Available online at www.elixirpublishers.com (Elixir International Journal)

Applied Botany

Elixir Appl. Botany 75 (2014) 27712-27715

ISSN: 2229-712X

Physico-chemical analysis of three different water bodies of sub tropical himalayan region of India

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ARTICLE INFO

Article history:

Received: 6 March 2013;

Received in revised form:

20 September 2014;

Accepted: 17 October 2014;

Keywords

Physico-chemical,

Aquatic productivity.

ABSTRACT

The research paper represents a brief analysis of physico-chemical characteristics of three different water bodies viz. earthen pond, cemented pond and lake located at Bhimtal, Nainital, Uttarakhand during winter season. Air temperature, water temperature, pH, DO, free CO_2, total alkalinity, total hardness, total nitrogen, nitrite, nitrate, phosphate, ammonium and silicate were the physico-chemical parameters observed during the experimental period.

Introduction

Water quality refers to all physical, chemical and biological characteristics of water. It is determined by various physical, chemical and biological parameters of the water body. Water quality plays an important role in the growth and survival of aquatic organisms. Relationship between water quality and aquatic productivity is a pre-requisite for obtaining optimum growth and production. The water used for aquaculture would not give the desired production unless the prevailing water quality parameters are optimum for the organism under culture. Study of the physico-chemical parameters of an aquatic ecosystem is basic for understanding its biological productivity. Although each factor plays its individual role but it is the synergistic effect of various parameters which determines the composition and productivity of the flora and fauna. Conducive range of these factors is essential for obtaining optimum fish production. Among physico-chemical factors influencing the aquatic productivity; temperature, pH, total alkalinity, dissolved gases like O_2 and CO_2 and dissolved inorganic nutrients like nitrate and phosphorus are considered to be important. An attempt has been made to find out the favorable ranges of these factors. As winter season is a lean period for the biological productivity of most of the temperate water bodies, the present study was carried out to assess the plankton biodiversity in different water bodies during winter season.

For the present study, various physico-chemical parameters of the water bodies have been taken into consideration. Water samples were collected in sampling bottles from the littoral zones (and limnetic zone of lake) of the sampling sites from 10:00 a.m. to 6:00 p.m. carefully excluding air bubbles for the estimation of various physico-chemical parameters in three monthly periodic samplings. Temperature, pH and dissolved oxygen were measured at sampling sites itself while the rest of the parameters were analyzed in the laboratory. The study was carried out in the laboratory of DCFR (ICAR), Bhimtal. The various physico-chemical parameters were analyzed as per standard method APHA (1985) and data were recorded during the study period.

Material and methods

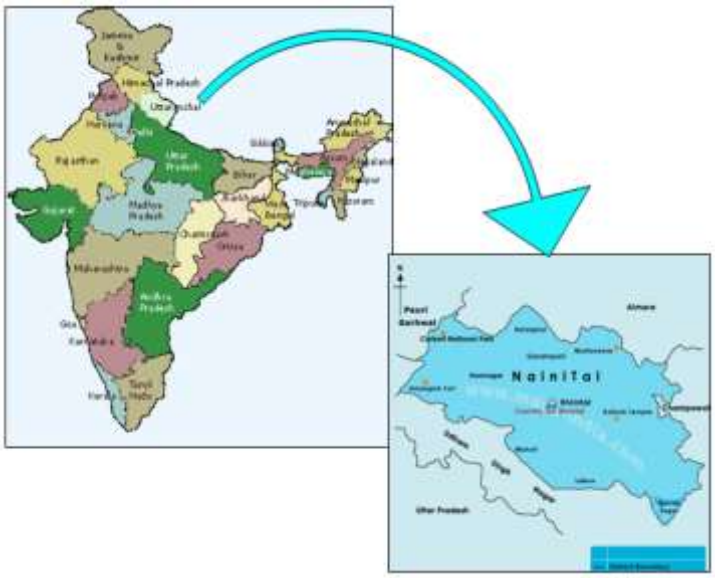

Fig.1. Study area (Bhimtal)

Result and discussion

Temperature

Temperature is one of the most important physical factors influencing the aquatic life. It is the basic environmental factor that effects chemical and biological reaction in water (Boyd, 1982). Water temperature, a regular factor for various physico-chemical as well as biological activities in ecosystems, was found to fluctuate markedly with the variations in air temperature (Sharma and Kumar, 2002). Water temperature, therefore is having a direct concern with the air temperature. Marked seasonal variations of temperature were recorded in the present study.

