The Role of Diatoms in Global Carbon Cycling and Climate Regulation: A Review

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Abstract

Diatoms are unicellular algae organism having silica deposition on their surface and habitat to live in freshwater and marine surroundings widely used in paleolimnology to study environmental pollution and ecosystem changes in water sediments. Diatoms play crucial role in life cycle of marine creature especially zooplankton and their food chain. They contribute to global oxygen level and carbon fixation by the process of photosynthesis as they release oxygen to the environment. Significant amount of carbon dioxide is trapped by diatoms silica frustules and sequester carbon settles down on water bed.

Hydrated silicon dioxide which forms frustules acting as cell wall is a part of oceans silica cycle which is recycled by diatoms. Nitrogen and phosphorous nutrients cause oxygen depletion and harmful pollution are recycled through their food chain and support marine life. Diatoms act as indicators of ocean health, global pollution and environmental stressors. As they are indispensable component of fresh water and marine ecosystems for carbon cycling and ecological climate balancing. Diatom has a major contribution to global carbon cycling, biological carbon pump, regulation of climatic changes. Micro algae contribute to carbon fixation and consider as environmental indicators. They regulate silicon cycle with interaction with nitrogen and phosphorous having key role in climatic conditions.

Keywords: Diatoms, Carbon fixation, zooplankton, Silicon dioxide, Paleolimnology, Zooplankton.

1. Introduction

Diatoms are the key producers for aquatic life they play crucial role in the food chain by the process of photosynthesis intake carbon dioxide and release oxygen [1,2]. Diatoms play interdisciplinary application in the field of ecology, biology, geology, environmental chemistry as they are ideal indicators for assessing environmental pollution and carbon cycle [3]. Quick response of diatoms in aquatic bodies towards change in pH, salinity, pollution, metal sediments ensure water quality [4].

Regression and transgression happen while in sea level change from marine habitat to fresh water habitat [5]. Diatoms are the primary producers in marine food chain, contribution of 25 per cent globally as primary producers. key contributors of marine carbon cycling, main producers of oxygen, and provides nutrients to whole aquatic bodies [6]. Microscopic diatoms have vital role nutrient cycling, sedimentation of silica on frustules of diatom, controls habitat of micro and microorganism [7].

Single celled algae, diatoms are arranged with silica deposit as their cell walls to protect from environmental conditions. They are made from hydrated silica by silicification and after their death they are left behind sea beds as become nutrients to aquatic organisms. While in process of formation of silica include silicle acid transporters where silicic acid is being transported to cells of diatoms. Silica deposition vesicle, where polymerization inside intracellular space of diatoms take place.

Silica structure is constructed by cytoskeletal dynamics [8]. Diatoms are photoautotrophic algae organism works with the carbon fixation in ocean intake of carbon dioxide and release of oxygen. Lowering of carbon dioxide diffusion rate in oceans, converting bio carbonates, increasing carbon dioxide availability on water surface major role of diatom as carbon fixation [9]. Diatom consider as diverse species in algae family with estimated species count of 100,000–200,000 is present.

Considered as primary produces, primary duty for carbon fixation, crucial role in climatic regulation, even diatoms are explored in other fields of biotechnology, biofuel, sustainable development, forensic science and more on [10].

Diatoms which belong to phylum Bacillariophyta drive key role in carbon cycling, sinking of silica shells, carbon sequestration in marine waters and iron fertilization boost diatom blooms which offers in potential carbon dioxide uptake which result in climatic mitigations [11].

Aim of the review is to focus on the key role and contribution of diatom in carbon cycling and occurrence, effects on climatic regulations.

2. Diatom Taxonomic Diversity and Ecological Insight

Diatom as unicellular organism from the family of algae occurs in different forms. Eukaryotic diatom belongs to Bacillariophyceae class under Cryophyte division. Structural trait of diatom is based different features which include valve, shape, symmetry, ornamentation also key features for classification [12].

Taxonomic classification is important for identification, water assessment, analysis, ecological monitoring [13]. There is basically two type of diatoms centric and pennate diatoms. Diplontic diatoms basically carry sexual reproduction, consider as parthenogenesis and apogamy [14].

Ecologically diatoms are primary produces of marine food web. They form the base line of food chain supporting other higher tropical level organisms. They possess high nutritional value and rapid growth of marine organisms [15].

3. Role In Global Carbon Cycling

Diatoms are free floating benthic forms having nucleus and pigments for synthesis of food. Diatoms contribute as carbon pump from ocean bed to whole ecosystem as they as key producer of ocean [16]. Generally, they carry out photosynthesis process for the production of their food.

These micro algae consist of two pigments chlorophylls and carotenoids which carry out photosynthesis [17]. Diatom contribute carbon from ocean surface to food web. Carbon also takes role in silica formation in diatoms as a protection wall (*as shown in figure 1*). Regulation on climatic changes on carbon accumulation and synthesis [18].

