SOME STUDIES OF PHYSICO CHEMICAL PARAMETERS IN AQUA POND WATERS AT VEMPA, BHIMAVARAM, AP, INDIA.

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Abstract:The present study about physico-chemical parameters of aqua pond waters at VempaVilage, Bhimavaram Mandal, West Godavari District, State of Andhra Pradesh, India. The total 20 physico chemical parameters in 6 sampling locations at three various seasons 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, Flouride and Chloride. We adopted different types of analytical methods for analysis of the 20 parameters.

IndexTerms- Vempa, magnesium, bicarbonate, phosphate, nitrate, sulphate, calcium and chloride.

I. INTRODUCTION

The knowledge of physico–chemical characteristics of pond water is essential for proper exploitation of aquatic environment. Hence, the current study was taken up for the study of fish pond water quality in Vempa Village, Bhimavaram Mandal, West Godavari District, Andhra Pradesh, India.

The objectives of this study are as follows:

i) To study the status of fish pond water quality 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.

II. REVIEW OF LITERATURE

The literature survey reveals that no fish pond water quality management studies are made in this Bhimavaram region so far. Hence the present study was planned and undertaken 6 fish pond water samples; located in Bhimavaram Mandal.

III. STUDY AREA

The study area of Vempa Village, Bhimavaram Mandal from West Godavari district is shown in Fig. 1. The total study area, satellite pictures, cultivating species, bounded latitude and longitude and the values are compared with BIS, WHO, EU, USEPA, Boyd (1998) and are given in tables 1-6.

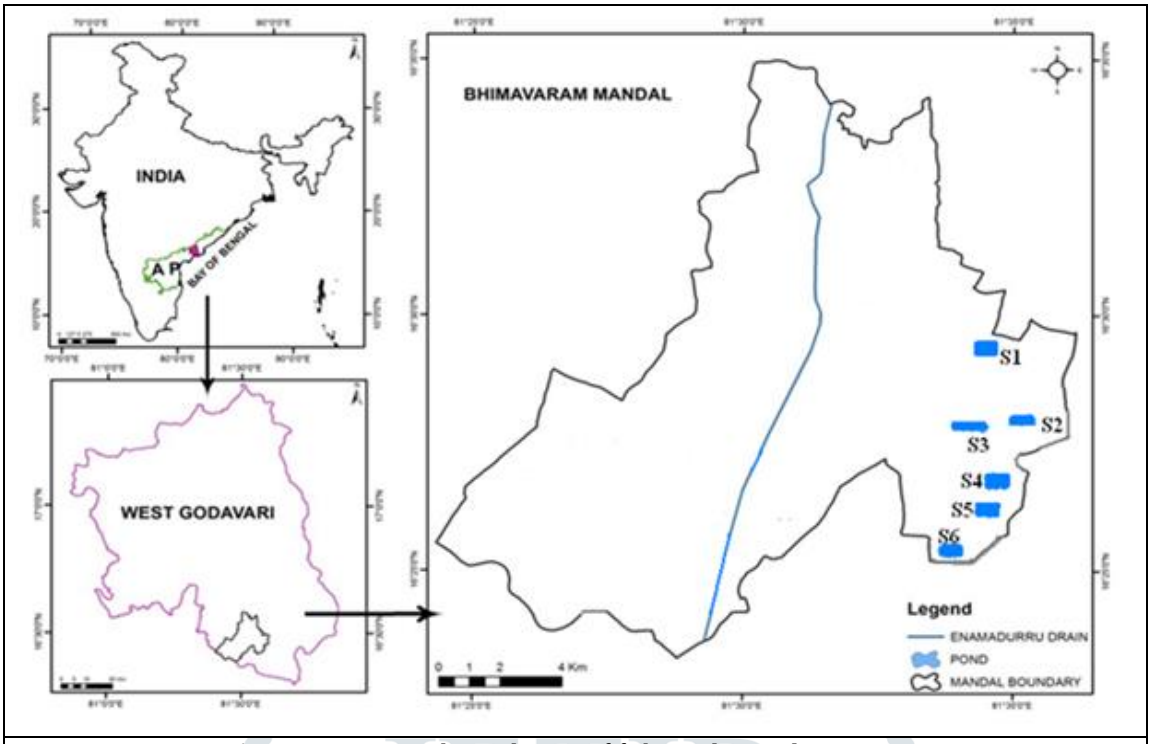

Fig. 1: Locations at the study area of fish ponds sampling stations.

