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# Aquaculture and its impact on ground water in East Godavari District Andhra Pradesh, India – A Case Study

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## Abstract

*Ground water is a significant source for drinking, agricultural and aquaculture purposes in Godavari region. Groundwater if contaminated due to manmade activities cause concern on environment and human health. The aim of the present study is to review the impact of aquaculture on environment briefly and to assess the ground water quality in East Godavari District. Aquaculture activities are major impact on water resources-they are physical, chemical and biological. Physically there is a lot of pressure on water; chemically it is polluted the water as well as land; biologically it introduces exotic species, pathogens and diseases. It is due to poor planning of land and water resources management. These aquaculture ponds require mixing of bore-well or creek waters with fresh water for daily change activities, due to this practice the polluted water is discharged into the channels from the upstream aquaculture ponds that same water is used by downstream aquaculture ponds; this is the main cause for increasing pollution in many folds aquatic environment. Over-exploitation of ground water and land use conversions to aqua-culture are becoming source of salt water intrusion. Pollution, destruction of sensitive coastal habitats, threats to aquatic bio-diversity and significant socio-economic costs must be balanced against the substantial benefits.*

**Keywords:** Aquaculture, ground water pollution, vannamei, drinking water quality, saltwater intrusion, exotic species.

## Introduction

Aquaculture was regarded as an environmentally sound practice as it can utilize farm resources including farm waters and generate food and income. World fish production has grown dramatically in the last few decades with an average growth rate of 3.2% per year in the period 1961-2011. Annual aquaculture production worldwide increased from 8 million tons in 1985 to 154 million tons by the end of 2011[1]. In Andhra Pradesh the shrimp farming increased from 6000 hectares in 1990 to 84,951 hectares in 2012. In terms of production, Andhra Pradesh tops India with 1.6 lakh tons out of 2.0 lakh tons by the end of 2012[2]. Environmental impact of shrimp farming in the country came to lime light for the first time with the reports of National Environmental Engineering Research Institute (NEERI) conducted at the instance of Supreme Court direction[3]. Aquaculture is a source of nutrient pollution. It has severe impacts on aquatic ecosystems, as nutrient wastes are discharged directly into the surrounding waters. For every ton of fish, aquaculture operations produce between 42 – 66 kilograms of Nitrogen wastes and 7.2 – 10.5 kilograms of phosphorus wastes. Algarswamy (1995) based on his studies inferred that except traditional and improved traditional shrimp farming, all other farming systems would lead to pollution and result in adverse impact on environment. Intensive aquaculture require large quantities of fresh water, usually obtained from ground water[4]. Pumping ground water near coastal areas may cause saltwater to enter into aquifer and contaminate the underground reservoir. Ground water extraction may also cause land subsidence. If aquaculture ponds are not distributed properly, salt water can seep into surface reservoirs, sub-surface ground water reservoirs, canals etc. By extracting large volumes of ground water to reach the desired salinity levels of brackish water shrimp ponds and hatcheries cause ground water levels to drop and thus deplete aquifer and contribute to salinization of fresh ground water aquifers[5]. The salt water in the ponds seeps into the ground water, and increased salinity damages their land and water sources by aquaculture farms[6].

A steady increase in the fish ponds and fast conversion of agriculture into aquaculture in East Godavari district has remained a major cause of concern for many. Depleting returns from paddy prompting farmers take to fish rearing. That paddy cultivation is not giving the expected returns to farmers of East Godavari area are forced to declare crop holiday for paddy, which is a classic example of sorry state of affairs in coastal region . As a result more farmers are venturing into aquaculture, for which the delta region is more conducive. The high green paddy farms are fast turning into fish tanks. Aquaculture is posing a threat to agriculture as the discharges from the fish ponds are being released into the nearby paddy fields. As the salt water is being used in aquaculture and there is every possibility of ground water salinity in the entire area.

