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Assessing Groundwater Quality for Drinking Purpose at Palar River Ambur at Tirupattur District Tamil Nadu By Using Water Quality Indexing

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Abstract**—***This study evaluates groundwater quality along the Palar River in Ambur, Tirupattur District, Tamil Nadu, to determine its suitability for drinking purposes. A Water Quality Index (WQI) was calculated based on key physicochemical parameters, including pH, total dissolved solids (TDS), total hardness, and major ions such as calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), and sulphate (SO_4^{2-}), analysed from collected water samples. Results revealed significant groundwater contamination, with all samples classified as either poor and unfit for human consumption. Elevated TDS, total hardness, and major ion concentrations exceed permissible limits, indicating a deterioration in water quality. The contamination is attributed to anthropogenic activities, including industrial effluents and agricultural runoff. The findings underscore the urgent need for groundwater management strategies in the region to mitigate the adverse effects of pollution on human health. This study highlights the critical role of continuous monitoring and effective remediation measures to ensure the sustainability of groundwater resources in the area.*

Keywords**—** *Drinking Water Suitability, Groundwater Quality, Water Contamination, Water Quality Index (WQI).*

I. INTRODUCTION

Groundwater serves as an essential and dependable freshwater resource for millions of people across the globe, providing water for both drinking and irrigation purposes. Historically, groundwater was considered inherently clean and safe due to the natural filtration processes that occur as water percolates through soil and rock layers. However, the advent of rapid industrialization and the exponential growth of the human population have significantly altered the quality of this vital resource. Today, groundwater is increasingly susceptible to contamination, posing serious risks to human health and the environment. The quality of groundwater in any specific region is governed by a complex interplay of physicochemical parameters. These parameters are primarily influenced by the underlying geological formations, regional climatic conditions, and a range of anthropogenic activities. However, it is the human-induced, or anthropogenic, activities that have the most profound impact on groundwater quality. Natural processes, such as the weathering of rocks and the leaching of minerals from soils, contribute to the baseline chemical composition of groundwater. The anthropogenic activities have introduced a range of contaminants into groundwater systems. Industrial operations, including mining and the processing of raw materials, often result in the discharge of heavy metals and other pollutants into the environment. The widespread use of metal-based materials in various industries further exacerbates the contamination issue. Agricultural practices, particularly the use of synthetic fertilizers, pesticides, and herbicides, have become prevalent worldwide. These chemicals, designed to enhance crop yields, often leach into groundwater, leading to the presence of hazardous substances that can be harmful to both humans and wildlife [1]. Faecal contamination of drinking water is another critical concern, particularly in areas with inadequate sanitation infrastructure. The presence of pathogenic microorganisms in water supplies can lead to the spread of waterborne diseases, which have been responsible for the deaths of millions of people globally [2; 3]. Industrial waste, including effluents from manufacturing, power generation, mining, construction, and food processing industries, represents a major source of water pollution [4]. These industries often discharge untreated or inadequately treated wastewater into the environment, leading to the accumulation of toxic substances in groundwater. According to estimates, untreated domestic sewage is responsible for 70-80% of water pollution, highlighting the significant impact of human activities on water quality [5; 6].

The increasing use of synthetic fertilizers, pesticides, and herbicides in agricultural and horticultural practices has become a global phenomenon. While these chemicals are effective in promoting plant growth and controlling pests, their infiltration into water bodies can have serious consequences. Once in the water system, these substances can cause a variety of health problems in humans and animals, ranging from acute poisoning to long-term chronic illnesses. It is critically important to evaluate water quality before its use for drinking, domestic, agricultural, or industrial purposes. Ensuring water safety requires comprehensive testing across various physicochemical parameters. The Water Quality Index (WQI) serves as a valuable tool in this regard, providing a singular, quantitative measure of overall water quality at a specific location and time, derived from the analysis of multiple water quality parameters [7; 8; 9]. The objective of the water quality index is to turn complex water quality data into statistics that are comprehensible and serviceable to the public [10]. Water quality indices typically integrate data from several key water quality parameters into a mathematical model that yields a numerical value representing the overall state of a water body

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[11; 12]. This approach allows for a straightforward comparison of water quality across different sites [13; 14].

