Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 157 (2021) 105-128 EISSN 2392-2192

A Significant Review to Indian Limnology

Rakesh Gothwal

Department of Bioscience, Faculty of Basic and Applied Sciences, Madhav University, Distt. Sirohi, Rajasthan, India

E-mail address: rakeshgothwal15@gmail.com

ABSTRACT

The limnological research has explored an immense momentum throughout the world over previous few decades. It has evolved as an individual division of ecology and numerous fields of specialization in limnology are acknowledged such as physical limnology, chemical limnology, planktonology, paleolimnology and limnology of specific areas like desert, high altitudes, temperate region, tropical region etc. The Swift advances in the field of limnology have taken place particularly in European countries and North America. Eutrophication, community dynamics, planktonology and pollution is an actively engaged viewpoint of various laboratories in exploring inland water bodies. The current article is an endeavor to give a widespread analysis and furnish a broad review of literature associated with the initiation of limnology and work done in Indian sub-continent with one hundred seventy four quoted references.

***Keywords*:** Limnology, Phytoplankton, Zooplanktons, Ecology

1. INTRODUCTION

Limnology emerge as a directive of science it consist of biological, chemical, physical, geological, and supplementary aspects of all inland waterbodies (Lentic and Lotic, fresh and marine, natural or man-made). Planktonology, Environmental Engineering, Aquatic Biology and Ecology, Geoinformatics (GIS), Hydrochemistry, Aquatic Toxicology, Pollution and eutrophication is an actively engaged viewpoint of various laboratories in exploring inland

(Received 06 April 2021; Accepted 24 April 2021; Date of Publication 25 April 2021)

water bodies. Life on earth depends on air, water and soil. Water is an expensive contribution of nature, which is essential for survival of human, plants and animals. The vigorous aquatic ecology is proportional to the biological and physico-chemical characteristics of a waterbody.

The physico-chemical characteristics of a wetland chiefly governs the existence of life and its growth, which gathers the complex interaction of the aquatic ecosystem; so many workers have investigated the properties (physical, chemical and biological) of various waterbodies. Aquatic ecosystem comprises of phytoplankton and hydrophytes as primary producers, zooplankton as primary consumers and fishes as secondary, tertiary consumers and several other organisms which together includes as one of the important part of aquatic-biodiversity.

2. CRITICAL DISCUSSION

Limnology expands as a division of science that chiefly deal with freshwater ecology together its interrelationship with physical and chemical environment.

It comprises the structural and functional study and co-relations of waterbodies, their dominant physical, chemical, and biological parameters and their exchange among organisms affects its biotic environments and vice-versa.

Leeuwenhoek initiated limnological studies with the microscopic description of Spirogyra in 1674 from Lake Berkelse in Netherland. Francois Alphonse Forel first proposed the term limnology while publishing his researches on Lake Geneva as a result of its practical value. **Fritsch (1888)** ingrained the initial mobile biological station to study the diverse lakes. **Forel (1901)** gave leading work of motivation to study limnology effectively and regarded as the father of modern limnology. **Fritsch (1907)** established the work to study the periodicity of algae in tiny ponds. **West and West (1907), West (1912), Hodgetts (1921), Pearsall (1921, 1923, 1930** and **1932)** gave a broad explanation of periodicity of fresh water algae and factors regulating it. **"August Thienemann"** and Swedish Botanist **"Einar Naumann" (1922)** a German Zoologist together founded the International Society of Limnology. Phenomenal contributions have been done on physical properties of the fresh water bodies by **Storm (1924), Howland and Lucy (1931). Hutchinson** and **Pickford (1932)** calculated chemical properties of fresh water lakes. **Fritsch** and **Rich (1932)** advertised a group "Studies on the occurrence and reproduction of British Fresh Water Algae in Nature". **Bailey (1938), Prescott (1938** and **1939)** studied ecology of phytoplankton in Lake Michigan dealt with abhorrent algae and their management in lakes. **Thresh et al. (1944)** recorded chloride of surface waters which endorsed elevated amounts of chloride to contamination. **Welch (1948)** has reckoned significant apprehension on biological and physico-chemical properties of freshwater and conceived the problem of "Biological Productivity" as the central theme of limnology.

India has highly diverse physiography, unique geology, cloudburst climate with extremes of temporal and spatial inconsistency, and high biotic variety is endowed with equally diverse aquatic habitats. Natural lakes of the diverse origin occur only in Himalayan belt, where the climate varies from cold in the west to humid tropical in the east In the early 19th century these aquatic habitat and their biota have been broadly investigated since then the interest has grown rapidly in past few years due to the increasing requirement for fish and water and the necessity for managing the water quality. **Ganpati (1940, 1955** and **1960)** was among the pioneer workers of limnology in India.

Ganpati broadly studied on the ecology of temple tanks and ponds, a variety of aspects were done including differences in various physico-chemical parameters and biological their importance, bloom forming algae and its ecology in tropical waterbodies, temporary ponds and temple tanks. **Gonzalves** and **Joshi (1946)** studied the seasonal occurrence of algae in a tank at Bandra, Mumbai. **Rao (1953** and **1955)** discussed and reported the propagation of fresh water algae in Hyderabad with six undersized ponds. **Krishnamurthy (1954)** studied the diatomic flora of lakes in southern India. **Zafar (1955, 1964, 1967** and **1969)** worked on ecology of freshwater ponds in Hyderabad with a variety of aspects. The discovery of Plankton by a German Biologist **Victor Hensen** in 1887 was a glorious incident across the ground of limnology and rise up a different perception. Hensen first used the term "Plankton'; and it includes all raw particles, which glide generously and reluctantly at coast and underneath in waterbodies, **(Hutchinson 1957).**

Freshwaters planktons include representation of algae and bacteria with numerous groups; they are microscopic organism that live pendant and move via twist of wind in almost every habitat of an aquatic ecosystem. They forms a very imperative division of the freshwater ecosystem, thousands of these organisms can be found due to their small size which occupies huge region of water and capable to multiply at an exponential rate. Planktonic communities comprise a wide variety of organisms which includes plants (phytoplankton) and animals (zooplankton) that form the basis of aquatic food webs. In natural waters, plankton accumulates a huge component of the living material along with function in biogeochemical cycles. Morphologically and physiologically they are adapted to survive in the aquatic ecosystem. They are non motile and their movement is induced by the wind and currents and many can move covering little distance with the help of various appendages helps in locomotion.

Plankton drifts or swims freely on the surface of waterbodies and has been used as bio-indicator to monitor the aquatic ecosystems in recent times. Phytoplanktons mainly consist of variety of algae such as diatoms, dinoflagellates of the plant kingdom and serve as the primary producer community. Zooplankton comprises a higher trophic position in the community of plankton and contributes significant role in the yield of the freshwater biome. They occupy succeeding trophic stage in the food chain and have intermediary level in the food web of the aquatic ecosystem and transfers energy from lower trophic levels to higher. In an aquatic ecosystem, zooplankton communities participate in cycling of organic materials due to their heterotrophic nature and respond quickly to the environmental alteration because of their short life cycle. Zooplanktons are also recognized as biological indicator of the eutrophication in the water bodies.

The biotic community of an aquatic ecosystem is directly affected by the changes in physico-chemical conditions. The density and diversity of the zooplankton in freshwater ecosystem is controlled by several factors i.e Temperature, Dissolved oxygen and organic matter. In Indian environment, researchers acknowledged planktons extensively by **Sreenivasan (1967), Philipose (1960)** studied inland fisheries and freshwater phytoplanktons. **Singh (1960)** evaluated the ecology of phytoplanktons in inland waterbodies of Uttar Pradesh. **George (1966)** covered a relative study of planktonic ecology of fish tanks. **Munnawar** and **Zafar (1967)** studied comparable assistance to the ecology of algae in unpolluted and polluted lakes of Hyderabad with the patterns of distribution in phytoplanktons. They analysed the significance of physico-chemical parameters and their impact on the growth of algae.

Vyas (1968) studied phytoplanktons in Lake Picchola, Udaipur.

Verma and **Shukla (1968)** calculated the biological characters of temple tanks, in Deoband. **Venkateshwarlu (1970)** studied the ecological aspects of Moosi River in Hyderabad and allied periodicity of algae and water pollution. **Munnawar (1970)** surveyed extensively of unpolluted and polluted environments along with the division of phytoplanktons in single and colonies. **Seenayya (1971)** studied planktonic arrangements in freshwater lakes. **Munnawar (1972)** reported that organic pollution can be gauged with the presence of Euglenophyceae. **Hosmani** and **Bharati (1975** and **1977)** examined the development of Euglena sanguinea and reported that temperature above 26 °C, phosphate with low concentrations of carbonates, albuminoidal ammonia, high pH, carbon dioxide, nitrates and free ammonia quickens the algal bloom.

George (1980) broadly classified categorise of Indian freshwater investigations and highlighted problems and priorities for supplementary limnological researches in the framework of freshwater resources in India. **Hosmani** and **Bharati (1980** and **1982)** prepared a wide-ranging investigation of freshwater hydrobiology of wetlands of Dharwad bothered by population of animals and humans, their investigation suggested that the increase in the number of species increases total production of algae. However during summer heavily polluted wetlands showed low production of algae, when different algal species emerge as blooms. **Singh (1990)** correlated primary production of planktons with physico-chemical parameters in their ecological studies associated with phytoplanktons.

