

Impact of Aquaculture on Physico-Chemical Characteristics of Water and Soils in the Coastal Tracts of East and West Godavari Districts, Andhra Pradesh, India

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Abstract— The Physico-chemical characteristics of water and soil in aquaculture areas were investigated. Water samples were analysed with respect to P^H , Phosphates, Sulphates, Total Alkalinity, Total Hardness, Total Dissolved Solids, Electrical Conductivity, Salinity, Chlorides, Nitrites, Nitrates, Ammonia, D.O., B.O.D. and C.O.D. The soil samples were analysed with respect to P^H , Total Dissolved Solids, Electrical Conductivity, Organic Carbon, Nitrogen, Phosphorus, Potassium, Sodium and Sulphur. Heavy metals like Iron, Manganese, Zinc and Copper were also measured in soil samples. A comparison of Irrigation canal waters of East and West Godavari in Antarvedi and Kalavapudi areas, which are flourished with intensive aquaculture practice were studied. Similarly soil samples were collected from dried aqua ponds from both the areas and are analysed for various parameters to understand the quality of soil and impact of aquaculture on these areas. Aquaculture impact is more pronounced in Kalavapudi area of West Godavari District in comparison to Antarvedi area of East Godavari District.

Keywords— Aquaculture, Soil salinity, Mangrove forest, Salt water intrusion, Heavy metals, Eutrophication and Soil nutrients.

I. INTRODUCTION

Aquaculture deals with the interaction of soil, water and biota. Conversion of agricultural lands to brackish water fisheries and / or shrimp aquaculture has been major threat to the coastal agriculture in tropical countries. Rice farms are the favored sites for conversion into aqua ponds because they pose several characteristics well suited for aquaculture (M.A.M.Siddique, 2012). Physico-chemical characteristics are highly important with regard to the occurrence, growth and abundance of species. Discharge of urban, industrial and agricultural wastes have increased the quantum of

various chemicals that enter the receiving water, which considerably alter the Physico-chemical characteristics. Nutrients like phosphorus and nitrogen from the domestic wastes and fertilizers accelerate the process of eutrophication and leads to the formation of algal blooms, which makes that water unfit for any purpose. Lentic water bodies have tremendous importance as they are recharging reservoirs for drinking water, domestic use and as infrastructure for aquaculture (B.R.Kiran, 2010).

The aquaculture boom along the East Coast region of India in 2001 – 2013, has transformed the landscape and environmental conditions in recent years (ARK Raju Penmetsa et al., 2013). The coastal belt of Godavari Delta is one such area where aquaculture activity is spreading in a rapid pace, in which barren dry mud flats, mangroves and fertile croplands are converted into aqua ponds. Conversion of agricultural and mangrove areas for aquaculture leads to salinization of surface water resource and agricultural land, besides causing pollution and diseases. The enormous population pressure, economic potential and the entrepreneurial attitude of majority of farmers in the Godavari Delta region have sufficiently transformed the land use; land cover pattern of the area, especially during the recent years (R.Sivakumar et al 2012). Water flowing out of an aquaculture pond can carry excessive nutrients, bacteria, other pathogens and polluting chemicals. These may harm surrounding habitats, cause algal blooms, poison ocean wild life and other severe disturbances. Feed and faecal matter from aquaculture facilities can deplete the dissolved oxygen levels, the waste water being discharged from an aquaculture operation may have large impacts outside the facility long before a problem is detected within (Top 10 Problems). Nutrients are represented as total concentration of nitrites, nitrates and phosphates which are indicators of the problems like algal blooms, reduction of dissolved oxygen, increase in organic carbon, release of toxic chemicals, change of taste and odour.

Waste water from shrimp farms is high in nitrogen, phosphorus, carbon compounds, organic matter, shrimp excretory products, some chemical and antibiotic residues. The discharge of pond effluent is found to have led to deterioration of water quality in irrigation canals of coastal areas. The salinization of surface water is another impact from shrimp farms to the receiving water. It is reported that shrimp farm construction can potentially alter surface water flow patterns and water quality (Emerson Kagoo I., 2002). Flow of water in canals was found to be affected by the temporary blockage of permanent division of canals. Further seepage of saline water from the ponds into the ambient areas also lead to salinization of ground waters. Seepage and discharges from aqua ponds can degrade the quality of water available to downstream users affecting drinking water, agriculture, capture fisheries and recreational uses of water bodies (EGSSA, 2009). The quality of water depends on the source and kind of soil it travelled over (Devi Priyamvada, 2013). Salinization of soil in nearby agricultural land and drinking water resources due to seepage and percolation from earthen shrimp ponds are the major environmental issues in aquaculture areas (M.Jayanthi, 2004).

