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WATER QUALITY ASSESSMENT OF UDUMALPET TALUK, SOUTH INDIA USING MNSF-WQI AND GIS METHOD

R. Chitradevi[1], P. N. Magudeswaran[2], Vikas D. Ghadamode[3], K. Poonkodi[4] and V. Anitha[1]
[1]Research and Development Center, Bharathiar University, Coimbatore, Tamil Nadu, India
[1]Department of Chemistry, Sri G.V.G Visalakshi College for Women, Udumalpet, Tamil Nadu, India
[2]Hindustan College of Engineering and Technology, Coimbatore, Tamil Nadu, India
[3]National Geophysical Research Institute, Hyderabad, Telangana, India
[4]Post Graduate Department of Chemistry, Nallamuthu Gounder Mahalingam College, Pollachi, Tamil Nadu, India
E-Mail: magudeswaran2021@gmail.com

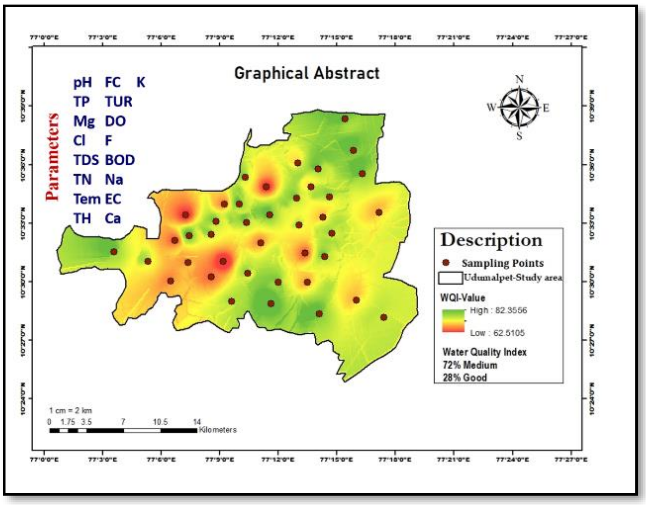
ABSTRACT

The present study was carried out to analyze the water quality of Udumalpet Taluk, Tamil Nadu, India by Water Quality Index. The spatial variation maps of physico-chemical parameter were produced using ArcGIS 10.8 software. Totally 40 samples were collected from different sampling points and investigated for 17 physico-chemical parameters. The MNSF-WQI result reveals that 72% of the collected water samples fall under good quality and 28% belongs to medium category. According to spatial distribution maps of WQI, water quality of the study area is fit for drinking and irrigation purposes.

Keywords: Udumalpet Taluk, Water Quality Index, NSF-WQI, MNSF-WQI and GIS.

INTRODUCTION

Water is one of the largest natural resources with a profound impact on the entire ecosystem. Of course, water is accumulated in oceans, seas, lakes, streams canals and ponds. Global urbanization has created major problems to the environment, particularly with regard to the water quality of these water bodies [1]. Protecting the environment and preserving water quality is one of everyone's core tasks worldwide [2]. The majority of the India's population depends on groundwater for drinking. Because of various human activities, demand for pure water has increased many times in recent years, which in turn has created stress on water resources. Also, they have led to over exploitation and pollution of land water resources in many areas. Once the ground water is polluted, it is very difficult to remediate it. This has led to a number of negative environmental impacts on the sustainability of groundwater resources. In addition, surface water quality is a very sensitive and critical problem in several regions. Clean water is a key for a healthy life. So, there is a keen demand to evaluate water quality to ensure its sustainability for various purposes. A variety of methods have been implemented to examine the water quality status of the water bodies [3-5]. The Water Quality Index (WQI) is used a excellent tool which convert a lot of data into single data to represent the water quality level of watersheds [6]. Geographic Information System (GIS) is the foremost tool to address diverse issues and manage geographic information broadly without losing spatial-temporal dispersal. The main purpose of the present study is to evaluate the ground and surface water quality of the Udumalpet Taluk, Tamil Nadu by means of detailed hydrochemistry within the study area and to determine the different water classifications, for drinking and irrigation purposes using Modified National Sanitation Foundation-Water Quality Index (MNSF-WQI) and GIS technique. To attain the aim of the present work, 17 important physico-chemical parameters such as pH, Temperature, Dissolved Oxygen, Biological Oxygen Demand, Fecal Coliform, Total Dissolved Solid, Total Phosphate, Turbidity, Total Nitrate, Electrical Conductivity, Total Hardness, Chloride, Calcium, Magnesium, Sodium, Potassium and Fluoride.



EXPERIMENTAL

Study Area

Udumalpet is Taluk belonging to the Tiruppur District in Tamil Nadu State. The study area is between 10.5823˚N and 77.2446˚E and covers a total area of 451.23 square kilometers, which is measured by using ArcGIS 10.8 software shown in Figure-1. The economy of Udumalpet and the surrounding area is largely relied on agriculture and the textile industry.

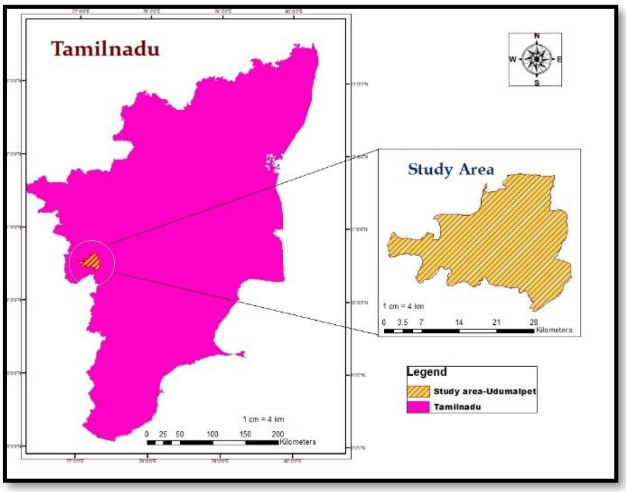


Figure-1. Study Area - Udumalpet Taluk, Tamil Nadu.

