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Popular Article

Macroalgae's Role in Mitigating Climate Change

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Abstract

Seaweed emerges as a crucial ally in mitigating human-induced climate change. With its ability to sequester carbon dioxide and counteract ocean acidification, seaweed offers promising solutions. Through carbon sequestration, seaweed absorbs significant carbon dioxide, reducing global emissions. The concept of Blue Carbon underscores seaweed's role in carbon absorption within coastal ecosystems, fostering biodiversity conservation and ecosystem resilience. Additionally, seaweed presents sustainable opportunities in biofuel production, agriculture, and various industries due to its rich nutritional profile and bioactive compounds. Harnessing seaweed's potential not only aids in climate change mitigation but also contributes to marine conservation and sustainable resource management.

Keywords: Seaweed, Climate Change Mitigation, Carbon Sequestration, Blue Carbon, Ocean Acidification

1. Introduction

Earth's climate is changing rapidly, with long-term shifts in temperature and weather patterns caused primarily by human activities like burning fossil fuels. While natural factors once played a larger role, the scientific community, which began raising concerns in the mid-20th century, now has overwhelming evidence that human actions are the main driver. This warming trend is impacting everything from increased frequency and intensity of heatwaves, droughts, floods, and wildfires to rising sea levels and ocean acidification. These changes threaten species with extinction, disrupt ecosystems and food webs, and cost trillions of dollars annually, impacting infrastructure, industries, livelihoods, and even our health. We are facing a real and urgent crisis, demanding immediate action to address the root causes of climate change.

Seaweeds hold promise as a tool to mitigate climate change due to their ability to absorb carbon dioxide from the atmosphere and store it in their biomass. They also contribute to oxygen production and

can be used for biofuels and other sustainable products. It might look like just ordinary underwater plants, but seaweed is turning out to be a powerful solution to many problems caused by climate change. It's like a shining light of hope in our efforts to make the planet better.

Seaweeds are very primitive types of plants lacking true roots, stems, and leaves. Based on photosynthetic pigments/colour the seaweeds are classified into three basic classes. i) Chlorophyceae (Green Seaweed), ii) Rhodophyceae (red seaweed), iii) Phaeophyceae (brown seaweed). In nature, there are roughly 900 species of green seaweed, 4000 species of red seaweed, and 1500 species of brown seaweed (Mohamed, 2015). Of these, about 216 species of green seaweed, 434 species of red seaweed, and 191 species of brown seaweed are found in India (Manickavasagam et al., 2019) and about 54 species of green seaweed, 109 species of red seaweed, and 35 species of brown seaweed are found in Gujarat (Jha et al., 2009). Seaweed aquaculture production in the year 2020 was nearly 35 million tonnes, which is a 1.4% increase year on year. Asia dominates the production accounting for 98% of the global total (FAO, 2022).

2. Carbon sequestration dynamics

Seaweed excels at capturing and storing large amounts of carbon dioxide, which is crucial for the environment. Various types of seaweed efficiently absorb significant quantities of carbon dioxide through photosynthesis. This process not only removes CO_2 from the air but also stores it effectively (Yong et al., 2022). Algae play a major role in global carbon fixation, contributing to about half of it (Chung et al., 2011), and are essential for naturally storing biological carbon, thereby serving as a natural method for reducing greenhouse gas emissions (Buschmann et al., 2017).

The concept of Blue Carbon (BC) is intimately tied to the role of seaweed in absorbing CO_2, a crucial factor in global climate change (Macreadie et al., 2019). BC refers to the organic carbon that coastal and oceanic ecosystems, particularly vegetated habitats, absorb and retain. This phenomenon has garnered worldwide attention due to its potential to mitigate climate change while offering additional benefits such as coastal protection and enhanced fisheries (Duarte et al., 2013).

Although there is ongoing debate regarding the extent to which wild seaweed aligns with the BC framework's criteria, mounting evidence supports the involvement of seaweeds in carbon sequestration, particularly in the context of cultivated production (Krause-Jensen et al., 2018). Therefore, seaweed beds represent a promising option for the sequestration and retention of BC.

3. Addressing Ocean acidification challenges

Seaweed emerges as a vital guardian in the face of escalating ocean acidification, playing a pivotal role in preserving the fragile equilibrium of marine ecosystems., Seaweed farming is proposed as a sustainable strategy to tackle the increasing acidity levels in our oceans (Gao et al., 2018). This innovative approach not only contributes to climate mitigation but also acts as a protective shield for marine life against the harmful effects of ocean acidification.

