07. CONCLUSION

Physico-Chemical Parameters

Hydro-biological assessment linked with the several ecological systems in support of the utilization of water (Boyd, 1984). Present research conducted to figure out the distinctiveness of reservoir water utility in an aquatic ecosystem. Remarkable, the variations in water quality influences to the biotic productions from unicellular to multicellular organism. Reservoir with immense water quality will create more and more beneficial fish than a lake with poor water quality, which is important for development of human wellbeing. Researcher also also provide a considerable explanation about the interrelationship among the water quality and production of fish species (Diana et al., 1997).

The variation and the outline of ranges between numbers physico-chemical features of water have examined, that are showing within table 6 as seasonal aspects (pre monsoon, monsoon and post monsoon). Likewise, the complete study periods for 10 different sampling sites water quality data also recorded and calculated in a mean value.

Practically, temperature also a density independent factor determining the living biota in a huge extent and showing distinct affects on biological–chemical process (Prasad, 1956).The changes of solar emission is the main cause for monthly variation of air and water variation. The rate of substance and natural responses is being increased with each 10°C increment in temperature. While for the growth of freshwater finfishes the appropriate temperature range is 32°C to 25°C.

Temperature of air is higher from May to September (25°C-30°C), whereas lowering from October – April (10°C-20°C) at Doyang reservoir. However, in case of the water temperature, variation showing higher than 30°C in month of May and June (Figure33A, B).

Water temperature of Doyang reservoir was only found to be completely correlated with air temperature (0.96), rest all water parameters like TDS, free CO_2, Total hardness, Total Alkalinity, Cl etc. having negative correlation as given in Table no. 8.

While the table 7 reflects significant data/scores of different common statistical parameters depending on physico-chemical data of water at Doyang reservoir during study periods.

As stated by Lewis (1987), comparatively slight series of deviation is observed about temperature within the superior varied layers of at the tropical waters. The temperature variations in Doyang reservoir is wide (16.7 to 30.9 ^{0}C) and consequently it's not look like the usual tropical waters (Table 6). Water temperature is severely influenced by the water discharge of adjoining hydroelectric power plant and most unusual during May when reservoir water level is at its lowest.

There is the seasonal variation of water transparency due to the differential amounts of the suspended solids, algae, silt and illumination (Salim and Ahmed, 1985). Low values of water transparency during monsoon season are caused by large amount of silt being supplied into the reservoirs through catchment area (Deorari, 1993 and Ray, 1978). During the monsoon phase, suspension of bottom deposits into water by wind action, accumulation of turbid water and high nutrients are responsible for decreasing the water transparency in stagnant ecosystems. The poor light penetration during rainy phase was due to high density of suspended particles but cannot be attributed to the moderate density of living microbiota. Beside that in February months of every studied year, may be due to lack of surface run off and minimum disturbances in water column (Figure 34). The reason may be recognized to the suspended clay particles which are settled due to less inflow and extension of euphotic zone beyond 4 m in post monsoon periods. The attributing factors for transparency are wind action, microorganism concentration, suspended silt particles and organic matter deposit at bottom. Light penetration was not hindered at all by water plants or animals during the year. Lentic water was most transparent than either littoral or lotic but not significant, indicating that very little or no outsides element was coming to the reservoir from the power plant released water. Other physical processes like wind action, factors greatly, as the reservoir is swept by heavy wind in most part of the year, excepting winter due to its flattened shape due to minimum coves and bays. The wind induce instability mixed the water to facilitate nutrient mixing, pumping DO into the entire water column and distribution of heat, rendering in equilibrium in temperature.

Water transparency of Doyang reservoir was establish to be positively correlated with Sp. Cond. (0.53), TDS (0.49), CO_2 (0.69), pH (0.47), DO (0.60), alkalinity (0.83), hardness (0.69), Cl (0.32), but negatively correlated with water temperature (-0.87) and air temperature (-0.85) (Table 8).

