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**Research Article**

# SOME STUDIES OF CONCENTRATIONS OF HEAVY METALS IN AQUACULTURE PONDS IN BHIMAVARAM MANDAL, AP STATE, INDIA

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**ABSTRACT**

This is the study of concentrations of heavy metals in Aqua culture ponds at Gollavanitippa and its vicinity in Bhimavaram Mandal, West Godavari District, Andhra Pradesh, India. The total 10 heavy metals 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 and 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.



## 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 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; and
3. To identify the causes of fish pond water pollution and to recommend suitable remedies.

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## MATERIALS AND METHODS

### *Study area*

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

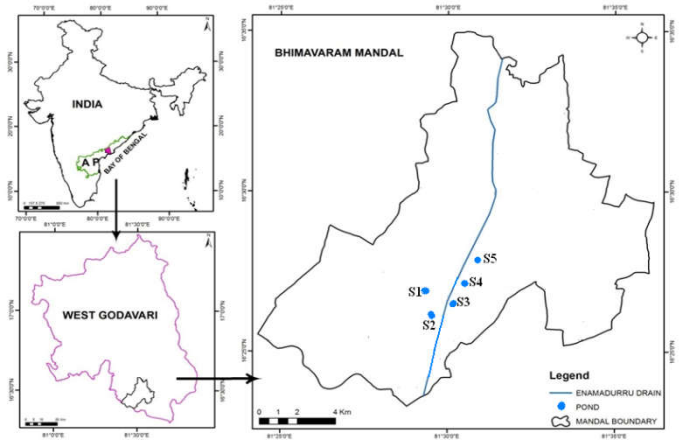


**Figure 1** Study area

### *Samples collection*

Aquaculture 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 2014 to June 2015. 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

| Sl. 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 |

## 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 Gollavanitippa 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 (Figure 2). 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 (Figure 3). 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 (Figure 4). 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 (Figure 5). 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 (Figure 6) 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 (Figure 7). 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 (Figure 8). 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.

**Sampling location: S1 Gollavanitippa**

Latitude: 16° 27' 12.034" N
Longitude: 81° 29' 36.186" E
Located near Ennamadur drain
Area (Hectare): 0.93

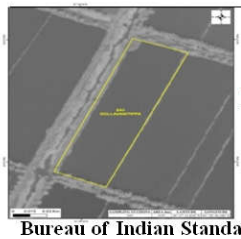

**Table 2: Results of heavy metal concentrations tested in 3 different seasons**

| Heavy Metals | | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cadmium (as Cd) | mg/L | 0.0009 | 0.0004 | 0.0001 | 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 | 0.002 | 0.001 | 0.001 | 0.01 | - | 0.01 | 0.015 | 0.01 | 0.003 |
| Arsenic (as As) | mg/L | 0.003 | 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 | 0.02 | 0.001 | 0.001 | 0.05 | - | 0.05 | 0.1 | 0.05 | - |
| Nickel (as Ni) | mg/L | 0.001 | 0.0002 | 0.0006 | 0.02 | - | 0.07 | 0.1 | 0.02 | 0.001 |
| Copper (as Cu) | mg/L | 0.001 | 0.001 | 0.001 | 0.05 | 1.5 | 2 | 1.3 | 2.0 | < 0.005 |
| Zinc (as Zn) | mg/L | 0.003 | 0.001 | 0.001 | 5 | 15 | 4 | 5 | 5.0 | < 0.01 |
| Iron (as Fe) | mg/L | 0.1 | 0.1 | 0.09 | 0.3 | - | 0.3 | 0.3 | 0.2 | 0.01 -0.3 |

**Species cultured: *Catla catla***

**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).**

**Remarks:** Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes (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:** Season wise data primarily compared with Boyd (1998) water quality standards for pond aquaculture.

**Sampling location: S2 Gutlapadu**

Latitude: 16° 26' 43.684" N
Longitude: 81° 29' 58.980" E
Located beside Ennamadur drain
Area (Hectare): 0.35

**Table 3: Results of heavy metal concentrations tested in 3 different seasons**

| Heavy Metals | | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cadmium (as Cd) | mg/L | 0.0009 | 0.0005 | 0.0002 | 0.003 | - | 0.003 | 0.005 | 0.005 | 0.001 |
| Mercury (as Hg) | mg/L | 0.0004 | 0.0001 | 0.0001 | 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 | 0.0004 | 0.0002 | 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 | 0.003 | 0.002 | 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 |

**Species cultured: *Catla catla***

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).

