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Impact of Aqua Ponds on Soils of Godavari Western Delta, West Godavari District, Andhra Pradesh, India

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Abstract: - Aquaculture is a key part of the regional economy in India and many other parts of Asia, but at present it is also responsible for diverse problems related with the environmental health. The industry is known to cause soil salinization, which can affect the productivity of surrounding croplands. Salinization of soil in nearby agricultural land and drinking water resources due to seepage and percolation from aqua ponds is one of the environmental issues in aquaculture as it merges and interacts with the environment. The high seepage rate not only results into water loss but also reduces pond fertility. In the present paper, soil salinization of agricultural lands around aqua ponds due to seepage of water from ponds was studied. The ponds selected were viz. aqua ponds with clay type of soil without any trench, a nearby aqua pond with a small trench of one meter width, a pond with integrated aquaculture and agriculture and a pond with sandy soil with one meter trench. Samples were collected from 0 meters (outer side of the pond or trench bund) up to 50meters distance from the pond and 10cm to 30 cm depth between 0 m to 50 meters and analyzed for pH, TDS, EC, Total Nitrogen, Phosphorous, Potassium, Sulphur, Sodium etc. Relationship with soil texture and seepage was also established. Seepage is more in case of a pond without any trench when compared to a pond with trench. Salinization due to seepage was observed to a long distance in case of sandy soils than clay soils. More soil acidification was observed up to 10cm depth from surface than deeper soils.

Keywords: - Aqua ponds, Salinization, Soil texture, Buffer zone, Seepage, Sodocity, Acidification, Agriculture

I. INTRODUCTION

Aquaculture is the fastest growing food sector. In the past decades aquaculture around the world has been pursued only on the basis of economic costs without considering the social costs and negative impacts on the environment. Aquaculture has diversified and intensified contributing significantly to economic and social well being in many countries. Of this, a large scale of production comes from the small scale production in developing countries like India. But marine aquaculture has been heavily criticized for its environmental impacts including pollution from fish waste and uneaten food escapes, chemicals to control diseases and parasites, and ecological impacts of sourcing raw materials from the sea to produce fish [1,2,3].

The east coast of India offers excellent opportunity for irrigated agriculture due to availability of vast stretches of arable fertile land created by river and coastal deltas [8]. The coastal regions suffer from environmental degradation due to increased salinity of soils, canals and ponds [11,12].

Seepage of salt water into the adjacent agricultural lands from aquaculture ponds is well documented and sometimes it makes cultivation impossible [10]. The seepage may take place through salt water leakage, aquaculture pond overflow and leaching from sludge pile during rain fall. In general, paddy fields are typically located behind the dense aqua ponds. Complaints were frequently received from local people about low yields and the contamination of ground water aquifers rendering large areas of land unsuitable for rice cultivation due to salinization [5,7]. The salinity and sodocity of soil were found to be inversely proportional to the distance from the sea and aquaculture ponds [6].

Study Area:-

Aquaculture is predominant land use practice in deltaic environment of Godavari western delta, having geographical coordinates of 16°31' N, 81°28' E, with toposheet number 65H/6 of clay soil, 16°33' N, 81°35'E with toposheet number 65H/10 and integrated pond 16°34' N, 81° 32' E with toposheet number 65H/10, West Godavari district. The location map of the study area is shown in the figure 1. Aqua ponds are selected and 28 samples are collected from Bhimavaram, Kalla and Palakoderu mandals of West Godavari district. These samples are collected from clay and sandy textured deltaic formations. Morphological features like tidal flat / mudflat and paleo beach regions are noticed in this region.

