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Physico-chemical parameters of lentic water bodies from Mid- Himalayan region (H.P.), India

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Abstract
The pond management requires an understanding of water quality as it is the first most important limiting factor in pond fish production. Keeping in view to exploit the village ponds for the aquaculture practices the present work has been undertaken in the mid hill region of Himachal Pradesh. The water quality parameters have been assessed fortnightly throughout the year. The parameters viz. water temperature, transparency, pH, dissolved oxygen, free carbon dioxide, alkalinity, total hardness, total dissolved solid, nitrate have been investigated and their seasonal variation is discussed. The correlation coefficient of the various physico-chemical parameters are computed and analyzed. The results of the present study revealed that pH, free CO_2, dissolved oxygen and nitrate were found within the permissible limits as a result water bodies can be used to enhance the fish production through small scale aquaculture practices.

Keywords: Water quality, ecological, fortnightly, village ponds

Introduction
The Water Quality is the most important factor controlling the ecological quality of a pond. Water supports life on earth and around which the entire fabric of life is woven. The requirement of water in all lives, from micro-organisms to man, is a serious problem today because all water resources have been reached to a point of crisis due to unplanned urbanization and industrialization [1]. Village ponds were once the life line of people in the area about two decades ago but due to urbanization, either these water bodies became a dumping place or used for bathing the animals. Therefore, the water quality of these ponds is being distressed and polluted due to various anthropogenic pressures and deteriorating at an alarming rate. Though, these water bodies can help in enhancing the fish production through small scale aquaculture. These ponds are used for harvesting rain water and run-off water, which contain clay and organic matter and act as sink for nutrients and minerals. The quality of water is characterized by various physico-chemical parameters and these parameters change widely due to many factors like source of water, type of pollution, seasonal fluctuations and adjacent human intervention [2]. The maintenance of a healthy aquatic ecosystem is dependent on the physico-chemical properties of water and its biological diversity. The details of pond ecosystem have been studied by a number of workers [3-8] but no such type of work was initiated in Himachal Pradesh. Some studies have been undertaken from the lotic as well as the lentic habitat from water drainage system of Beas [9-12].
The present study is providing detailed information on limnological parameters of the water of village ponds at Mid-Himalayan region (H.P.) and will go in long way for the sustainable development of the lentic bodies for the aquaculture practices in the area.

Materials and Methods
The water samples were collected fortnightly from the four ponds located in village Ladoh (Pond-1), Biyada (Pond-2), Tanda (Pond-3) and Ropa (Pond-4) in district Kangra of Himachal Pradesh during February 2012 to February 2013 (Fig.-1). The distance of these ponds from Palampur, district Kangra (Himachal Pradesh) are about 12, 13, 3 and 11Kms respectively. The water samples were collected in air tight neutral polythene bottles. Apparent color of water is determined on the original sample without filtration or centrifugation. The eye estimation method was used to note the water color in the field. The temperature was recorded at the time of sampling on the spot using centigrade thermometer. The water transparency was measured by using a Secchi disc. pH was measured with standard pH meter and other

parameters such as dissolve oxygen (DO), free carbon dioxide, total alkalinity, total hardness, total dissolve solid and nitrate have been done by the procedures of (APHA,1995) [13]. To study the seasonal variations the average of fortnightly parameters were computed for summer (March to June 2011), monsoon (July to October 2011) and winter (November 2011 to February 2012). Some of the parameters were recorded at sampling sites and others were analyzed in laboratory. Further, the data was analyzed statistically by calculating correlation coefficient (r) at 5% level of significance.