Remarks: Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes (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: Season wise data primarily compared with Boyd (1998) water quality standards for pond aquaculture.

### *Copper (Cu)*

The minimum and maximum copper concentrations were found to be 0.001 mg/L and 0.005 mg/L respectively (Figure 9). 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 (Figure 10). In the study period in S2 and S5 are very high in summer and reainy, 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.

Sampling location: S3 Gollavanitippa

**Latitude: 16° 27' 15.890" N**
**Longitude: 81° 30' 13.097" E**
**Located near Ennamadur drain**
**Area (Hectare): 0.12**

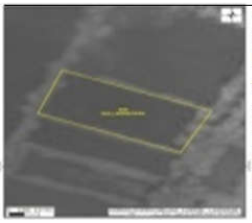

**Table 4: Results of heavy metal concentrations tested in 3 different seasons**

Water quality standards

Species cultured: *Catla catla*

| 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 | 0.0005 | 0.0003 | 0.003 | - | 0.003 | 0.005 | 0.005 | 0.001 |
| Mercury (as Hg) | mg/L | 0.0004 | 0.0003 | 0.0003 | 0.001 | - | 0.006 | 0.002 | 0.001 | 0.001 |
| Lead (as Pb) | mg/L | 0.002 | 0.001 | 0.002 | 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 | 0.005 | 0.0002 | 0.0002 | 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 | 0.008 | 0.003 | 0.002 | 5 | 15 | 4 | 5 | 5.0 | < 0.01 |
| Iron (as Fe) | mg/L | 0.2 | 0.1 | 0.04 | 0.3 | - | 0.3 | 0.3 | 0.2 | 0.01 -0.3 |

**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).**

**Remarks:** Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes (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:** Season wise data primarily compared with Boyd (1998) water quality standards for pond aquaculture.

Sampling location: S4 Gollavanitippa

Latitude: 16° 27' 28.807" N
Longitude: 81° 30' 36.440" E
Located adjacent to aquaculture ponds
Area (Hectare): 5.86

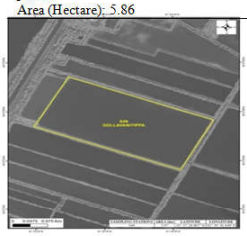

**Table 5: Results of heavy metal concentrations tested in 3 different seasons**

Water quality standards

Species cultured: *Catla catla*

| 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 | 0.0001 | 0.0001 | 0.0001 | 0.003 | - | 0.003 | 0.005 | 0.005 | 0.001 |
| Mercury (as Hg) | mg/L | 0.0004 | 0.0003 | 0.0003 | 0.001 | - | 0.006 | 0.002 | 0.001 | 0.001 |
| Lead (as Pb) | mg/L | 0.002 | 0.001 | 0.005 | 0.01 | - | 0.01 | 0.015 | 0.01 | 0.003 |
| Arsenic (as As) | mg/L | 0.004 | 0.005 | 0.003 | 0.01 | 0.05 | 0.01 | 0.05 | 0.01 | - |
| Manganese (as Mn) | mg/L | 0.05 | 0.06 | 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 | 0.0006 | 0.0003 | 0.02 | - | 0.07 | 0.1 | 0.02 | 0.001 |
| Copper (as Cu) | mg/L | 0.001 | 0.001 | 0.001 | 0.05 | 1.5 | 2 | 1.3 | 2.0 | < 0.005 |
| Zinc (as Zn) | mg/L | 0.005 | 0.002 | 0.008 | 5 | 15 | 4 | 5 | 5.0 | < 0.01 |
| Iron (as Fe) | mg/L | 0.2 | 0.2 | 0.09 | 0.3 | - | 0.3 | 0.3 | 0.2 | 0.01 -0.3 |

**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).**

**Remarks:** Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes (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:** Season wise data primarily compared with Boyd (1998) water quality standards for pond aquaculture.

***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 (Figure 11).

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.

