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RESEARCH ARTICLE

ASSESSMENT OF NITRATE CONTAMINATION IN THANJAVUR DISTRICT, TAMIL NADU (INDIA)

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ABSTRACT

Groundwater pollution has been reported in many aquifers because of high concentration of nitrate which is the result of excessive use of fertilizers to cropland. Systematic sampling was done, with a view to understand the source of nitrate concentration . 100 sample sites were selected and the samples were taken for a baseline study to understand the geochemistry of the study area and to assess its physicochemical charactertics. The water quality parameters were investigated for pre-monsoon (January 2011) and were compared with the standard values given by ICMR / WHO. The hydrochemical data of 100 samples indicates that the concentration of almost all parameters fall within the permissible limits expert nitrate. Linear Trend Analysis on seasonal basis clearly depicted that nitrate pollution in the study area is increasing significantly. None of the samples during the samples during pre-monsoon season were showing a high concentration of nitrate, exceeding permissible limits of WHO (50 mg /l), which is due to the use of nitrogenous fertilizer in the study area. Appropriate methods for improving the water quality and its management in the affected areas have been suggested.

INTRODUCTION

Water is one of the most essential requirements of all living things. For a long time, groundwater has been considered as a well protected resource. The reason for this was the belief in self purification of the soil and as a rule the protection of groundwater by the covering layers. Man's influence on the quality of water is quite apparent and now a major concern. Ground water has to be protected generally as it forms a principal source for drinking water and as it represents also a precious ecological part within the balance of water cycle. During recent years, much of the emphasis has been shown in groundwater investigations in industrialized countries. Rapid urbanization brings with it many problems as it places huge demands on land, water, housing, transport, health, education, etc. Environmental pollution has reached alarming levels in the last 5-6 years mainly due to industries and automobiles. This has shifted from problems of groundwater supply to considerations of groundwater quality. Fresh water being one of the basic necessities for sustenance of life, the human race through the ages has striven to locate and develop it. Water, a vital source of life in its natural state is free from pollution but when man tampers the water body, it loses its natural conditions. Groundwater has become an essential resource over the past few decades due to the increase in its usage for drinking, irrigation, and industrial uses, etc.

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The quality of groundwater is equally important as that of quantity. Groundwater is an essential natural resource for sustaining life and environment which is available in abundance and free gift of nature. Land – use practices have greatly polluted the groundwater quality. Nitrogen, an element considered to be the most abundant in the atmosphere, composing nearly 80% can be found in many forms, the major ones being N_2, N_2O, NO, NO_2, NH_3. Nitrate is part of the nitrogen cycle in nature and it represents the most oxidized chemical form of nitrogen found in the natural systems. All living systems need nitrogen for their existence since it is used to build many essential components such as proteins, DNA, RNA, vitamins, and as well as hormones and enzymes. Nitrates, though very essential for the very existence of life, is also one of the most widespread pollutants of ground water in many parts of the world and in several instances this is due to the intensification of agriculture. Nitrate is a wide spread contaminant of ground and surface waters worldwide (Hallberg, 1989; Puckett, 1995, Imran Ahmad Dar *et al*., 2010).

Although nitrate and the other nitrogenous compounds are the essential elements in the life process of flora and fauna. It's concentration is potentially high (Dissanayake and Weerasooriya, 1987). In addition, high nitrate level is monitored in municipal water supplies worldwide, and in foodstuffs, to prevent exposure of populations to harmful or toxic levels. Nitrate is contributed through biochemical activity by the microorganisms, freely and symbiotic species, such as nitrosomonas and nitrobacter (Lunkad, 1994). Numerous

studies have been done on nitrate contamination of groundwater in India and other countries; (Lakshmanan *et al*., 1986). Numerous sources in the environment contribute to the nitrate content of natural waters (Handa *et al*., 1982) viz., atmosphere, geological sources, soils atmosphere, nitrogen fixation, human, animal wastes, and agriculture.

