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Seasonality of nutrient content in epilimnion zone of a small reservoir in punjab (India)

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Abstract

The nutrients occur in the reservoir, however, majority as well as increased quantity of the nutrient elements get stacked in the hypolimnion zone of the reservoir. With a view to know the status of various nutrients in the epilimnion zone of reservoir, some elements such as phosphate-phosphorus (PO_4-P), nitrate-nitrogen (NO_3-N), calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) were analyzed on monthly basis after collection of water in 2.5litre polyethylene bottle from epilimnion zone of a small reservoir (Chohal) during December 2000 to November 2001 in Punjab. The nutrient parameters show considerable monthly and seasonal variation, which is also linked to the hydrological cycle. There were sharp changes observed in the seasonality of nutrient content in Chohal water as recorded after analyses. The maximum average monthly value of PO_4-P and Na was observed during summer whereas Ca and Mg in monsoon. The maximum average value of NO_3-N and K was recorded during winter season. The average monthly minimum value of PO_4-P, K and Na was recorded during monsoon whereas Mg in winter season. The value of NO_3-N and Ca was found to be minimum during summer. The overall range of NO_3-N was recorded from traces to 1.774 mg/l whereas other nutrient contents such as PO_4-P fluctuated from traces to 0.527 mg/l, Ca (9.0 to 15.9 mg/l), Mg (3.43 to 26.49 mg/l), K (2.1 to 7.8 mg/l), and Na (6.6 to 37.5 mg/l) in Chohal reservoir. The findings revealed that the circulation of nutrient occurs in the epilimnion zone of the reservoir and the nutrient content varies season to season, however, the nutrients are important determinants of biogenic productivity of the reservoir.

Introduction

The reservoir is characterized by fluviatile and lentic conditions co-exist along with certain unique features of their own. It offers enough scope for stock manipulation through ecological manoeuvring, paving way for production hikes at a relatively low capital investment. Reservoirs are man-made ecosystems without a parallel in nature. Man-made impoundments created by erecting a dam across a river to obstruct its flow. The developmental activities of post-independent India have been of harnessing rivers for irrigation and hydroelectric power. Consequently a good number of reservoirs have come into existence all over India, which constitutes an important inland fishery resources having immense potential. Our country holds over 3.15 million ha of tropical reservoirs (Sugunnan, 1995) and nearly half the reservoirs belong to small category (<1000 ha) which form common features of Indian rural landscape (Sugunan and Sinha, 2000). The fish-production systems of open-water have been classified as capture fisheries of rivers and estuaries; culture fisheries of ponds; culture-based fisheries of small reservoirs and floodplain wetlands; and enhancement fisheries of medium and large reservoirs. Fishery in small reservoirs that is almost like ponds and the bulk production of open waters is

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from reservoirs. The present fish production rate in small reservoir of Bihar is only 3.9kg/ha/year. The average national yield from small reservoirs in India is nearly 50 Kg/ha/yr. The present average fish production rate from Indian reservoir is very low (20kg/ha/ya) whereas it is surprisingly high in China (743kg/ha) and Indonesia (177kg/ha).

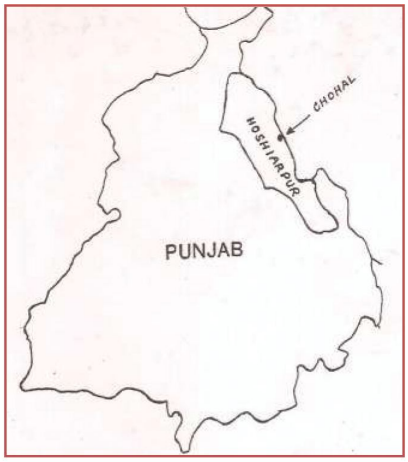
Punjab is a land locked state of India and recognized as agriculturally dominated food bowl of India. Punjab state is lying between 20 30° – 32 30° N longitude and 73 55° – 76 55°E latitude and covering an area of 50,360 km^2 is bestowed with vast aquatic resources in the form of lotic and lentic water bodies. Dams have been raised on rivers Satluj, Ravi and Beas to create multipurpose reservoirs for irrigation and controlling flood. These include Ranjit Sagar reservoir (3535 ha) on river Ravi, Nangal Lake (200ha) and Ropar barrage (80 ha) on River Satluj and Harike barrage (200ha) on the confluence of river Ravi and Satluj (Aggarwal, 1998). Also, there are many streams which flow from the foothills of lower shivalik range located in the Northeastern periphery of Punjab state. These are different from alluvial streams/rivers as there flow occurs only during monsoon season (June to September) or in the months of January/February. The flood peaks are of short duration. With an object of using flood peaks, reducing associated flood damage and for meeting the demand for irrigation water, the state is harnessing these flashy streams. Small dams have been raised at Dholwaha, Janauri, Damsal, Maili, Saleran, Chohal (District Hoshiarpur), Mirzapur, Perch, Siswan and Durgapur (District Roopnagar) on these streams. Some of the reservoirs have been studied for its water quality and fish productivity. However, the rate of fish production reflects around 61.2kg/ha/yr in Chohal reservoir (Sehgal, 2003).