In this study, nine critical parameters were selected to calculate the Water Quality Index for groundwater in Ambur, a town in the Tirupattur District of Tamil Nadu, India. These parameters include pH, Total dissolved solids (TDS), total hardness, and concentrations of major ions such as calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}) and sulphate (SO_4^{2-}). The primary aim of this research is to assess the groundwater quality in Ambur and to determine its suitability for drinking and other uses. The findings of this study emphasize significant contamination issues within the groundwater of Ambur study area.

II. STUDY AREA

The study area extents approximately 39 km^2 along the banks of the Palar River, situated roughly 190 km west of Chennai city, Tamil Nadu, India. Positioned within latitudes North Lat. 12°45'30" - 12°49'20" and East Long. 78°40'50" - 78°44'35", it falls within Survey of India Toposheet 57- L/9 & 13. The existence of a group of tanneries located on both banks of the river, with Ambur becoming a key area celebrated as the "Leather City. " The tanneries in Ambur focus on creating footwear for internationally acclaimed brands, while also accommodating manufacturing facilities of Indian enterprises [15; 16]. Nevertheless, the region suffers from pollution as a result of tannery wastewater discharge, making groundwater unfit for drinking. From a geological perspective, the study area displays a distinct formation: Archaean-age crystalline rocks and Quaternary alluvial deposits. The alluvial deposits are significant along the route of the Palar River, marked by sand, gravel, and sandy clay, with thicknesses growing towards the east. Conversely, the south-eastern area is primarily composed of charnockite formations, whereas gneiss formations are more common in the north-western section. These geological structures have experienced considerable metamorphic processes, leading to the formation of gneissic rock types. Furthermore, secondary geological features such as joints, fractures, along with the intrusions of dolerite dykes and quartz veins, additionally define the geological landscape of the region. The extensive discharge of industrial effluents over the years has significantly compromised the quality of both groundwater and surface water in the region. As a result, these water resources have become unsuitable for drinking, irrigation, or any other intended uses, posing serious environmental challenges.

III. MATERIALS AND METHODS

To assess the physicochemical parameters of groundwater, a total of 59 shallow groundwater samples were collected from Bore wells across the Ambur area in Tirupattur District of Tamil Nadu (Fig. 1). These samples were taken during two distinct periods: the pre-monsoon season and the post-monsoon season. The water samples were collected in 1-liter plastic containers specifically prepared for detailed chemical analysis. Prior to sample collection, the containers were thoroughly washed with distilled water and air-dried to prevent any potential contamination during the groundwater sampling process, each 1-liter plastic container was serially numbered and accompanied by detailed records including well/sample location, date of collection, and static water level. Prior to sampling, each well was pumped for a minimum of 5–10 minutes to ensure the collection of a representative composite sample. After collection, the water samples were stored at temperatures below 4°C and subsequently analysed. The chemical analysis of the samples included parameters such as pH, Total Dissolved Solids (TDS), Total Hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Chloride (Cl^{-}), and Sulphates (SO_4^{2-}), following the standard procedures outlined by [17]. Analytical results were meticulously evaluated and compared against the water quality guidelines established by [18]. Specific analyses included: pH, Chloride (Cl^{-}), Fluoride (F^{-}), and Nitrate (NO_3^{-}): Measured using a multiparameter ion meter (Thermo Orion 5 Star). Sulphate (SO_4^{2-}): Quantified using a double-beam UV-Vis spectrophotometer (Perkin Elmer Lambda 35) with turbidimetric, stannous chloride, and molybdosilicate methods. Sodium (Na^{+}), Potassium (K^{+}), Calcium (Ca^{2+}), and Magnesium (Mg^{2+}): Analyzed using a flame photometer (Elico CL-378, India). Total Hardness (TH): Determined using the EDTA titrimetric method. TDS: Measured gravimetrically.