Sampling an Analytical Procedure

Forty water samples were collected from different locations during pre-monsoon season of 2019. Samples are from open well, borewell and lake were filtered, collected in a pre-cleaned container using standard methods and labelled as from S1 to S40 (Table-1). Physicochemical and biological analysis was performed for 17 parameters i.e. as pH (units), Temperature (˚C), Fecal Coliform (MPN/100ml), Dissolved Oxygen (%), Biological Oxygen Demand (mg/L), Total Dissolved Solids (mg/L), Total Phosphates (mg/L), Turbidity (NTU), Total Nitrates (mg/L), Electrical Conductivity (µS/cm), Total Hardness (mg/L), Chloride (mg/L), Calcium (mg/L), Magnesium (mg/L), Sodium (mg/L), Potassium (mg/L) and Fluoride (mg/L) using standard APHA methods.

Table-1. Location of the sampling points.

Sampling Points	Place	Latitude	Longitude
S1	Dhali	10.483	77.16
S2	Andigoundanur	10.481	77.194
S3	Jallipatti	10.499	77.2
S4	Kurchikottai	10.499	77.225
S5	Manupatti	10.472	77.235
S6	Arasur	10.517	77.153
S7	Devanurputhur	10.517	77.089
S8	Erisanampatti	10.535	77.112
S9	Udukkampalayam	10.557	77.121
S10	Chinnavalavaddi	10.533	77.185
S11	Pallapalayam (OS)	10.524	77.223
S12	Bodipatti	10.555	77.238
S13	Udumalpet (Town)	10.572	77.244
S14	Poolankkinar (OS)	10.581	77.19
S15	Ganapathipalayam	10.601	77.217
S16	Chinnaveranpatti	10.612	77.264
S17	Bodigoundendasarapatti	10.639	77.257
S18	Jilobanaikampaalyam	10.516	77.123
S19	Kanakkampalayam	10.581	77.228
S20	Valayapalayam	10.5	77.108
S21	Krishnapuram	10.504	77.143
S22	Andigoundanur	10.484	77.267
S23	North Boothinatham	10.548	77.218
S24	Elayamuthur	10.469	77.29
S25	Periapappanuthu	10.566	77.154
S26	Periavalavadi	10.55	77.173
S27	Kannamanaickanur	10.559	77.286
S28	Anthiyur	10.589	77.172
S29	Redipalayam	10.54	77.143

S30	R.Velur	10.557	77.193
S31	Ragalbavi	10.571	77.216
S32	Kuralkuttai	10.541	77.246
S33	Kondingiam	10.539	77.124
S34	Sinnapapanuthu	10.566	77.167
S35	Periakottai	10.592	77.272
S36	Dhali	10.507	77.174
S37	Thinappati	10.551	77.147
S38	Kurunjeri	10.596	77.234
S39	Alampalayam	10.521	77.24
S40	Arthanaipalayam	10.525	77.06

(OS)- Open Source

Calcium, magnesium and total hardness were measured by titrimetry [7] and sodium, potassium ion was detected by flame photometer [8]. Turbidity was measured using turbidity meter. The Winkler's method was used for the determination of biological oxygen demand (BOD) and dissolved oxygen (DO). Fluoride and Phosphate ions were analyzed using UV-Visible Spectrophotometer. Replicate analysis was performed for quality assurance and quality control [9]. Temperature and total dissolved solids (TDS) were measured in the field during sampling using a sensitive thermometer and a TDS meter respectively for each sample [10]. All the water quality parameters and their analytical results are tabulated in Table-2 and compared with WHO, (2018) standard values.

Table-2. Physico-Chemical parameters of different Sampling points.

