agriculture and environment. For instance, nanotechnology-based fertilizers, such as the candidate hydroxyapatite (HAp) nanoparticles (Ca₁₀(PO₄)₆(OH)₂), can potentially increase the food production by rationally supplying



phosphorous to crops, although with inferior mobility in the environment (when compared to the soluble counterparts), avoiding eutrophication. Nonetheless, the widespread consumption of nanofertilizers also raises concern about feasible deleterious effects caused by their release in the environment, which ultimately imposes risks to aquatic biota and human health. Nanoparticles characteristics such as size, shape, surface charge and chemical functionality strongly alter how they interact with the surrounding environment, leading to distinct levels of toxicity. This investigation aimed to compare the toxicity of different HAp nanoparticles, obtained by two distinct chemical routes, against algae *Pseudokirchneriella subcapitata*, which composes the base of the aquatic trophic chain. The as synthesized HAp nanoparticles obtained by co-precipitation and co-precipitation followed by hydrothermal method were fully characterized regarding structure and morphology. Toxicity tests against the microalgae were carried out to evaluate the growth inhibition and the morphological changes experienced by the exposition to HAp nanoparticles. The results showed that high concentrations of coprecipitated HAp samples significantly decreased cell density and caused morphological changes on the algal cells surface when compared to HAp obtained by hydrothermal method. HAp nanoparticles obtained with dispersing agent ammonium polymethacrylate (APMA) indicated negligible toxic effects for algae, due to the higher dispersion of HAp in the culture medium as well as a reduced shading effect. Therefore, HAp nanoparticles obtained by the latter route can be considered a potential source of phosphorous for agricultural crops in addition to reduce eutrophication.

Microwave-enhanced pyrolysis of macroalgae and microalgae for syngas production

Source: Bioresource Technology, Volume 237

Author(s): Yu Hong, Wanru Chen, Xiang Luo, Chengheng Pang, Edward Lester, Tao Wu

In this study, three different marine biomasses, i.e., microalgae-spirulina, chlorella and macroalgae-porphyra, were pyrolyzed in a laboratory-scale multimode-microwave cavity at 400, 550 and 700°C. Ovalbumin and cellulose were also chosen as model compounds to simulate algae. The influence of heating rate on pyrolysis and the β i curves of different samples under different temperatures were studied in detail. The porphyra was found to be the most reactive and produced the largest gaseous fraction (87.1wt%) amongst the three algae, which comprised of 73.3vol% of syngas. It was found that nitrogenated compounds in bio-oil were derived from protein in algae while carbohydrate led to the formation of PAHs. For the production of bio-oil, protein-rich microalgae is favorable compared with porphyra due to their lower amount of PAHs, while porphyra is more suitable for the production of H₂+CO rich gas product, which is comparable with that of conventional gasification processes.

Macroalga *Padina pavonica* water extracts obtained by pressurized liquid extraction and microwave-assisted extraction inhibit hyaluronidase activity as shown by capillary electrophoresis

Source: Journal of Chromatography A, Volume 1497



Author(s): Syntia Fayad, Reine Nehmé, Mona Tannoury, Eric Lesellier, Chantal Pichon, Philippe Morin

Hyaluronidase degrades hyaluronic acid, the principal component of the extracellular matrix. Inhibition of this enzyme is thus expected to hinder skin aging. Brown alga *Padina pavonica* activity toward hyaluronidase was evaluated using capillary electrophoresis (CE)-based enzymatic assays. This green technique allows evaluation of the biological activity of the natural material in an economic manner. Pressurized liquid extraction (PLE), microwave assisted extraction (MAE), supercritical fluid extraction and electroporation extraction techniques were used. Extraction conditions were optimized to obtain cosmetically acceptable *Padina pavonica* extracts with the best inhibition activity. CE-based assays were conducted using only a few nanoliters of reactants, a capillary of 60cm total length and of 50µm internal diameter, +20kV voltage for separation in 50mM ammonium acetate buffer (pH 9.0) and 200nm wavelength for detection. The reaction mixture was incubated for 1h and CE analysis time was about 11min. A novel online CE-assay using transverse diffusion of laminar flow profiles for in-capillary reactant mixing allowed efficient monitoring of hyaluronidase kinetics with K_m and V_{max} equal to $0.46 \pm 0.04 \text{ mg mL}^{-1}$ and $137.1 \pm 0.3 \text{ nMs}^{-1}$ ($r^2 = 0.99$; $n = 3$), respectively. These values compared well with literature, which validates the assay. Water extracts obtained by PLE (60°C; 2 cycles) and MAE (60°C; 1000W; 2min) presented the highest anti-hyaluronidase activity. The half maximal effective concentration (IC50) of water PLE extract was $0.04 \pm 0.01 \text{ mg mL}^{-1}$ ($r^2 = 0.99$; $n = 3$). This value is comparable to the one obtained for *Eisenia bicyclis* phlorotannin fractions (IC50 = 0.03 mg mL^{-1}), which makes *Padina pavonica* bioactivity very promising.

Heterotrophy of filamentous oleaginous microalgae *Tribonema minus* for potential production of lipid and palmitoleic acid

Source: Bioresource Technology, Volume 239

Author(s): Wenjun Zhou, Hui Wang, Lin Chen, Wentao Cheng, Tianzhong Liu

Heterotrophic fermentation and high valuable co-product producing are thought to be effective ways to improve the economic viability and feasibility of commercial production of microalgae biofuels. This work reported the heterotrophic cultivation of *Tribonema minus* for lipid and palmitoleic acid (a novel functional fatty acid) production. Firstly, the heterotrophic ability of *T. minus* was identified for the first time with significant promotion in biomass and lipid productivity, and glucose and urea were then selected as the optimal carbon and nitrogen sources. Moreover, nutrient concentrations and culture conditions were optimized. Highest biomass and lipid productivity of 30.8 g L^{-1} and $730 \text{ mg L}^{-1} \text{ d}^{-1}$ were obtained respectively by adding 80 g L^{-1} glucose at once. In addition, 2 g L^{-1} urea, 0.8 g L^{-1} K_2HPO_4 , 24 mg L^{-1} ammonium ferric citrate, initial pH of 6, and temperature of 27°C were determined as the appropriate conditions for heterotrophic growth and lipid production.



Evaluation of the toxicity of herbicide topramezone to *Chlorella vulgaris*: Oxidative stress, cell morphology and photosynthetic activity

Source: Ecotoxicology and Environmental Safety, Volume 143

Author(s): Fangfang Zhao, Qingqing Xiang, Ying Zhou, Xiao Xu, Xinyi Qiu, Yi Yu, Farooq Ahmad

Topramezone is a new, highly selective herbicide of pyrazole structure for the post-emergence control of broadleaf and grass weeds in corn. In this study, the effects of topramezone on *C. vulgaris*, especially in relation to the cell growth, oxidative stress, cell morphology and photosynthetic activity were assessed. Results showed that topramezone treatment was detrimental to *C. vulgaris* growth during the 24–96h of exposure. The changes in cells pigments content and relative transcript of photosynthesis-related genes, which implies that topramezone disrupted the photosynthetic system. Moreover, topramezone induced membrane permeability in a significant proportion of cells with a maximum damage rate of 40.40%, and morphology of cells was more complicated than the control group. TEM images also revealed that topramezone compromised the integrity of the cells. The data corroborated topramezone induced ROS triggered oxidative stress, leading to an increase of MDA. These results suggested that topramezone could have significant effects on growth and physiological functions in algae species, and we supposed that this herbicide affected all of these parameters and the observed effects can be explained by the generation of oxidative stress. This research helps to understand how topramezone affects *C. vulgaris* and provides a scientific basis for applications of topramezone in aquatic environment.

Growth and phycocyanin synthesis in the heterotrophic microalga *Galdieria sulphuraria* on substrates made of food waste from restaurants and bakeries

Source: Bioresource Technology, Volume 238

Author(s): Jenni Katrine Sloth, Henriette Casper Jensen, Daniel Pleissner, Niels Thomas Eriksen

Galdieria sulphuraria 074G (Rhodophyta) was grown heterotrophically in defined medium and on amylolytic and proteolytic hydrolysed food waste from restaurants and bakeries. Substrate uptake, growth, and phycocyanin content were quantified in the cultures. The alga utilised carbohydrates and amino acids from the waste but ammonium and other inorganic nutrients were needed to stimulate phycocyanin synthesis. Highest specific phycocyanin contents (20–22mgg⁻¹) were observed in cells grown at 25°C or 34°C on the food wastes. Growth inhibition was observed when the hydrolysates were used in quantities resulting in glucose concentrations of 10 and 50gL⁻¹ for bakery and restaurant waste, respectively. Still, *G. sulphuraria* 074G grew and produced phycocyanin efficiently on food waste under adequate conditions and may potentially be utilised for synthesise of high-valuable products from food waste.



