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(53)

Analysis of Heavy Metal Concentrations in Aqua Pond Waters at Dongapindi, Bhimavaram, AP, India.

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Abstract - The present study about Heavy Metal Concentrations in aqua pond waters at Dongapindi Village, BhimavaramMandal, West Godavari District, State of Andhra Pradesh, India. The total 10 Heavy Metals in 5 sampling locations at 3 various seasons are taken for analysis. They are Cadmium (Cd), Mercury (Hg), Lead (Pb), Arsenic (As), Manganese (Mn), Chromium (Cr), Nickel (Ni), Copper (Cu), Zinc (Zn) and Iron (Fe). Atomic absorption spectrometric, Colorimetric, Cold vapour flame less atomic absorption and Colorometric - Phenanthroline methods are adopted for analysis of the heavy metals. The objective of this study is to test whether in Dongpindiand around Bhimavaram Aqua farmers have access to truly increase fish yield and to identify the causes of fish pond water pollution and to recommend suitable remedies.

Key Words - Dongapindi, Cadmium, Mercury, Lead, Arsenic, and Colorimetric Method.

I. INTRODUCION

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 Dongapindi, 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 a 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. Nowadays, standards of hygiene are strictly enforced while exporting. Hence, cleanliness and quality are also need of the hour. In this respect a regular monitoring of water quality is essential to determine the status of water bodies with reference to fish culture. Therefore, the knowledge of the concentrations of heavy metals is essential for proper exploitation of aquatic environment. Hence, the current study was taken up for the study of Aquaculture water quality in and around of Bhimavaram Town.

The objectives of this study are as follows:

1. To study the concentrations of heavy metals in Aqua culture pond water.
2. To test whether in and around Bhimavaram Aqua farmers have access to truly increase the fish yield, by calculating correlation coefficients.
3. To identify the causes of fish pond water pollution and to recommend suitable remedies.

Review of literature in heavy metals studies

Some are reported that the lake water pollution with heavy metals in Nagpur City, Maharashtra, India. The levels of the occurrence of heavy metals like cadmium (Cd), iron (Fe), zinc (Zn), arsenic (As), mercury (Hg), lead (Pb) and chromium (Cr) were estimated in Futala, Ambazari, Gandhisagar and Gorewada lake, within Nagpur city, for the session January to December 2008. Sampling points were selected on the basis of their importance. The average levels of metals in studied lakes followed the order Zn > Cr > Fe > Cd >Pb> Hg > As.

Analysis of water, plankton, fish and sediment reveals that the Cauvery River water in the downstream is contaminated by certain heavy metals. Water samples have high carbonate hardness. Concentrations of all elements andions increase in the downstream. Main ions are in the following order: Na >HCO3 >Mg > K >Ca>Cl> SO4. Heavy metal

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concentration in water was Cr>Cu _ Mn> Co > Ni >Pb> Zn, in fish muscles Cr >Mn> Cu > Ni > Co >Pb _Zn, in phytoplanktens Co > Zn >Pb>Mn> Cr and in the sediments the heavymetal concentration was Co > Cr > Ni _ Cu >Mn> Zn >Pb. Cauvery River may be classified as very good based on the salt andsodium for irrigation, Zn, Pb and Cr concentration exceeded the upper limit of standards. Metal concentrations in the downstream indicate an increase in thepollution load due to movement of fertilizers, agricultural ashes, industrial effluents and anthropogenic wastes.

The distribution of heavy metal concentrations in surface waters from Ennore Estuary, Tamil Nadu, India. Stated that the Nile River and its waterways against pollution must be enforced to prevent the obvious deterioration of the canal water and to improve its quality; and Cd, Cr, Cu, Ni, Pb and Zn in the surface sediments all had anthropogenic origins of Limnetic Ecosystems in Eastern China.

Some are assessed surface water quality and contaminations of heavy metal (Al^{3+}, Cd^{2+}. Cu^{2+}, Fe^{2+}, Mn^{2+}, Ni^{2+}, Pb^{2+} and Zn^{2+}) indices of Ismailia canal, Nile River, Egypt whereas studied surface water contamination by heavy metals from Enyigba Pb-Zn Mine District, Southeastern Nigeria using metal enrichment and pollution indices. Revealed that the higher levels of Cr, Cd, Zn and Pb indicating the anthropogenic sources (i.e. fishing activities).