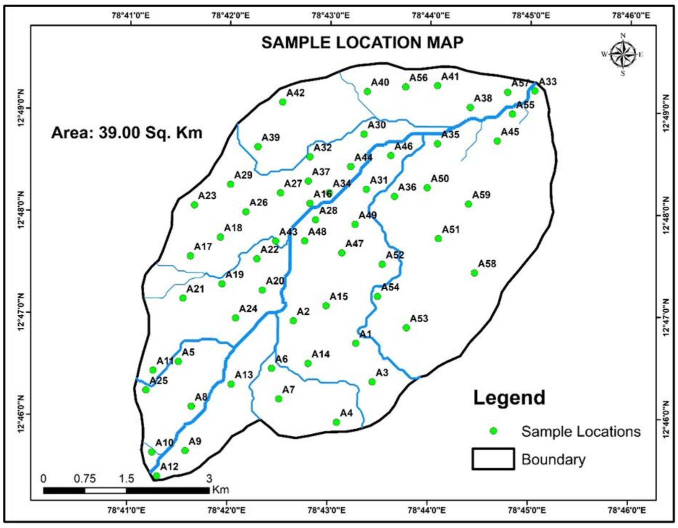

Fig. 1: Sample Location Map

IV. WATER QUALITY INDEX (WQI)

The Water Quality Index (WQI) serves a critical role in simplifying and communicating complex water quality data to the public. It addresses the need for a consistent method of monitoring ambient water quality and provides a means to compare and rank various water bodies within a region. By distilling numerous water quality parameters into a single, comprehensible metric, the WQI eliminates technical jargon and complexity, making water quality assessments more accessible to non-specialists.

The WQI is based on three key criteria related to the achievement of water quality objectives: (1) the number of objectives that are not met, (2) the frequency with which these objectives are not met, and (3) the extent by which the objectives are not met. The index is calculated using a weighted arithmetic formula:

$$WQI=\sum(q_i*w_i)/(w_i)$$

where: q_i represents the quality rating of the i-th parameter, and w_i denotes the weight assigned to that parameter

In this study, the WQI was computed for groundwater water samples collected during the pre-monsoon and post-monsoon periods. Nine key parameters were considered: pH, Total dissolved solids (TDS), total hardness, calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}) and sulphate (SO_4^{2-}). The classification of water quality based on the WQI follows the criteria established by [19; 20; 21] was classified as excellent (WQI <50), good (WQI = 50–100), poor (WQI = 100–200), very poor (WQI = 200–300), and water unsuitable/unfit for drinking and irrigation (WQI >300).

V. RESULTS AND DISCUSSION

The analytical results of the physical and chemical parameters of groundwater in this study are presented in Table 1 & 2. These results were compared with the World Health Organization (WHO) guidelines for drinking water quality. Below is a detailed discussion of the key physico-chemical attributes.

TABLE 1: Physico chemical analysis of Groundwater samples of study area collected during Pre-monsoon

Well ID	TDS	pH	Ca^{2}	K	Na	SO4^{2}	Mg^{2}	Cl	TH
A1	2380	8.2	82	20	421	380	169	773	900
A2	2672	8.12	95	90	503	589	151	842	858
A3	2769	7.93	88	90	517	457	166	915	903
A4	2390	8.17	58	75	520	290	116	840	622
A5	670	7.3	64	29	55	142	49	156	361
A6	2560	7.4	386	54	371	1001	34	568	1105
A7	2580	7.45	96	82	517	373	128	823	766
A8	3502	8.03	67	89	969	587	78	1086	488
A9	3742	7.22	150	110	975	980	63	951	634
A10	2711	7.23	175	54	268	862	245	603	1445
A11	679	7.14	75	26	51	129	47	113	381
A12	2548	7.53	124	114	209	824	258	502	1371
A13	3515	6.5	133	126	596	804	226	1087	1262
A14	1750	6.61	89	36	225	397	145	416	819
A15	2563	7.43	214	82	570	750	25	580	638
A16	4814	7.16	441	200	810	864	147	1605	1707
A17	1329	7.64	168	65	109	432	70	251	708
A18	1374	7.78	175	71	102	350	76	275	750
A19	2030	7.97	335	91	250	776	18	351	911
A20	2050	7.65	250	95	350	624	19	458	703
A21	2314	7.79	108	94	290	729	187	480	1039
A22	2447	7.84	340	116	364	646	25	698	953
A23	565	7.81	54	27	51	134	38	134	291
A24	1962	7.72	75	114	212	623	176	455	911
A25	504	7.43	46	24	46	113	35	122	259
A26	1647	6.79	215	105	224	539	28	330	653
A27	2252	7.13	350	160	260	652	24	589	972
A28	2241	7.62	323	80	350	669	15	460	870
A29	1837	7.55	169	105	250	549	78	444	743
A30	2072	8.17	178	68	398	489	50	554	651
A31	2627	7.74	240	87	562	469	24	758	699
A32	2221	8.07	436	84	174	875	35	347	1233
A33	9792	6.3	2041	671	3751	9480	286	3648	6278
A34	4350	6.89	773	139	509	1325	36	980	2081
A35	5143	5	280	86	780	1143	358	1456	2172
A36	1829	8.05	280	86	250	467	15	468	762
A37	2594	7.25	254	129	512	786	23	576	728
A38	4349	6.5	82	650	1012	1891	31	715	332
A39	815	7.32	112	27	79	231	35	94	424
A40	1153	7.47	53	42	158	266	88	267	494
A41	1149	7.44	52	22	183	303	81	286	463
A42	628	7.86	38	27	92	192	38	98	251
A43	3416	7.54	134	188	612	777	179	1052	1071
A44	3950	7.59	187	151	657	803	235	1252	1434
A45	5229	6	250	83	709	1251	431	1484	2397
A46	3539	7.72	423	66	653	996	43	788	1233
A47	1518	7.62	115	145	250	438	38	351	445
A48	3497	7.21	224	154	850	961	24	1105	660
A49	1300	8.16	58	47	200	213	89	395	511
A50	933	6.71	101	34	86	234	58	212	491
A51	981	6.9	115	35	77	243	63	236	547
A52	1684	6.64	105	74	340	247	50	525	469
A53	1815	7.74	87	54	215	560	158	457	867
A54	1836	6.57	356	85	140	646	28	342	1007
A55	5526	7.35	222	89	652	1303	532	1528	2743
A56	1487	6.29	28	83	268	329	95	360	462
A57	6049	7.62	288	82	789	1489	520	1752	2858
A58	892	7.64	86	96	128	114	18	282	289
A59	2144	7.72	85	51	359	490	146	589	813