Today almost every country has statutory regulations to ensure safety in use of fertilizers, chemicals and pesticides and there is also increasing choice to select a safer product for a given benefit. In recent time, there is growing emphasis on rational use of chemicals including pesticides thus arises out of the basic fact that technological progress is inevitable in our country and the challenges like pollution and hazards must be met to ensure progressive growth and prosperity (Hassan, 2002). Interestingly, variety of pollution hazards flows in freshwater resources in Punjab. The inflow and outflow of water for irrigation and power generation and sudden fluctuation in water level cause changes in standing crop of reservoirs affecting production process. The quality of impounded water varies from reservoir to reservoir and even within the same reservoir depending on the soil, climate and human activities. It also varies with morphometric characters, shape and size of the reservoir basin, photoperiod, wind action and amount of water change. However, the status of nutrient content varies from reservoir to reservoir. Such variability necessitates for separate evaluation of the water quality, nutrient status and productivity of different reservoir ecosystem prevailing in varied agro-climatic zones of Punjab. It is characteristics that fertility and productivity of reservoir improves after ageing compare to newly created reservoir. The productivity of reservoir depends upon the available nutrient content in the water as all aquatic plant and animal organisms require optimum amount of nutrient for their growth and survival. The nutrients occur in the reservoir, however majority as well as increased quantity of the nutrient elements get stacked in the hypolimnion zone of the reservoir. With a view to know the status of various nutrients in the epilimnion zone of Chohal reservoir, some elements were examined.

Materials and Methods

The salient features of irrigation dam and morphometric features of Chohal reservoir were studied through survey in reservoir area as well as visit in irrigation department, Punjab. Water samples from epilimnion zone were collected from small reservoir i.e. Chohal reservoir for knowing the dynamics of available nutrient constituents, supporting other chemical and physical parameters their seasonal fluctuations as well as impact on the living organisms. Samples were analyzed on monthly basis after collection of water in a 2.5 litre polyethylene bottle from epilimnion zone of a small reservoir (Chohal), District- Hoshiarpur, three meters away from the bank to avoid any interference as well as mid-zone of the reservoir (Fig. 1 & 2). The water samples were collected using indigenously made boat (Fig.3). The estimation of light intensity, ambient temperature, water temperature, secchi disc transparency, specific conductivity, pH, salinity, was done at the sampling sites. For immediate analyses of some elements such as phosphate-phosphorus (PO_4-P), nitrate-nitrogen (NO_3-N), calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) the samples were brought to the laboratory. These analyses were done with the use of Thermometer, Pen Type Pocket pH Meter, Conductivity Meter, Salinity Meter, Lux Meter and Field Water Analyzer Kit, Flame- photometer, Spectrophotometer following Standard Methods (APHA, AWWA and WEF, 1992; Trivedi and Goel, 1984). Available phosphate-

Fig. 1: Map of Punjab state showing Hoshiarpur



phosphorus was analyzed by stannous chloride method using standard phosphate solution and spectrophotometer (Model: Systronics - 106). The optical density (OD) of PO_4-P was read at 690 nm. Similarly, nitrate-nitrogen was analyzed by phenol disulphonic acid method using standard nitrate solution and spectrophotometer. The OD of NO_3-N was read at 410 nm. Sodium and potassium was measured by flamephotometer (Model: Systronics) where as calcium, and magnesium by EDTA titrimetric method. Samples of existing ichthyofauna were also collected from Chohal reservoir and identified following Talwar and Jhingran (1991).

