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A Brief Historical Resume of the Science of Limnology : Past to Present

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Abstract

The world is diverse with a bewildering diversity of flora, fauna and microbes. The ecosystem must be protected and conserved for sustenance of life on earth. There is need to deepen our understanding about the various abiotic and biotic factors and their interaction in the ecosystem; so that, it could function as a harmonious unit. Limnology assists in understanding the various kinds of intricate interactions in the aquatic domain. Legendary Limnologists had been toiling very hard, since the inception of the discipline, to explain how the aquatic domain is functioning harmoniously with fruitful interaction among biotic and abiottic factors. Here is a humble attempt to pay tribute to them by briefly discussing about their contributions.

Keywords: Limnology; Bewildering Diversity; Flora and Fauna; Ecology and Environment; Limnotopography; Limnochemistry; Limnophysics; Limnobotany; Limnozoology; Limnobacteriology

Introduction

`Water' is life; and, having originated in water, life has evolved itself into an enchanting world of rich and vastly diverse flora and fauna; which must be protected and conserved. There is need to deepen our understanding of the aquatic environment with regard to its physical, chemical and biological characteristics and interactions. Various functions are performed by aquatic ecosystems, e.g., nutrient re-cycling, re-charge of ground water, augmentation and maintenance of stream flow and recreation of people to name a few. Human civilization, since its dawn, being usually developed in close proximity to water, viz., the lakes/wetlands and rivers; freshwater (FW) had been used not only for drinking, agriculture and navigation, etc.; but, also, for energy production, industrial growth and waste and effluent disposal; and, thus, surface water had been degraded by contaminated run-off from expanding urban and agricultural areas, air-borne pollutants, etc. This made it essential to know the interaction of the water body with its watershed; and, to ascertain the factors influencing the quality of water bodies with regard to physical, chemical and biological characteristics. Limnology assists in understanding the various kinds of intricate interactions in the aquatic domain. Legendary Limnologists had been toiling very hard, since the inception of the discipline, to explain before the world how the water bodies are functioning as a harmonious unit with fruitful interaction among biotic and abiottic factors.

Here is a humble attempt to pay tribute to them by briefly discussing about their contributions. `Limnology'(being part of broad domain of Ecology and Environment), basically, is the study of different aspects of water. Ecology (synonymised as Hexicology, Natural History, etc) is universally accepted to deal with the study of interrelationships between the organisms and their environment Welch [1], Shelford [2], Welch [1] conceived `Biological productivity' as the central theme of Limnology. Schwoerbel [3] considers limnology as the study of inland water ecosystems together with their structure, materials and energy balances. Kiihnelt (1960) considered limnology as a sub-set of ecology. Broadly, limnology is the study of all forms of aquatic systems, both fresh and saline (including lakes, wetlands, marshes, bogs, ponds, reservoirs, streams, rivers, oceans, etc.) with regard to their physical, chemical and biological characteristics. The terms, Hydrobiology, Freshwater biology, Aquatic biology, Aquatic ecology, etc., may be used exclusively for faunistic/floristic studies; and, are not synonymous to Limnology.

Since the time of Forel, there had been two different usages of the term:

a) Restricted usage: Here, limnology refers to the study of various units of lentic or standing water series, i.e., lake/wetland→pond→swamp.

b) Extended usage: Here, limnology is sometimes used to include all forms of inland waters, viz., lentic and lotic (running water series).

Essential nature and Objectives of Limnological study

Limnology and Applied Limnology tries to help in FW management by explaining the system properties; and, by unravelling the modus operandi of the complex web of climatic, physical, chemical and biological factors and phenomena in natural aquatic domain by embracing physics, chemistry, geology, geography, meteorology, hydrography, etc. These, in turn, formed various research pathways within Limnology, like Limnotopography, Limnochemistry, Limnophysics , Limnobotany, Limnozoology, Limnobacteriology, Hydrobiology, etc. in order to explain aspects like, geology, climatology, physiography, bathymetry, fluvial dynamics, thermal, chemical and biological profile, etc., including the microbes and the plankton. Concomitantly, limnological applications in Fishery could promote organic production in natural and artificial waters; and, thus, could give an answer to diminishing protein supply affecting human nutrition.