Lack of good sanity practices and improper drainage systems may cause high rate of nitrate in the groundwater. The main thrust of this paper is to provide a methodological approach to explain high nitrate concentrations. The toxicity of nitrate to humans is due to the body's reduction of nitrates to nitrate which is demonstrated by vasodilatory/ cardiovascular effects at high dose levels and methemoglobinemia at lower dose levels (Federal Register, 1985). Consumption of drinking water with nitrate, at concentrations greater than 50 mg/l causes Blue baby syndrome, a disease where the skin becomes blue due to decreased efficiency of hemoglobin to carry in the oxygen (Canter, 1987). This phenomenon can occur in infants when approximately 70% of total hemoglobin has been converted to methemoglobin (WHO, 1983). High levels of nitrate in livestock feed and drinking water can result in reduced vitality and increased stillbirth, low birth weight, and slow weight gain and even death of the animals affected (National Research Council, 1972). Chronic nitrate poisoning is correlated with abortions, still birth, and stunted calves. Abortion is attributed to maternal and fetal methemoglobinemia resulting in fetal anoxia (Particularly in the last trimester of pregnancy).

Study area

The investigatigated area North latitudes 10°15'0" and 11°15'0", East longitudes between 78°45'0" and 79°45'0". covered Thanjavur district of Tamil Nadu. The area is demarcated from the survey of India Topographical maps and covers an area about 3411 km². (Fig.1). The area has been selected for it's under developed nature and also for its varied lithological conditions, geomorphology, hydrological characteristics, consolidated nature of rocks etc. Physiographically the area is almost flat and monotonous undulating terrain, except the pocking relief hills along the fringes of the study area. The climate of the study area is subtropical and the average annual rainfall is around 1047mm.

MATERIALS AND METHODS

Since the two seasons didn't showed a marked change in the water quality; hence the research study has been restricted to one season only. A total of 100 samples from shallow wells and deep- tube wells were collected from various locations of the study area during pre-monsoon (January, 2011) seasons. Sample was collected in 1-1 capacity polyethylene bottles. Prior to collection the bottles were thoroughly washed with diluted nitrate acid (HNO3, 1N) and then with distilled water in the laboratory. The bottles were rinsed to avoid any possible contamination in bottling and every precautionary measure was taken. Methods of collection and analysis of water samples was

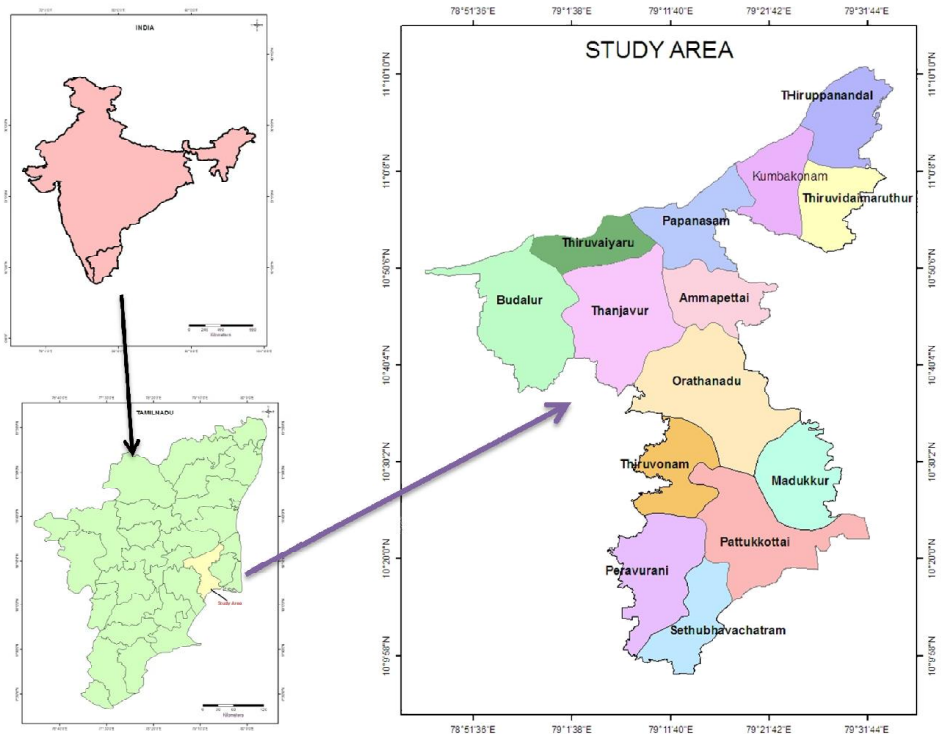

Fig.1. Study area

adopted using standard protocols (APHA, AWWA, WPCF 1998). Then, the samples were sealed, numbered, and were carefully taken to the laboratory for the chemical analysis.