Feeds are the basic materials of aquaculture, and the source of main nutritional matters. Most feeds of aquaculture are outside source foods and given to aquatic animals directly. Large amount of residual feeds and the excrements of aquatic animals affect the water environment. Braaten (1983) found that in the sea water, 20% of wet or dry feeds cannot be eaten by aquatic animals and directly disperse in the waters and become a pollution source. In the eaten feed, only 25% Nitrogen is used for the growth of fishes and other 75% N is excreted out into the ponds. It means that only 1/5 of feeds are utilized effectively and others are discharged to the environment as environmental pollution. It is obvious that, the feeds which have not been eaten seriously impact the water environment. Funge-Smith et al., 1998 studied the material balance in the shrimp pond of paddy field and found that only 10% N and 7% P were utilized in the aquaculture and others are entered into the environment by various forms.

Pumping of ground water to supply fresh water to marine shrimp farms has resulted in depletion and sometimes salinization of local water supplies, which causes water shortage for coastal communities. There have also been many reports of crop losses after agricultural land has become salinized by effluent water pumped out from shrimp farms onto land (Okomoda Victor, 2011). In some areas

pumping of ground water and/or construction or modification of canal systems has resulted in salt water intrusion into what were previously fresh water areas (Mynor Babu P., 2013). Disturbance and release of acid from acid sulphate soils as a result of pond digging has also had negative impacts on resource productivity, including aquaculture yields (Mitra Rajarshi 2011). Excessive acidity is likely to reduce disease resistance (TROPECA).

In order to have a clear understanding of the various Physico-chemical characteristics and aquaculture as well as effective management of soils for increased productivity of the ponds, one needs to have good knowledge on the nature and properties of soil. The present study evaluated the Physico-chemical characteristics of the water in irrigation canals and soil samples of dried aqua ponds in aquaculture intensive areas of East and West Godavari Districts of Andhra Pradesh, India.

STUDY AREA:

The study area (Figure 1) forms a part of the river Godavari deltaic system in East and West Godavari Districts of Andhra Pradesh in India. Water samples are collected from two Irrigation Canals – one in West Godavari lies within the geographical coordinates N16° 23' to N16° 33' latitudes and E 81°19' to 81°31' longitudes the Survey of India toposheet numbers 65H6 and 65 H7 and the other in East Godavari lies within the geographical coordinates of N16° 18' to 16°23' latitudes and 81° 42' to E 81° 57' longitudes and falls within the survey of India toposheet numbers 65H11 and 65H15. Similarly soil samples from the dried aqua ponds of the same areas are also collected.

II. MATERIALS AND METHODS:

Samples were collected by dipping one litre polythene bottles 10-cm beneath the water surface. The location of each pond was determined by Global Positioning System (GPS) using a Garmin e Trex Vista. Water P^H was measured with a portable pH meter at the time of sample collection. Water samples collected during field work have been analysed for various chemical parameters like pH, Phosphates, Total Alkalinity, Total Hardness, Chlorides, TDS, EC, Salinity, DO, BOD, COD, Ammonia, Nitrite and Nitrate.