TABLE 2: Physico chemical analysis of Groundwater samples of study area collected during post-monsoon

Well ID	TDS	pH	Ca^{2}	K	Na	SO4^{2}	Mg^{2}	Cl	TH
A1	1806	8.3	80	31	296	273	125	580	714
A2	2108	8.01	96	74	335	393	138	595	807
A3	2028	7.63	80	65	351	336	127	678	722
A4	2100	7.91	55	61	436	238	112	770	598
A5	561	7.32	58	22	50	101	37	117	297
A6	2099	7.21	275	58	302	880	50	348	893
A7	2154	7.5	90	55	430	278	106	582	661
A8	2611	7.86	85	80	684	510	53	656	430
A9	3084	7.1	160	81	786	772	42	698	573
A10	2309	7.21	176	55	218	677	195	508	1242
A11	570	7.2	80	24	36	100	32	84	332
A12	2057	7.26	120	94	185	486	187	451	1069
A13	2620	6.92	127	88	375	612	190	881	1099
A14	1383	6.97	68	24	150	253	132	277	713
A15	2208	7.25	189	52	481	558	30	515	596
A16	3508	7.38	328	150	620	645	86	1006	1174
A17	955	7.64	155	35	67	257	39	164	548
A18	852	7.77	137	46	60	186	31	138	470
A19	1693	7.86	280	75	189	710	25	283	803
A20	1920	7.28	215	87	324	612	32	386	669
A21	1695	7.33	76	80	219	621	132	326	733
A22	2295	7.36	327	88	317	623	38	640	974
A23	513	7.53	55	25	42	113	33	87	273
A24	1659	7.61	70	95	189	582	140	368	751
A25	437	7.32	61	20	34	79	21	90	239
A26	1592	6.94	213	89	220	486	26	326	639
A27	2276	7.37	328	165	254	641	43	576	997
A28	2149	7.62	300	74	325	579	27	446	861
A29	1629	7.32	138	97	241	523	65	405	612
A30	1982	7.51	186	75	379	378	36	468	613
A31	2633	7.36	231	86	560	429	32	750	709
A32	2150	7.53	400	88	172	903	43	325	1177
A33	17657	6.88	2538	557	2752	7651	150	2965	6962
A34	4020	6.93	650	127	487	1298	64	889	1888
A35	4020	7.02	221	70	558	963	305	1045	1807
A36	1751	7.88	256	75	220	426	34	389	780
A37	2579	7.34	240	123	505	754	34	545	740