Sampling Points	DO %	FC MPN/ 100ml	pH	BOD mg/L	Tem °C	TP mg/L	TN mg/L	TUR NTU	TDS mg/L	EC μS/cm	TH mg/L	Ca mg/L	Mg mg/L	Cl mg/L	F mg/L	Na mg/L	K mg/L
S1	87.3	3	8.41	2.3	25.6	1	0.3	1	414	1.38	442.3	11	431.2	540	1	57	5
S2	86.3	5	7.44	1.2	23.4	0.1	1	2	22	0.04	96.2	0.8	95.4	430	0	1	1
S3	79.6	4	8.38	2.1	24.2	0.5	0.2	1	379	0.83	384.6	10	374.3	380	0	24	2
S4	82.9	5	8.2	2.3	24.7	1	3	0.5	813	1.84	403.8	4	399.8	470	1	97	9
S5	84.5	8	7.6	2.4	25.1	0.5	0.1	1	39	0.06	57.6	7.4	50.2	690	0	2	1
S6	46.3	12	7.78	2.5	25.7	1.5	4	0.5	24	1.58	557.6	8.2	549.4	930	0	64	6
S7	75.6	5	8.03	2.1	24.8	1.5	0.5	1	125	0.15	153.8	6.2	147.6	580	0	40	4
S8	79.8	6	8.68	2.6	26.1	1.5	0.4	1	857	2.12	351.4	6.1	345.3	580	0	7	1
S9	54.5	15	8.36	2.4	25.4	1	0.2	1	43	1.07	346.1	8.6	337.5	530	0	25	1
S10	69.3	5	7.95	2.1	24.5	1.5	0.6	1	1300	2.88	615.3	17	598.1	480	0	7	1
S11	68.4	120	7.56	2.1	23.9	2.5	1.8	0.5	46	0.1	173.7	12	161.4	890	1	50	5
S12	89.4	6	7.99	2.1	24.7	2	1.2	1	443	1.05	326.9	12	315.4	850	0	20	1
S13	76.3	3	8.36	2	24.2	1.5	0.9	1	56	0.84	346.2	12	334.1	750	0	20	1
S14	81.2	110	7.99	2.2	24.8	1.5	0.7	1	698	1.74	755.1	5.3	749.8	320	0	30	3
S15	84.6	4	8.21	1.9	25.1	1.5	5	1	79	0.17	115.3	5.7	109.6	260	0	95	4
S16	81.2	4	7.93	2.1	24.8	1	0.2	1	34	0.07	115.3	14	101.8	590	1	32	7
S17	76.5	6	8.37	2.1	24.6	0.1	1	0.5	401	0.99	576.9	27	549.5	540	0	36	4
S18	77.9	5	8.68	1.8	25.2	1	0.6	0.5	495	1.17	461.5	9.2	452.3	890	0	30	4
S19	79.5	5	8.17	2.4	24.9	1	0.3	1	317	0.75	346.5	14	332.2	740	0	98	3
S20	53.4	3	8.47	2	25.2	1	0.4	1	52	0.42	365.3	13	351.9	250	0	26	4
S21	64.9	4	7.97	2.3	24.3	1.5	0.8	1	651	1.63	764.5	14	750.2	650	1	74	2
S22	83.9	5	8.38	2	24.5	1.5	1.1	1	459	1.04	365.3	8.2	357.1	540	0	65	8
S23	79.6	2	8.07	1.9	23.5	1	0.6	1	496	1.43	596.1	17	578.8	690	0	95	5
S24	82.6	3	8.27	1.8	24.2	1	0.5	1	543	1.53	423.7	4.2	419.5	980	0	45	3
S25	76.8	2	8.71	2.5	24.3	2	1.3	1	356	1.25	211.5	2.1	209.4	1020	0	47	9
S26	76.5	3	7.86	2	24.6	1.5	1.1	1	86	0.07	153.8	1.9	151.9	520	0	35	5
S27	74.5	2	7.95	2.4	25.1	1.5	0.7	0.5	1692	4.64	788.4	9.1	779.3	780	0	52	2
S28	79.8	4	8.13	2	24.8	1.5	0.5	0.5	89	0.47	288.4	16	272.3	510	0	23	2
S29	72.2	2	8.27	2.1	24.9	1.5	0.4	1	68	0.41	307.6	8.1	299.5	420	0	82	5
S30	46.3	2	7.44	1.2	23.4	0.1	0.1	0.5	22	1.53	634.6	5.2	629.4	210	0	10	4
S31	68.5	2	7.1	1.4	24.6	1.1	0.2	1	127	2.24	576.9	28	548.5	590	0	17	1
S32	73.9	3	7.6	1.6	25.1	1	0.1	1	425	2.65	1442	11	1431.1	560	0	40	2
S33	86.2	2	6.9	1.2	24.6	1	0.3	1	59	3.37	461.5	8.8	452.7	260	0	21	4
S34	84.9	4	7	2.1	25.2	1.2	0.1	0.5	73	3.06	1174	14	1159.5	420	0	60	5
S35	82.6	2	7.6	1.5	26.8	1.1	0.2	0.5	236	2.55	442.3	3.1	439.2	450	0	50	6
S36	94.6	3	8.2	1.4	24.3	1	0.4	1	584	1.48	365.3	11	354.1	120	0	15	4
S37	86.7	2	7.5	2.1	25.4	1.5	0.2	1.5	368	1.45	769.2	23	745.9	530	0	30	4
S38	79.8	3	7.1	1.5	26.2	1.5	0.1	1.5	167	0.25	173.7	15	158.4	680	0	14	6
S39	78.6	4	7.9	1.3	24.6	2	0.1	0.5	69	0.69	237.8	52	185.5	93	0	63	6
S40	75.8	2	6.9	1.4	25.1	1	0.1	1	142	1.24	156.2	90	66.6	56	1	89	4

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GIS and IDW Process

Inverse-distance-weighted interpolation (IWI) techniques were used to prepare spatial distribution maps for each physicochemical parameter. To predict a value for any unmeasured location, IDW will use the measured values surrounding the prediction location. Those measured values closest to the prediction location will have more influence on the predicted value than those farther away. Thus, IDW assumes that each measured point has a local influence that decrease with distance [11].

Water Quality Index

NSF-WQI was computed by using qi and Wi as shown below (eq (1))

$$WQI = \sum_{i=1}^{n} W_i \; q_i \qquad \text{---------- (1)}$$

Where

W_i - Weighing factor of parameter i

q_i - Water quality score of parameters i

n - number of parameters

To calculate the water quality index, the parameters such as DO, FC, pH, BOD, Tem, TP, TN, TUR and TDS were selected.

NSF-WQI = (0.17DO+0.16FC+0.11pH+0.11BOD+0.10Tem+ 0.10TP+0.10TN+0.08TUR+0.07TDS) ---------- (2)

The MNSF-WQI formula was derived by altering NSF-WQI with seven water quality parameters. For that, the weighing factor of BOD and Total phosphate (TP) was distributed to other seven parameters i.e. Temperature (Tem), Dissolved Oxygen (DO), Faecal coliforms (FC), pH, Total nitrate (TN), Turbidity (TUR) and Total Dissolved Solids (TDS) by using mathematical principles of proportion and summation.

The resultant formula of MNSF-WQI was

MNSF-WQI= 0.22DO+0.20FC+0.14pH+0.13Tem+0.13TN+0.10TUR+0.09TDS --------- (3)

The schematic representation of entire experimental part is given in Figure-2.