IV. SAMPLE COLLECTITON

Fish pond water samples were collected from 6 ponds located in Vempa village in the morning hours between 7 am and 9 am twice a month during July 2017 to June 2018. The samples of water were collected in a glass bottles. Initially the bottles were rinsed with the sample water. Water was collected labelled with sample code and transported to the laboratory in an ice box. 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 on site, while the remaining parameters were analyzed in Environmental Laboratory, Andhra University Visakhapatnam. The samples were processed and analyzed consciously following the appropriate methods.

V. ANALYTICAL METHODES

Sl. No.	Physico-chemical Parameters	Method
1.	Temperature	Measured with calibrated thermometer
2.	Salinity	Gravimetric method
3.	Turbidity	Turbidometric 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	Wrinkler's 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	Turbidometric 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

Sampling location: S1 Nadipalle

Latitude: 16° 29' 18.792" N
Longitude: 81° 34' 32.130" E

Located beside Muttumkodu branch channel

Area (Hectare): 2.87

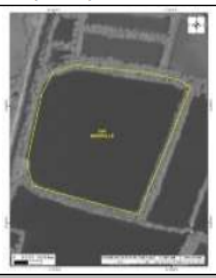

Table: 1 Results of water quality parameters tested in 3 different seasons

Physico-chemical parameters		Summer	Rainy	Winter	Water quality Standards: BIS 10500 : 2012 Acceptable limit	BIS 10500 : 2012 Permissible limit	WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
Temperature	°C	45.6	25.7	19.2	-	-	-	24-32	-	25-30
Salinity	mg/L	3.4	1	1	-	-	-	-	-	1-250
Turbidity	NTU	7.3	8	7.9	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	245.7	409.95	245.7	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	447	759	372	500	2000	2500	-	2500	-
pH	0 -14	8.5	8.4	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	158	125	134	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	6.01	6.2	4.7	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	1.2	0.4	1.1	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	1.4	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	5.12	5.16	2.3	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	19.8	18.92	17.2	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	51	48	62	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	98	63	63	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	0	0	0	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	167	158	143	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	312	380	254	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.92	0.67	0.86	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	133	116	122	250	1000	250	250	250	1-100

Remarks

- Out of 20 parameters studied 4 exceeded the permissible limits of different standards compared and 3 parameters (Temperature in winter, DO in winter and Turbidity) are below the optimum range of Boyd (1998) water quality standards for pond aquaculture.

Species cultured: *Labeo rohita*

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).

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

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.

Sampling location: S2 Tundurru

Latitude: 16° 27' 41.686" N
Longitude: 81° 35' 32.351" E

Located nearby aquaculture ponds

Area (Hectare): 0.82

Table: 2 Results of water quality parameters tested in 3 different seasons

Physico-chemical parameters		Summer	Rainy	Winter	Water quality Standards: BIS 10500 : 2012 Acceptable limit	BIS 10500 : 2012 Permissible limit	WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
Temperature	°C	48.6	28.1	19.4	-	-	-	24-32	-	25-30
Salinity	mg/L	12.1	9	9.7	-	-	-	-	-	1-250
Turbidity	NTU	6.5	7	6.6	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	633.3	879.55	687.9	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	1038	1353	1042	500	2000	2500	-	2500	-
pH	0 -14	8.8	8.1	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	152	145	132	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	3.2	4.3	0.3	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	2.3	1.2	1.2	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	1.2	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	1.2	1.64	1.2	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	78	78	44	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	77	34	89	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	276	216	154	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	78	62	31	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	98	88	65	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	2234	2530	1843	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.89	0.71	0.71	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	467	399	423	250	1000	250	250	250	1-100

Remarks

- Out of 20 parameters studied 8 exceeded the permissible limits of different standards compared and 3 parameters (Temperature in winter, DO and Turbidity) in 3 seasons are below the optimum range of Boyd (1998) water quality standards for pond aquaculture.

