Physico-chemical parameters of water in aquaculture ponds at Gollavanitippa in Bhimavaram Mandal, Andhra Pradesh

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Abstract

This is the study of physico-chemical parameters of waters at Gollavanitippa and its viscinity in Bhimavaram Mandal, West Godavari District, Andhra Pradesh, India. The total 20 physico-chemical parameters 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: Gollavanitippa, Calcium, Magnesium, Carbonate, Bicarbonate, Total Hardness, pH, BOD, COD, TDS and DO.

INTRODUCTION

Recently, Prawn culture was also started in many areas vigorously. With flourishing fish and prawn processing industries, a number of ancillary units like Ice plants are of recent emergence on a large scale in Bhimavaram Mandal. It is not only an agricultural Mandal but also aquaculture producing Mandal in our country and it is next to Cochin in exporting aquaculture products. Large extent of fertile lands in Bhimavaram Mandal regions having rich resource potential of Flora-Fauna is converted into fish ponds. As a result several adverse effects arise in the region, both in physical environment and socio-economic environment. The data is taken from Mandala Revenue Office (MRO) Bhimavaram.

MATERIALS AND METHODS

Study area

Gollavanitippa Village, Bhimavaram Mandal, Andhra Pradesh in India is shown in Figure 1 and Table 1.

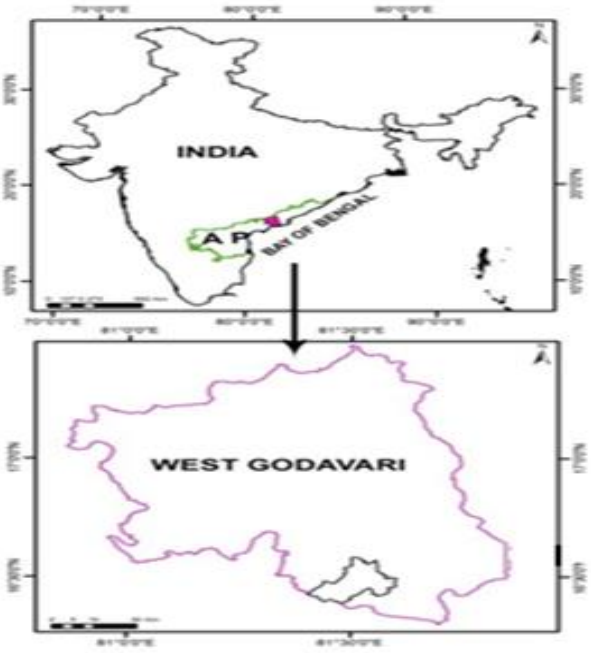

Table 1: Sampling stations.

Sampling Stations	Village Name	Area (Hectares)	Latitude	Longitude	Description of the study area
S1	Gollavanitippa	0.93	16° 27' 12.034" N	81° 29' 36.186" E	Located near Ennamadur drain
S2	Gutlapadu	0.35	16° 26' 43.684" N	81° 29' 58.980" E	Located beside Ennamadur drain
S3	Gollavanitippa	0.12	16° 27' 15.890" N	81° 30' 13.097" E	Located near Ennamadur drain
S4	Gollavanitippa	5.86	16° 27' 28.807" N	81° 30' 36.440" E	Located adjacent aquaculture ponds
S5	Gollavanitippa	0.61	16° 28' 13.984" N	81° 30' 50.410" E	Located adjacent Ennamadur drain

Samples collection

Fish pond water samples were collected from 5 ponds located in the village Gollavanitippa in the morning hours between 7 am and 9 am twice a month during July 2013 to June 2014. Water was collected in polyethylene bottles labeled with sample code and

transported to the laboratory in an ice box. They were kept cool, preferably between 4° to 10° C, but not frozen. The temperature of water, pH, dissolved oxygen, EC and Total dissolved solids were analyzed immediately at on site, while the remaining parameters were analyzed immediately in Environmental Laboratory, Andhra University, Visakhapatnam. The samples were processed and analyzed conscientiously following the appropriate methods.

Methods of sampling for physico–chemical analysis

Accuracy of the analytical data:

The errors in the estimation of the chemical parameters involving gravimetric estimations are less than 1.0% and the estimations involving volumetric methods may be up to 2.0%. GC, Ion selective electrode meter and flame photometer, the errors are in the range of 1.0-5.0%.

Water analyses procedures – in brief		
S. No.	Physico-chemical Parameters	Method
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

Teble 3: (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
					Acceptable limit	Permissible limit				
Temperature	°C	45.2	24.6	18.2	-	-	-	24-32	-	25-30
Salinity	mg/L	108	98	98	-	-	-	-	-	1-250
Turbidity	NTU	12.3	42	34.4	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	986.6	1136	1024.3	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	1473	1925	1552	500	2000	2500	-	2500	-
pH	0-14	8.8	8.5	8.5	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	212	178	178	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	7.2	7.8	6.4	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	6	4.3	4.5	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	2.3	0.12	0.1	0.5	-	1.5	-	-	0.05-0.2
Nitrate (as NO_3-N)	mg/L	0.3	0.6	0.3	45	-	50	10	10	< 5
Phosphate (as PO_4-P)	mg/L	0.92	1.5	0.89	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	275	250	210	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	225	205	276	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	387	345	367	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	0	0	0	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	102	90	58	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	1437	1957	1437	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.87	0.2	0.66	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	6116	5107	5723	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.