In the present study, water temperature was found in the range of 12 to 17.5°C, while atmospheric temperature in the range of 9 to 21°C. The low temperature was recorded during

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winter in the experimental water bodies (and higher during summer). Similar observations were also recorded by Pathani (1995), Mahar (2002), Bhatt and Pathak (1992) in the Kumaun Himalayan region of Uttarakhand. Wide fluctuation in temperature in cemented ponds followed by earthen pond and open water body, lake might be due to volume of water. Low temperature was observed in lake due to more depth of water comparatively. Also January was the month of lowest temperature in all habitats. Data on this parameter are significantly different ($P<0.05$).

pH (Hydrogen ion concentration)

The water tend to be more alkaline if it possesses more carbonates and less alkaline when possesses large quantities of calcium, bicarbonates and CO_2 (Sarwar and Wazir, 1991). However, it is more often governed by the photosynthetic activities of producers in lakes (George, 1961). The hydrogen ion concentration (pH) of water is considered as an index of environmental conditions. According to Boyd and Pillai (1984) better fish production could be possible in pond water with pH value ranging between 6.5 - 9.0.

In present study, the pH values varied from 6.5 to 8.8, which indicate the favorable condition of productivity. This is generally the normal range of pH in fresh water bodies unless contaminated by acidic or alkaline wastes. High pH was observed in cemented ponds followed by earthen ponds and lake respectively due to the presence of organic matter and less soil contact in cemented ponds.

Dissolved oxygen (DO)

Dissolved oxygen is the most crucial factor for the growth and survival of fish. The optimum concentration of DO in pond waters is 6-9 mg/l (Boyd, 1982).

In the present study, DO content was in the range of 5.7 to 8.0 mg/l. The low level of dissolved oxygen in these water bodies in winter months, reflects the richness of organic matter, which consumes large amount of dissolved oxygen in the process of decomposition.

Free CO_2

Free CO_2 was significantly inversely correlated with DO in the present study and was observed in the minimum concentration from 0.36 to 2.7 mg/l. An inverse relationship between DO and Free CO_2 in fresh water bodies was also reported by Joshi et al. (1993). The lake was having comparatively highest CO_2 concentration followed by earthen ponds while as it was absent in cemented ponds due to absence of vegetation. Because of negligence of photosynthesis in winter months, the lake was showing the value of free CO_2 as 2.7 mg/l.

Total alkalinity

Total alkalinity was observed in the present study in the range of 38 to 63 mg/l. Total alkalinity fluctuated in experimental water bodies, generally lower than the range (100-120 gm/l) suggested by Tripathi, 1982 for optimal fish production. The maximum value of alkalinity was recorded in earthen ponds due to high fish biomass followed by lake and cemented ponds respectively.

Nitrite, Nitrate, Phosphate, Ammonium, Silicate, Total hardness, Total nitrogen

The observed values of ammonium were 0.01 to 0.23 mg/l. The ammonium level in the experimental water bodies was lower than the maximum acceptable level (1.0 gm/l) as recommended by Boyd and Pillai (1984). Lake was having high concentration of ammonium followed by cemented and earthen pond respectively.

Nitrite and nitrate concentration play an important role in primary production. The concentration of nitrite in the present study was 0.02 to 0.15 mg/l and the concentration of nitrate being high than nitrite was 0.4 to 4.3 mg/l in the experimental water bodies. The total nitrogen and nitrite were comparatively high in cemented ponds due to the absence of nitrifying bacteria and because of the absence of soil media in the pond bottom. Nitrate was found in higher side in the earthen ponds due to the richness of nitrifying bacteria in the earthen bottom followed by lake and cemented ponds respectively.

Phosphate, silicate, total hardness and total nitrogen were found to be in the range 0.36 to 2.38 mg/l, 0.4 to 158 mg/l, 31 to 46 mg/l, 1.0 to 2.2 mg/l, respectively in the experimental water bodies. Phosphate and silicate were in higher side in the cemented ponds, might be due to the negligible photosynthetic activities, followed by earthen ponds and lake respectively. Hardness was reported in higher side in the lake habitat due to the large stagnant water body, followed by earthen and cemented ponds respectively.

In winter season the concentration of ammonia nitrogen (0.01 to 0.23 mg/l), nitrite nitrogen (0.02 to 0.15 mg/l) and nitrate nitrogen (0.4 to 4.0 mg/l) was minimum, probably due to reduced rate of decomposition of organic matter.