Species cultured: *Labeo rohita*

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).

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

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.

Sampling location: S3 Vempa

Latitude: 16° 27' 52.756" N
Longitude: 81° 34' 19.364" E

Located nearby aquaculture ponds

Area (Hectare): 1.72

Table: 3 Results of water quality parameters tested in 3 different seasons

Physico-chemical parameters		Summer	Rainy	Winter	BIS 10500 : 2012 Acceptable limit	BIS 10500 : 2012 Permissible limit	WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
Temperature	°C	45	26.2	19.3	-	-	-	24-32	-	25-30
Salinity	mg/L	5.3	3	3	-	-	-	-	-	1-250
Turbidity	NTU	8.6	14.2	12.7	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	299.3	462.5	412.3	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	460	712	676	500	2000	2500	-	2500	-
pH	0 -14	9	8.4	8.2	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	96	66	66	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	4.6	4.8	4.6	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	1.2	0.8	0.2	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	0.6	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	4.23	4.7	3.2	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	24.6	22.89	11.2	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	66	58	82	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	114	82	94	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	28	20	16	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	89	76	47	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	988	1030	897	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.56	0.26	0.34	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	277	198	213	250	1000	250	250	250	1-100

Water quality Standards

Remarks

- Out of 20 parameters studied 8 exceeded the permissible limits of different standards compared and 3 parameters (Temperature in winter, DO and Turbidity) in 3 seasons are below the optimum range of Boyd (1998) water quality standards for pond aquaculture.

Species cultured: *Labeo rohita*

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).

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

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.

Sampling location: S4 Vempa

Latitude: 16° 27' 7.656" N
Longitude: 81° 34' 42.416" E

Located nearby aquaculture ponds

Area (Hectare): 4.83

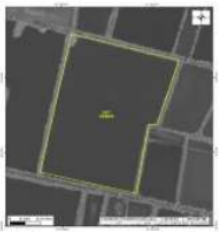

Table: 4 Results of water quality parameters tested in 3 different seasons

Physico-chemical parameters		Summer	Rainy	Winter	BIS 10500 : 2012 Acceptable limit	BIS 10500 : 2012 Permissible limit	WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
Temperature	°C	54	22.3	19.7	-	-	-	24-32	-	25-30
Salinity	mg/L	5.6	3.5	3.5	-	-	-	-	-	1-250
Turbidity	NTU	5.8	7	6.6	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	467.8	597.96	534.4	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	688	892	891	500	2000	2500	-	2500	-
pH	0 -14	7.9	7.4	7.4	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	90	76	87	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	5.5	6.2	4.9	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	5.1	4.2	4.3	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	0.3	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	1.01	1.21	0.92	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	56	56	34	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	156	143	188	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	67	58	58	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	0	0	0	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	102	90	44	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	866	1020	734	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.67	0.55	0.67	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	287	249	266	250	1000	250	250	250	1-100

Water quality standards

Remarks

- Out of 20 parameters studied 6 exceeded the permissible limits of different standards compared and 3 parameters (Temperature in Rainy, winter, DO in winter and Turbidity) are below the optimum range of Boyd (1998) water quality standards for pond aquaculture.

Species cultured: *Labeo rohita*

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).

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

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.

