



Analysis of physico-chemical parameters of water and soil in relation to fish culture of Borina pond, Chargavan, Teh Rithi, Dist. Katni, Madhya Pradesh, India

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Abstract

During last few years there has been an increasing trend to monitoring water quality and soil analysis of various fresh water bodies for fish culture and drinking purpose by regular measurement of their physico-chemical characteristics. Borina pond is situated in tehsil Rithi of district, Katni (M.P.) and lies at latitude 23°90" N and longitude 81°14" E. It is a perennial big pond and spread in about 15.40 hectares area. The depth of pond becomes about 15 meters in rainy season and mainly used for irrigation and fish culture. This study was carried out during November 2014 to October 2016. Four sampling stations were selected for the physico-chemical studies of water quality and soil analysis. Various physico-chemical parameters of water like temperature, transparency, pH, dissolved oxygen, free carbon dioxide, biochemical oxygen demand, chemical oxygen demand, conductivity, total alkalinity, total solids, calcium hardness, magnesium hardness, total hardness, chloride contents Nitrate, phosphate and potassium contents were measured. The soil samples are analysed in with respect to colour, plasticity, phosphorus, nitrogen, sodium, potassium, electrical conductivity and other micronutrient elements (Fe, Cu, Mn, Zn, S, B).

Keywords: water quality, aquaculture, borina pond, physico-chemical parameters

Introduction

The fish productivity mostly depends upon the water quality and soil condition of fresh water fish aquaculture. The physico-chemical condition of water and soil in fish culture mostly depend on the regional climate condition and geographical condition of this area that is affected to biotic factors. The biotic factors in fresh water are like phytoplanktons and zooplanktons living in various zones that are used food by different type of fishes and influenced water quality and soil condition to Correlated the fish productivity. The principal physico-chemical parameter of water such as temperature, transparency, pH, DO, BOD, COD, free CO₂, Electrical conductivity, alkalinity, hardness contents of chloride, phosphate, nitrate and potassium. Similarly the physico-chemical analysis of soil such as color, plasticity, organic carbon, pH, Electrical conductivity, nitrogen, phosphorus, potassium and other micronutrient elements (Fe, Cu, Zn, Mn, S and B).

The object of the present study is to review and present a concise opinion for the optimum level of water quality and soil condition parameters required for maximum fish productivity. Many workers have studied the water quality of fresh water bodies of India i.e. Munsiri *et al.* (1996) ^[15] chemical and physical characteristics of bottom soil profile in pond at Abasa Egypt. Munsiri *et al.* (1996a) ^[16] texture and chemical composition of soil from Shrimp pond near Chaluteca Honduras. Wudtisin, Boyd CE, (2006) ^[29] physical and chemical characteristics of sediment in catfish freshwater prawn and carp pond in Thailand. Ansari *et al.* (2012) ^[2] on water quality of a Temple pond of Surat (Gujrat) India, Dixit *et al.* (2015) ^[9] on physico-chemical parameters of different

pond water of Bilaspur district Chhattishgarh, India, Nagmani *et al.* (2015) ^[9] on water quality in five blocks of Bangalore, Sandhya and Benarjee (2016) ^[19] on physico-chemical properties of some selected fresh water fish ponds in Warangal area of Telangana state, Kashyap (2016) ^[13] on physico-chemical properties of water of Rewa (M.P.) and Younas *et al.* (2017) ^[30] on physico-chemical parameters of water and soils of three dams of district Korak (K.P.), Pakistan. The present study on water quality and soil condition of Borina pond is aimed to assess the success of fish culture in relation to physiographic of the pond.

Materials and Methods

The physico-chemical parameters of water quality and soil condition in the Borina pond were studied during two years of study period (November 2014 to October 2016) from four different sampling stations. Water and soil samples were analyzed for some physico-chemical parameters. The yearly minimum and maximum mean values and mean \pm SD value of water quality are given table 1 and soil analysis are given table 2. The results obtained were compared with WHO and BIS standards. Water samples were collected in monthly interval from the surface of the pond at 9.30 am to 10.30 am in order to maintain uniformity. Samples were collected in one litre clean white polythene containers. Collected samples were brought to the laboratory and kept in the refrigerator for further analysis. Field parameters like temperature pH and transparency were determined at sampling site while other parameters like EC (μ mhos/cm), total solids (mg/l), TDS (mg/l), TSS (mg/l), total alkalinity (mg/l), calcium (mg/l), Mg (mg/l), total hardness (mg/l), chloride (mg/l), DO (mg/l), BOD

(mg/l), COD (mg/l), phosphate (mg/l), chloride (mg/l), nitrate (mg/l) and potassium were analyzed in the laboratory by following the methodology of APHA (2005) [3], Trivedi and Goel (1984) [25] and Wetzel and Likens (1991) [27]. Temperature, transparency, pH and conductivity were measured by using Celsius thermometer (0-110°C), Secchi disc, digital pH meter and conductivity meter respectively. Total solids, TDS and TSS were measured by volumetric analysis. Total alkalinity, total hardness, calcium, magnesium, chloride, free CO₂, DO, BOD, and COD were analyzed by titration method. Phosphate and Nitrate were analyzed by using UV-VIS spectrophotometer and potassium by flame photometer.

