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Full Length Research Paper

Ground water pollution due to aquaculture in east coast region of Nellore district, Andhrapradesh, India

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Ground water quality parameters were studied for pollution due to aquaculture in the east coast region of district Andhrapradesh, India. Over a period of two years, 46 groundwater samples were collected for analyses. The results showed that the alkalinity ranged from 120 - 482 mg/L, and pH ranged from 7.1 to 8.6. The chloride concentration ranged from 65 – 4950 mg/L, Dissolved Oxygen (DO) was 2 to 8.4 mg/L, and Biochemical Oxygen Demand was 3 to 23 mg/L. Conductivity ranged from 68 to 8200 umho/cm. Approximately 86 % of water samples exceed the international chloride standards for drinking water (200 – 250 mg/L). The Dissolved Oxygen (DO) concentration was within the acceptable standards of 6 mg/L. The DO concentration of the ground water satisfied the DO requirement for aquaculture. However, open well number 12 has less (3.1 mg/ml), potentially indicating contamination from aquaculture farm effluents. Low concentrations of Dissolved Oxygen in nearby well water provided further evidence that these wells are contaminated with biodegradable organic compounds. The effect of aqua farms on the ground water quality was discussed in line with public health standard.

Key words: Ground water pollution, aquaculture, water quality, physical-chemical, Parameters.

INTRODUCTION

The demand for penaeid shrimp for human consumption has increased worldwide, particularly during the last two decades. Due to this, a large number of shrimp culture industries are coming-up very rapidly in east coast of India. Shrimp culture practices in India are mostly con-fined to extensive, modified-extensive and semi-intensive systems (Kurian and Sebastain, 1994).

The culture practices in the terrestrial environment with seawater are the man's attempt to duplicate the natural cycle of shrimp similar in the estuarine conditions. In order to provide optimal growth of shrimp with high stock-ing density in small area, various artificial inputs in the form of feed, fertilizers and drugs. These are added regularly in the shrimp ponds as food to kill the predators and control of diseases. These activities originate the pollution in the aquaculture ponds. The organic load in terms of unutilized feed due to extensive feeding (due to over feeding), Faucal matter release by shrimp, dead algae etc. which are rich in proteins and carbohydrates, settle at the bottom of the pond and contribute to the pollution of the pond bottom (Chien, 1992) . During the harvesting of crop, the ponds effluents are emptied re-sulting in a huge quantity of waste water discharge either in to the canal or creak. The discharge of these effluents in to the environment poses a threat to the coastal eco-system and its natural resources (Chua et al., 1989).

A sustainable development of aquaculture system in the coastal zone is a prerequisite, since coastal zone is both fragile and important ecosystem. Such development should be linked with the preservation of the environ-ment. The carrying capacity of the coastal environment is to be considered for the sustainable development of aquaculture.

For understanding the carrying capacity of the envi-ronment and effective manage mental plan to be drawn for sustainable development of aquaculture system in the

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Table 1. Description of water stations sampled annually.

Sampling stations	Location of wells near to	Distance in meters from Aqua farm	Water depth (meters) range
1	Bommidala aquafarm(BW)	200	0.3-1.8
2	Bommidala aquafarm(BW)	300	0.8-2.0
3	Javvagalashmi puram (OW)	900	1.2-3.8
4	Javvagalashmi puram (OW)	800	1.1-3.4
5	Javvagalashmi puram (BW)	750	2.1-4.0
6	Javvagalashmi puram (BW)	600	5.5-10.3
7	Sarath sea foods (BW)	800	4.8-8.9
8	Sarath sea foods (BW)	120	2.6-4.2
9	Venkanna palem(BW)	400	1.9-3.8
10	Venkanna palem(BW)	520	2.4-4.3
11	Venkanna palem(BW)	630	2.3-4.2
12	Venkanna palem(OW)	700	1.9-3.8
13	Pattapupalem (BW)	1500	2.4-4.3
14	Mahalakshmi puram (BW)	1500	2.3-4.2
15	Mahalakshmi puram (OW)	1580	1.2-3.6
16	Kotha Kodur(BW)	800	0.9-3.0
17	Kotha Kodur(OW)	750	2.3-4.2
18	Kodur(BW)	1500	0.9-2.9
19	Varakavipudi (OW)	1500	1.3-3.3
20	Varakavipudi (BW)	700	2.2-4.2
21	Ananthapuram (BW)	650	1.8-3.8
22	Ananthapuram (OW)	600	1.5-3.8
23	Ananthapuram (BW)	600	1.6-3.9

the coastal region, the nature of contaminant releases and their magnitude and impact on the segment of environment are to be assessed. Therefore, the major objecttive of the present investigation is to assess the ground water pollution in and around the aqua farms by sampling the water from both open and bore wells.

MATERIALS AND METHODS

Study area

The study area of the present investigation is located along the coast of the Nellore district, Andhrapradesh, India. It is extended from Iskapalli village of Allur Mandal, Nellore district to Krishnapatnam village of Muthukuru, Mandal and Nellore District. The length of the study area along the Buckingham Canal is about 52 km, which is running from Vijayawada to Madras along the east coast of Andhrapradesh. This canal carries only saline water and many of the major and minor aqua farms are located al along this canal. Most of these aqua farms are using this Buckingham canal as a source of water to there grow out farms and discharge of their pond exchange water in to the canal.