Graphical abstract



Nutrient utilization and oxygen production by *Chlorella vulgaris* in a hybrid membrane bioreactor and algal membrane photobioreactor system

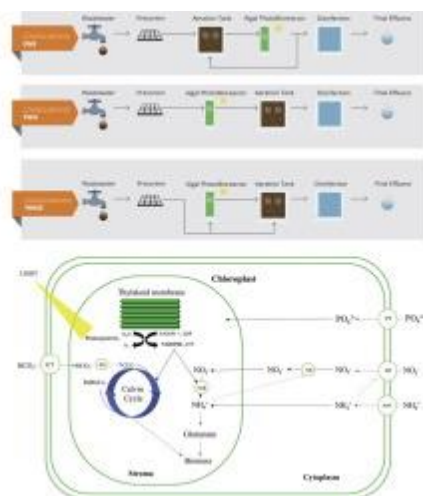
Source: Bioresource Technology, Volume 237

Author(s): Yasmeeen Najm, Sanghyun Jeong, TorOve Leiknes

This work studied oxygen production and nutrient utilization by *Chlorella vulgaris* at different organic/inorganic carbon (OC/IC) and ammonium/nitrate ($\text{NH}_4^+ \text{-N}/\text{NO}_3^- \text{-N}$) ratios to design a hybrid aerobic membrane bioreactor (MBR) and membrane photobioreactor (MPBR) system. Specific oxygen production by *C. vulgaris* was enough to support the MBR if high growth is accomplished. Nearly 100% removal (or utilization) of $\text{PO}_4^{3-} \text{-P}$ and IC was achieved under all conditions tested. Optimal growth was achieved at mixotrophic carbon conditions (0.353d^{-1}) and the highest $\text{NH}_4^+ \text{-N}$ concentration (0.357d^{-1}), with preferable $\text{NH}_4^+ \text{-N}$ utilization rather than $\text{NO}_3^- \text{-N}$. The results indicate the potential of alternative process designs to treat domestic wastewater by coupling the hybrid MBR – MPBR systems.



Graphical abstract



Electricity and biomass production in a bacteria-Chlorella based microbial fuel cell treating wastewater

Source: Journal of Power Sources, Volume 356

Author(s): Audrey S. Commault, Olivier Laczka, Nachshon Siboni, Bojan Tamburic, Joseph R. Crosswell, Justin R. Seymour, Peter J. Ralph

The chlorophyte microalga *Chlorella vulgaris* has been exploited within bioindustrial settings to treat wastewater and produce oxygen at the cathode of microbial fuel cells (MFCs), thereby accumulating algal biomass and producing electricity. We aimed to couple these capacities by growing *C. vulgaris* at the cathode of MFCs in wastewater previously treated by anodic bacteria. The bioelectrochemical performance of the MFCs was investigated with different catholytes including phosphate buffer and anode effluent, either in the presence or absence of *C. vulgaris*. The power output fluctuated diurnally in the presence of the alga. The maximum power when *C. vulgaris* was present reached $34.2 \pm 10.0 \text{ mW m}^{-2}$, double that observed without the alga ($15.6 \pm 9.7 \text{ mW m}^{-2}$), with a relaxation of $0.19 \text{ gL}^{-1} \text{ d}^{-1}$ chemical oxygen demand and $5 \text{ mg L}^{-1} \text{ d}^{-1}$ ammonium also removed. The microbial community associated with the algal biofilm included nitrogen-fixing (*Rhizobiaceae*), denitrifying (*Pseudomonas stutzeri* and *Thauera sp.*, from *Pseudomonadales* and *Rhodocyclales* orders, respectively), and nitrate-reducing bacteria (*Rheinheimera sp.* from the *Alteromonadales*), all of which likely contributed to nitrogen cycling processes at the cathode. This paper highlights the importance of coupling microbial community screening to electrochemical and chemical analyses to better understand the processes involved in photo-cathode MFCs.

Allometric scaling of microbial fuel cells and stacks: The lifeform case for scale-up

Source: Journal of Power Sources, Volume 356



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Author(s): John Greenman, Ioannis A. Ieropoulos

This case study reports for the first time on the comparison between allometric scaling of lifeforms and scale-up of microbial fuel cell entities; enlarging individual units in volume, footprint and electrode surface area but also multiplying a static size/footprint and electrode surface area to scale-up by stacking. A study published in 2010 by DeLong et al. showed for the first time that Kleiber's law does not apply uniformly to all lifeforms, and that in fact growth rate for prokaryotes is superlinear, for protists is linear and for metazoa is sublinear. The current study, which is utilising data from previous experiments, is showing for the first time that for individual MFC units, which are enlarged, growth rate/power is sublinear, whereas for stacks this is superlinear.

Biodegradation and metabolic fate of levofloxacin via a freshwater green alga, *Scenedesmus obliquus* in synthetic saline wastewater

Source: Algal Research, Volume 25

Author(s): Jiu-Qiang Xiong, Mayur B. Kurade, Dilip V. Patil, Min Jang, Ki-Jung Paeng, Byong-Hun Jeon

Levofloxacin (LEV), a fluoroquinolone antibiotic has been frequently observed in water resources imposing ecotoxicological effects on aquatic microbiota. The biodegradation and metabolic fate of LEV via a microalga, *Scenedesmus obliquus* in synthetic saline wastewater were investigated in this study. LEV removal (1mgL^{-1}) by *S. obliquus* was relatively low in the synthetic wastewater without the addition of sodium chloride (NaCl); however, its removal increased significantly from 4.5 to 93.4% with increasing of its salinity from 0 to 171mM NaCl. Kinetic studies showed that the removal rate constant (k) increased from 0.005 to 0.289d^{-1} and degradation half-life decreased from 272 to 5d in the presence of NaCl (0–856mM). The removal mechanism analysis showed that the major mechanism of NaCl mediated enhancement of LEV removal was the bioaccumulation and subsequent intracellular biodegradation of LEV in microalgal cells. Six metabolites were identified via gas chromatography–mass spectrometry analysis after biodegradation of LEV. A metabolic pathway was postulated with regard to various cellular biocatalytic reactions in *S. obliquus*, including decarboxylation, demethylation, dehydroxylation, side chain breakdown, and ring cleavage.



Graphical abstract



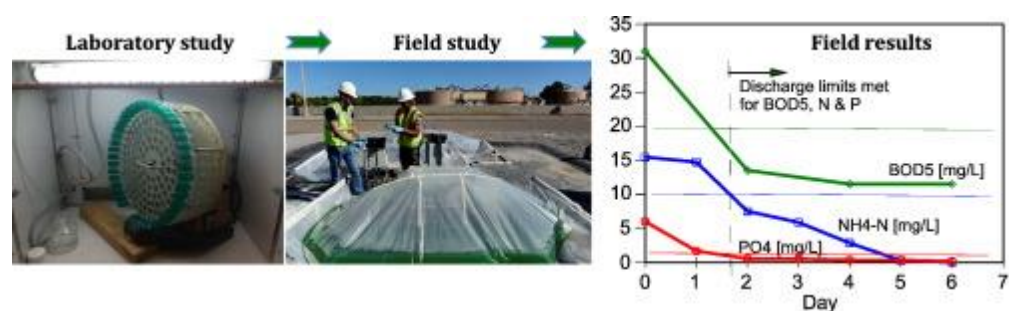
Removal of dissolved organic carbon and nutrients from urban wastewaters by *Galdieria sulphuraria*: Laboratory to field scale demonstration

Source: Algal Research, Volume 24, Part B

Author(s): S.M. Henkanatte-Gedera, T. Selvaratnam, M. Karbakhshravari, M. Myint, N. Nirmalakhandan, W. Van Voorhies, Peter J. Lammers

Previous laboratory studies have demonstrated the ability of microalgae *Galdieria sulphuraria* (*G. sulphuraria*) in removing organic carbon and nutrients from filtered primary-settled urban wastewater via mixotrophic metabolism. An advantage of mixotrophic cultivation of *G. sulphuraria* over heterotrophic conditions is higher biomass yield that can potentially translate into higher energy recovery from the biomass. This study recorded a yield of 0.63g biomass/g glucose under mixotrophic conditions while that under heterotrophic conditions was 0.42g biomass/g glucose. These laboratory studies were extended to cultivate *G. sulphuraria* under field conditions in a 700L photobioreactor (PBR) fed with primary-settled wastewater. Biomass growth and removal of dissolved organic carbon and nutrients in this PBR under batch mode were monitored over a range of influent and operating conditions. This field study confirmed that *G. sulphuraria* was able to grow well in primary-settled wastewater and reduce organic carbon (measured as BOD₅), ammoniacal nitrogen, and phosphate levels to below the respective discharge standards; corresponding 3-day removal efficiencies ranged 46–72%; 63–89%; and 71–95%.