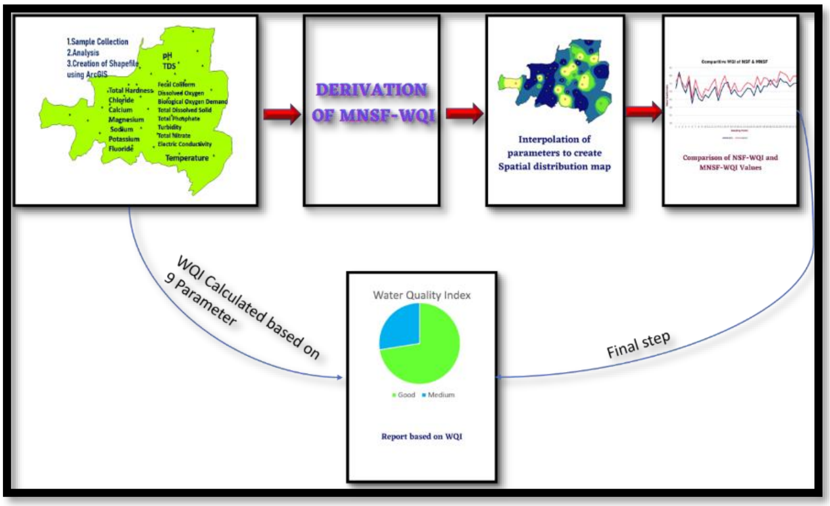

Figure-2. Water quality assessment using GIS and comparison of MNSF-WQI with NSF- WQI.

RESULT AND DISCUSSIONS

The spatial database and the created attributes were integrated for the generation of spatial variation layers of major water quality parameters. Based on those layers of spatial variation of the main water quality parameters, an IDW water map for the Udumalpet Taluk was prepared using Arc GIS 10.8 software. The major findings are discussed as below:

pH

pH is an important property of water because it determines the suitability of water for multiple purposes. In the present study, the pH varies from 6.9 to 8.71. The spatial distribution map (Figure-3) showed that study area from S1 to S40 have a pH within the desired range of 6.5 to 8.5 as recommended by WHO standards. Red indicates the minimum pH value and blue denotes the higher value.

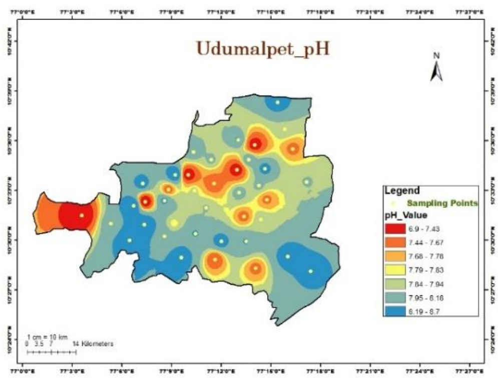

Figure-3. Spatial Distribution of pH.

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Fecal Coliform

The presence of Fecal coliform in drinking water indicated that the water is contaminated by fecal matter or the water line is mixed with the sewing line. In the current study area, FC was the range from 2 MPN/100ml to 120 MPN/100ml. The chart of spatial variation for FC is shown in Figure-4. The sampling points (S11 and S14) have higher FC which was collected from open sources.

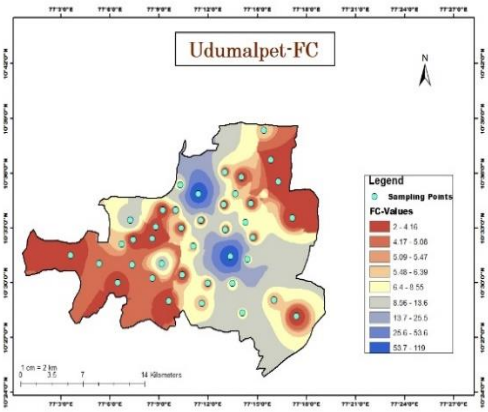

Figure-4. Spatial Distribution of FC.

Total Dissolved Solids (TDS)

TDS results mainly from soluble inorganic salts and organic matter, often results from waste water, urban runoff and industrial wastes. The major component of TDS in water is calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chlorides and sulphates [12]. In accordance with WHO standards, the desirable limit for TDS is 500mg/L, excess TDS of more than 500 mg/L can cause gastrointestinal irritation. Figure-5 illustrates the spatial distribution of total dissolved solids across the study area which ranges from 220mg/L to 1692mg/L(S27). Samples from S4, S8, S10, S14, S24, S27 and S36 have TDS values above 500 mg/L. High concentrations of TDS were observed in the eastern parts of the study area.

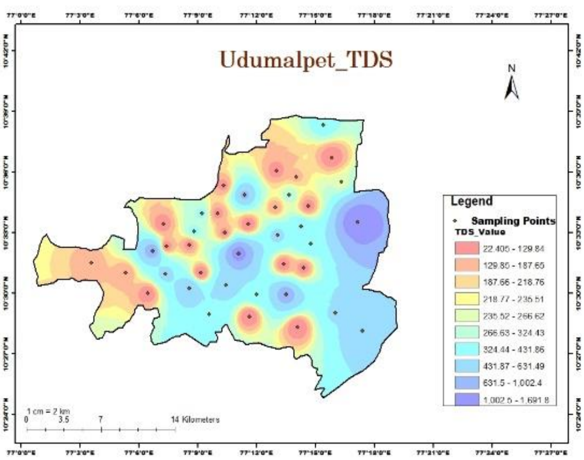

Figure-5. Spatial distribution of TDS.

Dissolved Oxygen

Low DO can cause an unpleasant odour and can infect water in many cases. A low dissolved oxygen is usually expressed as a concentration of oxygen in a volume of water in mg/L. In this study mg/L is converted to % and varies from 46.3 to 94.6. The spatial variation map for the DO (Figure-6) showed a low DO in the western part of the region due to the presence of FC.