The study area ground water quality was monitored within and around the aqua farms. The study area consists of both open and bore wells. The location and details of the sampling frequency and the depth of the ground water table of wells are shown in Table 1. The depth of the ground water table in the study area ranges from 1.8 to 10.3 m. Approximately, 18% of the area is covered by agriculture and the rest is covered by aquaculture, residential and barren lands. Twenty-three existing wells were chosen for ground water quality monitoring. During the study period, 46 samples in two replicates were collected from ground water. The water samples were analyzed for various parameters such as temperature, pH, dissolved oxygen, alkalinity, salinity BOD, COD, Suspended solids, Ammonia- Nitrogen, Nitrite-N, MPN index and Hydrogen Sulfide according to standard methods for examination of water and waste water (ASTM, 1986 and APHA, 1992)

RESULTS AND DISCUSSION

Ground water was monitored in order to assess the ground water pollution due to aqua culture farms in the study area. Twenty three ground water samples are collected in all, Out if which 15 were Bore well (BW) and 8 from Open well (OW). These samples were analyzed for various physical-chemical parameters such as pH, total alkalinity, dissolved oxygen, COD, BOD, Suspended solids, Chlorides, MPN index and conductivity (Tables 2 and 3) and that 35% of the samples exceeded pH of drinking water quality standards. Although, this satisfied the International Standards for Drinking Water standards for aquaculture purpose. The International standards for drinking water and Standards for pollution parameters in seawaters (Tables 4 and 5) indicated some differences (Tables 2 and 3).

Table 2A. First year water quality parameters analyzed on well water samples collected in the study area

Parameter	Sampling stations																						
	1	2*	3*	4*	5	6	7	8	9	10	11	12*	13	14	15*	16	17*	18	19	20	21	22*	23
pH	8.4	8.0	8.0	8.4	8.1	7.6	8.0	8.6	8.4	8.6	7.9	8.0	7.1	7.8	7.9	8.3	8.5	8.1	7.9	8.0	7.9	8.2	8.1
Alkalinity	220	124	120	260	130	230	210	260	250	164	160	252	450	350	250	272	300	310	290	192	210	260	290
DO	2	2	3	5.3	7.3	7.2	7.8	7.2	7.0	6.5	7.4	3.1	8.4	7.9	6.9	6.2	6.1	6.1	6.3	6.4	6.9	5.4	5.7
COD	52	102	54	20	29	19	59	54	37	29	30	148	43	20	22	29	43	23	30	32	140	62	138
BOD	9.3	20	8.7	3	4.6	3.0	9.8	10.8	3.0	5.0	4.8	22	6.0	3.0	3.0	5.0	6.0	3.9	4.6	4.2	23	10	20
SS	60	69	95	85	47	60	34	32	87	50	50	92	58	64	54	42	110	110	89	79	80	100	90
Chlorides	1050	4950	1510	1420	650	580	125	65	1200	250	200	1200	360	400	350	250	1580	1480	1250	1150	1280	1750	650
MPN index	32	2	2	2	2	2	2	6	2	23	2	2	96	2	2	3	3	2	2	3	2	2	2
Conductivity	580	1250	840	850	700	295	280	820	850	800	750	800	750	68	790	1200	930	310	320	8200	710	1400	900

Note: All the above values are in mg/L except unit-less pH and Conductivity at mho/cm.
*Indicates Open well sampling stations, remaining are Bore well sampling stations.

Table 2B. The minimum, maximum and mean of first year water quality parameters analyzed on well water collected samples.

Parameter	Min	Max	Mean	%RSD	Min
pH	7.1	8.6	8.1	0.3	7.1
Alkalinity	120	450	241.5	76.6	120
DO	2	8.4	6.0	1.8	2
COD	19	148	52.8	40.0	19
BOD	3	23	8.4	6.5	3
SS	32	110	71.2	23.5	32
Chlorides	65	4950	1030.4	1009.3	65
MPN index	2	96	8.6	20.4	2
Conductivity	68	8200	1060.6	1589.1	68

The chloride concentration of all well waters ranges from 65 - 4950 mg/l indicating about 86% of water samples exceeds the drinking water standards and about 65% water of samples exceeds irrigation water quality standards. High chloride content in the irrigation water impairs the crop growth and its yield. The high chloride con- tent is indication of the high influence of nutrient laden surrounding soil on this water.

Dissolved oxygen (DO) concentrations of all the wells except-OW-12 are varied between 6.1 - 9.5 mg/L (Tables 2, 3). This indicates that about 90% of the DO concentrations in ground water were satisfying the DO requirements for aquaculture (4 to 7 mg/ml) while 86% of the samples are within the drinking water standards. DO concentration in OW-12 is very less (3.1 mg/ml) indicating that the ground water is contaminated due the aquaculture farm effluents (Boyd, 1989). Echnenfelder (1980) observed that the concentration of dissolved oxygen is a major limiting factor to the mineralize-tion of both carbonaceous and nitrogenous waste materials in a river considering the oxygen-sag curve for a river. Also, Ramesh et al. (1997) repor-ted that there was gradual deterioration of water quality monthly due to the effect of organic wastes in the farm and other metabolic wastes.