A38	4182	7.52	102	628	952	1580	26	700	362
A39	606	7.37	87	21	54	108	26	67	324
A40	1007	7.75	41	35	160	221	69	260	386
A41	1036	7.38	36	25	165	263	78	280	411
A42	557	7.22	40	23	82	164	30	88	223
A43	3287	7.46	125	176	610	756	165	973	991
A44	3663	7.48	169	133	624	751	215	1153	1307
A45	4491	6.56	230	95	587	1052	365	1258	2076
A46	3221	7.05	389	53	607	861	32	720	1104
A47	1379	7.34	106	127	241	385	28	336	380
A48	3184	7.66	202	126	779	778	25	948	608
A49	1147	8.02	50	35	188	210	75	329	433
A50	706	7.56	84	26	73	120	35	183	354
A51	719	7.32	83	27	65	159	42	155	380
A52	1666	7.89	126	70	297	243	58	487	553
A53	1620	7.45	89	46	201	470	130	384	757
A54	1770	7.47	342	67	125	621	38	298	1011
A55	4533	7.51	157	48	534	1037	460	1274	2284
A56	1346	7.58	25	69	243	324	88	345	424
A57	4708	7.36	158	51	650	1095	430	1327	2163
A58	735	7.33	74	75	102	102	16	200	251
A59	1995	7.29	88	43	326	465	136	527	779

A. *Hydrogen ion (pH)*

The seasonal average pH value was determined to be neutral at 7.3. During the pre-monsoon season, pH values ranged from 5.0 to 8.2, while in the post-monsoon season, values ranged from 6.5 to 8.3 (Fig. 2). The observed lower pH levels are partially attributed to the application of agricultural fertilizers, such as ammonium sulfate and super phosphate [22].

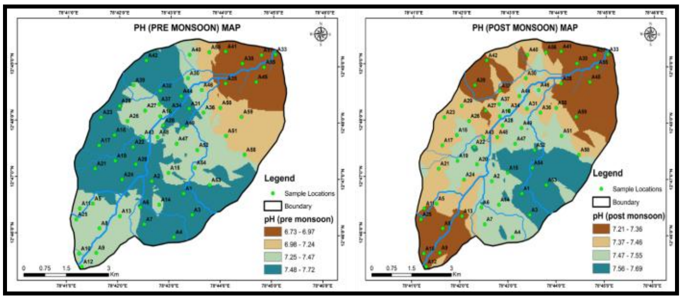

Fig. 2: Spatial Distribution Map (pH)

B. *Total Dissolved Solids (TDS)*

TDS is a critical parameter for assessing the potability and suitability of groundwater for domestic use. None of the samples analyzed fell within the WHO recommended limit of 500 mg/L. Specifically, 84.7% of pre-monsoon samples and 79.7% of post-monsoon samples exceeded this limit (Table 3) (Fig. 3). The primary contributors to elevated TDS levels included livestock waste, landfills, and dissolved minerals, particularly iron and manganese.

C. *Total Hardness (TH)*

Total hardness values ranging from 150 to 300 mg/L classify water as hard, while values exceeding 300 mg/L indicate very hard water [23]. In this study, 100% of pre-monsoon samples and 98.3% of post-monsoon samples (Fig. 4) were above the WHO limit of 100 mg/L for drinking water quality [24] as in (Table 3). The predominant sources of hardness were identified as calcium and magnesium from soil and aquifer minerals. High TH levels are associated with health risks, including kidney stones and cardiovascular diseases.

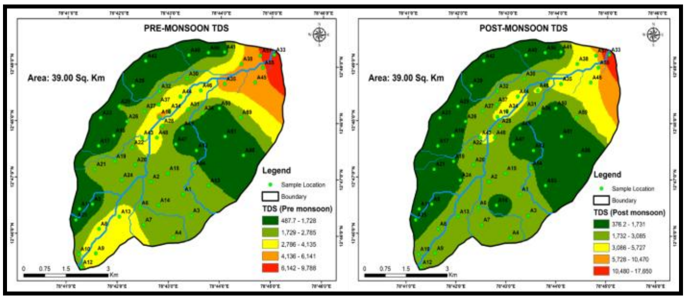

Fig. 3: Spatial Distribution Map (TDS)