RESULTS

The different quality parameters of the study area were determined for 100 samples each for Pre –monsoon (January, 2011) and the results are presented in Table 1.

Table 1. Geochemical parameters(in ppm) in Thanjavur District, Tamil Nadu India

S.No	Location	EC	Ph	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	F	Fe	PO4	TDS
1	Sattur	1240	6.7	26	64	136	19	445	160	38	0.12	3.16	65	0.02	793.6
2	Thirukodikaval	580	6.9	32	32	30	23	250	57	10	0.16	2.89	45	0.03	371.2
3	Kathiramangalam	780	6.8	32	41	55	18	275	106	19	0.13	2.75	49	0.04	499.2
4	Mallangudi	2100	6.6	48	107	230	19	622	326	53	0.15	2.56	62	0.06	1344
5	Lower anaicut	790	7	28	44	58	20	311	92	15	0.09	3.06	60	0.02	505.6
6	Thirupanandal	770	6.9	28	33	74	20	415	28	12	0.12	3.16	60	0.02	492.8
7	Shozhapuram	540	7.1	20	28	41	18	293	18	14	0.11	2.25	55	0.03	345.6
8	Neerathanallur	1260	6.9	40	51	138	18	671	39	24	0.08	3.25	54	0.05	806.4
9	Thibbirabiyaum	1650	6.7	20	43	253	19	616	202	43	0.13	3.25	66	0.02	1056
10	Kovilachery	2170	6.9	40	90	276	18	836	213	82	0.12	2.25	68	0.01	1388.8
11	Thirumangalakudi	110	7.1	20	56	115	17	445	128	23	0.15	3.26	55	0.03	70.4
12	Aaduthurai	580	7.1	24	41	18	18	244	53	21	0.06	3.24	54	0.05	371.2
13	Nachiyarkovil	920	6.9	24	55	74	18	378	106	10	0.08	3.22	58	0.04	588.8
14	Thirucherai	910	7.1	24	47	85	18	445	64	10	0.16	2.28	62	0.02	582.4
15	Shozhanmaligai	1090	7.3	14	58	117	19	378	117	62	0.12	3.24	64	0.03	697.6
16	Thiruvaikkavur	790	7.3	14	36	90	18	427	26	12	0.12	3.12	45	0.02	505.6
17	Kabisthalam	1490	7	14	16	278	19	689	106	42	0.12	3.14	54	0.03	953.6
18	Sundraperumal kovil	1050	7.1	24	57	106	19	445	99	64	0.15	3.24	52	0.02	672
19	Suwamymalai	940	7.2	14	63	74	20	403	92	65	0.19	3.12	55	0.03	601.6
20	innampur	470	7.6	18	28	28	19	415	18	45	0.01	2.32	48	0.05	300.8
21	Melacauvery	1520	7.8	24	59	65	22	360	74	44	0.15	2.25	68	0.04	972.8
22	Kumbakonam	1650	7.2	20	52	45	18	360	85	48	0.16	2.14	72	0.06	1056
23	Thukkachi	980	7.4	20	56	49	18	378	74	54	0.12	2.14	78	0.03	627.2
24	Thiruvidaimaruthur	1260	7.3	32	58	62	39	311	72	57	0.15	2.25	74	0.02	806.4
25	Thiruneelakudi	510	7.4	30	62	60	18	555	88	54	0.06	2.36	75	0.06	326.4
26	Thiruneswaram	1340	7.7	42	59	78	19	549	84	56	0.12	3.14	72	0.05	857.6
27	Thippirajapuram	1480	7.7	22	58	72	20	561	102	52	0.16	3.15	74	0.04	947.2
28	Rajakiri	1510	7.9	26	65	86	20	604	106	58	0.15	3.18	78	0.02	966.4
29	Ayyampet	660	7.2	30	68	85	18	537	94	54	0.14	3.24	74	0.03	422.4
30	Thanjavur	970	7.8	28	55	98	18	610	94	62	0.15	3.24	76	0.05	620.8