Fig. 2: Outline map of Chohal reservoir (Hoshiarpur) Showing depths at various range lines

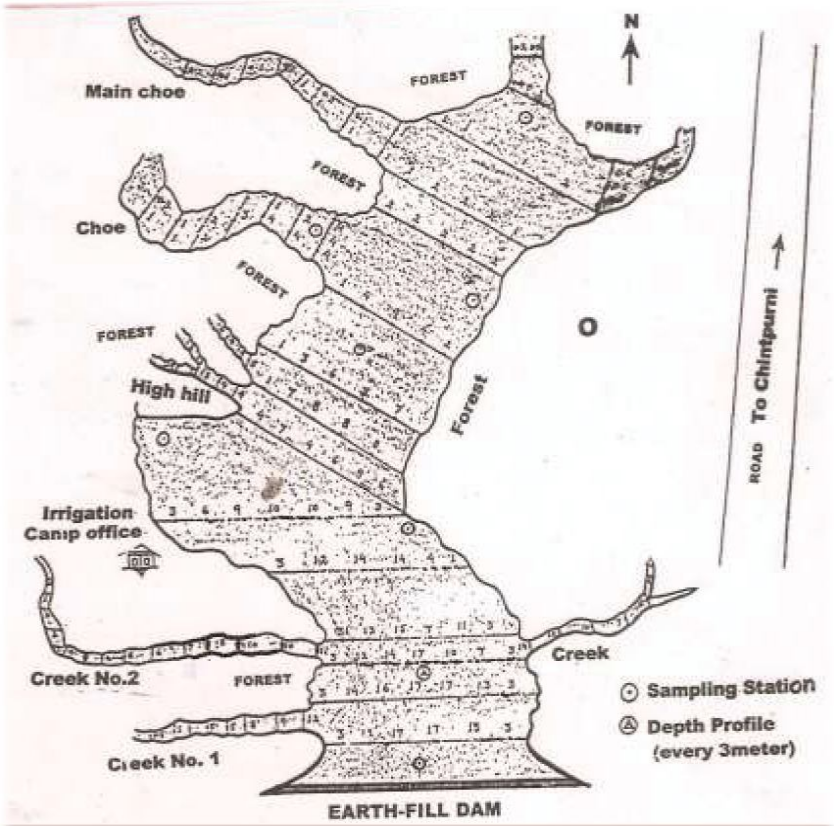


Fig. 3: Collection of water and soil samples from Chohal reservoir

Results and Discussion

Geo-morphology and hydrography features of Chohal Reservoir

The Chohal irrigation dam is located in the Kandi area of Punjab under the Kandi Watershed Development Program of the World Bank. It consists of reservoir, spillway, irrigation outlets, and irrigation distribution system as its main component. The reservoir construction was started in January 1991 and completed in March 1993 with expenditure cost of Rs 1248 lakh. Chohal reservoir is located at a distance of about 91 km away from Ludhiana district. The reservoir occupies an area of 61 ha. It is 12 km away from Hoshiarpur district headquarter and situated on the Northeastern periphery of the Punjab state. The bathymetry, morphometric characters and special features of the irrigation dam are mentioned below and also simply depicted in figure-1.

The top level and height of dam above foundation is 388.6m and 28.6m where as length and width of top is 330m and 6m respectively. The maximum depth of reservoir is 17.08m during the normal reservoir level whereas 20.08m during the full reservoir level. The mean depth of the reservoir was calculated to be 6.5m. The gross storage capacity of the reservoir is 396.71ha m or 3267.55 AF or 39,67,100m^3 whereas the dead storage capacity is 44.80ha m or 369 AF or 4,48,000m^3. The dead storage level is 366m and the depth at dead storage level is 1.6 m. The discharge capacity of the carrier is 675 cusec. The gross culturable areas (GCA) and culturable command area of the reservoir is 1125 ha and 900 ha respectively. The dam is an earthen fill dam, which is 330m long. The width of the dam is 200m at the base and 6 m at the top. The characteristics of spillway of Chohal irrigation dam having crest level is 381.5m, width at crest (20m) and design flood (275 cusec) (Jindal *et al*, 2000).