The soil samples were collected from four sampling stations in the pond bottom surface of Borina pond and analysed by standard soil analysis methods as described by the Munsiri *et al.* (1995). The soil samples were analysed in with respect to color, pH, electrical conductivity, organic carbon, nitrogen, phosphorus, potassium and micronutrient elements such as Fe, Cu, Mn, Zn, S and B.

Result and Discussion

Minimum, maximum and mean±SD values of physico-chemical parameters of water are given in Table 1 and physico-chemical parameters of soil is given in table 2.

Analysis of Water Sample

The water temperature was found to be ranged between 17.95°C to 26.68°C with mean±SD value of 38 ± 2.59°C during first year and between 18.08°C to 23°C with mean ± SD value of 22.51±2.35°C during second year of study period. The minimum values of water temperature were observed in the month of January and maximum in the month of May during study period. Shinde *et al.* (2010) [21] reported the range of water temperature between 17.0°C to 32.08°C in Harsool-Savangi dam, Maharashtra. Sandhya and Benarjee (2016) [19] observed the water temperature between 8±2.90°C to 27.00±2.00°C in different ponds of Warangal area of Telangana. The ideal water temperature for biological activities of microorganisms is 20-25°C. Boyd (1998) [6] reported the optimum range of water temperature between 25-32°C for tropical climate of a fishpond.

The mean values of transparency were recorded between 28.83 cm to 69.45 cm with mean±SD value of 99±14.12 cm during first year and between 28.45 cm to 69.75 cm with mean±SD value of 49.54±14.06 cm during second year of study period.

The minimum transparency was observed in the month of July and maximum in the month of November during study period. Boyd (1998) [6] reported the optimum level of transparency between 30-40 cm. for fresh water aquaculture. USEPA (1974) [26] reported that water transparency value less than 0 m is considered a eutrophic lake. Sawant and Chavan (2013) reported the transparency between 32.5 cm (July) to 62 cm (November) in Mahagaon reservoir, Gadhinglaj, Maharashtra. Querijero and Mercurio (2016) [18] observed the highest transparency in the month of January and February in Taal lake, Batangas, Philipines.

pH was recorded to varying from 7.28 to 8.78 with mean±SD value of 8.07±0.46 during first year and from 28±8.73 with

mean value of 8.10±0.47 during second year of study period. The maximum pH was recorded in summer season and minimum in rainy season. Borina pond pH was within the desirable limits as set for protection of aquatic life by USEPA (6.5-9.0), BIS (6.5-8.5) and ICMR (5.5-9.0). Sandhya and Benerjee (2016) [19] reported the acceptable range of pH would be 6.5 to 9.0.

The recorded values of DO were ranged between 7.10 to 9.55 mg/l with mean±SD value of 8.07±0.46 mg/l and between 7.20 to 9.40 mg/l with mean±SD value of 8.05±0.75 mg/l during first and second years of study period respectively. The minimum values of DO were observed in summer season and maximum in winter season. WHO limits for DO was between 8-10 mg/l and BIS 6.0 mg/l. Banerjee and Babulal (1990) [4] reported the pond water between 5.0 to 10.00 ppm of dissolved oxygen is ideal for fish culture. Sawant and Chavan (2013) [20] reported the values of DO between 6.081 to 12.026 mg/l, minimum in the month of May and maximum in the month of December. Sandhya and Benarjee (2016) [19] observed DO between 6.8±1.02 to 7.4±1.56 mg/l in Warangal area of Telangana.

During the study period, BOD was between 3.88 to 7.70 mg/l with mean ±SD value of 5.16±1.18 mg/l during first year and between 3.83 to 7.65 mg/l with mean± SD value of 5.14±1.22 mg/l during second year of study period. The higher values of BOD were recorded in summer season and lower in winter season. ICMR standard for BOD was 5.0 mg/l. WHO (1998) reported the minimum limit of pollution is indicated by BOD of 6mg/l. Boyd (1998) [6] reported the optimum level of BOD 10 mg/l for fresh water aquaculture. Sandhya and Benarjee (2016) [19] reported the range of BOD between 1.89±0.074 to 3.14±0.015 mg/l in different ponds of Warangal area.