II. MATERIALS AND METHODS

Study area

Dongapindi Village, BhimavaramMandal, Andhra Pradesh in India is shown in Figure 1.

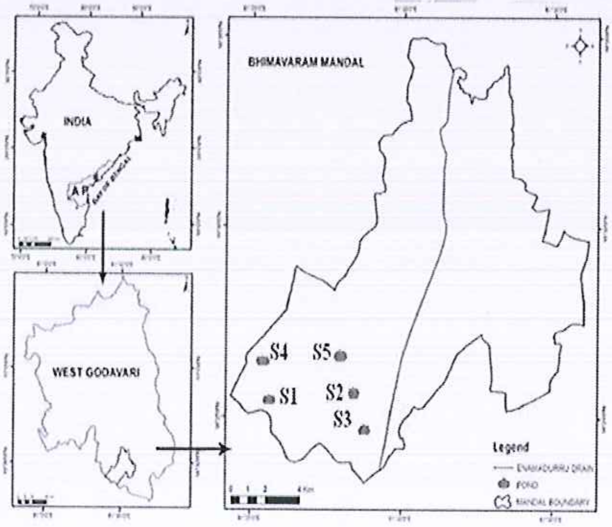

Figure 1 Study area

Samples collection

The determination of trace metals in the samples was carried out by using ICP- MS (plate-15). The determination of the metals consists of four parts.

a) Complexation of metals with APDC and extraction with MIBK
b) Back extraction of the metals with 4N HNO_3
c) Removal of MIBK by evaporation and the metals were redissolved in 2% HNO_3 solution and made up to 25mL.
d) Determination of trace metals in HNO_3 using ICP-MS

500mL of the sample was taken and pH was adjusted to 2 using either dilute supra pure dilute nitric acid or dilute sodium hydroxide solution. The sample was then transferred to one liter separating funnel, to which 2mL 4% APDC solution and 15mL MIBK were added. The contents were shaken vigorously for sufficient time. After visualizing the separated aqueous and organic layers clearly, the organic layer (MIBK) was collected in another separating funnel. To ensure complete extraction of the metals from the samples, the extraction was repeated 3 times by adding similar fractions of APDC and MIBK. All the MIBK fractions were in another separating funnel. The metals were back extracted into 4M HNO_3 by extracting with small portions of 4mL acid for 3 times. All the acid fractions were added together and the solution was made up to 25mL. A similar procedure was adopted for the standards and the reagent blank. The HNO_3 solution containing trace metals was evaporated to almost dryness so that the MIBK was completely removed. Then 20mL of 2% HNO_3 was added to the beaker and gently heated and then the contents were carefully transferred to a 25mL volumetric flask and makeup to the mark using 2 % HNO_3 solution.

Aquaculture water samples were collected from 5 ponds located in the village Dongapindi in the morning hours between 7 am and 9 am twice a month during July 2018 to May 2019. 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 heavy metal concentrations are studied in Environmental Laboratory, Andhra University, Visakhapatnam. The samples were processed and studied following the appropriate methods shown in Table 1.

Table 1 Analytical Methods

S.No	Heavy Metals	Method
1	Cadmium	Atomic absorption spectrometer method
2	Mercury	Cold vapour flame less atomic absorption
3	Lead	Atomic absorption spectrometer method
4	Arsenic	Atomic absorption spectrometer method
5	Manganese	Atomic absorption spectrometer method
6	Chromium	Colorimetric method
7	Nickel	Atomic absorption spectrometer method
8	Copper	Atomic absorption spectrometer method
9	Zinc	Atomic absorption spectrometer method
10	Iron	Colorometric – Phenanthroline method

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III. RESULTS AND DISCUSSION

Heavy metal concentration of Aquaculture waters

All the 5 samples were labelled properly and analyzed for the heavy metal (Cd, Hg, Pb, As, Mn, Cr, Ni, Cu, Zn and Fe) concentrations. The minimum and maximum heavy metal concentration, sampling location maps, comparision with different standard references, source of contamination, recomendations and photos of cultivating species of fishes in different parts of the Dongapindi Village, Bhimavaram region has been presented in Tables 2-6.