Physico-chemical and nutrient status of Chohal reservoir

Various physico-chemical and nutrient parameters of Chohal reservoir were analysed with sufficient degree of accuracy. After the analyses of various physicochemical and nutrient parameters during different season revealed that water quality is the major determinants of biogenic productivity of Chohal reservoir. There were sharp changes in the seasonality of physico-chemical and nutrient features observed after analyses. The nutrient content in epilimnion zone of a small reservoir i.e., Chohal in Punjab is depicted in Table – 3 to 5.

The range of light intensity varies from 28000 to 39800 lux in the reservoir. The overall range of ambient and water temperature varies from 16.0 to 44.0 C and 13.5 to 36.0°C respectively. The other physicochemical characteristics such as water transparency fluctuated from 21.0 to 244.0cm, salinity (0.3 to 0.7ppt), conductivity (0.144 to 0.469mS), total dissolved solids (66.4 to 243.0ppm), pH (7.5 to 9.0), CO_3 (8.8 to 28mg/l), HCO_3 (104 to 162mg/l), total alkalinity (126.6 to 162.0 mg/l), chloride (2.0 to 11.5mg/l), and hardness (30 to 118mg/l) in the reservoir water. The content of dissolved oxygen was found to be in the range of 4.87 – 11.61mg/l. The range of pH showed the Chohal reservoir water is alkaline throughout the year and maintained high buffering capacity. Similar pH observation also reported in floodplain-wetland and Ganges River (Hassan *et al,* 1998a & 1998b). The alkalinity is mainly caused due to carbonate, bicarbonate and hydroxyl ions where as hardness may be due to Ca and Mg content in the water (Hassan, 2000). The available dissolved oxygen in water depends on the balance mechanism of respiration by reservoir fauna and putrefaction of organic matter. Concentration of high DO content is an indication of healthy system, which is good for distribution, behavior, and physiological growth of aquatic organisms including fisheries (Hassan *et al,* 1998a & 1998b; Hassan, 2000).

The nutrient parameters show considerable monthly and seasonal variation, which is also linked to the hydrological cycle.

Nutrient content of Chohal reservoir

The inorganic solids when in solution consists of anions like carbonates, chlorides, sulphates, phosphates, nitrates etc in combination with metallic cations such as calcium, sodium, potassium, magnesium, iron etc. The dissolved solids in water mass influence the chemical density of the environment, and abundance and composition of the biotic community (Jhingran, 1977). These nutrients are considered important in aquaculture and freshwater ecosystem, but their amount if excess in the medium, is harmful to the aquatic organisms including fish species. Phosphorus and nitrogen have been identified as the growth limiting nutrients in most water bodies (Vollenweider, 1978; Sugunan, 1995).

Phosphate-phosphorus (PO_4-P)

Phosphorus is least abundant but it most commonly limits the biological productivity in a vast majority of aquatic ecosystems. It is clearly realized

that among the nutrients, nitrates and phosphates seem to be limiting to some extent in nearly all the freshwater ecosystems. While in tropical waters nitrogen often limits the metabolic processes, phosphorus generally does this in temperate waters. In natural waters phosphorus is available in three forms i.e. inorganic or soluble phosphate phosphorus, soluble organic phosphorus and particulate organic phosphorus of seston contained in plankton, detritus, etc. The only significant form of inorganic phosphorus is orthophosphate. Hence in aquatic ecosystems only inorganic phosphorus as soluble orthophosphate plays significant role. The major source of phosphate in water is domestic sewage, agriculture effluents and industrial waste waters. The high concentration of phosphate is therefore indicative of pollution. There were sharp changes observed in the seasonality of nutrient content in Chohal water as recorded after analyses. The maximum average monthly value of phosphate-phosphorus was recorded to be 0.2395 mg/l during summer followed by 0.013 in winter where as average monthly minimum value of PO_4-P was observed to be 0.002 mg/l during monsoon. However, traces of phosphate-phosphorus were noticed during the month of January, February, July, August and November. The overall range of phosphate-phosphorus was recorded from traces to 0.527 mg/l in the epilimnion zone of Chohal reservoir (Table 3 to 5). Sinha *et al* (1998) revealed higher PO_4-P content in downstream of the River Ganga during monsoon period. The value analyzed in Chohal reservoir was found to be under the limit during investigation period.

