Importance of Plankton in Aquaculture

Aquaculture organisms have to obtain all their nutritional requirements, except for part of the mineral requirements, through the food they consume. In nature, most of the organisms subsist on live food consisting of plants and animals obtained from the environment, but some do ingest and possible utilize detritus along with associated organisms. The initial source of food for many larval organisms is phytoplankton. This is probably associated with the size of the larvae at hatching. After a certain period of time, the larvae of most species can be fed exclusively on zooplankton or a combination of plant and animal matter i.e., plankton. The term 'plankton' can be defined chiefly as microscopic drifting or floating organisms in the sea and fresh waters and may be having feasible floating devices. The plant components of all the plankton are the phytoplankton and are the primary producers for the entire aquatic body, whereas the animal components of the plankton are the zooplankton and are the primary consumers.

Phytoplankton

Aqua-farmers pay much attention to the colour of the pond water. In other words, they place great importance on the promotion of phytoplankton in pond water. In nursery and grow-out ponds, they are generally produced as a result of biological cycle initiated by mineral nutrients in water. Using the sun's heat and light they transform the inorganic matter and carbonic acid in solution into organic matter, in the form of vegetable tissues consisting of a variety of phytoplankton. The following objectives are associated with the phytoplankton:

1. To increase dissolved oxygen and to decrease toxic gases like ammonia, nitrite, hydrogen sulfide, methane, carbon dioxide in pond water.
2. To stabilize pond water quality and to lower the content of toxic compounds.
3. To make use of plankton as a natural feed.
4. To provide shade and to decrease cannibalism.
5. To increase and stabilize water temperature.
6. To minimize pathogenic and unwanted microbial population by competing with the available nutrients in the water.

So, Phytoplankton plays a significant role in stabilizing the whole pond ecosystem and in minimizing the fluctuations of water quality.

A suitable phytoplankton population enriches the systems with oxygen through photosynthesis during daylight hours and lowers the levels of carbon dioxide, ammonia, nitrite, hydrogen sulfide, methane etc. A healthy phytoplankton bloom can reduce toxic substances since phytoplankton can consume ammonia-nitrogen and tie up heavy metals. It can prevent the development of filamentous algae since phytoplankton can block the light to reach the pond bottom. A healthy bloom also provides proper turbidity and subsequently stabilizes shrimp and reduces cannibalism. It decreases temperature loss in winter and stabilizes water temperature.

Phytoplankton also competes for nutrients with other microbes and lowers pathogenic bacterial population while increasing the density of food. Maintaining a stable water colour is the key factor in water quality management. The color of pond water usually indicates the predominant phytoplankton species.

A change of water colour or its intensity indicates changes of phytoplankton flora and densities. Sometimes the water colour changes suddenly resulting in mass mortality of phytoplankton. It usually takes place when the phytoplankton reaches the peak of its reproductive cycle, or the physicochemical environment suddenly becomes unfavourable to phytoplankton, such as a drastic salinity or temperature change or a shortage of nutrients, or through massive grazing of zooplankton. Phytoplankton can approach their peak rapidly during warm days in intensive culture ponds where nutrients are abundant. Caution should be taken when plankton is getting dense.

Mass mortality of phytoplankton during warm days possesses a threat to the prawn, shrimp and fish survival. High temperature makes decay of the deposited dead plankton cells quickly and it leads to the consumption of oxygen and hence depletion of oxygen. The resulting anaerobic sediment can release ammonia and sulphide, which stress *to* the benthic shrimp and prawn, causing the need to build a capability to do rapid water exchange in the aquaculture farms.

Mass mortality of phytoplankton usually proceeds in four stages. First, water colour intensity increases progressively. The colour intensity is homogeneous throughout the water column. This occurs when a few phytoplankton species have become dominant in the community and have started to propagate rapidly. Second, clusters of colour appear on the water surface. This occurs when some of the phytoplankton has not yet ruptured. Third, milky clouds appear in the water column, water becomes sticky and scum and foam on the water surface when paddlewheels are running. This may occur when the cell walls of the phytoplankton have ruptured, the cell substance and pigment have reached out and the phytoplankton has lost its colour. Fourth, the water clears up and the transparency readings dramatically increase. The dead phytoplankton is no longer suspended in the water and either floats up or sinks to the bottom.

