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GIS Based Groundwater Quality Mapping along Banks of River Noyyal in Tiruppur District of Tamil Nadu

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***Abstract*:** Due to the rapid economic and industrial growth in the Tiruppur district after globalization has adversely affected the quality of the environment. The major source of ground water pollution in Tiruppur is due to the domestic, agricultural and industrial activities. In this study, it has been evaluated the extend of the ground water contamination in Tiruppur district due to the Agricultural and Industrial activities. Forty sampling stations were selected along the banks of the river Noyyal on both sides in the Tiruppur district. The samples were analyzed for various physico-chemical parameters. From this study, it was found that the underground water was contaminated more at few sampling sites due to the Industrial and agricultural activities in the Tiruppur District. The sampling sites namely Samalapuram, Velayudhapalayam, Agraharapudur, Sulthanpettai, SR Nagar, MGR Nagar, Segudanthali and Vanjipalayam shows notable variation in the physio-chemical parameters. This study concludes that the groundwater quality in the entire region shows variation in the parameters for the monsoon period of July to October 2021 due to seasonal variation. Hence, it is important to take periodical monitoring of the groundwater quality in these regions for our future sustainability.

Keywords: Groundwater, Physio-chemical parameters, Correlation Matrix, GIS, Mapping

Tiruppur has become one of the country's largest hosiery manufacturing industrial cluster. This region emerged as a garment producing cluster because it is located in the cotton belt of Tamil Nadu, India. The first automatic ginning factory was established at Tiruppur in 1901 (Ajith Babu et al 2017). The post first world war era saw the mushrooming of hosiery factories in the region and it gained momentum since 1930. In textile and garment production, a large quantity of effluents is generated mainly due to the processes of dyeing and bleaching. The largest polluting industry in the Noyyal river basin are the dyeing and bleaching industries, particularly those units located in Tiruppur district. The growth of dyeing and bleaching units corresponds to the growth of export garment units. According to the most recent figures available, there are 800 dyeing and bleaching companies in Tiruppur district, involved in export-oriented garment production. The small-scale industries located at the entire river basin are in unorganized manner. These industries often dump their wastes into nearby water bodies that are assumed as dumping yards for the wastes. The cotton textile and hosiery industries are clustered more in Coimbatore, Sulur, Avinasi, Palladam, and Tiruppur. Metal and machinery product industries are higher at Coimbatore in PN Palayam and Palladam. Groundwater is the main source for all the industries located at Tiruppur district. Hence, this study was focussed to identify the groundwater quality of Noyyal River basin in Tiruppur district during the periods of July 2021 and October 2021.

MATERIAL AND METHODS

Study area: River Noyyal is considered as one of the major source of water for both domestic and agricultural activities for the districts of Coimbatore, Tiruppur, Erode and Karur. It has started its journey from the vellingiri hills of Western Ghats in the Coimbatore district and joins to Kaveri River at the place called Noyyal in Karur District. It is a Non-Perennial River which flows in the regions from Coimbatore and Karur through Tiruppur and Erode districts. In this project work, the area along the banks of the Noyyal River in the Tiruppur District is studied for the period of July 2021 and October 2021 by taking groundwater samples at forty locations along the banks of the river (Table 1).

Identification of source of wastewater: The major source of wastewater in the Tiruppur district were identified through the field survey and consists of domestic wastewater collected through sewer called sewage; industrial wastewater during the process of dyeing and bleaching process; surface runoff water from agriculture field during irrigation and rainfall period. (Babunath and John 2017, Selvakumara et al 2017).

Site selection and collection of ground water sample: The site for the collection of the groundwater sample was selected based on the distance between the two locations and distance between the site and Noyyal River. The distance between the two sampling sites are selected such that it should not exceed 2 km. (Siva Dharshini et al 2018) and

the distance between the sampling site and the Noyyal River is selected such that it should not exceed 1 km, because the study area contains cluster of industrial sector. The sampling bottles for the collection of groundwater samples were made of plastic, usually polythene. The groundwater samples were collected from the open wells and bore wells along the banks of the Noyyal River in plastic bottles of 1 litre capacity after rinsing it with distilled water and with the groundwater sample before collection of samples as mentioned in the standard procedure for method of collection.

RESULTS AND DISCUSSION

Analysis of groundwater sample: During the first phase of the study the forty groundwater samples were collected and analyzed for the various physio-chemical parameters such as electrical conductivity (EC), resistivity, pH, turbidity, total dissolved solids (TDS), dissolved oxygen (DO), hardness and chlorides in the laboratory for July 2021 (Table 2).