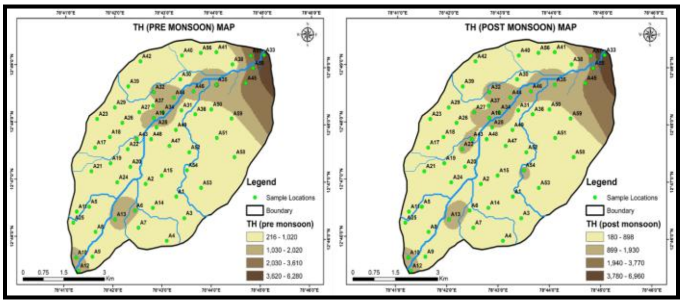

Fig. 4: Spatial Distribution Map (TH)

D. *Calcium and Magnesium*

Calcium concentrations demonstrated seasonal variation, with a majority of samples remaining within the permissible limit of 75 mg/L. However, 79.7% of pre-monsoon and 78% of post-monsoon samples exceeded this threshold (Fig. 5). Concentrations of calcium up to 1,800 mg/L do not impair physiological reactions in humans [25]. Magnesium levels were generally lower than those of calcium, exhibiting a gradual increase from post-monsoon to pre-monsoon. In both seasons, 78% of pre-monsoon and 79.7% of post-monsoon samples surpassed the permissible limit for magnesium, influenced by local geochemical conditions (Fig. 6).

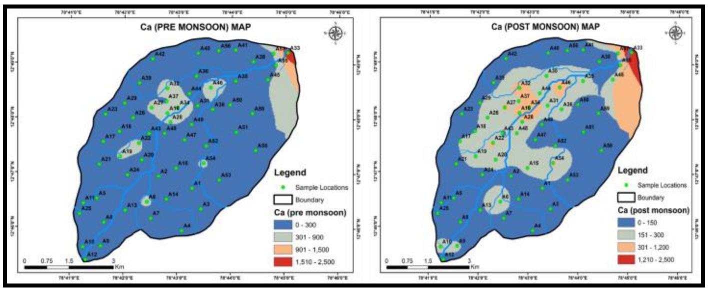

Fig. 5: Spatial Distribution Map (Ca)

E. *Chloride (Cl)*

The principal sources of chloride in groundwater include animal organic matter, sewage effluent, and fertilizers used in agriculture. The WHO recommends a maximum chloride concentration of 250 mg/L [24]. In this study, 86.4% of pre-monsoon samples and 79.7% of post-monsoon samples exceeded this limit (Table 3) (Fig. 7).

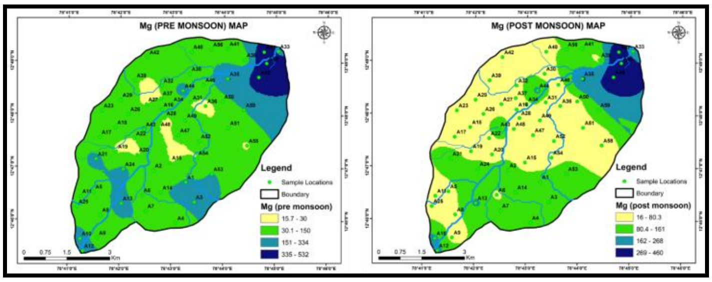

Fig. 6: Spatial Distribution Map (Mg)

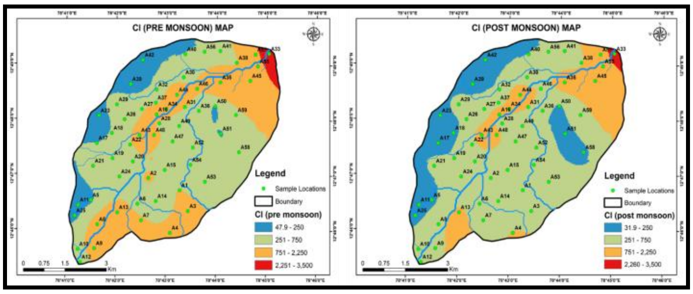

Fig. 7: Spatial Distribution Map (Cl)

F. *Sodium And Potassium*

Sodium is a significant naturally occurring cation, with concentrations in freshwater typically lower than those of calcium and magnesium. However, in this study, the average sodium concentration was found to be higher than that of both calcium and magnesium. The WHO limit for sodium in drinking water is 50 mg/L, with 98.3% of pre-monsoon samples and 91.5% of post-monsoon samples exceeding this guideline (Table 3) (Fig. 8). Potassium concentrations were consistently high across all seasons, often exceeding the acceptable limit of 12 mg/L (Fig. 9) [26; 24]. Elevated potassium levels in groundwater can result from the excessive application of inorganic fertilizers, contributing to nutrient leaching and degradation of water quality in arid and semi-arid regions [27; 28; 24].