Goviathan (1990) studied seasonal progression of algal growth in waste stabilization ponds. **Ibrahim (1990)** studied wastewater treatment plants with respect to algal productivity. **Naik** and **Hegde (1990)** examined Sharavathi estuary and express organized description of Diatoms. **Kumar and Patel (1990)** delineate desmids of Gujarat. **Naganandini** and **Hosmani (1990)** studied inland lakes of Mysore, their research proceedings conveyed that cyanophycean blooms were conquered by Microcystis aeuruginosa. Death and decay of Spirulina nordestedtii coupled with dissolved organic matter, dissolved oxygen carbon dioxide, phosphorous, calcium the influenced the cyanophycean bloom. **Swarnalatha** and **Narsing Rao (1991, 1993, 1994** and **1998)** assessed water quality and pollution in Lake Sarror Nagar and Banjara Lake, and supports the observations of Naganandini and Hosmani (1990), their research conclusion states that Cyanophycean blooms indicates pollution of water.

Kumar and **Sharma (1991)** concluded in their research verdict high electrical inductance, pH, total alkalinity and nitrates increases trophic level of water. **Sarwar** and **Wazir (1991)** studied the water chemistry allocation of phytoplanktons followed up by invariability of planktons studied by **Kaushik et al. (1991). Jyothi et al. (1992)** discussed the higher concentrations of chlorides, phosphates and organic matter in an environment controlling the blooms of Cyclotella**. Choudhary (1991)** studied the influence on diatoms due to optimum change rate of pH and temperature using the algal bioassay method. **Vaishya** and **Adoni (1992)** concluded that due to unbalanced physico-chemical characterstics Lake Sagar had turn out to be Hypereutrophic with low lucidity. **Chatterjee (1992)** reported that external organic and inorganic material majorly controlling the ecology of Lake Nandan Kannan. **Borker et al. (1992)** accomplished that the pollution rate in a lake at Goa and was accelerated due to higher concentration in physico-chemical parameters including dissolved oxygen, free carbon dioxide, pH, chloride and total alkalinity. **Adhakari** and **Sahu (1992)** concluded that Trichodesmium bloom for the duration of summer in Chilka lake conscientious alkaline pH with temperature above 20 °C. **Mohapatra** and **Mohanty (1992)** concluded water quality of lakes, their research study and found that efficiency of Chlorella was more than Anabaena in reducing pollution and

nutrient load. **Dixit et al. (1992)** suggested that environmental issues like Lake Acidification, eutrophication and climate changes can be addressed using diatoms as biological indicators. **Parvateesham** and **Mishra (1993)** studied algae various groups of algae used as indicators of pollution that showed a definite correlation between physico-chemical parameters and abundance in Pushker Lake. **Rao et al. (1993)** studied nutrients status and phytoplankton production of Ooty Lake and it classified as eutrophic. **Swarnalatha** and **Narsing Rao (1993)** extensively studied and described various factors responsible for appearance of a bloom of Microcystis aeruginosa in Banjera Lake of Hyderabad. **Heckey (1993**) suggests that nutrient loads input into the lakes are allied together with atmospheric deposition and land runoff with an approximate account of 94% nitrogen and 90% phosphorous.

Shaji and **Patel (1994)** highlighted physico-chemical parameters and phytoplankton ecology of a polluted pond at Anand, Gujarat. **Khan** and **Chowdhary (1994)** studied the physico-chemical limnology of Lake Katpal. **Swarnalatha** and **Narsing Rao (1994)** while conducting their research study in two ponds reported that continuous bloom of Cyanophyceae results in more pollution compared to other pond supported with Desmids was less polluted. **Goel et al. (1994)** reported that dominance of blue green algae is reliant on phosphorous nitrogen ratio. **Bairagi** and **Goswami (1994)** find similar observations in their research study across water blooms of some ponds in North India. **Miyajuima et al. (1994)** studied eutrophic Lake Biwa of Japan and concluded that the population of diatoms and silica composition were in higher range. **Sahu et al. (1995)** demonstrated seasonal variations in physico-chemical parameters with impact of COD and TDS on phytoplanktons and its pollution category. **Hosmani** and **Kumar (1996)** studied water pollution with its biochemical aspects and inferred that Dalvoi Lake is productive in planktons whereas Kukkarahalli Lake is highly productive in biochemical products.

Pandey et al. (1995 and 1998) analyzed in their study with Kosi River and Lake Fateh sagar, that inflow of nutrients and consequent algal growth deteriorates the water quality, while the seasonal abundance and dependence of phytoplankton is related with physico-chemical environment. **Agarkar (1998)** reported pollution tolerant algae species and water quality in Sakegoan reservoirs. **Gandhi (1998)** reported new species of freshwater diatoms of central Gujarat. **Wani (1998)** concluded diatoms were the most represented species in seasonal dynamics of phytoplanktons in Himalaya lakes. **Verma** and **Mohanty (1998)** reported a straight relative index between phytoplanktons and pH. **Pandit (1999)** reported trophic structure of some phytoplankton communities of tropical wetlands. **Nair (1999)** reported variations in the correlations of the physico-chemical parameters and phytoplanktons. **Johari et al. (1999)** studied physico-chemical parameters of lakes in Amaravathi district while **Chidambaram (1999)** worked on coastal aquaculture. **Borse** and **Bhave (2000)** studied that dissolved CO_2 was dependent on carbonates and bicarbonates in water and pH observed maximum in summer and minimum in winter. **Dhanapati (2000)** concluded that under favorable environmental conditions occurrence and growth of rotifers is rapid.

Gevrey et al. (2001) and **Nandan et al. (2001)** reported that seasonal concentration of dissolved carbon-dioxide, carbonates, total alkalinity, phosphates and chlorides was higher due to abundance of blue-green algae in Hentala Lake of Jalgaon. **Noor Alam (2001)** recorded significant variations in physico-chemical parameters while working on a pond at Hatwah, Bihar and suggested measures to prevent deterioration. **Rajkumar (2001)** studied seasonal distribution of planktons in freshwater pond of Pollachi, Tamil Nadu and reported minimum number of phytoplanktons occurred in winter months. **Mahadev** and **Hosmani (2002, 2004** and

2005) concluded water quality by means of the Langlier's index as a factor of phytoplankton distribution index. Conclusion of their study indicates that one of the lake had propensity of heavy scale deposition while the other had a tendency of hard water with light scale deposition. Their research finding also confirms the levels of organic pollution with presence of Chlorocaccales and blue-green algae having tendency of light scale deposition.

Nagarathna and **Hosmani (2002)** studied the factors influencing the bloom of Nitzschia obtusa in a polluted lake. Correlation matrix and cluster analysis indicated that most of the physico-chemical parameters were inversely proportional to the growth of the Diatoms; the appearance of few species of Desmids indicated that the water was polluted.

Pejavar et al. (2002) reported polluted water with an appearance of few species of Desmids. Their research explain variations in the levels of phosphorous and carbon-dioxide in lake Ambegosale. **Chinmoy** and **Raziuddin (2002)** reported the industrial areas with degraded water quality index. **Hosmani** and **Lingannaiah (2002)** studied the inter-relationships of phytoplankton and zooplankton with the contributory factors of fish kills due to algal blooms.

Hariprasad and **Ramakrishnan (2003)** determined organic pollution with the application of algal assay. **Juttner et al. (2003)** identified diatoms as indicators of water quality. **Ahmed et al. (2004)** evaluated water quality of streams with an innovative index. **Pandey** and **Verma (2004)** studied the chemical and biological characteristics with influence of catchment in two tropical freshwater lakes Baghdara receiving runoff from undisturbed woodlands and UdaiSagar receiving runoff from urbanized regions of Udaipur, Rajasthan, physico-chemical and biological analysis of both the lakes reveals that lake Udai Sagar was polluted and reaching eutrophic condition, whereas lake Baghdara was unpolluted, which further concludes that dredging of sediment containing phosphorus could be an effective measure for the restoration of dryland lakes or eutrophic lakes. **Mahadev** and **Hosmani (2005)** extensively studied of Langlier's index relation to fresh waters, their conclusion states that growth of phytoplanktons in saturated waters had a propensity to change its pH.

Nandan and **Aher (2005)** assessed algal communities and water quality of Haranbaree dam, Maharashtra, their findings recorded Navicula, Oscillatoria and Euglena as most pollution tolerant species. **Hosmani (2006)** extensively applied Principal Component Analysis (PCA) to calculate Trophic State Indices for Mysore lakes, their tesearch values inferred less than 40 were considered Oligotrophic, 40-50 were considered Mesotrophic (moderate pollution), more values than 50 were eutrophic (highly productive).

Thomas et al. (2006) studied the Mysore lakes and inferred that, growth of Myxophyceae is significantly affected by phosphates, nitrates, oxygen and CO_2, they reported that Chlorococcales and their members had capacity to tolerate excessive concentrations of nutrients. **Veeresh Kumar** and **Hosmani (2006)** studied physico-chemical parameters and their relation to freshwater algal biodiversity; they concluded that occurrence of Desmids in fairly advanced records dependent on high temperature, pH and bicarbonates.