Water having pH range of 6.4to 9.0 before daylight is measured appropriate for biotic production in freshwater ponds and lakes (Swingle,1967). Banerjea (1967) observed, a unbiased pH (6.5 to 7.5) could be considered as the most productive in pond ecosystems. pH value in case of normal waters is considered as an index of environmental conditions. It affects the biochemical reactions and controls the activities and distribution of aquatic organism (Basu et al., 1973; Jhingran, 1991; Sugunan, 1995). While Jhingran (1991) reported that pH is determined by relationship between free CO_2 and carbonates. Ali and Khan (1976) have stated that pH values over 8.0 are the result of improved photosynthetic activity which consumes more carbon dioxide than what is evolved in respiration and decomposition, thereby shifting the pH towards alkaline side. Water reaction in Doyang reservoir, Nagaland was nearly neutral varying to the extent of 7.3 to 7.4 (Figure 35). The mean value of pH comes within the value prescribed by WHO (6.5-8.5).

The low pH in monsoon season was owing to increased dilution of water and decomposition of the greater quantity of the added organic matter whereas higher pH value during winter phase may be due to increased photosynthesis.) Previous work stated that during decomposition, large amounts of macrobiotic acids are liberated which lower the pH of water bodies (Russel,1973). At Doyang pH was found to be positively correlated with transparency (0.47), Sp. Cond. (0.28), TA (0.59), DO (0.59), hardness (0.03), Cl (0.14), CO_2 (0.53), but negatively correlated with air temperature (-0.61),TDS (-0.099), water temparature (-0.63). Sreenivasan (1978) and Jhingran (1991) have also stated that moderately alkaline nature of reservoir is favorable for fish production. Thus, Doyang reservoir with constructive pH regime is suitable for fish growth.

The required quantity of DO is essential for the metabolic activities of all aerobic aquatic organisms. DO in water depend on biological and chemical activities, playing an important role in the distribution and abundance of organisms. Oxygen diffusions being affected by the atmospheric pressure and water temperature. DO also provides valuable information on the prevailing biological and biochemical reactions of the system, which affects the aquatic life and the capacity of water to receive organic matters without causing adverse impacts (Wetzel, 1990 a). The DO value in Doyang reservoir was generally observed higher during winters (upto 7.57 mg/l recorded in February, 2017). The increased ranges of DO value during this period might be due to increased rate of photosynthesis. The same trend was also found by Rawat (1991) and Mishra et al., (2003) in their studies. The peak value during winter and lower value of DO in summer was also observed by Kadam et al., (2005), Kolekar, (2006), Negi et al., (2006), Pawar and Pulle (2005), Pulle et al., (2003), Sharma et al., (2008), and Upadhaya and Dwivedi, (2006).

Wide fluctuations in DO content of water in the lakes might be due to dense aquatic vegetation, shallow water depth and intense anthropogenic activities (Yadava et al., 1987).Seasonal variation in DO was insignificant due to strong wind action and absence of any *Microcystis* bloom throughout the year. DO was found to be positively correlated with free CO_2 (0.61), transparency (0.60), Sp. Cond. (0.27), pH (0.55), TA (0.57), TDS (0.08), hardness (0.26), but negatively correlated with water temperature (-0.64), and air temperature (-0.68).

In the light of the account presented above, it may be inferred that the water parameter of Doyang reservoir is suitable from the productivity point of view in connection to freshwater fish species.

Fish and Fisheries

Current research work depicted 64 fish species contributing to about 42.95% of ichthyofauna from Nagaland state. Deorari (1993) recorded 35 fish species within the Dhaura reservior, Uttar Pradesh state of India. Medeiros et al., (2006) reported 13 to 16 fish species in one stream reservoir of Brazil. Remarkably, the elevation and slope grade function as the principal influence to the abundance patterns and distribution fashion of the fin fish species (Johal and Rawal, 2005). While it might be difficult to pinpoint one single factor for the species richness and diversity within reservoirs to classify them as all these factors are interrelated and cannot be overlooked for the distribution of different fin fish species abundance. Generally, properly managed inland fisheries are compatible which encourage the maintenance of natural waters at a satisfactory quality for fisheries resource and other purposes (Welcomme, 1998).