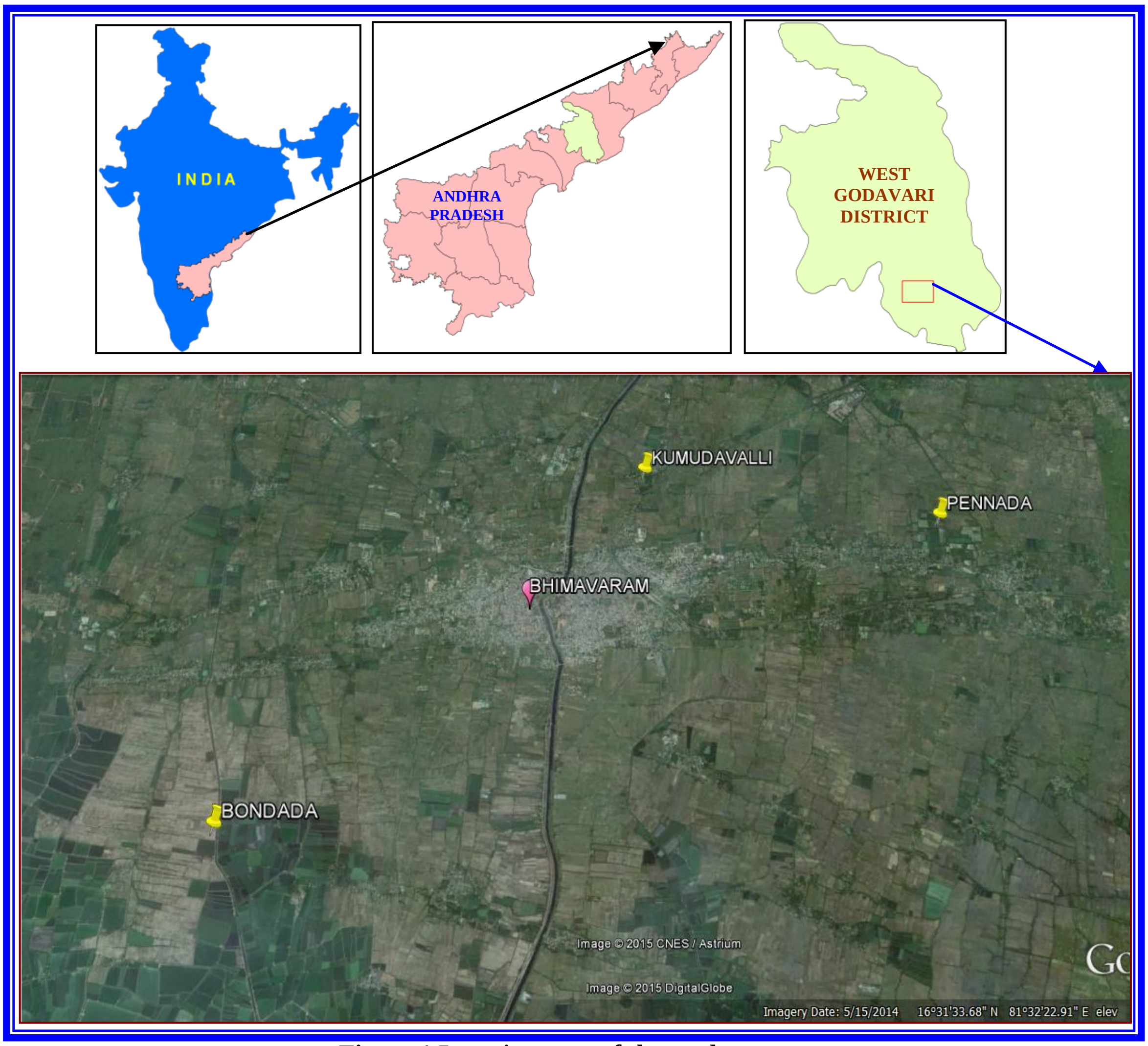

Figure.1 Location map of the study area

II. MATERIALS AND METHODS

Aqua ponds are selected for analysis viz. first pond with clay soil type without any trench, second in the same area (Clay type soil) with a small 1 meter trench, third pond with sandy soil also with 1 meter trench and fourth tank with clay type of soil with integrated agriculture and aqua culture practice. Soil samples are collected with the aid of a Global Positioning System (GPS) - Garmin eTraxvista.

In the adjacent agriculture fields of the above ponds, samples are collected (1kg) from 0 to 50 meters. The samples were dried in the shade and analysed for pH, TDS, EC, Total Nitrogen (TN), Phosphorus (P), Sulphur(S), Sodium (Na), Potassium (K) and Soil texture- Sand, Silt and Clay. For analysis of particle size, soil was gently crushed to pass through a 2-mm sieve; water soluble salts are removed by washing with distilled water and organic matter was destroyed by oxidation with hydrogen peroxide. Soil was dispersed in a solution prepared by dissolving sodium carbonate and sodium hexa meta phosphate. Sand was separated and determined by sieving and washing. The dissolved soil suspensions are then placed in 1000 ml sedimentation cylinder for determination of silt and clay by the pipette method. Soil samples are analysed according to standard protocol [13]. However more emphasis was given on pH and Electrical conductivity to know the acidification of the soil and increased saltation by the seepage from aqua ponds. Emphasis was also given to soil texture of sand, silt and clay to study the seepage variation with the type of soil. Similarly soil samples are also collected from surface to 10cm, 20 cm and 30 cm depth all along the 50 meters distance from the pond.