Graphical abstract



From low-cost substrates to single cell oils synthesized by oleaginous yeasts

Source: Bioresource Technology

Author(s): Lei Qin, Lu Liu, An-Ping Zeng, Dong Wei

As new feedstock for biofuels, microbial oils have received worldwide attentions due to their environmentally-friendly characters. Microbial oil production based on low-cost raw materials is significantly attractive to the current biodiesel refinery industry. In terms of SCOs production, oleaginous yeast has numerous advantages over bacteria, molds and microalgae based on their high growth rate and lipid yield. Numerous efforts have been made on the competitive lipid production combining the use of cheap raw materials as substrates by yeasts. In this paper, we provided an overview of lipid metabolism in yeast cells. New advances using oleaginous yeast as a cell factory for high-value lipid production from various low-cost substrates are also reviewed, and the enhanced strategies based on synergistic effects of oleaginous yeast and microalgae in co-culture are discussed in details.

The industrial ecology of freshwater macroalgae for biomass applications

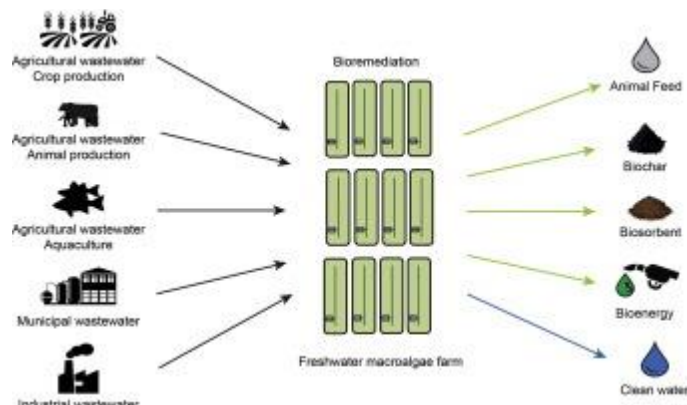
Source: Algal Research, Volume 24, Part B

Author(s): Rebecca J. Lawton, Andrew J. Cole, David A. Roberts, Nicholas A. Paul, Rocky de Nys

Industrial ecology is focused on recognising the inherent value in waste streams and developing techniques that can efficiently recover this value. Freshwater macroalgae can become a foundation of this concept as they can be cultured in a range of waste streams where they can effectively remove excess nutrients, metals and metalloids, providing both a bioremediation service and a biomass resource. The cultured algal biomass can then be used as a product in animal feeds, biochar, biosorbents or as a feedstock biomass for the production of bioenergy. Freshwater macroalgae provide a unique opportunity to transform a range of industries through the utilisation of wastewater to produce biomass that can be converted into valuable bioproducts.



Graphical abstract



Impact of inorganic contaminants on microalgae productivity and bioremediation potential

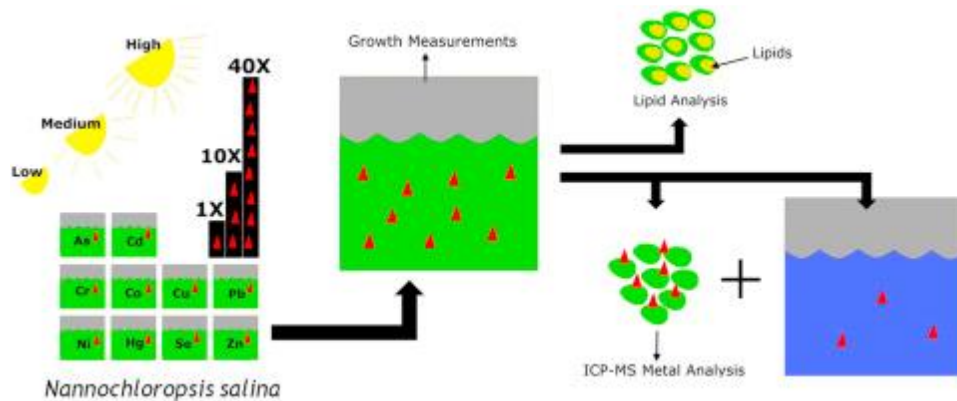
Source: Ecotoxicology and Environmental Safety, Volume 139

Author(s): Eric M. Torres, Derek Hess, Brian T. McNeil, Tessa Guy, Jason C. Quinn

As underdeveloped nations continue to industrialize and world population continues to increase, the need for energy, natural resources, and goods will lead to ever increasing inorganic contaminants, such as heavy metals, in various waste streams that can have damaging effects on plant life, wildlife, and human health. This work is focused on the evaluation of the potential of *Nannochloropsis salina* to be integrated with contaminated water sources for the concurrent production of a biofuel feedstock while providing an environmental service through bioremediation. Individual contaminants (As, Cd, Cr, Co, Cu, Pb, Ni, Hg, Se, and Zn) at various concentrations ranging from a low concentration (1X) to higher concentrations (10X, and 40X) found in contaminated systems (mine tailings, wastewater treatment plants, produced water) were introduced into growth media. Biological growth experimentation was performed in triplicate at the various contaminant concentrations and at 3 different light intensities. Results show that baseline concentrations of each contaminant slightly decreased biomass growth to between 89% and 99% of the control with the exception of Ni which dramatically reduced growth. Increased contaminant concentrations resulted in progressively lower growth rates for all contaminants tested. Lipid analysis shows most baseline contaminant concentrations slightly decrease or have minimal effects on lipid content at all light levels. Trace contaminant analysis on the biomass showed Cd, Co, Cu, Pb, and Zn were sorbed by the microalgae with minimal contaminants remaining in the growth media illustrating the effectiveness of microalgae to bioremediate these contaminants when levels are sufficiently low to not detrimentally impact productivity. The microalgae biomass was less efficient at sorption of As, Cr, Ni, and Se.



Graphical abstract



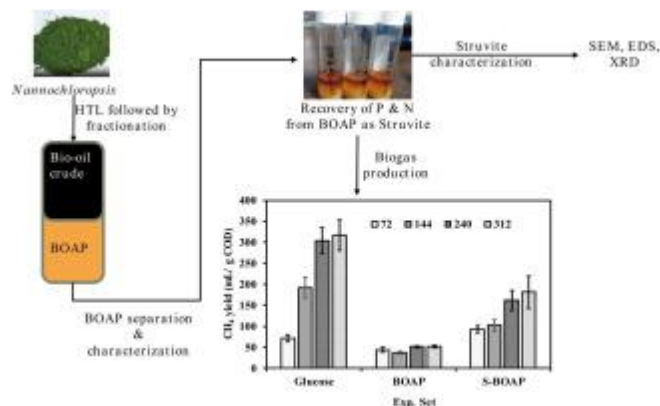
Nutrient removal and energy production from aqueous phase of bio-oil generated via hydrothermal liquefaction of algae

Source: Bioresource Technology, Volume 230

Author(s): Saravanan R. Shanmugam, Sushil Adhikari, Rajdeep Shakya

Removal of nutrients (phosphorus and nitrogen) as struvite from bio-oil aqueous phase generated via hydrothermal liquefaction of algae was evaluated in this study. Effect of process parameters such as pH, temperature and reaction time on struvite formation was studied. More than 99% of phosphorus and 40–100% ammonium nitrogen were removed under all experimental conditions. X-ray diffraction analysis confirmed the formation of struvite, and the struvite recovered from bio-oil aqueous phase can be used as a slow-release fertilizer. Biogas production from struvite recovered bio-oil aqueous phase showed 3.5 times higher CH₄ yield (182±39mL/g COD) as compared to non-struvite recovered aqueous phase. The results from this study indicate that both struvite and methane can be produced from bio-oil aqueous phase.