The family Cyprinidae with 39 different species dominated the samples (Figure 18). Nelson (1994) reported the maximum freshwater diversity in Cypriniformes and Siluriformes in the freshwater habitats. Majority have high commercial importance as food and ornamental fishes. Das and Shrivastava, (2003) reported 20-70% contribution of catla fish to the total IMC fish catch. During the present study also, *Catla catla* continues to be the major contributor among

IMC. Indigenous groups (particularly *P. sophore, P. chola and O. barna*) represented by cat fishes, medium carps and miscellaneous minnows contribute substantially, amounting to 40% to the total landings.

The delineation of ecological parameters as given in the foregoing paragraphs tend to suggest that the reservoir is medium productive. The low yield during could be attributed to the inadequate stocking, non utilization of certain food niches and limited spawning habitat. The production of carps in the reservoir is also affected by the dominance of catfishes like *Clarias bratacus, Heteropneustes fossilis* that feed at higher trophic levels and consequently result in greater loss of energy stored at primary producer level. Breeding of common carps is a regular feature even it may be disturbed by invasive species or some exotic species.

The fishing methods are designed to suit the local conditions and the availability of different fishes in the reservoir. The main fishing gears are gill nets (40-150 mm bar) of which 40, 60 and 70 are most commonly used for commercial fishing. Drag net is also operated during low water level at Doyang reservoir. Besides, the cast nets and long lines are also used for fishing purposes. Comprehensive accounts of inland freshwater fishing apparatus and technique have been given by George (1971). As stated by earlier researchers the gill nets with mesh sizes of 40, 50 and 70 mm were found to be more effective for commercial fishing in Hirakund Tungabhadra, Govindsagar reservoirs (David and Rajagopal, 1969),

Winburg and Baurer (1971), Sugunan (1995) and Sharma et al., (2005) have make clear the significance of reservoir managing methodologies such as, maintenance of fish stock in closed areas as per seasonal requirement, control of mesh size, and restrictions of fishing gears for obtaining high fish yield. Regulations of the mesh size have been widely practiced for regulating the least marketable size of various fishes. Jhingran (1991) has suggested that minimum mesh size permitted for gill nets should not be less than 30 mm. Srinivasan and Sreenivasan (1977) have also reported that, capturing of Indian major carps of less than 15cm in length was banned in water channels, barrages river system, ponds and reservoirs.

Globally known facts explained that, many interacting physical and biological factors influence the occurrence, distribution, abundance and diversity of reservoir fishes.

Various kinds of biodiversity threats were studied through actual observations and discussions with local peoples and fishermen. Unsustained exploitation through secret use of small meshed net is very rampant. Strict reservoir management actions with large range of fisheries stakeholder awareness program definitely needed targeted to save the ichthyodiversity of Doyang reservoir, Nagaland. Since, the sewage and industrial pollution are major threats, meanwhile proper sewage disposal system and regulation on the use of pesticides and agrochemical should be enforced. Effective implementation on the regulations about the mesh size of fishing equipments is much urgent to prevent over exploitation of fin fishes. Land retrieval activities in this area should be made in strict mode. Successful finfish conservation is a time taking aspects mainly depends on accurate habitat protection and can be achieved only through public awareness.