COD was found to be ranging between 16.13 to 23.65 mg/l with mean±SD value of 19.79±2.85 mg/l and between 16.38 to 22.55 mg/l with mean±SD value of 19.48±2.39 mg/l during first and second years of study period respectively. The maximum values of COD were recorded in summer season and minimum during winter season. Boyd (1998) [6] reported the optimum level of COD <50 mg/l for fresh water aquaculture. Kumar *et al.* (2014) reported the COD between 10.85 mg/l (minimum in month of July) to 26.80 mg/l (maximum in February) in Yamuna River at Kalpi, Jalaun (U.P.).

During present study the minimum and maximum values of free CO₂ varied between 2.37 to 4.13 mg/l with mean±SD value of 3.30±0.54 mg/l during first year and between 2.32 to 4.13 mg/l with mean value of 3.25±0.55 mg/l during second year of study period. The higher values of free CO₂ were recorded during winter season and lower during summer seasons. Hynes (1970) [11] reported 25 mg/l of free CO₂ as upper limit for fish culture. The values of free CO₂ in Borina Pond were found within tolerable limit for fish culture since it did not exceed 10 mg/l (APHA, 1998).

The values of electrical conductivity varied between 160.50 to 327.25 µmhos/cm with mean±SD value of 229.42±49.40 µmhos/cm during first year and between 161.25 to 319.25 µmhos/cm with mean value of 228.23±48.62 µmhos/cm during second year of study period. The values of electrical conductivity were recorded maximum in the month of May and minimum in the month of November during both study

year. The BIS standard for electrical conductivity was 300 $\mu\text{mhos/cm}$. Garg *et al.* (2010) ^[10] classified conductivity value greater than 500 $\mu\text{mhos/cm}$ as eutrophic. Sandhya and Benarjee (2016) ^[19] reported the conductivity between 115.06 \pm 6.54 to 118.9 \pm 3.872 $\mu\text{mhos/cm}$ of the three ponds in Warangal area of Maharashtra.

The mean values of alkalinity were varied between 56.20 to 82.20 mg/l with mean \pm SD value of 70.95 \pm 10.00 mg/l and between 56.50 to 82.30 mg/l with mean \pm SD value of 71.26 \pm 10.02 mg/l during first and second years of study period respectively. The minimum value of alkalinity was recorded in the month of September and maximum in the month of May during study period. Boyd (1998) ^[6] reported the range of alkalinity between 50 to 300 mg/l for fish culture. The BIS standard for alkalinity was 600 mg/l. Chakravarty *et al.* (2016) ^[7] reported the alkalinity between 120 to 500 mg/l between different ponds of east Godavari district. Andhra Pradesh. Thus, the value of alkalinity in Borina Pond has been found within the desirable limit of BIS standard.

The mean value of total solid varied between 423.25 to 961.25 mg/l with mean value of 607.13 \pm 173.44 mg/l during first year and between 421.75 to 951.25 mg/l with mean value of 605.60 \pm 172.00 mg/l during second year of study period. The minimum values of total solids were recorded in the month of January and maximum in the month of May during study period. Boyd (1998) ^[6] reported the optimum water quality requirement for total solids <500 mg/l. The permissible limits for TDS as per WHO and BIS standard are 2000 mg/l and 2100 mg/l respectively (Shrivastva *et al.*, 2015). Younas *et al.* (2017) ^[30] reported that a sudden extreme changes in TDS could be killed aquatic life.

The minimum and maximum values of Ca hardness ranged between 80.25 to 153.58 mg/l with mean value of 107.56 \pm 24.68 during first year and between 79.00 to 150.33 mg/l with mean \pm SD value of 106.79 \pm 24.30 mg/l during second year of study period. The BIS standard for Ca hardness was 200 mg/l. Boyd (1998) ^[6] reported the optimum level of calcium hardness between 75 to 150 mg/l for fresh water aquaculture.

The values of magnesium hardness varied between 13.28 to 25.45 mg/l with mean \pm SD value are 18.03 \pm 3.77 mg/l during first year and between 13.10 to 25.28 mg/l with mean \pm SD value of 18.14 \pm 3.84 mg/l during second year of study period. BIS standard for Mg was 100 mg/l.