Sampling location: S5 Vempa

Latitude: 16° 25' 41.710" N
Longitude: 81° 34' 16.262" E

Located nearby aquaculture ponds

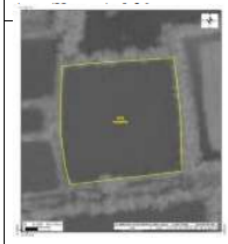

Table: 5 Results of water quality parameters tested in 3 different seasons

Physico-chemical parameters		Summer	Rainy	Winter	Water quality standards: BIS 10500 : 2012 Acceptable limit	BIS 10500 : 2012 Permissible limit	WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
Temperature	°C	39.5	25.7	20.2	-	-	-	24-32	-	25-30
Salinity	mg/L	6.8	5	5.8	-	-	-	-	-	1-250
Turbidity	NTU	6.5	9	8.4	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	869.2	1139.7	1023.3	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	1358	1727	1895	500	2000	2500	-	2500	-
pH	0 -14	8.9	8.4	8.2	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	184	144	165	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	6.3	6.7	4.9	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	4.99	3.4	3.4	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	0.8	0.3	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	3.21	3.27	2.76	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	26.8	24.03	20.6	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	133	120	166	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	245	206	232	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	26	20	15	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	178	164	125	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	1084	1150	1032	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	1.3	1.1	1.1	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	633	569	589	250	1000	250	250	250	1-100

Remarks

- Out of 20 parameters studied 8 exceeded the permissible limits of different standards compared and 3 parameters (Temperature in winter, DO in winter and Turbidity) are below the optimum range of Boyd (1998) water quality standards for pond aquaculture.

Species cultured: *Labeo rohita*

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).

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

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.

Sampling location: S6 Vempa

Latitude: 16° 25' 29.301" N
Longitude: 81° 33' 31.403" E

Located nearby aquaculture ponds

Table: 6 Results of water quality parameters tested in 3 different seasons

Physico-chemical parameters		Summer	Rainy	Winter	Water quality standards: BIS 10500 : 2012 Acceptable limit	BIS 10500 : 2012 Permissible limit	WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
Temperature	°C	37.9	24.7	20.2	-	-	-	24-32	-	25-30
Salinity	mg/L	7.1	5	6.1	-	-	-	-	-	1-250
Turbidity	NTU	6.4	7	7	1	5	< 5	-	< 4	20-35
Total Dissolved Solids (TDS)	mg/L	665.4	824.63	555.4	500	2000	500	1000	-	500-1200
Electrical Conductivity (EC) at 20°C	(µS/cm)	1167	1213	782	500	2000	2500	-	2500	-
pH	0 -14	8.6	8.2	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	164	156	160	200	600	50-200	-	20-200	50-300
Dissolved Oxygen (DO)	mg/L	5.2	5.9	4.9	> 5	-	> 5	> 5	> 5	> 5
Biochemical Oxygen Demand (BOD)	mg/L	3.4	2.1	2.1	-	-	-	-	-	< 10
Ammonia (as total NH_3-N)	mg/L	1.4	0.3	0.1	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	2.43	3.11	1.34	-	-	0.1	-	-	0.005-0.2
Sulphate (as SO_4)	mg/L	78	67	56	200	400	250	250	250	5-100
Calcium (as Ca)	mg/L	113	90	144	75	200	200	-	-	75-150
Magnesium (as Mg)	mg/L	176	152	166	30	100	150	-	-	5-100
Carbon Dioxide (CO_2)	mg/L	26	20	12	-	-	-	-	-	<10
Bicarbonate (HCO_3)	mg/L	165	144	120	-	-	-	-	-	50-300
Total Hardness (as $CaCO_3$)	mg/L	784	900	645	200	600	500	-	100-500	5-200
Fluoride (as F)	mg/L	0.65	0.32	0.65	1.0	1.5	1.5	4	1.5	-
Chloride (as Cl)	mg/L	423	348	365	250	1000	250	250	250	1-100

Remarks

- Out of 20 parameters studied 7 exceeded the permissible limits of different standards compared and 3 parameters (Temperature in rainy, winter, DO in winter and Turbidity) are below the optimum range of Boyd (1998) water quality standards for pond aquaculture.