These observations suggest that the lakes are tending to become Eutrophic from Oligotrophic. **Ranjan et al. (2007)** observed dominance of Chlorophyceae over the year and seasonal variations in the other phytoplanktons while studying physico-chemical characters of Ghariyarwara pond, Nepal. **Bhuiyan** and **Gupta (2007)** made hydrobiological study of Barak pond, Assam. They reported diverse plankton population dominated by euglenophyceae in the lake ecosystem with high dissolved oxygen and neutral pH. **Tiwari** and **Shukla (2007)** observed high values of alkalinity, phosphates, ammonia and chloride indicating eutrophic status in temporary waterbodies of Kanpur. **Yogendra** and **Puttaiah (2007)** reported that due

to nitrification BOD and COD decreases with increase in nitrogen. **Venkatasubramani** and **Meenombal (2007)** studied lakes of Bodham and drew a conclusion, that due to discharge of sewage in water increase sulphate and chloride indicating pollution into it.

Khare et al. (2007) concluded in their research that organic matter in waterbodies constantly change dissolved oxygen levels. **Smitha et al. (2007)** contributes that magnesium and calcium levels can interfere with high sodium levels to salinity problems. **Hosmani (2008)** reported in certain waterbodies of Dharwad that euglenophyceae responded to high temperature, oxidisable organic matter and low concentration of dissolved oxygen. **Kumar** and **Verma (2009)** studied the quantitative and qualitative information on the seasonal variation of zooplankton and based on the nutrient data index of selected physico-chemical variables and plankton abundance in certain lotic systems of Jharkhand, India. **Jayashankara et al. (2010)** described physico-chemical parameters and microbial diversity of temple tanks of Udapi district. **Sawanth et al. (2010)** studied limnological parameters of Atyal pond in Kolhapur, Maharashtra and reported eutrophic pond with rich in nutrients. **Aijyaz et al. (2010)** studied the diversity index of algal flora in Wular Lake, Kashmir. They reported that diversity was significantly correlated with physico-chemical parameters. There was a positive correlation with conductivity, carbon dioxide, hardness and nitrate. **Shinde et al. (2010)** studied physico-chemical characteristics and their seasonal variations of Harssooli, Aurangabad and confirmed that the pond was suitable for fish culture. **Hosmani (2010)** extensively studied phytoplankton diversity in Mysore lakes and reported uniformly distribution of algal species were, however low population within the diversity. **Bhosale et al (2010)** reported great variations in phytoplankton population along with physico-chemical complexes while studying diversity of plankton in water bodies of Miraj district, Maharashtra. **Xiaofeng et al.** evaluated international scientific creation in Science Citation Index of limnology from 2001 to 2010 applying bibliometric analysis to their study. The compilation of their study suggested that over the past decade there is constant increment in limnological research attentive to growth and dynamic models of phosphorus, eutrophication and diatoms.

Sharma et al. (2011) studied the physico-chemical characteristic, planktonic and fish diversity through seasonal surveys in two annual cycles of 2005-06 and 2006-07 in Lake Pichhola, Udaipur, (Rajasthan) India. Their research verdict states that the water samples showed low mean values with moderately alkaline with pH 7.5, electrical conductance 0.39 mS/cm, TDS 237.5 mg/l, chloride 176 mg/l, hardness 174.33 mg/l, alkalinity 207.16 mg/l, dissolved oxygen \ 5.75 mg/l, nitrate and phosphate levels were 3.70 mg/l and 2.79 mg/l. They observed high rate of primary production as 302.08 mgc/m/hr with diversity of phytoplankton in 58 forms, zooplankton 104 forms and 15 species of fishes. **Basavarajappa et al. (2011)** examined water quality parameters based on the CCME-WQI in four freshwater lakes of Mysore. Their research finding evaluated fresh water diatoms are an excellent source of water quality and ecology. The research study shows presence of nitrogen eutrophic tolerant species and concluded that water quality of lakes were threatened and often deviated from the standard condition.

Hosmani et al. (2011) used CFCME-WQI, while studying water quality index for protection of aquatic life and reported endangered water quality in many lakes which were unable to support and protect aquatic life their conditions were deviated from normal situations.

Hosmani (2011) studied freshwater diatom assemblages and their nestedness patterns in Mysore lakes, their research findings concluded that Synedra ulna and Nitzschia obtusata are perfectly nested, while Caloneis permagma was idiosyncratic species.

Gomphonema sumatranse, Gomphonema baltonis, Gyrosigma kuetzingii, Nitzschia virudla and Navicula gracilis were in hierarchical range of diatoms. **Hosmani (2011)** examined Hassan Lake and rated water quality of lakes as medium to bad using National Sanitation Foundation-Water Quality Index, oxygen saturation levels had a major impact on the water quality. **Bhat et al. (2011)** examined Lake Pangong with at an altitude of 4,266 m of eastern Ladakh which remains frozen for around three months during winter season, their research outcome concludes that high salinity and harsh environmental conditions lower the biodiversity in the lake.

The physico-chemical analysis states that the lake is highly alkaline with pH ≤ 9.0, electrical conductivity 1639 μS, the progression of cations are $Mg^{2+} > Na^{+} > K^{+} > Ca^{2+}$.

Twenty-three identified phytoplanktons were recorded and some unidentified taxa of red colored copepods, diaptomus spp. and their larvae represent the zooplankton in the lake. **Hosmani (2012)** monitored lake water quality using benthic diatoms, the plankton species indentified in the lake indicating anthropogenic pollution due cattle rearing at the surroundings of the lake. **Hosmani** and **Mruthunjaya (2012)** reported pristine nature of water by appling the one way ANOVA to the limnological data. Their research explains that carbon dioxide and dissolved oxygen appears to be most significant parameters with optimum desmids during certain months. **Hosmani (2012)** studied implication on aquaculture and ionic composition of fresh waters. The experimental finding suggest that the lakes were not appropriate for aquaculture due to high content of residual sodium carbonate, sodium content and their sodium absorption ratio could be used for reclamation of lake. **Ayaz et al. (2012)** examined summer limnology in high mountain Lake 'Kailash Lake' their study reveals that total 14 species of phytoplankton of the total phytoplankton population were recorded, out of which 7 species (50%) to the total phytoplankton contributed by bacillariophyceae, 5 species (35.71%) of chlorophyceae and 1 specie (7.14%) was contributed by cyanophyceae and dyanophyceae. Zooplankton population includes copepod (45%), Cladocera (33%) and Rotifera (22%).

Shah and **Pandit (2012)** recorded various limnological parameters of Wular Lake, Kashmir, their study indicate the eutrophic status of the lake with high values records of the physico-chemical characterstics of water. The transparency ranges from 0.2 to 2.2 m; pH from 7 to 8.8; dissolved oxygen from 3.4 to 11.5 mg/L; total alkalinity from 47 to 257 mg/L; free CO_2 from 8 to 28 mg/L; ammonical nitrogen from 49 to 542 μg/L; total phosphate from 102 to 297 μg/L, orthophosphate 13.0 to 36 μg/L and nitrate nitrogen from 146 to 483 μg/L. **Hosmani (2012)** concluded distribution of euglenophyceae by multivariate analysis and observed hierarchical associations between Peranema trichosporium and Phacus tortus.

Hosmani and **Manjunath (2013)** analyze a competent study of algae as indicators of water quality with diverse methods, their study shows low matrix fill of 59.59% and high system temperature of 32 °C which is a deprived division of algal species in the lakes.

Bisht et al. (2013) examined limnological parameters of three unlike water bodies at Bhimtal, (Nainital), Uttarakhand during winter season. Their research findings with earthen pond, cemented pond and lake suggested that the parameters promotes the aquatic efficiency of the waterbodies and initiate to be in range of optimal values; temperature 12 °C to 17.5 °C, pH 6.5 to 8.8, dissolved oxygen 5.7 to 8.0 mg/L, total alkalinity 38 to 63 mg/L, ammonia 0.01 to 0.23 mg/L, nitrite 0.02 to 0.15 mg/L, free carbon dioxide 0.36 to 2.7 mg/L, nitrate 0.4 to 4.3 mg/L, phosphate 0.36 to 2.38 mg/L, silicate 0.4 to 158 mg/L, total hardness 31 to 46 mg/L and total nitrogen 1.0 to 2.2 mg/L respectively.

Mushatq et al. (2013) monitored 21 physical and chemical characteristics of surface water were from six different site spread in four basins of lake on monthly basis from June 2010 to April 2011 at Dal lake Srinagar. Their research findings decorated the worsening of potability due to urbanization and anthropogenic movements. **Bini Das** and **Bindi (2014)** examined the soil samples of Jaisamand lake (Rajasthan), their research finding express that the pH value ranges from 8.25 to 9.00, while ideal pH ranges from 7.5 to 7.8, which appears that due to excessive evaporation of water in dry areas, the soil of Jaisamand lake is slightly alkaline, which bring salts to the surface. **Bhat et al. (2014)** gauged the spatio-temporal variability and water quality of Sukhnag stream Himalayas, Kashmir with multivariate analysis. The multivariate outcome reflects primarily inclination between stream water quality, agricultural runoff and wastewater discharge. Natural soluble salts and anthropogenic organic pollutants in the downstream areas are resultant for inclination in water quality.

