ECOLOGICAL DYNAMICS AND HYDROBIOLOGICAL CORRELATIONS IN FRESHWATER PONDS IN INDIA

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Abstract:

The utilization of the pond resources depends upon their limnological, hydrobiological and ecological knowledge in order to augment fish production by adopting scientific approach. As ponds play a vital role in commercial fisheries, sound ecosystem based management is necessary and it is pre-requisite to study their fundamental ecosystem dynamics for proper utilization or conservation. An account of recent researches on hydrobiological correlations existing in freshwater ponds and lakes is also given in the following article.

Introduction:

Water is an elixir of life. It governs the evolution and function of the universe on the earth hence water is called as the 'mother of all living world.' Majority of water available on the earth is saline in nature; only small quantity is fresh water (Gupta and Shukle, 2006). Aquatic ecosystem is the most diverse ecosystem in the world. The first life originated in the water. Water covers about 71% of the earth of which more than 95% exists in gigantic oceans. Global aquatic ecosystems fall under two broad classes defined by salinity – freshwater ecosystems are inland waters that have low concentrations of salts (<5 ppt). Freshwater ecosystem (habitats lakes and their associated biodiversity Aquatic habitats and organisms) includes rivers and streams, ponds and lakes and their associated biodiversity. Aquatic habitats provide the food, water, shelter, and space essential for the survival of aquatic animals and plants, both microscopic and macroscopic. Aquatic biodiversity is generally rich and harbours variety of plants and animals i.e. from primary producers like algae to tertiary consumers like large carnivorous fishes, intermittently occupied by zooplankton, small herbivorous or planktivorous fishes, aquatic insects, etc. Many of these animals and plants species live in water forever, whereas other like insects and frogs may use waters only during the breeding season or as juveniles (UNEP, 1996).

Limnology –A tool for scientific investigation

The study of freshwater habitats is known as limnology. Freshwater habitats can be further divided into two groups as lentic and lotic ecosystem i.e. –standing water and flowing water respectively. The water residence time in a lentic ecosystem on an average is 10 years and the average flow velocity ranges from 0.001 to 0.01 m/s. The lentic habitats further differentiate from lotic habitats by having a thermal stratification with is created in a lake due to differential heating of water layers, where lighter water floats on top of the heavier cooler water resulting in a thermocline at the middle. Ponds, tanks and lakes comes under lentic water systems (Wetzel, 2001).

Ponds –A Neglected Aqua Resource

Ponds are relatively shallow water bodies that are potential habitats for microscopic or macroscopic plants and animals comprising plankton, periphyton, nekton, neuston, benthos, finfish and shellfish (Denny 1985). These shallow fresh water impoundments in the tropics are becoming increasingly important as sources of fish and various methods including introduction of new species, semi intensive to intensive culture technologies, and ecosystem based management approaches are frequently being tried in the hope of improving fisheries (Dokuliet al. 1983).

Various eological dynamics in a freshwater pond

In aquatic habitats, the environmental factors include various physical properties of water such as solubility of gases and solids, the penetration of light, temperature, and density. The chemical factors such as salinity, pH, harness, phosphates and nitrates are very important for growth and density of phytoplankton, on which, growth and zooplankton and some higher consumer depend for their existence (Jhingran, 1985). The term 'Water quality" refers for the physical, chemical and biological parameters of water and all these characteristics directly or indirectly effect species (Byd, 1998). The seasonal variation in the distribution and population density of both animal and plants (Odum, 1971). The productivity in terms of planktonic biomass in fresh water lakes, rivers and ponds is regulated by various physico-chemical factors viz., temperature, transparency, pH, electrical conductivity, total hardness, nitrogen and phosphorous (Mahboobet al., 1988).

Temperature Dynamics

Temperature is one of the most important and essential parameter of aquatic habitats because almost all the physical, chemical and biological properties are governed by it. It influences the oxygen contents of water quantity and quality of autotrophs, while affecting the quantity and quality of heterotrophs, while affecting the rate of photosynthesis and also indirectly affecting the quantity and quality of hetrotrophs (Barnabe, 1994). The temperature of water varies throughout the year with seasonal changes in air temperature, day length, and solar raditations. Fishes and zooplankton are stressed when temperature changes rapidly, because there is no enough time for physiological adaption (Boyd, 1998). Water temperature generally depends upon climate, sunlight and depth. The intensity and seasonal variation in temperature of water directly affect the productivity of lakes. All organisms posses limits of temperature tolerance. The seasonal fluctuation of temperature influences the feeding habits of the fish. All biological activities like ingestion, reproduction, movement and distribution are greatly influenced by water temperature. Decrease in temperature is also directly related to increase in DO. High temperature intensifies the effect of toxic substances and speed up biological degradation process (Boyd, 1998). A temperature of about 35^0C is generally considered as threshold for survival of aquatic life (ICAR, 2011).