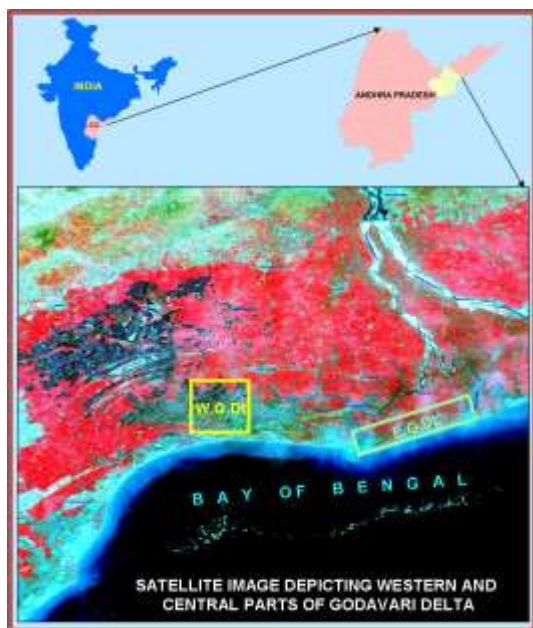


Figure.1. Location map of the study area

Soil samples were taken from different places from the bottom of each pond with a 5 cm diameter soil core. The 5 cm layer from the other core samples are combined to make a composite sample for each pond. The composite samples are dried in a mechanical convection oven at 60°C. One portion of each dry sample is pulverized with a hammer mill type soil crusher to pass a screen with 2.0mm openings and stored in plastic bags for chemical analysis. Water samples and soil samples are analysed according to standard protocol (APHA, 2008, Jackson M.L., 1958). Soil samples collected during field work have been analysed for various chemical parameters like pH, TDS, EC, Total Organic Carbon, Nitrogen, Phosphorus, Potassium, Sodium, Sulphur, Iron, Manganese, Zinc and Copper.

III. RESULTS AND DISCUSSION:

Most of the water samples indicated slightly alkaline nature with pH varying from 7.5 to 8.1 with an average of 7.6 in W.G.Dt and 7.6 to 8.3 with an average of 8.0 in E.G.Dt. High pH was the result of high rates of carbon dioxide removal by phytoplankton for use in photosynthesis which indicates high phytoplankton density. This is a common phenomenon in aquaculture ponds. In the practice of shrimp farming, farmers reported that, external bacterial diseases and parasitic infestations are much less in saline water than in natural fresh water. So, for the practice of shrimp farming, salt water is used from nearby creeks and also pumping from bore wells. Fresh water

does not contain more than 1000 ppm TDS, but in W.G.Dt area the TDS values ranged from 290ppm to 24000 ppm with an average of 6204ppm; whereas in E.G.Dt area the values range from 160 ppm to 4963 ppm with an average of 1233ppm. The average Electrical conductance of canal water was 8606 $\mu\text{S}/\text{cm}$ in West Godavari and 1698 $\mu\text{S}/\text{cm}$ in East Godavari respectively. For practical purposes, electrical conductance multiplied by the factor 0.7 will provide an estimate of TDS that agrees well. Salinity and Chloride contents contribute to taste and odour problems and same as TDS and EC in both the areas. High values of TDS, EC, Salinity and Chloride contents can be attributed to possible sea water intrusion in the area. In Pallepalem irrigation canal and Modi Aqueduct canal of W.G.Dt., the TDS, EC, Salinity and Chloride values are very high. In E.G.Dt. Antarvedi Kara and Karavaka waters have high values of TDS, EC, Salinity and Chlorides as these villages are adjacent to coast of Bay of Bengal.

Nevertheless, pond waters with less than 20ppm total alkalinity often have low abundance of phytoplankton because of low availability of carbon dioxide and removal of phosphates from water by acidic soils. In ponds with moderate alkalinities (20 to 50 ppm), the buffering capacity of the water is not great enough to prevent wide diurnal shifts in pH in response to phytoplankton photosynthesis. High total alkalinity is not harmful to fish, but waters with alkalinities above 150 or 200 ppm naturally have high pH values than lower alkalinity waters. Blue green algae tend to dominate phytoplankton communities in nutrient rich, high pH waters. Total alkalinity tends to increase with increasing Electric Conductance. Total alkalinity values ranged from 130ppm to 550ppm with an average of 260ppm in W.G.Dt and 80ppm to 838 ppm with an average of 241ppm in E.G.Dt. The waters with total hardness above 250ppm ponds filled with saline ground water. These waters tended to have greater total hardness than total alkalinity. In the study area, total alkalinity values are varied in Pallepalem (550ppm) and Modi (270ppm) but hardness of Modi Aqueduct is very high(1440ppm) when compared to Pallepalem (580ppm).The total hardness ranged from 64ppm to 1440ppm but the average is 456ppm in W.G.Dt and 40ppm to 330ppm with an average of 160ppm in E.G.Dt. Sulphate concentration ranged from 0.0ppm to 1613 ppm with an average of 536ppm in W.G.Dt and 0.0 ppm to 411ppm with an average of 68.5ppm in E.G.Dt. Sulphates contribute to osmotic pressure, and sulphur is a component of protein. Sulphates were observed only in Pallepalem and Modi aqueduct waters in

W.G.Dt. may be due to salt water intrusion from Upputeru. Sulphates were also observed in E.G.Dt., in Karavaka region may be also due to Sea water intrusion. The chloride concentration is 78 ppm to 11698ppm with an average of 2904ppm in W.G.Dt and 31ppm to 1630ppm with an average of 383ppm in E.G.Dt. Nitrate concentration of Antarvedi Kara (64.4ppm) is the only sample which crossed the permissible limit of 45ppm. The average values of comparison of water parameters in West and East Godavari are given in Table: 1 and shown in figures 2a and 2b.