Species cultured: *Labeo rohita*

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).

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

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.

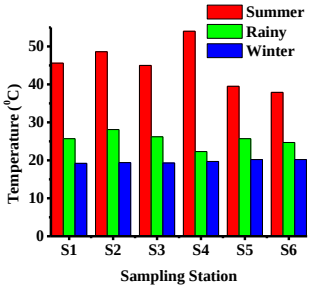

Fig. 2: Temperature

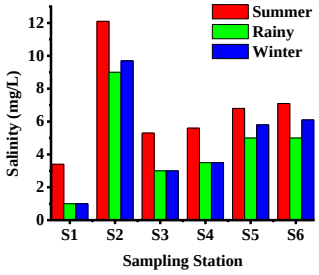

Fig. 3: Salinity

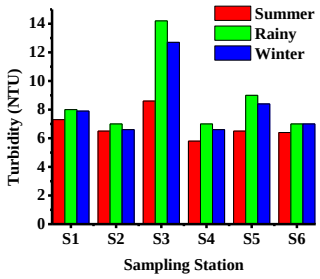

Fig. 4: Turbidity

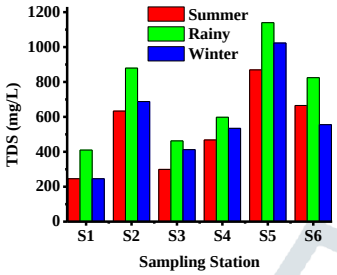

Fig. 5: Total Dissolved Solids

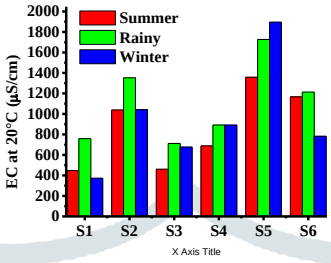

Fig. 6: Electrical Conductivity

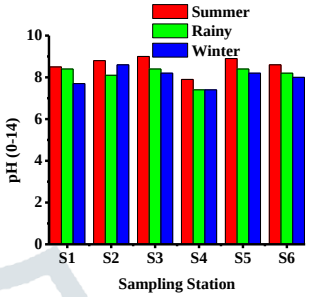

Fig. 7: pH

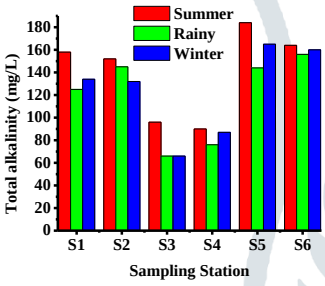

Fig. 8: Total alkalinity

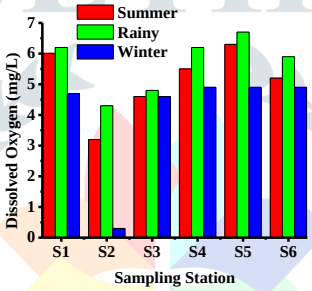

Fig. 9: Dissolved Oxygen

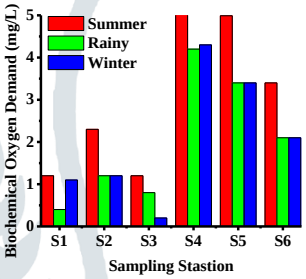

Fig. 10: Biochemical Oxygen Demand

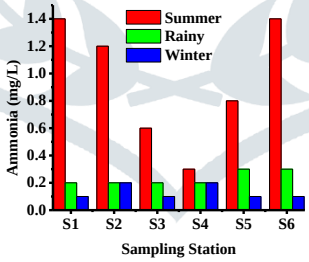

Fig. 11: Ammonia

VI. DISCUSSION ON EACH PHYSICO-CHEMICAL PARAMETERS

TEMPERATURE

The highest temperature was recorded in S4 in summer during (54^0 C), where as the minimum in S1 in winter season (19.2^0 C) during the study period (Fig. 2). Higher temperature increases the rate of bio-chemical activity of the micro biota, plant respiratory rate, enhances the protein breakdown and so increase in oxygen demand. It further causes decreased solubility of oxygen and also increased level of ammonia in water causing fish death.