**Study area:** The study area is situated on East coast of India between Vasista Godavari River and Vainateyam Godavari

River of East Godavari district, Andhra Pradesh. The location map of the study area is shown in figure 1. The study area is bounded on east by Vainateyam, west by Vasista Godavari, south by Bay of Bengal, and north by deltaic plain of central delta. The study area admeasures to an extent of 125 sq.km, lies with in the geographical coordinates of N16° 18' to 16° 23' latitudes and E 81° 42' to 81°57' longitudes and falls within the survey of India toposheet numbers 65H11 and 65H15. It is extended 5km from the coast line of the central delta covering Antarvedi, Karra, Chintalamori, Mori, Kesanapalli, Karavaka, Mutyalapalem, Lakkavaram and Bettalanka villages of Sakhinetipalli and Malikipuram Mandals, East Godavari District, A.P.

**Scope and Objectives:** The principal objective of the present study is to understand the hydrochemistry of ground waters in the study area and the impact of aquaculture on ground water quality of the investigated area. Investigations are aimed at prediction of probable areas of pollution due to sea water intrusion and monitoring salinity levels of ground water in space and time which is of considerable significance for pisci, prawn culture as well as for drinking water sources.

## Methodology

It includes field work and laboratory analysis. The field work consists of collection of water samples from 30 wells for one year period in the study area. The underground water sources include open dug wells, bore wells and hand pumps. The laboratory work consists of chemical analysis of water samples by different analytical methods. The ground water samples collected from the study area have been analysed in the laboratory for various chemical parameters like pH, electrical conductance, TDS, Alkalinity, Chlorides, Nitrates, Phosphates, DO, BOD, COD, MPN and bacterial count etc by standard methods[7,8]. For understanding the influence of sea water intrusion, special parameters like Na/Cl, Cl / ($CO_3$ +$HCO_3$) are also calculated.

## Results and Discussion

A total number of 30 samples were collected from shallow wells. Both physical and chemical parameters were analysed using standard laboratory techniques. The Chemical analysis of the ground water samples of the study area is shown in table 1. The maximum and minimum values of various chemical parameters are shown in table 2.