Biochemical oxygen Demand (BOD) of all the wells varied from 2 to 32 mg/l. High BOD value 32 mg/l was observed in BW-2.BOD concentration in well water indicate less organic pollution. This is probably caused due to aqua farm effluent contami-nation. Ramesh et al. (1996) had earlier observed in Backingham canal in East of India that there was pollution carrying capacity mainly due to aquacul-ture. They noted that aquaculture was able to impact pollution on the canal.

Chemical Oxygen Demand (COD) of the well waters ranges 19 - 172 mg/l. highest concen-tration was observed in well –21. High COD also a mea-sure of organic pollution. Concentrations of metals and non metals in aquatic environment are known to affect the metabolism of bacteria and higher organisms in sea water. The prediction of effect of pollution on a body of water can be re-duced to that of predicting the dissolve oxygen content (Umesi, 1989; Obire et al., 2008).

Suspended solids (SS) in wells varied from 32 – 130 mg/l. Suspended Solids (S.S) concentration

Table 3A. Second year Water quality parameters analyzed on well water samples collected in the study area

Parameter	Sampling stations																						
	1	2*	3*	4*	5	6	7	8	9	10	11	12*	13	14	15*	16	17*	18	19	20	21	22*	23
pH	8.6	8.2	8.4	9.2	8.5	8.2	8.2	9.2	9.2	9.2	8.2	8.4	7.3	8.0	8.1	8.5	9.1	8.3	8.3	8.4	8.3	8.6	8.5
Alkalinity	284	148	128	300	142	258	270	380	326	188	176	268	482	382	254	290	324	320	306	200	220	276	302
DO	8.5	6.2	5.3	6.3	7.5	8	8.2	8.3	7.2	9.5	7.8	3.9	9.4	8.3	8.3	6.8	7.1	6.3	6.7	7.2	7.3	6.0	6.7
COD	76	122	58	28	35	29	69	112	59	35	34	156	53	28	26	35	53	27	40	38	172	74	146
BOD	119	32	9.9	5	6	5	114	18.4	13	5.6	5.8	30	10	5	6	65	10	4.3	7	7.4	27	12.6	27.2
SS	70	89	121	131	67	64	58	44	97	58	60	104	66	74	64	5.4	130	118	91	8.3	98	130	98
Chlorides	1150	5810	1890	1880	700	660	175	85	1600	300	250	1650	590	550	400	350	1720	1520	1550	1250	1420	1850	750
MPN index	46	4	6	6	6	4	4	8	4	63	4	4	204	4	4	3	5	4	4	5	6	4	6
Conductivity	720	1610	1060	1010	760	345	460	880	950	860	850	1000	830	84	990	1600	990	330	430	8840	750	1460	1000

Note: All the above values are in mg/L except PH and Conductivity mho/cm
*Indicates Open well sampling stations, remaining are Bore well sampling stations

Table 3B. The minimum, maximum and mean of second year water quality parameters analyzed on well water collected samples

Parameter	Min	Max	Mean	%RSD
pH	7.3	9.2	8.5	0.5
Alkalinity	128	482	270.6	84.4
DO	3.9	9.5	7.3	1.3
COD	26	172	65.4	44.9
BOD	4.3	119	23.7	32.4
SS	5.4	131	80.2	34.9
Chlorides	85	5810	1221.7	1175.9
MPN index	3	204	17.7	43.1
Conductivity	84	8840	1209.1	1706.0

in all the wells (except-BW-2 (179 mg/l) satisfying the S.S requirement for aquaculture less than 150 mg/ml. The statistical analysis (Steel and Torries, 1980) carried out on pooled borehole well samples and open well indicated there was significant difference in the suspended solids at 5% level of significant. High S.S concentration in BW-1 is an indicator of acute ground water pollution. The biodegradable organic substances deplete the dissolved oxygen content of the well waters during the biological oxidation (Smith and Piedrahita, 1988). Extensive algal growth was also noted by visual observation in the open wells near the aqua farms, indicating that these wells are receiving nutrients from peculating aquaculture pond effluent.

Conclusion

Comparative assessment of the ground water samples showed that the wells near the aqua farms had much higher values than those far from the aquaculture farms. Low concentration of dissolved Oxygen in the near by well water is further evidence that these wells are contaminated with biodegradable organic compounds. Aquaculture pond effluents need pre treatment before they should be established away from the residential discharge in to the natural canals and aqua farms areas. Ground water potential areas should be demarcated using the remote sensing and should be consulted for clearing at least 200-300 meters of buffer zone for smaller villages, and 1 to 2 km for the bigger settlements may be reserved for this purpose. Utilization of ground water from deeper aquifers, which are used for mixing, should be avoided.

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