Graphical abstract



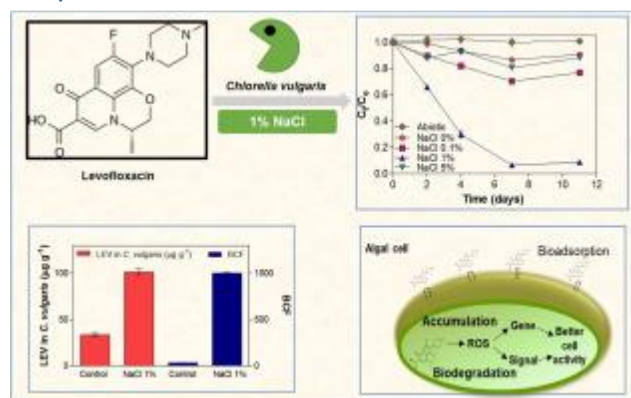
Biodegradation of levofloxacin by an acclimated freshwater microalga, *Chlorella vulgaris*

Source: Chemical Engineering Journal, Volume 313

Author(s): Jiu-Qiang Xiong, Mayur B. Kurade, Byong-Hun Jeon

The extensive contamination of levofloxacin (LEV) in aquatic ecosystems has attracted increasing attention because of the potential for development of bacterial resistance and its eco-toxicity to non-target organisms. Biodegradation of LEV was significantly improved upon the acclimation of a freshwater microalga, *Chlorella vulgaris* and in the presence of elevated salinity. Among the six wild species (*Chlamydomonas mexicana*, *Chlamydomonas pitschmannii*, *Chlorella vulgaris*, *Ourococcus multisporus*, *Micractinium resseri*, *Tribonema aequale*), *C. vulgaris* showed the highest removal capacity (12%) of LEV at 1mgL⁻¹. The acclimated *C. vulgaris*, which was pre-exposed to 200mgL⁻¹ of LEV for 11days, exhibited enhanced removal of 1mgLEV⁻¹ by 16% after 11days of cultivation. The addition of 1% (w/v) sodium chloride into the microalgal media significantly improved LEV removal by >80% in the *C. vulgaris* culture. The bioaccumulation of LEV at day 11 in *C. vulgaris* cells without NaCl was 34μgg⁻¹, which was elevated to 101μgg⁻¹ LEV at 1% NaCl. The bioconcentration factor for LEV was 34 and 1004 in 0 and 1% NaCl, respectively. The mass balance analysis of LEV showed that more than 90% of LEV was biodegraded by *C. vulgaris* at day 11 with the addition of 1% NaCl. These results demonstrated that the enhanced removal of LEV by salinity was mainly through bioaccumulation and subsequent intracellular biodegradation by *C. vulgaris* cells.

Graphical abstract



Mixotrophic cultivation of *Chlorella* for local protein production using agro-food by-products

Source: Bioresource Technology, Volume 230

Author(s): Silvia Salati, Giuliana D'Imporzano, Barbara Menin, Davide Veronesi, Barbara Scaglia, Pamela Abbruscato, Paola Mariani, Fabrizio Adani

A local strain of *Chlorella vulgaris* was cultivated by using cheese whey (CW), white wine lees (WL) and glycerol (Gly), coming from local agro-industrial activities, as C sources (2.2gCL^{-1}) to support algae production under mixotrophic conditions in Lombardy. In continuous mode, *Chlorella* increased biomass production compared with autotrophic conditions by 1.5–2 times, with the best results obtained for the CW substrate, i.e. $0.52\text{gL}^{-1}\text{d}^{-1}$ of algal biomass vs. $0.24\text{gL}^{-1}\text{d}^{-1}$ of algal biomass for autotrophic conditions, and protein content for both conditions adopted close to $500\text{gkg}^{-1}\text{DM}$. Mixotrophic conditions gave a much higher energy recovery efficiency (EF) than autotrophic conditions, i.e. organic carbon energy efficiency (EFoc) of 32% and total energy efficiency (Eft) of 8%, respectively, suggesting the potential for the culture of algae as a sustainable practice to recover efficiently waste-C and a means of local protein production.

Algal-microbial community collaboration for energy recovery and nutrient remediation from wastewater in integrated photobioelectrochemical systems

Source: Algal Research, Volume 24, Part B

Author(s): Shuai Luo, John A. Berges, Zhen He, Erica B. Young

Integration of algae and cyanobacteria with microbial fuel cell bioelectrochemical systems (BES) can significantly improve energy recovery and nutrient remediation in wastewater treatment. One innovative option is an integrated photobioelectrochemical system (IPB). Algae can contribute to BES function as an organic feedstock to support bacterial growth, by assisting anode bacteria to generate electricity, by providing oxygen from photosynthesis as a cathode electron acceptor, and by removing N and P from effluent water. However, critical interactions among bacteria-algae communities are poorly understood and practical questions such as light and pH conditions and taxa selection need more research to optimize microbial interactions and promote IPB function. Only a few 'lab weed' algal and cyanobacterial taxa have been tried in IPB systems but algae offer additional metabolic flexibility such as mixotrophy, to further process organic carbon, and nutrient hyperaccumulation, which have yet to be examined for potential in wastewater IPB treatment systems. This review aims to serve as a guide for wastewater bioenergy engineers to address challenges in IPB systems, and identifies a need for more collaboration between algal biologists and engineers to optimize algal-microbial community collaboration and work towards improved sustainability of wastewater treatment.



Graphical abstract



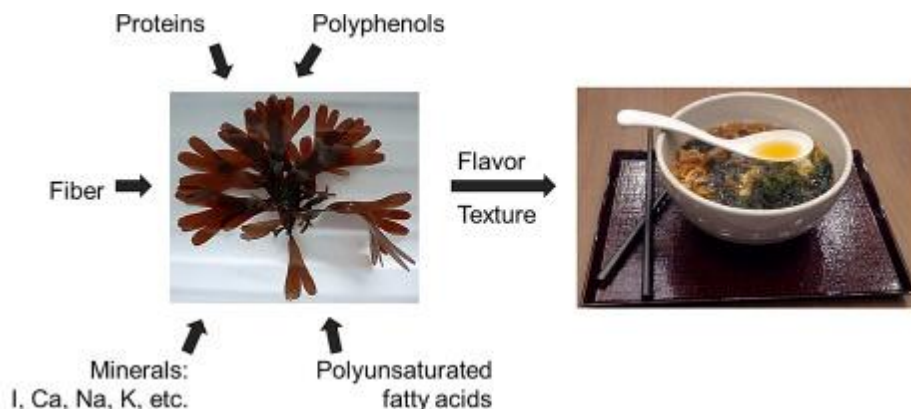
Seaweeds: A traditional ingredients for new gastronomic sensation

Source: Food Hydrocolloids, Volume 68

Author(s): Laurie-Eve Rioux, Lucie Beaulieu, Sylvie L. Turgeon

Seaweeds have a long tradition in Asian cuisine. In Canada and US, seaweed consumption is mostly limited to sushi and other imported Asian dish. However, seaweeds are well recognized for their richness in several nutrients such as fiber, protein and minerals. But what is limiting seaweed and seaweed derived ingredients utilization in home cooking? Finding fresh seaweeds within inland cities is one limiting step but also the seaweed marketing need to propel the image that seaweed are not only nutritive but can bring flavor and texture in cuisine dish. With the rise of TV cooking shows, blogs and online recipes hosted by several renowned chefs, it is now time to bring seaweed in the spotlight. The aim of this review is to look at seaweeds to support a wider use in culinary applications for their nutritional contribution but also from a sensory perspective.