Inaotombi and **Gupta (2014)** divulge data of water quality of a lake on various parameters and concluded to be under desirable limit for the human consumption. Hence it can be exploited for fish production by artificial culture. **Mahajan** and **Billore (2014),** explored in their research from July 2008 to June 2010, their research verdict explains that physico-chemical parameters like phosphate, nitrate and chloride are beyond with permitted edge and waterbody tend towards eutrophication. **Kumari et al. (2014)** carried out detailed study over various limnological parameters of two dams near river Narmada from Sep 2011 to Aug 2012. Their research findings recorded forty-five genera of phytoplankton comprise of belonged to Chlorophyceae with 21 genera, Bacillariophyceae 14 and Cyanophyceae with 10 genera. **Khan et al. (2015)** statistically analyzed limnological study to determine and check the present status of Lake at five different sites from Sep 2011 to June 2012 in Monsoon, Post-Monsoon, Winter, Summer season at Upper Lake, Bhopal.

Mohammad et al. (2015) assessed the quality of water and monthly changes in physico-chemical parameters from Jan to Dec 2011 at Wyra reservoir of Khammam, Telangana. The quality of water is within the adequate values with seasonal fluctuations in some physico-chemical parameters and water be able to use for drinking purpose, irrigation and pisiculture. **Sharma et al. (2015)** studied that the load of inorganic and organic pollutants in Dal lake (Kashmir) resuming the macrophytic growth and reducing the biological oxygen demand (BOD) and water quality, which leads to deteriorate and diminished the recreational and aesthetic appeal of the lake will likely turn it into eutrophic condition.

Watkar and **Barbate (2015)** examined all the limnological parameters at river Chandrabhaga, Kalmeshwar (Maharashtra), the analysis concluded that the parameters were in tolerable edge except slight variations and the river is suitable for irrigation and fishery purpose and proper measures are needed to maintain the potability and avoid contamination of water.

Sharma and **Singh (2016)** observed the physico-chemical parameters of water during Aug 2014 to May 2015 at Pani Ki Dharamsala (Jhasi). pH, salinity, temperature and EC were minimum in February and maximum in August; however the month of May shows inclination in turbidity TDS, Alkalinity, Hardness. DO and BOD have different variation during the season in which DO minimum in May and maximum in February and BOD maximum in May and minimum in August.

Balai et al. (2016) studied Jaisamand Lake, Rajasthan and reported the presence of essential nutrients in ample amount in physico-chemical characteristics needed for primary producers and its suitability for aquaculture. **Deepika** and **Singh (2017)** explored the physico-chemical parameters and water quality of lake Bhalswa and their results indicate that water of

the lake and is appropriate for leisure activities due to contamination as per the standards by Central Pollution Control Board (CPCB) water samples shows the presence of high amount of organic matter, algal growth, slightly high pH and BOD. Bhalswa Lake exhibits threshold level of eutrophication and nutrient enriched lentic ecosystem due to excess concentration of phosphorous and total nitrogen increasing the lake productivity which reflects through presence of floating algae. **Sharma et al. (2017)** examined the limnological characteristics of Mid-Himalayan lentic water bodies they conclude seasonal variations in water temperature, dissolved oxygen, pH, free carbon dioxide, transparency, total dissolved solid, total hardness, alkalinity, and nitrate. The correlation results of various physico-chemical parameters revealed that permissible limits were found in pH, free CO_2, dissolved oxygen and nitrate, therefore small scale aquaculture practices can be used to enhance the fish production in water bodies. **Shah et al. (2017)** reported fading the water quality and eutrophication at Horesker wetland of Jammu and Kashmir region due to anthropogenic activities. They also concluded, since nutrient removal differs significantly between wetlands and vary deeply, it is difficult to predict the quantitative effect of wetland restoration with occurrences of lofty flow.

Sharma and **Tiwari (2017)** surveyed the physico-chemical parameters and water quality of four sampling stations during May 2015 to April 2016 at Nachiketa Tal, Garhwal Himalaya. The research verdict revealed that during the monsoon season, the concentration of dissolved oxygen decreases with increase in bounds of TDS, electrical conductivity, turbidity in all the sampling stations resulting in deprivation in the water quality. Winter season enhances the water quality by exhibiting highest dissolved oxygen levels through its low water temperature. **Kumari** and **Sharma (2018)** conducted study on limnological variables including water temperature, pH, conductivity, Total Dissolved Solids (TDS), Dissolved Oxygen, Hardness, Chloride, Nitrate and Phosphate covering five seasons of Winter (November-February) Spring (March-April), Summer (May-June), Monsoon (July-August) and Autumn (September-October) at Prashar lake, Himachal Pradesh. Their research findings express that winter season express maximum DO and pH, maximum TDS and BOD were observed during summer, whereas monsoon exhibits maximum conductivity, Nitrates and Phosphates.

Durge et al. (2018) studied the limnological parameters including Humidity, Atmospheric and water temperature, pH, Electrical Conductivity, Total Dissolved Solids, Dissolved oxygen, Biochemical Oxygen Demand, Total alkalinity, Bicarbonate Alkalinity, Total Hardness, Calcium Hardness, Chloride, Nitrate-Nitrogen and Phosphate of a pond, situated in Ghugus town (Chandrapur) Maharashtra, parameters were collected monthly and represented seasonally with standard deviation. The result of the study indicates that the water quality of the pond is below the level of eutrophication. **Basu et al. (2018)** examined that the unplanned settlements led to huge deposition of organic matter into the Motijheel Lake which is an environmentally and economically significant water body of Murshidabad district.

The waterbody is currently depicts the impact of cultural eutrophication on the biodiversity leading to irreversible structural changes within the aquatic ecosystem also resulting in potential health hazards which could be encountered by the residents consuming the contaminated water of the lake.

Amaraneni et al. (2018) used GIS mapping to study the spatial distribution of air and water pollutants in Lake Kolleru. The water samples were collected in three seasons per year till three years; their research verdict indicates that the during summer season average distribution in water quality parameters of TDS, Hardness, Chloride, Sodium, BOD and COD is elevated in eastern zone compared to western zone of lake. The ecosystem of Kolleru Lake

is dishonored due to trade, automobile, farming, aqua-cultural actions. It results in increment of Hardness, TDS, Sodium, Chloride, COD and BOD, affecting the potable nature of lake water and declination of soil quality and aquatic organisms.

Gothwal and **Gupta (2018)** conducted limnological study on Nakki Lake, Mount Abu in summer season. The outcome of the research reports moderately alkaline water with pH 7.08, alkalinity of 102.16 mg/L and other limnological parameters showed low mean values including TDS 161.83 mg/L, hardness 95.66 mg/L and chloride 109.73 mg/L. The average dissolved oxygen levels were at 5.75 mg/L while average nitrate and sulphate levels were 31.19 mg/L and 123.73 mg/L. Based on the results of quality parameters of water, Nakki Lake is prone to be eutrophic.

Gothwal and **Jangir (2019)** analyzed icthyofauna of Nakki lake, Mount Abu and applied statistical analysis to conclude total precise fish population using quadrat sampling method and concluded the significance in homogeneity with chi-square test.

Gothwal and **Gupta (2019)** examined limnological parameters and planktonic diversity in Sant-Sarover pond, Mount Abu. Further, they have applied methodology of quadrat sampling to calculate total precise fish population and test of goodness for homogeneity in fish population.

Shah et al. (2019) concludes a growing movement in limnological parameters chiefly for dissolved oxygen, nitrogen and phosphorus at Hokersar wetland, Jammu and Kashmir. Their research outlook confirms that due to natural release of domestic sewage and agricultural effluents, which would cause cultural eutrophication and generate pollution of the wetland results in distressing the aquatic environment.

Shahid et al. (2020) used high-resolution GIS satellite data of 2003 and 2016 to map lake surrounding area studied limnological characters, water quality, lake bathymetry and settlements using multiple datasets with at Nigeen Lake, Kashmir. Bathymetry was measured transversely; spread the lake surface with 235 points. Limnological characterization of surface water with 22 parameters was analyzed at five sampling sites. The water quality was as per the drinking standards by World Health Organization within the acceptable limits.

Sharma et al. (2020) analysed that enzymes present in soil ecosystem are biomarkers of environment changes. Their research conclusion states an augment in deliberation of heavy metals and water pollution level in river Yamuna resulting in amplifying movement of certain enzyme such as nitrate reductase, dehydrogenase and arginine deaminase while inhibitis activity of urease enzyme. During the summer season high temperature increases the enzyme activity of arginine deaminase and urease, whereas during winter season higher soil moisture fascinates activity of dehydrogenase enzyme.

Ishtiyaq and **Abdul (2020)** accomplished that increase in loads of nutrient and silt from its catchment area deteriorates water quality in Dal Lake as a result of unprecedented land use/land cover (LULC) changes. LULC change analysis with five time-periods indicateds that the dominant land cover in forest class was 135.72 km^2 in 1980, 131.84 km^2 in 1992, 126.83 km^2 in 2000, 120.63 km^2 in 2010, and 118.30 km^2 in 2018, respectively. Aquatic vegetation noticed an enlargement of 180.65% within the lake, with 2.03 km^2 of area in 1980, and 5.70 km^2 in 2018; however agriculture land noticed a decline in 30.02% area with 34.44 km^2 of land in 1980 got reduced to 24.10 km^2 in 2018.

Kate et al. (2020) conducted analysis of water quality including pH, Conductivity (μMho/cm), TDS (ppm), Residual Chlorine (mg/L), Chloride (mg/L) and Hardness (mg/L) from fourteen different wards with three water samples per ward of Urun-Islampur City of

Maharashtra. The results of physico-chemical analysis as per the World Health Organization (WHO) standard indicates permissible limits of water quality within the range of 80 to 90 in Water Quality Index (WQI) under the test from all fourteen wards.

