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Review Article

Ecological Potentiality of Plankton: A Perspective on Nutrition, Toxicity and Bio-Indication

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Abstract

The base of aquatic energy is initiated and concreted by plankton such as primary photosynthetic algae and consequently their immediate secondary grazers as zooplankton. The nutritional features of algae or phytoplankton are controlled by aquatic nutrients (e.g. nitrogen, phosphorus, silica and other essential minerals). Moreover, the biochemical content of zooplankton reflects their diet profiles (e.g. bacteria and algae). The promising and sustainable fisheries prospects are crucially subjective by nutritional quality and quantity of plankton (e.g. algal bloom). Additionally, both algae and zooplankton are efficient as auspicious biological tools for indicating the aquatic environments.

Introduction

Aquatic algae provide essential nutrients directly to higher trophic level or through zooplankton. Thus, zooplankton have an obvious role in this nutrition transportation in aquatic food web. Phytoplankton as algae can synthesize their own energy by photosynthesis in the presence of sunlight. Furthermore, prominent aquatic nutrients such as phosphorus and nitrogen are known as important nutrients to the algal chemical composition and growth. Consequently, zooplankton are exclusively dependent on an algal diet for self-nourishment with several essential amino acids, fatty acids, vitamins and minerals [1-9]. Most prominently, the fundamental linoleic/linoleic acid and essential pigments are only produced by algae so higher aquatic fauna are entirely dependent on algal biomass [10]. Therefore, the major groups of zooplankton like rotifer, copepod, cladocera and crustacea are dominated in aquatic environments with their specific morphological and habitual features [11-13]. The interconnection between algae and zooplankton constitute the nutritional composition in the food web. The zooplankton and larvae of fish or crustacean demands HUFA (Highly unsaturated fatty acids) and PUFA (Polyunsaturated fatty acids) in their diet for healthy growing and sufficient nutritional requirement [3,4]. Despite this essential nutritional contribution of algae, they are also well known for their secondary metabolites as allelochemicals and toxins. In most of the time, the toxins expel from their ruptured cells after death during the end of the bloom. Moreover, algae secrete their allelochemicals to dominate in competition with other algal communities and self-defense from predators (e.g. zooplankton, fish and crustacean) [15]. Algal toxicity has dynamic effects in aquatic food web subsequently in human health [5, 16-19]. Besides, the tolerance of algae and zooplankton to the harsh environment due to natural stresses (e.g. global warming, sea level rising and intrusion of saline water to freshwater environment) and anthropogenic hassles (e.g. pollution of plastic, heavy metal and pesticides) [20] is also draw attention to the scientists [21-28]. However, algae and zooplankton both have a number of benefits and threats in wild or aquaculture fisheries and in perspective on human health issues (Table 1). Their tolerance level to polluted environments is evidently supported to illustrate several reasonable pollution indices. This review attempts to focus on nutritional contribution, toxicity and bio-indicating roles of algae and zooplankton.