Table 2: (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
					Acceptable limit	Permissible limit				
Temperature	°C	52	26.4	19.4	-	-	-	24-32	-	25-30
Salinity	mg/L	112	102	102	-	-	-	-	-	1-250
Turbidity	NTU	22.89	36	34.2	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	1678.3	1858	1834.4	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	2997	3378	2738	500	2000	2500	-	2500	-
pH	0-14	8.6	8.6	6.6	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	212	189	197	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	6.9	8.1	6	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	2	1.2	1.22	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	1.2	0.1	0.1	0.5	-	1.5	-	-	0.05-0.2
Nitrate (as NO_3-N)	mg/L	0.2	0.3	0.2	45	-	50	10	10	< 5
Phosphate (as PO_4-P)	mg/L	1.12	2.2	1.12	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	288	275	231	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	225	205	246	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	621	568	602	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	31	20	12	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	89	76	66	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	2756	2889	2534	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.57	0.3	0.44	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	8609	8308	8507	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.

Table 4: (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
					Acceptable limit	Permissible limit				
Temperature	°C	45	26.6	19	-	-	-	24-32	-	25-30
Salinity	mg/L	156	143	148	-	-	-	-	-	1-250
Turbidity	NTU	22.33	30	29.3	1	5	<5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	1022	1107	1079.5	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	1793	1977	1588	500	2000	2500	-	2500	-
pH	0-14	8.5	8.5	8.5	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	150	120	127	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	6.6	9.2	6.7	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	10.11	6.7	6.7	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	0.8	0.65	0.42	0.5	-	1.5	-	-	0.05-0.2
Nitrate (as NO_3-N)	mg/L	0.2	0.6	0.3	45	-	50	10	10	< 5
Phosphate (as PO_4-P)	mg/L	1.2	2.8	1.2	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	223	214	187	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	373	373	389	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	982	891	876	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	21	20	7	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	187	164	143	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	4023	4660	3777	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.97	0.4	0.73	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	14324	13075	13789	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.

Table 5: (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
					Acceptable limit	Permissible limit				
Temperature	°C	38.9	25.3	18	-	-	-	24-32	-	25-30
Salinity	mg/L	134	126	131	-	-	-	-	-	1-250
Turbidity	NTU	12.4	28	27.8	1	5	<5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	872	1165	934	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	1342	1820	1557	500	2000	2500	-	2500	-
pH	0-14	8.9	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	150	134	145	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	6.5	10.3	6.4	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	3.4	2.3	3.1	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	0.8	0.2	0.1	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	2.22	3.1	2.22	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	77	66	22	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	302	298	321	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	880	790	821	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	23	20	11	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	178	144	123	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	3998	4054	3978	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.63	0.5	0.63	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	12345	10964	1145	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.

Table 6: (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
					Acceptable limit	Permissible limit				
Temperature	°C	39	23.3	18.1	-	-	-	24-32	-	25-30
Salinity	mg/L	123	99	102	-	-	-	-	-	1-250
Turbidity	NTU	22.4	33	30.2	1	5	< 5	-	<4	20-35
Total Dissolved Solids (TDS)	mg/L	578	987	687	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	1070	1673	1272	500	2000	2500	-	2500	-
pH	0 -14	8.7	8.6	8.6	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	150	128	128	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	5.9	6.6	5.5	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	2.2	1.2	1.2	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	0.3	0.12	0.12	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	3.42	3.8	2.34	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	212	201	175	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	298	280	312	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	934	902	902	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	25	25	23	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	121	110	98	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	4271	4473	3065	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.87	0.3	0.52	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	14567	13007	14231	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.

RESULTS AND DISCUSSION

Water quality analyses of fish ponds at Gollavanitippa in Bhimavaram Mandal were performed and different physico-chemical parameters were estimated and the results were shown in Tables 2-6. During recent years pond water resources were used to provide a habitat for fishes.[1] Good water quality is characterized by adequate oxygen, proper temperature, transparency, limited levels of metabolites and other environmental factors affecting fish culture. The early studies of water quality of a fish pond in India were most likely conducted.[2-5] A numerous workers have studied the physico-chemical condition of inland waters either in relation to fish mortality or as part of general hydrological survey.[6, 7] The fine points of various pond ecosystems also have been studied by workers[8-11] in relation to water quality at Haryana. However, the present study would provide the basic guidelines parameter wise for the fish farmers in obtaining high fish yield via maintaining water quality of their ponds.

Physico-chemical parameter analysis

The following physico-chemical parameters are discussed as follows.