III. RESULTS AND DISCUSSION

The aquaculture sector in India especially shrimp farming is passing through a transitional stage and facing many problems. The condition of pond's bottom and the exchange of substances between soil and water are strongly influenced water quality. The water is slowly leaked through earthen bunds of the pond and altering the soil quality of nearby paddy fields. Various physico-chemical parameters are analysed and tabulated in the following tables1, 2, 3 and 4. Horizontal and vertical distribution of chemical parameters are analysed and their average values of pH, EC, TDS and Na are shown in table 5 & 6 and graphically represented in the figure 2 & 3. Textures of the soils and their percentages are calculated and shown in table 7.

Table 1.Physico-chemical characteristics in agricultural soils adjacent to aquaculture (Prawn pond) without trench in Clayey Soil

S. No	Distance from prawn pond (meter)	pH	T.D.S (ppt)	E.C (mS/cm)	T.N kg/Acre)	P (kg/Acre)	K (kg/Acre)	S (kg/Acre)	Na (ppm)	Sand (%)	Silt (%)	Clay (%)
1	2.74	8.0	1.50	2.20	76	307	270	102	180	5.0	25.8	69.2
2	3.35	7.9	1.40	2.10	77	272	232	91	177	5.4	25.6	69.0
3	5.48	7.5	1.80	2.60	121	291	297	228	175	4.9	22.6	72.5
4	6.40	7.3	1.60	2.30	32	284	297	196	175	5.7	29.5	64.8
5	7.32	7.1	1.70	2.40	111	290	297	193	172	5.7	28.4	65.9
6	8.23	7.0	1.80	2.60	188	277	286	163	172	5.1	26.5	68.4
7	9.14	7.0	1.60	2.30	81	267	270	153	163	4.8	22.5	72.7
8	13.71	6.9	1.80	2.50	178	256	270	141	167	5.0	36.3	58.7
9	18.29	6.9	1.50	2.10	176	235	270	156	160	4.6	33.1	62.3
10	22.86	6.7	1.11	1.60	169	228	243	136	145	5.0	30.2	64.8
11	27.43	6.9	1.00	1.43	167	210	243	124	143	5.0	25.8	69.2
12	32.00	6.6	1.08	1.57	143	201	254	142	140	4.8	27.4	67.8
13	41.18	6.8	0.95	1.39	134	197	270	128	137	5.2	28.7	66.1
14	50.29	6.6	0.72	1.03	107	188	286	132	133	5.5	24.7	69.8
15	59.44	6.8	0.96	1.03	107	173	286	123	133	5.9	31.5	62.6
16	68.58	6.7	0.94	1.03	67	163	270	89	130	5.9	30.4	63.7

Table 2. Physico-chemical characteristics in agricultural soils adjacent to aquaculture (Prawn pond) with 1m trench – Clayey Soil

S.No	Distance from pond (meter)	pH	T.D.S (ppt)	E.C (mS/cm)	T.N (kg/Acre)	P (kg/Acre)	K (kg/Acre)	S (kg/Acre)	Na (ppm)	SAND (%)	SILT (%)	CLAY (%)
1	00	7.9	1.40	2.10	77	272	232	91	177	5.4	24.0	70.6
2	05	7.0	1.80	2.60	188	277	286	163	172	5.2	26.6	68.2
3	10	6.9	1.80	2.50	178	256	270	141	167	5.0	25.9	69.1
4	15	6.9	1.50	2.10	176	235	270	156	160	4.6	33.1	62.3
5	20	6.7	1.11	1.60	169	228	243	136	145	5.0	36.3	58.7
6	25	6.9	1.00	1.43	167	210	243	124	143	5.0	30.3	64.7
7	30	6.6	1.08	1.57	143	201	254	142	140	4.8	22.5	72.7
8	40	6.8	0.95	1.39	134	197	270	128	137	5.2	28.7	66.1
9	50	6.6	0.72	1.03	107	188	286	132	133	5.5	27.7	66.8
10	60	6.8	0.96	1.03	107	173	286	123	133	5.9	31.0	63.1
11	70	6.7	0.94	1.03	67	163	270	89	130	5.9	20.1	74.0