31	Melttur	1350	6.8	28	59	93	19	531	82	54	0.34	3.12	52	0.04	864
32	Thiruppanuruthi	990	6.5	34	58	92	18	610	88	56	0.33	3.14	54	0.06	633.6
33	Kallaperumpur	940	7.4	38	54	87	17	561	86	66	0.42	3.08	57	0.02	601.6
34	Thiruvaiyar	990	7.6	30	55	118	21	455	96	10	0.31	3.06	59	0.02	633.6
35	Vilankudi	1070	7.6	40	56	120	19	500	85	12	0.65	3.12	62	0.03	684.8
36	Pundi (Thirukkattupalli)	850	7.2	14	55	86	23	415	46	15	0.62	3.08	65	0.05	544
37	Vadakku Puliyakudi	720	7.1	24	52	96	20	360	43	15	0.34	3.04	62	0.02	460.8
38	Ammapet	760	7.9	28	54	93	18	360	50	23	0.78	3.05	54	0.03	486.4
39	Thogoor	780	7.9	12	45	97	18	378	50	16	0.82	3.06	52	0.02	499.2
40	Grand anaicut	710	7.3	12	46	95	18	311	64	13	0.29	3.08	58	0.06	454.4
41	Shozhagampatti	1220	7.4	14	48	125	39	555	96	23	0.34	3.12	68	0.04	780.8
42	Badalur	1480	7.7	12	47	124	19	549	142	78	0.33	3.14	64	0.08	947.2
43	Thirukattupalli	1670	7.7	34	46	102	22	561	227	67	0.34	3.06	65	0.02	1068.8
44	Aavarampatti	1540	7.9	32	52	113	18	604	170	62	0.31	3.08	65	0.02	985.6
45	Valaiyapatti	1400	7.2	44	55	119	20	537	181	25	0.65	3.04	62	0.03	896
46	Thulukkapatti	2280	7.8	38	65	78	18	610	390	82	0.84	3.14	68	0.02	1459.2
47	Pudukudi	1290	7.4	40	62	72	18	531	131	30	0.81	3.12	64	0.03	825.6
48	Okkanankadu Keezhiyur	1970	7	28	64	85	39	610	305	65	0.31	3.05	62	0.05	1260.8
49	Oraddanadu	1280	6.5	24	68	98	18	561	116	33	0.32	3. 12	61	0.04	819.2
50	Thirumanganlakottai	1200	7.8	24	62	87	18	494	128	20	0.64	3.14	67	0.06	768
51	Thoranam Keezhiyur	1300	6	32	58	124	18	555	124	26	0.54	3.12	52	0.03	832
52	Karungakottai	1470	7.9	44	48	112	20	622	142	28	0.64	3.14	55	0.02	940.8
53	Vadakkur	870	7.8	36	49	125	20	311	121	16	0.34	3.06	56	0.06	556.8
54	Thoppuviduthi	780	7.7	32	55	207	18	216	156	83	0.63	3.08	58	0.05	499.2
55	Naduvur	710	6.8	22	65	131	18	235	147	65	0.31	3.04	64	0.04	454.4
56	Peravoorani	480	7.2	38	45	76	39	242	159	68	0.94	3.16	65	0.02	307.2
57	Kallathur	500	7.7	20	44	232	19	251	165	57	0.29	3.12	56	0.03	320
58	Thiruchirambalam	820	7.6	40	48	242	22	263	103	49	0.12	3.12	68	0.05	524.8
59	Kalagam	1420	7.9	44	54	129	18	250	125	58	0.31	3.14	64	0.06	908.8
60	Sevvapatti	1220	7.6	30	57	196	20	239	115	45	0.62	2.14	62	0.04	780.8
61	Uranikadu	800	7.4	34	54	28	18	248	119	42	0.12	3.14	85	0.04	512
62	Mettuvayal	1060	7.2	44	56	216	18	230	124	48	0.16	2.87	39	0.08	678.4
63	Kollukadu	1080	7.8	32	52	216	39	243	126	47	0.13	2.96	64	0.02	691.2
64	Kallapattu	1150	7.2	44	58	290	18	213	123	43	0.15	2.84	66	0.12	736
65	Sedubachathiram	1160	7.6	24	54	53	19	256	136	58	0.09	2.95	68	0.06	742.4

