ҚАЗАҚСТАН РЕСПУБЛИКАСЫ ҒЫЛЫМ ЖӘНЕ ЖОҒАРЫ БІЛІМ МИНИСТРЛІГІ

«Л.Н. ГУМИЛЕВ АТЫНДАҒЫ ЕУРАЗИЯ ҰЛТТЫҚ УНИВЕРСИТЕТІ» КЕАҚ

# Студенттер мен жас ғалымдардың
# «ǴYLYM JÁNE BILIM - 2023»
# XVIII Халықаралық ғылыми конференциясының
# БАЯНДАМАЛАР ЖИНАҒЫ

# СБОРНИК МАТЕРИАЛОВ
# XVIII Международной научной конференции
# студентов и молодых ученых
# «ǴYLYM JÁNE BILIM - 2023»

# PROCEEDINGS
# of the XVIII International Scientific Conference
# for students and young scholars
# «ǴYLYM JÁNE BILIM - 2023»

2023
Астана

**УДК 001+37**
**ББК 72+74**
**G99**

**«ǴYLYM JÁNE BILIM – 2023» студенттер мен жас ғалымдардың XVIII Халықаралық ғылыми конференциясы = XVIII Международная научная конференция студентов и молодых ученых «ǴYLYM JÁNE BILIM – 2023» = The XVIII International Scientific Conference for students and young scholars «ǴYLYM JÁNE BILIM – 2023». – Астана: – 6865 б. - қазақша, орысша, ағылшынша.**

**ISBN 978-601-337-871-8**

Жинаққа студенттердің, магистранттардың, докоранттардың және жас ғалымдардың жаратылыстану-техникалық және гуманитарлық ғылымдардың өзекті мәселелері бойынша баяндамалары енгізілген.

The proceedings are the papers of students, undergraduates, doctoral students and young researchers on topical issues of natural and technical sciences and humanities.

В сборник вошли доклады студентов, магистрантов, докторантов и молодых ученых по актуальным вопросам естественно-технических и гуманитарных наук.

**УДК 001+37**
**ББК 72+74**

**ISBN 978-601-337-871-8**

6. Ravanbakhsh Shirdam. Phytoremediation of hydrocarbon-contaminated soils with emphasis on the effect of petroleum hydrocarbons on the growth of plant species / Shirdam Ravanbakhsh, Ali Daryabeigi Zand, Gholamreza Nabi Bidhendi, Nasser Mehrdadi // Phytoprotection. - 2008. - N 89 (1). - P. 21-29.
7. Аренс В.Ж., Гридин О.М. Эффективные сорбенты для ликвидации нефтяных разливов // Экология и промышленность России. 1997. №3. С. 8–11. [14]
8. Физико-химические исследования и структура природных сорбентов // Под. ред. Ф.Я. Слисаренко. Саратов, 1971. 112 с
9. Solntseva N.P., Guseva O.A. Distribution of oil and soil products in soils of tundra landscapes within the European territory of Russian // Proc. Intern. Symp. of physics, chemistry and ecology of seasonally frozen soils. Alaska, 1997. P. 449–455
10. Елизарьева Е. Н. Растения для фиторемедиации воды, загрязненной тяжелыми металлами / Е. Н. Елизарьева, Ю. А. Янбаев, А. Ю. Кулагин // Вестн. Оренбург. гос. ун-та. - 2016. - № 3 (191). - С. 69-76.
11. Маргезин Р., Шиннер Ф. (2001) Биоремедиация (естественное ослабление и биостимуляция) почвы, загрязненной дизельным топливом, в зоне катания на горных ледниках. Приложение Environ Microbiol 67:3127-3133

УДК 504.064.43

# OVERVIEW OF THE POTENTIAL OF MICROALGAE FOR CO2 FIXATION

**Ablayeva Akzharkyn Galymzhankyzy**
azhar.ablayeva@mail.ru
Doctoral student of the 1st year in the specialty "Technology of environmental protection"
of the ENU named after L.N. Gumilyov, Astana, Kazakhstan
Scientific adviser - B.Kapsalyamov

