Study of physico-chemical parameters of water in aquaculture ponds at Dongapandi, Bhimavaram Mandal, West Godavari (AP)

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Abstract

The present study of physico-chemical parameters of waters at Dongapandi Vilage, Bhimavaram Mandal, West Godavari District, Andhra Pradesh, India. The total 20 physico chemical perameters are taken for analysis. They are Temperature, Salinity, Turbidity, Total Dissolved Solids, Electrical Conductivity, pH Total alkalinity, Dissolved Oxygen, Biochemical Oxygen Demand, Ammonia, Nitrate, Phosphate, Sulphate, Calcium, Magnesium, Carbonate, Bicarbonate, Total Hardness, Fluoride and Chloride. We adopted different types of analytical methods for analysis of the 20 parameters.

Key Words: Dongapandi, pH, BOD, COD, TDS and DO

Introduction

Water is essential for the survival of any form of life since life depends upon water in virtually for every process. In fact, the early life on the earth originated in water and evolved in water. For this reason water is called 'the elixir of life', 'matrix of life' or more poetically 'the cradle of life'. Living organisms like fishes use water as medium for carrying out biological processes.

The study of fish pond water quality in Dongapandi Village, Bhimavaram Mandal, Andhra Pradesh, India was conducted.

The objectives of this study are as follows:

i) To study the status of fish pond water quality of in and around Bhimavaram town in the course of physico-chemical investigations;
ii) To test whether in and around Bhimavaram Aqua farmers have access to truly increase fish yield, by calculating correlation coefficients; and
iii) To identify the causes of fish pond water pollution and to recommend suitable remedies.

MATERIALS AND METHODS

Study area

The study area of the Dongapandi Village, Bhimavaram Mandal, Andhra Pradesh, India and satellite pictures of sampling areas are shown in Figures 1-6.

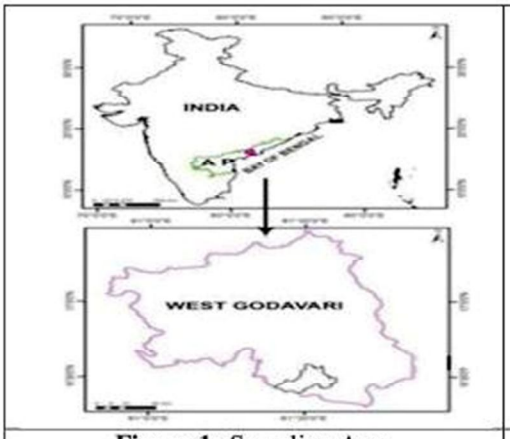

Figure 1: Sampling Area

Figure 2: Satellite picture for S1

Figure 3: Satellite picture for S2

Figure 4: Satellite picture for S3

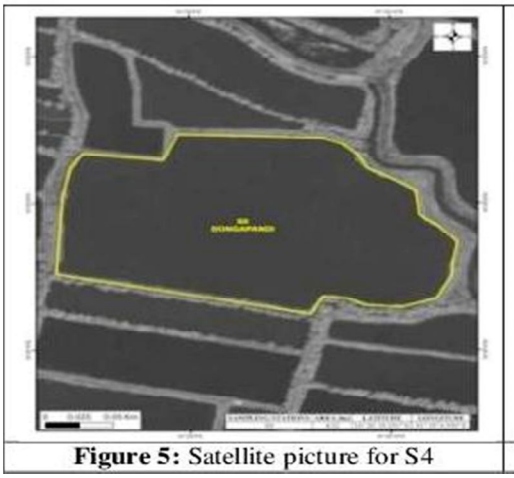

Figure 5: Satellite picture for S4

Figure 6: Satellite picture for S5

Samples collection

Fish pond water samples were collected from 5 ponds located in Dongapandi Village in the morning hours between 7 am and 9 am twice a month during July 2013 to June 2014. The samples of water were collected in the polyethylene bottles or in a glass bottle. They were kept cool, preferably between 4°and 10° C, but not frozen. The temperature of water, pH, dissolved oxygen, pH, EC and Total dissolved solids were analyzed immediately at on site, while the remaining parameters were analyzed done immediately in Environmental Laboratory, Andhra University Visakhapatnam.