Light Dynamics

Turbidity is the measurement in inhibition of light passing through a water sample (Landau, 1992). Turbidity is the most suitable name given to the clarity of water which is affected by the amount of the suspended solids in it. High turbidity often accompanies organic pollution. Turbidity reduces the primary productivity (Landau, 1992). Turbidity by plankton is considered beneficial whereas clay turbidity adversely affects plant growth (Boyd, 1998). Quality and quantity of light entering in an aquatic habitat are important. Availability of light energy to a fish pond greatly influences its productivity. Synthesis of carbohydrates is a photochemical process energized by light (Rath, 1993). Transparency gives an indirect measure of turbidity. It also gives an estimate about the amount of fish food organisms i.e.- plankton available in the water body. Generally a transparency of less than 15 cm or greater than 45 cm is considered unsuitable for fish culture operations (ICAR, 2011).

pH Dynamics

The pH expresses the acidity or alkalinity of water which is determined by means of hydrogen ion (H+) and the hydroxyl ion (OH-) in water. Higher concentration of H+ ions gives lower score on the pH scale and lower concentration of H+ ions gives higher scores on the pH scale. Waters of around pH 7 are called as neutral. During daylight, aquatic plants usually remove the CO_2 from the water, as a result quickly pH increases. At might, CO_2 accumulates and pH declines. The magnitude of daily fluctuation in pH depends on the buffering capacity (total alkalinity) of water water with pH values ranging from about 6.5-9.0 at daybreak is most suitable for fish production (ICAR, 2011). It shows diurnal fluctuation, being low at night and high in the afternoon.

Alkalinity Dynamics

The amount of a acid required for titration of bases is a measure of alkalinity of water or it is the ability of water to neutralize acids. Carbonates and bicarbonates are the major titraable bases present in the pond water and their concentrations are expressed as total alkalinity. Calcareous water with alkalinity more than 50 ppm is most productive. However, the range of alkalinity as 0-20 ppm for the low production, 20-40 ppm for medium production and 50-200 ppm for high production are considered. Influence of alkalinity is probably masked by other more important factor such as dissolved nitrogen and phosphorus (Rath, 1993). It also shows diurnal fluctuation, being low at night and high in the afternoon.

Hardness Dynamics

Hard water contains high concentrations of alkaline earth metals while soft water has low concentrations. Harness usually includes only Ca++ and Mg++ions expressed in the terms of equivalent $CaCo_3$ (Abbasi, 1998). Total hardness of 15 ppm or above are satisfactory for the growth of fish. Water having hardness less than 5 ppm $CaCo_3$ equivalent causes low growth, distress and eventually death of fish (Rath, 1993). For optimal fish production total hardness of a water body should be nearly equal to its total alkalinity value (ICAR, 2011). Fluctuation in water hardness occurs hand in hand with the total alkalinity.

Conductivity Dynamics

Conductivity of natural water is measure of its ability to convey an electric current. Specific conductivity can be utilized as rapid measurement of dissolved solids (Frank et. al., 1974). The level of conductivity in water gives a good indication of the amount of joinable substances dissolved in it, such as phosphate, nitrate and nitrites. Generally conductivity of the natural water is directly proportional to the concentration of ions. Distilled water has a conductivity of about 1umphos/cm, while natural water normally has conductivity of 20-1500 umbos/cm. The conductivity of solutions depends upon the quantity of dissolved salts present (Boyd, 1998). Conductivity varies seasonally, being high during summer time due to evaporation and concentration while being low during rainy season due to dilution.

TDS Dynamics

Total dissolved solids (TDS) indicate organic and inorganic matter in the sample. It is aggregated amount of the entire floating suspended solids present in water sample. The solids may be organic or inorganic in nature depending upon volatility of the substances. A high concentration of dissolved solids increases the density of water affects osmoregulation of fresh water organisms, reduces solubility of gases and utility of water for drinking irrigational and industrial purposes (Boyd, 1998). TDS also varies seasonally, being high during summer time and reaching a peak in monsoon while it lowers in winter.