The beginning of drastic water colour can be observed by unusual mass moulting of shrimp or when feed consumption decreases too suddenly. This is due to the leaching of nutrients from the unconsumed feed during moulting or period of ill health and also due to overfeeding. High organic loading can result in overabundance of nutrients in an aquaculture system. Over development of phytoplankton from such nutrients can result in excess photosynthetic oxygen generation in the afternoon hours. When water becomes supersaturated with oxygen, shrimp may suffer from gas bubble disease which is indicated in their floating on the water surface with bubble-congested gills. Meanwhile, on overcast days or during evening hours, when phytoplankton change from being oxygen producers to consumers of oxygen the pond water system often becomes deficient in oxygen. Therefore, a pond with a heavy bloom of phytoplankton has wide fluctuations in diurnal pH value and dissolved oxygen concentration. Conditions of high pH, DO and ammonia can be found in ponds with dense phytoplankton concentration during the afternoon.

When these conditions occur increased unionized ammonia due to high pH can be a threat to shrimps/prawns/fish health. Low levels of phytoplankton have more stable pH and dissolved oxygen values, but are unsuitable for aquaculture. This is because phytoplankton are also needed to provide a food base and to provide turbidity to control the light penetration to the pond bottom where filamentous algae can grow. It is suggested that moderate plankton is more desirable than heavy production. Phytoplankton density is usually monitored with the help of secchi disc reading.

Phytoplankton species composition and densities can be manipulated by adjusting salinity. Lowering salinity helps the development of green algae communities. Increasing salinity favours the growth of diatom communities. Species composition can also be changed by inoculating phytoplankton from hatcheries that produce a mass culture of phytoplankton. It can also be changed, by altering pH, by adding the substances like lime and dolomite. Lime, dolomite and zeolite can raise pH. Teaseed cake can lower pH. Increasing the water exchange rate can lower phytoplankton density whereas aeration can improve water quality.

The types of water colours of aquaculture ponds and their relationship is given below:

1. Golden brown or reddish brown:

This kind of water colour has a high probability of comprising diatoms in the pond. It occurs frequently due to lower temperature, and in saline waters having high organic matter concentration. Transparency is normally between 25 and 35 cm.

The blooming of diatoms causes this colour. Algae species such as *Chaetoceros, Navicula, Nirzschia, Skeleronema, Cyclotella, Synedia, Achnanthes, Amphora* and *Euglena* are often found in pond water of this colour, especially the first three species. This colour is quite difficult to achieve.

Diatoms are abundant in nutrients and are easily digestible. Golden brown colour is usually related to a crop of healthy shrimp, with brilliant body colour and is an indicator of an expected good yield.

2. Light or Bright Green:

This colour is due to the growth of green algae, especially *Chlorella.* In addition, *Dunaliella, Plarymonas, Carteria, Chlamydomonas* are also present. In less saline water, *Scenedesmus* and *Euglena* can also be found. Water of this colour is usually quite stable. In other words, the mortality of prawns is low.

Transparency is usually between 20 and 70 cm. It usually occurs in a new pond, sandy bottom pond and ponds with less organic sediments. The growth rate of shrimp/prawn/fish in this environment is quite stable, although it is comparatively slower than that in the brownish water and they grow with less variability of size.

This kind of water colour is easy to manage. Culture animals in a pond are susceptible to disease when the green water turns too dense with a dark green color. However, it seldom causes high mortality.

3. Dark Green or blackish green colour:

When the pond water temperature gets too high, deterioration of the pond bottom or organic materials accumulate too fast, blue-green algae bloom faster than green algae. Blue-green algae such as *Oscillatoria, Phormidium* and *Microcoleus* dominate (accounting for 90%). Although the survival rate of shrimp in ponds with this colour still remains high, the growth rate sinks.

The appearance of shrimp in this water colour becomes dark green or acquires a black colour. Sometimes it is even bad looking having been infested with protozoa and germs. In this environment, shrimp grow slower and unevenly with the great difference between large one and small one and a high degree of skewness of size. Furthermore, it causes a higher percentage of soft-shelled shrimps and blue-sky coloured shrimps especially in low salinity conditions. It also weakens the shrimp. It is not a desirable colour in semi-intensive culture and should be transformed and improved through management.