SL. No.	Scientific name	Symbol	IUCN (2018)	Population trends
1	*Anguilla bengalensis* (Gray, 1831)	A	NT	Unknown
2	*Cyprinion semiplotum* (McClelland, 1839)	B	VU	Decreasing
3	*Cyprinus carpio*(Linnaeus, 1758)	C	VU	Unknown
4	*Devario naganensis* (Chaudhuri, 1912)	D	VU	Decreasing
5	*Hypophthalmichthys molitrix* (Valenciennes, 1844)	E	NT	Decreasing
6	*Labeo pangusia* (Hamilton, 1822)	F	NT	Decreasing
7	*Neolissochilus hexagonolepis* (McClelland, 1839)	G	NT	Decreasing
8	*Schizothorax richardsonii* (Gray, 1832)	H	VU	Decreasing
9	*Tor putitora* (Hamilton, 1822)	I	EN	Decreasing
10	*Schistura manipurensis* (Chaudhuri, 1912)	J	NT	Unknown
11	*Schistura reticulofasciata* (Singh & Banarescu, 1982)	K	VU	Unknown
12	*Oreochromis mossambicus* (Peters, 1852)	L	NT	Unknown
13	*Ompok bimaculatus* (Bloch, 1794)	M	NT	Unknown
14	*Ompok pabo* (Hamilton, 1822)	N	NT	Decreasing

Table No 9: Checklist of fish species having NT, VU, EN status with their population trends.

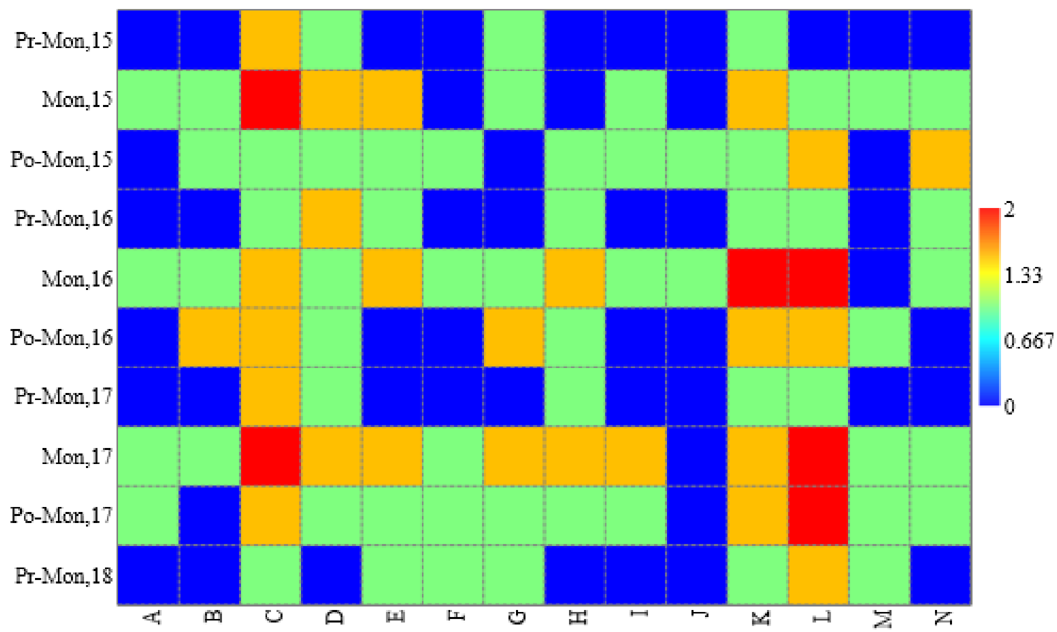

Figure 44: Matrix plot showing the availability of fish species based on IUCN status at Doyang reservoir on different seasons.

Reservoir Fishery Management

The limnological features of the freshwater reservoir specify the possibility of better yield. The moderate temperature (17.5-29.8^{0}C) is favorable for good growth of aquatic organism. Likewise, the pH values (7-8) are also suitable for a high rate of biological production.

The fish production /catch documented from Doyang reservoir, Nagaland is moderately lower. The low fish production value in this reservoir under study could be attributed to inadequate stocking, wrong selection of species and irrational exploitation. The dominance of weed fishes might have interfered with the growth of major carps. Besides competing for food and space, the weed fishes provide a forage base for predatory cat fish populations which in turn affect the recruitment potential of economic carps as well. The need to control trash fishes to enhance the yield of economic fishes has been stressed by several workers (Sharma et al., 1991; Rawat, 1991).