Graphical abstract



Successful large-scale hatchery culture of sandfish (*Holothuria scabra*) using micro-algae concentrates as a larval food source

Source: Aquaculture Reports, Volume 9

Author(s): Thane A. Militz, Esther Leini, Nguyen Dinh Quang Duy, Paul C. Southgate

This paper reports methodology for large-scale hatchery culture of sandfish, *Holothuria scabra*, in the absence of live, cultured micro-algae. We demonstrate how commercially-available micro-algae concentrates can be incorporated into hatchery protocols as the sole larval food source to completely replace live, cultured micro-algae. Micro-algae concentrates supported comparable hatchery production of sandfish to that of live, cultured micro-algae traditionally used in large-scale hatchery culture. The hatchery protocol presented allowed a single technician to achieve production of more than 18,800 juvenile sandfish at 40 days post-fertilisation in a low-resource hatchery in Papua New Guinea. Growth of auricularia larvae fed micro-algae concentrates was represented by the equation $\text{length } (\mu\text{m}) = 307.8 \times \ln(\text{day}) + 209.2$ ($R^2 = 0.93$) while survival over the entire 40-day hatchery cycle was described by the equation $\text{survival} = 2 \times \text{day} - 1.06$ ($R^2 = 0.74$). These results show that micro-algae concentrates have great potential for simplifying hatchery culture of sea cucumbers by reducing infrastructural and technical resources required for live micro-algae culture. The hatchery methodology described in this study is likely to have applicability to low-resource hatcheries throughout the Indo-Pacific and could support regional expansion of sandfish hatchery production.

Extraction of lipids from wet microalga *Auxenochlorella protothecoides* using pulsed electric field treatment and ethanol-hexane blends

Source: Algal Research, Volume 29

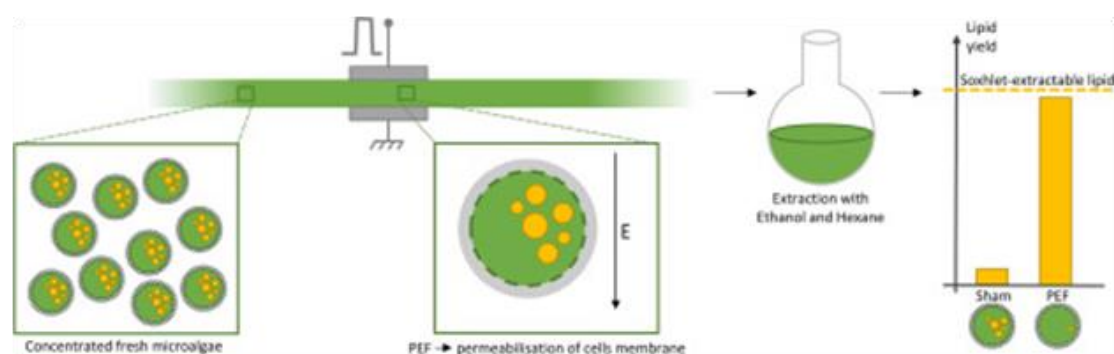
Author(s): A. Silve, I. Papachristou, R. Wüstner, R. Sträßner, M. Schirmer, K. Leber, B. Guo, L. Interrante, C. Posten, W. Frey

Pulsed Electric Field (PEF) treatment was used as pre-treatment on the microalga strain *Auxenochlorella protothecoides* (A.p.) prior to organic solvent extraction of lipids. Experiments were performed on fresh biomass from mixotrophic or autotrophic culture which both had an evaluated lipid content of 30–35% of cell dry weight. Lipid yield was determined gravimetrically and compared to the reference lipid content assessed by bead-milling and subsequent Soxhlet extraction. The biomass was concentrated at 10% w/w solids prior to PEF-treatment and further dewatered afterwards to approximately 25% w/w before extraction. PEF-treatment with an energy input of 1.5 MJ per kilogram of dry matter induced electroporation of the microalga cells detected by the increase of the conductivity of the microalga supernatant. This greatly increased the lipid yield upon subsequent monophasic solvent extraction. A mixture of Water/Ethanol/Hexane 1:18:7.3 vol/vol/vol enabled to recover 92%, and 72%, of the evaluated lipid content of mixotrophically, and autotrophically respectively, grown A.p., after 2h of extraction. Recovery increased to 97%, and 90% respectively, after 20h of extraction. The same extraction system on untreated



biomass yielded maximum 10% of lipid content. The highest yields were obtained with 80mL of solvent for 1g dry biomass but solvent volume could be reduced by a factor two in case of mixotrophically grown microalgae. However, the solvent:biomass ratio still remains high, and includes a water-miscible solvent, ethanol. Total lipid extraction was confirmed by Nile red staining of residual biomass combined with fluorescence microscopy imaging and flow cytometry. Gas chromatography analyses of extracted lipids after transesterification revealed that PEF- treatment did not alter their fatty acid composition. Overall PEF-treatment shows promising features for upscaling especially in a biorefinery concept since it avoids potentially harmful temperature increase and small debris problematic for further processing.

Graphical abstract



Magnetic field action on outdoor and indoor cultures of Spirulina: Evaluation of growth, medium consumption and protein profile

Source: Bioresource Technology, Volume 249

Author(s): Kricelle Mosquera Deamici, Lucielen Oliveira Santos, Jorge Alberto Vieira Costa

This study aimed at evaluating whether a magnetic field (MF) affects the growth of *Spirulina* sp. when applied to it at different exposure times in indoor and outdoor culture systems. The effects of MF on chlorophyll content, medium consumption and protein profile were also investigated. In raceway tanks, a 25 mT MF was applied for 24 h or for 1 h d⁻¹. MF for 24 h to outdoor assays increased biomass concentration and chlorophyll-a content besides altering the protein profile. Outdoor *Spirulina* growth was higher (~3.65 g L⁻¹) than the growth found in indoor assays (~1.80 g L⁻¹), while nitrogen and phosphorus consumption was not enhanced by the application of MF. This is the first study that investigated the influence of MF on outdoor microalga assays, and the results showed that MF affected the metabolism of *Spirulina* cultured in raceways, especially when it was grown outdoors in uncontrolled environmental conditions.



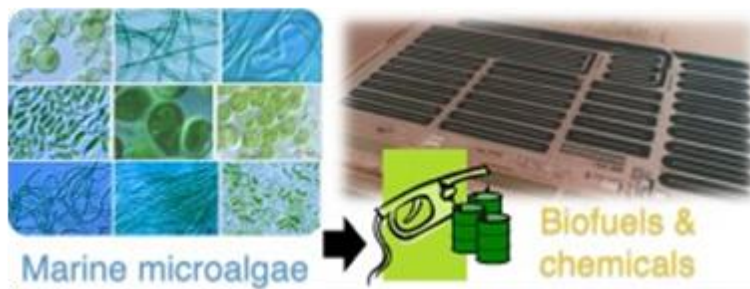
Marine microalgae for production of biofuels and chemicals

Source: Current Opinion in Biotechnology, Volume 50

Author(s): Yoshiaki Maeda, Tomoko Yoshino, Tadashi Matsunaga, Mitsufumi Matsumoto, Tsuyoshi Tanaka

Marine microalgae are recognized as promising feedstocks for biofuels and chemicals owing to their higher growth rates than those of terrestrial crop plants. We aimed to summarize the production of biofuels and chemicals by marine microalgae and to discuss their advantages and potential from the aspect of bioprocess. The present circumstances of the microalgae industry were briefly described and large-scale industrial plants for microalgae production, where some marine microalgae are cultivated, were introduced. The advantages of marine microalgae in terms of water and land usage were also discussed. Finally, novel genome editing tools that could further exploit the potential of marine microalgae were reviewed. The present study provided comprehensive information regarding current biotechnology using marine microalgae.

Graphical abstract



Towards a sustainable biobased industry – Highlighting the impact of extremophiles

Source: New Biotechnology, Volume 40, Part A

Author(s): Anna Krüger, Christian Schäfers, Carola Schröder, Garabed Antranikian

The transition of the oil-based economy towards a sustainable economy completely relying on biomass as renewable feedstock requires the concerted action of academia, industry, politics and civil society. An interdisciplinary approach of various fields such as microbiology, molecular biology, chemistry, genetics, chemical engineering and agriculture in addition to cross-sectional technologies such as economy, logistics and digitalization is necessary to meet the future global challenges. The genomic era has contributed significantly to the exploitation of nature's biodiversity also from extreme habitats. By applying modern technologies it is now feasible to deliver robust enzymes (extremozymes) and robust microbial systems that are active at temperatures up to 120°C, at pH 0 and 12 and at 1000bar. In the post-genomic era, different sophisticated "omics" analyses will allow the identification of countless novel enzymes regardless of the lack of cultivability of most



microorganisms. Furthermore, elaborate protein-engineering methods are clearing the way towards tailor-made robust biocatalysts. Applying environmentally friendly and efficient biological processes, terrestrial and marine biomass can be converted to high value products e.g. chemicals, building blocks, biomaterials, pharmaceuticals, food, feed and biofuels. Thus, further application of extremophiles has the potential to improve sustainability of existing biotechnological processes towards a greener biobased industry.

