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Assessment of Nitrate Contamination in Ariyalur 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 crop land. 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 characteristics. The water quality parameters were investigated for pre-monsoon (January 2011) and were compared with the standard values given by ICMR / WHO. The hydro chemical 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 area have been suggested.

Keywords: Hydro Geochemistry, Fertilizer, Nitrate, Linear Trend Line, Ariyalur District.

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 p 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.

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 greatly polluted the groundwater quality. Nitrogen, an considered to be the most abundant in the atmosphere, composing nearly 80% can be found in many forms, the major ones being N2, N2O, NO, NO2, NH 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 wate (Hallberg, 1989; Puckett, 1995, Imran Ahmad Dar 2010).

Although nitrate and the other nitrogenous compounds are the essential elements in the life process of flora and fauna. Its concentration is potentially high (Diss 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 1986). Numerous sources in the environment contribute to the nitrate content of natural waters (Handa et al 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 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 investigated area North latitudes N 10º 53' to 11 26' East longitudes E 78º 56' to 79 31' between covered Ariyalur district of Tamil Nadu. The area is demarcated from the survey of India Topographical maps and covers an area about 1944 km². (Fig 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 1096 mm.

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 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 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.

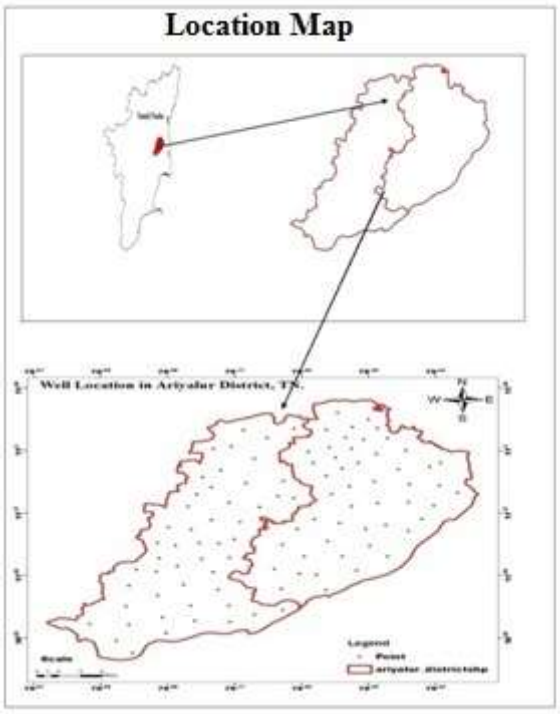


Figure. 1. Map Showing of Lotion Map in Ariyalur District, Tamil Nadu

TABLE.1 GEOCHEMICAL PARAMETERS OF ARIYALUR DISTRICT, TAMIL NADU (PPM VALUE)