Methods of sampling for physico–chemical analysis

The time between sampling and analysis was tried to be kept at minimum. Samples are in clean glass or polythene bottles at a low temperature (putting ice in the box e.g. 4^0C) and in the dark were carried to the laboratory.

Sampling Stations	Village Name	Area (Ha)	Latitude	Longitude	Description of the study area
S1	Dongapandi	7.68	16° 25' 19.559" N	81° 25' 5.501" E	Located nearby aquaculture ponds
S2	Dongapandi	2.31	16° 24' 46.954" N	81° 26' 32.846" E	Located beside KottacheduNala canal
S3	Dongapandi	3.36	16° 24' 26.013" N	81° 27' 2.437" E	Located adjacent to Upputeru river
S4	Dongapandi	4.22	16° 26' 19.251" N	81° 25' 6.556" E	Locatedadjacent Bondadachannel extensition
S5	Dongapandi	3.31	16° 25' 53.072" N	81° 26' 9.176" E	Located nearby old Ennamaduru drain

Water analyses procedures – in brief

S. No.	Parameters	Method
	Physico-chemical	
1	Temperature	Measured with calibrated thermometer
2	Salinity	Gravimetric method
3	Turbidity	Turbiditymetric method
4	Total Dissolved Solids	Gravimetric method
5	Electrical Conductivity	Electronic method
6	pH	Electrometric method
7	Total alkalinity	Titration with standard acid using indicator
8	Dissolved Oxygen	Winkler method with the azide modifications
9	Biochemical Oxygen Demand	Wet oxidation procedure
10	Ammonia	Tested with Nessler's reagent
11	Nitrate	Ultraviolet screening/cadmium reduction method
12	Phosphate	Colorimetric- Molybdophosphoric acid method
13	Sulphate	Turbidity metric method – precipitation with barium chloride and measured the turbidity photometrically at 420 nm using Spectrophotometer.
14	Calcium	Calculation followed by complexometric method using EDTA
15	Magnesium	Calculation followed by complexometric method using EDTA
16	Carbonate	Titrimetric method
17	Bicarbonate	Titrimetric method
18	Total Hardness	Complexometric titration using EDTA and Eriochrome Black T as indicator
19	Fluoride	SPADNS method – Ions selective electrode
20	Chloride	Argentometric titration with chromate ions as indicator

Results and Discussion

Water quality analyses of fish ponds at 5 samples were performed and different physico-chemical parameters were estimated and the results were shown in table 1

Correlation coefficient of physico-chemical parameters.

The correlations among different parameters in fish pond water in different regions during the study period 2013 to 2014 were summarized in table 2.

Table 1: Seasonal variation of Mean of physico-chemical parameters

S. No.	Parameters	Summer	Monsoon	Winter
1	pH	8.580769231	8.219230769	7.848076923
2	Turbidity	9.294615385	13.13096154	11.88326923
3	DO	5.710192308	6.671153846	4.890384615
4	F^-	0.785961538	0.4614	0.601346154
5	SO_4^{2-}	109.7794231	98.44903846	79.72134615
6	PO_4^{3-}	6.778653846	7.902884615	5.458254902
7	Cl^-	2570.038462	2310.096154	2245.019231
8	Ca^{2+}	137.4230769	122.7307692	155.1730769
9	Mg^{2+}	259.6346154	227.3692308	236.0769231
10	TH	1406.288462	1558.153846	1250.692308
11	Alkalinity	113.7884615	146.2692308	127.7692308
12	CO_2	17.53846154	25.63461538	32.53846154
13	HCO_3^-	95.21153846	117.75	130.8654
14	NO_3^-	0.096154	0.15	0.105769
15	NH_3	1.288462	0.455	0.273846
16	TDS	1140.19	5203.015	837.7963
17	EC (µS/ho).	1911.235	8169.362	1355.052
18	BOD	3.43057692	2.078077	2.473846
19	Salinity	45.96731	41.24038	40.33846
20	Temperature	44.30392	23.78077	19.42157

Physico-chemical parameter analysis

The following physic-chemical parameters are discussed as follows.