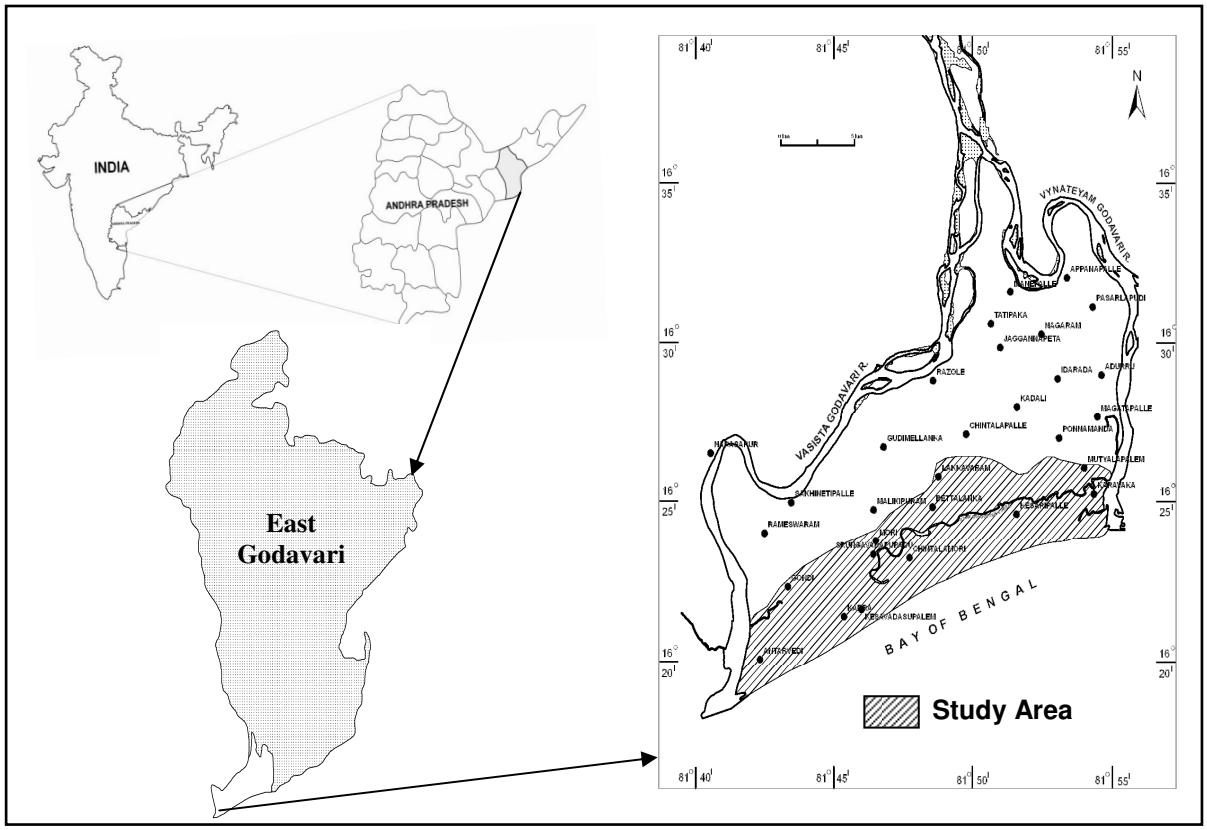


**Figure-1**
**Location map of the Study Area**

**Table-1**
**Analysis of Ground Water Samples**

| S.No | Village | pH | TDS (ppm) | EC (µS/cm) | Chlorides (ppm) | Phosphates (ppm) | Sulphates (ppm) | Total Alkalinity (ppm) | Total Hardness (ppm) | Salinity (ppt) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Visweswarayapuram (DW) | 8.0 | 1320.0 | 1820.0 | 233.9 | 0.0 | 0.0 | 613.1 | 230.0 | 1.0 |
| 2 | Lakkavaram(DW) | 7.6 | 700.0 | 980.0 | 99.2 | 0.1 | 0.0 | 393.7 | 175.0 | 0.0 |
| 3 | Bettalanka(DW) | 8.1 | 300.0 | 410.0 | 21.2 | 0.0 | 0.0 | 180.0 | 85.0. | 0.0 |
| 4 | Adavipalem(DW) | 8.0 | 570.0 | 970.0 | 106.3 | 0.1 | 0.0 | 258.7 | 100.0 | 0.0 |
| 5 | Adavipalem(DW) | 8.1 | 520.0 | 720.0 | 92.1 | 0.1 | 0.0 | 219.3 | 85.0 | 0.0 |
| 6 | Gubbalapalem(DW) | 8.2 | 820.0 | 1140.0 | 141.8 | 0.1 | 0.0 | 427.5 | 130.0 | 1.0 |
| 7 | Gubbalapalem(DW) | 8.2 | 1210.0 | 1690.0 | 354.5 | 0.0 | 0.0 | 258.7 | 100.0 | 1.0 |
| 8 | Gudapalli(DW) | 8.0 | 270.0 | 380.0 | 35.4 | 0.1 | 0.0 | 135.0 | 55.0 | 0.0 |
| 9 | Gudapalli(DW) | 8.1 | 1600.0 | 2200.0 | 397.0 | 0.0 | 288.1 | 365.6 | 285.0 | 1.0 |
| 10 | Katrenipadu Kodapa(DW) | 8.1 | 270.0 | 380.0 | 56.7 | 0.0 | 0.0 | 140.6 | 60.0 | 0.0 |
| 11 | Mutyalapalem(DW) | 8.4 | 1600.0 | 2200.0 | 219.7 | 0.1 | 0.0 | 855.0 | 115.0 | 1.0 |
| 12 | Karavaka(DW) | 8.4 | 960.0 | 1330.0 | 226.8 | 0.1 | 74.0 | 241.8 | 85.0 | 1.0 |
| 13 | Kesanapalli(DW) | 8.0 | 340.0 | 470.0 | 56.7 | 0.1 | 0.0 | 140.6 | 25.0 | 0.0 |
| 14 | Padamatipalem(DW) | 8.2 | 810.0 | 1,120.0 | 155.9 | 0.1 | 107.0 | 185.6 | 75.0 | 0.0 |
| 15 | Sankaraguptam(DW) | 8.2 | 760.0 | 1,050.0 | 163.0 | 0.1 | 0.0 | 253.1 | 75.0 | 0.0 |
| 16 | Chintalamori(DW) | 8.2 | 970.0 | 1350.0. | 198.5 | 0.0 | 131.7 | 343.1 | 105.0 | 1.0 |
| 17 | Kesavadasupalem(DW) | 7.6 | 4800.0 | 6600.0 | 1963.9 | 0.0 | 0.0 | 337.5 | 28.0 | 5.0 |
| 18 | Antarvedi(DW) | 7.5 | 1700.0 | 2300.0 | 340.3 | 0.1 | 0.0 | 720.0 | 100.0 | 1.0 |
| 19 | Mori(DW) | 7.6 | 3400.0 | 4700.0 | 794.0 | 0.0 | 255.1 | 1,040.6 | 170.0 | 3.0 |
| 20 | Visweswarapuram(HP) | 7.9 | 330.0 | 460.0 | 42.5 | 0.1 | 0.0 | 163.1 | 90.0 | 0.0 |
| 21 | Bettalanka(HP) | 8.3 | 560.0 | 760.0 | 85.0 | 0.1 | 0.0 | 258.7 | 110.0 | 0.0 |
| 22 | Bettalanka(HP) | 7.8 | 220.0 | 290.0 | 42.5 | 0.0 | 0.0 | 123.7 | 55.0 | 0.0 |
| 23 | Adavipalem(HP) | 8.1 | 540.0 | 750.0 | 99.2 | 0.1 | 0.0 | 180.0 | 85.0 | 0.0 |
| 24 | Gudapalli(HP) | 8.2 | 550.0 | 460.0 | 63.8 | 0.1 | 0.0 | 270.0 | 95.0 | 0.0 |
| 25 | Gudapalli(HP) | 8.3 | 1060.0 | 1470.0 | 198.5 | 0.1 | 296.3 | 382.5 | 155.0 | 1.0 |
| 26 | Toorpupalem(HP) | 8.4 | 1070.0 | 1490.0 | 184.3 | 0.1 | 0.0 | 444.3 | 80.0 | 1.0 |
| 27 | Kesanapalli(HP) | 8.3 | 780.0 | 1080.0 | 170.1 | 0.0 | 0.0 | 315.0 | 90.0 | 0.0 |
| 28 | Padamatipalem(HP) | 8.1 | 890.0 | 1230.0 | 198.5 | 0.0 | 0.0 | 326.2 | 70.0 | 0.0 |
| 29 | Antarvedikara(HP) | 7.6 | 4900.0 | 6800.0 | 1630.7 | 0.0 | 411.6 | 838.1 | 330.0 | 5.0 |
| 30 | Gondi(HP) | 7.9 | 15000.0 | 20000.0 | 4963.0 | 0.0 | 1432.3 | 1265.6 | 830.0 | 10.0 |