**Sampling location: S5 Gollavanitippa**

Latitude: 16° 28' 13.984" N
Longitude: 81° 30' 50.410" E
Located adjacent Ennamadur drain
Area (Hectare): 0.61

**Table 6: Results of heavy metal concentrations tested in 3 different seasons**

| Heavy Metals | | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cadmium (as Cd) | mg/L | 0.0001 | 0.0008 | 0.0005 | 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 | 0.002 | 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 | 0.06 | 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 | 0.0005 | 0.0001 | 0.02 | - | 0.07 | 0.1 | 0.02 | 0.001 |
| Copper (as Cu) | mg/L | 0.005 | 0.001 | 0.001 | 0.05 | 1.5 | 2 | 1.3 | 2.0 | <0.005 |
| Zinc (as Zn) | mg/L | 0.001 | 0.002 | 0.009 | 5 | 15 | 4 | 5 | 5.0 | <0.01 |
| Iron (as Fe) | mg/L | 0.1 | 0.1 | 0.09 | 0.3 | - | 0.3 | 0.3 | 0.2 | 0.01 -0.3 |

**Species cultured:** *Catla catla*

**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).**

**Remarks:** Heavy metal concentrations are well below the standards given for drinking (BIS, WHO, EU, US EPA) and pond aquaculture purposes (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:** Season wise data primarily compared with Boyd (1998) water quality standards for pond aquaculture.

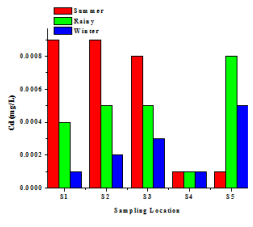

**Figure 2:** Graph showing seasonal variation in Cd metal readings

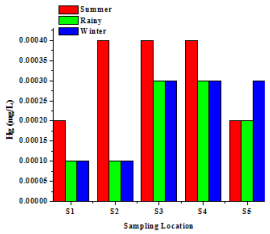

**Figure 3:** Graph showing seasonal variation in Hg metal readings

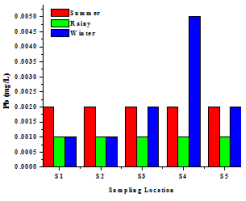

**Figure 4:** Graph showing seasonal variation in Pb metal readings

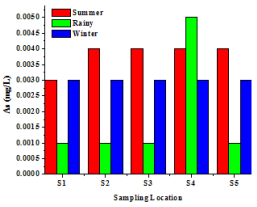

**Figure 5:** Graph showing seasonal variation in As metal readings

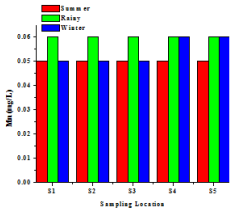

**Figure 6:** Graph showing seasonal variation in Mn metal readings

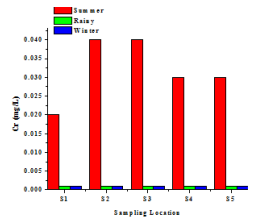

**Figure 7:** Graph showing seasonal variation in Cr metal readings

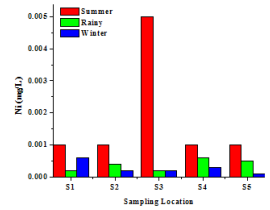

**Figure 8:** Graph showing seasonal variation in Ni metal readings

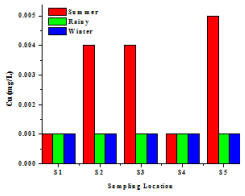

**Figure 9:** Graph showing seasonal variation in Cu metal readings

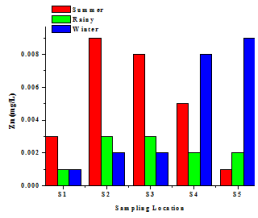

**Figure 10:** Graph showing seasonal variation in Zn metal readings

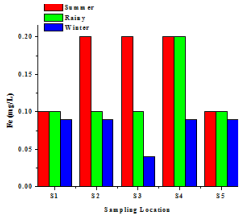

**Figure 11:** Graph showing seasonal variation in Fe metal readings

## SUMMARY, CONCLUSION AND SUGGESTIONS

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

### *Suggestions*

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 Gollavanitippa 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.

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