
Chapter 01: General Introduction

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GENERAL INTRODUCTION

There is no denying the fact that water is of great importance to all living organism. It is used generally in agriculture, drinking purpose, food processing, washing, transportation, chemical uses, heat exchange, fire extinguishing purpose, recreation, water industry, power generation and pisciculture. The freshwater available for human consumption which is varies between 12500 km^3 and 14000 km^3 each year (Mc Michael, 2014**).**

Water is the most prime abiotic factor which supports life in this world and aquatic ecosystem is considered as diverse ecosystem in the nature. Particularly the physico-chemical properties of water govern the life of aquatic organisms living in it. Any change in the water quality has direct influence on biotic communities where different species of flora and fauna exhibit create variations in their responses to the altered environment (Loeb, Stanford L., 1994). The ranges of different parameters determine the quality of water body. On tallying these parameters, desirable and acceptable limit are recommended by several reputed organizations like WHO (World Health Organization), ICAR (Indian Council of Agricultural Research), SRAC (Southern Regional Aquaculture Centre), FAO (Food and Agricultural Organization), NRAC (North-Eastern Regional Aquaculture Centre).

It is undeniable that physico-chemical parameters of the water, state of aquatic environment and season of the year are most important to determine the food and feeding habit of different fishes of ponds for the increase of fish production in the ponds. Aquatic macrophyte plays a vital role to maintain a healthy ecosystem, **(**Dhote, 2007). Different parameters of freshwater like temperature, pH, DO, salinity, transparency, alkalinity, total hardness, Ca, Mg. play a vital role for healthy fish production. As per Lacoul and Jha et al., (1999) fish is a cold blooded animal. Its body temperature changes according to the environment affecting its metabolism

and physiology and ultimately affecting the production. Higher temperature increases the rate of biochemical activity of the micro biota and decreased solubility of oxygen and increased level of ammonia in water, CO_2 builds up dangerous high level affecting fish health.

India has plenty of freshwater and receives most of it during monsoon months (almost 75%). Rest of the month is drier and likely to be depended on ground water or stored water. It is estimated that freshwater requirement in India by the year 2025 will be as follows:

Irrigation 770 cubic kms, thermal power generation 160 cubic kms, industries 120 cubic kms, domestic requirements 39 cubic kms, livestock management 11 cubic kms (Kathpalia and Nag, 1975). Aquatic ecosystems are those systems which composed of living organisms and non-living elements in a watery environment. Freshwater body includes lake, river, pond, canals, reservoir and ditch, marsh which are exclusively important directly and indirectly in our everyday life. Several abiotic factors impact on aquatic life. Temperature, pH, dissolved oxygen, alkalinity, hardness, phosphate and nitrogen have so much significant. Mainly plankton and fish population show variation in their density and diversity regarding the abiotic components. Government of India has taken various plans and programmes to conserve the freshwater ponds, canals, tanks and dams which have been made to resolve the water crisis during drier months. Fishery product, food processing, transport developing are the economical strength of the concerned people. Fish contains a lot of minerals, vitamins, proteins, oils. Fishes contain good quality of balanced and digestible protein. Plankton has special characteristics like-easy availability, easily accessible food possess, low BOD, rapid microbial degradation, short life span and rapid propagation. Plankton acts as regulator to limit the transparency and dissolved oxygen by means of regulating sunlight penetration, decreasing temperature and accumulation of CO_2, NH_3, NO_2 and H_2S in water. Prawn helps to regulate NH_4^+ and tie up with heavy metals consuming phytoplankton. The nutritional status of planktonic microalgae

depends on cell size, digestibility, production of toxic materials and biochemical formula-exhibiting protein 12 to 35%, lipid, 7.2 to 23.0 % and carbohydrate 4.6 to 23.0% respectively. Copepods contain 44 to 52% protein and amino acids. Zooplankton is preferred as natural food for larval stage of fish and prawn. The *Rotifera brachionus* is a live feed in aquaculture. Dry weight of mixed zooplankton contains protein 40.27% to 63.24%, carbohydrate 1.68 to 4.55% and lipid 16.23 to 32.09% (web. ref. aquafind.com).

Plankton is the collective name for certain organisms (mostly microscopic) that drift in the lakes, rivers, ponds, reservoirs, oceans and other water bodies. The term "plankton" is derived from the Greek word "plankton" which means 'wanderer'.