Water colour

The colour light greenish or greenish waters suitable for aqua fish culture.

pH

The pH is as important factor for the growth of aquatic vegetation because it affects the metabolism and other physiological processes of culture organisms. pH between 7.0 to between 7.0 to 8.5 is ideal for biological productivity.

Temperature

The highest temperature was recorded in summer during (54^0 C), where as the minimum in winter season (21^0 C) during the study period.

Turbidity

The turbidity range from 30-80 cm is good for fish health.

Dissolved oxygen (DO)

Dissolved oxygen (DO) indicates physico-chemical and biological activities in a water body. It is an important indicator of water quality. DO between 3.0-5.0 ppm in ponds is unproductive and for average or good production it should be above 5.0. In the present study DO values were more than 5.0 mg/L, optimal for aquatic life. DO values range 5.2-7.1 mg/L.

Biochemical oxygen demand (BOD)

BOD level between 3.0-6.0 ppm is optimum for normal activities of fishes.

Carbondioxide (CO_2)

Free carbon dioxide, highly soluble gas in water, main source of carbon path way in the nature, is contributed by the respiratory activity of animals and can exist in water as bicarbonate or carbonates in the dissolved or bound form in earth crust, in limestone and coral reefs regions.

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^- \leftrightarrow 2H^+ + CO_3^{2-}$$

When dissolved in water it forms carbonic acid which decreases the pH of any system, especially insufficiently buffered systems, and this pH drop can be harmful for aquatic organisms.

The correlation studies performed, carbonated showed moderately positively correlation with Salinity (r = 0.424) while weakly correlated with pH (r = 0.304).

Alkalinity

Alkalinity in water is due to the presence of the carbonates, bicarbonates and hydroxides. According to alkalinity highest values were recorded in summer and the lowest was found in monsoon due to high photosynthetic rate, increase in bicarbonates and carbonates in the pond water.

Total hardness (TH)

Total hardness is the parameter of water quality used to describe the effect of dissolve minerals (mostly calcium and magnesium) determining suitability of water for aquaculture practice purpose Hardness indicates water quality mainly in terms of $Ca^{2+}$and Mg^{2+}.

Calcium

Fish must then use energy supplied by their feed to re-absorb lost salts. That can reduce the energy available for growth and may extend the time necessary to grow fish to market size. Recommended range for free calcium in culture waters is 25 to 100 mg/L. **Electrical conductivity (EC)**

Electrical conductivity (EC) is a measure of how well a solution conducts electricity. It is related to salt content; the higher the salt content, the higher the EC will be. Acceptable range 30-5,000 m Siemens/cm for pond fish culture.

During the study period, the highest values 3378μS/cm, 3215μS/cm and 2954μS/cm were recorded.

Salinity

Salinity is defined as the total concentration of electrically charged ions (cations – Ca^{++}, Mg^{++}, K^+, Na^+ ; anions – CO_3^{2-}, HCO_3^-, SO_4^{2-}, Cl^- and other components such as NO_3^-, NH_4^+ and PO_4^{3-}). Freshwater fish exhibit a range in salinity tolerance. Salinity plays an important role in the growth of culture organisms through osmoregulations of body minerals from that of the surrounding water. Standard limit for Salinity is 250 mg/L.

Chloride

Chlorine is a highly reactive compound and is used as a disinfectant. During the study period the chloride content was found to be high during summer season

while, lowest content of chloride was found during monsoon season.

Ammonia

Ammonia is the by-product from protein metabolism excreted by fish and bacterial decomposition of organic matter such as wasted food, dead planktons, sewage etc.

During the study period, ammonia showed moderately positive correlated with fluoride (r = -0.424) and no significant correlation was observed with the other parameters.

Nitrate

Nitrate is relatively non-toxic to fish and is not a health hazard except at exceedingly high levels (more than 90 mg/L NO_3^-- N).

Phosphates

The element phosphorous is necessary for plant and animals growth. The correlation studies performed, phosphate showed a moderate negative correlation with turbidity (r = -0.412) while weakly negative correlated with Chloride and Salinity (r = -0.300, -0.342).