Table: 1

COMPARISON OF Averages of WATER PARAMETERS OF IRRIGATION CANALS IN WEST AND EAST GODAVARI DISTRICTS

PARAMETER	W.G.DIST	E.G. DIST
P ^H	7.6	8.0
Phosphates(ppm)	0.32	0.0
Sulphates (ppm)	536.0	68.5
Total Alkalinity(ppm)	260.0	241.0
Total Hardness (ppm)	456.0	160.0
Chlorides (ppm)	2904.0	383.0
TDS(ppm)	6204.0	1233.0
EC(μS/cm)	8606.0	1698.0
Salinity (ppt)	4.2	1.0
D.O(ppm)	4.1	5.9
B.O.D(ppm)	19.4	5.3
C.O.D(ppm)	172.8	37.0
Ammonia(ppm)	3.9	0.3
Nitrite(ppm)	0.63	0.22
Nitrate(ppm)	8.9	15.0

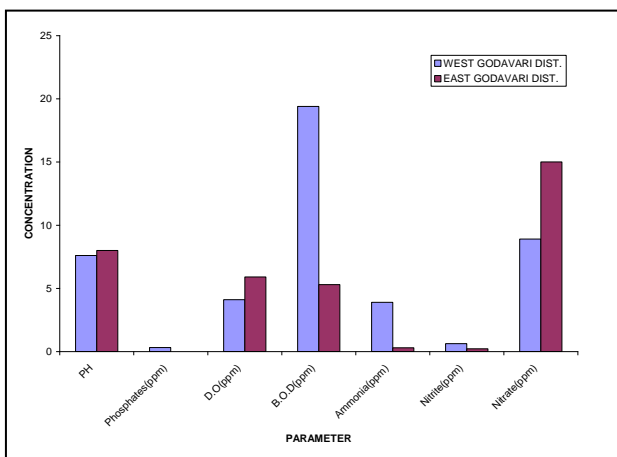


Figure.2a. Comparison of Chemical parameters of water

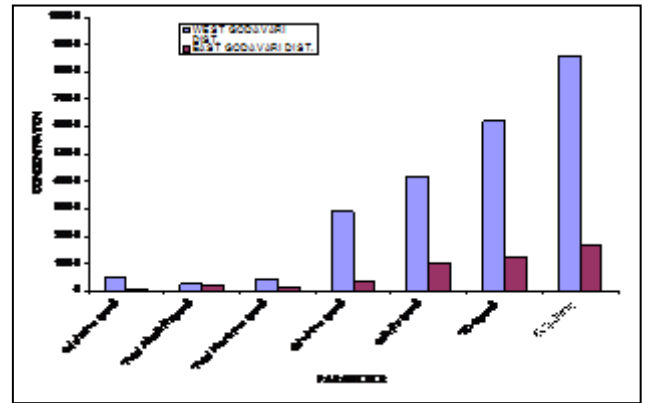


Figure.2b. Comparison of Chemical parameters of water

Pond soil plays an important role in the balance of an aquaculture system and consequently on the growth and survival of aquatic organisms. The pond soil can function as a buffer to aquatic ecosystem. It provides all the important nutrients into water and serves as a biological filter through the adsorption of the organic residues of feed, fish /shrimp excreta and algal metabolites. Feed applied to increase fish / shrimp growth is settled at the pond bottom. An excessive application of formulated feed results in the loss of the capacity of soil to keep uniformity in constituents. In semi-intensive and intensive fish/shrimp ponds, significant quantities of organic material can be accumulated in bottom sediments. Inorganic nutrients released to the water from microbial decomposition of residual feed can stimulate heavy phytoplankton bloom. In the shallow water bodies, there is an intensive interchange of organic or mineral compounds between the soil and water and higher water exchange may result in large amount of sediment input.

Soil colour was highly variable with hues of red, brown, grey and black. The lighter colours, red and brown suggest that, the soil contains iron oxide and is aerobic. Darker colours suggest a higher organic matter content or anaerobic condition. The present soil in the study area is mostly black in color and in some areas it is red. The black color of soil indicates high aeration, high available nitrogen and high fertility. The present soil of fish ponds is black cotton soil exhibiting the behaviour of clay soils. These soils have extremely large surface area with fine pores, poor drainage in nature, high water holding capacity, act as a storehouse for aeration and nutrients.