Performance of different microalgae-based technologies in biogas slurry nutrient removal and biogas upgrading in response to various initial CO₂ concentration and mixed light-emitting diode light wavelength treatments

Source: Journal of Cleaner Production, Volume 166

Author(s): Xue Wang, Shumei Gao, Yuejin Zhang, Yongjun Zhao, Weixing Cao

Microalgae-based technologies were studied for nutrient removal in biogas slurry and biogas upgrading in the photobioreactors constitute, which were cost-effective, environment-friendly alternatives to conventional physical-chemical methods. The effects of CO₂ concentration on nutrient removal and biogas upgrade using *Chlorella vulgaris* monocultivation, *Ganoderma lucidum*-*Chlorella vulgaris* cocultivation and activated sludge-*Chlorella vulgaris* cocultivation were investigated. Besides, the influences of three ratios of red to blue light wavelength on nutrient removal and biogas upgrading were also investigated. The results showed that optimum biogas slurry nutrient reduction could be achieved by *Ganoderma lucidum*-*Chlorella vulgaris* cocultivation using the pelletization method. The optimal ratio of red to blue light wavelength for nutrient removal and biogas upgrading was 5:5, resulting to maximal mean removal efficiencies of 86.08± 6.27%, 85.69± 6.34%, 86.17± 6.13%, and 79.11 ± 5.97% for chemical oxygen demand, total nitrogen, total phosphorus and CO₂, respectively. The results will provide a reference for simultaneously purifying wastewater and upgrading biogas using microalgae-based technology.

Removal and recovery of Critical Rare Elements from contaminated waters by living *Gracilaria gracilis*

Source: Journal of Hazardous Materials, Volume 344

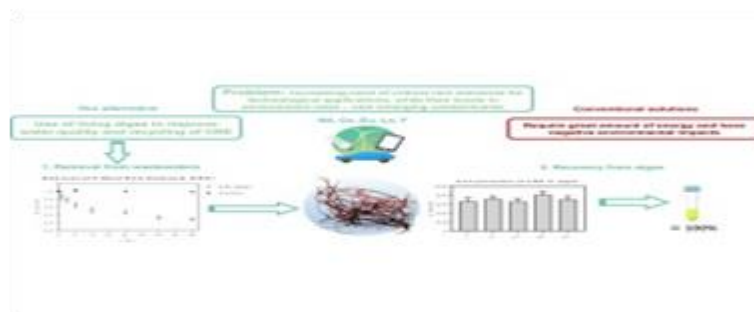
Author(s): Jéssica Jacinto, Bruno Henriques, A.C. Duarte, Carlos Vale, E. Pereira

The experiments performed in this work proved the ability of *Gracilaria gracilis* to concentrate and recover Critical Rare Elements (CRE) from contaminated waters. The importance of recycling these elements is related to their very limited sources in Nature and progressive use in technologies. Moreover, their mining exploitation has negative environmental impact, and recent studies point them as new emerging pollutants. To the best of our knowledge, this is the first report on the application of living macroalgae for the removal and recovery of CRE. *G. gracilis* (2.5gL⁻¹, fresh weight) was exposed to mono- and



multi-element saline solutions of $500\mu\text{gL}^{-1}$ of Y, Ce, Nd, Eu and La. Removal was up to 70% in 48h, with bioaccumulation following Elovich kinetic model. In multi-element solutions, selectivity was not observed although removal of lanthanides improved comparatively to single-element solutions. No mortality or adverse effect on growth was registered. The subsequent macroalgae digestion allowed collecting virtually 100% of all elements in a 300-fold more concentrated solution. The overall results suggest the application of living macroalgae as a simple and effective alternative technology for removing and recovering CRE from wastewaters, contributing to an improvement of water quality and CRE recycling.

Graphical abstract



Toward biotechnology in space: High-throughput instruments for in situ biological research beyond Earth

Source: Biotechnology Advances, Volume 35, Issue 7

Author(s): Fathi Karouia, Kianoosh Peyvan, Andrew Pohorille

Space biotechnology is a nascent field aimed at applying tools of modern biology to advance our goals in space exploration. These advances rely on our ability to exploit in situ high throughput techniques for amplification and sequencing DNA, and measuring levels of RNA transcripts, proteins and metabolites in a cell. These techniques, collectively known as “omics” techniques have already revolutionized terrestrial biology. A number of on-going efforts are aimed at developing instruments to carry out “omics” research in space, in particular on board the International Space Station and small satellites. For space applications these instruments require substantial and creative reengineering that includes automation, miniaturization and ensuring that the device is resistant to conditions in space and works independently of the direction of the gravity vector. Different paths taken to meet these requirements for different “omics” instruments are the subjects of this review. The advantages and disadvantages of these instruments and technological solutions and their level of readiness for deployment in space are discussed. Considering that effects of space environments on terrestrial organisms appear to be global, it is argued that high throughput instruments are essential to advance (1) biomedical and physiological studies to control and reduce space-related stressors on living systems, (2) application of biology to life support and in situ resource utilization, (3) planetary protection, and (4) basic research about the limits on life in space. It is also argued that carrying out measurements in situ



provides considerable advantages over the traditional space biology paradigm that relies on post-flight data analysis.

Microalgae: Prospects for greener future buildings

Source: Renewable and Sustainable Energy Reviews, Volume 81, Part 1

Author(s): Ghada Mohammad Elrayies

As a result of the growing global demand for energy, together with the depletion of resources and the growing emphasis on mitigating climate change and greenhouse gas emissions, an urgent need for an evolution of the renewable energy resources has emerged. On the architectural scene, we have become accustomed to seeing buildings incorporated with photovoltaics and wind turbines. Despite the great contribution of biomass as a clean energy producer, the integration of biomass into architecture is quite modest and still in its initial phases. Microalgae, as a plant-based biomass, can outperform other renewable resources with their potential to absorb CO₂, recycle wastewater, and release O₂. The limited experience regarding building-integrated microalgae photobioreactors (PBRs) requires shedding light on some issues. So, this paper aims to explore the following: 1) the proper types of PBRs for integration with buildings, 2) the overall bioprocess and the design considerations regarding PBRs and their technical requirements, 3) the environmental and energetic performance of PBRs, 4) their challenges, and 5) their prospects. Thus, the paper's methodology consists of 1) reviewing the promulgated literature concerning microalgae and PBRs, 2) reviewing and analyzing three building-integrated PBRs and three urban-integrated PBRs, and 3) reviewing the environmental and energetic performance of building-integrated PBRs. The paper has concluded that the symbiosis between PBRs and façades encounters some challenges, including 1) the biorefinery infrastructure, 2) the provision of a source of CO₂, and 3) the high initial cost. On the other hand, the multifaceted environmental prospects of building-integrated PBRs are represented in 1) energy savings; 2) GHG emissions reduction; 3) oxygen and hydrogen release; 4) biofuel production; and 5) wastewater treatment. The unique benefits of the bio-façades through the combination of the technical and biological cycles within buildings inaugurate an innovative approach to sustainability by integrating environmental, energetic, and iconic values.

Algae cathode microbial fuel cells for electricity generation and nutrient removal from landfill leachate wastewater

Source: International Journal of Hydrogen Energy, Volume 42, Issue 49

Author(s): Hai T.H. Nguyen, Ramesh Kakarla, Booki Min

Landfill leachate is one of the most toxic and difficult-to-treat wastewater due to its high level of contamination and complex composition. In this study, landfill leachate at different percentages (5–40%) was fed to algae cathode microbial fuel cells (MFCs) for electricity generation along with chemical oxygen demand (COD) and nutrient removal. Maximum cell voltage of 300 ± 11 mV was obtained with 5% leachate, but the cell voltage decreased with an increase in leachate percentage. The maximum dissolved oxygen (DO) was 19.57 mg/L



with 5% leachate. The COD in the anode chamber was almost completely removed (97%) with all leachate percentages, while the maximum COD removal was 52% with 10% leachate in the cathode chamber. Enhanced nitrogen and phosphorus removal was observed with leachate percentages less than 10%, but nitrogen removal efficiency was significantly reduced and even more phosphorus was observed with leachates higher than 25% ($\text{NH}_4 + \text{N} = 651 \text{ mg/L}$). This study suggests that leachate can be treated at an appropriate dilution with simultaneous electricity generation in algae cathode MFC.