S. No. Sample Number, DW- Dug Well, HP- Hand Pump

The ground water pH in the study area is alkaline in nature and ranges from 7.50 to 8.40. TDS in water is due to inorganic salts, organic matter, suspended solids, silt, clay and plankton. Dissolved salts in the ground water contain mainly sodium, potassium, calcium, magnesium, bicarbonates, sulphates etc. TDS indicate the general quality of the ground water. In the study area, the TDS values ranging from 230 to 28000 ppm. The higher values are observed in the samples of Visweswarapuram and Padamatipalem (1320 ppm), Gudapalli, Karavaka, Muthyalapalem (1600 ppm), Mori (3400 ppm) Kesavadasupalem (4800 ppm), Srungavarappadu (4900 ppm) and Gondi (15000 ppm). E.C. is a measure of how well a solution conducts electricity and it is connected with salt content. TDS values reflect in EC values also. The EC values of the study area ranges from 290 to 20000 µS/cm. Salinity of water is essential for fish health and it enhances the natural slime coating it fights-off fungus and disease. It also kills most parasitic infestations. TDS and EC values are reflected in salinity values also. It ranges from 0.0 to 10 ppt in the study area. Among the anions, chloride is the dominant ion in the study area. In most of the samples chloride content is more than the permissible limit (250 ppm) for drinking purpose and especially high in Gondi, Kesavadasupalem, Srungavarappadu, Antarvedi, Antarvedi Karra, Karavaka areas. Sulphates are generally less abundant than the chlorides in most of the natural waters. The same is observed in the study area also. It was appeared in a few samples of Mori, Karavaka, Gudapalli, Antarvedikara and Gondi.It ranges from 0.0 to 1432.3 ppm where as the permissible limit is 150-200 ppm. All the water samples have Phosphates and their concentrations are within the permissible limits (5 ppm). In the study area, most of the area encountered with very hard waters with concentrations more than 300mg/l. They are the water samples from dug wells of Srungavarappadu (520 ppm), Kesavadasupalem (400 ppm) and Hand pump samples of Antarvedikara (330 ppm) and Gondi (830ppm) respectively. According to Twort et al[9] water with hardness <75 ppm is soft; 75-150 ppm is moderately hard; 150-300ppm is hard and > 300 ppm is very hard. Nitrite values in the study area are in general very low and highest value is observed at Kesavadasupalem (5.0 ppm). The nitrate concentrations in the study area are higher than the permissible limit i.e.45ppm, especially high in Mori, Padamatipalem,