Once the Chlorella microalgae have absorbed the pollutants from the flue gases, they can be harvested and treated with recycling water. The recycling water acts as a medium for the microalgae to continue photosynthesis and CO2 fixation, as well as providing nutrients for growth. The treated microalgae can then be reused for further treatment of flue gases. The process of CO2 fixation by microalgae involves several steps. First, the microalgae are cultivated in a suitable growth medium containing the necessary nutrients and CO2. The microalgae then absorb CO2 from the air or from a source such as flue gas from a power plant. The absorbed CO2 is then used in photosynthesis, where the microalgae convert it into organic compounds such as lipids, proteins, and carbohydrates. No additional CO2 is created, while nutrient utilization is achieved in a continuous fashion leading to the production of biofuels and other secondary metabolites. Therefore, microalgal-mediated CO2 fixation coupled with biofuel production, and wastewater treatment could present a promising alternative to existing CO2 mitigation strategies (Wang et al. 2008; Lam et al. 2012). Biological CO2 fixation appears to be the only economical and environmentally viable technology of the future (Ho et al. 2011; Kumar et al. 2011).

In practice, the treatment of flue gases with recycling water after treatment with Chlorella microalgae involves several steps. Firstly, the flue gases are passed through a bioreactor containing Chlorella microalgae. The microalgae absorb CO2 and other pollutants from the flue gases, and continue to grow and produce biomass in the bioreactor. Once the microalgae have absorbed the pollutants, they are harvested and treated with recycling water. The recycling water provides a medium for the microalgae to continue photosynthesis and CO2 fixation, while also providing nutrients for growth. The treated microalgae can then be reused for further treatment of flue gases, providing a sustainable and cost-effective solution. Past research initiatives suggest that practical CO2 utilization using microalgae still requires innovative scientific and technological breakthroughs to render this a feasible technology. Unless coupled with other technologies or coprocesses, investments into microalgae R&D are unlikely to make a considerable contribution to solving the CO2 problem globally. The use of microalgae can be classified as a direct CO2 mitigation technology. Direct strategies usually encompass much higher economic projections, going into billions of dollars, as opposed to indirect approaches. Therefore, for this technology to be a success, future R&D should focus on achieving higher biomass productivities, culture stability over long periods of time, economical harvesting techniques and improved biomass to-fuels conversion technologies. The economics of microalgal CO2 utilization may be improved by integrating this procedure with other co-processes. Potential co-processes include wastewater treatment, production of useful metabolites, as well as biofuels, animal feed and biofertilizer manufacturing (V. Bhola et al. 2011).

Microalgae

The use of Chlorella microalgae in treating flue gases with recycling water has several advantages. Firstly, it is a highly efficient process that can remove up to 90% of the pollutants from flue gases. Secondly, it is a sustainable process that does not require any chemicals or energy inputs. Thirdly, the harvested microalgae can be used for a variety of applications, such as biofuels or animal feed, providing a valuable resource. Microalgae are able to endure high concentrations of CO2, and this inherent ability makes them very advantageous in utilizing CO2 from flue gases of power plants. They are fast growers with biomass volumes that double within 24 h. At a flow rate of 0.3 L/min of air with 4 % CO2 concentration, most microalgal strains are able to achieve a carbon-fixation rate of roughly 14.6 gcm-2/day (Farrelly et al. 2013).

Photobioreactor (PBR)

Microalgal production using closed PBR technology has been implemented to overcome some of the key problems associated open pond production systems. A major advantage of PBRs when compared to open raceway systems is that they permit culture of single species of microalgae for prolonged durations with lower risk of contamination (Brennan and Owende 2010). Harvesting costs may also be significantly reduced owing to the higher cell mass productivities attained, and CO2 is also utilized more effectively (Chisti 2007; Brennan and Owende 2010; Vasumathi et al. 2012). Despite the fact that a great deal of work has already been done to develop PBRs for microalgal cultures and effective CO2 utilization, more efforts are still required to improve PBR technologies and know-how of microalgal cultures. Photobioreactor design and development is perhaps one of the first major steps that should be undertaken for efficient mass cultivation of microalgae for carbon mitigation (Ugwu et al. 2008). An increase in the maximum growth rate of microalgal species due to higher CO2 concentrations has been investigated by many researchers (Cheng et al. 2006; Ono and Cuello 2006; Lo ́pez et al. 2010; Ho et al. 2011; Kumar et al. 2011). Microalgal-CO2 fixation occurs via photoautotrophic growth. Therefore, the CO2-fixation potential of microalgal species should positively correlate with their light utilization efficiency and cell growth rate. Increases in temperature (20 C) can cause significant reduction in CO2 solubility, which eventually leads to a decline in the photosynthetic efficiency.