Nutritional Contribution

Algal nutritional composition is constituted by availability and abundance of chemical nutrients (e.g. nitrogen, phosphorus). Moreover, the nutritional content is also varied with specific algal groups such as green algae (chlorophyta), diatom (bacillariophyta), blue-green algae (cyanophyta) and euglena (euglenophyta). Particularly, diatoms are dependent on silica content in the environment for their frustules and blue-green algae (cyanobacteria) are required phosphorus for dominating in the environment [2]. Unlike a continuous supply of phosphorus, cyanobacteria can also survive from their stored phosphorus in food scarce environments. In addition, diazotroph (e.g. Nitrogen fixing organisms) cyanobacteria can also survive and provide nutrition to higher trophic levels in nitrogen limited conditions [14]. All of these algae (chlorophyta, bacillariophyta, cyanophyta and euglenophyta) have obligatory roles in supply unique nutrition (e.g. HUFA, PUFA, Vitamins and Minerals) to the aquatic higher trophic (e.g. zooplankton, fishes, crustaceans) levels [29]. As secondary and immediate consumers of algae, zooplankton accumulate a satisfactory level of nutrients through their diet on algal biomass [10]. As filter feeders, rotifers, cladocerans and crustaceans are broadly fed on algal diversities. In exception, copepods have shown their selective feeding mode due to their picky palatability or extraordinary food screening capability. However, the diet of zooplankton reflects their nutritional contribution and suitability to the upper trophic organisms through larval (fish or crustacean) feeding. The larvae of all aquatic higher organisms (e.g. fishes, crustacean and mammals) have preferred micro algae and zooplankton due to their tiny mouths and improving digestive tracts for easy digestion and sufficient protein (HUFA/PUFA) requirement. Furthermore, larvae have favored zooplankton for their thin exoskeleton and digestive enzymes (amylases, lipases) and especially zooplankton movements (swift swimming and jerking) have attracted larvae more than algae or any inert food items. The algae and zooplankton are also exclusive sources of several pigments (e.g. astaxanthin, canthaxanthin) which act as antioxidants in fish, crustacean and mammal bodies. The exclusive version of proteins such as DHA (Docosahexaenoic acid), EPA (Eicosapentaenoic acid) and ARA (Arachidonic acid) have crucial roles in neurological development, reproductive improvement and growth stimulation. Additionally, several vitamins (e.g. Vitamin A, B1, B12, C and E) and minerals (Iodine, Copper, Calcium and Selenium) from algae and zooplankton act as precursors of critical enzymatic actions and prevent malnutrition and genetically derived abnormalities [3, 4, 10, 29]. The several preservation methods (e.g. cryo-freezing) are successfully experimented on many algae and zooplankton (e.g. resting eggs, juveniles and adults) species [13]. Hence, cryopreservation is a very promising tool in preserving strains of any organisms for further utilization but this method is also cost unbearable in economic scale [30, 31].

Table 1: The fundamental benefits and threats of algae and zooplankton in wild fisheries, aquaculture an health issues.

Algae/ Zooplankton	Benefits or Threats	Wild Fisheries	Aquaculture	Health Issues
Algae	Benefits	Algae are recognized as primary energy producers in aquatic bodies. They can generate their own energy (e.g. photosynthesis). Algae also synthesize some unique amino acids rather than other organisms [2, 3].	Algae are the basic components of "green water technique" for zooplankton culture. Furthermore, algae are the basic foods in oyster culture. The algal biomass is the foundation of aquaculture industries [3, 50].	Algal selective essential metabolites are used in pharmaceutical and food industries. Algae are commercially cultured for maximum exploration of their several metabolites. Algae are used in many ways such as food ingredients, medicinal ingredients and fish feed ingredients [48, 49].
	Threats	Algal blooms create a suffocative (e.g. deficiency of oxygen) environment for aquatic living organisms. The toxins from ruptured algal cells are caused to enormous fish mortalities [14, 16].	Harmful algal secondary metabolites (e.g. off-flavoring agents, ichthyotoxin) are caused to off-flavor in water bodies even in fish or crustacean mussels and massive fish mortalities [52, 53].	Algal toxins (e.g. cyanotoxins derived from cyanobacteria) are caused to many human neurological and hepatic diseases. Algal toxins are responsible for deteriorating the water quality and make it undrinkable to local people [14, 18, 19].
Zooplankton	Benefits	Zooplankton are potential secondary nutrients (HUFA, PUFA, DHA, EPA, ARA and essential vitamins/minerals) sources to fisheries [3, 10].	Many freshwater and marine groups (e.g. rotifer, copepod, cladocera and crustacean) are commercially applied as live feeds in larval nourishing [4, 29].	Healthy and essential nutrients (e.g. HUFA/ PUFA/Vitamins/Minerals) enriched fishes and crustaceans are consequently better for human health [3, 10].
	Threats	Excessive zooplankton grazing could be a threat to algal diversity and abundance [11,12].	Nutritionally poor zooplankton have caused neurological and physiological abnormalities of larvae [3, 10].	Zooplankton (e.g. copepods) have acted as potential vectors of pathogenic bacteria (e.g. Vibrio cholerae) and caused severe diseases [51].