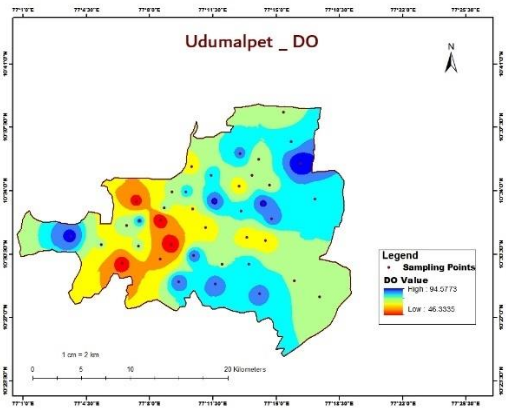

Figure-6. Spatial distribution of DO.

Temperature

Generally weather condition around the study area is normal as it is surrounded by Western Ghats. Temperature is of great importance as it regulates various physicochemical and biological activities. The maximum Temperature of 26.8°C and the minimum Temperature of 23.8°C were measured in the survey area. The map of spatial changes is shown in Figure-7, in this map Low Temperature is observed in the south eastern portion of the study area. The result revealed that the Temperature has no influence on water quality.

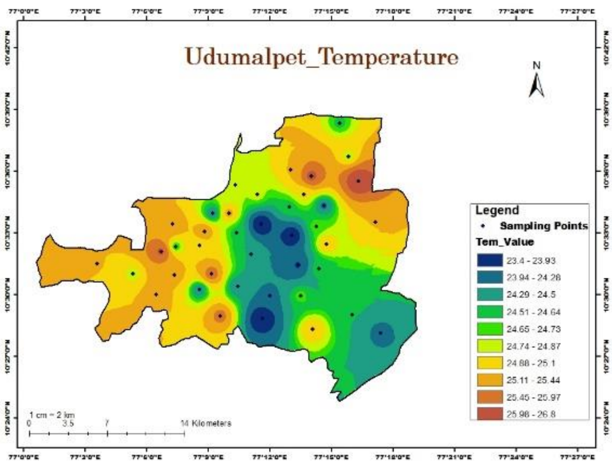

Figure-7. Spatial distribution of temperatue.

Total Nitrates

High levels of nitrate in water often results from improper well construction, location, excess of fertilizers. However, the nitrate content in the proposed area is between 0.1 mg/L and 5 mg/L, which is within the recommended limit of 45 mg/L. The spatial distribution of total nitrate is illustrated in the Figure-8.

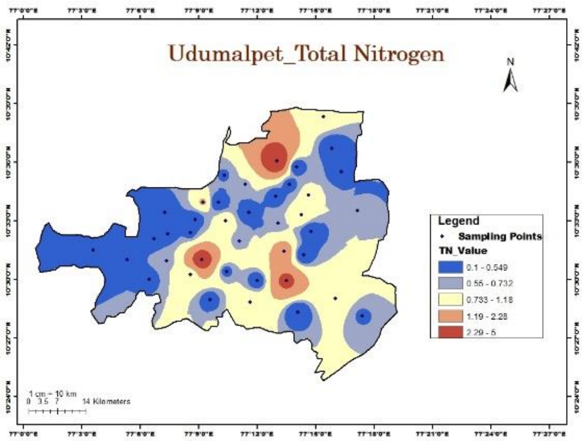

Figure-8. Spatial distribution of TN.

Total Phosphates

Concentration of phosphate in water from all parts of sampling points are in the range of 0.1 mg/L to 2.5 mg/L. The phosphate content of the water may be due to the use of detergent and fertilizers in the agricultural zone around the sampling points. The chart of spatial variation for Total Phosphate is shown in Figure-9, which shows that all the sampling points are within the recommended limit.

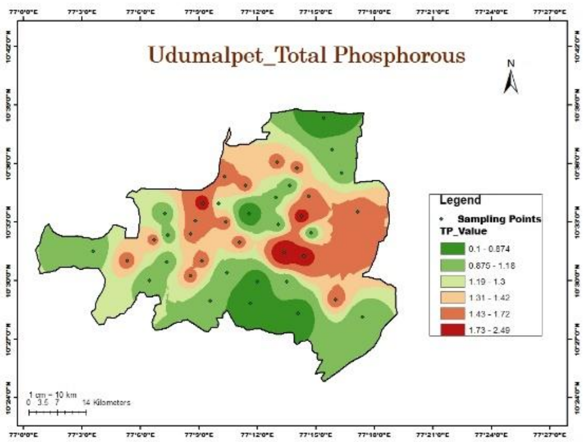

Figure-9. Spatial distribution of TP.

BOD

Biological Oxygen Demand is used to describe the potential for household and industrial waste water to pollute water bodies. Biological oxygen demand measures the amount of oxygen consumed by living organisms by decomposing the organic portion of a waste. Table-2 shows that the BOD ranges from 1.2 mg/L to 2.6 mg/L, which falls within the desired limit. A map of BOD spatial variation is shown in Figure-10.

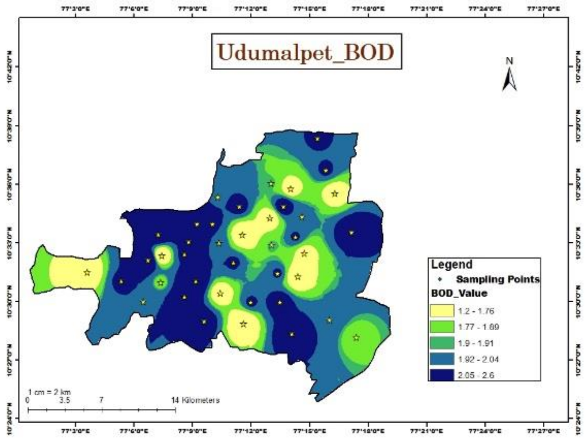

Figure-10. Spatial distribution of BOD.