Karavaka, Toorpupalem, Sankaraguptam, Gudapalli, Antarvedikarra, Srungavarappadu, Adavipalem, Gondi villages. Ammonia concentrations of the study area are very high and crossed the permissible limit 0.1ppm. It ranges from 0.0 to 11.3 ppm in the study area. It is very high in Antarvedi followed by Srungavarappadu, Kesavadasupalem, Kesanapalli, Karavaka, Gollapalem, Shankaraguptam, Chintala Mori, Mori and Katrenipadu Kodapa. Sodium concentration in the study area ranges from 33ppm to 1158 ppm. If the TDS is below 1000 ppm generally sodium is in ionic form. High potassium values in the water are due to contamination from nutrient -enriched return irrigation and aqua flows. In the study area the values ranged from 3 ppm to 483 ppm. BOD is a measure of oxygen required by microbes to degrade the organic matter under aerobic conditions. In most of the cases the B.O.D. values are higher than the permissible limit due to high organic load in the water. COD values of all the samples are higher than the permissible limits which indicate the high contamination of underground water. MPN Index values and high bacterial count are observed in almost all the ground water samples of the study area and thereby it reflects high contamination.

An attempt has been made to evaluate the chemical nature of the ground water and inter relation of various chemical parameters. Quality of ground water in the study area has shown limited relation to the topography but has shown good correlation to lithology. Ground waters in the area are of good quality in the beach ridge regions and paleo channels of arenaceous aquifer environment. The quality of ground water is poor due to salt water intrusion from Bay of Bengal. This intrusion is due to over exploitation of ground water thereby attracting salt water intrusion and causing high salinities to the ground water. An attempt has also been made to inter relate various chemical parameters for understanding the salt water intrusions into the study area. Special parameters like Na/Cl, Cl/Alkalinity are calculated and shown in table 3.