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66	Muthukadu	1130	7.5	26	64	131	20	234	120	59	0.12	2.64	48	0.08	723.2
67	Sandapettai	1230	7.4	28	62	214	20	225	126	62	0.11	2.59	42	0.06	787.2
68	Nedivayal	1090	7.1	48	62	138	18	263	145	63	0.08	2.65	44	0.02	697.6
69	Pinnavasal	1200	7.3	46	64	55	18	283	152	67	0.13	2.48	66	0.04	768
70	Ammanichathiram	1240	7.2	48	54	51	19	269	129	65	0.12	2.47	64	0.08	793.6
71	Thambikottai	1230	7.3	34	54	30	18	256	152	64	0.15	2.65	39	0.06	787.2
72	Maravakottai	1200	7.4	36	58	23	17	274	123	68	0.06	3.69	39	0.06	768
73	Athirampadinam	1120	7.7	36	54	87	18	261	136	67	0.08	3.48	85	0.08	716.8
74	Kathivatti	1030	7.2	42	65	45	18	289	125	62	0.16	5.26	43	0.06	659.2
75	Pattukottai	1200	7.6	44	64	49	18	287	136	58	0.12	4.36	34	0.06	768
76	Nammivayal	1090	7.6	48	65	62	19	298	134	54	0.12	4.12	45	0.04	697.6
77	Karambiyam	1050	7.2	46	64	60	26	295	129	52	0.18	3.25	124	0.02	672
78	Alathur	1090	7.1	14	62	78	25	236	169	65	0.18	3.65	114	0.06	697.6
79	Madukkur	1280	7.9	14	68	72	23	216	178	69	0.04	3.27	50	0.03	819.2
80	Muthunkuruchi	960	7.9	12	65	86	20	235	146	56	0.12	3.19	225	0.03	614.4
81	Maduraipallayam	850	7.3	18	48	85	21	242	123	54	0.5	3.48	115	0.02	544
82	Omavayal	960	7.4	22	47	98	29	251	143	63	0.32	3.15	68	0.03	614.4
83	Andikadu	890	7.7	24	46	96	37	263	136	48	0.16	3.26	72	0.05	569.6
84	Kalagamangalam	1120	7.7	26	52	92	35	216	125	59	0.23	3.19	74	0.04	716.8
85	Senganathpuram	1030	7.9	32	55	94	31	263	124	84	0.48	3.16	68	0.06	659.2
86	Ponnavayal	1540	7.2	38	65	78	36	245	78	86	0.1	3.26	175	0.03	985.6
87	Nolikadu	1290	7.8	40	62	82	23	256	75	82	0.37	2.15	52	0.02	825.6
88	Elamkulam	1120	7.6	44	64	86	26	236	72	68	0.23	2.36	96	0.06	716.8
89	Karathadakudi	980	7.2	24	65	216	28	265	86	64	0.05	2.54	51	0.05	627.2
90	Karabai	740	7.8	24	45	216	29	254	85	65	0.25	2.58	40	0.04	473.6
91	Ullur	890	7.6	22	44	290	24	202	75	64	0.16	2.48	107	0.02	569.6
92	Villar	750	7.6	14	48	53	18	222	86	62	0.18	3.19	134	0.03	480
93	Vadakadi	690	7.3	28	54	131	18	233	78	68	0.2	3.26	85	0.05	441.6
94	Kovilur	1060	7.8	26	57	214	39	314	89	65	0.28	3.27	83	0.04	678.4
95	Cholapuam	1120	7.2	28	54	138	19	356	74	48	0.16	3.19	71	0.06	716.8
96	Thennamanadu	1060	7.6	30	56	55	22	324	88	47	0.24	3.24	68	0.02	678.4
97	Paruttikottai	1080	7.5	32	52	78	18	322	80	46	0.28	3.65	219	0.02	691.2
98	Natarajapuram	1150	7.4	44	58	84	20	321	85	52	0.28	6.59	64	0.03	736
99	Avavam	1160	7.1	48	54	82	18	256	84	55	0.34	3.48	94	0.05	742.4
100	Kalayapatti	1130	7.3	24	62	58	18	224	84	65	0.16	3.74	79	0.02	723.2