These photosynthetic organisms composed of exoskeleton that is frustules having two valves, pores, spines and rimoportulae. During the time of reproduction diving of cells absorption of silica acid take place for silica deposition vesicle and form cell wall composed of silica [19].

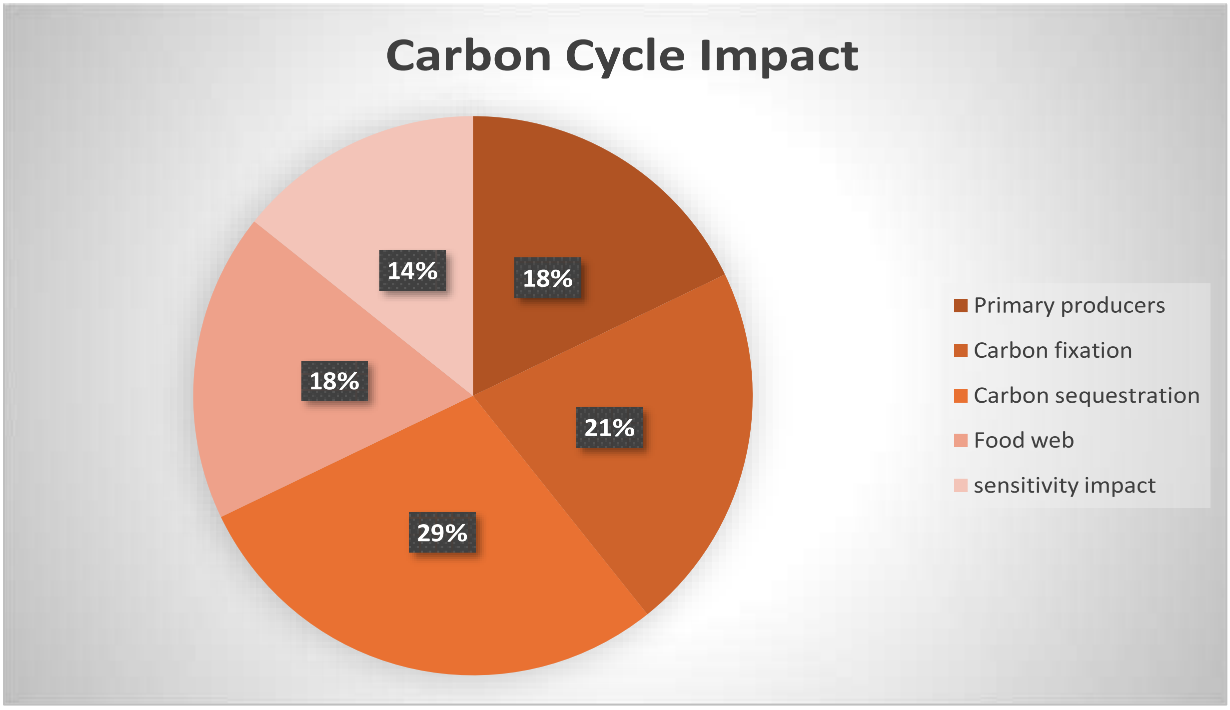

Fig 1- Pie chart showing the factors cause major impact of diatom on carbon cycling

4. Diatom Influence on Climate Regulation

Marine planktonic diatoms are responsible for carbon dioxide export and oxygen expiration. They are capable for climate regulation as they intake and export carbon dioxide. They maintain the carbon level in water and atmosphere surfaces.

They use carbon dioxide concentration mechanism and carry carbon fixation [20]. Through photosynthesis diatom contributes 20 percent for global production. They regulate carbon cycle as carbon cycle is the main cause of climatic changes (*as shown in figure 2*). Carbon pump in ocean sediments regulate carbon production in aquatic ecosystem. They control the global temperature correlation which changes warmer climate to lower diversity and cooler climate to higher diversity [21].