Results and discussion

The quantitative analysis of different physicochemical parameters is presented in Table 1. The water colour varied from light green to dark green except pond-2 where it was reaming brown throughout the study period indicating abundance of zooplankton (personal observation). The water temperature ranged between 5 to 22^0C and varied with the season that is lowest in winter and highest in monsoon. The similar findings were reported by (Dhanze *et al*., 2002b; Lashari *et al*., 2009 and Tidma and Shinde, 2012) [10, 14, 15]. Transparency of water showed a fluctuation from 13cm to 47cm and minimum value was noticed in summer in pond-2 and 3 but in monsoon in pond-1 and winter in pond-4. Further maxima was reported during winter in pond- 2 and 3 though pond-1 showed summer peak and pond-4 monsoon peak. The findings of pond-2 and 3 coincide with the view of Datta *et al*., 1985 and Dhanze *et al*., 2002a [16, 9]. There was not much seasonal variation in pH value and falls under the acceptable range (5.5 to 10) for aquaculture as per Stone and Thormforde, 2003 [17]. The free CO_2 varied from 3.25 mg/l (pond-4) to 4.78mg/l (pond-2) of which maxima were noticed during summer and minima during monsoon. The seasonal variations indicated comparatively high value in summer in all the ponds due to high temperature and fast decomposition of organic materials (Narayan *et al*. 2007) [19]. Joshi *et al*. (1995) [19] have observed the addition of drainage was the main causal factor for increase in carbon dioxide in the water bodies. The availability of dissolved oxygen is one of the most critical factors for the survival of the aquatic organisms. Dissolved oxygen ranged from 8.07mg/l (pond-2) to 12.33mg/l (pond-1) of which maximum value was encountered during winter and lowest in monsoon. The quantity of DO in water is directly or indirectly dependent on water temperature, partial pressure of air etc. Similar results were observed by Saloom and Ducan, 2005 and Chaurasia and Pandey, 2007 [20, 21]. Alkalinity is an indicator of productivity of water body and varied from 28 mg/l (pond-1) to 69mg/l (pond-3). The maximum value was recorded in monsoon and minimum in summer, whereas Sharma *et al*., 2007 and Tidame and Shinde 2012 [15, 22] have reported highest value in summer and lowest in winter. Shiddamallayya and Pratima 2008 [23] also noticed lowest value of alkalinity recorded during winter. Total hardness ranged from 12mg/l (pond-1) to 84mg/l (pond-3). The highest value was noticed during winter season except pond-1 (monsoon) whereas lowest one was reported during summer. Though, Dhanze *et al*., 2002b) and Kaur and Sharma, 2001[10, 24] were reported the highest value during summer. Jhingran, 1988 [25] opined that the hardness ranged between 40mg/l to 200mg/l is most suitable for higher growth of fishes thus it showed that these ponds have average productivity. The total dissolved solid content of fresh water was reported from 20mg/l to 100mg/l and it is composed of mainly carbonate, bicarbonate, chloride and nitrates of calcium, magnesium, sodium, potassium, iron and manganese, as a rule hardness of water increases with level of total dissolved solids. Total dissolved solids varied from 25.7mg/l (pond-2) to 202mg/l (pond-3). The maxima were recorded in winter and minima during monsoon in all ponds except pond-3 where piggery farm was located in vicinity and might be affected this parameter. The present findings confirmed the observation of Dhanze *et al*., 2002a. Manjare *et al*., 2010 [9, 26] observed maximum value during monsoon season and lowest in summer which almost in confirmation of the present findings regarding pond-3. It showed direct relationship with water temperature in pond-3 and confirmed the findings of Chowdhury and Mamun, 2006 [27]. Nitrate is the most oxidized form of nitrogen compounds present in natural waters, because it is a product of aerobic decomposition of organic nitrogenous matter and an important plant nutrient. Nitrate content was varied from 0.6mg/l (pond-4) to 3.5mg/l (pond-3). The peak value was observed in monsoon season but the lowest in summer season in pond-1 and 3 whereas winter in pond-2 and 4. Almost similar findings were reported by Shinde *et al*., 2011 and Manjare *et al*., 2010 [26, 28]. The quantity of nitrate remained comparatively high in pond-3 throughout the year. During summer season the reduction in nitrates could be due to algal assimilation and other biochemical mechanism and higher value during monsoon season may be due to surface runoff, domestic sewage and specially washing activities which coincide with the view of Rajashekhar *et al*., 2010. Dhanze *et al*., 2002a [9, 29] have also reported its highest concentration in August and September due to influx of allochthonous material. Pailwan *et al*., 2008 [30] observed that the pond water containing more than 1.0ppm nitrate is considered good for optimum production of fishes which coincide with the present findings.