Quality of the groundwater will be varying from season to season and from stratum to stratum. From the field investigation it is observed that all the groundwater samples collected from all the location during July 2021 is free from physical impurities such as colour and odor (Natarajan and Sekaran, 2019). The collected groundwater sample is tested for other physico-chemical parameters in the Environmental Engineering laboratory. The quality of groundwater samples were compared with the water quality standards prescribed in IS10500-2012 for drinking and IS11624-2009 for irrigation purposes (Irfan Jamila and Yousuf, 2018). The observed values of electrical conductivity (EC) of groundwater samples during July 2021 varies from minimum of 398 µS/cm at Mangalam bore well location to maximum of 9418 µS/cm at Agraharapudur bore well location. The acceptable limit of electrical conductivity for drinking purpose is 2000 µS/cm and for irrigation purpose in semi-tolerant and tolerant crops are 8000 µS/cm and 10000 µS/cm respectively. Among 21 out of 40 groundwater samples were exceeding the acceptable limit of electrical conductivity for drinking purpose and all the groundwater samples EC values are within the limit for irrigation purpose. The seven groundwater samples tested at Velayuthapalayam open well, Agraharapudur bore well, Bavani nagar bore well, MRG nagar bore well, Vanjipalyam bore well, Veliyampalayam bore well and Anaipalayam Pirivu has electrical conductivity more than 5000 µS/cm. The resistivity value of the groundwater sample varies between 107 Ω at Agraharapudur bore well location and maximum of 3150 Ω at Mangalam bore well location. The highest value recorded at the bore well groundwater sample located at the place Mangalam bore well.

The observed pH of groundwater samples during July 2021varied from minimum of 7.01 at Sivasakthi nagar bore well to maximum of 8.36 at Tiruppur Old bus stand open well. Anaipalayam bore well and Sivasakthi nagar bore well groundwater samples has a pH value more 8. But all the 40 groundwater samples were within the acceptable limit of 6.5-8.5 as per drinking water quality standards. The turbidity of groundwater samples during July 2021 varies from minimum of 1.10 NTU at Vijayapuram bore well to maximum of 4.25 NTU at Kavilpalayam bore well. The groundwater samples collected at Bavani nagar bore well, Kavilpalayam bore well, Kurukkapalayam bore well and Semmandampalayam bore well have the turbidity values of more than 4 NTU even though all the samples were within the permissible limit of 5 NTU. The total dissolved solids of the ground water samples during July 2021 varied between minimum of 150 mg/L at Mangalam bore well and maximum at 4767 mg/L Agraharapudur bore well location. From the groundwater quality analysis study the TDS values at 11 different sampling locations such as Samalapuram bore well, Velayuthapalayam open well, Agraharapudur bore well, Sulthanpettai open well, Parmasivampalayam bore well, Bavani nagar bore well, MRG nagar bore well, Sirupooluvapatti bore well, Kavilpalayam bore well, Veliyampalayam bore well and Anaipalayam Pirivu bore well exceeded the permissible limit of 2000 mg/L. The dissolved oxygen of the groundwater samples during July 2021 varied between 0.9 mg/L and 3.10 mg/L, but all the samples are below the acceptable limit of 4 mg/L.

The hardness of the ground water sample during July 2021 varied between 275 mg/L at Mangalam bore well and 2350 mg/L at Agraharapudur bore well. From the water quality analysis study, the groundwater samples at 24 out of 40 locations exceeded the permissible limits of 600 mg/L. The eight locations such as Samalapuram bore well, Velayuthapalayam open well, Agraharapudur bore well, Bavani nagar bore well, MRG nagar bore well, Vanjipalyam bore well, Veliyampalayam bore well and Anaipalayam Pirivu bore well has shown the hardness values of more than 1000 mg/L. The chloride values of the groundwater sample during July 2021 varies between 223 mg/L at Semmandampalayam bore well location and 3613 mg/L at Agraharapudur bore well location. The Chlorides at 15 different locations such as Samalapuram bore well, Velayuthapalayam open well, Agraharapudur bore well, Sulthanpettai open well, Kozhipannai open well, Mundalipalayam bore well, Parmasivampalayam bore well, Bavani nagar bore well, VSA nagar bore well, MRG nagar bore well, Sirupooluvapatti bore well, Pudur bore well, Segudanthali bore well, ACS modern City bore well and Veliyampalayam bore well has exceeded the permissible limit of 1000 mg/L. In order to identify the