SALINITY

Salinity is defined as the total concentration of electrically charged ions. Salinity plays an important role in the growth of culture organisms through osmoregulations of body minerals from that of the surrounding water. Maximum values of Salinity were observed in the summer season of sample points S2 (12.1 mg/L), while lower value 1.0 mg/L of salinity were found at sample location S1 (Fig. 3) during rainy and winter seasons.

TURBIDITY

Among the 6 different locations on the fish ponds, as per the tables 1-6, the sampling location of S3 showed higher value (14.2 NTU) of turbidity during rainy season, where as the sampling location of S6 showed lowest value (6.4 NTU) during summer season (Fig. 4) throughout the study period. The increase turbidity during the rainy season was attributed because of decomposed organic matter, algal growth and heavy soil erosion in the nearby pond tanks. Higher turbidity of pond water can cause clogging of gills or direct injury to the tissues of fish.

TOTAL DISSOLVED SOLIDS (TDS)

The maximum amount of total dissolved solids was recorded at sample location S5 (1139.7 mg/L) during rainy and minimum amount S1 (245.7 mg/L) during summer season (Fig. 5) during the study period. The observed variation may be due to dilution effect associated with rainy season while high rate of evaporation of water during summer season. The higher values of total dissolved solids are associated with increased turbidity due to silt and organic matter, the dissolved solids reduces the water clarity decreases photosynthesis and increases water temperature.

ELECTRICAL CONDUCTIVITY (EC)

Electrical conductivity (EC) is the capacity of a solution to conduct the electric current and is correlated with salt content. Minimum salt content is desirable for some fish to maintain their osmotic balance. During the study period, the highest value 1895 µS/cm recorded at station S5 during winter and the lowest value 372 µS/cm location S1(Fig. 6) during same season. During the annual season cycle EC showed significant changes. The increased electrical conductivity of the pond water may be due to the enhanced amount of dissolved solids.

pH

The pH is an important factor, between 0-14 for the growth of aquatic vegetation because it affects the metabolism and other physiological processes of cultured organisms. In the study period the pH is high (9.0) in S3 in summer and low (7.4) in S4 in rainy and winter seasons (Fig. 7). pH also determines the water quality, if it deteriorates or sick or dead fish are found, dò not pump water from that pond.

ALKALINITY

Alkalinity in water is due to the presence of the carbonates, bicarbonates and hydroxides. Alkalinity was found high in S5 (184 mg/L) in the summer season, where as lower values were found at location S3 (66 mg/L) in rainy and winter seasons (Fig. 8). 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 pond water.

DISSOLVED OXYGEN (DO)

Dissolved oxygen (DO) indicates physico-chemical and biological activities in a water body. A higher content of dissolved oxygen in rainy season at sampling location S5 (6.7 mg/L) was probably due to the conditions during those periods which are more favourable for high rate of photosynthesis (Fig. 9) in winter season, a critically low dissolved oxygen levels are recorded at sampling pond S2 (0.3 mg/L). Chronically low dissolved oxygen levels can reduce growth, feeding and moulting frequency particularly when algal blooms die-off and subsequent decomposition of algal blooms can cause stress or mortality of fish in ponds.

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. Higher values of BOD was observed (Fig. 10) at sample point S4 (5.1 mg/L) during the summer season, where as the lower value at sample station S3 (0.2 mg/L) wase recorded in winter season. This may be attributed due to high organic load in these ponds thus causing higher level of BOD.

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. Results revealed that ammonia values were very low (0.1 mg/L) at the beginning of the winter season in S1, S3, S5 and S6 but whereas in summer showed a maximum value of 1.4 mg/L at locations (Fig. 11) S1 and S6. During 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.