The planktonic animals are known as zooplankton and planktonic plants are known as phytoplankton (APHA, 2008). They constitute as fish food organism in the aquatic habitat. Some important groups of plankton of freshwater ponds are found which are as follows:

Zooplankton

The term zooplankton comes from Greek word "Zoon". It means animals. They feed on the phytoplankton and other zooplankton. The zooplankton occupies an intermediate position in the food web and mediates the transfer of energy from lower to higher trophic level (Sinha et al., 2002). It plays an important role as indicators of trophic condition of the aquatic ecosystem by (Sharma et al., 1998). As zooplankton are the most important food for fish in aquatic environment like ponds, rivers and other natural water bodies. The change in zooplankton population and their diversity may affect the growth, development and maturity of fish (Dewan et al., 1979; Qasim et al., 1964 and Jhingran, 1991). They comprise of Cladocera, Protozoa, Copepoda, Rotifera, Amphipoda and Ostracoda.

Cladocera: Cladocera is also known as branched horns and body covered by carapace. It has high nutritive value as fish food. They mainly take food like smaller zooplankton and algae (Murugan et al., 1998).

Protozoa: These are unicellular, microscopic organism and carry cilia and flagella as locomotary organelle.

Copepoda: They are the important food sources for many fishes as well as aquatic organisms. They are freshwater Crustacean usually having six pairs of limbs on the thorax; elongated body and a forked tail. They are mainly of three groups, viz. Cyclopoida, Calanoida and Harpacticoida. Algae, bacteria and detritus matter are consumed by Cyclopoida while Rotifers, ciliates, bacteria, algae, detritus are consumed by Calanoida. Their diet changes with sex, age and season and food availability. Copepoda can with stand much harsher environmental condition as compared to Cladocera (Kalff, 2000).

Rotifera: This group is also known as "wheel bearers" as because a rotating wheel of cilia is there. They can multiple within short period of reproductive life and reach to enormous in number under favourable environment conditions (Dhanapathi, 2000).

Amphipoda: It is an order of *Malacostraca Crustacean* with no carapace. Its body size ranges from 1 to 340 millimetres. The thorax bears 8 pairs of uniramous appendages.

Ostracoda: This group possesses shell and is also called as bivalve organism. They are fishes and benthic invertebrates (Chakrapani et al., 1996).

Phytoplankton

This term is derived from Greek word 'phyton' which means 'plant' and plankton means wanderer or drifter. Phytoplankton are autotrophic in nature. These are of many varieties of pigments like Chlorophyll, Xanthophyll. The following classes of freshwater phytoplankton are:

Charophyceae: They can live as single cell, colonies or branched and unbranched filaments. Cell wall is made of lignin.

Chlorophyceae: It is also known as green algae, in which large and important chlorophyll a and b pigments are present. The chloroplast may be plated like, cup-shaped, spiral and ribbon shaped in different species. Green algae are made of outer pectose and inner cellulose.

Cyanophyceae: It is found in fresh and salt water. They arise single and colonial. Their availability is observed in extreme condition of temperature, pH and nutritional resources.

Bacillariophyceae: They are also known as diatoms. These classes are unicellular and colonial. They are filaments, ribbons, fans shaped and cell wall is made of silica. It is used in studies of water quality.

Dinophyceae: They are dark yellow to brown algae. They are free living parasitic organisms. Their reserve food materials are starch and oil.

Xanthophyceae: Xanthophyceae is also known as yellow-green algae. These are possessing Chlorophyll a and b. Cell wall contains cellulose and hemicelluloses.

Tribophyceae: They are yellow-green algae and unicellular, filamentous. It is pigmented by chlorophyll whereas they lack fucoxanthin.