PATENTES

NOODLES AND NOODLE DOUGH CONTAINING A MICROALGAL FLOUR

Page bookmark WO2016184506 (A1) - NOODLES AND NOODLE DOUGH CONTAINING A MICROALGAL FLOUR

Inventor(s): ITO GOICHI [JP]; OKUBO YOSHITAKA [JP] ± (ITO, Goichi, ; OKUBO, Yoshitaka)

Applicant(s): ROQUETTE FRERES ± (ROQUETTE FRERES)

The present invention relates to noodle products comprising a high-lipid microalgal flour, and to noodle doughs suitable for preparing such noodle products. More particularly, the noodle dough comprises from 0.05% to 15% w/w of a microalgal flour comprising at least 50% of lipid by dry weight. The resulting noodle products show a reduced cooking time compared to regular noodles free of such microalgal flour.

Microbial oils with lowered pour points, dielectric fluids produced therefrom, and related methods

Page bookmark AU2016202999 (A1) - Microbial oils with lowered pour points, dielectric fluids produced therefrom, and related methods

Inventor(s): FRANKLIN SCOTT; LU WENHUA; RAKITSKY WALTER; RODRIGUEZ FELIPE ARANA; RUDENKO GEORGE; WEE JANICE; ZHAO XINHUA ± (FRANKLIN, SCOTT, ; LU, WENHUA, ; RAKITSKY, WALTER, ; RODRIGUEZ, FELIPE ARANA, ; RUDENKO, GEORGE, ; WEE, JANICE, ; ZHAO, XINHUA)

Applicant(s): SOLAZYME INC ± (SOLAZYME, INC)



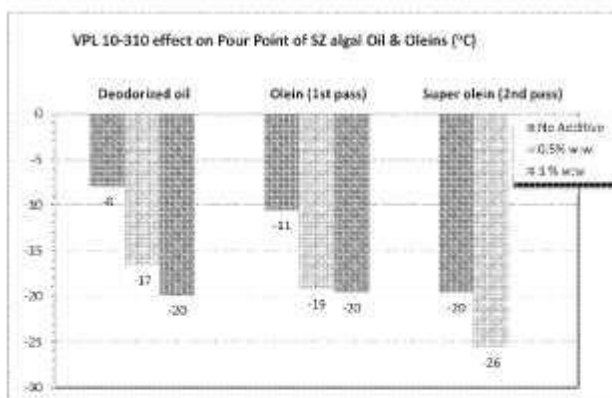


Fig. 3

Methods and compositions for the production of dielectric fluids from lipids produced by microorganisms are provided, including oil-bearing microorganisms and methods of low cost cultivation of such microorganisms. Microalgal cells containing exogenous genes encoding, for example, a sucrose transporter, a sucrose invertase, a fructokinase, a polysaccharide-degrading enzyme, a lipid pathway modification enzyme, a fatty acyl-ACP thioesterase, a desaturase, a fatty acyl-CoA/aldehyde reductase, and/or an acyl carrier protein are useful in manufacturing dielectric fluids.

PRODUCTION METHOD OF ANTIVIRAL DRUG AND ANTIVIRAL DRUG OBTAINED BY METHOD THEREOF

Page bookmark JP2016065037 (A) - PRODUCTION METHOD OF ANTIVIRAL DRUG AND ANTIVIRAL DRUG OBTAINED BY METHOD THEREOF

Inventor(s): KOMATSU TAKAYUKI; SUGIYAMA TSUYOSHI; MORI NOBUO; SUENO OSAMU; WASHIMI AKIRA ± (KOMATSU TAKAYUKI, ; SUGIYAMA TSUYOSHI, ; MORI NOBUO, ; SUENO OSAMU, ; WASHIMI AKIRA)

Applicant(s): NIKKEN SOHONSHA CORP ± (NIKKEN SOHONSHA CORP)

PROBLEM TO BE SOLVED: To provide a production method of an antiviral drug obtained from microalgae in which the remained amount of a lipid is little, and an antiviral activity and immune activity are enhanced to new and seasonal human influenza virus, coronavirus, and norovirus; and to provide an antiviral drug obtained by the method. **SOLUTION:** The invention provides a production method of an antiviral drug having an antiviral activity enhanced to the above viruses, the method comprising performing two or more degreasing



operations of mixing Coccomyxa or Chlorella of microalgae, benzene:methanol (2:1), or a volatile solvent consisting of ethanol, acetone, and hexane, and centrifuging in combination with one or more of ultrasonic vibration, hyperbaric pressure homogenization, and blade-agitation; adding given amount of water after the degreasing step, and heating over a given time to extract with hot water; and concentrating and drying a solution layer subjected to solid liquid separation by centrifugation of the hot water extract

IMPROVED MICROALGAL FLOUR.

Page bookmark MX2015009656 (A) - IMPROVED MICROALGAL FLOUR.

Inventor(s): PATINIER SAMUEL [US]; NORRIS LESLIE; PIECHOCKI JOHN; BALIU ENRIQUE; DESAI RUCHIR; PASSÉ DAMIEN; DRUON AMANDINE; RUYET MARIE LE ± (SAMUEL PATINIER, ; LESLIE NORRIS, ; JOHN PIECHOCKI, ; ENRIQUE BALIU, ; RUCHIR DESAI, ; DAMIEN PASSÉ, ; AMANDINE DRUON, ; MARIE LE RUYET)

Applicant(s): SOLAZYME ROQUETTE NUTRITIONALS LLC [US] ± (SOLAZYME ROQUETTE NUTRITIONALS, LLC)

The present invention relates to microalgal food products with acceptable sensory characteristics and methods of producing the food products. The flour can be produced by cultivating microalgal cells of a strain of Chlorella protothecoides under conditions of acceptable pH and dissolved oxygen to produce a desired amount of lipid. The microalgal cells can be lysed, heat-treated, washed and dried to produce a microalgal flour that can be incorporated into a variety of products.



Otras noticias de interes

Biotechnology: Fermentalg finally arrives on the market with an algae oil rich in omega-3

The laboratory Fermentalg manufactures microalgae particularly in the area of the nutrisanté — Fermentalg

- Fermentalg has redefined its strategy and is the sector of the nutrisanté his priority.
- At the same time it has signed a commercial agreement with the japanese DIC for the production of natural pigments.

The year 2017 will be the year of transition for Fermentalg, nugget regional biotechnology in New-Aquitaine. Seven years after its launch, this manufacturer of microalgae, which now employs 64 people at Libourne (Gironde), is in fact passed from the research phase to the commercial phase, including the placing on the market, this summer, its first product, the DHA 350, an algae oil rich in omega-3.

<https://sherbrooktimes.com/biotechnology-fermentalg-finally-arrives-on-the-market-with-an-algae-oil-rich-in-omega-3/18469>

J. Craig Venter Institute-led Team Awarded 5-year, \$10.7 M Grant from U.S. Department of Energy to Optimize Metabolic Networks in Diatoms, Enabling Next-Generation Biofuels and Bioproducts

LA JOLLA, Calif., Oct. 3, 2017 /PRNewswire-USNewswire/ -- Scientists, led by the J. Craig Venter Institute (JCVI), a not-for-profit genomic research organization, were recently awarded a 5-year, \$10.7 million grant by the United States Department of Energy, Office of Science, Biological and Environmental Research (BER), BER Genomic Science Program to optimize metabolic networks in model photosynthetic microalgae, called diatoms. The aim of this work is to substantially increase oil, or lipid production, enabling next-generation biofuels and bioproducts.

<http://markets.businessinsider.com/news/stocks/J-Craig-Venter-Institute-led-Team-Awarded-5-year-10-7-M-Grant-from-U-S-Department-of-Energy-to-Optimize-Metabolic-Networks-in-Diatoms-Enabling-Next-Generation-Biofuels-and-Bioproducts-1002948526>

IHI to test algae-based jet fuel production in Thailand

Project with Siam Cement scales up previous experiments in Japan

BANGKOK -- IHI will conduct large-scale verification experiments in Thailand on a process for producing jet fuel from the oil extracted from cultured microalgae.