Toxicity

Algal toxicities have many remarkable adverse impacts on aquatic environment and consequently in the human body. As previously mentioned, algal blooms are initiated and sustained by the aquatic nutrients (e.g. nitrogen and phosphorus), afterwards the toxicity could be explored from dead algal bodies by rupturing cell walls. Blue-green algae (cyanobacteria) are most well-known for toxicity in aquatic environments (e.g. aquatic columns and bottom sediments) and organisms (e.g. fishes, crustaceans, mammals) consequently human body [14, 15, 17]. Massive fish mortalities are caused by cyanotoxins (e.g. cyanophyta) and euglenophycin (e.g. euglenophyta) in wild and aquaculture industries [30]. The algal toxicity also interrupted the zooplankton feeding (e.g. filter feeding) of rotifers and cladocerans. Naturally, the filter feeder zooplankton as rotifers, cladocerans and crustaceans have very limited options to avoid toxic algae might be caused to many diseases such as except understanding the presence of toxic algae [14-17]. The algal toxins have infected human skins, lungs and stomach through direct contamination (e.g. swimming, toxin aero soling, drinking water). The aquatic fisheries foods (e.g. sushi) and oysters are associated with either only processing and dressing or cooking at low temperature are caused to many human diseases. The edible fisheries food items are infected by PSP (Paralytic shellfish poisoning), ASP (Amnesic shellfish poisoning), DSP (Diarrheal shellfish poisoning) and NSP (Neurotoxic shellfish poisoning) which consequently effects human body through direct consumption [14, 15, 17, 18, 19]. Molecular experiments on determination of algal evolutions and toxin origins are found possibly appropriate in advanced research [13, 33]. Algal toxins worldwide have threatened the freshwater, estuarine or marine water bodies. The coastal regions and estuaries are very sensitive to harmful algal (e.g. Dinoflagellate) bloom [34]. The surplus nutrients (e.g. nitrogen and phosphorus) supplies influence the harmful algal (e.g. cyanobacteria and euglena) and cause avoidance for drinking, bathing, fishing and other daily activities. Algal toxins increase the value of drinking water by contaminating the natural drinkable water sources (e.g. rain-fed ponds, lakes, wetlands). People are irritated by direct contamination and unsafe drinking water from these contaminated freshwater reservoirs due to poisonous algal pollution [8, 14, 35].

Bio-Indication

The survival of algae is developed by their self-protective attitudes not by competition [36]. Thus, a number of algal groups have succeeded to survive in harsh environments such as highly organic polluted environments [37]. For many years, the scientists have worked on algal tolerance and adaptability in environmental and anthropogenic stressful conditions. Algae are categorized in several groups according to their tolerance capability to aquatic pollution. Habitually readily identifiable and captive cultivable algal species, which have low variability and enough ecological data, are suitable for use as bio-indicator. A remarkable number of studies are conducted to use algae as bio-indicator to evaluate the water quality of ponds, canals, rivers, estuaries and coastal areas [37-41]. Mostly, cyanophyta (e.g. Oscillatoria) and euglenopyta (e.g. Euglena) are found highly tolerant to organic pollution [37]. Furthermore, the major groups of zooplankton such as rotifers, copepods, cladocerans and crustaceans are also accepted as potential bio-indicator of water pollution (e.g. natural or anthropogenic) [42,43]. The composition of zooplankton and their relative abundances in any specific water reservoirs indicates the water quality. The tolerance to food scarcity, competition with co-predators and avoidance of predation have influenced the zooplankton efficiency in challenging survival [1, 11, 12, 42, 44, 45]. Thus, these challenging survival approaches of zooplankton are supportive to evaluate the pollution (e.g. algal bloom, heavy metal, pesticides and plastic) level of their belonging ecosystem [11, 12]. The freshwater bodies are compromised with many environmental and anthropogenic hassles [5, 11, 46, 47]. The up growing urbanization has created an intolerable pressure on zooplankton and algal survival in aquatic bodies. In this perspective, the evaluation and grading of water quality in several types of aquatic bodies (e.g. ponds, lakes, wetlands, rivers and estuaries) are necessary for better monitoring of ecosystem and biodiversity conservation. Many studies showed that the zooplankton and algal composition have shown relation with a number of physico-chemical parameters such as temperature, transparency, salinity, alkalinity, ammonia, phosphorus, silica and well as others [11, 12]. However, the applications of some well-established algae and zooplankton pollution indices are supportive to evaluate the preliminary features of aquatic fisheries productivity.

Conclusion

Planktonic creatures both algae and zooplankton, have important roles in aquatic food webs with their nutritional contribution and bio-indication capability. Moreover, Algal toxins and allelochemicals have interruptions in zooplankton feeding and consequently infections and mortalities in tertiary aquatic organisms. However, the obvious nutritional involvement of algae and zooplankton in wild fisheries or aquaculture is obligatory for sustainable ecological balance.

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