Ulvophyceae: These are weeds. Phytoplankton are aquatic food web. Plankton are needed by the freshwater bodies of fishery management. Physico-chemical and biological characters of water lead to the production of phytoplankton which in turn on water quality of the pond. The plankton in the tropical ecosystem is used in estimating potential fish yield energy flow Trophic status (Reynolds, 1999), management (Beyruth, 2000) and yield energy flow (Simcic, 2005). The phytoplankton is an assemblage of heterogeneous microscopic algal forms of aquatic systems whose movement is more and less dependent upon water currents stated by Maranon (2015). On the other hand, the zooplankton are the microscopic free swimming animal

consumers of phytoplankton. Plankton population is very much sensitive to the environment in which they reside. Alternations among zooplankton population lead to change in the communities in terms of tolerance, abundance, diversity and dominance in their habitat. Several zooplankton species are served as bio-indicators (Ahmad et al., 2011). Phytoplankton is not only serves as food for aquatic animals but also plays an important role in maintaining the biological balance and quality of water. Phytoplankton densities are sensitive to physical and chemical change in the water comprising the qualitative and quantitative fluctuation concerned with biological productivity. The pH, dissolved oxygen, alkalinity, phosphate, nitrate and other nutrients are responsible for phytoplankton production in the aquatic environment. According to Khattak et al., 2005, the species, composition, biomass, relative abundance, spatial and temporal distribution of phytoplankton are an expression integrity of a particular water body. The total quantity of phytoplankton per unit volume of water shows variations from year to year depending upon the nature of floral elements present stated by Nayak and Patra (1982). Dinophyceae shows a peak during the south-west monsoon period (June and July) and one and more peaks during the north-east monsoon season. Cyanophyceae exhibits a peak during the north-east monsoon in the warmer months. Among zooplanktons, the commonly encountered organisms during south-west monsoon are *Foraminifers*, *Polychaet*e larvae, Cladocerans, small Copepoda, *Nauplii*, Amphipoda, *Salps*, Prawn larva dominating towards the end of the period.

Anatomical

Morphometric measurement is different of external body parts of an organism and monistic counted (Talwar and Jhingran, 1991). The morphometric relationship between length and weight of fish are suitable index for understanding growth, maturity, reproduction, general well being and it enables conversion of one variable to another.

Morphometric relationships of length and weight have been determined in several air-breathing fish species. The gut length is longest in herbivorous fishes and detrivores fishes with more than twenty times of the body length in certain detritus eating fishes. Gut length can vary with nutritional status. When they feed a higher quality diet (Evans, 2000). Carnivorous fishes usually have a large stomach and short intestine and this is applicable to many invertebrate feeders (Leveque, 2005). In herbivorous fishes, stomach is poorly developed and not distinguishable from the intestine. In omnivorous fishes, stomach is continuous with the intestine. In carnivorous fishes, stomach is with strong musculature clearly separable from intestine (Kar, 2007).

Air-breathing fishes possess a special accessory air-breathing labyrinthine organ, which facilitates the utilization of atmospheric air for their respiration (Graham et al., 1997) and can live out of water for extended period of time. *Anabas testudineus* is carnivorous mostly consumes invertebrates and their larva (Chandra et al., 2010). *Anabas testudineus* is naturally distributed in India, Bangladesh, Pakistan, China and Malaysia (Talwar and Jhingran, 1991 and Rahman, 2005). It inhabits both fresh and brackish waters and occurs in low lying water bodies like lakes, ponds, canals, paddy fields and estuaries.

There is seasonal variation of gastrosomatic index (weight of the fish) of several species of fishes. It is maximum during the post-spawning period and minimum during the breeding period (Yadav, 2006). Knowledge of the spawning period is one of the most important pre-requisite in fishery management. The gastrosomatic index indicates the spawning period in some teleostean fishes.

Different aspects of biology of air-breathing fishes are very scanty and considering its importance, attempt is made to study the different aspects of gastrosomatic index (GaSI), gonadosomatic index (GSI). Weight of fish body and weight of stomach give the gastrosomatic

index (GaSI), body weight of fish and weight of gonad gives the gonadosomatic index (GSI). It is the ratio of fish gonad weight and body weight. It is particularly helpful in identifying seasons of spawning as the ovaries of gravid females swiftly increase in size just prior to spawning. Present study ensures that the growth of fish, body weight and gonadal development are correlated. The gonadosomatic index of fish is related to spawning and reproduction of fish. Air-breathing fishes are good source of food for poor people and hence they must be reproduced in large number. So they are easily available to poor people and hence the study of GSI is important and essential. Fish has maximum GSI value at maturity stage and after spawning GSI value is declined. The GSI value is also related to amount of food available to them in water and temperature of water. So during the breeding season of air-breathing fishes shows maximum GSI value and after spawning it is reduced. In this study, we have carried out GSI value of male and female fish simultaneously. When GSI of both sexes are compared and come to know that maximum value of GSI has occurred almost at the same time in both sexes and after spawning it is recorded that there is a great decrease in GSI values.