Turbidity

Turbidity is the transparent nature of water. The greater the number of suspended solids in the water, the cloudier it appears and, as a result, the higher the turbidity values. Turbidity values varied from a minimum of 0.5 NTU to a maximum 2 NTU with a mean value of 0.9 NTU. Figure-11 illustrates that turbidity is within the desirable boundary at all sampling sites.

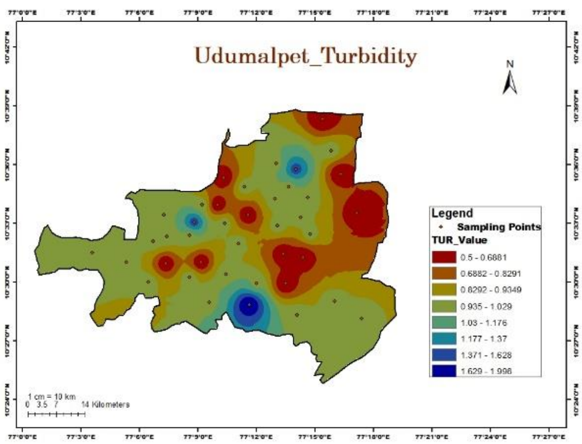

Figure-11. Spatial distribution of TUR.

Electrical Conductivity (EC)

Electrical Conductivity of water is directly related to the concentration of dissolved solids in the water. In addition, contaminants can cause high EC values in the waterbodies [13]. EC and dissolved content in a sample, are directly proportional to each other. Figure-12 illustrates the spatial distribution of electrical conductivity in the study area between 0.04 µS/cm and 4.64 µS/cm.

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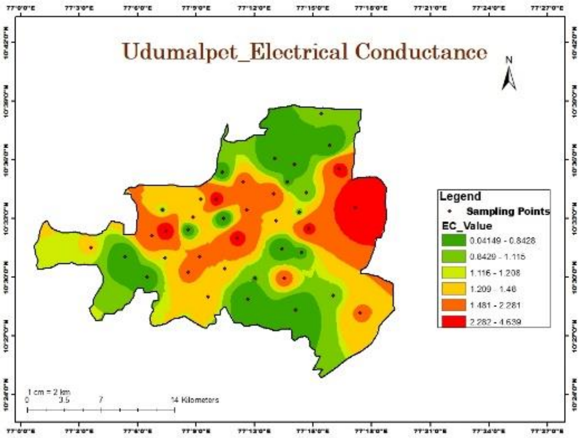

Figure-12. Spatial distribution of EC.

Chloride

The higher chlorine concentration in the water makes it dangerous for human health which is subject to laxative effects [14]. Higher levels of chloride in water can cause gastrointestinal irritation. Chloride concentration at the Table-2 varies from 56 mg/L to 1020 mg/L, which exceeds the desirable limit 1000 mg/L (S25). Chloride is present in varying concentrations in natural water depending on the geochemical conditions. Chloride concentrations may occur due to industrial waste, sewage disposal, leaching of saline residues to all soil. The IDW maps shown in Figure 13.

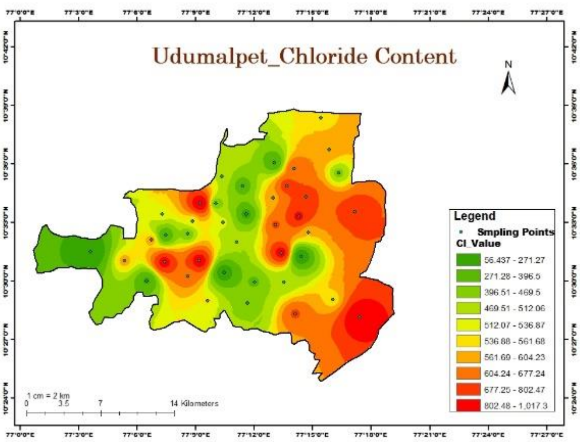

Figure-13. Spatial distribution of Cl.

Fluoride

The primary source of fluoride in the water is geographically based. There are many harmful effects of fluoride in both cases, i.e., very low doses of fluoride (1.5 mg/L), it leads to dental fluorosis or mottled enamel. However, an extremely high concentration (>3.0 mg/L) of fluoride may result in skeletal fluorosis. Table-2 showed that most of the sampling locations contain 0 mg/L of fluoride. In this study, the fluoride concentration ranges from 0 mg/L to 1 mg/L, which is within the desirable boundary, and its spatial distribution map is shown in Figure-14.

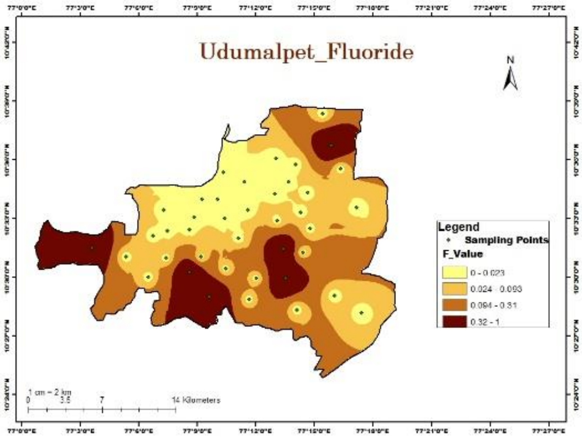

Figure-14. Spatial distribution of F.