Historical Development and Scope of Limnology

Studies on Limnology, probably, had initiated from Aristotle (384-322 BC) Anon [4], which were mainly strange mixtures of facts and fancy with little scientific value; but, coupled with simple accurate recordings of certain FW phenomena. Later, Euclid (c325–265 BC) Berggren JL & Thomas RSD [5], Busard HLL [6], and, further later, the invention of microscope, had given a quantum jump to the field of limnology by enabling exploration of the microbes in water. This followed description of microbes by Anton Van Leewenhoek (1632-1723), the first classification of microbes by the Danish biologist, Otto Friedrich Müller (1786) Anon [7] publication of the Treatise, `Infus Animalcules' by Ehrenburg [8]; laying the foundation stone of limnological study by Peter Erasmus Müller; pioneering works in lacustrine limnology on lakes in the Bohemian forest by Anton Fritsch; discovery of thermal stratification by F. Simony [9] (who is, often called the Founder of Limnology). In brief, the History of modern limnology could be dated back to approx. 100 years. Some works were done on the habits, nutrition, movement, behaviour, etc., of certain aquatic organisms by different workers during the 17th and 18th centuries, notably, Otto Friedrich, Müller, Johann Christian Schaffer, etc. Discovery of marine plankton by Johannes Müller in 1845, helped Limnology to slowly emerge out of the hydrobiological domain. True studies on the relationships of biota to freshwaters could be treated as initiated from Junge [10] and Forbes [11] who were the first to treat the native waters as microcosm. Apropos to the known relationships between organic production, lake depth and morphology of the water body with its oxygen balance; the observations of Hoppe-Seyler Anon [12] on Lake Constance in 1896; and, oxygen balance and lake type by Birge and Juday in 1911 led to the formulation of the system of lake classification. Later, Swede Eince Naumann (1917) first emphasized the biological relationships in the lake water column.

Works on `Plankton' (the heterogeneous group of suspended drifting microscopic organisms which inhabit both fresh and salt waters and which have a profound role in the aquatic domain) were done by Johannes Müller [13] in the North Sea using very fine net followed by Peter Erasmus Müller who discovered the micro-crustaceans in certain Swiss lakes dispelling the previously-held idea that the clear lakes were devoid of microscopic life. Later, Liljeborg and Sars Needham and Lloyd [14] had worked on plankton. Hensen [15] proposed the definite term `plankton' to this mass of drifting microscopic life in order to include all the minute plants, animals and debris which are suspended in natural waters; and, study of plankton had been a significant component of limnological research during the last part of 19th and first part of 20th century. Notwithstanding the above, it had, however, perhaps, remained practically everything for Forel [16-18], a Professor in the University of Lausanne, Switzerland, to recognize the real biological opportunity of lake investigations; for taking decisive step forward from hydrobiology to limnology through his investigations in Lake Geneva, not only from the biological point of view but also from physical and chemical stand points; thereby, formulating the concept of lake types; also, for his pioneering works on the profundal fauna of FW lakes; etc. The design of his first program for limnological investigations in FW and its subsequent execution turned out to be a model for future researches. Thus, the science of Limnology is indebted to him for his comprehensive vision and complete anticipation about the future of this subject. Forel's publications in limnology, notably, Instruction a'l'e'tude de la fauna profonde du la fauna profonde du Le' man (1874-79); `Handbook der Seenkunde, Allgemeine Limnologie' (as the first text book of Limnology) and Le'man Monographie Limnologieque' (1892-1901) in 3 volumes, which are not only the first comprehensive limnological treatise; but, also, opened up a new vista in biological research. And, for his 110 publications, he is regarded as the Founder of Modern Limnology Chumley [19].