Mahajan and **Sharma (2020)** studied geomorphological evolution and comparative assessment of nine Himalayan watersheds and concluded estimation of the stage and rate of erosional processes for improved planning and management with GIS system and remote sensing data. The research verdict states that morphometric analysis is important to study the drainage behavior and its impact on the prevailing rock units in a watershed area.

Gothwal and **Jangir (2020)** studied soil properties of a lentic ecosystem, Nakki Lake in semi-arid region, their research verdict determines that the soil parameter balances the ecological symmetry in a lake-ecosystem and maintains the portability of water through its inter-relationship among phytoplanktons and zooplanktons.

3. CONCLUSION

On reviewing the amount of work done on a specific research criterion, the utmost difficult countenance is availability of research publications. Across the globe enormous numbers of journals are published in limnology and closely related fields. The author regrets the exclusion of few other publications from Indian workers are not included in this review, however on the basis of certain proceedings and literature available on the theme, it has been probable to mount up the current review associated with the initiation of limnology and work done in Indian sub-continent with adequate percent of references available from (1901) to the present (2020).

References

[1] Adhakari S. P., and Sahu J. K., (1992): Distribution and seasonal abundance of algal forms in Chilika Lake, East Coast of India. *Japanese Journal of Limnology* 53(3): pp 197-205

[2] Agarkar S. V., (1998): Assessment of water quality of Sakegaon Reservoir, Maharashtra. *Asian Journal of Chemistry* 10(4): 997-998

[3] Ahmed S., Sterans D. K., and Shelke G., (2004): An innovative Index for evaluating water quality in streams. *Environmental Management* 34(3): 406-414

[4] Aijyaz Mir R., Wangones A., Yoursef A. R., and Wanyanes, (2010): Diversity Index of algal flora in Water Lake Kashmir. *Nature Environment & Pollution Technology* 9 (2): 293-298

[5] Amaraneni S. R., Singh S., and Joshi P. K., (2018): Mapping the spatial distribution of air and water pollutants in Kolleru Lake, India using geographical information systems (GIS). *Management of Environmental Quality* Vol. 15 No. (6), 584-607. DOI 10.1108/14777830410560683

[6] Ayaz Naik A., Wanganeo A., Ishaq. A., and Bhat N. A., (2012): Summer Limnology of a high mountain Lake 'Kailash Lake' Bhaderwah, Jammu and Kashmir. *International Journal of Environmental Sciences* 3 (3), 931-939. DOI: 10.6088/ijes.2012030133001

[7] Bailey W. A., (1938): A Quantitative study of the phytoplankton of Lake Michigan collected in the vicinity of Easton Illinois. *Butler University of Botanical Studies* (4): pp 65-83

[8] Bairagi S. P., and Goswami M. M., (1994): Ecology of water blooms in some ponds of North India. *Ecology, Environment and Conservation,* 12 (93): pp 568-571

[9] Balai V. K., Sharma L. L., and Ujjania N. C., (2016): Limnological study of Jaisamand Lake (India) and its suitability for aquaculture and fisheries. *International Journal of Applied and Pure Science and Agriculture* Volume 02, Issue 1; pp 25-30

[10] Basavarajappa S.H., Raju N. S., and Hosmani S. P., (2014), Limnology: A Critical Review. *Current World Environment,* Vol. 9(3); pp 741-759. http://dx.doi.org/10.12944/CWE.9.3.23

[11] Basavarajappa S. H., Raju N. S., Hosmani S. P., and Niranjana S. R., (2011): Freshwater diatoms as indicators of water quality of some important lakes of Mysore. *Indian Hydrobiology,* 14(1); pp 42-52

[12] Basu A., Biswas M., Mandal D., Sonar R., Dey B., Ghosh S., Chatterjee J., Bhattacharyya B., Shamsuzzaman A., and Saha I, (2018). Motijheel Lake - Victim of Cultural Eutrophication. *World News of Natural Sciences* 21, 154-163

[13] Bhat F. A., Yousuf A. R., Aftab A., Arshid J., Mahdi M. D., and Balkhi M. H., (2011): Ecology and biodiversity in Pangong Tso (lake) and its inlet stream in Ladakh, India. *International Journal of Biodiversity and Conservation* Vol. 3(10): pp 501-511

[14] Bhat S. A, Meraj G., Yaseen S., and Pandit A. K., (2014): Statistical assessment of water quality parameters for pollution source identification in Sukhnag stream, an inflow stream of Lake Wular (Ramsar site), Kashmir Himalaya. *Journal of Ecosystems,* Vol. (2014); Article ID 898054, pp 1- 18. https://doi.org/10.1155/2014/898054

[15] Bhosale L. J., Patil S. M., Dhumal S. N., and Sale S. S., (2010): Occurrence of phytoplankton in the water bodies of Miraj Tahasil of Maharashtra. *The Ecoscan* 4: pp 73-76

[16] Bhuiyan J. R., and Gupta S., (2007): A comparative hydrobiological study of few ponds of Barak valley, Assam and their role on sustainable water resources. *Journal of Environmental Biology* 28(4): pp 801-805

[17] Bini Das and Bindi (2014): Physical and Chemical Analysis of Soil Collected from Jaisamand, Rajasthan (India). *Universal Journal of Environmental Research and Technology,* Volume 4, Issue 5: pp 260-264

[18] Bisht A. S., Gulam A., Rawat D. S., and Pandey N. N., (2013): Physico-chemical behaviour of three different water bodies of sub tropical Himalayan Region of India. *Journal of Ecology and the Natural Environment* Vol. 5(12): pp 387-395. DOI: 10.5897/JENE12.087

[19] Borker M. R., Saraswat K., Quadros S.V., and Fernandes .S.V. (1992): The cycle of some abiotic and microbial quality of a fresh water reservoir during monsoon at Marmugoa, Goa. *Bioved* 2: pp 133-136

[20] Borse S. K., and Bhave P. V., (2000): Seasonal temperature variation and their influence on the level of water. Jalgoan (Maharashtra). *Asian Journal of Microbiology, Biotechnology & Environmental Sciences* 2 (3-4): pp 159-163

[21] Chatterjee A. K., (1992): Water quality of Nanda Kanan Lake. *Indian Journal of Environmental Health* 34(4): pp 329-332

[22] Chidambaram P. S., (1999): Cyanobacteria as indicators of power station hot water effluents. *Journal of Environmental Pollution* (2-3): pp 157-166

[23] Chinmoy C., and Raziuddin M., (2002): Determination of water quality Indices (WQI) of a degraded river in Asansol Industrial area West Bengal. *Nature Environment & Pollution Technology* 1 (2): pp 181-189

[24] Choudhary T., (1991): Studies on the relationship between bicarbonate and chlorophyll-A in lentic and Lotic Systems. *Journal of Indian Prosthodont Society* 69(324): pp 403-407

[25] Deepika and Singh S. K., (2017): Assessment of water quality parameters of Bhalswa Lake in New Delhi. *International Journal of Environmental Engineering,* Vol. 9, No. 1, pp 52-69

[26] Dhanapati M. V., (2000): Taxonomic notes on the Rotifers from India. *Indian Association of Aquatic Biologists* (10): pp 1-180

[27] Dixit S. S., Smol P., Kingston J. C., and Charles D. F., (1992): Diatoms-Powerful indicators of Environmental change. *Environmental Science & Technology* 26: pp 23-33

[28] Durge L. S., Dhammani A. A., and Chavhan R. N., (2018): Physico-Chemical Characteristics of a Fresh Water Pond of Ghugus, District Chandrapur, Maharashtra (India). *International Journal of Scientific Research in Biological Sciences* Vol. 5, Issue.3; pp 59-64

[29] Forel F. A., (1901): Hand Buch den Seckende Allgemeinc Limnologie. *Stuttgant* 3: pp 249.

[30] Fritsch A., (1888): International commission on limnology-in Hutchinson G. 1957. A treaties on limnology; Vol. 1, John Wiley and Sons. Inc. New York; pp 1015.

[31] Fritsch F. E., (1907): The sub aerial and fresh water algal flora of the tropics. *Annales Botanici* 21: pp 235-275

[32] Fritsch F. E., and Rich. F., (1932): Contributions to our knowledge of the fresh water algae of South Africa-4. *Transactions of the Royal Society of South Africa* 11: pp 207-308

[33] Gandhi H. P., (1998): Fresh water diatoms of Central Gujarat-with a review and some others. Bishen Singh Mahendra Pal Singh, Dehradun. pp 324

[34] Ganpati S. V., (1940): The ecology of a Temple Tank containing a permanent bloom of Microcystis aeuroginosa (Kutz). *Journal of the Bombay Natural History Society* 42: pp 65-77

[35] Ganpati S. V., (1955): Diurnal variations of dissolved gases Hydrogen ion concentration and some of the important dissolved substances of biological significances in three temporary lake pools in stream bed at Mettur Dam. *Hydrobiologia* 7: pp 283-303.

[36] Ganpati S. V., (1960): Ecology of tropical waters. Proc. Symp. Algology, ICAR New Delhi. pp 204-208.