**Table-1**
**Analysis of Ground Water Samples**

| S.No | Nitrite (ppm) | Nitrate (ppm) | Ammonia (ppm) | Sodium (ppm) | Potassium (ppm) | B.O.D (ppm.) | C.O.D. (ppm) | MPN Index / 100 ML | Total Bacterial Count (CFUs/ml) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 12.9 | 0.0 | 137.0 | 43.0 | 11.0 | 64.0 | 430.0 | $182x10^3$ |
| 2 | 0.0 | 4.2 | 0.0 | 87.0 | 23.0 | 13.0 | 32.0 | 210.0 | $137x10^3$ |
| 3 | 0.0 | 2.3 | 0.0 | 33.0 | 8.0 | 12.0 | 32.0 | ≥2400.0 | $242x10^3$ |
| 4 | 0.0 | 19.8 | 0.0 | 95.0 | 17.0 | 11.0 | 64.0 | 240.0 | $134x10^3$ |
| 5 | 0.0 | 28.5 | 0.0 | 87.0 | 30.0 | 8.0 | 32.0 | 240.0 | $154x10^3$ |
| 6 | 0.0 | 4.3 | 0.0 | 120.0 | 53.0 | 16.0 | 46.0 | ≤2.0 | $116x10^3$ |
| 7 | 0.0 | 4.0 | 0.0 | 123.0 | 212.0 | 16.0 | 48.0 | ≥2400.0 | $142x10^4$ |
| 8 | 0.0 | 1.3 | 0.0 | 52.0 | 18.0 | 12.0 | 64.0 | 350.0 | $116x10^3$ |
| 9 | 0.0 | 60.9 | 0.0 | 150.0 | 78.0 | 11.0 | 32.0 | 1600.0 | $115x10^3$ |
| 10 | 0.0 | 0.7 | 1.2 | 50.0 | 03.0 | 12.0 | 32.0 | 13.0 | $52x10^3$ |
| 11 | 0.5 | 6.0 | 0.1 | 195.0 | 100.0 | 15.0 | 48.0 | 5.0 | $169x10^4$ |
| 12 | 0.0 | 73.7 | 0.2 | 117.0 | 77.0 | 11.0 | 64.0 | 220.0 | $268x10^4$ |
| 13 | 0.0 | 29.2 | 0.0 | 58.0 | 70.0 | 16.0 | 68.0 | 130.0 | $126x10^4$ |
| 14 | 0.1 | 71.6 | 0.1 | 108.0 | 17.0 | 14.0 | 64.0 | 430.0 | $61x10^4$ |
| 15 | 0.1 | 60.8 | 0.1 | 98.0 | 60.0 | 12.0 | 48.0 | 540.0 | $5x10^4$ |
| 16 | 0.0 | 31.9 | 0.1 | 112.0 | 37.0 | 15.0 | 32.0 | 240.0 | $152x10^4$ |
| 17 | 5.0 | 8.7 | 0.3 | 257.0 | 85.0 | 12.0 | 46.0 | 9.0 | $89x10^3$ |
| 18 | 0.0 | 9.4 | 0.2 | 178.0 | 103.0 | 13.0 | 32.0 | 5.0 | $246x10^3$ |
| 19 | 0.0 | 139.8 | 1.3 | 230.0 | 268.0 | 13.0 | 48..0 | 49.0 | $159x10^3$ |
| 20 | 0.0 | 19.6 | 0.0 | 48.0 | 23.0 | 13.0 | 32.0 | ≤2.0 | 182x103 |
| 21 | 0.0 | 13.4 | 0.0 | 67.0 | 100.0 | 13.0 | 42.0 | 46.0 | 126x103 |
| 22 | 0.0 | 0.0 | 0.0 | 33.0 | 02.0 | 11.0 | 32.0 | ≥2400.0 | 287x103 |
| 23 | 0.5 | 64.5 | 0.0 | 85.0 | 37.0 | 13.0 | 38.0 | 21.0 | 162x103 |
| 24 | 0.0 | 6.2 | 0.0 | 93.0 | 45.0 | 17.0 | 64.0 | ≤2.0 | 58x103 |
| 25 | 0.0 | 1.9 | 0.0 | 133.0 | 113.0 | 12.0 | 38.0 | 46.0 | 96x103 |
| 26 | 0.3 | 73.9 | 0.1 | 133.0 | 140.0 | 13.0 | 42.0 | ≤2.0 | 64x103 |
| 27 | 0.0 | 4.2 | 0.1 | 95.0 | 27.0 | 11.0 | 32.0 | 130.0 | 147x104 |
| 28 | 0.8 | 0.0 | 0.0 | 125.0 | 20.0 | 13.0 | 38.0 | ≤2.0 | 164x104 |
| 29 | 1.0 | 64.4 | 0.0 | 252.0 | 193.0 | 12.0 | 32.0 | 22.0 | 174x104 |
| 30 | 2.0 | 67.1 | 0.0 | 1158.0 | 483.0 | 12.0 | 32.0 | 13.0 | 115x103 |