Concomitantly, Forel's work led to the establishment of `Limnological Society' in 1887 as a component of Swiss Natural History Society (in order to promote limnological works); and, later the International Commission of Limnology was established in 1890. Concomitant to above, impetus on FW research began to be felt as upsurge in the study of lakes in Europe , America, Asia, Australasia, etc., manifesting itself in the establishment of Freshwater Biological Stations (FBS), (conducting many works), notably, at Plön (Germany) by Orozaeharias (1901); at Wisconsin

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(USA) by Birge and Juday [20]; and, so on. Initially, much of the works clung to the traditional approaches to FW biology; which had added a volume of information to modern limnology. Later, Gaarder and Gran [21] had measured the photoautotrophic production (primary production) by quantitative determination of oxygen produced by photosynthesis. Later, the direct measurement of carbon assimilation in the water bodies was achieved in 1952 using radio-carbon method Steemann N [22]. The estimation of trophic dynamics concept having regard to the biomass, material turn over and energy transport along the food chain by Lindeman [23] not only revolutionized the field of general ecology but also gave a new direction to limnology Cook [24] . Later limnologists, like Welch [25], Wetzel [26], Hutchinson [27], Ruttner [28], Schwerbel (1987), Likens [29], Ganapati [30], Srinivasan [31], Philipose [32,33], Michael [34], Banerjea [35], Battish [36], Biswas and Calder [37], Dey [38], Dey & Kar [39,40], Das [41], Devi [42], Dhar N [43]; Fernando and Furtado [44]; Gadgil & Kar [45] ; Kar [46-60], Kar and Sen [61], Kar and Barbhuiya [62,63], Kar [64], Zutshi [65], etc., contributed significantly to limnological and fish researches. Further, bacteria and fungi were also studied in limnological works as thery are constituents of ecosystem as decomposers of organic matter Winogradski, 1897 in Zavarzin [66]. Both bacteria and fungi are constituents of ecosystem which are responsible for decomposing organic matter and microbial transformation.

Concomitant to works on lakes, limnological researches had also begun on flowing watercourses (the lotic ecosystem), as a consequence of four very considerable stimuli, viz., (a)The aspect of existence of river plankton ; (b)The search for glacial relics in the fauna and flora of mountain torrents; (c)The effect of sewage effluents on the colonization of lotic systems with particular emphasis on indicator organisms; (d) aspects like water movement and its biological significance, structure of material budget of an open ecosystem in dynamic equilibrium and so on. Thus, the lotic systems were included within the purview of limnology in the First Congress of International Association of Theoretical and Applied Limnology held at Kiel in 1922. Henceforth, limnology ceased to be merely the science of `lakes'; rather, with the inclusion of rivers, it has been broadly named as the science of `Inland waters' Rodhe [67]. Notwithstanding the above, there have been profound impact of Marine Biology on the study of limnological science. The attention of biologists at large being attracted to the rich diversity of marine life. Although overshadowed by the overwhelming progress of marine biology during most part of the 19th century, study of freshwater biology and limnology did not suffer a setback because the development of the methods of study and an increase in biological knowledge, in general, indirectly but materially, helped the future advances of limnology. Similarly, oceanography began to take on more definite form and its gain also contributed later to the progress of limnology indirectly because there are many features common to both freshwater and marine biota [68-71].

Conclusion

Of the vast array of freshwater lentic systems throughout the globe, very few have received adequate attention from the limnologists. Also, those which have been studied are, for the most part, confined to restricted geographical regions [72,73]. The inland lentic systems, distributed along the length and breadth of Asia, Africa, America, Canada, Europe and Australia present wide open opportunity for doing in-depth limnological research. The diversity of these lentic systems, physically, chemically and biologically, are infinitely greater than previously supposed.

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