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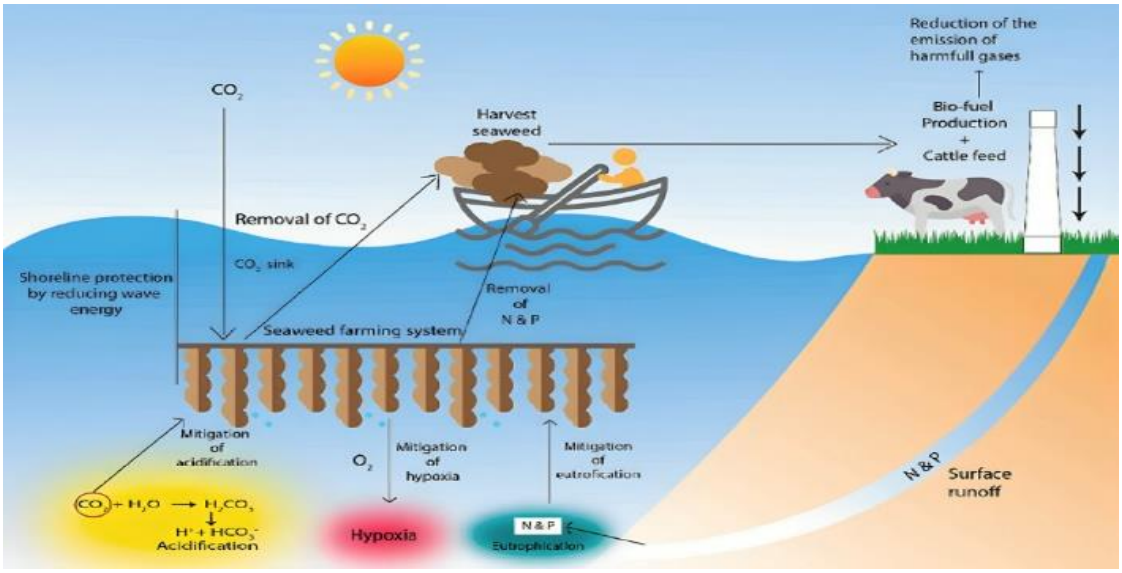
Seaweed's unique ability to absorb CO_2 during growth serves as a dual-purpose solution. Firstly, it aids in reducing the overall carbon footprint, contributing to global climate efforts. Secondly, and perhaps more importantly, the absorbed CO_2 releases calcium carbonate into the surrounding water, which acts as a buffer, mitigating the acidity in the surrounding water (Yu et al., 2019). This helps maintain a more neutral pH level near the seaweed. This protective function is crucial for the well-being of marine organisms, preventing adverse impacts on their shells, skeletons, and overall health.



4. Ecosystem resilience and biodiversity conservation

Seaweed does more than just help with carbon - it's essential for marine life and ocean health (Steneck et al., 2002). It cleans water by absorbing nutrients and filtering out pollutants. With a diverse range of species, seaweed communities contribute to the overall stability of marine ecosystems. They're a key food source for many marine herbivores and support decomposers, which recycle nutrients. Some seaweeds, like kelps, are foundation species, shaping entire ecosystems and providing habitat for a variety of marine life. Kelp forests harbor a greater variety and higher diversity of plants and animals than almost any other ocean community. These underwater forests created by seaweeds offer food, shelter, and breeding grounds for numerous organisms (National Oceanic and Atmospheric Administration [NOAA]).

5. Seaweed as a Sustainable Resource: Biofuel and Agriculture

Due to their exceptional capacity for carbon absorption and storage, seaweeds have the potential to counterbalance emissions resulting from the combustion of fossil fuels (Langton et al., 2019). Referred to as "Blue biofuel," seaweed biofuels present a sustainable alternative to terrestrial crop-based biofuels, as they do not require freshwater, arable land, fertilizers, or pesticides (Duarte et al., 2013). The conversion of seaweed into bioethanol could significantly enhance carbon sequestration (Zacharia et al., 2015), with harvested seaweed capable of yielding biofuel with a remarkable CO_2 mitigation capacity of approximately 1,500 tons of CO_2 per square kilometer per year, thus mitigating fossil fuel emissions (Duarte et al., 2017).

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Various seaweed species possess high concentrations of polysaccharides that can be efficiently converted into ethanol using appropriate technology (Borines et al., 2013). Additionally, seaweed residues from various processing industries could be repurposed for biofuel production, particularly bioethanol. The widespread conversion of seaweed into bioethanol holds significant potential for enhancing climate resilience (Zacharia et al., 2015).

Seaweed extracts serve as stabilizers and stiffeners in the food industry, cosmetics, pharmaceuticals, and biotechnology. These extracts contain plant growth regulators (PGRs) like Auxins, Cytokinins, and Gibberellins (Zhang and Ervin, 2008), which enhance a plant's metabolic functions, promoting rapid growth. Seaweed sap is an economical source of nutrients and inorganic fertilizers in nature. Rich in potassium salt, micronutrients, and growth substances, it boosts yields. Additionally, seaweed finds utility as soil conditioners, fertilizers, green manure, and sources of nitrogen, potassium, and phosphorus. Seaweeds contain abundant organic minerals, complex carbohydrates, proteins, lipids, vitamins, volatile compounds, and pigments. Numerous studies have indicated that incorporating seaweed into the diet of livestock enhances weight gain, decreases methane emissions, and exhibits antioxidant, anti-inflammatory, antiviral, and prebiotic properties. Consequently, seaweed represents a viable alternative feed source for enhancing livestock productivity (Patel et al., 2017).

6. Conclusion

Seaweed emerges as a versatile solution to address various challenges posed by climate change. Its capacity for carbon sequestration and its role in Blue Carbon dynamics underscore its significance in mitigating global carbon emissions and combating ocean acidification. Furthermore, seaweed cultivation promotes biodiversity conservation, ecosystem resilience, and the creation of sustainable resources such as biofuels and agricultural products. By harnessing the potential of seaweed, we not only address climate change but also contribute to the resilience of marine ecosystems and the sustainability of various industries. Seaweed represents a promising avenue for achieving climate resilience and promoting environmental sustainability in the face of the ongoing climate crisis.

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