Green microalgae that are effective carbon sequesters generally belong to the genera Chlorococcum, Chlorella, Scenedesmus and Euglena. A study by Kurano et al. (1995) showed that C. littorale was able to reach a maximum cell concentration of 4.9 g L-1 at a 20 % CO2 concentration. When exposed to CO2 concentrations of more than 20 %, a short lag phase was observed prior to active photosynthesis. It must be noted that the performance of microalgal strains does not solely depend on CO2 concentrations, but also on culture and experimental conditions, such as culture medium, temperature, light intensity as well as reactor design. Variation in any of these conditions could have an effect on the CO2-fixation efficiency of the strains (Ho et al. 2011).

Challenges and economics associated with microalgal CO2 sequestration

There are numerous hurdles that need to be overcome before microalgae can be employed to significantly reduce CO2 emissions at a commercial level. Strain selection and design of the culturing system are key factors in maximizing CO2 mitigation rates. Even though open systems are much more cost-effective compared to closed PBRs, it is difficult to maintain culture purity in such systems. Closed systems are efficient vessels for sustaining axenic cultures as well as minimizing CO2 loss to the atmosphere. However, cleaning and sterilizing of large-scale PBRs is difficult, and this then poses a problem in the production of high value-added products. Land availability for set-up of propagation vessels also becomes a problem in developing countries (V. Bhola et al. 2011). For example, Kadam (2001) demonstrated that 1,000 ha of land area will be required for the construction of open ponds to mitigate CO2 emissions from a 50-MW power plant. Carbon-fixation rates for microalgal cultures differ under varying operational conditions. Geographical considerations must also be taken into account: fluctuations in temperature and solar irradiation over the seasons. Tropical areas are often considered most suitable for microalgal cultivation. To maximize the overall economic and environmental efficiency of microalgal CO2 sequestration, culturing systems should be located as close as possible to the point source. Furthermore, a comprehensive plan should be compiled for the large-scale production of microalgae. This scheme should encompass modeling and LCA of the overall process. Failure in doing so could render many algal production systems unsustainable. It should also be noted that potential leaks from large-scale algal systems could cause ecological damage by eutrophication (Pires et al. 2012; Farrelly et al. 2013).

Biomass recovery poses a challenge in microalgal biomass production processes. Common harvesting practices include flocculation, filtration, flotation and centrifugal sedimentation. Some of these procedures can be highly energy intensive. Selecting an appropriate harvesting technology during microalgal cultivation is crucial to economic production of microalgal biomass (Brennan and Owende 2010). The choice of harvesting technique is dependent on microalgae characteristics such as size, density and the value of the target products (Packer 2009; Brennan and Owende 2010). Flocculation is a popular technique as it is straightforward and cost-effective. This harvesting mode uses multivalent cations to overcome the overall negative charge present on the surface of microalgae. Multivalent metal salts (ferric chloride, aluminum sulfate and ferric sulfate) and polymers (polyelectrolyte and chitosan) are usually effective flocculants. An ideal flocculant is one that can be applied at low concentrations, inexpensive, non-toxic, and further downstream processing is not adversely affected by its use. For effective microalgal harvesting, flocculation is often combined with ‘‘floating.’’ This simple technique allows microalgae to float on the surface of the medium and can be easily removed as scum (Packer 2009). Life cycle analysis (LCA) essentially covers cultivation, harvesting, lipid extraction and finally product formation. Wastewater emissions as well as waste (solids or wastewater) treatment is generally not covered in a LCA study (Khoo et al. 2011).

