

SUSTAINABLE MANAGEMENT OF SOLID WASTES PROMOTED BY ALGAE

Abstract

Algae-based green technology has been recommended for the treatment of solid waste in landfill sites in response to the rising demand for sustainable development. The resulting biomass can be used to produce value-added products in a sustainable manner. The development of a circular economy and a strategy for waste prevention will be crucial steps toward sustainable solid waste management. There are a number of cutting-edge solutions for disposing of solid waste that are environmentally friendly and sustainable. The potential of algae and their unique mechanisms involved in waste treatment were the main topics of this chapter.

Keywords: Algae, Landfill leachate, Solid waste, Sustainable development,

Authors

S. Murugesan

PG and Research Department of Botany
Pachaiyappa's College, Chennai
Tamil Nadu, India.
smurugesan5@gmail.com

N. Shanthi

PG and Research Department of Botany
Pachaiyappa's College, Chennai
Tamil Nadu, India.
prithishanthi@gmail.com

I. INTRODUCTION

The process of gathering, handling, and getting rid of solid wastes includes segregation, dumping, composting, drainage, employing scrubbers or electrostatic precipitators, and burning. Solid waste creation has been greatly aided by rapid industrialization, urbanization, and rise in living standards, population growth, and rising economies in both developed and developing nations. In order to enhance the community's environment, sociocultural diversity, political stability, health, and economy, new technologies for SWM should be adopted. (Abdel-Shafy and Mansour, 2018; Shaili Vyasa et al., 2022).

Land filling is the most popular and simple method of getting rid of solid waste, yet it has various negative effects on the environment and human health. The majority of developing nations dispose of their solid waste, including organic and inorganic wastes, in open drains and canals, which eventually cause blockages and non-operation. The majority of the items that are dumped also include dangerous poisonous compounds that, when discharged into water bodies, raise the biological oxygen demand (BOD) and chemical oxygen demand (COD). However, due to ongoing dumping and land filling, the development of landfill leachate (LL) increases, which poses serious environmental problems. (Dogaris et al., 2020).

Due to their broad applicability, long-term viability, and great efficacy, novel biological treatment methods like algae technologies are being proposed to address this issue. In order to produce biomass-based value-added goods for a sustainable economy, it is also discussed to cultivate algae connected to LL and wastewaters on a wide scale outdoors. To address the solid waste issue, integrated phycoremediation technologies with other remediation methods already in use are generally mentioned.

By reducing plastic pollution and preventing the invasive dissemination of otherwise dangerous and toxin-producing bacteria participating in the biodegradation process, phycoremediation promotes ecosystem health. A more practical and environmentally beneficial method for wastewater treatment to stop eutrophication is bioflocculation of microalgae. The use of microalgae as a source of bioenergy is the area of recent academic research with the highest scientific interest; nevertheless, multidisciplinary efforts are still needed to make this process sustainable, and the use of the biorefinery model offers a plausible outlet.

II. ROLE OF ALGAE IN SOLID WASTE MANAGEMENT

Hazardous material has been introduced into our soil, sediments, and aquatic resources by the industrial world of today. Because incorrect management and absence of adequate disposal methods for domestic trash cause environmental pollution, segregation of this different type of waste is crucial for environmental safety. It has an impact on aquatic resources.

Algae-based green technologies are economically and ecologically sustainable than other conventional methods. Algae grow naturally on the contaminated sites and wastewaters and remove toxic metals and nutrients by phycoremediation including biosorption and

bioaccumulation. Moreover, the high biomass obtained from contaminated sites can be utilized for the biorefinery approach including biofuels, value-added products, bioactive compounds and nutrient supplements (Nawaz et al., 2020). Most of the studies have been focused on algae-based wastewater treatment and algae cultivation using wastewater. However few studies have demonstrated algae-based lab-scale and pilot-scale technologies.

Green technologies based on algae are more environmentally and economically sustainable than other traditional approaches. On contaminated areas and wastewaters, algae naturally develop and use phycoremediation techniques like biosorption and bioaccumulation to remove hazardous metals and nutrients. Additionally, the high biomass derived from contaminated sites can be used for the biorefinery approach, which includes the production of biofuels, value-added goods, bioactive substances, and nutrient supplements (Nawaz et al., 2020). The majority of research has been concentrated on algal-based wastewater treatment and wastewater-based algae production. However, just a few studies have shown the viability of lab- and pilot-scale algae-based technology.

Advanced technology, plastics, and other materialistic items are widely used. This led to various waste properties, which hindered the management of home garbage and disposal methods. This environmental issue is so urgent that it requires careful study and investigation. Because trash is left lying around on the streets, scattered among trash cans, and dumped all over the neighbourhood, there is often a foul smell and a risk to passersby's and people health.

In sewage water, algae have been shown to colonize artificial surfaces like polythene sheets, and these colonizing algae were found to be less toxic and harmful (Sharma et al., 2014). The process of biodegrading plastic will begin when algae adhere to the surface, and the development of ligninolytic and exopolysaccharide enzymes by these organisms is essential (Sarmah and Rout, 2018). The liquid media's algae enzymes interface with the plastic's surface's macromolecules to start the biodegradation process (Chinaglia et al., 2018). *Anabaena spiroides*, a blue-green alga, demonstrated the highest level of LDPE breakdown (8.18%), followed by the diatom *Navicula pupula* (4.44%), and the green alga *Scenedesmus dimorphus* (3.74%) (Kumar et al., 2017). *Chlorella vulgaris*, a common green microalga, and the bacterium *Aeromonas hydrophila* effectively break down other widely-used plastics like BPA without estrogenic activity (Wai Yan Cheah et al., 2023).