Total Hardness

In this study, hardness varies between 57.6 mg/L and 1442 mg/L exceeds permitted limits (600 mg/L) and the average concentration of hardness was found to be 433 mg/L. The highest total hardness occurred at S10, S14, S21, S27, S30 and S37. Elevated levels were observed in the northern and eastern portions of Figure-15. Bicarbonate occurs in considerable amounts as a function of carbonate ions. Carbonate- rich rocks such as crystalline limestone, dolomitic limestone are major sources for carbonate weathering. The carbonates available in these rocks could have been dissolved and added to the groundwater system during irrigation, rainfall infiltration groundwater displacement [15].

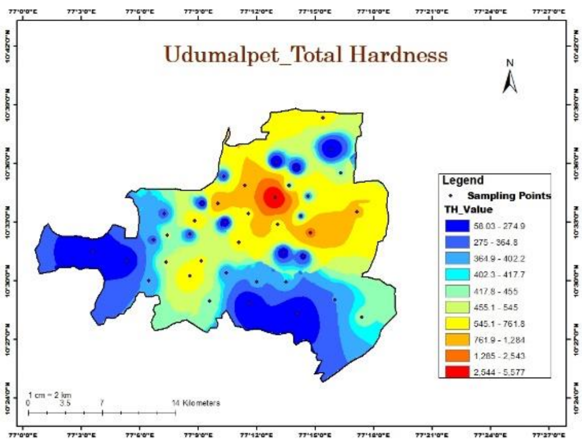

Figure-15. Spatial distribution of TH.

Magnesium

Magnesium concentrations in the study area ranges between 50.2 mg/L and 1431 mg/L. The maximum permissible limit for magnesium according to WHO standards is 50 mg/L. Magnesium is a contributing factor to a water hardness. Figure-16 depict the geographic distribution of magnesium in the study area. All sampling locations exceed the desired limit. The concentration of Sodium in the study location lies between 1.0 mg/L to

98.0 mg/L, which is within the acceptable limit of 200mg/L.

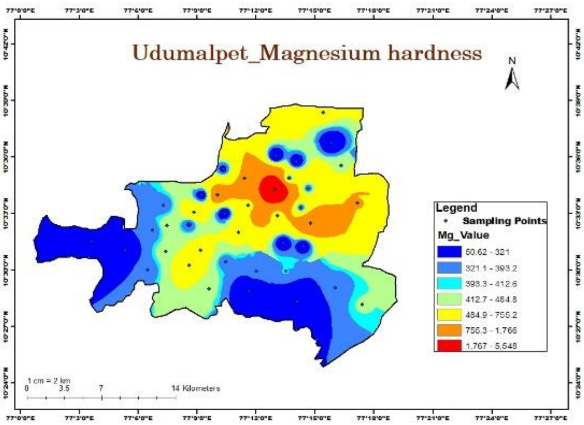

Figure-16. Spatial distribution of Mg.

Excess sodium in drinking water can contribute to high blood pressure, heart disease and kidney problems. The IDW maps are illustrated by Figure-17, the blue colour reflects the low concentration of Na ions. The potassium content of water varies between 1.0 mg/L and 9.0 mg/L. Table-2 shows that all the sampling points have values below 12 mg/L. The red area in Figure 18 shows a potassium concentration from 27 to 50 mg/L.

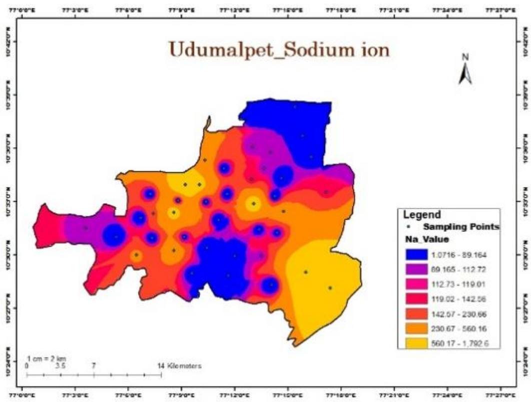

Figure-17. Spatial distribution of Na^{+}.

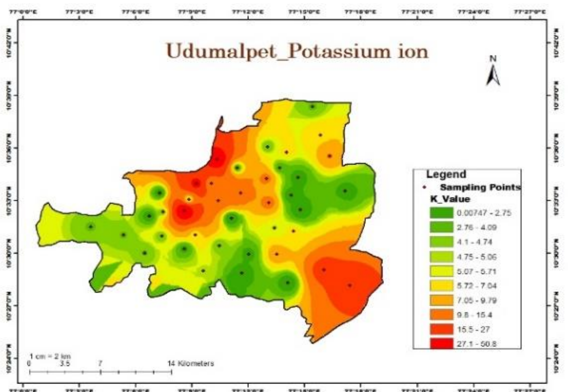

Figure-18. Spatial distribution of K^{+}.

Calcium content in the study area ranges from 0.8 to 89.6 mg/L. The S40 sampling points exceed the WHO recommended limit of 75 mg/L and the remaining samples are under 75 mg/L. Based on Figure-19 of the Calcium IDW map, the highest concentration is observed in the western and northern portions of the study area. Ca^{2+} and Mg^{2+} are the dominant cations in the river waters. Calcium can be produced by dissolving carbonated rocks. The primary source of magnesium in natural water is ferromagnesian minerals within igneous, metamorphic, sedimentary rocks and magnesium carbonate.

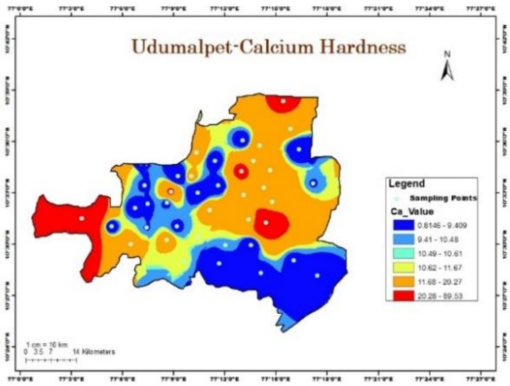

Figure-19. Spatial distribution of Ca.