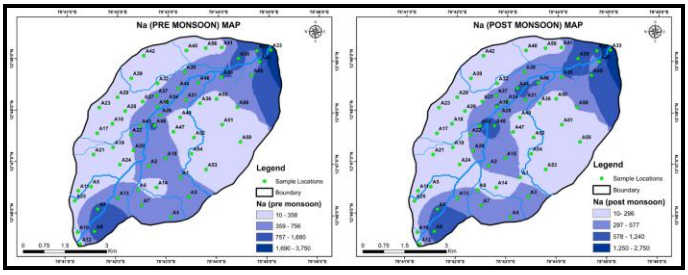

Fig. 8: Spatial Distribution Map (Na)

G. *WQI RESULTS*

In the study area, water samples were predominantly classified into poor, very poor, and unfit, with 15% poor, 10% Very poor, and 75% as Unfit, during the Pre-monsoon period and 22% poor, 15% Very poor, and 63% as Unfit during the Post-monsoon period. All the samples were categorized as unsuitable for drinking purposes, reflecting significant quality concerns in the region (Table 4 & 5).

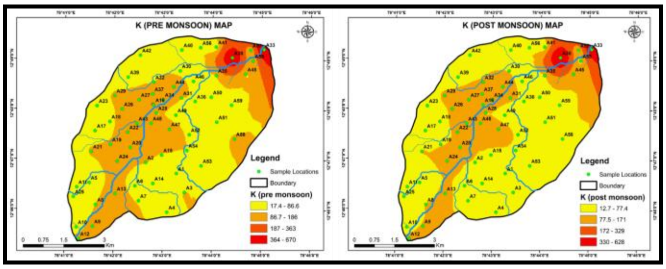

Fig. 9: Spatial Distribution Map (K)

TABLE 3: Quality of groundwater samples from Palar River Ambur at Tirupattur District For drinking purpose (WHO standards)

Parameters	WHO Standards	Pre monsoon sample %		Post monsoon sample %	
		Within limits	Exceed limits	Within limits	Exceed limits
TDS	500	15.3	84.7	20.3	79.7
pH	8.5	100.0	0.0	100.0	0.0
Ca^2	75	20.3	79.7	22.0	78.0
K	12	0.0	100.0	0.0	100.0
Na	50	1.7	98.3	8.5	91.5
SO$_4$	200	10.2	89.8	18.6	81.4
Mg^2	30	22.0	78.0	20.3	79.7
Cl	250	13.6	86.4	20.3	79.7
TH	100	0.0	100.0	1.7	98.3

The spatial distribution of the Water Quality Index (WQI) for pre-monsoon and post-monsoon periods in Ambur city indicates significant groundwater pollution. The pre-monsoon map shows that a substantial portion of the study area falls under the "Poor" category, with localized regions classified as "Very Poor" and "Unfit" for drinking purposes, particularly in the northeastern and central parts. Post-monsoon data suggests some improvement, as the area classified as "Unfit" slightly reduces. However, the extent of "Very Poor" water quality increases, indicating persistent contamination despite seasonal dilution (Fig. 10).

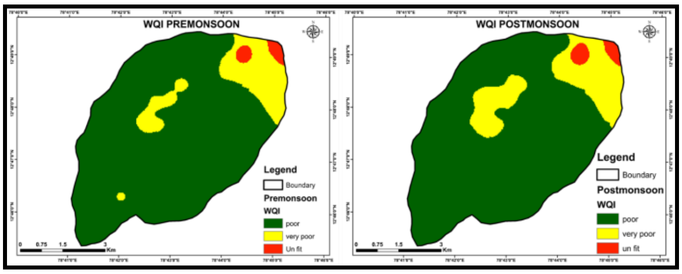

Fig. 10: Spatial Distribution Map of WQI

TABLE 4: WQI of groundwater for pre-monsoon and post-monsoon period

WELL ID	Water Quality Index (WQI) (WHO Standards)	
	Pre-Monsoon	Post-Monsoon
A1	257.9368926	241.2623861
A2	432.3408716	359.4808639
A3	439.6676271	329.9142428
A4	371.9292767	321.5637485
A5	150.7291206	125.3627459
A6	307.3217337	295.5438428
A7	397.7385132	305.7389374
A8	453.9225888	377.1507277
A9	508.7771749	398.5438175
A10	371.4378875	337.9148887