## Conclusion

In conclusion, the use of Chlorella microalgae in treating flue gases with recycling water is a promising approach for reducing air pollution and greenhouse gas emissions. The theoretical basis of this approach is based on the ability of microalgae to photosynthesize and fix CO2, as well as remove other pollutants from flue gases through bioadsorption. The practical basis involves several steps, including passing the flue gases through a bioreactor, harvesting the microalgae, and treating them with recycling water. While there are challenges to be addressed, the potential benefits of this treatment approach make it an important area of research and development in the fight against climate change. For effective CO2 sequestration, an in-depth knowledge of flue gas composition and biology of microalgal cells would be required. Temperature, pH, SOx, NOx, heavy metals, light, culture strain and density, as well as CO2 mass transfer and O2 accumulation are major factors that affect CO2 sequestration and biomass production. LCA is imperative to ascertain economic feasibility and environmental sustainability of algal CO2 sequestration systems. For example, harvesting and dewatering are processes that are highly energy intensive; thus, research efforts should focus on developing an optimal harvesting strategy. Furthermore, strategic engineering decisions should be taken into consideration to realize effective microalgal CO2 sequestration systems. Microalgal cultivation requires the development of suitable reactors with features such as high S/V ratio, mixing, mass transfer, scalability and ease of operation. Airlift bioreactors that distribute light through optical fibers could be a possible solution (this increases the ratio between the illumination surface and reactor volume).

## References

1. Zhang X. Microalgae removal of CO2 from flue gas //IEA Clean Coal Centre, UK. – 2015, P. 4

2. Wang B, Li YQ, Wu N, Lan CQ (2008) CO2 bio-mitigation using microalgae. Appl Microbiol Biotechnol 79, 2008. P.707–718

3. Lam MK, Lee KT, Mohamed AR (2012) Current status and challenges on microalgae-based carbon capture. Int J Greenh Gas Con 10, 2012. P.456–469

4. Ho SH, Chen CY, Lee DJ, Chang JS. Perspectives on microalgal CO2-emission mitigation systems-a review. Biotechnol Adv 29, 2011. P.189–198

5. Kumar A, Ergas S, Yuan X, Sahu A, Zhang Q, Dewulf J, Malcata FX, Langenhove HV. Enhanced CO2 fixation and biofuels production via microalgae: recent developments and future directions. Trends Biotechnol 28, 2011. P. 371–380

6. Bhola V. et al. Overview of the potential of microalgae for CO 2 sequestration //International Journal of Environmental Science and Technology. – 2014. – T. 11. – C. 2103-2118.

7. Farrelly DJ, Everard CD, Fagan CC, McDonnell KP. Carbon sequestration and the role of biological carbon mitigation: a review. Renew Sustain Energy Rev 21, 2013. P. 712–727

8. Brennan L, Owende P. Biofuels from microalgae-a review of technologies for production, processing, and extractions of biofuels and co-products. Renew Sustain Energy Rev 14, 2014. P. 557–577

9. Chisti Y. Biodiesel from microalgae. Biotechnol Adv 25, 2007. P. 294–306

10. Vasumathi KK, Premalatha M, Subramanian P. Parameters influencing the design of photobioreactors for the growth of microalgae. Renew Sustain Energy Rev 16, 2012. P. 5443–5450

11. Ugwu CU, Aoyagi H, Uchiyama H. Photobioreactors for mass cultivation of algae. Bioresour Technol 99, 2008. P. 4021–4028

12. Cheng LH, Zhang L, Chen HL, Gao CJ. Carbon dioxide removal from air by microalgae cultured in a membranephotobioreactor. Sep Purif Technol 50, 2006. P. 324–329

13. Ono E, Cuello JL. Feasibility assessment of microalgal carbon dioxide sequestration technology with photobioreactor and solar collector. Biosyst Eng 95, 2006. P. 597–606

14. Kurano N, Ikemoto H, Miyashita H, Hasegawa T, Hata H, Miyachi S. Fixation and utilization of carbon dioxide by microalgal photosynthesis. Energy Convers Manag 36, 1995. P. 689–692

15. Kadam KL. Microalgae production from power plant flue gas: Environmental implications on a life cycle basis. Technical report, National Renewable Energy Laboratory Contract No. DE-AC36-99-GO10337, 2001

16. Pires JCM, Alvim-Ferraz MCM, Martins FG, Simo˜es M. Carbon dioxide capture from flue gases using microalgae: engineering aspects and biorefinery concept. Renew Sustain Energy Rev 16, 2012. P. 3043–3053

17. Packer M. Algal capture of carbon dioxide; biomass generation as a tool for greenhouse gas mitigation with reference to New Zealand energy strategy and policy. Energy Policy 37, 2009. P. 3428– 3437

18. Khoo HH, Sharratt PN, Das P, Balasubramanian RK, Naraharisetti PK, Shaik S. Life cycle energy and CO2 analysis of microalgae-to-biodiesel: preliminary results and comparisons. Bioresour Technol 102, 2011. P. 5800–5807