Table 1. Locations of wells along the banks of river Noyyal in Tiruppur District

Sample No.	Sampling location	Type of well	Latitude	Longitude
1	Samalapuram	Bore well	11° 4' 23.27"N	77° 11'40.31" E
2	Pallapalayam	Bore well	11° 4' 57.47"N	77° 12'27.69" E
3	Velayuthapalayam	Open Well	11° 5' 33.68"N	77° 14'02.87" E
4	Agraharapudur	Bore well	11° 06' 05.8"N	77° 15'01.10" E
5	Mangalam	Bore well	11° 6' 07.06"N	77° 16'07.46" E
6	Sulthanpettai	Open Well	11° 6' 05.47"N	77° 16'49.26" E
7	Koluthupudhur	Open Well	11° 6' 05.47"N	77° 17'45.56" E
8	Kozhipannai	Open Well	11° 5' 57.34"N	77° 18'15.77"E
9	Karuvampalayam	Bore well	11° 5' 45.42"N	77° 20'18.78"E
10	Old bus stand	Open Well	11° 6' 12.17"N	77° 21'01.87" E
11	Renukanagar	Bore well	11° 6' 24.12"N	77° 21'57.64" E
12	Mundalipalayam	Bore well	11° 7' 15.1"N	77° 24'25.27" E
13	Kavin garden	Bore well	11° 5' 23.68"N	77° 25'45.55"E
14	Parmasivam palayam	Bore well	11° 5' 19.68"N	77° 13'33.96" E
15	Chinnaputhur	Bore well	11° 4' 22.08"N	78° 8'58.56" E
16	SR nagar	Bore well	11° 5' 33.72"N	77° 19'21.72" E
17	Bavani nagar	Bore well	11° 6' 17.64"N	77° 21'43.56" E
18	Vijayapuram	Bore well	11° 5' 19.68"N	77° 24'24.12" E
19	VSA nagar	Bore well	11° 6' 45.36"N	77° 22'44.04" E
20	MRG nagar	Bore well	11° 6' 30.6"N	77° 20'29.76" E
21	Kathankanni	Bore well	11° 6' 36.83"N	77° 28'40.62" E
22	Tamma Reddy palayam	Bore well	11° 5' 38.54"N	77° 30'30.13" E
23	Savadipalayam	Bore well	11° 5' 27.71"N	77° 31'13.22" E
24	Rayapuram	Bore well	11° 6' 12.92"N	77° 19'50.88" E
25	Thiru VK nagar	Bore well	11° 6' 31.68"N	77° 19'34.68" E
26	Sirupooluvapatti	Bore well	11° 6' 44.5"N	77° 18'16.92" E
27	Kavilpalayam	Bore well	11° 7' 04.94"N	77° 18'00.32" E
28	Kurukkapalayam	Bore well	11° 7' 07" N	77° 14'55.82" E
29	Semmandampalayam	Bore well	11° 6' 29.74"N	77° 13'22.3" E
30	Segudanthali	Bore well	11° 6' 25.63"N	77° 12'28.76" E
31	Pudur	Bore well	11° 6' 41.08"N	77° 14'22.09"E
32	Vanjipalyam	Bore well	11° 6' 59.51"N	77° 16'34.57" E
33	Annapalayam	Bore well	11° 6' 31.75"N	77° 18'44.32" E
34	Sivasakthi nagar	Bore well	11° 6' 52.24"N	77° 22'25.75" E
35	Kolathupalayam	Bore well	11° 7' 26.94"N	77° 23'09.78" E
36	ACS modern City	Bore well	11° 8' 04.27"N	77° 24'40.68" E
37	Veliyampalayam	Bore well	11° 8' 31.34"N	77° 24'04.73" E
38	Jeravampalayam	Bore well	11° 8' 14.35"N	77° 26'03.26" E
39	Anaipalayam	Bore well	11° 7' 49.33"N	77° 27'14.83" E
40	Anaipalayam Pirivu	Bore well	11° 7' 05.23"N	77° 27'39.2" E

Table 2. Physico-chemical parameters of the ground water samples during July 2021