The goal is to have a practical technology ready by 2020 so the biojet fuel can be used for test flights during the Tokyo Olympics. Commercialization of the fuel is not expected until around 2030, however.

<https://asia.nikkei.com/Japan-Update/IHI-to-test-algae-based-jet-fuel-production-in-Thailand>

New funding for bio-production with microorganisms

Using bacteria and microalgae to produce valuable compounds from alternative, sustainable sources: biology professors Prof. Dr. Olaf Kruse and Prof. Dr. Volker F. Wendisch are



investigating this topic with their research groups at the Center for Biotechnology (CeBiTec) and the Faculty of Biology at Bielefeld University. The researchers have now received funding approval for their work within three new cooperative research projects: the international research consortia will be funded with a total of 4.8 million Euro over a period of three years.

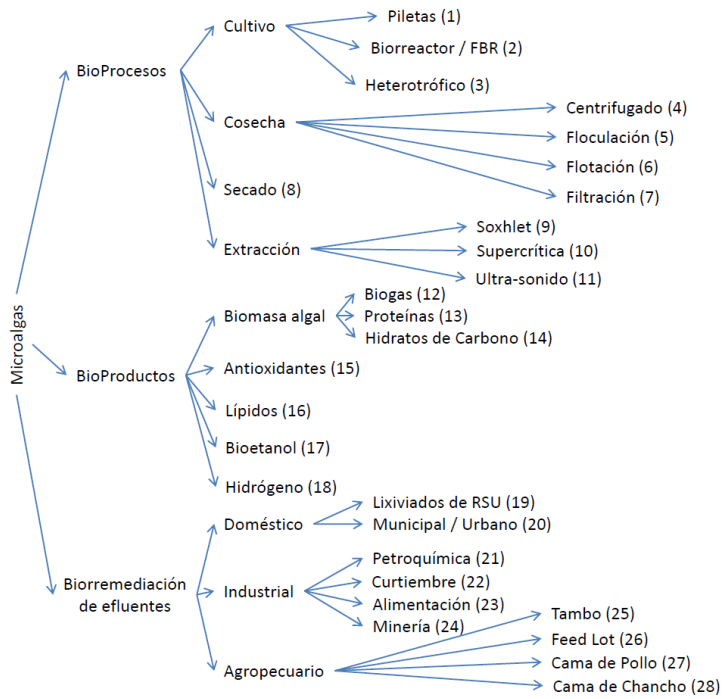
The Bielefeld University professors are working together with partners from Argentina, Denmark, Germany, France, Great Britain, the Netherlands, Norway, and Slovenia in the three research networks.

https://www.eurekalert.org/pub_releases/2017-11/bu-nff110617.php

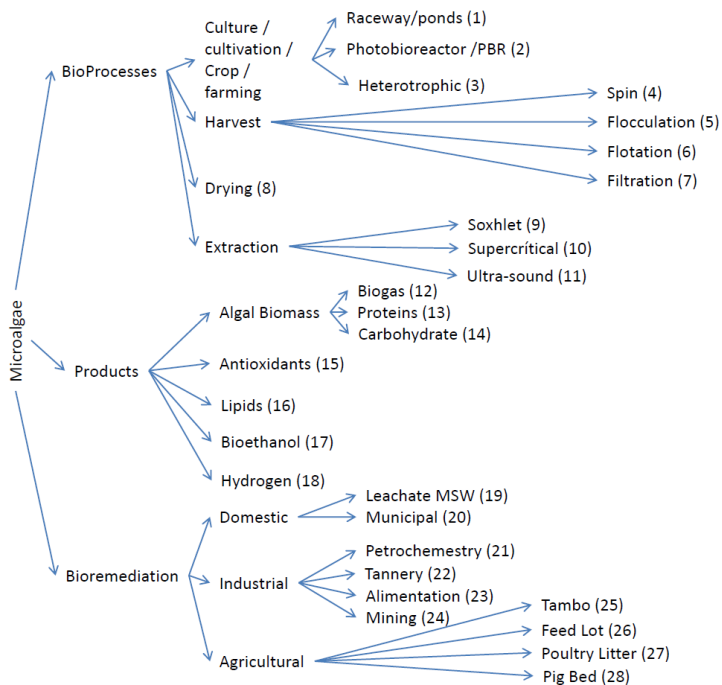


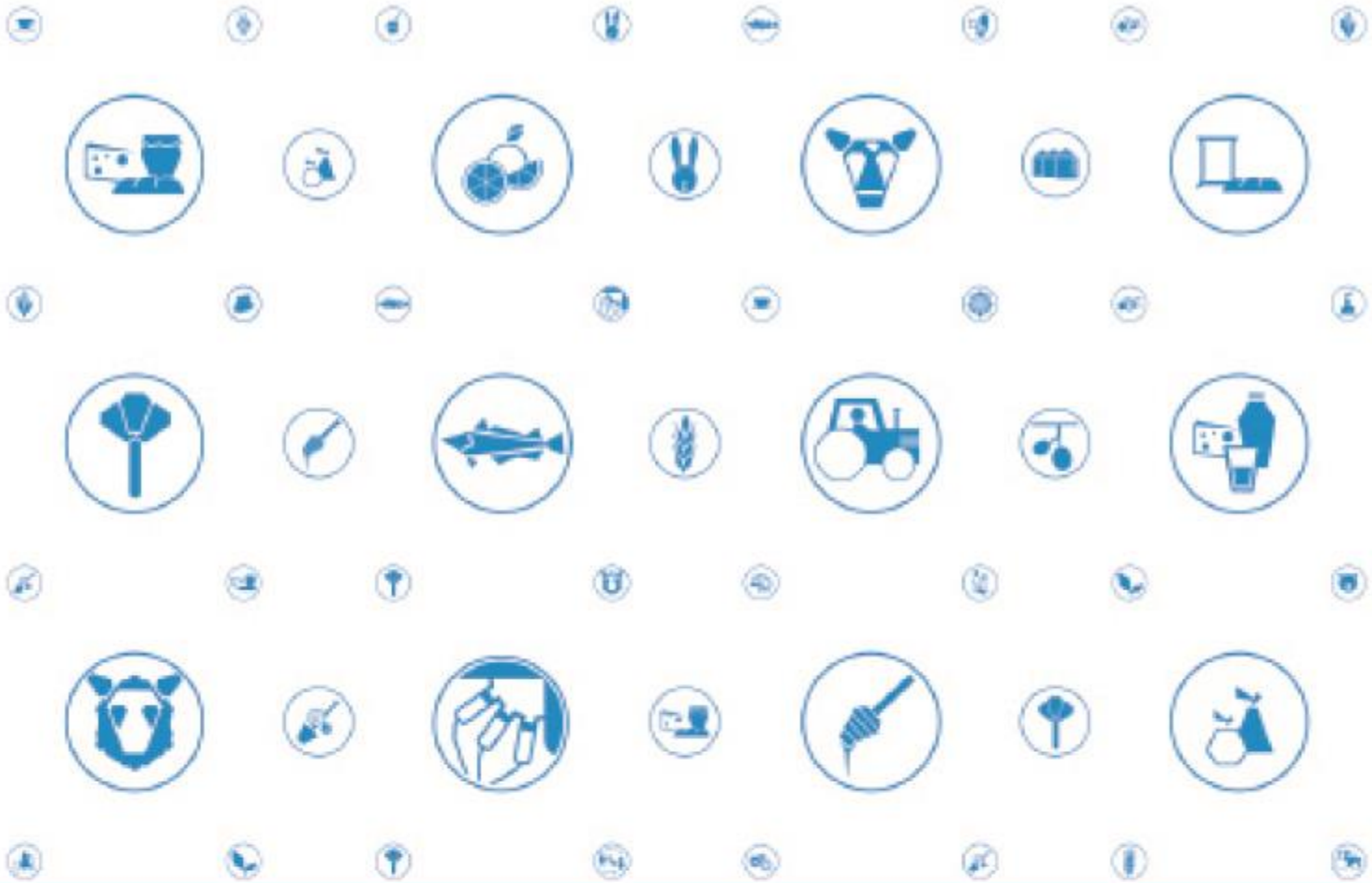
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