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International standard for CO2 sequestration using marine biological system: effect and influence of nutrient fertilization

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Biological systems play important role in regulating marine carbon cycles. As the organic carbon fixed by phytoplankton passes through consumers in food web most of it is converted to CO_2 by respiration and microbial activity (decomposition) in surface waters, and released back to the atmosphere. But, some of them sink to the deep ocean by escaping from grazers or microbes, resulting in the transport of CO_2 from the atmosphere to the deep ocean; a process called the biological carbon pump. Phytoplankton productivity increases with increasing availability/concentrations of nutrients (nitrogen, silica and phosphate). The availability of these nutrients also alters the species composition of primary producers. Changes in phytoplankton composition bring changes in food web dynamics and this eventually brings a given impact to the CO_2 sequestration and marine ecosystem. More oceanic CO_2 can be sequestered by enhancing photosynthesis of organic matter but by reducing grazing and delaying remineralization of the detrital material sinking in the water column. Nutrients generally occur naturally in seawater in fairly constant ratios that can be altered by anthropogenic additions. Shifts in biogeochemical processes in the ocean also alter the nutrients ratios. Hence, fertilization of nutrients in marine ecosystems is one of the useful options for removing the atmospheric CO_2. In this paper, we will report the influence of nutrient fertilization (in different concentrations and ratios) to marine ecosystem in order to propose the standard references for nutrient fertilization for effective CO_2 sequestration with minimum changes in the food web and diversity of marine ecosystem.

We performed incubation experiments by adding nitrate alone or nitrate with ammonium or silicate in different combinations to seawater collected from two different stations (St. C and St. O) off Japan Sea near the Northwest of Kyushu Island, Japan at 33^o29'N and 129^o 26'N. Nutrients were added in the following combinations and concentrations to make 6 set of enrichment for each station: nitrate (1 micromole(s) l^{-1}), nitrate (3 micromole(s) l^{-1}), nitrate & ammonium (1.0 & 0.25 micromole(s) l^{-1}), nitrate & ammonium (1.0 & 0.5 micromole(s) l^{-1}), nitrate & silicate (1.0 & 0.5 micromole(s) l^{-1}), nitrate & silicate (3.0 & 1.5 micromole(s) l^{-1}). In addition to these seawater from each station was incubated without adding any nutrient (control).

The results showed that in all cases of enrichments, primary production (measured using 13C tracer) increased compared to control. However, the combination of nitrate and silica was the best condition for higher primary productivity. Our results suggest that modified nutrient concentrations and ratios can significantly impact marine food web structure and biodiversity. At high concentrations of nutrients nitrate and silicate (with N/Si ratio of 1) the productivity is high with maximum changes in initial ecosystem but the diversity is low because of rapid growth of certain groups e.g. diatoms, resulting in high possible sequestration of carbon. At low N and high Si (N/Si = 0.5 or smaller than 0.5), the productivity will be medium with moderate possible sequestration of carbon but the change in ecosystem and biological diversity will also be moderate to low. At low N and low Si (N/Si = 0.5~1), the productivity is low with minimum changes in initial ecosystem structure (high biological diversity), resulting in less possible sequestration of carbon. Therefore, we propose that for high productivity and effective sequestration of CO_2 with less change in ecosystem structure and diversity, fertilization of nutrients should be around 5micromole(s) l^{-1} for nitrate with an N/Si ratio of ~1.