A11	142.4520458	128.1227064
A12	507.2364974	412.5686653
A13	573.6670106	429.7132116
A14	247.3270386	197.2934742
A15	370.0664892	281.108863
A16	793.6885197	592.1874517
A17	276.9157882	178.1266683
A18	294.7332204	196.4522692
A19	362.396701	309.0722004
A20	371.5915676	347.9549365
A21	430.5038235	348.3865814
A22	443.5506441	371.5714905
A23	140.1965119	129.7938078
A24	455.23061	384.8384759
A25	127.3748311	109.8381348
A26	371.6380285	331.3737124
A27	531.6586725	550.6981949
A28	344.7672658	328.7739546
A29	399.3988549	365.620405
A30	320.868957	324.1365564
A31	384.4449454	382.428964
A32	360.5232769	366.2245711
A33	2733.538221	2316.839868
A34	594.4866817	558.0801941
A35	594.3677157	492.7216388
A36	338.740452	312.8616553
A37	479.3856105	467.7299717
A38	1790.071075	1731.056744
A39	149.7170561	122.0839771
A40	218.3953208	190.7487121
A41	170.1888122	170.1462362
A42	144.1368247	125.7360681
A43	704.8218459	665.7772231
A44	661.7512673	598.7411974
A45	617.3637148	590.2552832
A46	389.5159461	335.8681447
A47	465.0025691	411.7168906
A48	588.0602864	507.3544335
A49	241.2895071	200.8969848
A50	175.9439661	142.861825
A51	183.0182273	146.7425661
A52	306.3343964	303.7587535
A53	302.9382158	264.4403519
A54	333.0288685	294.5340953
A55	680.6202859	513.6865757
A56	328.1911306	292.7126253
A57	691.066231	521.6200198
A58	311.3593133	252.1452866
A59	309.5480047	278.056989

TABLE 5: Water Quality Index (WQI) Classification of Groundwater Samples (Pre-Monsoon and Post-Monsoon)

Water Quality Index (WQI)	Category	Pre-Monsoon sample %	Post-Monsoon sample %
<50	**Excellent**	0	0
50-100	**Good**	0	0
100-200	**Poor**	15	22
200-300	**Very Poor**	10	15
>300	**Unfit**	75	63

VI. CONCLUSION

The analysis of physicochemical parameters in the groundwater of Study area reveals elevated levels of Total dissolved solids (TDS), total hardness, calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}) and sulphate (SO_4^{2-}). across the sampled locations. A significant proportion of these samples exceed the permissible limits established by the World Health Organization (WHO). The primary contributors to this groundwater contamination are anthropogenic activities and pollutants from the tannery industry. The elevated Water Quality Index (WQI) observed in this study underscores the substantial degradation of water quality, rendering it unsuitable for human consumption. This analysis suggests that industrial and anthropogenic activities continue to impact groundwater quality. The findings emphasize the need for effective pollution control measures, sustainable water management strategies, and regular monitoring to mitigate groundwater contamination risks in study area.

VII. AUTHORS' CONTRIBUTION

V. Satish Kumar designed the study, wrote the protocol and collected data and conducted data analysis and drafted the manuscript, All the authors reviewed and contributed to the writing of manuscript. V. Satish Kumar is the corresponding author.

VIII. AVAILABILITY DATA AND MATERIALS

Data will be made available upon request.

IX. DECLARATIONS CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

X. ETHICAL APPROVAL

Before initiating the study, approval was obtained from the supervising authority, as this research forms part of the author's Ph.D. work. The purpose and scope of the study were clearly communicated, and informed consent was secured prior to data collection. No psychological or physical risks were posed to either the researchers or the members involved throughout the course of the study.

XI. CONSENT FOR PUBLICATION

All authors have agreed that the manuscript should be published.

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