EC (µS/cm)	Resistivity (Ω)	pH	Turbidity (NTU)	TDS (ppm)	DO (ppm)	Hardness (ppm)	Cl (ppm)
4280	233	7.93	2.1	2138	1.1	1050	1650
955	1050	7.24	2.2	478	1.2	300	425
5118	193	7.93	3.6	2600	2.5	1050	1900
9418	107	7.18	1.9	4767	2.5	2350	3613
398	3150	7.83	1.7	150	1.5	275	308
4127	243	7.48	1.9	2053	1.3	900	1518
1037	965	7.37	2.5	518	1.3	375	318
2924	417	7.21	2.7	1207	1.4	750	1020
1236	1590	7.33	2	317	2.6	300	350
1404	1692	8.36	3.5	276	1.7	325	258
1343	748	7.41	2.1	665	2.5	350	335
3254	501	7.08	2.8	1001	0.9	825	1250
1029	1360	7.11	2.7	366	2.7	300	358
4097	221	7.42	2.7	2106	1.5	900	1520
1697	1269	7.81	3.1	384	1.9	475	373
2369	721	7.05	3.6	702	3	600	380
5243	183	7.62	4.1	2598	1.6	1025	2105
4108	236	7.43	1.1	1994	1.5	850	815
2411	409	7.23	1.9	1198	0.9	750	1023
5298	169	7.18	1.9	2698	1.7	1050	1923
1249	1002	7.21	2.2	598	1.2	350	318
1665	1261	7.49	2.5	376	0.9	475	293
1896	1377	7.4	2.8	387	1.8	450	613
3215	498	7.39	1.8	997	2	825	625
1726	598	7.63	1.9	867	1.8	600	463
3002	179	7.82	1.3	2883	1.9	725	1025
3319	164	7.1	4.5	2902	2	775	805
2042	735	7.21	4.2	382	2.4	550	420
1456	706	7.29	4	796	2.2	650	223
1794	1260	7.22	1.2	395	1.8	900	255
3826	262	7.41	1.5	1922	1.4	750	1590
5197	943	7.07	1.6	1040	2	1600	383
1896	715	7.82	1.8	699	2.7	625	428
738	1350	7.01	1.9	372	3.1	500	285
1067	955	7.54	2.8	527.4	0.9	750	378
3175	327	7.4	2.9	1570	1.4	750	1115
5418	183	7.32	2.8	2763	1.6	1475	1863
1375	728	7.09	3.4	687	1.2	325	330
1720	584	8.01	3.4	855	2.4	625	703
5715	174	7.69	2.9	2895	1.3	1225	1940

variations of water quality parameters and to check the consistency of groundwater quality parameters at the above 40 locations the repeated sampling was done in October 2021 and was tested for the above parameters (Table 3).

Table 3. Physico-chemical parameters of the groundwater samples during October 2021

EC (µS/cm)	Resistivity (Ω)	pH	Turbidity (NTU)	TDS (ppm)	DO (ppm)	Hardness (ppm)	Cl (ppm)
4386	226	8.01	2.2	2198	1.2	1125	1775
1214	694	7.21	2.2	608	1.3	350	600
5263	186	7.82	3.5	2677	2.2	1100	1993
9718	103	7.68	1.8	4910	2.8	2425	3635
428	2868	7.79	1.9	169	1.3	325	325
1118	890	7.52	2.1	2155	1.1	925	1675
1089	912	7.87	2.6	546	1.6	400	438
3028	405	7.45	2.7	1250	1.5	775	1268
1489	1312	7.27	2.2	382	1.9	350	425
1629	1458	8.45	3.6	320	1.8	375	293
1539	653	7.49	2.4	762	2.6	400	378
3459	481	7.18	2.9	1064	1.2	850	1478
1038	1345	7.22	2.8	369	2.4	300	380
4179	217	7.35	2.6	2148	1.8	900	1595
1630	1269	7.76	3	384	2	475	395
2466	689	7.01	3.8	740	3.2	600	413
5324	179	7.9	4	2644	1.1	1030	2213
4201	232	7.35	1.7	2046	1.3	856	878
2426	409	7.48	1.5	1206	1.1	754	1083
5309	188	7.15	1.8	2705	1.5	1052	2015
1605	784	7.29	2.2	780	1.5	450	335
1927	1102	7.58	2.6	455	1.2	550	308
2001	1319	7.31	2.4	412	1.5	475	648
3409	459	7.59	1.9	1079	1.9	875	680
1726	608	7.61	1.9	889	1.9	600	450
3209	169	7.92	1.5	3089	2	775	1080
3640	142	7.05	4	3183	2.5	850	815
2093	1369	7.34	4.1	384	2.2	600	445
1521	712	7.39	4.1	833	1.9	675	248
1901	1159	7.18	1.9	426	1.9	975	260
3899	245	7.49	2.1	1802	1.2	800	1540
5365	924	7.11	2.2	1040	2.4	1650	398
1987	701	7.9	1.9	732	2.9	700	450
812	1317	7.19	2.2	391	3.2	550	303
1124	916	7.51	2.1	561	1.2	775	395
3259	367	7.39	1.9	1620	1.5	725	1095
5591	162	7.34	1.6	2805	1.9	1425	1998
1459	701	7.06	2.8	718	1.3	400	390
1755	542	7.94	3.5	877	2.5	650	760
5824	153	7.75	3.6	2946	1.6	1300	1993