DISCUSSION ON EACH METAL

Cadmium (Cd):

For Cadmium (Cd) metal the minimum and maximum concentration is between 0.001 to 0.009 mg/L (Graph 1). High in summer and low in winter, well below are the standards given for drinking (BIS, WHO, EU, USEPA) and pond aquaculture purposes (Boyd, 1998) relevant maximum contaminant limits prescribed for Cd.

Mercury (Hg):

Mercury (Hg) the minimum and maximum concentrations vary between 0.0001 to 0.0004 mg/L (Graph 2). High in summer and low in winter, the most common sources are caustic soda, fossil fuel combustion, paint, pulp and paper, batteries, dental amalgam and bactericides.

Lead (Pb):

The minimum and maximum lead concentrations vary between 0.001 to 0.005 mg/L. All the samples exceeded the relevant prescribed limits for drinking water for that element (Graph 3). High in winter and low in rainy, the major sources of lead in drinking water are due to corrosion of household plumbing systems; and erosion of natural deposits.

Arsenic (As):

During the study period 2014-15 the Arsenic concentration levels in aquaculture water locations of study area vary from 0.001 to 0.004 mg/L (Graph 4). Very high and low in rainy season, as it enters aquaculture pond water sources by dissolution from rocks and soils, from biological recycling, from atmospheric fallout and especially from industrial wastes.

Manganese (Mn):

The minimum and maximum manganese concentrations vary between 0.05 to 0.06 mg/L (Graph 5) high in rainy and winter, and low in summer season. However, measurable concentrations of the manganese metal were found in all samples. In, ground waters subject to reducing conditions in which Mn can be leached from the soil and occur in high concentrations.

Chromium (Cr):

The minimum and maximum Cr concentrations were found to be 0.001 to 0.04 mg/L respectively (Graph 6). In the study period very high in summer, very low in rainy and winter seasons. However, the entire sample exceeded the Cr maximum contaminant limits stipulated for drinking water.

Nickel (Ni):

Five water samples had measurable concentrations of Ni between 0.0001 to 0.005 mg/L (Graph 7). In S3 very high in summer, very low in rainy and winter. Ni enters groundwater and surface water sources by dissolution from rocks and soils, from biological recycling, from atmospheric fallout and especially from industrial wastes.

Copper (Cu):

The minimum and maximum copper concentrations were found to be 0.001 mg/L and 0.005 mg/L respectively (Graph 89). In S5 very high in summer, very low in rainy and winter seasons. Cu salts are sometimes purposely added in small amounts to water supply reservoirs to suppress the growth of algae.

Zinc (Zn)

The maximum and minimum concentration of zinc metal varied between the 0.001 to 0.009 mg/L (Graph 9). In the study period in S2 and S5 are very high in summer and rainy, in S1 very low in winter seasons. The metal concentration is not exceeding the limits. Zn has lots of use like galvanization of steel, preparation of negative plates in electric batteries, vulcanization of rubber, wood preservatives and antiseptics and in rat and mouse poison.

Iron (Fe)

The minimum and maximum iron concentrations varied between 0.04 to 0.2 mg/L Measurable concentrations of the metal were found in all samples (Graph 10). In the study period, very high in summer, rainy and low in winter seasons. However, all samples exceeded the relevant prescribed limits for drinking water. Iron exists naturally in rivers, lakes, and underground water.

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Table 2: Results of Heavy Metal Concentrations tested in 3 different seasons at Sampling location: S1 Dongapindi