The statistical analysis of the correlation coefficient is presented in Table 2a, 2b and 2c. The study of correlation coefficient of various physico-chemical parameters shows that they are related with each other. The pH is significantly correlated with dissolved oxygen during summer except pond-3 and pond-4 and indicates high correlation in all the seasons. The temperature is significantly correlated with transparency during summer and monsoon. The free CO_2 shows significant relationship with dissolved oxygen in all the seasons. The alkalinity depicts significant relationship with nitrate and water temperature in all the ponds. The total hardness shows significant relationship with dissolved oxygen whereas least correlation was found during winter and summer in pond-3. Total dissolved solid indicates statistically significant relationship with dissolved oxygen but least correlation during winter in pond-1 and monsoon in pond-2. Further, it also shows a positive relationship with alkalinity except in pond-1 during summer and winter. The nitrate depicts significant relationship with water temperature and dissolved oxygen but the least correlation was observed during monsoon in pond-1 with water temperature. Further, Pond-2 exhibits least correlation with dissolved oxygen during monsoon.

Thus based on above investigations it may be concluded that most of the physico-chemical parameters *viz.* pH, free CO_2, Dissolved oxygen and nitrate were found within the permissible limits as per Boyd, 1988 [31] for aquaculture but total alkalinity, total dissolved solids and total hardness were less and fall within the range of medium productivity as such the village ponds can be used to enhance fish production through small scale aquaculture.

Table 1: Seasonal Physico-chemical parameters (mean (mg/l) ± standard deviation) of village Ponds

Parameter	Summer			Monsoon					Winter			
	1	2	3	4	1	2	3	4	1	2	3	4
Water temp. ^{0}C	18 ± 3.34	17.58± 3.35	16.75 ± 3.30	17.63 ± 3.30	19.5 ± 1.23	20.33± 1.51	18.38 + 1.25	20.25± 1.26	10 ± 3.11	9.75 ± 3.10	9.88 ± 2.66	9.5 ± 2.68
Transparency (cm)	21.95 ± 8.04	15.3 ± 1.64	23.6 ± 2.44	17.73± 2.4	18 ± 2.48	18.18 ± 1.26	36.9 ± 8.56	20.28 ± 3.38	18.38 ± 1.11	18.4 ± 1.69	42.78 ± 6.08	16.4 ± 2.30
DO (mg/l)	10.33 ± 1.75	9.31 ± 0.48	8.08 ± 1.33	10.21± 1.59	8.47 ± 1.55	8.07 ± 1.51	8.72 ± 0.85	8.46 ± 1.51	12.33 ± 3.19	11.33 ± 0.54	9.95 ± 0.77	11 ± 1.41
pH	6.98 ± 0.29	6.7 ± 0.21	6.58 ± 0.3	7.05 ± 0.42	6.81 ± 0.67	6.71 ± 0.39	6.45 ± 0.59	7.25 ± 0.93	6.74 ± 0.52	6.87 ± 0.59	6.49 ± 0.59	6.78 ± 0.55
Free CO_2 (mg/l)	4.13 ± 1.26	4.3 ± 1.19	4 ± 0.82	4.78 ± 0.97	4 ± 0	3.75 ± 0.5	3.25 ± 0.5	3.75 ± 0.5	3.75 ± 0.5	3.75 ± 0.5	4 ± 0	3.75 ± 0.5
Alkalinity (mg/l)	37.5 ± 8.35	38.58± 7.0	42.33± 12.12	43.75± 15.95	42.65 ± 3.5	42.75 ± 5.0	58.75 ± 11.1	52.25 ± 7.63	52.75 ± 8.26	41.28 ± 6.36	49.75 ± 6.7	47.05 ± 7.27
T. hardness (mg/l)	35 ± 18.8	38.25± 17.33	37 ± 16.06	38.25 ± 9.32	59.63 ± 6.4	57 ± 4.55	53.88 ± 10.28	53.38 ± 4.03	56.38 ± 10.78	59.34 ± 10.58	65.13 ± 21.34	58.88 ± 14.4
TDS (mg/l)	78.58 ± 10.74	61.13± 12.48	121 ± 19	74.2 ± 9.48	78.98 ± 17.43	43.15 ± 14.12	158 ± 29.44	65.3 ± 9.05	83.95 ± 11.39	72.88 ± 7.80	127.75 ± 7.41	73.95 ± 3.47
Nitrate (mg/l)	1.16 ± 0.43	1.77 ± 1.65	1.73 + 0.95	1.24 ± 0.49	2.1 ± 0.58	1.78 ± 0.52	2.02 ± 0.50	1.81 ± 0.71	1.19 + 0.31	1.59 ± 0.51	1.95 ± 1.09	1.15 ± 0.25