The observed values of electrical conductivity (EC) of groundwater samples during October 2021 varied from minimum of 428 µS/cm at Mangalam bore well location to maximum of 9718 µS/cm at Agraharapudur bore well location. During this period also 21 out of 40 groundwater samples were exceeding the acceptable limit of electrical conductivity for drinking purpose but all the groundwater samples EC values were within the limit for irrigation purpose. The seven groundwater samples tested at Velayuthapalayam open well, Agraharapudur bore well, Bavani nagar bore well, MRG nagar bore well, Vanjipalyam bore well, Veliyampalayam bore well and Anaipalayam Pirivu has electrical conductivity values more than 5000 µS/cm and have moderate variation during October 2021. The resistivity value of the groundwater sample during October 2021 varied between 103 Ω at Agraharapudur bore well location and maximum of 2868 Ω at Mangalam bore well location. The highest value also recorded at the bore well groundwater sample located at the place Mangalam.

The observed values of pH of groundwater samples during October 2021 varied from minimum of 7.01 at S R nagar bore well to maximum of 8.45 at Tiruppur Old bus stand open well. Samalapuram bore well and Tiruppur old bus stand open well groundwater sample has a pH value more than 8. But all the 40 groundwater samples were within the acceptable limit of 6.5-8.5 as per drinking water quality standards. The turbidity value of groundwater samples during October 2021 varied from minimum of 1.5 NTU at two locations VSA nagar bore well and Sirupooluvapatti bore well to maximum of 4.1 NTU at Kurukkapalayam bore well and Semmandampalayam bore well and all the samples were within the limit of 5 NTU.

The total dissolved solids of the ground water samples during October 2021 varied between minimum of 169 mg/L at Mangalam bore well and maximum at 4910 mg/L at Agraharapudur bore well location. During this period also the TDS values at 11 different sampling locations such as Samalapuram bore well, Velayuthapalayam open well, Agraharapudur bore well, Sulthanpettai open well, Parmasivam palayam bore well, Bavani nagar bore well, MRG nagar bore well, Sirupooluvapatti bore well, Kavilpalayam bore well, Veliyampalayam bore well and Anaipalayam Pirivu bore well exceeded the permissible limit of 2000 mg/L. The dissolved oxygen of the groundwater samples during October 2021 varied between 1.1 and 3.2 mg/L, and all the samples were below the acceptable limit of 4 mg/L.

The hardness of the ground water sample during October 2021 varies between 325 mg/L at Mangalam bore well and 2425 mg/L at Agraharapudur bore well. During this period also the groundwater samples at 24 out of 40 locations exceeded the permissible limits of 600 mg/L. The same eight locations such as Samalapuram bore well, Velayuthapalayam open well, Agraharapudur bore well, Bavani nagar bore well, MRG nagar bore well, Vanjipalyam bore well, Veliyampalayam bore well and Anaipalayam Pirivu bore well have shown the hardness values of more than 1000 mg/L. The chloride values of the groundwater sample during October 2021 varies between 248 mg/L at Semmandampalayam bore well location and 3635 mg/L at Agraharapudur bore well location. During this periods also the values of chlorides at 15 different locations such as Samalapuram bore well, Velayuthapalayam open well, Agraharapudur bore well, Sulthanpettai open well, Kozhipannai open well, Mundalipalayam bore well, Parmasivampalayam bore well, Bavani nagar bore well, VSA nagar bore well, MRG nagar bore well, Sirupooluvapatti bore well, Pudur bore well, Segudanthali bore well, ACS modern City bore well and Veliyampalayam bore well have exceeded the permissible limit of 1000 mg/. But for continuous monitoring of water quality parameters the groundwater sampling and testing are to be done in all the observed locations at various seasons. The monitoring of groundwater quality sample will be helpful in

Table 4. Pearson correlation matrix among the groundwater quality parameters

Parameters	pH	Electrical conductivity	Resistivity	Turbidity	Total dissolved solids	Dissolved oxygen	Hardness	Chlorides
pH	1							
EC	-0.0632	1						
Resistivity	-0.1341	-0.6276	1					
Turbidity	0.0632	-0.0547	-0.0707	1				
TDS	-0.0316	0.8966	-0.7368	-0.001	1			
DO	-0.0948	-0.0025	-0.0836	-0.184	-0.001	1		
Hardness	-0.0447	0.9203	-0.5576	-0.155	0.7918	0.0447	1	
Chlorides	-0.1095	0.8966	-0.6387	-0.045	0.8848	-0.118	-0.798	1

identification of the exact variation of groundwater quality at different seasons (Kumar and Balamurugan 2018) as well as to identify the consistency of records.