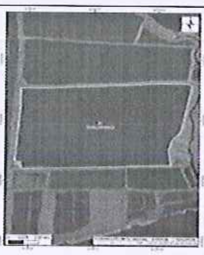
Sampling location: S1 Dongapindi

Latitude: 16° 25' 19.559" N

Longitude: 81° 25' 5.501" E

Located nearby aquaculture ponds

Area (Hectare):7.68

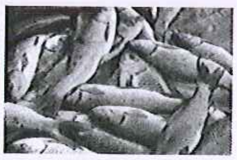


Results of Heavy Metal Concentrations tested in 3 different seasons					Water quality standards					
Heavy Metals		Summer	Rainy	Winter	BIS 10500 : 2012 Acceptable limit	BIS 10500 : 2012 Permissible limit	WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
Cadmium (as Cd)	mg/L	0.0009	0.0008	0.0008	0.003	-	0.003	0.005	0.005	0.001
Mercury (as Hg)	mg/L	0.0004	0.0002	0.0003	0.001	-	0.006	0.002	0.001	0.001
Lead (as Pb)	mg/L	0.002	0.001	0.001	0.01	-	0.01	0.015	0.01	0.003
Arsenic (as As)	mg/L	0.004	0.001	0.003	0.01	0.05	0.01	0.05	0.01	-
Manganese (as Mn)	mg/L	0.05	0.06	0.05	0.1	0.3	0.1	0.05	0.05	0.05 -0.2
Chromium (as Cr)	mg/L	0.04	0.001	0.001	0.05	-	0.05	0.1	0.05	-
Nickel (as Ni)	mg/L	0.001	0.0005	0.0007	0.02	-	0.07	0.1	0.02	0.001
Copper (as Cu)	mg/L	0.004	0.001	0.001	0.05	1.5	2	1.3	2.0	< 0.005
Zinc (as Zn)	mg/L	0.009	0.002	0.005	5	15	4	5	5.0	< 0.01
Iron (as Fe)	mg/L	0.2	0.1	0.09	0.3	-	0.3	0.3	0.2	0.01 -0.3

Remarks

- Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes (Boyd, 1998).
- 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.

Species cultured: Catlacatla



Bureau of Indian Standards IS 10500 : 2012[1]; WHO Guidelines for Drinking-Water Quality (2011)[2];US EPA Primary Drinking Water Standards[5]; E.U: European Union /European Communities (Drinking Water)[6]

(No. 2) Regulations 2007 (S.I. 278 of 2007)[7]; Water Quality for Pond Aquaculture-Acceptable Concentration Ranges in Aquaculture Pond Waters" Boyd (1998)[4].

Note: 1. Season wise data primarily compared with Boyd (1998)[3]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

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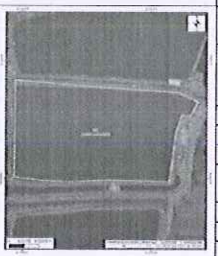
Table 3: Results of Heavy Metal Concentrations tested in 3 different seasons at Sampling location: S2 Dongapindi

Sampling location: S2 Dongapindi

Latitude: 16° 24' 46.954" N
Longitude: 81° 26' 32.846" E

Located beside KottacheduNala canal

Area (Hectare):2.31



Results of Heavy Metal Concentrations tested in 3 different seasons / **Water quality standards**

Heavy Metals		Summer	Rainy	Winter	BIS 10500 : 2012		WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
					Acceptable limit	Permissible limit				
Cadmium (as Cd)	mg/L	0.0008	0.0008	0.0007	0.003	-	0.003	0.005	0.005	0.001
Mercury (as Hg)	mg/L	0.0003	0.0001	0.0001	0.001	-	0.006	0.002	0.001	0.001
Lead (as Pb)	mg/L	0.001	0.001	0.001	0.01	-	0.01	0.015	0.01	0.003
Arsenic (as As)	mg/L	0.002	0.003	0.002	0.01	0.05	0.01	0.05	0.01	-
Manganese (as Mn)	mg/L	0.05	0.05	0.05	0.1	0.3	0.1	0.05	0.05	0.05 -0.2
Chromium (as Cr)	mg/L	0.03	0.02	0.02	0.05	-	0.05	0.1	0.05	-
Nickel (as Ni)	mg/L	0.001	0.0003	0.0003	0.02	-	0.07	0.1	0.02	0.001
Copper (as Cu)	mg/L	0.003	0.002	0.002	0.05	1.5	2	1.3	2.0	< 0.005
Zinc (as Zn)	mg/L	0.008	0.006	0.005	5	15	4	5	5.0	< 0.01
Iron (as Fe)	mg/L	0.1	0.1	0.1	0.3	-	0.3	0.3	0.2	0.01 -0.3

Remarks

- Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes (Boyd, 1998).
- 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.

Species cultured:*Catlacatla*

Bureau of Indian Standards IS 10500 : 2012[1]; WHO Guidelines for Drinking-Water Quality (2011)[2];US EPA Primary Drinking Water Standards[5]; E.U: European Union /European Communities (Drinking Water)[6]
(No. 2) Regulations 2007 (S.I. 278 of 2007)[7]; Water Quality for Pond Aquaculture-Acceptable Concentration Ranges in Aquaculture Pond Waters" Boyd (1998)[3].