Magnesium

Magnesium is essential for fish growth, but a specific recommended concentration is not available. Magnesium levels was recorded the highest in summer at sample, while it was observed the lowest in sample during monsoon season to the investigation period at all the sites .

Total dissolved solids (TDS)

The values of the Total Dissolved Solids indicate the general nature of the water quality. TDS recommended level is 2100 mg/L for fish culture. The maximum amount of total dissolved solids was recorded at sample during monsoon and minimum amount during winter season during the study period.

Fluoride

Fluoride is a trace element levels at or above 3 mg/L are reported to cause losses of some fish species, depending up on complex water conditions. In the present investigation, it was noted that the fluoride values were maximum in the summer than other seasons.

Sulphate

Sulphates are usually occur in natural water samples. Maximum values of sulphates were observed in the summer compared to other seasons.

Bicarbonate

The concentrations of Bicarbonate content of the pond waters were highest during summer season but exhibited a lowest trend in winter season

The results of water quality parameters tested in 3 different seasons are shown in tables 3-7

Table 2: Correlation analysis of physico-chemical parameters

	pH	Turbidity	D.O	F^-	SO_4^{2-}	PO_4^{3-}	Cl^-	Ca^{2+}	Mg^{2+}	TH	Alkalinity	CO_3^{2-}	HCO_3^-	NO_3^-	NH_3	TDS	EC	BOD	Salinity	Temperature
pH	1.000																			
Turbidity	0.087	1.000																		
DO	0.149	0.497	1.000																	
F^-	-0.051	-0.075	0.069	1.000																
SO_4^{2-}	0.076	0.323	0.183	0.154	1.000															
PO_4^{3-}	-0.002	-0.412	-0.228	0.057	-0.088	1.000														
Cl^-	0.138	0.860	0.550	-0.064	0.271	-0.300	1.000													
Ca^{2+}	0.066	0.706	0.612	-0.003	0.347	-0.267	0.833	1.000												
Mg^{2+}	0.111	0.832	0.503	-0.013	0.319	-0.277	0.982	0.826	1.000											
TH	-0.001	0.732	0.442	-0.005	0.129	-0.297	0.896	0.784	0.921	1.000										
Alkalinity	0.208	0.234	0.150	0.239	0.429	0.056	0.191	0.068	0.238	0.045	1.000									
CO_3^-	0.304	0.284	0.265	-0.207	0.100	-0.032	0.247	0.080	0.230	0.164	0.282	1.000								
HCO_3^-	-0.051	-0.041	-0.137	0.368	0.309	0.147	-0.018	-0.035	0.056	-0.064	0.695	-0.217	1.000							
NO_3^-	-0.020	0.251	0.209	-0.039	0.106	-0.187	0.250	0.278	0.258	0.340	0.123	0.148	0.029	1.000						
NH_3	-0.006	-0.158	0.024	0.424	0.138	0.183	-0.197	-0.209	-0.191	-0.166	0.131	-0.101	0.194	0.189	1.000					
TDS	0.023	0.321	0.186	0.065	0.056	-0.114	0.562	0.396	0.558	0.519	0.035	-0.019	0.040	-0.017	-0.141	1.000				
EC	0.016	0.319	0.171	0.064	0.056	-0.106	0.559	0.386	0.555	0.514	0.034	-0.023	0.042	-0.023	-0.143	0.999	1.000			
BOD	-0.088	0.270	0.356	0.192	-0.078	-0.279	0.402	0.370	0.370	0.394	-0.145	0.069	-0.199	0.090	-0.096	0.419	0.415	1.000		
Salinity	0.144	0.830	0.619	0.010	0.201	-0.342	0.856	0.693	0.824	0.746	0.202	0.424	-0.119	0.284	-0.088	0.523	0.517	0.377	1.000	
Temperature	0.037	0.119	0.044	-0.045	0.209	-0.063	0.160	0.176	0.217	0.203	0.139	0.144	-0.089	0.229	-0.211	-0.004	-0.004	-0.001	0.173	1.000