Formulation of correlation matrix: Correlation matrix for the groundwater quality parameters is formulated to identify the relationship between any two parameters. It is a statistical method used to measure how the water quality parameters were related to each other. It was developed by Karl Pearson

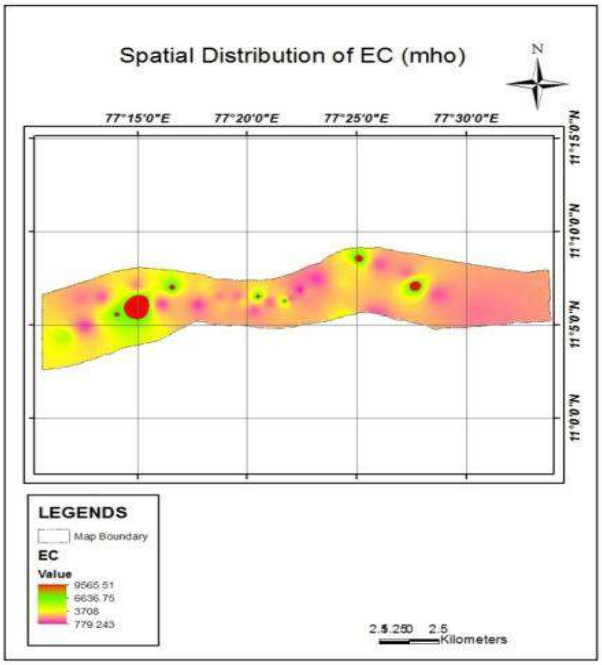

Fig. 1. Spatial distribution of EC

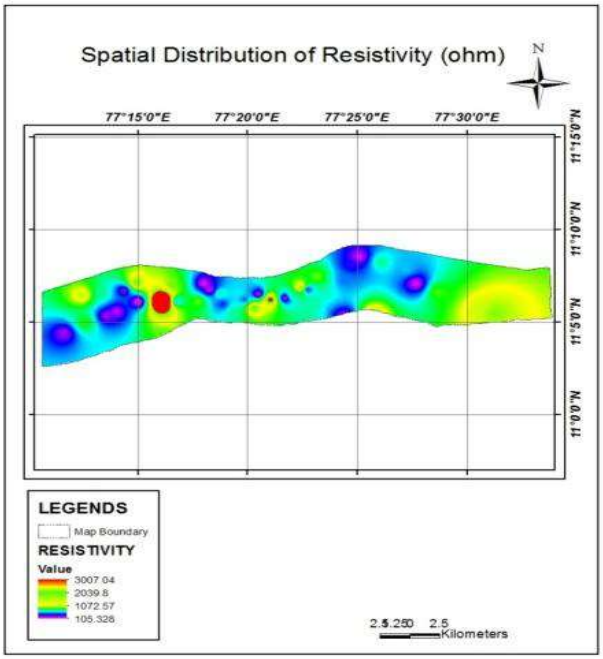

Fig. 2. Spatial distribution of resistivity

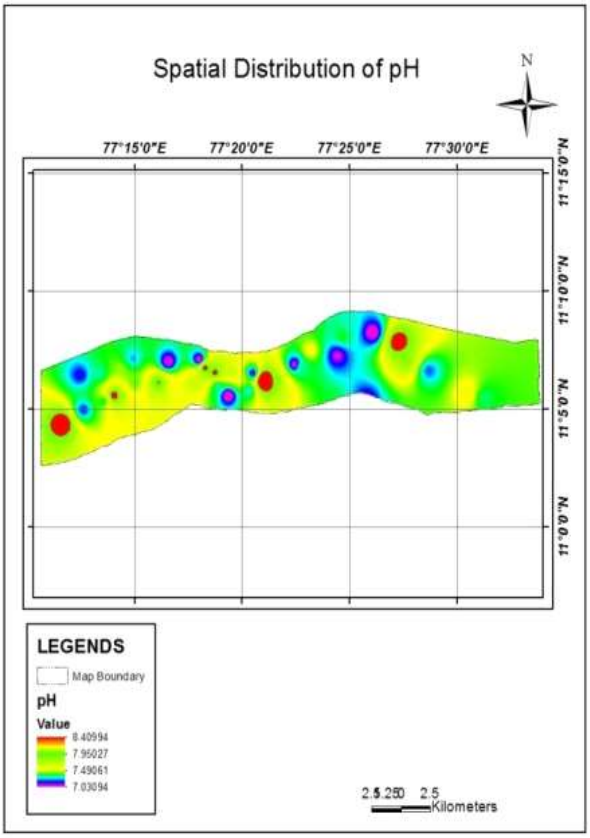

Fig. 3. Spatial distribution of pH

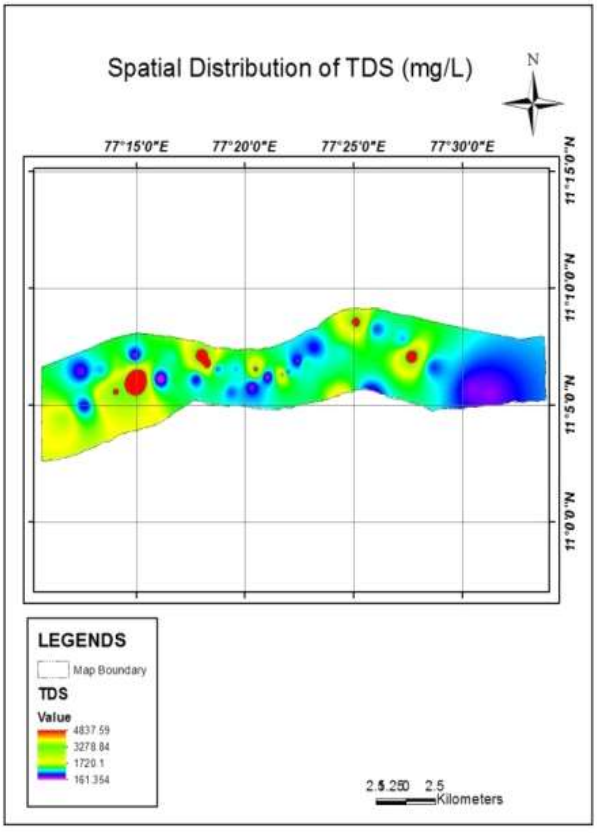

Fig. 4. Spatial distribution of TDS

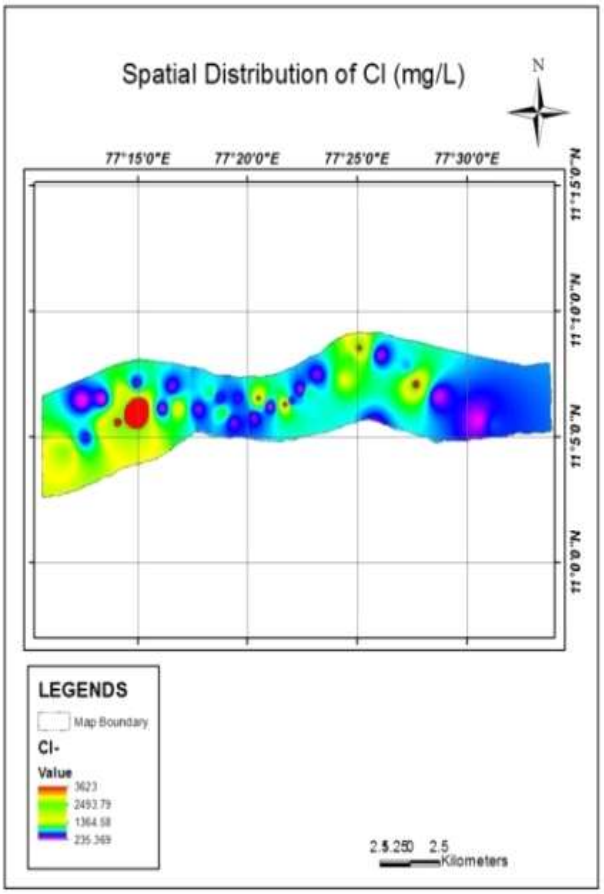

Fig. 5. Spatial distribution of chlorides

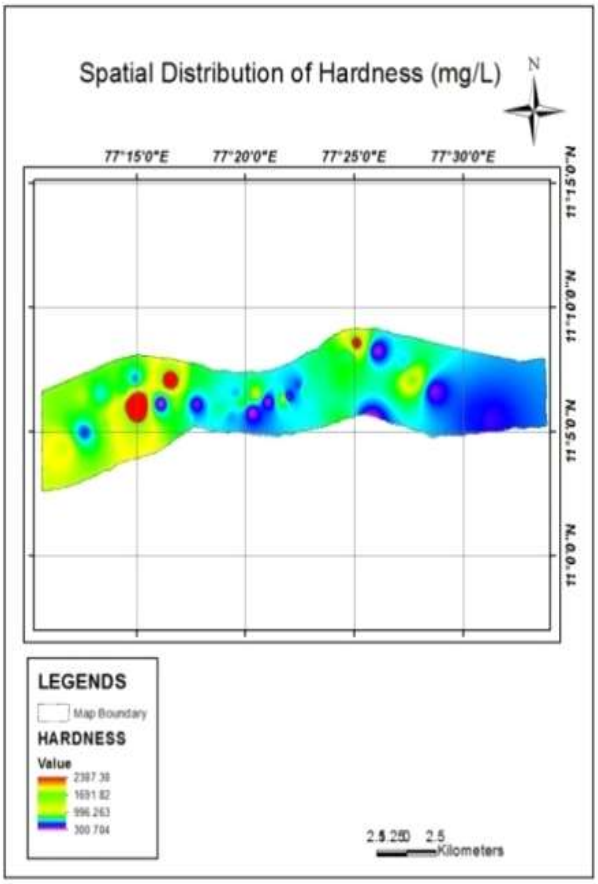

Fig. 6. Spatial distribution of hardness

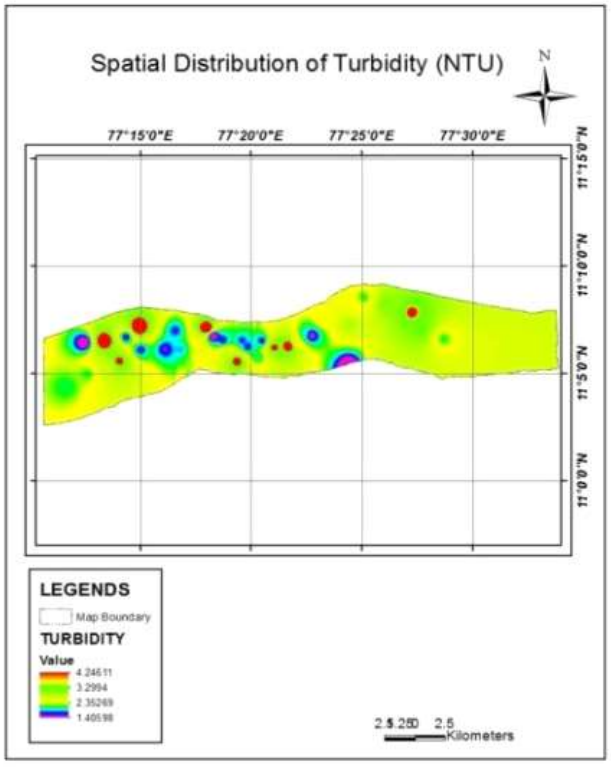

Fig. 7. Spatial distribution of turbidity