Table 3. Physico-chemical characteristics in clayey soil of Integrated culture system (Paddy field with Aquaculture)

S. No	Distance from pond (meter)	pH	T.D.S (ppt)	E.C (mS/cm)	T.N (kg/Acre)	P (kg/Acre)	K (kg/Acre)	S (kg/Acre)	Na (ppm)	SAND (%)	SILT (%)	CLAY (%)
1	00	6.8	0.59	0.83	129	126	162	44	123	2.4	14.4	83.2
2	05	6.8	1.07	1.55	103	123	151	108	130	2.7	22.1	75.2
3	10	6.8	1.24	1.82	101	128	162	141	138	3.4	12.2	84.4
4	15	6.6	0.84	1.20	100	126	162	137	135	3.7	12.1	84.2
5	20	7.2	0.83	1.20	88	121	162	122	128	2.9	13.0	84.1

Table 4. Physico-chemical characteristics in agricultural soils adjacent to Aquaculture (Fish pond) without trench – Sandy Soil

S .No	Distance from pond (meter)	pH	T.D.S (ppt)	E. C . (mS/cm)	SAND (%)	SILT (%)	CLAY (%)
1	00	7.4	4.50	6.70	13.8	20.5	65.7
2	05	6.5	6.80	10.30	17.8	18.1	64.1
3	10	6.5	4.30	6.20	21.7	17.5	60.8
4	15	6.5	4.90	7.10	22.1	19.8	58.1
5	20	6.6	3.40	5.20	23.2	16.9	59.9
6	30	6.4	3.30	4.82	23.0	17.2	59.8
7	40	6.6	3.20	4.70	23.4	13.6	63.0
8	50	6.4	2.90	4.30	11.7	21.6	66.7

Table 5. Horizontal variation of chemical parameters in different ponds

Distance →	0 m				05m				10m				20m			
Pond ↓	pH	TDS Ppt	EC mS/cm	Na ppm	pH	TDS ppt	EC mS/cm	Na ppm	pH	TDS ppt	EC mS/cm	Na ppm	pH	TDS ppt	EC mS/cm	Na ppm
P1	7.1	3.7	5.5	245	5.9	2.3	3.4	203	6.5	1.7	2.5	188	6.6	1.3	2.1	183
P2	7.9	1.4	2.1	177	7.0	1.8	2.6	172	6.9	1.6	2.5	167	6.5	1.1	1.6	145
P3	6.8	0.6	0.8	123	6.8	1.0	1.5	138	6.8	1.2	1.8	135	6.6	0.8	1.2	128
P4	5.7	3.3	4.7	184	5.0	4.2	6.0	192	4.8	4.2	6.1	224	4.7	4.2	6.0	158

Distance →	30m				40m				50m			
Pond ↓	pH	TDS ppt	EC mS/cm	Na ppm	pH	TDS ppt	EC mS/cm	Na ppm	pH	TDS ppt	EC mS/cm	Na ppm
P1	6.1	1.3	2.1	172	6.5	1.3	2.1	163	6.5	1.2	1.8	148
P2	6.6	1.0	1.5	140	6.8	0.9	1.4	137	6.6	0.7	1.0	133
P3	7.2	0.8	1.2	128	7.2	0.8	1.1	120	7.2	0.7	0.8	115
P4	4.9	3.8	4.5	142	5.0	3.8	4.5	156	5.0	3.0	4.4	136

P1- Pond without trench in clayey soil, P2- Pond with trench in clayey soil, P3- Pond with integrated practice, P4- Pond with trench in sandy soil

Table 6. Vertical variation of chemical parameters in sandy (Pond with trench) soils