Table 2.a: Correlation of different physico chemical parameters of village ponds during summer

Seasons	Summer			
Correlation between	**Value of "r" 1**	**2**	**3**	**4**
Water temperature and transparency	0.7896	0.8118	0.6617	0.8001
pH and dissolved oxygen	0.7665	0.6745	0.0496	0.9384
Free carbon dioxide and pH	0.5899	0.5541	0.9461	0.7021
Dissolved oxygen and water temperature	0.2052	0.72922	0.2869	0.2941
Total hardness and dissolved oxygen	0.6538	0.9999	0.1632	0.6808
Total dissolved solids and dissolved oxygen	0.4938	0.9767	0.3772	0.3685
Alkalinity and water temperature	0.9363	0.9990	0.8862	0.9468
Alkalinity and nitrate	0.8309	0.8626	0.8113	0.8444
Nitrate and water temperature	0.9579	0.8655	0.3778	0.6952
Nitrate and dissolved oxygen	0.0867	0.4256	0.5887	0.5697
Total dissolved solids and alkalinity	0.0542	0.7568	0.8930	0.9293

Table 2.b: Correlation of different physico chemical parameters of village ponds during Monsoon

Seasons	Monsoon			
Correlation between	**Value of "r" 1**	**2**	**3**	**4**
Water temperature and transparency	0.9876	0.7619	0.8427	0.9596
pH and dissolved oxygen	0.2334	0.1887	0.5178	0.7879
Free carbon dioxide and pH	1	0.6722	0.5297	0.9987
Dissolved oxygen and water temperature	0.5174	0.5768	0.2724	0.9613
Total hardness and dissolved oxygen	0.2887	0.2398	0.7867	0.7542
Total dissolved solids and dissolved oxygen	0.7349	0.0954	0.2775	0.7803
Alkalinity and water temperature	0.7020	0.5710	0.7727	0.8147
Alkalinity and nitrate	0.6905	0.7756	0.4257	0.1206
Nitrate and water temperature	0.0413	0.6243	0.6611	0.6739
Nitrate and dissolved oxygen	0.5629	0.0388	0.4271	0.4443
Total dissolved solids and alkalinity	0.6207	0.4959	0.5602	0.9440

Table 2.c: Correlation of different physico chemical parameters of village ponds during winter

Seasons	Winter			
Correlation between	**Value of "r" 1**	**2**	**3**	**4**
Water temperature and transparency	0.1093	0.5228	0.5293	0.4731
pH and dissolved oxygen	0.4747	0.4543	0.3322	0.7968
Free carbon dioxide and pH	0.7422	0.9525	1	0.8843
Dissolved oxygen and water temperature	0.1258	0.2303	0.3145	0.7464
Total hardness and dissolved oxygen	0.8908	0.9108	0.0842	0.9804
Total dissolved solids and dissolved oxygen	0.0037	0.9844	0.3838	0.8872
Alkalinity and water temperature	0.2531	0.8649	0.1623	0.8344
Alkalinity and nitrate	0.9371	0.2629	0.3687	0.7676
Nitrate and water temperature	0.5682	0.2348	0.1228	0.9981
Nitrate and dissolved oxygen	0.7545	0.8378	0.8423	0.7024
Total dissolved solids and alkalinity	0.0713	0.4413	0.6125	0.8115

Pond-1

Pond-2

Pond-3

Pond-4

Fig 1: Different ponds undertaken for study

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