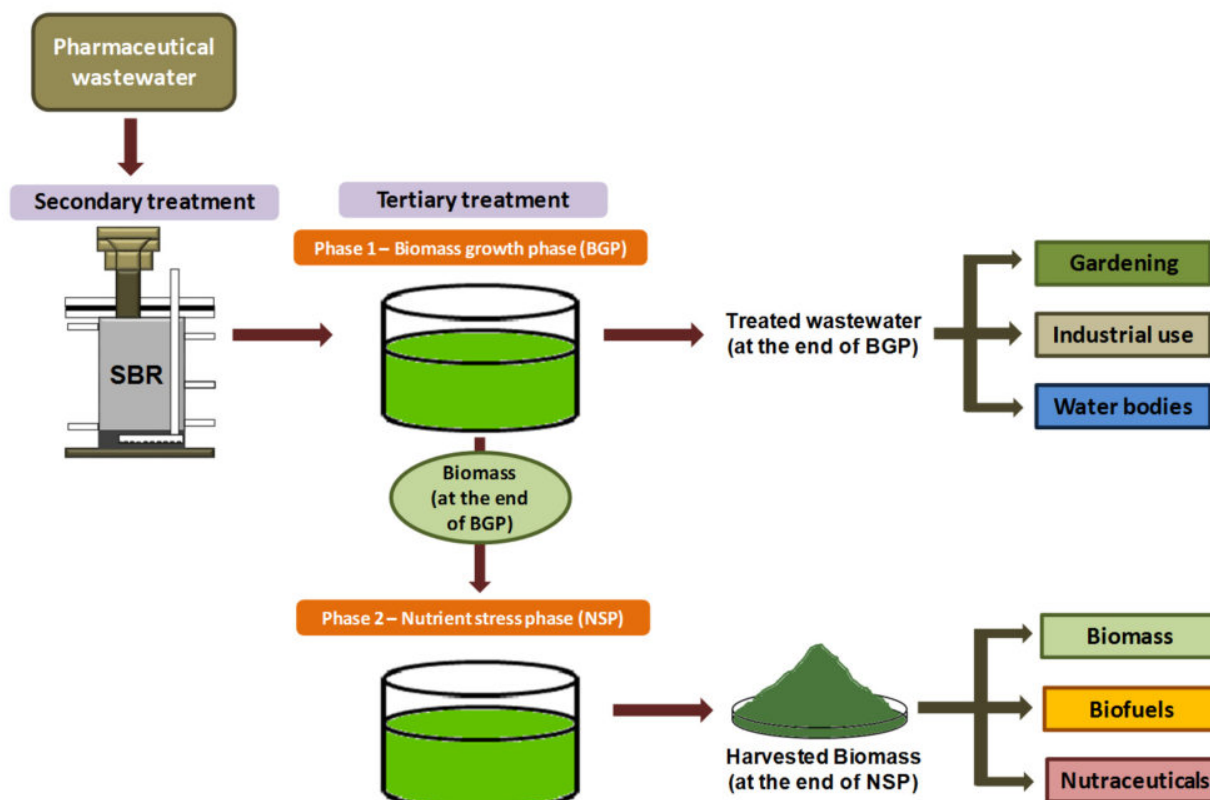


Microalgae - a potential biocatalyst for waste remediation with value Addition

Microalgae have the ability to sequester carbon dioxide, and grow in nutrient-rich environments and accumulate nutrients and metals from wastewater contributing for environmental sustainability and carbon neutrality. More recently, utility of microalgae as biocatalyst is garnered much prominence in bioeconomy through sequestration of carbon from both gaseous and aqueous phases in the context of bioenergy, nutraceutical, biomass, pharmaceutical products, etc. It assimilates pollutants into cellular constituents such as lipid, carbohydrate, starch, proteins, etc. thus achieving pollutant reduction in a more environment-friendly way. The metabolic versatility of microalgae to grow under diverse nutritional modes makes it a potential candidate in bioeconomy domain. The tertiary treatment units using algae is re-gaining the importance and relevance in the context of sustainability. This integration of algae-based biodiesel production from wastewater is considered both economically and environmentally viable, considering the increasing quest for the development of alternate biofuels.

Microalgae based treatment was studied to polish biologically treated pharmaceutical wastewater (COD 4704 mg/l, Nitrates 158 mg/l, Phosphates 99 mg/l, pH 7.87) under mixotrophic mode of operation with both biomass growth phase (BGP) for biomass production and nutrient stress phase (NSP) for lipid production. The microalgae showed COD and nitrates removal of 73% and 62% along with the maximum utilization of phosphates and sulphates with the biomass (algae) productivity of 2.8 g/l at the end of BGP. The observed removal rates and biomass increment suggests effective utilization of carbon/nutrients sources for microalgae growth with simultaneous biological waste remediation. BGP favours the biomass production rather than lipid synthesis this might be due to the activity of cell growth enzymes that facilitates towards growth rather than lipid accumulation. Biomass growth is in proportionate with increment in carbohydrates and pigments (chlorophyll) which are considered as the indices of carbon assimilation during the process of photosynthesis and respiratory metabolism.

The BGP biomass when subjected to NSP in presence and absence of light showed decrement in biomass, pigment and carbohydrates. Decrement in carbohydrates indicates the conversion of accumulated carbohydrates to lipids or other metabolites. This led to a marked increase in lipid content and caused a decrease in cellular thylakoid membrane content by activating the acyl hydrolase and stimulates the hydrolysis of phospholipids. The nitrogen limitation can also activate the diacylglycerol acyl transferase, which converts acyl-CoA to triacylglycerol (TAG). These changes increase the intracellular content of fatty acid acyl-CoA (Total lipids, 17%; neutral lipids, 6%).



Schematic representation of microalgae cultivation for polishing pharmaceutical wastewater

The lipid produced at the end of BGP and NSP were transesterified to FAME. Fatty acid profile showed the presence of saturated and unsaturated fatty acids with varying ratios. BGP showed medium chain fatty acids (C6:0-C12:0) where NSP showed long chain fatty acids (C13:0-C20:0) including both saturated and unsaturated fatty acids. The fatty acids depicted to have economic importance with antifungal, antimicrobial along with application in health care, medicine, detergent and cosmetic. The presence of palmitic and stearic acid having fuel property was found to be in noticeable fraction of 8.84 and 18% respectively. Monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) also have wide application as remedy for arthritis, blood pressure, cardiovascular disease, anti-inflammatory agent etc. MUFA and PUFA are also used in the manufacturing of skin care products. The biomass growth and fatty acid profile support the feasibility of integrating microalgae cultivation with advanced biological treatment process in a waste biorefinery approach. Thus the integration process offers multiple benefits to both bioeconomy and environment sector. In this regard microalgae cultivation can be considered as a sustainable route to treat wastewater with simultaneous production of valuable products.

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