The other factors contributing to some extent, to the low yield of that reservoir are illegal fishing during breeding period, poaching, dynamite fishing and undesired poisoning. Consequently, extreme expansion of surface floating and submerged weeds obstructs the fishing activity. To overcome this difficulty, control of aquatic weeds in biological ways are safe and economical (Jhingran, 1991).

The reservoir fishery also enjoyed substantial economic importance in view of its vast resources, potential employment opportunities and better implication as a rich source of animal protein in our daily diet. Even though the average fish yield from reservoirs has been extremely low from the past few decade or so (Desai, 2006). This was perceptibly because of the prevalent of unscientific management practices resulting from insufficient knowledge of the ecology and production biology of the reservoirs.

At national and international level, numerous executive methods are take on to intensify the production of reservoirs either or in combination. These measures range from conservation of habitat and fish stocks to various forms of fisheries enhancement. These can be in the form of improving the fish stocks, changing exploitation patterns, introducing new form of access etc. (Sugunan, 1995; Sharma et al., 2005; and Desai, 2006). However, with all these available options of reservoir management, it is very much imperative to adopt them on the basis of assessment of causal factors working on a specific reservoir with suitable concern of other ecological constraints.

Enhancement of the fish stock is the main familiar management measure that is followed in reservoirs in most countries of the world. Stocking of reservoirs with fingerlings not less than 100 mm size of economically important fast growing species would result in utilization of all the available food resources. This may served like the effective management tools to increase the fish yield in small and medium reservoirs (Sugunan, 1995).

In a large sized reservoir like Doyang reservoir, stocking is done as temporary measure to compensate for natural recruitment failure. Stocking attempts in such reservoirs is only successful when stocked fishes naturalize, breed and propagate. In such a situation we may look for a habitat restoration strategy to make positive attributes for fish yield.

Necessary precautionary measures may be taken against to the overfishing of a special species having population density less than the carrying capacity of the aquatic system. The reservoir has moderate amount of macro benthos, hence moderate stocking of omnivorous fishes may be advocated. Rational exploitation of predatory cum catfishes should be regulated for the establishment of carp fisheries. Majority of carps are herbivorous/omnivorous and feed mainly on plankton. However during larval stages, the microscopic biota constitutes the main food of all carps. Large population of weed fishes depleting the plankton that could have become food for the major carps like calta, rohu which is zooplankton feeder. Uneconomical weed fish population should be kept under control and the exploited stock of these groups of fin fish's maybe utilized for fish feed production.

The prime causes of success or failure of particular fishery in reservoirs are so many. The changed ecomorphological features, adaptability of a fish to the new ecosystem, availability of food, spawning success, survival and recruitment of young ones to the fishable stock, application of suitable gears, season of fishing etc. are some of the factors that contribute to the success or failure of the fishery. Rajagopal (1978) has observed that the decline of fishery in Tungabhadra reservoir could be attributed to elimination of juveniles by the non-selective gears like shore seine and intensive exploitation of natural stock by gill nets. Initiative should be taken to check unauthorized encroachment with operation of household or agricultural activities within the peripheral zone of the reservoir. Indiscriminate non-judicious fishing of resources should be avoided by involving fool proof planning and effective regulatory measures (Sugunan, 1995; Sharma et al., 2005 and Desai, 2006).

The stocking pattern of major carps is being done at present but without any consideration of size of the stocking material, time and place of stocking. Obviously, the chances of survival of the introduced seed would have been very poor. It is therefore proposed that the reservoir be stocked with large sized fingerlings (at least 10-15 cm long) of fast growing Indian major carps. Fish stocking has been crucially winning and real tools into the reservoir fishery management aspect in India. It has been indicated that stocking of 200 to 500 fingerlings per hectare leads to production of 40-60 kg/ha in medium to large sized reservoirs (Sinha and Ghosh, 1988). The annual stocking rates in Stanley and Bhawanisagar reservoir have been reported as 105-500 fingerlings/ha and 135-475 fingerlings/ha respectively (Sreenivasan, 1978).