[37] George, M. G. (1966): Comparative plankton ecology of five fish tanks in Delhi, India. *Hydrobiologia* 27: pp 81-108

[38] George, M. R (1980): A Historical Resume of Indian Limnology, Hydrobiologia; Springer (Vol. 72), pp: 15-20

[39] Goel P. K., Khatvakar S. D., and Kulkarni A.Y., (1994): Nitrogen to phosphorus dependent blue green algal dominance in lakes. *Journal of Environment and Pollution* 1(2): pp 67-78

[40] Gonzalves, E. A., and Joshi. D. B., (1946): Fresh water algae near Bombay. *Journal of the Bombay Natural History* Society 46(1): pp 154-176

[41] Goviathan V S., (1990): Seasonal succession of algal flora in waste stabilization ponds. Perspectives in Phycology. (Centenary Celebration Volume, International Symposium on Phycology, (Madras 1987) Today and Tomorrows Publishers. pp 195-200.

[42] Gothwal R., and Gupta G., (2018): Limnological study of Lentic Fresh Water Ecosystem during Summer Season: Nakki Lake, Mount Abu, (Rajasthan), India. *World Scientific News* 114, 44-54

[43] Gothwal R., Gupta G., (2018): Physico-Chemical Analysis of Soil during Summer Season: Sant-Sarover Pond, Mount Abu. *Madhav Research and Review* 4 (Issue-1, Jul–Dec); pp 18-22

[44] Gothwal R., and Gupta G., (2019). Physico-Chemical Analysis of Soil during Summer Season in Lentic Fresh Water Ecosystem: Nakki Lake, Mount Abu (Rajasthan), India. *World Scientific News* 115, 117-127.

[45] Gothwal R., and Gupta G., (2019): Limnology, Planktonic diversity and Icthyofauna of Sant-Sarover Pond: Mount Abu (Rajasthan), India. *World News of Natural Sciences,* Vol. 22; pp 129-138

[46] Gothwal R., (2019): Study of Icthyofauna, fish population and homogeneity in Sant-Sarover Pond: Mount Abu (Rajasthan), India. *World News of Natural Sciences,* Vol. 24; pp 323-335

[47] Gothwal R., and Jangir O. P., (2019): Analysis of Icthyofauna and Fish Demography of Nakki Lake, Mount Abu, India. *Applied Ecology and Environmental Science,* Vol. 7, No. 6; pp 238-244

[48] Gothwal R., and Jangir O. P., (2020): Assessment of soil properties of a lentic ecosystem in semiarid region: Nakki Lake, Mount Abu, India. *World Scientific News* 149, 81-91

[49] Hariprasad P., and Ramakrishnan N., (2003): Algal assay used for the determination of organic pollution level in fresh water body at Tirurannamalai, India. *Journal of Ecotoxicology and Environmental* 13(4): pp 241-248

[50] Heckey R. E., (1993): The Eutrophication of Lake Victoria. *Verhandlungon der International Vercinigung fur Limnologic* 25: pp 856-859

[51] Hensen V., (1887): Uber die bestimmung des planktons order des im Meere treibenden materials on pffanzen und thieren. *Berichte der Deutschen Wissenschaftlichen Kommission fur Meeresforschung. Kiel* 5: pp 1-107

[52] Hodgetts W. J., (1921): A study of the factors controlling the periodicity of fresh water algae in nature. *New Phytologist* 20: pp 150-164

[53] Hosmani S. P., and Bharati S. G., (1975): Hydro biological studies in ponds and lakes of Dharwad-III. Occurrence of two Euglenoid blooms. *Science Journal* 30: pp 151-156

[54] Hosmani S. P., and Bharati S. G., (1977): Notes on the occurrence of 'Euglena sanguinea' at Dharwad. *Journal of the Karnatak University Science* 22: pp 122-124

[55] Hosmani S. P., and Bharati S. G., (1980): Algae used as indicators of organic pollution. *Phykos* 19(1): pp 23-26

[56] Hosmani S. P., and Bharati S. G., (1982): Use of algae in classifying water bodies. *Phykos* 21: pp 48-51

[57] Hosmani S. P., and Kumar L. V., (1996): Calcium Carbonate Saturation index and its influence on phytoplankton. *Pollution Research* 15(3): pp 285-288

[58] Hosmani S. P., and Lingannaiah B., (2002): Mass mortality of fish in Yennehole Lake, Mysore. *Pollution Research* 21(4): pp 435-437

[59] Hosmani S. P., (2006): Algal biodiversity in Fresh waters and related Physico-chemical factors. *Nature Environment Pollution Technology* 5(1): pp 37-40

[60] Hosmani S. P., (2008): Ecology of Euglenaceae from Dharwad, Karnataka. *Indian Hydrobiology* 11 (2): pp 303-312

[61] Hosmani S.P. (2010): Phytoplankton diversity in Lakes of Mysore District, Karnataka State, India. *The Ecoscon* 4(1): pp 53-57

[62] Hosmani S. P., Mahesh M. K., and Alakananda B., (2011): Water Quality Index (WQI) for protection of aquatic life in Lakes of Mysore, Karnataka State, India. *International Journal of Lakes and Rivers* 5 (1): pp 91-102

[63] Hosmani S. P., (2011): Assessment of water quality of Hassan Lakes using NSF-Water Quality Index. *Indian Journal of Applied Research* 1(3): 18-19

[64] Hosmani S. P., (2011): Nestedness patterns of Freshwater Diatom assemblages in Lakes of Mysore. *Online International Interdisciplinary Journal* 1(2): pp 7-13

[65] Hosmani S. P., (2012): Fresh water diatoms as indicators of River water quality. *Paripex - Indian Journal of Research* 1(1): pp 36-38

[66] Hosmani S. P., (2012): Ionic composition of a fresh water lake and its implications on aquaculture. *International Journal of Scientific Research* 1(2): pp 1-2

[67] Hosmani S. P., (2012): Multivariate analysis for distribution of Euglenophyceae in Karanji Lake of Mysore. *Phykos* 42(2): pp 74-79

[68] Hosmani S. P., and Mruthunjaya T. B., (2012): Distribution of phytoplankton in lakes of Tirumalakudal Narasipura of Mysore district. *Abhinav* 1(7): pp 28-32

[69] Hosmani S. P., and Manjunath R. A., (2013): Dynamics of algal diversity in Hombargalli Lake of H.D. Kote, Mysore District, Karnataka. *Abhinav* 2(7): pp 14-18

[70] Howland L., and Lucy J., (1931): A four year investigation of the Hertford Shire pond. *New Phytologist* 30: pp 210-265

[71] Hutchinson G. E., and Pickford G. E., (1932): Limnological observations on Mountain Lake, Virginia. *International Review of Hydrobiology* 27; pp 252-264

[72] Hutchinson G. E., (1957): A Treatise on Limnology Vol. I, Geography, physics and Chemistry of lakes. John Wiley and Sons New York, U.S.A.

[73] Ibrahim B., (1990): Waste water treatment and algal productivity in an integrated pond system. *Biological Wastes* 32(4): pp 265-275

[74] Inaotombi S., and Gupta P. K., (2014): Water quality of a Central Himalayan lake, Lake Sattal, Uttarakhand. *Journal of Ecophysiology and Occupational Health* 14(1 & 2) pp 83-102

[75] Ishtiyaq A. R. and Abdul Q. D., (2020): Assessing the impact of land use and land cover dynamics on water quality of Dal Lake, North-West Himalaya, India. *Applied Water Science* 10: 219; pp: 1-18. DOI:10.1007/s13201-020-01300-5

[76] Jayashankara M., Vijaya R. G., and Hosmani S. P., (2010): Microbial Diversity and water Quality Index in Temple ponds of Udupi District, Karnataka, India. *Nature Environment and Pollution Technology* 9 (1): pp 197-202

[77] Johari S., Chaudhari U. S., and Chaudhari P. R., (1999): Eutrophic status of some lotic and lentic water bodies in Amravati district. *Journal of Ecotoxicology and Environmental Monitoring* 9(1): pp 35-40

[78] Juttner I., Sharma S., Mani D. B., Ormerod S. J., Chimonides J., and Cox E, J., (2003): Diatoms as indicators of stream quality in the Kathmandu valley and middle Hills of Nepal and India. *Freshwater Biology* 48: pp 2065-2084

[79] Jyothi B., Sudhakar G., and Venkateshwarulu V., (1992): Chlorophycean blooms and their ecological aspects. *International Journal of Environmental Studies* 40: pp 151-164

[80] Kate S., Shridhar K., Prajkta J., (2020): Water quality analysis of Urun-Islampur City, Maharashtra, India. *Applied Water Science* 10: 95; pp: 1-8. DOI:10.1007/s13201-020-1178-3

[81] Kaushik S., Agarkar M. S., and Saxena D. N., (1991): Water quality and periodicity of phytoplankton algae in Chambal Tal, Gwalior, Madhya Pradesh. *Bio nature* 11(2): pp 87-94

[82] Khan M. A., and Chowdhary S. H., (1994): Physical and chemical limnology of Lake Katpai; Bangladesh. *Tropical Ecology* 35 (1): pp 3551

[83] Khan A. A., Shammi Q. J., Hussain S. D., and Gulam N. N., (2015): Seasonal variations in physico-chemical parameters in upper lake of Bhopal (M.P.). *International Journal of Applied and Universal Research* Vol. 2 (2); pp 1-7

[84] Khare S. L., Paul S. R., and Dubey A., (2007): A study on water quality of Khomp-Miwari lake of Chitrapur (M.P) India. *Journal of Environmental Biology* 6(2): pp 539-544

[85] Kumar A., and Patel. R. J., (1990): Desmids of Gujarat -1 Genus Cosmarium corda. *Phykos* 29 (1 & 2): pp 95-101