Table 3: for S1 Results of water quality parameters tested in 3 different seasons					Water quality standards					
Physico-chemical parameters		Summer	Rainy	Winter	BIS 10500 : 2012		WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
					Accepta-ble limit	Permissi-ble limit				
Temperature	°C	38	21	21	-	-	-	24-32	-	25-30
Salinity	mg/L	8	5	6.1	-	-	-	-	-	1-250
Turbidity	NTU	5.9	6	6	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	980.2	1069.1	995.2	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	1463	1527	1843	500	2000	2500	-	2500	-
pH	0 - 14	8.6	8	8	6.5-8.5	-	6.5-8.5	6.5- 9	6.5-9.5	6.5 - 9.0
Total Alkalinity (as $CaCO_3$)	mg/L	152	120	123	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	6.1	6.8	4.5	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	3.02	1.21	2.01	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	2.8	2.5	1.2	0.5	-	1.5	-	-	0.05-0.2
Nitrate (as NO_3-N)	mg/L	0.1	0.2	0.2	45	-	50	10	10	< 5
Phosphate (as PO_4-P)	mg/L	2.65	3.1	1.67	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	402	380	345	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	196	180	204	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	145	130	138	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	26	20	12	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	145	132	121	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	843	980	670	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.78	0.28	0.3	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	270	221	245	250	1000	250	250	250	1-100

Bureau of Indian Standards IS 10500 : 2012; WHO Guidelines for Drinking-Water Quality (2011); US EPA Primary Drinking Water Standards; E.U: European Union /European Communities (Drinking Water) (No. 2) Regulations 2007 (S.I. 278 of 2007); Water Quality for Pond Aquaculture-Acceptable Concentration Ranges in Aquaculture Pond Waters" Boyd (1998).

Note: 1. Season wise data primarily compared with Boyd (1998) water quality standards for pond aquaculture. 2. Parameters which exceed the permissible limits and which fall below the optimum range are highlighted with red colour.

Remarks: Out of 20 parameters studied 9 exceeded the permissible limits of different standards compared and 3 parameters (Temperature in rainy and winter, DO in winter and Turbidity) are below the optimum range of Boyd (1998) water quality standards for pond aquaculture.

Sources for contamination: Agricultural runoff, Aqua-cultural practices such as addition of fish feeds and biocides, Irrigation canals contaminated by sewage, Fine organic or inorganic particles, Industrial effluents

Suggestions: Less contaminated feeds should be preferred, Caution should be exercised while choosing biocide brands, Management of pond water quality by periodic monitoring, Minimize river pollution

Table 4: for S2 Results of water quality parameters tested in 3 different seasons					Water quality standards					
Physico-chemical parameters		Summer	Rainy	Winter	BIS 10500 : 2012		WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
					Accepta-ble limit	Permissi-ble limit				
Temperature	°C	53	22.4	18	-	-	-	24-32	-	25-30
Salinity	mg/L	1.3	0.5	0.7	-	-	-	-	-	1-250
Turbidity	NTU	6.5	7	6.6	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	1034.1	1214.4	1154.2	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	1668	2249	1776	500	2000	2500	-	2500	-
pH	0 -14	8.9	8.6	7.7	6.5-8.5	-	6.5-8.5	6.5- 9	6.5-9.5	6.5 - 9.0
Total Alkalinity (as $CaCO_3$)	mg/L	174	143	154	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	5.3	5.8	4.6	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	1.99	0.1	0.1	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	1.5	0.2	0.2	0.5	-	1.5	-	-	0.05-0.2
Nitrate (as NO_3-N)	mg/L	0	0	0	45	-	50	10	10	< 5
Phosphate (as PO_4-P)	mg/L	20	20	6.7	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	298	278	225	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	212	190	225	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	156	128	134	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	0	0	0	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	189	174	134	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	301	320	223	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.9	0.2	0.2	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	476	432	454	250	1000	250	250	250	1-100

Bureau of Indian Standards IS 10500 : 2012; WHO Guidelines for Drinking-Water Quality (2011); US EPA Primary Drinking Water Standards; E.U: European Union /European Communities (Drinking Water) (No. 2) Regulations 2007 (S.I. 278 of 2007); Water Quality for Pond Aquaculture-Acceptable Concentration Ranges in Aquaculture Pond Waters" Boyd (1998).