in 1880s (Samantray et al 2009, Sidhardhan and Adish Kumar 2019). From the correlation analysis, most of the parameters were negatively correlated to each other and some parameters were positively correlated to other parameters (Table 4).

GIS based water quality mapping: In this project Arc-GIS software is used to plot the spatial distribution of the various physico-chemical parameters for getting visual interpretation of the consistent values of groundwater quality parameters (Jebastina and Arulraj 2017, Subbaiah et al 2022). The calculated concurrence values of the water quality parameters during July 2021 and October 2021 at different well locations were presented in the mapping format using GIS software (Fig. 1 to 7).

CONCLUSION

Thee most of the groundwater source is contaminated in the selected sites due to the poor effluent treatment methods and poor agricultural practices in the Tiruppur district. The range of the physico-chemical parameters exceeds the permissible limits in most of the samples except at the three locations such as at Pallapalayam bore well, Mangalam bore

well and Sivasakthi nagar. The pH and turbidity values of all the groundwater samples are well within the permissible limits as per IS codes. The other physico-chemical parameter of most of the regions along the banks of the Noyyal River is more than the permissible limits. The bore well located at Agraharapudur is need to be monitored continuously due to its higher level of contamination compared to other wells. Hence, continues monitoring of groundwater samples at the selected locations facilitate in improves the quality of groundwater and helps in sustainability in water management practices.

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