[86] Kumar A., and Verma M. C., (2009): Spectrum of Plankton abundance in certain lotic systems of Jharkhand, India. *Indian Journal of Environment and Ecoplanning* 16 (2-3): pp 633-654

[87] Kumar S., and Sharma L., (1991): Comparative physico-chemical limnology of lakes Picchola and Fatehsagar, Udaipur (Rajasthan). *Pollution Research* 10(3): pp 173-178

[88] Kumari M., Mudgal L. K., Patidar K. C., and Singh A. K., (2014): Comparative Phytoplankton studies of two reservoirs Punasa and Omkareshwar of Narmada River, MP, India. *International Journal of Advanced Research* Vol. 2, Issue 3, pp 773-779

[89] Kumari R., and Sharma R., (2018): Seasonal variation in the physico-chemical variables of Western Himalayan Sacred Lake Prashar, Himachal Pradesh, India. *International Research Journal of Environmental Science* Vol. 7(7), pp 29-36

[90] Krishnamurthy V., (1954): A contribution to the diatom flora of south India. *Indian Botanical Society* 33: pp 334-381

[91] Mahadev J., and Hosmani S. P., (2002): Langlier's Index and relation to phytoplankton in two lakes of Mysore City. *Nature Environment & Pollution Technology* 1(1): pp 19-21

[92] Mahadev J., and Hosmani S. P., (2004): Community structure of cynobacteria in two polluted lakes of Mysore city. *Nature Environment & Pollution Technology; Nature* 4(3): pp 523-526

[93] Mahadev J., and Hosmani S. P., (2005): Algae for bio-monitoring of organic pollution in two lakes of Mysore city. *Nature Environment & Pollution Technology* 4(1): pp 97-99

[94] Mahajan S., and Billore D., (2014): Seasonal Variations and Assessment of Water Quality of Nagchoon pond of Khandwa District (M.P.) India. *Current World Environment* Vol. 9(3), pp 829-836. DOI:10.12944/CWE.9.3.33

[95] Mahajan A. K. and Sharma S., (2020): GIS-based sub-watershed prioritization through morphometric analysis in the outer Himalayan region of India. *Applied Water Science* 10: 163; pp: 1-11. DOI:10.1007/s13201-020-01243-x

[96] Miyajuima T., Nakanishi M., Nakana S. I., and Tezuka Y., (1994): An autumnal bloom of the diatom Melosira granulates in a shallow eutrophic lake. *Archiv fuer Hydrobiologia* 130 (2): pp 143-162

[97] Mohapatra P. K., and Mohanty R. C., (1992): Determination of the water quality of two water bodies using algal bioassay method. Utkal River. *Phykos* 31(1&2) pp 77-84

[98] Mohammad M. J., Krishna P. V., Lamma O. A., and Khan S., (2015): Analysis of Water Quality using Limnological Studies of Wyra Reservoir, Khammam District, Telangana, India. *International Journal of Current Microbiology Applied Science* Vol. 4(2): pp 880-895

[99] Mushatq B., Raina R., Yaseen T., Wanganeo A., and Yousuf A. R., (2013): Variations in the physico-chemical properties of Dal Lake, Srinagar, Kashmir. *African Journal of Environmental Science and Technology* Vol. 7(7); pp 624-633. DOI: 10.5897/AJEST2013.1504

[100] Munnawar M., and Zafar A. R., (1967): A preliminary study of vertical movement of Eudorina elegans and Trinema lineare during a bloom caused by them. *Hydrobiologia* 29(1-2): pp 141-148

[101] Munnawar M., (1970): Limnological studies on fresh water ponds of Hyderabad, India. The Bicenose – Distribution of unicellular and colonial phytoplankton in the polluted and unpolluted environments. *Hydrobiologia* 37(1): pp 105-128

[102] Munnawar M., (1972): Ecological studies of Euglenaceae in certain polluted and unpolluted environments. *Hydrobiologi*a 36: pp 105-128

[103] Naganandini M. N., and Hosmani S. P., (1990): Ecology of certain inland waters of Mysore district. Occurrence of Cyanophycean bloom at Hoskere lake. *Pollution Research* 17(2): pp 123-125

[104] Nagarathna S., and Hosmani S. P., (2002): Factors influencing the bloom Nitzschia obtuse in a polluted lake. *Indian Journal of Environment and Ecoplanning* 6(2): pp 223-227

[105] Naik P. R., and Hegde G. R., (1990): A systematic account of Diatoms of Sharavathi estuary. Karnataka. *Phykos* 29(122): pp 63-71

[106] Nair R., (1999): Seasonal variation of phytoplankton in relation to physico-chemical factors in a village pond at India (Vidisha). *Journal of Ecotoxicology and Environmental Monitoring* 3: pp 177-182

[107] Nandan S. N., Mahajan S. R., Kumavat M. R., and Jain D. S., (2001): Limnological study of Hartala Lake of Jalagaon, Maharashtra. Proceedings of Indian Science Congress, New Delhi. Part III.

[108] Nandan S. N., and Aher N. H., (2005): Algal community used for assessment of water quality of Haranbaree Dam and Mosam river of Maharashtra. *Journal of Environment Biology* 26(2): pp 223-227

[109] Noor Alam M., (2001): Study on variation in the physico-chemical parameters of pond at Hatwa, Bihar. *Journal of Environment and Pollution* 8 (2): pp 179-181

[110] Pandey B. N., Jha A. K., Dal P. K. L., Parky P. K., and Mishra. A. K., (1995): On the seasonal abundance of phytoplankton in the stretch of Kosi River. *Pollution Research* 14(3): pp 283-293

[111] Pandey J., Pandey U., Tyagi H. R, and Rai. N., (1998), Algal flora and physico chemical environment of Fateh Sagar lake. *Phykos* 37 (1 & 2): pp 29-39.

[112] Pandey J., and Verma A., (2004): The influence of catchment on chemical and biological characteristics of two freshwater tropical lakes of southern Rajasthan. *Journal of Environmental Biology* 25(1) pp 81-87

[113] Pandit A. K., (1999): Trophic structure of plankton community in some typical wetlands of Kashmir, India. Limnological Research in India, Daya Publishing House, New Delhi, pp 190-224

[114] Parvateesham M., and Mishra M., (1993): Algae of Pushkar Lake including pollution indicating forms. *Phykos* 32 (1 and 2): pp 27-39

[115] Pearsall W. H., (1921): The development of vegetation of English lake considered in relation to general evolution of glacial and rock basins. *Proceedings of the Royal Society of London* 13: pp 259-284

[116] Pearsall W. H., (1923): A Suggestion as to the factors influencing the distribution of free floating vegetation. *Journal of Ecology* 8(3): pp 163-201

[117] Pearsall W. H., (1930): A suggestion to Phytoplankton as to the factors influencing the distribution of free floating vegetation. *Journal of Ecology* 19(2): pp 241-262

[118] Pearsall W. H., (1932): Phytoplankton in the English lake. II the composition of the phytoplankton in relation to dissolved substances. *Journal of Ecology* 20: pp 241-262

[119] Pejavar M., Somani V., and Borker M., (2002): Physico-chemical studies of Lake Ambegosale (Thane) India. *Journal of Ecobiology* 14(4): pp 277-281

[120] Philipose M. T., (1960): Fresh water phytoplankton of inland Fisheries. *Proc. Sym. Algal.* ICAR: pp 272-299

[121] Prescott G. W., (1938): Objectionable; algae and their control in lakes and reservoirs. *Louisiana Municipal Review:* pp 2-3

[122] Prescott G. W., (1939): Some relationships of phytoplankton on limnology and aquatic biology. *American Advance Science* 10: pp 65-78.

[123] Rajkumar N., (2001): Biodiversity and quantative analysis of phytoplankton of a polluted fresh water pond (Pollachi), Tamil Nadu. Proceedings of the Indian Academy of Sciences 88th Indian Science Congress, Part III, pp 4-5.

[124] Ranjan G., Singh N. P., and Singh R. B., (2007): Physico-chemical characteristics of Ghrigareva pond of Birganji Nepal in relation to growth of phytoplankton's. *Nature Environment & Pollution Technology* 6(4): pp 629-632

[125] Rao C. B., (1953): On the distribution of algae in six small ponds. *Journal of Ecology* 41: pp 62-71

[126] Rao C. B., (1955): On the distribution of algae in a group of six small ponds. Algal periodicity. *Journal of Ecology* 43: pp 291-308

[127] Rao V. N. R., Mohan R., Hariprasasd V., and Ramasubramanainah, R., (1993): Seasonal dynamics of physico-chemical factors in a tropical high altitude lake: an assessment in relation to phytoplankton. *Indian Journal of Biology* 14(1): pp 63-75

[128] Sahu B. K., Rao R. J., Behera S. K., and Pandit R. K., (1995): Phytoplankton and primary production in the River Ganga from Rishikesh to Kanpur. *Journal of Ecological Biology* 7(3): pp 219-224

[129] Sarwar S. G., and Wazir M. A., (1991): Physico-chemical characteristics of a fresh water pond of Srinagar (Kashmir). *Pollution Research* 10 (4): pp 233-237

[130] Saxena D. K., and Saxena A., (2000): Uptake of metals in Plagiochasma and their uses in pollution monitoring. *Geophytology* 28(1& 2): pp 129-137