**Table-2**
**Maximum and Minimum values of various parameters**

| Parameter | | Minimum | Maximum |
|---|---|---|---|
| PH | | 7.50 | 8.40 |
| TDS | (ppm) | 220.00 | 15000.00 |
| EC | (µS/cm) | 290.00 | 20000.00 |
| Chlorides | (ppm) | 21.27 | 4963.00 |
| Sulphates | (ppm) | 0.00 | 1432.40 |
| Phosphates | (ppm) | 0.00 | 0.10 |
| Total Alkalinity | (ppm) | 123.75 | 1265.63 |
| Total Hardness | (ppm) | 25.00 | 830.00 |
| Salinity | (ppt) | 0.00 | 10.00 |
| Nitrite | (ppm) | 0.00 | 5.0 |
| Nitrate | (ppm) | 0.00 | 139.83 |
| Ammonia | (ppm) | 0.00 | 1.32 |
| Sodium | (ppm) | 33.00 | 1158.00 |
| Potassium | (ppm) | 3.0 | 483.00 |
| BOD | (ppm) | 1.00 | 8.00 |
| COD | (ppm) | 32.00 | 64.00 |
| MPN Index | ( /100ml) | 2.00 | 2400.00 |

**Table-3**
**Sodium to Chloride Ratio and Chloride to Alkalinity Ratio**

| Sample No. | Village | Na/Cl ratio | Cl/Alkalinity Ratio |
|---|---|---|---|
| 1 | Visweswarayapuram | 0.59 | 0.38 |
| 2 | Lakkavaram | 0.88 | 0.25 |
| 3 | Bettalanka | 1.57 | 0.11 |
| 4 | Adavipalem | 0.90 | 0.40 |
| 5 | Adavipalem | 0.95 | 0.42 |
| 6 | Gubbalapalem | 0.98 | 0.33 |
| 7 | Gubbalapalem | 0.35 | 1.30 |
| 8 | Gudapalli | 1.49 | 0.25 |
| 9 | Gudapalli | 0.38 | 1.00 |
| 10 | Katrenipadu kodapa | 0.88 | 0.40 |
| 11 | Mutyalapalem | 0.89 | 0.25 |
| 12 | Karavaka | 0.52 | 0.93 |
| 13 | Kesanapalli | 1.02 | 0.40 |
| 14 | Padamatipalem | 0.69 | 0.83 |
| 15 | Shankaraguptam | 0.60 | 0.64 |
| 16 | Chintalamori | 0.56 | 0.58 |
| 17 | Kesavadasupalem | 0.13 | 5.80 |
| 18 | Antarvedi | 0.52 | 0.47 |
| 19 | Mori | 0.29 | 0.76 |
| 20 | Visweswarapuram | 1.12 | 0.26 |
| 21 | Bettalanka | 0.79 | 0.32 |
| 22 | Bettalanka | 0.77 | 0.34 |
| 23 | Adavipalem | 0.86 | 0.55 |
| 24 | Gudapalli | 1.45 | 0.23 |
| 25 | Gudapalli | 0.67 | 0.54 |
| 26 | Toorpupalem | 0.72 | 0.41 |
| 27 | Kesanapalli | 0.56 | 0.53 |
| 28 | Padamatipalem | 0.63 | 0.61 |
| 29 | Antarvedikara | 0.15 | 1.90 |
| 30 | Gondi | 0.23 | 3.10 |

According to Hem[10], if Cl/Alkalinity ratio is 0.05 is considered as fresh water, 0.05 to 1.30 is slightly contaminated ground water; 1.30 to 3.80 is moderately contaminated; 2.80 to 6.60 is injuriously contaminated; 6.60 to 15.5 is highly contaminated. According to this Antarvedi Kara, Karavaka ground water source is moderately contaminated, Kesanapalli, Chintalamori are slightly contaminated and Kesavadasupalem water is injuriously contaminated. The Na/Cl ratios clearly shows that Gondi, Mori, Gubbalapalem, Kesanapalli ground waters are contaminated with salt water intrusion.

## Conclusion

Potable water is a genuine basic need of any human inhabitation and care should be taken to see that this basic need is not curtailed by any way. Salt water intrusion is very high in Antarvedi, Antarvedi Kara, Kesavadasupalem, Gondi, Mutyalapalem, Toorpupalem, Mori, Srungavarappadu and Karavaka. This is due to the fact that the surrounding villages of this area are completely covered with aquaculture and very adjacent to Estuary and Bay of Bengal. In Chintalamori, Gubbalapalem and Sankaraguptam water is drawn from Sankaraguptam creek and thereby causing moderate salt water intrusion as shown in figure 2. In Visweswarapuram, Padamatipalem and Gudapalli some areas are contaminated with salts and other areas are free from contamination, which is again due to aquaculture domination in those particular areas. In this region mostly bore water is pumped into aqua ponds for prawn culture. Bettalanka, Katrenipadu Kodapa, Adavipalem, Kesanapalli, Lakkavaram villages are free from salt water contamination. This is due to the fact that this area is free from aquaculture and the area is still covered with horticulture and agriculture (mainly paddy cultivation).