Distance →	0 m				05m				10m				20m			
Depth ↓	pH	TDS ppt	EC mS/cm	Na ppm	pH	TDS ppt	EC mS/cm	Na ppm	pH	TDS ppt	EC mS/cm	Na ppm	pH	TDS ppt	EC mS/cm	Na ppm
0 cm	5.7	3.30	4.70	184	5.0	4.20	6.00	192	4.8	4.20	6.10	224	4.7	4.20	6.00	155
10 cm	5.8	1.23	1.75	212	4.8	1.23	1.75	200	4.9	1.22	1.74	158	4.6	1.50	2.10	156
20 cm	6.0	0.93	1.32	220	5.7	0.97	1.38	124	6.6	0.73	1.04	158	5.2	1.18	1.68	142
30 cm	6.7	0.53	0.76	220	7.0	0.69	0.98	160	7.2	0.57	0.81	152	6.8	0.72	1.02	132

Distance →	30m				40m				50m			
Depth ↓	pH	TDS ppt	EC mS/cm	Na ppm	pH	TDS ppt	EC mS/cm	Na ppm	pH	TDS ppt	EC mS/cm	Na ppm
0 cm	4.9	3.80	4.50	142	5.0	3.80	4.50	156	5.0	3.00	4.40	136
10 cm	4.7	1.16	1.65	150	4.7	1.17	1.67	126	5.8	0.94	1.34	124
20 cm	5.9	0.76	1.08	132	6.1	0.67	0.95	120	7.5	0.57	0.81	118
30 cm	7.1	0.49	0.70	132	7.2	0.48	0.68	120	7.7	0.48	0.68	116

Table7.Texture of the soil (Percentages of Average Values)

S.NO	Sand %	Silt %	Clay %
P1	5.2	28.0	66.8
P2	5.2	27.8	67.0
P3	3.0	14.8	82.2
P4	19.6	18.1	62.3

The values of pH are decreased from the pond to agricultural land whereas TDS, EC, organic carbon, total nitrogen, phosphorus, potassium, sodium and sulphur increased in the beginning and slowly decreased up to 70 meters. The seepage of effluents discharged from an inland shrimp farm increases salinity of soil up to 70 meters. Any land area with recorded EC value more than 2 mS/cm is considered to be salt affected area and is not suitable for cultivation. Accumulation of salts in soil can degrade the vegetation and soil quality.

The decrease in pH indicates the acidification of the soil. In case of sandy soil, pH varies from 5.7 to 4.7 with an average of 5.0, infers more acidification, pH ranges from 7.1 to 5.9 with an average of 6.4 for clay pond without any trench and 7.9 to 6.6 with an average of 6.8 with trench for the clay soil. In case of integrated culture, change in pH is only from 7.2 to 6.6 with an average of 6.8. Electrical conductivity values increased in the order of 4.71 to 6.57 with an average of 5.9 in case of sandy soil, 1.8 to 5.5mS/cm with an average of 2.7 (without trench), 1.03 to 2.6 mS/cm with an average of 1.8 mS/cm (with trench) and 0.83 to 1.82 with an average of 1.3 mS/cm (integrated culture). It indicates seepage is very high in sandy soil (more permeable) and moves to more distance which causes high content of salt deposition when compared to clay soils(less permeable).