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Suggestions: Less contaminated feeds should be preferred, Caution should be exercised while choosing biocide brands, Management of pond water quality by periodic monitoring, Minimize river pollution

Table 5: S3 Results of water quality parameters tested in 3 different seasons					Water quality standards					
Physico-chemical parameters		Summer	Rainy	Winter	BIS 10500 : 2012		WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
					Accepta-ble limit	Permissi-ble limit				
Temperature	℃	38.2	21.5	18.2	-	-	-	24-32	-	25-30
Salinity	mg/L	7.7	5.5	6.4	-	-	-	-	-	1-250
Turbidity	NTU	5.6	6	5.9	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	834.2	1158.7	1054.1	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	1303	2280	1917	500	2000	2500	-	2500	-
pH	0 -14	8.8	8.8	8	6.5-8.5	-	6.5-8.5	6.5- 9	6.5-9.5	6.5 - 9.0
Total Alkalinity (as $CaCO_3$)	mg/L	298	119	223	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	6.1	6.2	4.5	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	1.57	1.1	1.2	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	1.6	0.2	0.1	0.5	-	1.5	-	-	0.05-0.2
Nitrate (as NO_3-N)	mg/L	0	0	0	45	-	50	10	10	< 5
Phosphate (as PO_4-P)	mg/L	18.23	20	12.3	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	298	278	220	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	56	48	68	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	204	187	187	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	99	88	34	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	225	210	178	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	404	480	345	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.8	0.5	0.5	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	376	327	345	250	1000	250	250	250	1-100
Bureau of Indian Standards IS 10500 : 2012; WHO Guidelines for Drinking-Water Quality (2011); US EPA Primary Drinking Water Standards; E.U: European Union /European Communities (Drinking Water) (No. 2) Regulations 2007 (S.I. 278 of 2007); Water Quality for Pond Aquaculture-Acceptable Concentration Ranges in Aquaculture Pond Waters" Boyd (1998).										
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Remarks: Out of 20 parameters studied 9 exceeded the permissible limits of different standards compared and 3 parameters (Temperature in rainy and winter, DO in winter and Turbidity) are below the optimum range of Boyd (1998) water quality standards for pond aquaculture.										
Sources for contamination: Agricultural runoff, Aqua-cultural practices such as addition of fish feeds and biocides, Irrigation canals contaminated by sewage, Fine organic or inorganic particles, Industrial effluents										
Suggestions: Less contaminated feeds should be preferred, Caution should be exercised while choosing biocide brands, Management of pond water quality by periodic monitoring, Minimize river pollution										

Table 6: S4 Results of water quality parameters tested in 3 different seasons					Water quality standards					
Physico-chemical parameters		Summer	Rainy	Winter	BIS 10500 : 2012		WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
					Accepta-ble limit	Permissi-ble limit				
Temperature	°C	54	22.1	19.2	-	-	-	24-32	-	25-30
Salinity	mg/L	5.1	2	3.1	-	-	-	-	-	1-250
Turbidity	NTU	5.7	7	6.8	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	337.8	509.31	478.9	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	573	849	855	500	2000	2500	-	2500	-
pH	0 -14	8.9	8.7	8.1	6.5-8.5	-	6.5-8.5	6.5- 9	6.5-9.5	6.5 - 9.0
Total Alkalinity (as $CaCO_3$)	mg/L	310	220	301	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	5.7	5.7	4.4	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	3.4	2.1	2.14	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	0.6	0.5	0.2	0.5	-	1.5	-	-	0.05-0.2
Nitrate (as NO_3-N)	mg/L	0.1	0.1	0.1	45	-	50	10	10	< 5
Phosphate (as PO_4-P)	mg/L	8.4	12	8.4	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	25.2	20.2	14.2	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	55	48	78	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	79	63	65	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	78	60	34	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	256	250	210	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	243	380	150	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.67	0.21	0.34	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	88	56	75	250	1000	250	250	250	1-100
Bureau of Indian Standards IS 10500 : 2012; WHO Guidelines for Drinking-Water Quality (2011); US EPA Primary Drinking Water Standards; E.U: European Union /European Communities (Drinking Water) (No. 2) Regulations 2007 (S.I. 278 of 2007); Water Quality for Pond Aquaculture-Acceptable Concentration Ranges in Aquaculture Pond Waters" Boyd (1998).										
Note: 1. Season wise data primarily compared with Boyd (1998) water quality standards for pond aquaculture. 2. Parameters which exceed the permissible limits and which fall below the optimum range are highlighted with red colour.										
Remarks: Out of 20 parameters studied 9 exceeded the permissible limits of different standards compared and 3 parameters (Temperature in rainy and winter, DO in winter and Turbidity) are below the optimum range of Boyd (1998) water quality standards for pond aquaculture.										
Sources for contamination: Agricultural runoff, Aqua-cultural practices such as addition of fish feeds and biocides, Irrigation canals contaminated by sewage, Fine organic or inorganic particles, Industrial effluents										
Suggestions: Less contaminated feeds should be preferred, Caution should be exercised while choosing biocide brands, Management of pond water quality by periodic monitoring, Minimize river pollution										