Water colour

The colour of an object is defined by the wavelengths of visible light that the object reflects. During the study period fish pond water appears turbid especially during monsoon days and at the time of discharge of soil run off by surrounding pond bunds.

pH

The pH is an important factor for the growth of aquatic vegetation because it affects the metabolism and other physiological processes of culture organisms. In the present investigation, it was noted that fish pond water was found to be slightly high in pH values during summer season, where as in winter season pH values were found to be low. This may be due to increase in photosynthetic activity of submerged algae population in pond water, while in winter decrease in photosynthesis, and then monsoon it may be due to greater inflow of water.

Temperature

Temperature is probably the most important physical variable on aquatic ecology. As fish is a cold-blooded animal, its body temperature changes according to that of environment affecting its metabolism and physiology, and ultimately affecting the yield of the fish production. The highest temperature was recorded in summer (54^0 C), where as the minimum in winter season (21^0 C) during the study period.

Turbidity

The turbidity is striking character to know the physical status of the water sources. The increase in turbidity during the rainy season was attributed to decomposed organic matter, algae growth and heavy soil erosion in the nearby pond tank bunds.

Dissolved Oxygen (DO)

Dissolved oxygen (DO) indicates physico-chemical and biological activities in a water body. It is an important indicator of water quality. A higher content of dissolved oxygen in monsoon season probably due to the conditions during these periods is more favorable for high rate of photosynthesis.

Biochemical Oxygen Demand (BOD)

BOD is the measurement of total dissolved oxygen consumed by microorganisms for biodegradation of organic matter such as food particles or sewage etc. The results revealed that the higher values of BOD parameters were observed especially during summer season, where as lower values in winter season. This may be attributed to high organic load in these ponds thus causing higher level of BOD.

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 CO_2 is dissolved in water it forms carbonic acid which decreases the pH of any system. The results reveals that the lowest amount of free carbon-dioxide is recorded in winter and highest during the summer. This may be due to carbonates are accumulated in large quantities during the summer months because of free CO_2 produced in the process of decomposition of deepest deposits, resulting in conversion of insoluble carbonate into soluble bicarbonates.

Alkalinity

Alkalinity in water is due to the presence of the carbonates, bicarbonates and hydroxides. The pond water exhibits an increased alkalinity which could be due to the mixing of toxic substances, high evaporation rate and change in alkalinity with increased decomposition. 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)

Water hardness is important to fish culture and is a commonly reported aspect of water quality. The higher values of hardness recorded during monsoon season and lower values in winter season recorded.

Calcium

Calcium is an essential element for fish, and moderate calcium levels in aquaculture water aid in fish osmoregulation during stressful periods. As noted above, calcium is important for egg and larvae development. Calcium has an important role in the biological processes of fish. It is necessary for bone formation, blood clotting and other

metabolic reactions. The results revealed that the highest calcium values during winter while, lower value during monsoon season.

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. During the study period, the highest values were recorded during monsoon and the lowest values were found during the summer in the study period.

Salinity

Salinity is defined as the total concentration of electrically charged ions. Maximum values of Salinity were observed in the summer season compared to other seasons, while lower value during monsoon season.

Chloride

Chlorine is a highly reactive compound and is used as a disinfectant. Chloride is the same element in the form of a salt. While chlorine is very lethal to fish, chloride is a component of most waters and is essential in helping fish maintain their osmotic balance. 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 summer, the increased levels of ammonia were due to precipitation which eroded the land containing fertilizer, the regeneration and release of total phosphorus from the bottom mud in the water column by turbulence, and also aqua cultural backwaters which have come into the canal and mixture of soluble alkali metal phosphates in the upstream carried into the estuaries.

Nitrate

Nitrate is relatively non-toxic to fish and is not a health hazard except at exceedingly high levels. In the present investigation Nitrate values were found higher in the monsoon than compared to other seasons, none of the sampling sources crossed the maximum permissible limit.

Phosphates

The element phosphorous is necessary for plant and animals' growth. The phosphates were minimum levels in winter season and the maximum in monsoon season during the study period.

Magnesium

Magnesium is essential for fish growth. Magnesium levels were recorded the highest in summer; while it was observed the lowest during monsoon season during the investigation period at all the sites. Higher values in summer might be due to higher decomposition rate of organic matter, higher evaporation rate and other anthropogenic activities.

Total Dissolved Solids (TDS)

The values of the Total Dissolved Solids indicate the general nature of the water quality. The maximum amount of total dissolved solids was recorded during monsoon and minimum amount during winter season during the study period. The observed variation may be due to dilution effect associated with rainy season while to high rate of evaporation of water during summer season.

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; none of the

sampling sources crossed the maximum permissible limit.

Sulphate

Sulphates are usually occurring in natural water samples. Maximum values of sulphates were observed in the summer compared to other seasons due to low water level during summer and the production of hydrogen sulphate by anaerobiosis.

Bicarbonate

The concentrations of Bicarbonate content of the pond waters were highest during summer season but exhibited a lowest trend in winter season. This might be due to evaporation of water as well as increase in level of pH of water in summer season. Thus, there are no specific bicarbonate recommendations in fish culture water.

Remarks

Out of 20 parameters studied 12 exceeded the permissible limits of different standards compared and 1 parameter (Temperature in winter) is 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 and Conclusions

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

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