Note: 1. Season wise data primarily compared with Boyd (1998)[4] 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

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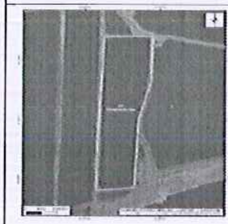
Table 4: Results of Heavy Metal Concentrations tested in 3 different seasons at Sampling location: S3 Dongapindi

Sampling location: S3 Dongapindi

Latitude: 16° 24' 26.013" N
Longitude: 81° 27' 2.437" E

Located adjacent to Upputeru river

Area (Hectare):3.36



Results of Heavy Metal Concentrations tested in 3 different seasons					Water quality standards					
Heavy Metals		Summer	Rainy	Winter	BIS 10500 : 2012 Acceptable limit	BIS 10500 : 2012 Permissible limit	WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
Cadmium (as Cd)	mg/L	0.0007	0.0006	0.0007	0.003	-	0.003	0.005	0.005	0.001
Mercury (as Hg)	mg/L	0.0001	0.0001	0.0001	0.001	-	0.006	0.002	0.001	0.001
Lead (as Pb)	mg/L	0.001	0.001	0.001	0.01	-	0.01	0.015	0.01	0.003
Arsenic (as As)	mg/L	0.001	0.001	0.002	0.01	0.05	0.01	0.05	0.01	-
Manganese (as Mn)	mg/L	0.05	0.05	0.05	0.1	0.3	0.1	0.05	0.05	0.05 -0.2
Chromium (as Cr)	mg/L	0.05	0.04	0.01	0.05	-	0.05	0.1	0.05	-
Nickel (as Ni)	mg/L	0.001	0.0001	0.0002	0.02	-	0.07	0.1	0.02	0.001
Copper (as Cu)	mg/L	0.002	0.001	0.001	0.05	1.5	2	1.3	2.0	< 0.005
Zinc (as Zn)	mg/L	0.006	0.003	0.002	5	15	4	5	5.0	< 0.01
Iron (as Fe)	mg/L	0.02	0.02	0.03	0.3	-	0.3	0.3	0.2	0.01 -0.3

Remarks

- Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes (Boyd, 1998).
- Out of 20 parameters studied 8 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.

Species cultured:*Catlacatla*

Bureau of Indian Standards IS 10500 : 2012[1]; WHO Guidelines for Drinking-Water Quality (2011)[2];US EPA Primary Drinking Water Standards[5]; E.U: European Union /European Communities (Drinking Water)[6]
(No. 2) Regulations 2007 (S.I. 278 of 2007)[7]; Water Quality for Pond Aquaculture-Acceptable Concentration Ranges in Aquaculture Pond Waters" Boyd (1998)[3].

Note: 1. Season wise data primarily compared with Boyd (1998)[4] 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

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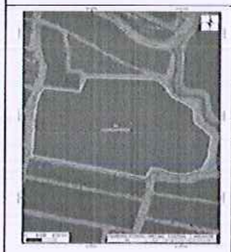
Table 5: Results of Heavy Metal Concentrations tested in 3 different seasons Sampling location: S4 Dongapindi

Sampling location: S4 Dongapindi	Results of Heavy Metal Concentrations tested in 3 different seasons					Water quality standards						Remarks
Latitude: 16° 26' 19.251" N Longitude: 81° 25' 6.556" E Located adjacent Bondada channel extensition Area (Hectare):4.22	Heavy Metals		Summer	Rainy	Winter	BIS 10500 : 2012 Acceptable limit	BIS 10500 : 2012 Permissible limit	WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture	➢ Heavy metal concentrations are well below the standards given for drinking (BIS, WHO. EU, US EPA) and pond aquaculture purposes (Boyd, 1998). ➢ Out of 20 parameters studied 6 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.
	Cadmium (as Cd)	mg/L	0.001	0.001	0.001	0.003	-	0.003	0.005	0.005	0.001	
	Mercury (as Hg)	mg/L	0.0002	0.0001	0.0001	0.001	-	0.006	0.002	0.001	0.001	
	Lead (as Pb)	mg/L	0.001	0.002	0.001	0.01	-	0.01	0.015	0.01	0.003	
	Arsenic (as As)	mg/L	0.002	0.001	0.003	0.01	0.05	0.01	0.05	0.01	-	Species cultured:*Catlacatla*
	Manganese (as Mn)	mg/L	0.06	0.05	0.05	0.1	0.3	0.1	0.05	0.05	0.05 -0.2	
	Chromium (as Cr)	mg/L	0.03	0.001	0.001	0.05	-	0.05	0.1	0.05	-	
	Nickel (as Ni)	mg/L	0.001	0.0004	0.0006	0.02	-	0.07	0.1	0.02	0.001	
	Copper (as Cu)	mg/L	0.003	0.001	0.001	0.05	1.5	2	1.3	2.0	< 0.005	
	Zinc (as Zn)	mg/L	0.005	0.002	0.004	5	15	4	5	5.0	< 0.01	
	Iron (as Fe)	mg/L	0.2	0.1	0.07	0.3	-	0.3	0.3	0.2	0.01 -0.3	