Sl.No	Location	Ec	pH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	TH	TDS
1	Thirumanur	1300	7.1	88	27	49	45	41	180	96	26	332	832
2	Thoothur	1010	7.4	80	34	45	84	45	112	40	16	340	646.4
3	Alagiyamanavalam	2400	7.1	96	43	62	86	46	368	107	14	420	1536
4	Elakkurichi	2600	7.3	120	82	48	51	48	532	147	9	640	1664
5	Sullangudi	1370	7.3	56	24	65	67	40	180	84	12	240	876.8
6	Keelakolathur	860	6.7	56	24	52	52	45	92	28	1	240	550.4
7	Ayansuthamalli	1070	7.7	96	29	53	68	48	112	56	27	360	684.8
8	Poondi	1790	7.9	80	19	61	80	46	240	80	8	280	1145.6
9	Kovilesanai	1010	7.4	83	33	49	90	43	152	37	10	344	646.4
10	Sembiyakudi	680	7.0	51	17	41	46	44	132	39	24	200	435.2
11	Kulamanickam	830	7.3	67	28	49	57	47	140	29	28	284	531.2
12	Varanavasi	820	7.3	75	24	61	83	41	152	29	1	288	524.8
13	Vettriyur	1460	7.3	176	31	52	86	44	192	46	95	568	934.4
14	Keelapalur	900	8.0	43	22	57	71	49	64	42	11	200	576
15	Pudukottai	700	7.0	48	16	68	68	48	140	39	23	188	448
16	Arungal	360	6.7	29	10	84	51	42	20	19	12	112	230.4
17	Andipattakadu	1080	7.1	88	28	76	59	40	212	23	15	336	691.2
18	Karupilakkattalai	1480	7.7	35	24	82	53	47	152	46	52	188	947.2
19	Siruvalur	4600	7.7	104	77	78	68	41	912	145	24	580	2944
20	Thavuthaikulam	1920	7.6	48	40	88	75	49	192	93	16	288	1228.8
21	Hasthinapuram	920	7.6	59	32	55	84	48	116	40	13	280	588.8
22	Vilangudi	3860	7.6	182	69	64	86	43	812	200	12	744	2470.4
23	Kayarlabath	2700	7.5	112	67	58	84	48	468	144	95	560	1728
24	Ottakovil	810	7.7	40	17	86	87	44	112	44	3	172	518.4
25	Iluppaiyur	950	7.1	56	37	64	90	49	140	22	18	296	608
26	Pottaveli	3960	7.5	141	100	61	48	45	612	565	3	768	2534.4
27	Usenabath	360	6.7	22	12	69	46	41	60	16	22	104	230.4
28	Kavanur	3960	7.3	176	150	54	58	47	1112	71	20	1064	2534.4
29	Kadugur	3960	7.3	179	147	75	84	48	952	230	35	1060	2534.4
30	Periyathirukonam	1240	7.6	90	23	87	86	48	120	84	8	320	793.6
31	Melakkaruppur	1060	7.2	77	31	76	68	44	60	15	6	320	678.4
32	Sendurai	620	7.9	32	19	81	54	42	72	36	0	160	396.8
33	Anandhavadi	330	6.7	24	13	52	63	48	48	5	12	116	211.2
34	Vanathirayanpattinam	760	7.1	67	29	64	84	47	80	34	15	288	486.4
35	T.Cholankurichi	260	6.6	22	10	53	90	43	36	10	22	96	166.4
36	Thathanur	1405	7.2	157	38	59	73	48	240	63	20	552	899.2
37	Kumiliyam	1770	8.0	91	80	67	65	42	272	81	75	560	1132.8
38	Palayakudi	1020	7.5	72	38	62	84	48	112	36	19	340	652.8
39	Sirugadambur	970	7.6	99	32	82	53	45	112	33	28	380	620.8
40	Veerakkan	830	7.5	64	32	74	87	44	72	23	30	292	531.2
41	Nallapalayam	905	7.3	59	19	83	86	47	48	43	19	228	579.2
42	Maruvathur	870	6.8	67	17	71	84	40	92	25	2	240	556.8
43	Periyakurichi	590	7.4	32	22	48	64	42	32	4	14	172	377.6
44	Sirukalathur	870	7.7	27	14	66	80	41	92	73	7	128	556.8
45	Vanjinapuram	850	8.0	40	28	54	79	46	40	67	3	216	544
46	Athanakurichy	880	7.9	42	38	53	87	45	80	64	8	264	563.2
47	Sannasinallur	880	7.7	74	21	58	74	48	132	74	4	272	563.2
48	Thalavai	360	7.1	24	14	87	86	47	28	9	27	120	230.4
49	Alathiyur	855	7.7	77	30	81	54	48	72	37	20	316	547.2
50	Adhanakuruchi	1050	7.7	54	39	72	62	47	112	34	21	300	672
51	Anikudichan	2210	7.5	67	40	46	68	48	312	132	15	336	1414.4
52	Andimadam	710	7.8	51	32	59	87	41	92	42	1	260	454.4
53	Rackiyam	300	7.0	16	8	68	72	40	44	24	15	72	192
54	Thirukalappur	640	7.3	51	21	61	86	44	60	6	3	216	409.6
55	Viludhudaiyan	330	6.6	24	14	50	71	48	20	8	27	120	211.2
56	Olaiyur	360	6.6	19	15	67	46	40	72	18	4	112	230.4
57	Alagapuram	320	7.1	24	12	75	58	46	20	7	18	108	204.8
58	Kodukkur	480	7.7	40	21	83	51	41	20	10	18	188	307.2