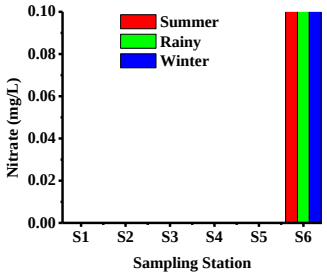

Fig. 12: Nitrate

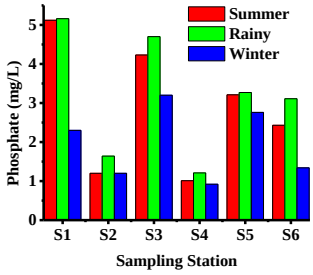

Fig. 13: Phosphate

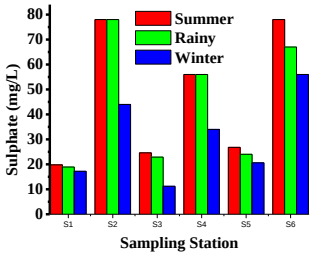

Fig. 14: Sulphate

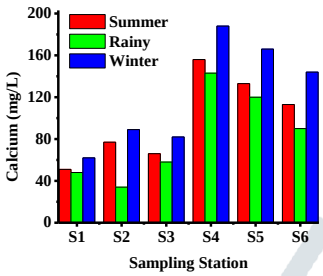

Fig. 15: Calcium

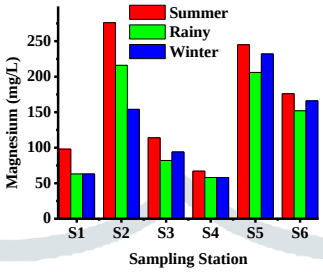

Fig. 16: Magnesium

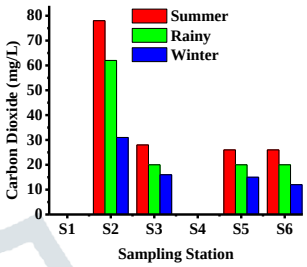

Fig. 17: Carbon Dioxide

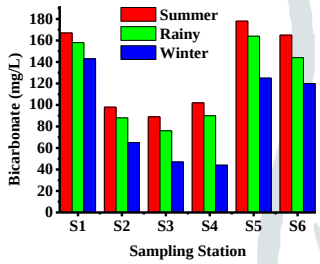

Fig. 18: Bicarbonate

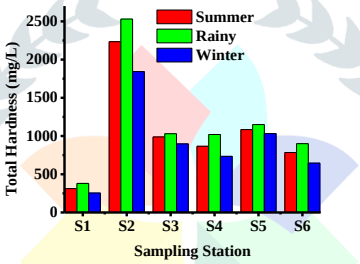

Fig. 19: Total Hardness

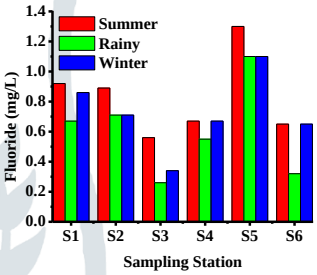

Fig. 20: Fluoride

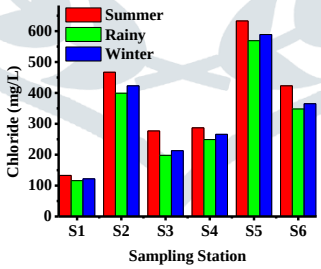

Fig. 21: Chloride

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 (Fig. 12) were found in location S6 (0.1 mg/L), where as in S1 to S5 locations, nil Nitrogen was observed in all the three seasons. Nitrate is mostly accumulated as a result of biological nitrogen fixation from atmosphere to the soil by the process of denitrification and occurs in high concentrations. Low nitrate levels while the contrary results of high nitrate values were due to agriculture run-off.