Table 7: S5 Results of water quality parameters tested in 3 different seasons					Water quality standards					
Physico-chemical parameters		Summer	Rainy	Winter	BIS 10500 : 2012		WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
					Accepta-ble limit	Permissi-ble limit				
Temperature	℃	37.8	18.7	19.4	-	-	-	24-32	-	25-30
Salinity	mg/L	5	4	3.2	-	-	-	-	-	1-250
Turbidity	NTU	5.4	6	5.9	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	458.2	785.31	678.2	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20℃	(µS/cm)	818	1402	1130	500	2000	2500	-	2500	-
pH	0 - 14	8.8	8.7	8.1	6.5-8.5	-	6.5-8.5	6.5- 9	6.5-9.5	6.5 - 9.0
Total Alkalinity (as $CaCO_3$)	mg/L	140	112	127	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	6.1	6.6	4.4	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	2.2	0.2	0.9	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	1.2	0.6	0.3	0.5	-	1.5	-	-	0.05-0.2
Nitrate (as NO_3-N)	mg/L	0	0.1	0.1	45	-	50	10	10	< 5
Phosphate (as PO_4-P)	mg/L	20.56	23	18.2	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	78	54	43	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	98	82	121	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	166	143	156	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	0	0	0	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	148	140	120	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	765	950	734	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.78	0.21	0.24	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	389	343	367	250	1000	250	250	250	1-100
Bureau of Indian Standards IS 10500 : 2012; WHO Guidelines for Drinking-Water Quality (2011); US EPA Primary Drinking Water Standards; E.U: European Union /European Communities (Drinking Water) (No. 2) Regulations 2007 (S.I. 278 of 2007); Water Quality for Pond Aquaculture-Acceptable Concentration Ranges in Aquaculture Pond Waters" Boyd (1998).										
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Sources for contamination: Agricultural runoff, Aqua-cultural practices such as addition of fish feeds and biocides, Irrigation canals contaminated by sewage, Fine organic or inorganic particles, Industrial effluents										
Suggestions: Less contaminated feeds should be preferred, Caution should be exercised while choosing biocide brands, Management of pond water quality by periodic monitoring, Minimize river pollution										

Conclusions

A total of 20 quality parameters related to physico-chemical characteristics were analysed during the study period 2013-2014. According to my observations, considering the physico-chemical analysis, while comparing the values of pond water quality parameters with respective recommended standards are at with in the limits

Based on the results obtained in the present investigations, critical analysis of the data and correlating the data with the prevailing conditions of the cultural practices, the water of fish ponds.

These following precautions and guidelines if taken well, not only raise productivity and economic benefits but will also help the farmers in maintaining eco-friendly fish ponds, environment required for sustainable for aquaculture.

- Regularly physico-chemical tests should be carried out to protect the fishes from the waterborne disease.
- Rectangular ponds are recommended to adjust length/width ratios to increase bottom velocities and reduce bio-solid accumulation.
- A common method is to control ammonia is bio-filter adding in the fish ponds.
- Provide separate drainages for the aqua farms which must be constructed far away from agricultural field.
- To allow aquaculture effluent discharges after treatment only.
- Strict enforcement of laws to ban the use of harmful feed materials pesticides and antibiotics.

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