Nitrate-nitrogen (NO_3-N)

The concentration of nitrate-nitrogen (NO_3-N) range from undetectable levels to nearly 10 mg/l in unpolluted freshwaters, but are highly variable seasonally and spatially (Wetzel, 1983). The overall range of nitrate-nitrogen was recorded from traces to 1.774 mg/l in the epilimnion zone of Chohal reservoir which also shows to a good natural condition of the water. The maximum average monthly value of nitrate-nitrogen (0.803 mg/l) was observed during winter followed by 0.228 mg/l during monsoon, whereas average monthly minimum value of NO_3-N was recorded to be 0.1435 mg/l during summer (Table - 3 to 5). However, traces of NO_3-N were noticed during the month of June, July and November. In freshwater systems close to land, nitrate can reach high levels that can potentially cause the death of fish. While nitrate is much less toxic than ammonia or nitrite, levels over 30ppm of nitrate can inhibit growth, impair the immune system and cause stress in some aquatic species. In most cases of excess nitrate concentrations in aquatic systems, the primary source is surface runoff from agricultural or landscaped areas which have received excess nitrate fertilizer. These levels of nitrate can also lead to algal blooms, and when nutrients become limiting (such as potassium, phosphate or nitrate) then eutrophication can occur. As well as leading to water anoxia, these blooms may cause other changes to ecosystem function, favoring some groups of organisms over others. Consequently, as nitrates form a component of total dissolved solids, they are widely used as an indicator of water quality. Alderfer and Lovelace (1977) believed that inorganic nitrogen above 0.03 mg/l stimulates algal growth.

Calcium (Ca)

Calcium is one of the most abundant substances of natural water being present in high quantities in rocks. The disposal of sewage and industrial wastes are also important source of calcium. Calcium, magnesium, iron and manganese cations contribute to the hardness of water (Shrivastava and Patil, 2002). It was reported that hard waters are more productive than the soft water from fisheries point of view (Barrett, 1953). Plankton usually needs calcium as a micronutrient (Wetzel, 1983). Various species have different sensitivity for calcium. Species of the larger genera are divisible into those adapted to acidic (pH < 6), calcium deficient waters (< 10 mg Ca/L), through a series of those adapted to increasingly alkaline, calcium-rich waters (Hutchinson, 1967). The overall range of calcium was fluctuated from 9.0 to 15.9 mg/l in the epilimnion zone of Chohal reservoir. The maximum average monthly value of calcium (12.73 mg/l) was recorded during monsoon followed by 7.37mg/l in winter, whereas average monthly value of calcium (11.63mg/l) was found to be minimum during summer (Table 3 to 5). Calcium is essential for living organisms, particularly in cell physiology, where movement of the calcium ion Ca^{2+} into and out of the cytoplasm functions as a signal for many cellular processes. Calcium metal reacts with water, evolving hydrogen gas at a rate rapid. Part of the slowness of the calcium-water reaction results from the metal being partly protected by insoluble white calcium hydroxide. Calcium acts as neurotransmitter and help in muscle contraction of fish body. Calcium poisoning in fish are similar to those of sodium salts. NaCl and MgCl reduce the toxicity of calcium chloride. The value of calcium in reservoir was found to be under the limit during the study period.

Magnesium (Mg)

The overall range of magnesium was fluctuated from 3.43 to 26.49 mg/l in the epilimnion zone of Chohal reservoir. The maximum average monthly value of magnesium (17.0 mg/l) was observed during monsoon followed by 9.69 mg/l of Mg in summer, whereas average monthly minimum value (7.37 mg/l) in winter season (Table - 3 to 5). Magnesium ion's high solubility in water helps ensure that it is the third most abundant element dissolved in water. Magnesium compounds are much more soluble than their calcium counterparts. The monocarbonates of hard waters are usually more than 95% $CaCO_3$ under ordinary CO_2 pressures, and $MgCO_3$ and $Mg(OH)_2$ precipitate significantly only at very high pH values (>10) under most natural conditions (Wetzel, 1983). Magnesium is also the metallic ion at the center of chlorophyll, porphyrins and is thus a common additive to fertilizers. Magnesium ion is necessary for all life. Due to the important interaction between phosphate and magnesium ions, magnesium ions are essential to the basic nucleic acid chemistry of life, and thus are essential to all cells of all known living organisms. Magnesium poisoning in fish causes similar symptoms to those of poisoning in sodium salts. The sluggish eye movement and subsequent turn on their sides in fish are the indication of magnesium poisoning. The value of magnesium in reservoir was found to be under the limit during the study period.