59	Marudhur	180	6.6	10	5	64	68	47	28	8	25	45	115.2
60	Vallam	430	7.0	32	16	52	83	4	28	14	24	148	275.2
61	Kallathur	1040	7.3	64	38	58	75	48	52	14	9	320	665.6
62	Devanur	1310	7.2	115	24	61	90	41	192	62	30	388	838.4
63	Elaiyur	440	7.6	32	17	67	78	46	20	29	28	152	281.6
64	Pudukudi	1990	7.4	83	51	87	54	47	272	120	24	420	1273.6
65	Keelakudiyiruppu	990	7.4	67	44	78	51	48	112	33	25	352	633.6
66	Kaluvanthondi	885	7.3	70	25	71	86	48	80	17	2	280	566.4
67	Devamangalam	1280	7.1	88	47	70	67	49	236	42	29	416	819.2
68	Thaluthalaimedu	530	6.9	35	22	58	50	40	52	12	2	180	339.2
69	Gangaikondacholapuram	300	6.8	21	7	83	57	48	52	20	13	80	192
70	Muthuservamadam	190	6.6	10	7	74	87	43	18	4	14	54	121.6
71	Vettiyarvettu	330	6.9	22	11	68	49	41	32	6	15	100	211.2
72	Eravangudi	350	7.0	27	11	61	68	43	32	6	28	112	224
73	Vangudi	860	7.8	48	32	59	58	47	32	56	9	252	550.4
74	Pappagudi	670	7.5	51	23	43	53	48	60	19	1	224	428.8
75	Padanilai	870	7.6	77	19	67	71	40	112	61	3	272	556.8
76	Udayanatham	200	6.7	12	7	68	69	47	23	4	27	58	128
77	Kodalikaruppur	210	7.1	13	8	53	58	48	18	6	18	65	134.4
78	Vembukudi	480	7.9	38	15	57	63	46	36	25	21	160	307.2
79	Kalumangalam	315	6.7	16	12	51	59	44	48	16	17	92	201.6
80	Koovathur	860	7.4	67	17	79	84	48	32	40	18	240	550.4
81	Sriraman	850	7.9	30	12	80	72	47	88	80	7	128	544
82	Kaduvettankurichi	215	7.4	13	8	85	82	41	14	10	17	66	137.6
83	Manakkal	460	7.7	24	10	49	68	44	20	13	5	100	294.4
84	Edayakurichi	1390	7.3	99	34	40	75	47	160	99	32	388	889.6
85	Udayarnatham	535	7.4	43	13	67	83	41	88	15	31	164	342.4
86	Suthamalli	2400	7.7	58	23	90	54	46	476	131	12	240	1536
87	Keelakavattankurichi	845	7.8	82	26	81	48	48	72	39	19	312	540.8
88	Chinnapattakadu	1770	7.4	77	27	51	75	42	232	71	8	304	1132.8
89	Kadambur	655	8.0	67	17	58	68	40	52	15	22	240	419.2
90	Kasankottai	1280	7.4	123	20	68	61	41	192	59	29	392	819.2
91	Periyakrishnapuram	940	7.1	77	29	67	52	47	132	19	19	312	601.6
92	Varatharajanpettai	1165	7.6	96	42	59	58	43	196	35	58	416	745.6
93	Managathi	630	7.2	70	15	81	87	42	44	24	12	240	403.2
94	Venmankondan	480	7.9	54	8	52	68	48	60	6	0	168	307.2
95	Nagampandal	440	8.0	40	10	59	48	41	52	26	16	140	281.6
96	Irugaiyur	880	7.3	75	24	67	75	46	112	102	10	288	563.2
97	Valaikurichi	2050	7.4	184	58	87	82	47	392	101	4	700	1312
98	Edankanni	3120	8.0	216	86	83	52	45	748	66	18	900	1996.8
99	Sripuranthan	840	7.3	46	25	89	67	48	72	32	3	220	537.6
100	Anaikudam	770	7.4	83	19	48	75	42	76	21	17	288	492.8

Table.2 Statistical measure such as Minimum, Maximum and Average

Water Quality parameters	Units	Minimum	Maximum	Average
EC	µS/cm	180	4600	1098.7
Ca	Mg/l	10	216	66.24
Mg	Mg/l	5	150	29.77
Na	Mg/l	40	90	65.35
K	Mg/l	45	90	69.37
Hco3	Mg/l	4	49	44.52
Cl	Mg/l	14	1112	160.97
So4	Mg/l	4	565	52.32
No3	Mg/l	0	95	18.27
TH	Mg/l	45	1064	289.84
TDS	Mg/l	115.2	2944	703.17