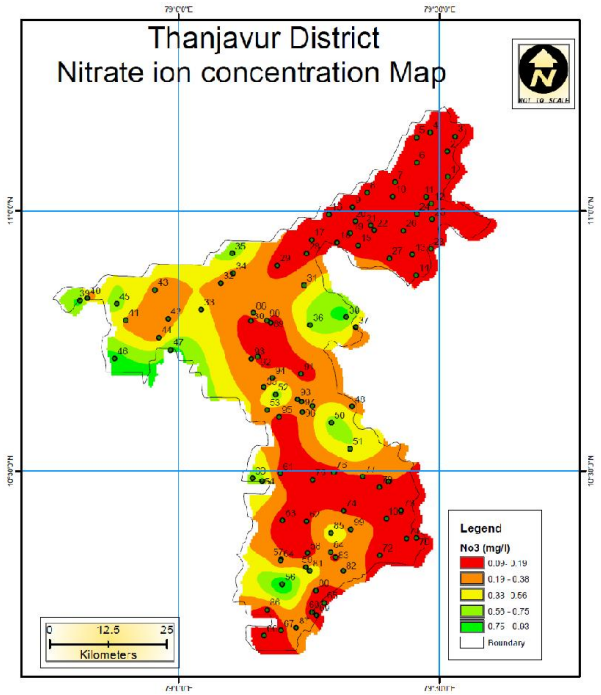


Fig. 2. Nitrate ion Concentration Thanjavur district, Tamil Nadu

The values were compared with the standard values given by WHO and ICMR shown in Table 2. Chemical analysis of nitrate shows that the nitrate concentration at most places is exceeding the permissible limits; 60% during pre –monsoon season. From Fig 2, it is clear that the value of nitrate concentration is found maximum in sample Thiruppanandal, and Thanjavur, Ponnavayal, Thiruvaiyaru, Badaur (67 mg/ l, 76 mg / l, 84 mg/ l,88 mg/ l and 92 mg / l) representing the drinking waters of Thirukatupalli, Muthukadu, Thambikottai, Avarampatti, and Immanapur areas respectively. The main source of this nitrate pollution during Pre –monsoon season was found to be the excessive use of nitrogenous fertilizers, as these areas are mainly agricultural areas.

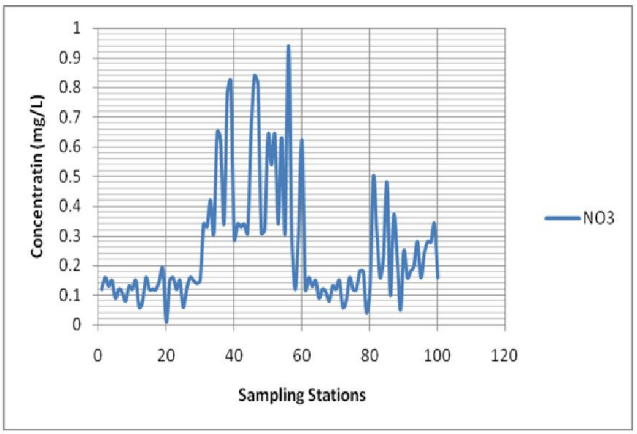


Fig. 3. Nitrate Contamination During Pre – monsoon - 2011

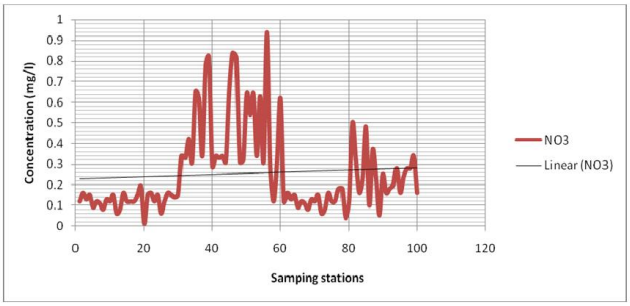
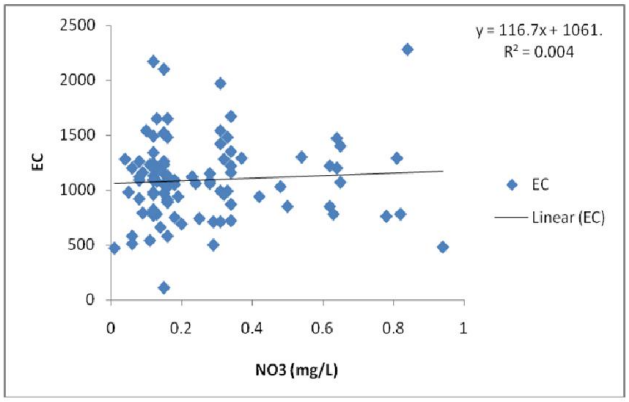
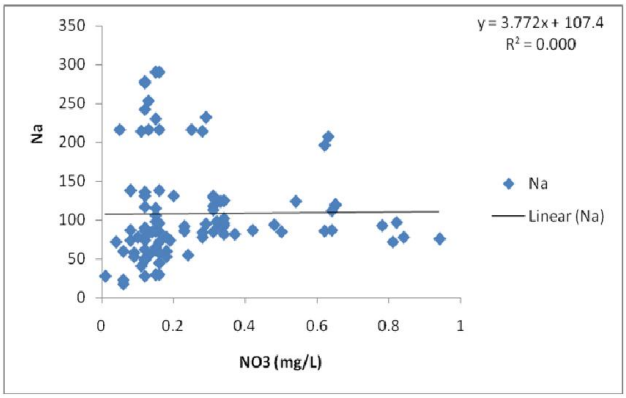