Conclusion

The low level of dissolved oxygen in these water bodies in winter months reflects the richness of organic matter, which consumes large amount of dissolved oxygen in the process of decomposition. Existing DO level favors the conducive condition for the survival and replication of zooplankton. The lake was observed for highest CO_2 concentration followed by earthen ponds while as it was absent in cemented ponds due to absence of vegetation. Because of negligence of photosynthesis in winter months, the lake was showing the value of free CO_2 as 2.7 mg/l. Diurnal fluctuation in the free CO_2 content reflects the dense population of chlorophyll bearing plankton.

Total alkalinity reflected that the water bodies were medium to high productive. The maximum value of alkalinity was recorded in earthen ponds due to high fish biomass, followed by lake and cemented ponds respectively.

Phosphate and silicate were in higher side in the cemented ponds, might be due to the negligible photosynthetic activities. Hardness was reported in higher side in the lake habitat due to the large stagnant water body. Therefore, N-P ratio reflects the high primary productivity in earthen pond and lake water.

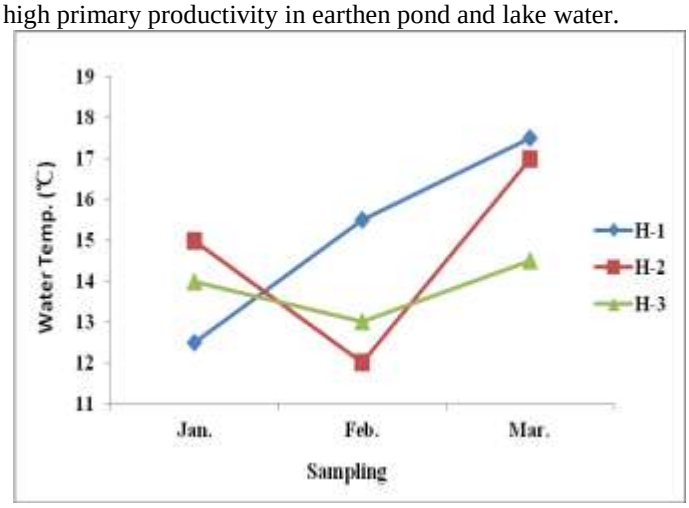