Table.3 Range of Concentration of chemical parameters of the study area and WHO and Indian Standard Institution for drinking water

Sl.No	Water Quality Parameter	Range in Concentration	(BIS, 2012) Desirable limit
		Ariyalur District	Ariyalur District
1	EC	180-4600	*
2	Ca	10-216	75
3	Mg	5-150	30
4	Na	40-90	100
5	K	45-90	10
6	Hco3	4-49	200
7	Cl	14-1112	250
8	So4	4-565	200
9	No3	0-95	45
10	TH	45-1064	300
11	TDS	115.2-2944	500

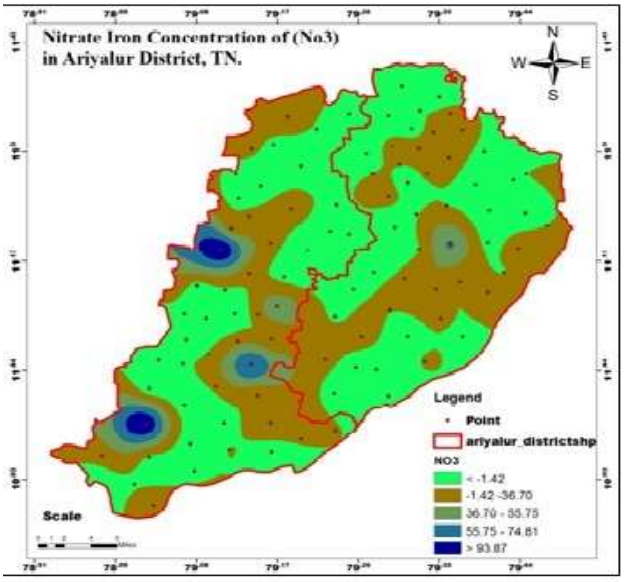
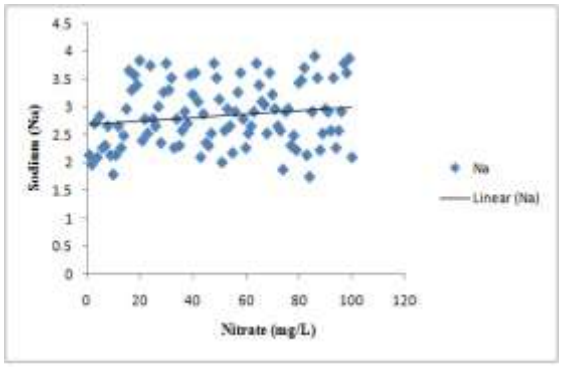
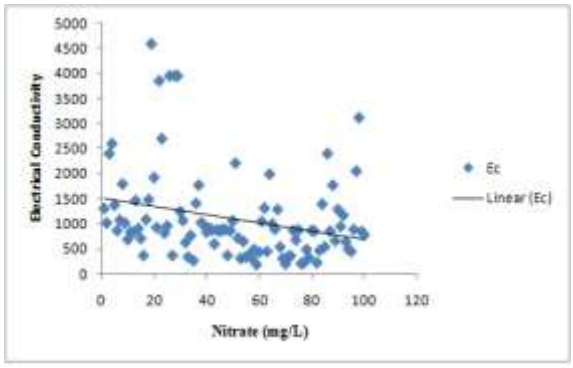


Figure.2. Map Showing of Nitrate Concentration of Ariyalur District

The values were compared with the standard values given by BIS and WHO shown in Table 3. Chemical analysis of nitrate shows that the nitrate concentration at most places is exceeding the permissible limits; 60% during monsoon season. From Fig 2, it is clear that the value of nitrate concentration is found maximum in sample Vettriyur, Karupilakkattalai, Kayarlabath, Kumiliyam and Varatharajanpettai (95 mg/l, 52 mg/l, 95 mg/l, 75 mg/l and 58 mg/l) representing the drinking waters of Ayansuthamalli, Andipattakadu, Iluppaiyur, Usenabath and Koovathur areas respectively. The main source of this nitrate pollution during monsoon season was found to be the excessive use of nitrogenous fertilizers, as these areas are mainly agricultural areas.