Potassium (K)

Potassium in nature occurs only as ionic salt. As such, it is found dissolved in water, and as part of many minerals. Potassium ion is necessary for the function of all living cells, and is thus present in all plant and animal tissues. It is found in especially high concentrations in plant cells. Potassium compounds generally have excellent water solubility, due to the high hydration energy of the K^+ ion. The potassium ion is colorless in water. Potassium cations are important in neurons function, and in influencing osmotic balance between cells and the interstitial fluids, with their distribution mediated in all animals by the so-called Na^+/K^+-ATPase pump. Potassium is also important in allowing muscle contraction and the sending of all nerve impulses in animals through action potentials. It is the major cation inside animal cells, and it is thus important in maintaining fluid and electrolyte balance in the body. Potassium also produces potassium hydroxide in the reaction with water. Potassium hydroxide is a strong alkali and so is a caustic hazard, causing burns. The coloration of fish body is lighter in case of potassium poisoning. The epithelium of fish gill swells, disintegrates, undergoes lysis leading to disruption of the gas exchange. Symptoms of potassium poisoning are analogous to those of poisoning with sodium. Potassium salts are more toxic than sodium salts (Metelev *et al*, 1983). Moderate epilimnetic reduction in potassium concentration, which has been observed in extremely productive lakes, is presumably related to potassium utilization by the massive algal populations and by submerged macrophytes (Mickle and Wetzel, 1978). The overall range of potassium was recorded from 2.1 to 7.8mg/l in the epilimnion zone of Chohal reservoir. The maximum average monthly value of potassium (4.73mg/l) was observed during winter season followed by 3.875mg/l of K in summer, where as average monthly minimum value (2.53mg/l) was recorded during monsoon (Table 3 to 5). The value of potassium was found to be under the limit during the study period which is not harmful for the fish species exist in the Chohal reservoir.

Sodium (Na)

Sodium is one of the important cation occurring naturally. Sodium is present in great quantities in the Earth's oceans as sodium chloride. It is also a component of many minerals, and it is an essential element for animal including fish life. Sodium ions are necessary for regulation of blood and body fluids, transmission of nerve impulses, heart activity, and certain metabolic functions. Sodium is needed by animals, which maintain a high blood sodium concentration and extracellular fluid sodium concentration. Excitable animal cells, for example, rely on the entry of Na^+ to cause a depolarization. System for maintaining optimal salt and water balance in the body is a complex one. Excess sodium toxicity supports erratic behavior of fish swimming, fish respond poorly to mechanical stimuli; sometimes turn on their side or abdomen upward and paralytic phenomena leading to death. The dark coloration of fish body is the characteristic symptoms of sodium toxicity. A threshold level of sodium (4 mg/l) is required for near optimal growth of several species (Kratz and Myers, 1955). The overall range of sodium was recorded from 6.6 to 37.5 mg/l in the epilimnion zone of Chohal reservoir. The maximum average monthly value of sodium (30.8 mg/l) was observed during summer followed by 30.1 mg/l of Na in winter, where as average monthly minimum value (12.97 mg/l) was found during monsoon (Table - 3 to 5). The value of sodium was found to be under the limit during the study period which is not harmful for the fish species exist in the Chohal reservoir. However, sodium concentration in irrigation water and soil is of great interest as high sodium contents makes soil hard to plough and unsuitable for seedling emergence.

Table 1: Nutrient Content in Epilimnion Zone of a Small Reservoir in Punjab during winter

Reservoir Nutrient	Month				Average
	November	December	January	February	
PO_4-P (mg/l)	Trace	0.052	Trace	Trace	0.013
NO_3-N (mg/l)	Trace	1.774	0.503	0.935	0.803
Calcium (mg/l)	15.9	12.2	10.8	9.8	12.18
Magnesium (mg/l)	3.43	8.7	9.04	8.31	7.37
Potassium (mg/l)	7.8	3.9	3.6	3.6	4.73
Sodium (mg/l)	37.5	29.3	25.6	28.0	30.1
Other supporting parameters :					
Luxmeter readingx100	395	-	-	-	395
Ambient Temp. (°C)	30.5	19.5	16.0	27.0	23.25
Water Temp. (°C)	21.5	16.0	13.5	20.5	17.875
Transparency (cm)	111.0	132.0	-	212.0	151.7
Sp. Conductivity (mS)	0.404	0.448	0.144	0.147	0.286
pH	7.5	8.32	8.5	8.7	8.26
Salinity (ppt)	0.4	0.5	0.3	0.3	0.375

