Opinion

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About Indicators of Nutritional Disbalance of Phytoplankton (e.g. Si/N, P/N, Fishery)

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SUMMARY

Well-being of diatoms is associated with well-being of watersheds, oceans and fishery. "Excess nutrition" with algal blooms and fish kill in watersheds and coastal waters is a common expressed problem nowadays. But opposite phenomena are experienced in Egypt and Japan: deficiency of nutrients has caused problems. Deficiency of dissolved Si (< 2 µM) and low P/N ratio can reduce diatom proportion in phytoplankton with harmful consequences in carbon binding and fishery. Low Fe can promote harmful metabolic disorders. Experimental studies on optimal nutrition of phytoplankton are suggested, in order to avoid metabolic disorders of watersheds (including oceans) and to secure their food production and CO2 binding.

Keywords: Fishery; Phytoplankton; dissolved Si (DSi), Si/N, N/P; Hypoxia; Trace Elements

Abbreviations: N: Nitrogen; P: Phosphorus; Si: Silica

Introduction

Sixty-five percent of the estuaries and coastal waters in the contiguous U.S. that have been studied by researchers are moderately to severely degraded by excessive nutrient inputs (eutrophication). Excessive nutrients – especially nitrogen (N) and phosphorus (P) - lead to algal blooms and low-oxygen (hypoxic) waters that can kill fish and seagrass and reduce essential fish habitats [1,2].

On the other side, in Egypt: "Prior to construction of the Aswan High Dam (1964), the annual Nile flood delivered about 9 000 t of biologically available phosphorus (P), at least 7 000 t of inorganic nitrogen (N), and 110 000 t of silica (Si) to the Mediterranean coastal waters of Egypt. These nutrients stimulated a dramatic "Nile bloom" of diatoms which supported a productive fishery. After closure of the dam in 1965, flow from the Nile was reduced by over 90%, and the fishery collapsed. It remained unproductive for about 15 years. The fishery began a dramatic recovery during the 1980s, coincident with increasing agricultural and urban discharges [3].

Explanations and Discussion

Explanations via Phytoplankton: Phytoplankton communities can be divided into 2 basic categories: those dominated by diatoms and those dominated by flagellates or non-diatomaceous forms. Growth of diatoms depends on the presence of silica while growth of the non-diatomaceous forms normally does not [4]. Flagellate communities are often associated with undesirable effects of eutrophication while diatoms are not [4], i.e. the N: Si ratio influences the composition of phytoplankton. Diatoms are a large group of algae, specifically microalgae, found in the oceans, waterways and soils. They are the most common type of the plankton [5]. Living diatoms make up a significant portion of the Earth's biomass: they generate about 20 to 50 percent of the oxygen produced on the planet each year, [6,7]. Diatoms are especially important in oceans, where they contribute an estimated 45% of the total oceanic primary production of organic material (food/feed) [5] and participate with silica (SiO2) and carbon cycle in carbon binding [5]. There are different evaluations on balanced nutrient levels in water. For Si:N:P ratios are given an estimate (16:16:1) [8]. An other evaluation is based on the growth limiting levels of dissolved silica [Si(OH)4, DSi, "dissolved Si" or "Si"]. Egge and Aksnes determined in 1992 experimentally that diatom percentage of total cell count was over 60 %, generally over 80 %, irrespective of the season, (independent of seasonal variation of other elements?) if DSi concentration exceeded a threshold of ~ 2 µM Si [9] resp 2 x 28 = 56 µg Si/l [10].

Historically in the Baltic Proper, the estimated DSi concentrations were at the begin of the last century (ca. 1900) 2.6 times higher than at present [11]. There are several explanations for it [8]. Possibly changes in fertilization associated with reduced weathering [12], reduced production of DSi in agricultural soils and obviously reduced DSi content in run-off waters, groundwaters and watersheds.

Recovery of fishery of the Nile in the 1980's was associated with increased high NP supply cum Si dominance in the Nile: Si (2700 μg/l, 96 μM), N (29 μg/l; 2.1 μM) and P (23 μg/l /0.74 μM), i.e. with Si:N:P atomic ratios 130:2.8:1 and (consequently) diatom dominance [13] of Upper Egypt" [which consists of the entire Nile River valley from Cairo south to Lake Nasser (formed by the Aswan High Dam)] [14]. Delay in recovery of fishery in Egypt after 1964 can be explained by the time needed to replace the historical discharges of fields and forests (the sediment transported by the Nile) by agricultural and urban discharges (e.g. N and P) [3] and to rejuvenate the large irrigated areas for the production of DSi [4] and other nutrients [12] promoted by soil microbes [15-18]. Between 1980 and 2000, the total lagoonal fishery of Nile delta tripled, but at Alexandria decreased obviously depending on increase of N above 100 μM/l. [19] (as a consequence of overconsumption of DSi? [4,9]).

Fish catch reduction at Nile delta opposite the Nile between 1965-80 was very limited [3,19]. Harmful effects of eutrophication (red tides) have been experienced in Japan, but its treatments (seawater "improvement") by reducing phosphorus lowered the phytoplankton (especially diatom) primary production, which caused a detrimental effect on the fishery production in the Seto Inland Sea [20].

There is a great variation inside diatoms. Some Pseudo-nitzschia species of diatom genus can be harmful, especially in iron deficiency, they are capable to produce toxic domoic acid [21].

Erosion can be defined as the geological process in which earthen materials are worn (e.g. weathered) away and transported by natural forces such as wind or water [22]. Enhanced erosion (mechanical crushing of stones and transportation by machines) has been tentatively successfully benefited in agriculture for carbon binding and increasing crop yields [23] and conceivably for DSi production. Possibly DSi (and other nutrient) production can be promoted by breeding microbes [15-18] for weathering of (analyzed) silicate wastes and silicates of cropland, too.

Conclusion

Besides of nutritional excess, nutritional deficiencies can produce harmful consequences in fishery, e.g. by insufficient amounts of dissolved Si (< 2 mM), low P/N ratio and by low Fe content. Experimental studies are suggested in order to find optimal nutrition for phytoplankton of watersheds (including oceans) and to secure their food production and CO_2 binding.

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