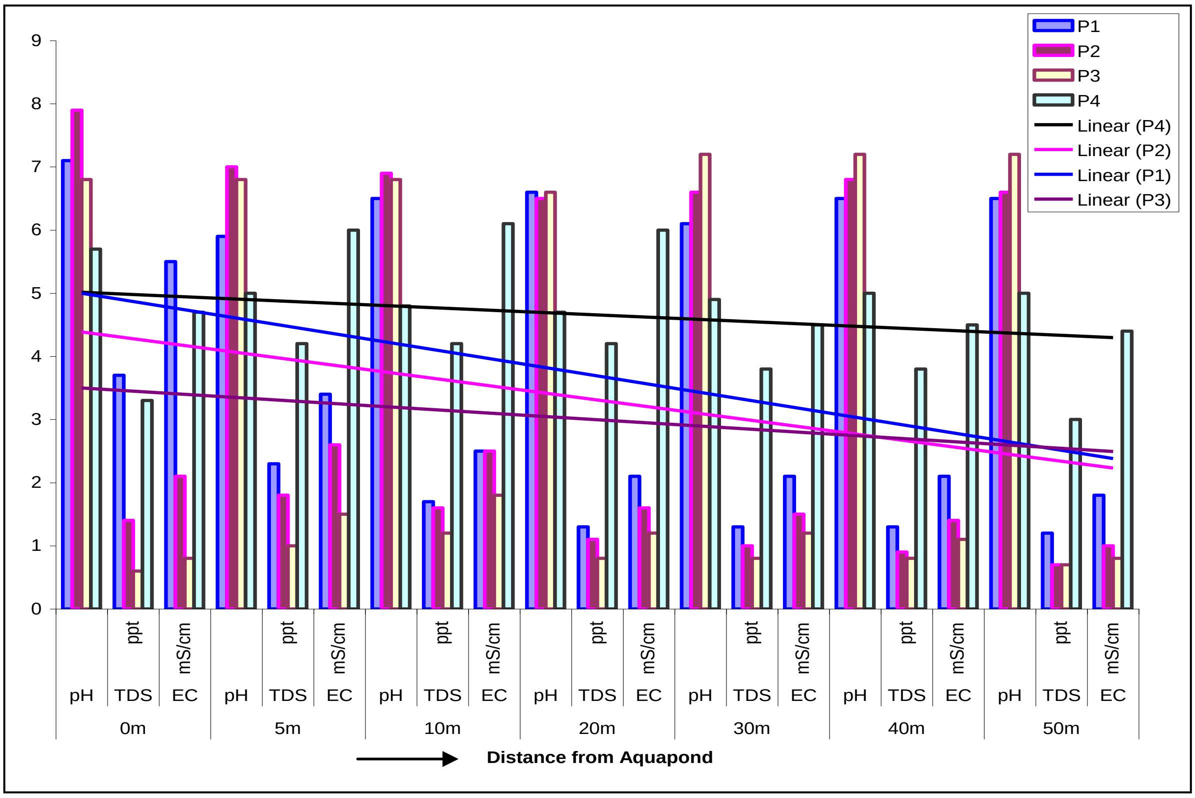

Figure2. Horizontal variation of chemical parameters in different ponds

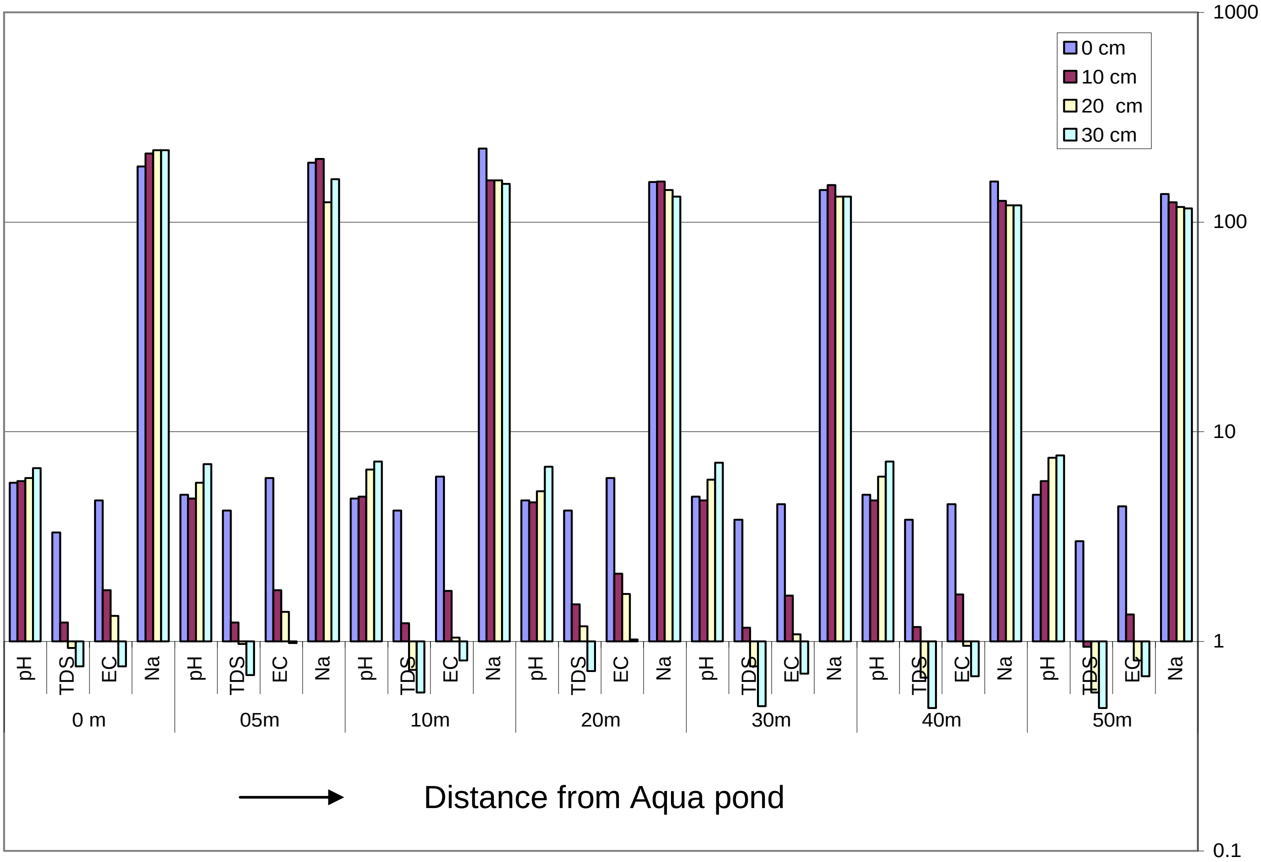

Figure 3. Vertical variation of chemical parameters in soil samples adjacent to aqua pond in sandy soils

In aqua pond with clay soil (without trench) percentage of clay varies from 58.7% to 72.7% with an average of 66.8%, the silt content percentage varies from 36.3% to 22.6% with an average of 28.0%, the percentage of sand varies from 4.6% to 5.9% with an average of 5.2%. In the pond with clay soil (with trench), the percentage of clay varies from 58.7% to 74.0% as maximum with an average of 67.0%, the silt varies in between 20.1% to 36.3% and with an average of 27.8% and the sand content varies from 4.6% to 5.9 % with an average of 5.2%. In case of sandy soils, the clay percentage varies from 58.10% to 66.70 % with an average of 62.3%, silt percentage from 13.6% to 21.6% with an average of 18.1% and sand percentage varies from 11.70% to 23.7% with an average of 19.6%. In integrated pond the percentage of clay varies from 75.2% to 84.4% with an average of 82.2%, silt varies from 12.1 % to 22.1% with an average of 14.8% and sand 2.4% to 3.7 % with an average of 3.0%

The values obtained from surface to 30 cm depth shows that pH varies from 4.6 to 5.8 with an average of 4.2 at 10 cm depth, which indicates that soil acidification is maximum up to 10 cm depth. This is followed by 5.2 to 7.5 with an average of 6.1 at 20cm depth, which is moderately acidic in nature and finally 6.7 to 7.7 at an average of 7.1 at 30 cm depth, which is more or less not affected by seepage water. This is also supported by EC values of 1.34 to 2.14 with an average of 1.72 mS/cm EC values at 10 cm depth, 0.81 to 1.68 with an average of 1.18mS/cm at 20cm depth and 0.68 to 1.08 mS/cm with an average of 0.75 mS/cm at 30 cm depth respectively. It clearly depicts the seepage problem is severe up to 10cm depth.