Fig.2.Temporal variation of water temperature in different water bodies

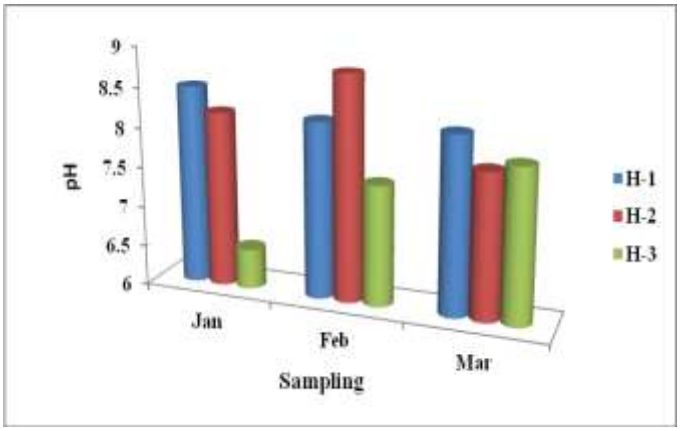

Fig.3.Temporal variation of pH in different water bodies

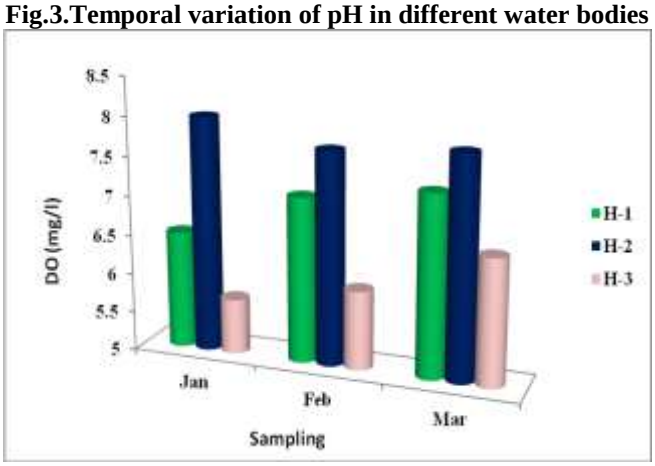

Fig.4.Temporal variation of DO in different water bodies

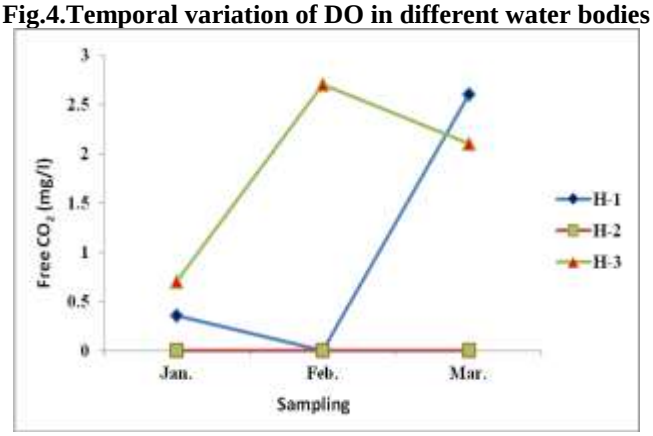

Fig.5.Temporal variation of free CO_2 in different water bodies

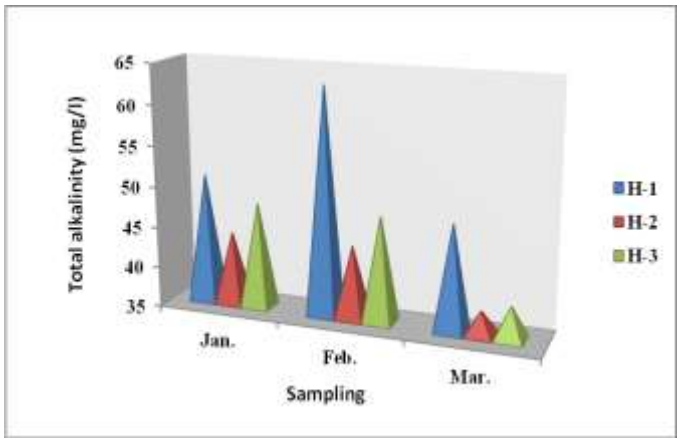

Fig.5.Temporal variation of total alkalinity in different water bodies

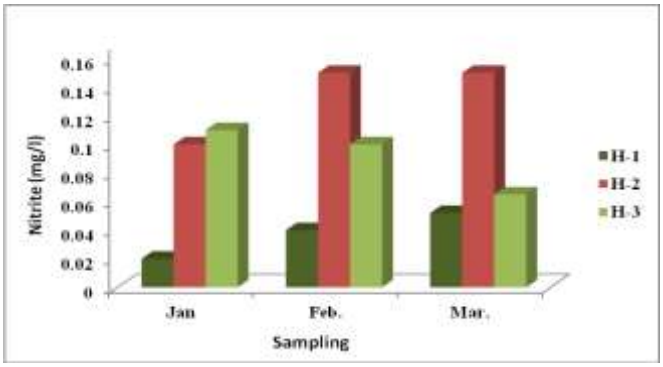

Fig.6.Temporal variation of nitrite in different water bodies

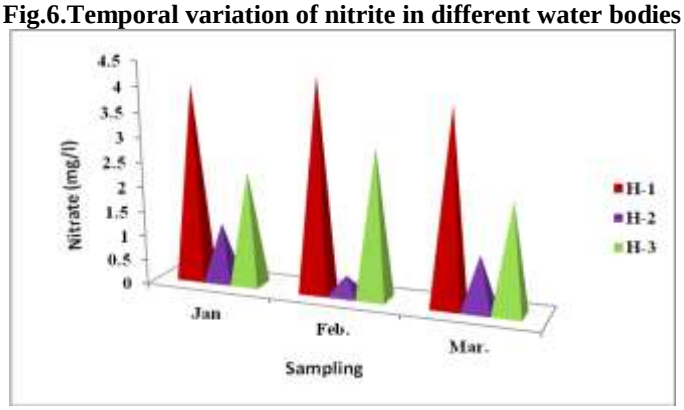

Fig.7. Temporal variation of nitrate in different water bodies

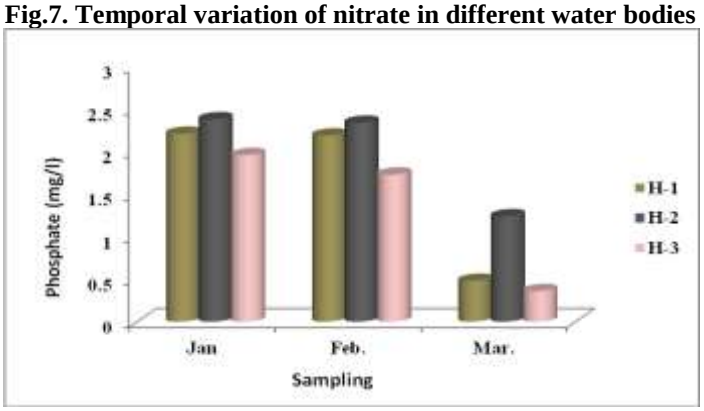

Fig.8.Temporal variation of phosphate in different water bodies

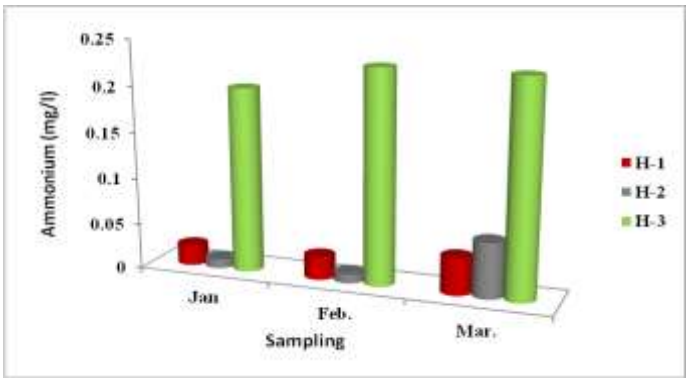

Fig. 9. Temporal variation of ammonium in different water bodies

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Table 1. Temporal variation of different physico-chemical parameters in earthen pond

Sampling	Temperature (^{O}C)		pH	DO (mg/l)	Free CO_2 (mg/l)	Total alkalinity (mg/l)	Nitrite NO_2^- (mg/l)	Nitrate NO_3^- (mg/l)	Phosphate PO_4^{3-} (mg/l)	Ammonium NH_4^+ (mg/l)	Silicate SiO_2 (mg/l)	Total hardness (mg/l)	Total nitrogen (mg/l)