(a)



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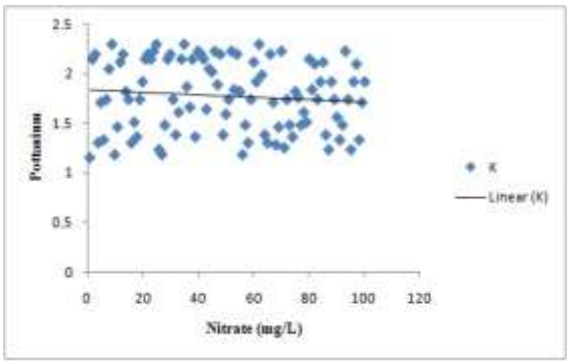

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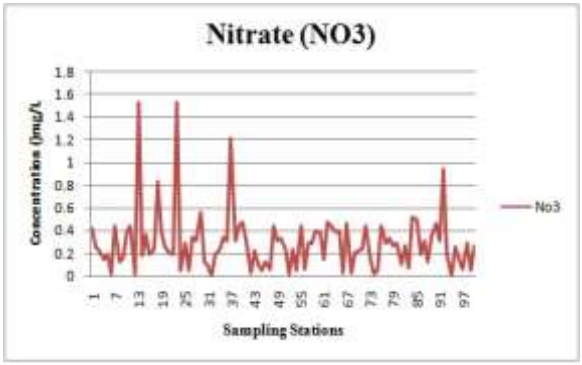

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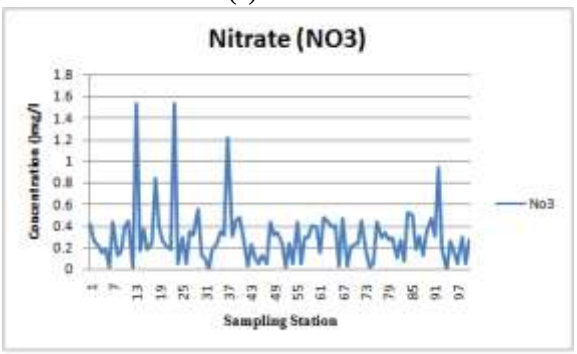

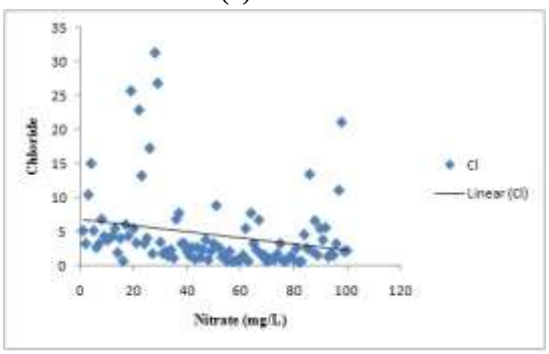

Fig. 3. Nitrate Contamination during Season
Fig 4. The Linear trend analysis of nitrate in pollution in the study area

Fig 5. The Inter relationship between Season ((a), (b), (c), (d)

In the study area, total concentration of Sodium ranges from 40 to 90 ppm in the groundwater samples within the average value 65.35 mg/l. The samples are 72% of falls within the permissible limit and 28% of the sample falls more than the permissible limit. In the study area, total concentration of Potassium ranges from 45 to 90 ppm in the groundwater samples within the average value 69.37 mg/l. The samples are 65% of falls within the permissible limit and 35% of the sample falls more than the permissible limit. In the study area, total concentration of Electrical Conductivity ranges from 180 to 4600 ppm in the groundwater samples within the average value 1098.7 mg/l. Monsoon linear trend line indicating that nitrate pollution is higher during seasons (Fig. 5). Nitrates show positive correlation with EC, Na, K and Cl which is more pronounced in the monsoon season; among the parameters, the close positive affinity with EC is even more distinct, 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 monsoon season as the groundwater is in a chemically imbalance state due to the increased recharge in monsoon. Between Na and Cl, nitrate shows close affinity with Cl, as the r2 (0.235) (Fig. 5b); whereas it does not exhibit any positive relationship with Na in 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 Ariyalur district indicate that the concentration of nitrate is higher 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 activities and animal wastes. Irrigation with waste water was found the main source of nitrate pollution in Irugaiyur, Thaluthalaimedu 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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