[131] Sawanth R. S., Telare A. B., Desai P. D., and Desai J. S., (2010): Variations in Hydro biological characteristics of Atyal pond in Gondhinglaj, (Kolhapur), Maharashtra. *Nature Environment and Pollution Technology* 9(2): pp 273-278

[132] Seenayya G., (1971): Ecological Studies in the plankton of certain fresh water ponds of Hyderabad, India. The Phytoplankton-I. *Hydrobiologia* 37 (1): pp 55-88

[133] Shahid A. D., Bhat S. U., Sheikh A., and Rashid I., (2020): A geospatial approach for limnological characterization of Nigeen Lake, Kashmir Himalaya. *Environmental Monitoring and Assessment* pp 192-121. DOI: 10.1007/s10661-020-8091-y

[134] Sharma R., Singh N. S, Singh D. K., (2020): Impact of heavy metal contamination and seasonal variations on enzyme's activity of Yamuna river soil in Delhi and NCR. *Applied Water Science* 10: 83; pp: 1-8. DOI: 10.1007/s13201-020-1166-7

[135] Sharma T. K., and Singh R., (2016): Seasonal Variation in Physico-Chemical Parameters of Water of Pani Ki Dharamsala, Jhansi, India. *International Journal of Innovative Research in Science, Engineering and Technology* Vol. 5, Issue 9, pp 17172-17177. DOI:10.15680/IJIRSET.2016.0509118

[136] Sharma I., Dhanze R., and Rana R., (2017): Physico-chemical parameters of lentic water bodies from Mid- Himalayan region (H.P.), India. *International Journal of Fisheries and Aquatic Studies* 2017; 5(2): pp 674-678

[137] Sharma R. C., and Tiwari V., (2017): Seasonal physico-chemical characterization of water of sacred lake Nachiketa Tal, Garhwal Himalaya. *Applied Water Science* 8: 164. doi.org/10.1007/s13201-018-0802-y

[138] Sharma R., Sharma V., Sharma M. S, Verma B. K., Modi R., and Gaur K. S., (2011): Studies on Limnological Characteristic, Planktonic Diversity and Fishes (Species) in Lake Pichhola, Udaipur, Rajasthan (India). *Universal Journal of Environmental Research and Technology*, Volume 1, Issue 3: pp 274-285

[139] Sharma J. N., Kanakiya R. S., and Singh S. K., (2015): Limnological Study of Water Quality Parameters of Dal Lake, India. *International Journal of Innovative Research in Science, Engineering and Technology* Vol. 4, Issue 2, February 2015, DOI: 10.15680/IJIRSET.2015.0402078

[140] Shah J. A., and Pandit A. K., (2012): Physico-Chemical characteristics of water in Wular Lake – A Ramsar Site in Kashmir Himalaya. *International Journal of Geology, Earth and Environmental Sciences* Vol. 2 (2) May-August, pp: 257-265

[141] Shah J. A., Pandit A. K., and Shah G. M., (2017): Dynamics of physico-chemical limnology of a shallow wetland in Kashmir Himalaya (India). *Sustainable Water Resource Management* 3: pp 465-477. DOI 10.1007/s40899-017-0115-6

[142] Shah J. A., Pandit A. K., and Shah G. M., (2019), Physico-chemical limnology of a shallow lake in the floodplains of western Himalaya from last four decades: present status. *Environmental Systems Research* 2019, 8: 9

[143] Shaji C., and Patel R. J., (1994): Phytoplankton ecology of polluted pond at Anand, Gujarat. *Ann. of Bio.* 10(2): pp 191-197

[144] Shinde S. E., Patnon T. S., Rant K. S., More P. R., and Sonawane D. L., (2010): Seasonal variations in Physico-chemical characteristics of Morsool Savangidam (Aurangabad), India. *The Ecoscon.* 4(1): pp 37-49

[145] Singh, V. P., (1960): Phytoplankton ecology on the inland water of Uttar Pradesh. Proc. Symp. Algol. ICAR, New Delhi. pp. 243-271

[146] Singh R., (1990): Correlation between certain physico-chemical parameters and primary production of phytoplankton at Jamalpur, Munger, India. *Geobios* 17 (5-6): pp 229-234

[147] Smitha P. G., Byrappa K., and Ramaswamy S. N., (2007): Physico-chemical characteristics of water samples of Bantwal Taluk, south-western Karnataka, India. *Nature Environment & Pollution Technology* 28(3): pp 591-595

[148] Sreenivasan A., (1967): Application of limnology and Primary production studies in fish culture. *FAO Fisheries Report*, 44(3); pp 104-113

[149] Storm K. M., (1924): Studies on the ecology and geographical distribution of fresh water algae and plankton. *Algological Studies* 1; pp 127-155

[150] Swarnalatha N., and Narsing Rao A., (1991): Investigation of Lake Sarror Nagar with reference to water pollution. *Journal of Phyta Research* 4(2); pp 121-129

[151] Swarnalatha N., and Narsing Rao A., (1993): Ecological investigation of two lentic environments with reference to Cyanobacteria and water pollution. *Indian Journal of Microbial Ecology* 3; pp 41-48

[152] Swarnalatha N., and Narsing Rao A., (1994): Assessment of water quality and pollution in lentic environments. *Journal of Swamy Botanical Club* 11(1); pp 44-47

[153] Swarnalatha N., and Narsing Rao A., (1998): Ecological studies of Banjara Lake with reference to water pollution. *Journal of Environmental Biology* 19(2): pp 179-186

[154] Thomas M., Deviprasad A. G., and Hosmani S. P., (2006): Evaluating the role of physico-chemical parameters in plankton population by application of cluster analysis. *Environment and Pollution Technology* 5(2): pp 219-223

[155] Thresh J. C., Sukling E. V., and Beale J. F., (1944): The examination of water and water supplies. Edited By Taylor, E. W., McGraw Hill Book Co. Inc., New York.

[156] Tiwari D., and Shukla M., (2007): Algal biodiversity and trophic status of some temporary water bodies of Kanpur. *Nature Environment & Pollution Technology* 6(1): pp 85-90

[157] Vaishya, A. K., and Adoni, A. D., (1992): Phytoplankton seasonality and their relationships with physico-chemical properties in a hyper eutrophic central Indian lake. *Proceedings of the Indian National Science Academy* 59: pp 153-160

[158] Veeresh Kumar N. S., and Hosmani S. P., (2006): Algal biodiversity in fresh waters and related physico-chemical factors. *Nature Environment & Pollution Technology* 5(1): pp 37-40

[159] Venkateshwarlu V., (1970): An ecological study of the algae in river Moosi Hyderabad (India) with special reference to water pollution on periodicity of some common species of algae. *Hydrobiologia* 35: pp 45-64

[160] Venkatasubramani R., and Meenombal T., (2007): Ground water quality modeling for Pollachi Taluk of Coimbatore District. *Nature Environment & Pollution Technology* 6(3): pp 443-447.

[161] Verma J. P., and Mohanty R. C., (1998): Effect of nutrient environment on Ankistroderms falcatus (Canada) Relfs var. acicularis. *Ecology, Environment and Conservation* 4(3): pp 151-155

[162] Verma S. R., and Shukla G. R., (1968): Hydrobilogical studies of a temple tank "Devikund" in Deobnd (U.P.) India. *Indian Journal of Environmental Health* (10); pp 177-188

[163] Vyas L. N., (1968): Studies in phytoplankton ecology of Picchola Lake. *Udaipur. Proc. Sym. Adv. Tropical Ecology* pp 334-347

[164] Wani. I. A., (1998): Limnology (2nd Edition) Mc Graw Hill Book Co. pp. 536.

[165] Watkar A. M., and Barbate M. P., (2015): Seasonal variations in Physico-chemical Properties of Chandrabhaga River in Dhapewada, Dist. Kalmeshwar Maharashtra, India. *Research Journal of Recent Sciences* Vol. 4(ISC-2014), pp 1-4.

[166] Welch P. S., (1948): Limnological Methods, McGraw-Hill Book Company.

[167] West W., and West G. S., (1907): Freshwater algae from Burma including a few from Bengal and Madras. *Annals of the Royal Botanic Gardens, Calcutta* 6; pp 260.

[168] West W., (1912): The freshwater algae of Clare Island. Clare Island Survey, Part-16. *Proceedings of the Royal Irish Academy* 31: pp 1-62.

[169] Xiaofeng Cao, Yi Huang, Jie Wang, Shengji Luan (2012): Research status and trends in limnology journals: A bibliometric analysis based on SCI database. *Scientometrics* 92: pp735–746. DOI 10.1007/s11192-012-0623-y

[170] Yogendra K., and Puttaiah E. T., (2007): Water quality assessment of Tunga River using factor analysis. *Journal of Nature Environment & Polution Technology* 6(3); pp 393-399

[171] Zafar A. R., (1955): On the periodicity and distribution an algae in certain fish ponds in the vicinity of Hyderabad, India. Ph.D Thesis

[172] Zafar A. R., (1964): On the ecology of algae in certain fresh ponds of Hyderabad, India. Distribution of unicellular and colonial forms. *Hydrobiology* 24; pp 556-566

[173] Zafar A. R., (1967): Two years observation on the periodicity of Euglenaceae in two fish breeding ponds. *Journal of Indian Botanical Society* 38(4); pp 549-560

[174] Zafar A. R., (1969): On the ecology of algae in certain fresh water ponds of Hyderabad, India. *Hydrobiologia* 30(1); pp 96-112