Table 2: Nutrient Content in Epilimnion Zone of a Small Reservoir in Punjab during summer

Reservoir Nutrient	Month				Average
	March	April	May	June	
PO_4-P (mg/l)	0.010	0.384	0.527	0.037	0.2395
NO_3-N (mg/l)	0.479	0.077	0.018	Trace	0.1435
Calcium (mg/l)	12.6	13.3	10.6	10.0	11.63
Magnesium (mg/l)	7.63	7.95	12.98	10.21	9.69
Potassium (mg/l)	4.1	3.7	4.0	3.7	3.875
Sodium (mg/l)	30.1	30.0	32.0	31.1	30.8
Other supporting parameters :					
Luxmeter readingx100	-	-	-	362	362
Ambient Temp. (°C)	18.0	42.0	42.0	39.0	35.3
Water Temp. (°C)	20.5	31.0	36.0	35.5	30.8
Transparency (cm)	-	244	140	127.0	170.3
Sp. Conductivity (mS)	0.371	0.319	0.415	0.469	0.394
pH	8.9	9.0	8.6	8.5	8.75
Salinity (ppt)	0.4	0.4	0.7	0.5	0.5

Table 3: Nutrient Content in Epilimnion Zone of a Small Reservoir in Punjab during monsoon

Reservoir Nutrient	Month				Average
	July	August	September	October	
PO_4-P (mg/l)	Trace	Trace	-	0.006	0.002
NO_3-N (mg/l)	Trace	0.551	-	0.132	0.228
Calcium (mg/l)	15.9	13.3	-	9.0	12.73
Magnesium (mg/l)	8.29	16.21	-	26.49	17.0
Potassium (mg/l)	2.1	2.9	-	2.6	2.53
Sodium (mg/l)	17.7	14.6	-	6.6	12.97
Other supporting parameters :					
Luxmeter readingx100	280	398	-	387	355
Ambient Temp. (°C)	39.0	42.0	-	44.0	41.7
Water Temp. (°C)	35.0	34.5	-	29.5	33.0
Transparency (cm)	175.0	186.0	-	21.0	127.3
Sp. Conductivity (mS)	0.405	0.262	-	0.271	0.313
pH	8.2	8.0	-	7.9	8.03
Salinity (ppt)	0.5	0.4	-	0.4	0.43

The nutrient contents and physico-chemical constituents of Chohal reservoir at Hoshiarpur district showed significant monthly / seasonal variations. Also, variety of aquatic flora and fauna such as phytoplankton, zooplankton, macro-phytes, benthic macro invertebrates, nekton communities including fish species was monitored from Chohal reservoir. Chohal reservoir does not receive any waste water. Available flora and fauna indicate that quality of reservoir water is suitable for their survival. Thus it is apparent that several environmental factors influence quality and productivity of water. The need of the day is to bring greater awareness for harmonizing population dynamics, adopting enhancement norms, advancement in eco-friendly technology like cage and pen culture, socio-economic development and harnessing of natural resources (Hassan, 2000; Hassan, 2005).

Conclusion

The available nutrient constituents in reservoir show considerable monthly and seasonal variation, which are linked to the hydrological cycle. The findings revealed that the circulation of

nutrient occurs in the epilimnion zone of the reservoir and the nutrient content varies season to season, however, the nutrients are important determinants of biogenic productivity of the reservoir. The nutrient features of chohal reservoir considered for the study revealed that reservoir water can serve as a good habitat for many aquatic fauna including fisheries. Therefore, nutrient status of small reservoir can be improved by input of fertilizers for the enhancement of productivity compare to natural carrying capacity of the reservoir. The fertility and productivity of reservoir may improve after ageing. However, productivity of reservoir mainly depends upon water qualities and availability of nutrients as well as existence of flora and fauna in the reservoir water.

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