The values of total hardness varied between 93.53 to 179.03 mg/l with mean \pm SD value of 125.60 \pm 28.23 mg/l in first year and between 92.10 to 175.60 mg/l with mean \pm SD value of 124.94 \pm 27.86 mg/l during second year of study period. The minimum value of total hardness were recorded in the month of January and maximum in the month of May during study period. The increase of hardness in summer month was due to the decrease in water level and increase in the rate of evaporation of high temperature. Sawant and Chavan (2013) ^[20] reported the total hardness between 88.5 mg/l to 136.0 mg/l in Mahagaon reservoir (Maharashtra) with higher values in summer season.

The mean values of chloride contents varied between 15.40 to 27.15 mg/l with mean \pm SD value of 20.87 \pm 3.30 mg/l during first year and between 15.95 to 27.23 with mean \pm SD value of 20.96 \pm 3.13 mg/l during second year of study period. The

chloride level of drinking water quality should be within 250 mg/l (WHO) and acceptable limit of BIS was 200 mg/l. Boyd (1998) reported the optimum level of chlorides between 31-50 mg/l for fresh water aquaculture. Kashyap (2016) ^[13] reported the chloride content between 120 to 190 mg/l in various water samples of Rewa (M.P.). The chloride content of water of Borina pond was within desirable limit of WHO and BIS standards and suitable for fish culture.

The mean values of phosphate contents varied between 0.30 to 0.56 mg/l with mean value \pm SD value of 41 \pm 0.08 during first year and between 0.28 to 0.54 mg/l with mean value \pm SD value of 0.39 \pm 0.09 during second year of study period. The maximum values of phosphate were observed in rainy season and minimum in summer season. Abdar (2013) also observed the higher concentration of phosphorus during monsoon months and lower during summer months. The level of phosphate of Borina pond was found higher than standard of DENR (0.05<1.0 mg/l) recommended for class C water (aquaculture purpose) during the entire study period. Sawant and Chavan (2013) ^[20] reported the range of phosphate contents between 0.0 mg/l to 0.225 mg/l in Mahagaon reservoir.

The mean values of nitrate content varied between 0.19 to 0.45 mg/l with mean \pm SD value of 0.30 \pm 0.08 mg/l during first year and between 0.21 to 0.43 mg/l with mean \pm SD value of 0.31 \pm 0.07 mg/l during second year of study period. Banerjee and Babulal (1990) ^[4] mentioned that pond water having more than 1.00 ppm of nitrate is considered to be good for optimum production of fishes. WHO standard for nitrate was below 45 mg/l. Chakravarty *et al.* (2016) ^[7] reported the range of nitrate between 3.36 mg/l to 6.40 mg/l in culture ponds of Andhra Pradesh. DENR (1990) reported 10 mg/l of nitrate for C class of water for growth of fish.

The minimum and maximum values of potassium content fluctuated between 4.12 to 6.82 mg/l with mean \pm SD value of 4.99 \pm 0.83 mg/l during first year and between 3.78 to 6.11 mg/l with mean \pm SD value of 4.69 \pm 0.72 during second year of study period. The maximum values of potassium content were observed in summer season and minimum in rainy season during study period. Boyd (1998) ^[6] reported the optimum level of potassium contents between 0.5-10 mg/l for fresh water aquaculture. Sandhya and Benarjee (2016) ^[19] observed the values of potassium between 1.73 \pm 0.001 to 2.1 \pm 0.042 mg/l in ponds of Warangal area.

Analysis of Soil Samples

Colour

Colour is one of the characteristics of carbon content, climate, soil drainage and soil mineralogy. The soil of Borina pond is pale yellow and occupied by alluvial, the soil is iron rich with deep orange-brown to yellow brown.

Plasticity of Soil

The present soil of the fish pond is yellow brownish. The texture of soil is mostly sandy and clay in the study area and particles that make up soil are characteristics into group by size, sand, silt and clay.

Soil Organic Carbon Contents

The pond with greatest production of fish and intensively

managed pond will have organic carbon contents and it will affect the production of water bodies and nitrogen fixation. The soil organic carbon of Borina pond was less (0.300%) than the normal value of organic carbon (0.5 to 0.75%) (Boyd *et al.* 1994), Smith (1996) ^[24], Munsiri *et al.* (1996 and 1996a) ^[15, 16].

pH of Soil Sample

pH of the present soil was found 6.5 to 8.5 and the pH value of Borina pond was found within desirable limit. It is ideal for fish production and associated for high rate of soil respiration.

Electrical Conductivity of Soil

Electrical conductivity is a parameter of how will a solution can conduct electricity and it is correlated with the salt contents. The average value of electrical conductivity of Borina pond soil was recorded 0.265 μ mhos/cm.