Sodium concentration decreases from the pond to 50m distance as 245 to 148 ppm with an average of 186 ppm in pond with clayey soil without any trench, 177 to 133 ppm with an average of 153ppm in pond with clayey soil having one meter trench (10-30% decrease) and 224 to 94 with an average of 201 ppm in pond with sandy soil with one meter trench (2.0 to 35 % increase) and 123 to 138 with an average of 130 ppm in case of clayey soil with integrated aquaculture and agriculture which are very much lower than all the above three ponds and variation is also negligible. This clearly indicates the efficacy of buffer zone between aqua pond and agricultural fields and the sustainability of integrated aqua and agriculture practice.

IV. CONCLUSIONS

The aquaculture and agriculture can coexist successfully in coastal areas if there are buffer zones in between. The above analysis clearly demonstrates the worth of a buffer zone between aquaculture pond and agriculture fields. If there is a fresh water buffer zone of 10 m width and 4m depth, then aqua farm will not impair paddy field in case of clayey soils but 50 meters buffer zone is required in case of sandy soils .In places where it is not possible to have a buffer zone with fresh water, a gap of more than 50m between the aqua pond and rice field is necessary. The country stands to gain on various counts through shrimp farming and it will be a loss if we fail to promote it in a sustainable way. The above analysis reflects that the buffer zone was found to be helpful in preventing salinization of the adjacent agricultural fields and to maintain electrical conductivity less than one was found which is harmless to the rice crop.