Bureau of Indian Standards IS 10500 : 2012[1]; WHO Guidelines for Drinking-Water Quality (2011)[2];US EPA Primary Drinking Water Standards[5]; E.U: European Union /European Communities (Drinking Water)[6]
(No. 2) Regulations 2007 (S.I. 278 of 2007)[7]; Water Quality for Pond Aquaculture-Acceptable Concentration Ranges in Aquaculture Pond Waters" Boyd (1998)[3].

Note: 1. Season wise data primarily compared with Boyd (1998)[4] 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

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Table 6: Results of Heavy Metal Concentrations tested in 3 different seasons at Sampling location: S5 Dongapindi

Sampling location: S5 Dongapindi

Latitude: 16° 25' 53.072" N
Longitude: 81° 26' 9.176" E

Located nearby old Ennamaduru drain

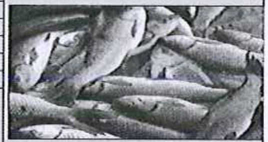
Area (Hectare):3.31

Heavy Metals		Summer	Rainy	Winter	BIS 10500 : 2012 Acceptable limit	BIS 10500 : 2012 Permissible limit	WHO	EU	US EPA	Boyd (1998) Water Quality for Pond Aquaculture
		Results of Heavy Metal Concentrations tested in 3 different seasons			*Water quality standards*					
Cadmium (as Cd)	mg/L	0.0004	0.0003	0.0003	0.003	-	0.003	0.005	0.005	0.001
Mercury (as Hg)	mg/L	0.0002	0.0002	0.0003	0.001	-	0.006	0.002	0.001	0.001
Lead (as Pb)	mg/L	0.002	0.001	0.001	0.01	-	0.01	0.015	0.01	0.003
Arsenic (as As)	mg/L	0.003	0.002	0.003	0.01	0.05	0.01	0.05	0.01	-
Manganese (as Mn)	mg/L	0.05	0.05	0.06	0.1	0.3	0.1	0.05	0.05	0.05 -0.2
Chromium (as Cr)	mg/L	0.03	0.001	0.001	0.05	-	0.05	0.1	0.05	-
Nickel (as Ni)	mg/L	0.001	0.0001	0.0002	0.02	-	0.07	0.1	0.02	0.001
Copper (as Cu)	mg/L	0.002	0.001	0.001	0.05	1.5	2	1.3	2.0	< 0.005
Zinc (as Zn)	mg/L	0.005	0.002	0.003	5	15	4	5	5.0	< 0.01
Iron (as Fe)	mg/L	0.2	0.1	0.1	0.3	-	0.3	0.3	0.2	0.01 -0.3

Remarks

- Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes (Boyd, 1998).
- Out of 20 parameters studied 6 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.

Species cultured: Catlacatla



Bureau of Indian Standards IS 10500 : 2012[1]; WHO Guidelines for Drinking-Water Quality (2011)[2];US EPA Primary Drinking Water Standards[5]; E.U: European Union /European Communities (Drinking Water)[6] (No. 2) Regulations 2007 (S.I. 278 of 2007); Water Quality for Pond Aquaculture-Acceptable Concentration Ranges in Aquaculture Pond Waters" Boyd (1998)[3].