Nitrogen in Soil sample

Nitrogen is present mostly in organic forms which are broken down through bacterial action into simpler inorganic molecules. Unlimited supply of nitrogen elements from the atmosphere through fixation by azobacter, blue green algae and electrical discharge is less acute compared to phosphorus deficiency. The average value of nitrogen content of Borina

pond soil was recorded 142.75 Kg/hect. Less than the normal value of nitrogen 250-400 Kg/hect. Smith (1996) ^[24].

Phosphorus soil Sample

The availability of phosphorus is the most important to aquatic productivity owing to the fact that PO_4 ion in soil from insoluble compound with iron and alumina under acidic condition and with calcium under alkaline condition. The normal value of phosphorus to be between 10 to 25 Kg/ hect. for soil health. Thus the value of phosphorus in the Borina pond 12.52 Kg/hect. was found within the desirable limit.

Potassium content in Soil sample

Generally, potassium is need relatively in small amount for fish pond. However, it is readily available absorbed by plant tissues and it is particularly effective in stimulating the growth of aquatic flora. The potassium value of Borina pond soil was recorded 270 Kg/hect. That is in desirable limit (250-400 Kg/hect.)

Micronutrient elements of Soil

During present study the important micronutrient elements such as Fe, Cu, Mn, Zn, S and B were also determined. The value of all micronutrient elements were normal except Zn in the soil of Borina pond.

Table 1: The magnitude of the mean values of Physico-Chemical factors of Borina Pond

S. No.	Parameters	Units	Nov. 2014 to Oct. 2015			Nov. 2015 to Oct. 2016		
			Min.	Max.	Mean \pm SD	Min.	Max.	Mean \pm SD
					Value			Value
1	Water temperature	$^{\circ}C$	17.93	26.68	22.38 \pm 2.59	18.08	26.23	22.5 \pm 2.35
2	Transparency	cm.	28.83	69.45	49.99 \pm 14.12	28.45	69.75	49.54 \pm 14.06
3	pH	Units	7.28	8.78	8.07 \pm 0.46	7.28	8.73	8.10 \pm 0.47
4	DO	mg/l	7.10	9.55	8.07 \pm 0.77	7.20	9.40	8.05 \pm 0.75
5	BOD	mg/l	3.88	7.70	5.16 \pm 1.18	3.83	7.65	5.14 \pm 1.22
6	COD	mg/l	16.13	23.65	19.79 \pm 2.85	16.38	22.55	19.48 \pm 2.39
7	Free CO ₂	mg/l	2.37	4.13	3.30 \pm 0.54	2.32	4.13	3.25 \pm 0.55
8	Electrical conductivity	μ mhos/cm	160.50	327.25	229.42 \pm 49.40	161.25	319.25	228.23 \pm 48.62
9	Total alkalinity	mg/l	56.20	82.20	70.95 \pm 10.0	56.50	82.30	71.26 \pm 10.02
10	total solids	mg/l	423.25	961.25	607.13 \pm 173.44	421.75	951.25	605.60 \pm 172.00
11	Ca hardness	mg/l	80.25	153.58	107.56 \pm 24.68	79.00	150.33	106.79 \pm 24.30
12	Mg hardness	mg/l	13.28	25.45	18.03 \pm 3.77	13.10	25.28	18.14 \pm 3.84
13	Total hardness	mg/l	93.53	179.03	125.60 \pm 28.23	92.10	175.60	124.94 \pm 27.86
14	Chloride content	mg/l	15.40	27.15	20.87 \pm 3.30	15.95	27.23	20.96 \pm 3.13
15	Phosphate content	mg/l	0.30	0.56	0.41 \pm 0.08	0.28	0.54	0.39 \pm 0.09
16	Nitrate content	mg/l	0.19	0.45	0.30 \pm 0.08	0.21	0.43	0.31 \pm 0.07
17	Potassium content	mg/l	4.12	6.82	4.99 \pm 0.83	3.78	6.11	4.69 \pm 0.72

Table 2: The values of Soil condition analysis of Borina Pond

S. No.	Parameters	Units	Average value
1	pH	Unit	6.96
2	Electrical Conductivity	μ mhos	0.265
3	Organic Carbon	%	0.300
4	Nitrogen	Kg/hect.	142.75
5	Phosphorus	Kg/hect.	12.52
6	Potassium	Kg/hect.	270
7	Iron	mg/kg	14.6
8	Copper	mg/kg	0.52
9	Zinc	mg/kg	0.205
10	Manganese	mg/kg	9.520
11	Sulphur	mg/kg	17.3
12	Boron	mg/kg	0.705

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