Fig 4. The Linear trend analysis of nitrate in pollution in the study area, 2011



(a)



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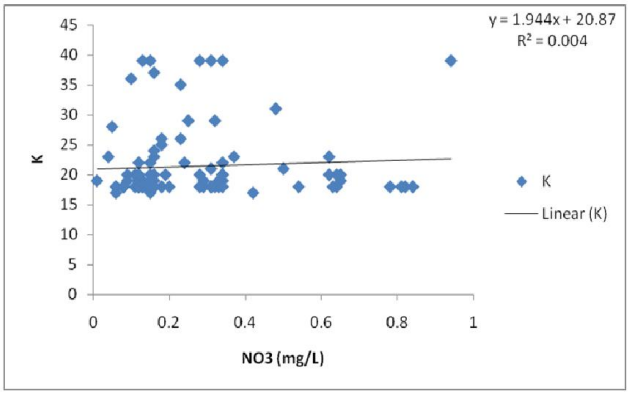

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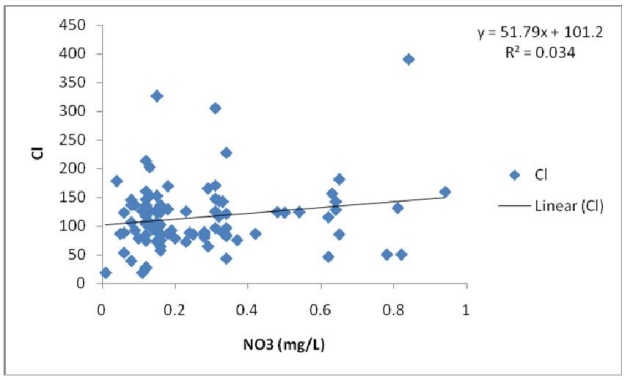

(d)

Fig 5. The Inter relationship between Pre - monsoon ((a),(b), (c), (d)

Monsoon linear trend line indicating that nitrate pollution is higher during Pre – monsoon seasons (Fig. 4). Nitrates show positive correlation with EC, Na and Cl which is more pronounced in the pre-monsoon season; among the parameters, the close positive affinity with EC is even more distinct (the r^2 is 0.343, Fig 5), reflecting that the more the groundwater is mineralized the more the chances of nitrate accumulation. The relationship of nitrate with other elements Fig 5a, is less distinct in than during the pre –monsoon season as the groundwater is in a chemically imbalance state due to the increased recharge in post – monsoon. Between Na and Cl, nitrate shows close affinity with Cl, as the r^2 (0.235) (Fig. 5b); whereas it does not exhibit any positive relationship with Na in post – monsoon where the r (0.048) (Fig. 5c). To find weather the fertilizer input is a probable source of nitrate to the groundwater (Dutta *et al*., 1997).

Conclusion

Hydrochemical studies of the Thanjavur district indicate that the concertration of nitrate is higer than permissible limits (50 mg/l) in most of groundwater collected from boreholes. The chief sources of nitrate pollution in the study area are agriculture activites and animal wastes. Irrigation with waste water was found the main source of nitrate pollution in Peravurani, Immnapur areas. Among the agricultural sources, the common sources are inorganic fertilizer, urea and irrigation with waste water. Animal waste and fertilizer are all potential sources of nitrate contamination through the soil and into the groundwater supply. The appropriate remedial measures should be implemented in order to restore the aquatic ecology of the polluted area.

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