Soil P^H averaged 7.4 in W.G.Dt and 7.6 in E.G.Dt., but the best pH for pond soil is 6.5 to 7.0. Concentration of organic carbon was between 0.84 and 2.1 percent with an average of 1.57 percent in

W.G.Dt and 0.15 to 1.05 percent with an average of 0.69 percent in E.G.Dt. Boyd (2000) re-evaluated organic carbon concentration in Aquaculture ponds and concluded that pond soil contain two types of organic carbon. The newly deposited organic carbon is highly reactive, and the old, residual organic carbon decomposes very slowly. The TDS, EC and percentage of Carbon in Modi aqua pond soils are very high in comparison to soils of other ponds in both the areas.

Average concentration of total Nitrogen is 125.4 Kg/Acre in W.G.Dt. Minimum and maximum concentrations are 15 and 235 kg/Acre respectively. In E.G.Dt the average concentration of total Nitrogen is 60 kg/Acre and minimum and maximum concentrations are 9.0 and 104 kg/Acre respectively. Low concentrations of Nitrogen are normal in soils with low Organic matter concentrations, because Nitrogen is present in pond soil primarily as a component of Organic matter. Nitrogen in present soil samples is higher and sufficient for good productivity of fishes. Nitrogen values are higher in Kalavapudi aqua pond in comparison to other ponds. Sulphur concentration ranged from 37 to 551 kg/Acre with an average of 256kg/Acre in W.G.Dt and 27.0 to160 Kg/Acre with an average of 74 Kg/Acre in E.G.Dt. Sulphur values are very high in Kalavapudi aqua ponds. Potassium average 474 Kg/Acre. Minimum 426kg/Acre and Maximum 547Kg/Acre in W.G.Dt. and average 238 Kg/Acre with minimum 55kg/Acre and maximum 551 Kg/Acre in E.G. Dt.

Table: 2

COMPARISON OF AVERAGES OF SOIL PARAMETERS OF AQUA PONDS OF WEST AND EAST GODAVARI DISTRICTS

PARAMETER	W.G.DIST	E.G. DIST
p ^H	7.4	7.6
TDS(ppt)	4.426	1.12
EC(ms/cm)	5.714	1.7
TOC (%)	1.57	0.69
Nitrogen(Kg/Acre)	125.4	60.0
Phosphorus (Kg/Acre)	212.0	50.0
Potassium (Kg/Acre)	474.0	238.0
Sulphur (Kg/Acre)	256.0	74.0
Sodium (ppm)	168.0	131.0
Iron (ppm)	44.0	33.8
Manganese(ppm)	16.08	13.50
Zinc (ppm)	2.517	0.955
Copper (ppm)	4.195	2.583

The availability of phosphorus is important to aquatic productivity owing to the fact that phosphate ions in soil form insoluble compounds with iron and aluminium under acidic conditions and with calcium under alkaline conditions rendering the phosphorus ion unavailable to water bodies. Similarly Phosphorus concentration average is 21Kg/Acre with minimum 62 Kg/Acre and maximum 355 kg/Acre in W.G.Dt and average 50Kg/Acre with minimum 14 kg/Acre and maximum 79kg/Acre in E.G.Dt. Soil samples of Pallepalem and Modi aqua ponds have higher values. Sodium concentration ranges from minimum 138kg/Acre and maximum 228kg/Acre with an average of 168Kg/Acre in W.G.Dt and minimum 47 Kg/Acre and maximum 200 kg/Acre with an average of 131 kg/Acre in E.G.Dt. It is usually assumed that high concentrations of calcium, magnesium and potassium are beneficial. High sodium concentration is acceptable provided that there are also high concentrations of other ions. Soils high in sodium, but low in other major cations have exceedingly high P^H.