Aquaculture combined with rice production enables a farmer to grow two crops on the same land. The fish will consume algae and weeds, fertilize the water and improve soil texture. In recent years, there has been increasing emphasis on developing sustainable integrated culture with micro algae, filter feeders and deposit feeders. It is ideal to accommodate two or more ecologically compatible species in one system without conflict for food and space and can co-inhabit in same environment.

By integrating fed mariculture (fish and shrimp) with inorganic and organic extractive mariculture (seaweeds and with filter feeding bivalves), the wastes of one resource consumer become a resource (fertilizer or food) for others in the system. Such balanced and integrated ecosystem approach provides nutrient bioremediation capacity, mutual benefits to co-cultured organisms and economic diversification by producing other value added profitable products [9].

Finally, inland shrimp farming represents a situation where significant short term economic benefits may be obtained, but at the risk of creating long term cumulative environmental impacts [4].

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REFERENCES

[1]. Physical and chemical characteristics of Pond Water and Bottom Soil in Channel Catfish Ponds in West Central –Alabama:Bulletin: Kom Silapajarn, C.E. Boyd and Orawan Silpajarn; 655:1-441 (166-168), 2004.

[2]. Effects of water quality on soil, plants and irrigation equipment, Department of Agriculture and Fisheries, Queensland Government site.

[3]. Risk analysis of the soil salinization due to low salinity shrimp farming in Central plain of Thailand- Seng-keh Teng; GESAMP reports and studies, No-76.

[4]. Shrimp, Salinity and Sustainability- An Assessment from Southern India, SANDEE No: 41-09,L.Umamahewari, K.Omar Hattab, P.Nasurudden and P.Selvaraj,2009.

[5]. Comparative Study of Physico-chemical properties of soil according to the age of aquaculture pond of Bangladesh..Mesopot. J.Mar.Sci., M.A.M.Siddique, P.Barua and M.H. Ghani, 27(1), 29-38. 2012.

[6]. Influence of Brackish water aquaculture on Soil Salinization, International Journal of Research in Chemistry and Environment, Mitra Rajarshi, Santra S.C. :1(2) 166-168,2011.

[7]. Aquaculture Vis-à-vis agriculture, Aqua-Byte, Naga, the ICLARM.,S.A. Khan, P. Lyla, N.Veerappan and S. Raja Gopal. Ed by M.V. Gupta. 23(13), 2000.

[8]. Studies on the effect of shrimp farming on adjacent agricultural land and underground water in Cuddalore district of Tamilnadu, Applied Fisheries and Aquaculture. B.P. Gupta, K.K. Krishnan, K.O.Joseph, M.Muralidhar, A.Nagarvel and V. Parimala.11(1):47-50, 2002.

[9]. Environmental Guidelines for Small Scale Activities in Africa. EGSSA, USAID, Fisheries:1-25,2009

[10]. Effects of Aquaculture on Environment. A Seminar on Aquaculture and the environment, Effects and Best practices, Okomoda Victor J- DE/12925/08:962,2011

[11]. Shrimp cultivation with water salinity in Bangladesh. The Implications of an Ecological Model. Universal Journal of Public Health. Md.Mizanur Rahman, Vincentos Ronaldas Giedraitis, Leslie Sue Lieberman and Tahmina Akthar vaida Taminskiene,1(3)131-142. DOI: 10-13189/ujph.2013010313, 2013.

[12]. Impact of Aquaculture on Physico-Chemical characteristics of Water and soils in the Coastal Tracts of East and West Godavari Districts, Andhra Pradesh, India., International journal of engineering Trends and Technology, A.Rama Krishna Raju Penmesta, Sitarama Reddy Muppidi, Raghuram Popuri , Suribabu Golla and Rambabu Tenneti 6(6):313-319, 2013.

[13]. “Soil Chemical Analysis”, Jakson, M.L., Prentice Hall, Englewood Cliff, New Jersey, 1958.

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