PHOSPHATES

The phosphates was at minimum levels of 0.92 mg/L at station S4 in winter season and the maximum phosphate levels was 5.16 mg/L at stations S1 (Fig. 13) in monsoon season during the study period. This may be due to the monsoon, the increased

level of phosphate was due to precipitation eroding the land containing fertilizer, the regeneration and release of total phosphorus from bottom mud in the water column by turbulence, and mixing of soluble alkali metal phosphates in the upstream carried into the estuaries.

SULPHATE

Sulphates are usually occurring in natural water samples. The highest sulphate content was found (Fig. 14) in S2 and S6 during summer and S2 during rainy seasons (78 mg/L) whereas, the lowest content was found at sample location S3 (11.2 mg/L) in winter season. The highest value of sulphate may be due to low water level during summer season and the production of hydrogen sulphide by anaerobiosis.

CALCIUM

Calcium is an essential element for fish, and moderate calcium levels in aquaculture water aid in fish osmoregulation during stressful periods. The results (Fig. 15) revealed that the fish pond water contain the highest calcium values at sampling point S4 (188 mg/L) during winter while, lower value of calcium 34 mg/L was found in S2 during rainy season.

MAGNESIUM

Magnesium is essential for fish growth, but the specific recommended concentration is not available. Magnesium levels were recorded highest in summer at sample location S2 (276 mg/L) and the lowest in sample location S4 (58 mg/L) during rainy and winter seasons during the investigation period (Fig. 16). Higher value in summer is due to higher decomposition rate of organic matter, higher evaporation rate and other anthropogenic activities.

CARBONDIOXIDE

The results reveal that the zero amount of free carbon-dioxide is recorded in all the three seasons at S1 and S4 and highest at location S2 (78 mg/L) during summer (Fig. 17). This may be due to the accumulation of carbonates in large quantities during summer because of free CO_2 production by the process of decomposition of deepest deposits, resulting in conversion of insoluble carbonate to soluble bicarbonates. During winter, due to slow decomposition rate of organic matter, the CO_2 production is less. These factors deplete CO_2 content in water and also the decomposition of organic matter is fast during summer season, whereas low in winter.

BICARBONATE

The concentrations of Bicarbonate content of the pond waters were highest at sample site S5 (178 mg/L) during summer season but exhibited a lowest trend S4 in (44 mg/L) winter season (Fig. 18). 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 for fish cultured water.

TOTAL HARDNESS (TH)

Total hardness is the parameter of water quality used to describe the effect of dissolved minerals (mostly calcium and magnesium) determining suitability of water for aquaculture practices Hardness indicates water quality mainly in terms of Ca^{2+} and Mg^{2+}. The highest value of hardness was recorded (Fig. 19) during the rainy season at location S2 (2530 mg/L) lowest value of hardness was recorded at location S1 (312 mg/L) in summer season.

FLOURIDE

Flouride is a trace element, the level at or above 3 mg/L is reported to cause loss of some fish species, depending upon complex water conditions. In the present investigation (Fig. 20), it was noted that the flouride value was maximum (1.3 mg/L) in summer at S5 than other seasons and low (0.32 mg/L) at S6 in the rainy and none of the sampling sources crossed the maximum permissible limit of 0.1-1.5 mg/L.

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 to fish in maintaining their osmotic balance. Seasonal data showed that during the study period the chloride content was found to be high during summer season in S5 (633 mg/L) while, lowest content of chloride was found in S1 (116 mg/L) during rainy season (Fig. 21). This might be due to decrease in amount of water and also high temperature which increase the decaying process.

VII. CONCLUSION AND SUGGESTIONS

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 aquaculture.

- Regularly physico-chemical tests should be carried out to protect the fishes from the waterborne diseases.
- Rectangular ponds are recommended to adjust length/width ratios to increase bottom velocities and reduce bio-solid accumulation.

- Adopt eco-friendly technologies in fish culture ponds (upon use of harmful feed, probiotics/antibiotics, effluent treatment facility etc.).
- Provide separate drainages for the aqua farms which must be constructed far away from agricultural fields.
- To allow aquaculture effluent discharges after proper treatment (ETP) only.

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