On the other hand, studies of hepatosomatic index of air-breathing fishes are also carried out simultaneously. When the food is available in large amount and conditions are favourable causes increase in the HSI value. Increase in the weight of the body is related to the increase in the HSI value and it is also observed that HSI also depends upon seasonal cycle. As weight of body increases weight of liver also increases. In poor environment, fish usually have a smaller liver with less energy reserved in the liver. HSI values are indirect indices of energy status on a seasonal basis and the HSI values are variable. Hepatosomatic index is defined as the ratio of liver weight and body weight. It provides an indication of status of energy reserve in an animal. Hepatosomatic index is not affected by pollution; it can be affected by other factors like temperature and food availability. The values of rise and fall of gastrosomatic index and

condition factor are always showing an inverse relationship with the gonadosomatic index and percentage of empty stomach. Gonad weight is given as an easily measured quantitative record of changes in gonad condition. The gonadosomatic index is an indirect method for estimating spawning season of a fish. Gonadosomatic index is particularly helpful in identifying days and seasons of spawning as the ovaries of gravid females swiftly increase in size just prior to spawning. If it is possible to collect reasonable numbers of gonads each month from adults (30 to 50 individuals) over a year, one can usually determine the spawning season for fish source; (Rheman et al., 2002).

Condition factor (K) has been used to growth condition of fish. A high condition factor reflects favourable condition whereas a low condition factor reflects poor environmental quality. Condition factor (K) is also used to investigate the seasonal and habitat differences in condition and fitness of fish. Such factors provide a useful comparison of the weight of the individual fish in relation to length. It is well known fact that knowledge on fish biology particularly on morphometry, length-weight relationship, condition factor, gastrosomatic index, gonadosomatic index, hepatosomatic index, food and feeding habit are almost important in increasing the technological efficiencies of the fishery entrepreneurs for evolving judicious pisciculture management. In this regard, an attempt has been made to investigate and present a comprehensive account on some of the important biological, anatomical and biochemical parameters which are recorded and estimated for the seasons of winter, summer, monsoon and post-monsoon study and a complete analysis has been done for a continuous period of twelve months.

Biology of fish is a subject of relevance to a wider audience for its considerable applied importance to mankind and biologists for interesting research (Chondar, 1999). Fishes have some unique anatomical and physiological characteristics that are different from mammals;

however they have still possess the same organ, systems that are present in other animals. Seasonal changes in gastrosomatic index (GaSI), gonadosomatic index (GSI), hepatosomatic index (HSI) and condition factor (K) of three air-breathing fishes were studied. Scientist concerned with any activity of fisheries should understand fish feeding activity which is the dominant activity of the entire life of any animal. Investigation into all the problems in respect of feeding, growth, reproduction and population studies in fishes call for appropriate methodology. An understanding of the biological parameters of fishes and food is of immense importance which will provide an effective opportunity to determine the developing requirement of fishes in culture system. The feeding intensity and the degree of feeding are related with season, maturity, spawning and availability of food materials through observations in the field.

The energy flows in an aquatic ecosystem from primary producer of phytoplankton to the consumer of zooplankton through the food chain and microbial food webs (Weiss and Stockner, 1993). Fisheries and aquaculture play an important role in addressing nutritional security of poor in developing countries (Gupta, 2008). Fishes are valuable natural asset and have great significance in shaping the life of mankind in many of the developing countries (Haniffa et al., 1991).

The air-breathing fishes, *Heteropneustes fossilis* (Bloch) commonly known as Singhi, *Clarias batrachus* (Linn) commonly known as Magur, *Anabas testudineus* (Bloch) commonly known as Kai are of hardiest fishes and needs less management practices for commercial production (Dehadrai et al., 1978). Moreover, it is very popular and highly priced fishes due to its high protein level, digestibility, palatability, medicinal value, nutritive value and lesser spines and fat. It can be cultured in monoculture as well as in poly-culture (along with carps) systems (Dehadrai et al., 1978; Haniffa et al., 1991). In India, air-breathing fish culture is not