Note: 1. Season wise data primarily compared with Boyd (1998)[4] 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

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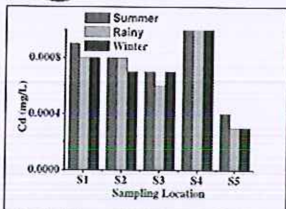
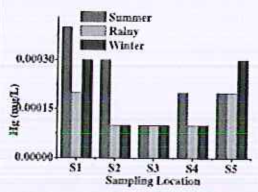
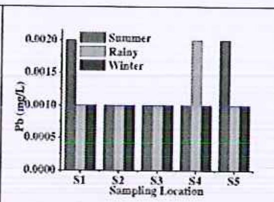


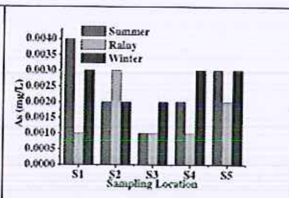
Graph 1: Seasonal variation in Cadmium concentrations.



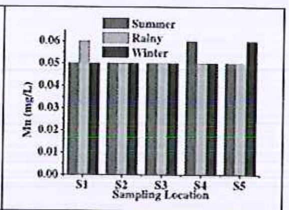
Graph 2: Seasonal variation in Mercury concentrations.



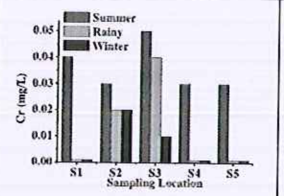
Graph3: Seasonal variation in Lead concentrations.



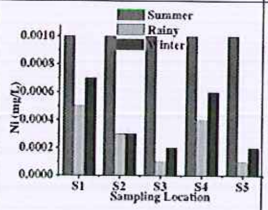
Graph 4: Seasonal variation in Arsenic concentrations.



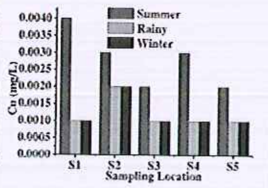
Graph 5: Seasonal variation in Manganese concentrations.



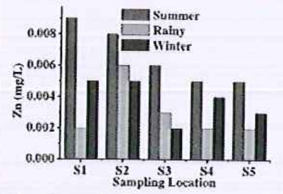
Graph 6: Seasonal variation in Chromium concentrations.



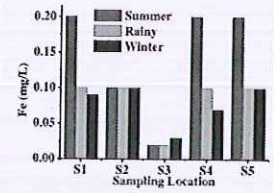
Graph 7: Seasonal variation in Nickel concentrations.



Graph 8: Seasonal variation in Copper concentrations.



Graph 9: Seasonal variation in Zinc concentrations.



Graph 10: Seasonal variation in Iron concentrations.

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IV. SUMMARY, CONCLUSION AND SUGGESTIONS

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

Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes (Boyd, 1998).

Out of 20 parameters studied 6 exceeded the permissible limits of different standards[8,9,10] 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.

All the 5 samples were labeled properly and analyzed for the heavy metals (Cd, Hg, Pb, As, Mn, Cr, Ni, Cu, Zn and Fe) concentrations. The minimum and maximum heavy metal concentrations in different parts of the BhimavaramMandal are reported. Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes.

V. SUGGESTIONS AND CONCLUSION

Based on the results obtained in the present investigations, critical analysis of the data with the prevailing conditions of the cultural practices, the water of fish pond in and around Dongapindi Village, Bhimavaram Mandal, we arrive at the following suggestions. At present, aquaculture has increasingly become a popular rural based occupation, recommended that the water sources need to be checked at regular intervals to monitor its quality and water should be refilled in ponds before use for aquaculture purposes. Quality of water is a necessity for high yield production. Aquaculture farmers use excess feed, pesticides and antibiotics without the guidelines are the main causes of fish pond water quality degradation in the pond waters. With sensible policies, water sources can be protected from pollution. These following precautions and guidelines if taken well, not only raise the productivity and economic benefits but will also help the farmers in maintaining eco-friendly fish ponds and environment required for sustainable aquaculture.

- 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, antibiotics, effluent treatment facility etc.).
- 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.
- To adopt the fish aquaculture practices of away from the agricultural fields.
- Effluent Treatment Plant (ETP) is to be strictly enforced and prior permission is to be given based on it from the concerned authorities.
- 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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