4. Dark Brown and Sauce-like Colour:

Poor pond management, such as over-feeding or using large amounts of trash fish, causes rapid growth of dinoflagellates and brown algae and consequently results in the formation of this water colour. Such water conditions are undesirable and it is recommended to change the pond water partially if this colour arises.

It indicates super-eutrophication that is usually caused by over-feeding, deterioration of pond bottom, low water exchange rate, high concentration of organic matter and high application of trash fish. Transparency of this water is about 15 cm. It forms a lot of bubbles while using aerators. It is not a desirable water colour in pond management because it usually weakens the shrimp and sometimes causes dropsy and makes the animal susceptible to gill disease. It always produces a poor harvest.

The reason for this dark brown colour to form is not due to algae, but by the pigment and tannic acid, that normally occurs a high concentration in mangrove area because of acid sulfate soils.

5. Yellowish Colour:

The formation of yellow water is due to the growth of *Chrysophyta.* In addition, green flagellates may also grow moderately. In a pond with water colour of this type of growth of benthic diatom, blue-green algae and green algae is inhibited. This kind of water is very stable in colour, although it is not a desirable one for the shrimp/prawn culture. It is usually formed in old fish ponds that have accumulated a high organic load over a long period and through bacterial action. In ponds with water of this colour, growth of shrimp/prawn is inhibited and chances of high mortality exist. Because all these algae/phytoplankton are very small in size, they cannot be used directly as natural foods by the shrimp/prawn. The phytoplankton forms an indirect source of food to shrimp/prawn through zooplankton as they consume phytoplankton.

6. Foggy White Water:

This mainly comprises zooplankton, clay particles and detritus. It is an ideal environment for the growth of fry or juvenile prawns since it provides natural feeds. On the other hand, for the adult prawn, there exists a disadvantage of competing with the environment during the culture period. In waters of this colour, zooplankton gathers together and gives the appearance of being suspended as a white spot. Too high a population of zooplankton in the environment interferes with shrimp behaviour and can cause damage to shrimps. It is also indicative of the die-off of algae or the deterioration of water quality with resulting propagation of bacteria. This water colour will need to be well controlled during culture period.

7. Turbid Water:

The formation of turbid water may be due to the suspension of zooplankton, clay particles or detritus. This kind of water can be beneficial or harmful, depending on the quality and quantity of the suspended materials.

It is formed by clay particles that originate from the dike and are dissolved by rain or from the river where freshwater is sourced. Sometimes, it is caused by strong wind and the resulting disturbing movement of shrimp at the bottom. This turbid water can provide some advantages not only to stabilize the water quality and shrimp habitat, but also provide some nutritional effect since the clay particle can absorb nutrients, organic particles and microorganisms to form “clay floccules” which can serve as shrimp natural feed. However, if the original water is clear, unlike the water that had the colour as discussed earlier, too many clay particles can be negative to the growth of shrimp.

8. Clear Water:

This water is transparent. This may be caused by a lack of nutrients, the presence of heavy metal pollutants like copper, manganese, iron or acid-bottom clay (pH 5.5 or lower). Under these conditions, no organisms can grow properly. It goes without saying that this kind of water cannot raise a good crop of shrimp/prawn/fish, because it indicates that something is wrong with the soil or the water quality. This must be improved at the start of shrimp/prawn/fish culture.

It is evident that some types of water colour are desirable, some are not. In order to achieve a particular colour, algal nutrients may be used. It is suggested that ammonium salts are good for green algae growth, while urea is good for brown algae (i.e. diatoms).

When the colour becomes undesirable owing to over-blooming, bactericides, insecticides and algaecides may be used.

Increasing aeration and/or partial replacement with clean water may also be helpful in changing water quality. Feeding greatly influences watercolour and water quality. Over-feeding should be avoided. The use of too much trash fish may cause a blooming of flagellates, which is not desirable.

Transparency

There is a high correlation between secchi disc visibility and phytoplankton (water colour) density. Secchi disc visibility is the average of the depth at which a disc, a round plate with alternating black and white quadrants disappears and reappears from view when sunlight is intense or moderate. The optimum range for secchi disc reading is between 30 and 60 cm to the juvenile stage and between 25 and 40 cm to the sub-adult and final stage.

