



Research Article

Algae Biomass as Alternative Biofertilizers for Sustainable Agriculture and Soil Enhancement

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Abstract | Because of a sustained growth rate in population and anthropologic activities there is a growing need for sustainable and cost-effective farming practices to meet current and future food demands. Because soil is often low in available nutrients and there is an increasing demand to increase crops yields, the application of chemical fertilizers (nitrogen-based inorganic fertilizers) has intensified over recent decades. However, the excessive application of chemical fertilizers can result in environmental pollution and disturb local ecosystem, and sometimes cause crop decline gradually. Furthermore, their continuous overuse may ultimately contribute to nutrient imbalances and soil degradation. For these reasons, it was necessary to reassess many of the agricultural practices currently in place, including the use of chemical fertilizers, pesticides, herbicides and fungicides, and to provide solutions in a sustainable way. In this scenario, algal biomass emerges as a viable option. Algal biomass considered plant-beneficial soil conditioner, which contains significant amounts of growth hormone, polysaccharides, antibacterial material and other bioactive metabolites. known to enhance soil microbial activity, stimulate beneficial microorganisms, and improve nutrient cycling in eutrophic soils. This review examines the feasibility of using algal biomass as a biofertilizer, with emphasis on its potential roles in improving soil properties and supporting sustainable crop production. Furthermore, algal biomass can also be applied in industrial agricultural processes, particularly in wastewater treatment and carbon reduction, thereby contributing to sustainable agricultural development.

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Introduction

Modern agriculture must meet the growing demand for food and natural resources for human consumption. To achieve this, strategies that ensure high agricultural productivity and enhance the efficiency of the agricultural sector

often rely on the intensive use of chemical fertilizers (Osorio-Reyes *et al.*, 2023). Fertilizer are products that supply essential nutrients to plants and may originate from either organic or inorganic (synthetic) sources (Bhatt *et al.*, 2019). Since their introduction in the mid - 20th century, chemical fertilizers have been extensively applied to maximize