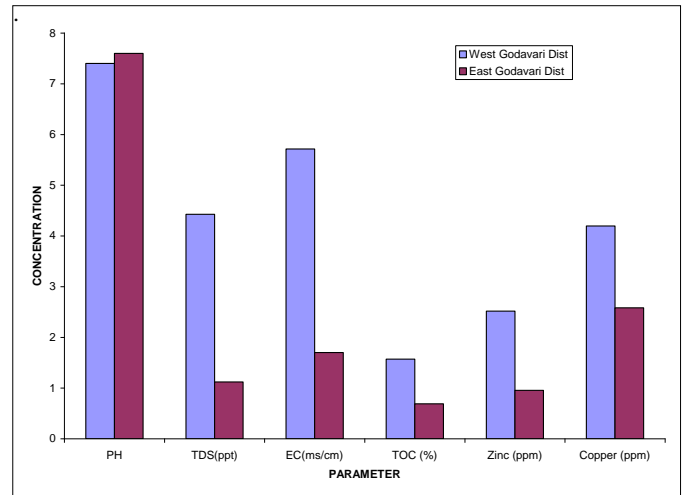


Figure 3a. Comparison of Chemical parameters of soils

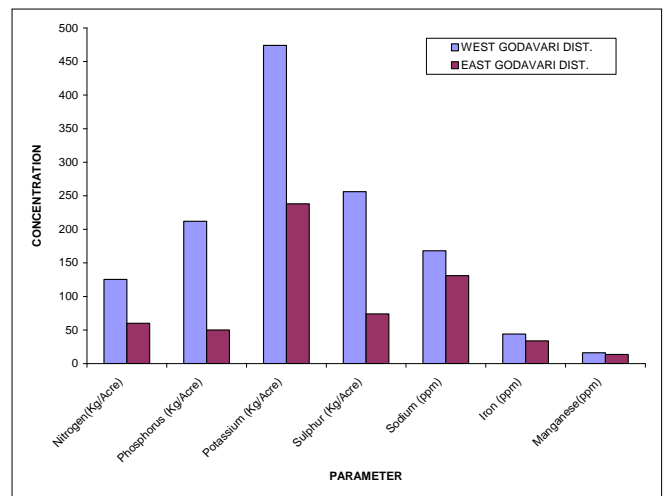


Figure.3b. Comparison of Chemical parameters of soils

Heavy metals like Iron, Manganese, Zinc and Copper which cause toxicity to the soil are found to be high in both the areas, and just like other parameters they are comparatively higher in W.G.Dt area than E.G.Dt area. The average value of Iron in W.G.Dt is 44.0 ppm in comparison to E.G.Dt where the average value is 33.8ppm. In Srungavarappadu (E.G.Dt) the Iron value is as high as 55.56 ppm and in Modi (W.G.DT) the value is still higher 57.51ppm. Similarly Manganese average value is 16.08ppm in W. G.Dt and it is 13.5ppm in E.G.Dt. Zinc average value is 2.517ppm in W.G.Dt and 0.955ppm in E.G.Dt. Copper mean values are 4.195ppm and 2.583 ppm in W.G.Dt and E.G.Dt respectively. Copper values are very high (11.3ppm) in Prathellameraka of W.G.Dt. The average values of comparison of soil parameters are given in Table: 2 and shown in figures 3a and 3b

Soil solution contain Bicarbonates, Sulphates and Chlorides as major anions, which ions are water soluble and usually present only in the pore water. Therefore major anions were not measured in soil samples (Kam Silapajarn, 2004)

IV. CONCLUSION

The analysis of both water samples from irrigation canals and soil samples from the bottom of aqua ponds in parts of West and East Godavari shows that, West Godavari canal waters and bottom soils of aqua ponds were more affected by aquaculture in comparison to East Godavari District. The rapid and over-concentrated development of aquaculture has resulted in deterioration of soil and water quality. The pumping of sea or salt water into shrimp farms and its long contact with the fertile soils is evident in some places of the study area. Some of the agricultural lands situated nearer to the aquaculture tanks facing the water logging problem. So that crop yield becomes very low.

All most all parameters of the soil like TDS, EC, TOC, Nitrogen, Potassium, Sodium, Sulphur, Iron, Manganese, Zinc and Copper are increased with the increase of the age of the pond. Only P^H is slightly less in W.G.Dt than E.G.Dt. The possible reasons are i. Aquaculture in the study area of West Godavari was started much earlier 25 to 30 years back in comparison to East Godavari, where it was started just 10-15 years back. So, deposition of organic matter and other nutrients may be more in the bottom soils of aqua ponds and thereby running waters of canals. ii. Aquaculture practice in the study area of West Godavari is very intensive (Most of the land is converted into aquaculture) in comparison to East Godavari. iii. The

influence of Upputeru which joins Bay of Bengal in this area is very high. The higher values of heavy metals indicate that metals are accumulated at the bottom of the aqua pond as sediment and have a negative impact on the pond productivity as well as neighbouring environment. Finally, inland fish/shrimp farming represents a situation where a significant short-term economic benefits may be obtained, but at the risk of creating long-term accumulative environmental impacts.

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