commercialized due to non-availability of seed and feed. Therefore, the breeding and seed production and non-availability of appropriate diets for the larval stages are the major constraints in its successful culture (Rao et al., 2013). Fish production in India today officially stands at 6.54 million tonnes, the production from inland sector being 3.40 million tonnes (Tripathi, 2008). Teleost (bony) fishes support subsistence and commercial fishes and aquaculture systems throughout the world (Wootton, 2002). *Heteropneustes fossilis, Clarias batrachus* and *Anabas testudineus* are commercially important fishes having high protein contents and taste. Sankar and Ramachandran (2001), Chandrashekhar et al., (2008) have studied the biochemical changes of Indian major carps in relation to size, sex and season in freshwater, seasonal protein variations in the muscles of air-breathing fishes, Ali et al., (2003). Seasonal protein variations in the muscles of air-breathing fishes has prolonged breeding period. August to September is the post spawning month and spent season is seen during October to November. This finding support that major changes in the body composition of fishes are brought about by the changes in the pond water in different seasons, nutritional status and breeding period of fish (Reinitz, 1983; Weatherly and Gill, 1987; Salam and Davies, 1994 and 1997; Ali et al., (2003).

Ecology of study fishes

Food is the most vital and major factor for the growth of all animals. Proper knowledge of food and feeding habit of fish is a fundamental idea for increasing fish production. Physico-chemical parameters of the water, state of aquatic environment and season of the year are most important to determine the food and feeding habit of different fishes of ponds for the increases of fish production in the ponds. Aquatic organisms are used as feed organism for fishes. Both animals and plants are used as feed organisms. The living foods are naturally available in the culture ponds. The plankton are of two types namely phytoplankton and zooplankton, *Spirulina,*

Tubifex, Rotifera *Artemia salina, Daphnia, Cyclops, Amoeba, Navicula* and *Spirogyra* are the examples of plankton.

Water quality and pollution in ponds

Monitoring of water quality and scientific management of water resources are very much essential for prevention, control and maintenance of water quality. Ecological impact, community structure and physical environment are creating the nature of pollution. Due to public use of land for cultivation, polythene bags, plastic, discharge of cooking materials, rotten vegetables, waste plastic bottles, for supplying drinks causes pollution. Certain species of plankton are the indicator of water quality. Aquatic macrophytes is normally found in standing water ponds, shallow lakes, ditches, canals, sewage, lagoons, marshes, reservoirs. Aquatic macrophytes play a vital role to maintain a healthy ecosystem (Ali et al., (2003).). They perform their role as primary producers of oxygen through photosynthesis. Aquatic macrophytes are also used to remove nutrients and reduce concentrations of phosphorus and nitrogen from raw sewage. *Chara* sp. (Horn wart), *Hydrilla* sp. (oxygen weed), *Elodea* sp. (pond weeds) are commonly used as fish feed. Aquatic macrophytes are known to suppress the development of wind wave in shallow water. It has the function in deciding the water quality of shallow water bodies (Vadenberg et al., 1998). De Nie (1987) has been described as aquatic macrophytes rooting in sediments, floating e. g. *Hydrilla* sp., *Cyperus* sp., *Chara* sp. Free floating macrophytes like *Azolla* sp, *Salvinia* sp., *Lemna* sp. Macrophytes are source of food for fishes, shelter of the zooplankton, invertebrates and they clean the water body.

Environmental Impacts of ponds

In biological point of view, ponds are a valuable resource, produces large amount of fishes.

The negative influence of ponds on environment are evident due to agricultural surface run off, pollution made by human-emerging dead animals, bathing of animals, washing clothes,

discharge of plastic goods into the ponds water.

Background of the study

Inland water plays a vital role in food production for human consumption and mitigating the protein deficiency by (Sugunan, 1995, FAO, Fisheries Technical Paper-345). Aquatic body is used for mitigating the protein deficiency as well as diet and reduces the financial lack by fish capturing and selling. The availability of water resources for fisheries and aquaculture are not only limited but are continually getting reduced with time for multiple reasons. Indigenous air-breathing fishes have a greater potentiality in utilizing shallow, swampy, marshy and derelict water bodies for aquaculture. Ait-breathing fishes live in diversified environmental conditions; there is a need of systematic study of complete knowledge about different life stages, food values, systematic study of anatomical index values and other physiological aspect of different season. It is tried to study seasonal water quality, plankton population, anatomical and biochemical (protein) change of air-breathing fishes in the ponds under study. The fish faunal diversity, water quality, aquatic vegetation, plankton population are the indicators to know the ecological status of the water bodies.