Oxygen Dynamics

Dissolved oxygen has primary importance in natural water as limiting factor because most organisms other than anaerobic microbes die rapidly when oxygen levels in water becomes low or falls to zero. Of all dissolved gases, oxygen plays the most important role in determining the potential biological quality of water. It is essential for respiration, helps the breakdown of organic detritus and enables completion of biochemical pathways (Boyd, 1998). It is added in the water via diffusion and photosynthesis whereas it is removed from the water via respiration and decomposition (Goldman and Home, 1983). DO is inversely related to water temperature and salinity. It shows diurnal fluctuation, being low at night and high in the afternoon (corresponding to the fluctuation of water pH).

Plankton Dynamics

The plankton community is comprised of the primary producers or phytoplankton and the secondary producers or zooplankton (Battish, 1992). It is well established fact that more than 75% of freshwater fish feed on plankton at one or the other stage of their life cycle.

Hydrobiological correlations in freshwater ponds

Mahajan and Mandloi (1998) showed that the plankton production of pond was dependent upon available nutrient value of soil and water, which came through inflow during monsoon season. The phytoplankton diversity in relation to physic-chemical parameters of a temple pond of Chidambaram in Tamil Nadu, India and reported that the distribution and population density of phytoplankton species depend upon the physic-chemical parameters of the environment.

Significant correlation is observed between silica and phosphate; similarly alkalinity and phosphate represent positive significance. This may be attributed to possible decomposition of organic material. Inverse relationship observed at significant level between total hardness and alkalinity may be due to the presence of more dissolved carbonates and bio-carbonates. A direct relationship was observed between dissolved oxygen and temperature. Nutrients like phosphates and nitrates released due to trophic level interactions and food chain relationship shows increasing trend annually, but negative correlation between them.

The limnological parameter and plankton diversity are important criteria for determining the suitability of water for fisheries purpose (Sharma etal., 2011)

Similarly, Pathak and Mankodi (2012) established several correlation coefficients between physic-chemical parameters and dissolved nutrients present in a water body. Temperature showed a significant inverse relationship with dissolved oxygen. Dissolved oxygen shows a significant negative relation with temperature, alkalinity, total hardness, electrical conductance, nitrate, phosphate and respiration. Total alkalinity shows a positive relationship with temperature, depth of visibility, pH, total hardness, TDS, conductivity, nitrate, phosphate and respiration. Nitrate showed positive relation with temperature, pH, alkalinity, total hardness, TDS, electrical conductivity, phosphate and productivity, and negative relation with dissolved oxygen. Gross Primary Production was found to have positive correlation with dissolved oxygen, depth of visibility, pH, alkalinity, conductivity, total solids, total dissolved solids and total suspended solids, nitrate, phosphate, BOD and COD were found to correlate with phytoplankton present in the pond. The study revealed that the water of the temple pond can be classified as moderately polluted in nature.

The study of correlation coefficient of various physic-chemical parameters and zooplankton groups shows that they are related with each other. The temperature is significantly positively correlated with rotifer and inversely proportional to turbidity. The pH is positively correlated with D.O. gross primary productivity, chloride, phosphate and negatively correlated with magnesium. The increase in turbidity causes decrease in hardness, alkalinity and rotifer density. Hardness shows significant positive correlation with copepod density and shows an inverse relation with cladocerans. The increase in carbon-dioxide shows decrease in GPP, phosphate, D.O. and increase in NPP. Dissolved oxygen shows positive correlation with phosphate, GPP and negative with that of NPP. GPP shows positive correlation with phosphate, chloride. The density population (Tidame and Shinde, 2012).

Aim and Scope

Maintenance of a healthy aquatic environment and production of sufficient fish food organisms in ponds are two factors of primary importance for successful pond cultural operations. To keep the aquatic habitat favourable for existence, physical and chemical factors like temperature, turbidity, odour, colour, dissolved gases, alkalinity, hardness and noxious gases will exercise their influence individually or synergistically. While the nutrient status of water and soil play an important role in governing the production of planktonic organisms or primary production in fish ponds.

Knowledge of the ecology of fish ponds provides an important tool for managing them for higher yields . The utilization of the pond resources depends upon their immunological, hydro biological and ecological knowledge in order to augment fish production by adopting scientific approach (Paria and Konar, 2003). As ponds play a vital role in commercial fisheries, sound ecosystem based management is necessary and it is prerequisite to study their fundamental ecosystem dynamics for proper utilization or conservation (Rao et. al., 1999).

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