High secchi disc reading is associated with low productivity of the pond and low secchi disc reading is associated with high productivity of the pond. In general, high productivity ponds are having high biomass that increases oxygen consumption, which may lead to oxygen depletion.

Secchi Disc Measurements

Secchi disc is a simple circular plate/disc with alternate segments painted black and white. The plate/disc is mounted at the end of a rod/stick upon which distances are marked with zero being at the plate end. To take transparency measurements a farmer can either stand on walkway platform or at the edge of the dike and lower the secchi disc holding the end of the stick slowly into the water. The depth at which the black and white segments of the disc disappear is the secchi disc reading.

What to do when an Algal Bloom collapse takes place?

For extensive farming 30-50% water exchange has to be done. Using pond bottom drain, followed by dolomite (PearlSpar) application, inoculation from a neighbouring healthy pond (transferring pond water from a healthy/good pond into an un-health adjacent pond can help to improve the water condition of pond) and then followed by nutrients application.

For semi-intensive farming – keep aerators on, to maintain dead algae in suspension. Later 30-50% water exchange is to be done using bottom drain followed by dolomite application, inoculation and algal nutrient to correct water colour.

Water colour, including true colour and apparent colour, is a colour appearing under the sunshine and is made of microorganisms, dissolved matter and minerals, clay particles, organic particles, pigments and suspended colloids etc.

Generally, microorganisms, comprising phytoplankton, zooplankton and bacteria are the major among all that can form the visible colour and the main reason that causes the change of water colour is the variation and fluctuation of microorganisms, especially the phytoplankton. Hence, water colour is usually related to productivity and the nutrient load and is significantly related to the production yield. The water colour can be used as a means to assess the pond condition by the farmer in the absence of instrumentation.

Among the major nutrients required by plants are phosphorus and nitrogen. Nitrogen is removed from water as nitrates (NO_3) by plants and phosphorous as PO_4. Animals excrete nitrogenous wastes and nitrogenous compounds are released during the bacteriological decomposition of plant and animal matter.

They are eventually transformed into ammonia, which undergoes nitrification to nitrate through a nitrite (NO_2) as a result of the action of aerobic bacteria. Phosphorous is an important major nutrient because it plays a key role in photosynthesis and intermediary metabolism and forms a constituent of nucleic acid and proteins. Available carbon is also of major importance as its deficiency is reflected in decreased production, the ratio of carbon: nitrogen: phosphorous required by most species of phytoplankton is about 106:16:1. Ammonium nitrate, ammonium sulphate, calcium metaphosphate, calcium nitrate, ammonium phosphate, muriate of potash, potassium nitrate, potassium sulphate, sodium nitrate, superphosphate (ordinary or double or triple) are some of the commonly used inorganic fertilizers. Sodium, calcium, magnesium, phosphorous, sulphur, potassium, ammonia, silicate (chlorides) etc. are considered as inorganic macronutrients. The micronutrients include aluminium, boron, cobalt, copper, iodine, iron, manganese, molybdenum, selenium and zinc etc. In addition, there are some of organic micronutrients like thiamin, nicotinic acid, calcium pantothenate, methionine, *P*-aminobenzoic acid, biotin, *i*-inositol, folic acid, cyanocobalamin, lysine, choline, ascorbic acid, riboflavin, pyridoxine, pantothenic acid, biotin, tocopherol, vitamins A, D and K etc. are used along with the fertilizers for better primary production.

Zooplankton

To feed the delicate larvae, juveniles and even adults of fish, prawn and shrimp in nurseries and grow-out ponds protein-rich and naturally occurring zooplanktonic organisms are essential. Different types of zooplanktons like larval forms of brine shrimp (*Artemia salina*), rotifers (*Brachionus* sp.), cladocerans (*Moina* sp.) *Euchlanis* sp., *Daphnia* sp., *Ceriodaphnia* sp.; copepods (calanoid, cycloid and harpacticoid copepods) and larval forms of different aquatic organisms etc., are considered as natural food for the prawn/ shrimp/ fish.

In view of the importance of plankton in aquaculture ponds, a new product by the name **AzoMax** is developed for use in aquaculture. **AzoMax** is a unique algal nutrient fortified with silicates to propagate diatoms and stabilizes the aquaculture pond ecosystem.