Very high values of Chlorides, TDS, EC and Salinity in some villages confirm that water is not suitable for drinking or agriculture purpose. The biological values of BOD, COD, ammonia, nitrates and MPN indicate that water is highly contaminated and not suitable even for domestic purpose. In some areas the data showed enrichment of nutrients particularly nitrates due to dumping of animal manures by the aqua culturists. The soil salinization further devalues marginal agricultural land. According to Cl / alkalinity ratio and Na/Cl ratios in the study area, it may be inferred that ground water is highly contaminated with salt water and not suitable even for agriculture purpose. The water is suitable only for aquaculture by adopting proper treatment methods for sustainable production.

If the societal value of the life supporting environment is not recognized, there is a grave risk that a short period of prosperous growth of aquaculture industry based on intensive ecosystem exploitation, will turn into severe ecological, economic and social problems of conflicts. In addition it will disrupt cultural traditions of significance for sustainable resource use. The management of sectoral aquaculture for short-

term profits does not recognize the interrelation between resource use, environmental impact and working of ecosystems. There is huge potential for recycling of resources and reduction of waste and pollutants in aquaculture. It is inferred that environmental effects can be considerably reduced by rearing commercial species and other feedback between the ecosystem and the cultured species.

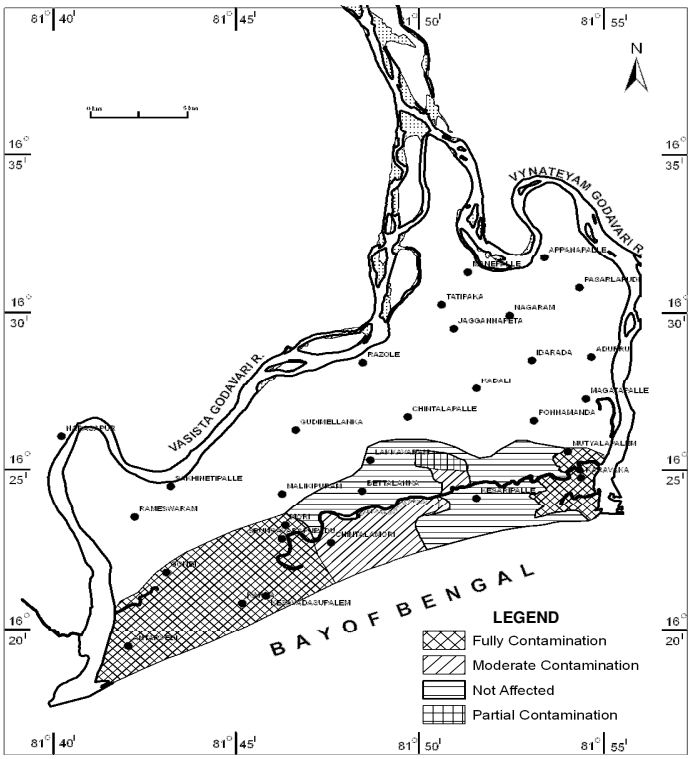


**Figure-2**
**Salt water intrusion map**

On the basis of this study it is felt necessary to promote aquaculture development in Andhra Pradesh through various policies that will benefit the farmers. But it is important that aquaculture and environmental preservation are achieved as a motto for sustainable development. In order to minmise the potential social conflicts and environmental issues, shared representation for sustainable aquaculture development by government authorities, farmers, manufacturers, supporters of aquaculture inputs, processors and traders of aquaculture products, financing institutions, researchers, special interest groups, professional associations, NGO's and others are felt essential. Identification of aquaculture zones, development of infrastructure and location of specific community master plan for satellite farming with participatory approach under the financial support of government at initial stage was suggested. Lower stocking density, reduced water exchange and good farm management practices including setting up of common effluent treatment plants by farmers having small farm holdings are recommended.

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