	Air	Water											
Jan.	10	12.5	8.5	6.5	0.36	51	0.02	4.0	2.21	0.022	-	-	-
Feb.	15	15.5	8.2	7.1	0	63	0.040	4.3	2.19	0.025	-	-	-
Mar.	18	17.5	8.2	7.3	2.6	48	0.052	3.9	0.48	0.04	143	41	2.0

Table 2. Temporal variation of different physico-chemical parameters in cemented pond

Sampling	Temperature (^{O}C)		pH	DO (mg/l)	Free CO_2 (mg/l)	Total alkalinity (mg/l)	Nitrite NO_2^- (mg/l)	Nitrate NO_3^- (mg/l)	Phosphate PO_4^{3-} (mg/l)	Ammonium NH_4^+ (mg/l)	Silicate SiO_2 (mg/l)	Total hardness (mg/l)	Total Nitrogen (mg/l)
	Air	Water											
Jan.	14	15	8.2	8.0	0	44	0.1	1.2	2.38	0.01	-	-	-
Feb.	9	12	8.8	7.7	0	44	0.15	> 0.5	2.34	> 0.02	-	-	-
Mar.	18	17	7.8	7.8	0	38	0.15	1.1	1.24	0.06	158	31	2.2

Table 3. Temporal variation of different physico-chemical parameters in lake

Sampling	Temperature (^{O}C)		pH	DO (mg/l)	Free CO_2 (mg/l)	Total alkalinity (mg/l)	Nitrite NO_2^- (mg/l)	Nitrate NO_3^- (mg/l)	Phosphate PO_4^{3-} (mg/l)	Ammonium NH_4^+ (mg/l)	Silicate SiO_2 (mg/l)	Total hardness (mg/l)	Total Nitrogen (mg/l)
	Air	Water											
Jan.	9	14	6.5	5.7	0.7	48	0.11	2.3	1.96	0.2	-	-	-
Feb.	11	13	7.5	6.0	2.7	48	0.1	3.0	1.73	0.23	-	-	-
Mar.	21	14.5	7.9	6.6	2.1	39	0.065	2.2	0.36	0.23	> 0.5	46	1.0

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