III. ALGAE-BACTERIA CO-CULTIVATION FOR TREATMENT OF LL

By recycling nitrogen, phosphorous, and carbon as key nutrients, the synergistic action of the algae-bacteria consortium resulted in considerable reduction of contaminants from wastewater and LL. According to research, the starting ammonia concentration, biomass concentration, and daylight hours are all directly connected with ammonia removal in LL or wastewater (Nawaz et al., 2020). *Chlorella*, *Scenedesmus*, *Stigeoclonium*, *Microcystis*, and *Oscillatoria* are just a few of the cyanobacteria and microalgal species that have been employed to cure 10% LL (Tighiri and Erkurt, 2019).

Even though SWM by algae on a commercial scale has significant limitations, some obstacles are worth facing for a brighter future. The first is the physicochemical parameters involved in the algae-based treatment; the second is the availability of large-scale algae

industries for biotechnological applications; the third is the cost-benefit ratio; the fourth is the need for pre-treatment in terms of dilution due to the high toxicity of leachate; the fifth is balancing the nitrogen and phosphorus ratio for better algal growth; the sixth is improving the rate kinetics process; the seventh is species-dependent remediation; and In comparison to unialgal strains, it has been discovered that algae-bacteria co-cultures are more tolerable to hazardous components Nawaz et al., 2020).

The traditional method of segregation is used to separate hospital waste from e-waste; this method cannot be completely replaced by algae-based treatment. These elements help us to solve societal and environmental issues.

A sustainable improvisation is needed in many algal technology applications. The economic production of algal biomass in open cultivation systems will also be improved by improvements in the cost-effective mechanical mixing of avoiding photo inhibition. The cost of producing biomass will be significantly reduced by using various industrial effluents and wastewater as culture media; nevertheless, this requires thorough research and optimization studies for commercial use. Further research on residential waste is needed in order to keep the ecosystem clean through environmental education, according to research on the removal of hazardous metals by marine algal waste.

IV. CONCLUSION

Microalgae are more advantageous than typical terrestrial vascular plants in terms of photosynthesis efficiency, faster biomass growth, and capacity to use and remove waste materials. This makes them useful in environmental technologies and in the production of valuable products. Large-scale algae farming in open raceway ponds may produce a lot of biomass, which can be used to make biofuels, medicines, nutraceuticals, fertilizer, and other valuable products.

REFERENCES

- [1] Abdel-Shafy, H.I. and Mansour, M.S.M. 2018. Solid waste issue: Sources, composition, disposal, recycling and valorization. *Egypt. J. Pet.* 27: 1275-1290.
- [2] Chinaglia, S. Tosin, M. Degli-Innocenti, F. Biodegradation rate of biodegradable plastics at molecular level *Polym. Degrad. Stabil.*, 147 (2018), pp. 237-244.
- [3] *CIBTech J Microbiol*, 3 (2014), pp. 43-47.
- [4] Dogaris, I., Ammar, E. and Philippidis, G.P. 2020. Prospects of integrating algae technologies into landfill leachate treatment. *World J. Microb. Biot.* 36: 39.
- [5] Nawaz, T., Rahman, A., Pan, S., Dixon, K., Petri, B. And Selvaratnam, T. 2020. A Review of Landfill Leachate Treatment by Microalgae: Current Status and Future Directions. *Processes* 8: 384.
- [6] Ramachandran Vimal Kumar, Gopal Rajesh Kanna and Sanniyasi Elumalai. Biodegradation of polyethylene by green photosynthetic microalgae. *J Bioremediat Biodegrad* 2017, 8:1.
- [7] Sarmah, P. Rout, J. Algal colonization on polythene carry bags in a domestic solid waste dumping site of Silchar town in Assam. *Phykos*, 48 (2018), pp. 67-77.
- [8] Shaili Vyasa, Priya Prajapati, Anil V, Shaha Sunita Varjania. Municipal solid waste management: Dynamics, risk assessment, ecological influence, advancements, constraints and perspectives. *Science of The Total Environment*. 2022. 814: 25, 152802.
- [9] Sharma, M. Dubey, A. Pareek, A. Algal flora on degrading polythene waste
- [10] Tighiri, H.O. and Erkurt, E.A. 2019. Biotreatment of landfill leachate by microalgae-bacteria consortium in sequencing batch mode and product utilization. *Bioresour. Technol.* 286: 121396.
- [11] Wai Yan Cheah, Ah Choy Er, Kadaruddin Aiyub, Nazlina Haiza Mohd Yasin, Sue Lin Ngan, Kit Wayne Chew, Kuan Shiong Khoo, Tau Chuan Ling, Joon Ching Juan, Zengling Ma¹, Pau Loke Sho. 2023. Current status and perspectives of algae-based bioplastics: A reviewed potential for sustainability. Volume 71, 1030783.