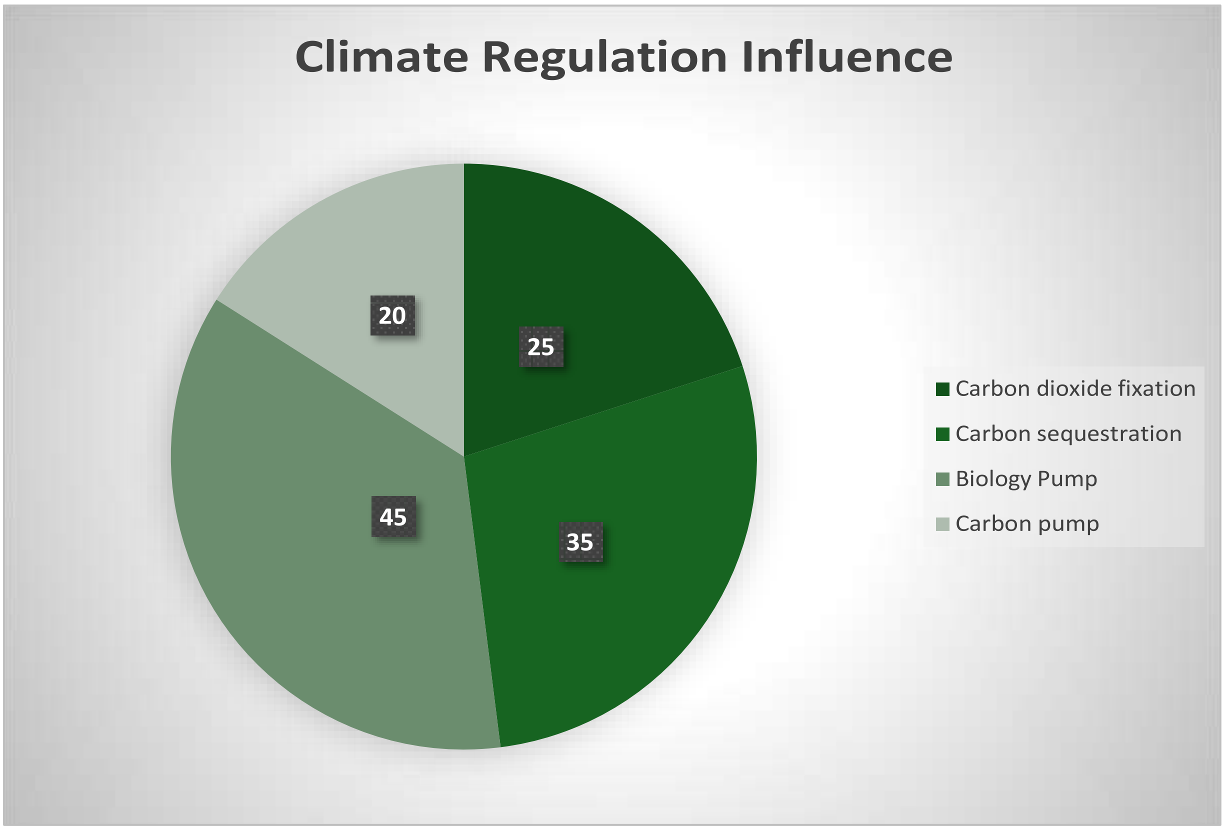

Fig 2 - Pie chart shows the major components of diatom contributed for climatic regulation

5. Environmental Impacts

Diatoms are colonial photoautotrophic microalgae have very much impact on environment and also sensitive to environmental variables. Carbon cycling is the most reason for environmental impact. Environmental variables such as pH, salinity, temperature, toxicity, metal deposition effect the diatom habitat, growth even food chain [22,23].

Physical environmental factors have less impact on diatom composition such as temperature, water current flow, invasive breeding more on. While higher concentration of toxicity, ion concentration and tropical status are major concerns of diatom [24,25]. Diatoms as indicators as they contribute to food web and nutrient cycling. Very much sensitive toward environmental factors [26]. There are prime impacts of diatom as the transference of benthic diatom to planktonic diatom cause change in diatom cycle.

As diatoms are considered as primary producers, increase in primary production and sedimentation could be another cause of impact. And the downstream effect especially in some seasons and invasion of species are a major cause of impact [27].

6. Evolution of Diatom

Trace of evolution of diatom goes back to Jurassic era. Evolution of diatom had taken place millions of years ago and it has significant role in ecologically and biologically. Two type of diatoms, pennate and rapid form emerged from period of late cretaceous and Paleocene period [28]. Diatoms footprint points back to Jurassic period as fossil are evidence for their presence. While examination of fossils shows unique cell division and cell life cycle similar to diatoms. Looking for deeper evolution roots molecular phylogenies are its proof that reveals evolutionary footsteps of diatoms [29].

7. CONCLUSION

Single celled photosynthetic diatoms are found in diverse aquatic environment. They contain nucleus and pigment for reproduction and photosynthesis. They are considered as micro fossil as they contribute to both ecological and environment factors [30,31]. Evolution of diatom took place in 200 million years back. Consider as it belongs to protist family. Their high abundance in both fresh water and marine water with different species diversity [32].

Diatom play major role in global carbon cycling and climate regulation. They contribute crucial role in carbon recycling. Carbon place a spot in photosynthesis and silica deposition on cell walls of diatoms. Carbon fixation converting carbon to organic carbon by the process of photosynthesis helps in ecosystem balancing and reduce carbon pollution. Emission of carbon depend upon the size, shape, synthesis of carbon, and silica formation.

Diatoms contribute a great role in carbon fixation which give a positive impact on environmental pollution and climate regulation. Day by day temperature is raising due to large production of carbon dioxide. Fossils of carbon can be used in paleoclimatology for analysis of climate conditions. They regulate the nitrogen, phosphorus productivity as they are linked with climatic changes. Diatoms are major indicators for pollution and toxicity. They are primary producers in food web can cause bio accumulation towards higher organism in marine ecosystem. This review studies on diatoms role in global carbon cycling and climatic regulation and further helps in their identification also.

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