Water Quality Index

WQI is a scale of 100 points used to summarize the results of different physicochemical parameter created by the National Sanitation Foundation. The used parameters are: DO, FC, pH, BOD, Tem, TP, TN, TDS and TUR. In this study, water quality of the different location of Udumalpet Taluk was evaluated for drinking and irrigation purpose. To calculate WQI values at each sampling point, the weight values were determined for each water quality parameter according to the irrelative importance in the overall quality of water. Water quality parameter data for Udumalpet Taluk were provided in Table-3.

Table-3. Water quality parameter data for Udumalpet Taluk.

Water Quality	Quality of the water	No. of Samples
90-100	Excellent	0
70-89	Good	29
50-69	Medium	11
25-49	Bad	0
0-24	Very bad	0

Results obtained from the 40 sampling points are used for Water Quality Index evaluation. Furthermore, the World Health Organization (WHO, 2018) limits were utilized for comparing the permissible limit value [13]. The highest weight of 0.17 was assigned to the parameter

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Dissolved Oxygen. The parameter FC was given with a weight of 0.16, pH and BOD with 0.11, whereas temp, TP and TN were allocated a weight of 0.10, TUR with 0.08 and TDS with 0.07. Then using the weighing factors (Wi) for each parameter, using Eq. (2) Water Quality Index for all 40 samples are calculated and their results are given in Table-4. This index reduces enormous amounts of data to a single number, thereby classifying water into one of the five categories: very bad water (0-25), bad (25-50), medium (50-70), good (70-90) and excellent (90-100). Water samples and its WQI values are presented in Table 4 and Figure-20. The computed WQI values are between 65.57 to 82.58. According to the NSF-WQI classification, 28% belong to the medium category and 72% of the sample belongs to the good category. The GIS based spatial analysis were performed using kriging - interpolation to determine the spatial distribution, water quality index (WQI) map of the study area. (Figure-21)

Table-4. WQI for NSF and MNSF.

Sampling Points	NSF	MNSF
S1	**71.84**	**76.03**
S2	82.37	80.29
S3	73.61	75.19
S4	68.92	72.28
S5	76.77	79.84
S6	62.5	65.57
S7	72.33	77.4
S8	65.77	70.14
S9	63.96	66.09
S10	67.93	71.73
S11	66.05	70.39
S12	69.73	74.59
S13	72.89	77.97
S14	64.19	67.43
S15	70.75	75.04
S16	75.15	79.86
S17	75.74	73.19
S18	68.22	70.42
S19	71.18	75.34
S20	67.61	69.96
S21	66.56	70.37
S22	69.48	73.61
S23	72.13	75.66
S24	71.51	74.61
S25	67.34	72.34
S26	74.15	79.56
S27	69.23	73.92
S28	73.42	78.65
S29	73.06	78.29
S30	77.37	73.74
S31	74.15	77.77
S32	72.37	75.54
S33	78.39	82.58
S34	76.02	81.48
S35	75.98	80.28
S36	73.03	76.15
S37	74.79	79.61
S38	75.46	79.64
S39	74.81	79.96
S40	75.73	79.57

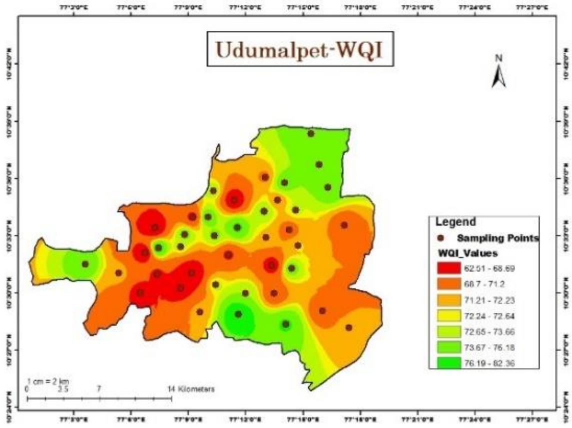

Figure-21. Spatial distribution of WQI.

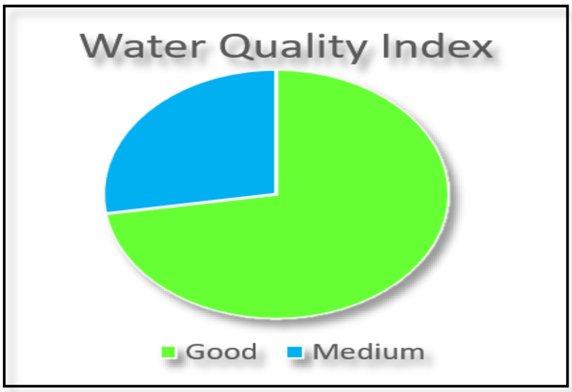

Figure-20. Pie diagram of water quality index.

Water Quality Parameters Based on the Modified NSF-Water Quality Index (MNSF -WQI)

A modified water quality index was derived using seven water quality parameters, excluding biological oxygen demand (BOD) and Total Phosphate (TP). A comparison of the WQI calculated using NSF and another method is consistent. We learn that the WQI indices differ by their numerical value, but that the quality of the water sample remains the same. It may be concluded that NSF and Modified NSF method could be used to assess water quality characteristics [16]. Normally BOD calculation requires 5 days since it is a time-consuming process, that process may be eliminated. Thus, the new formulated

WQI formula (without, BOD and Total Phosphate) can be used to calculate the WQI without delay and without serious error. The WQI calculated from NSF and MNSF are compared and it was found that the variation was only 4 to 5 unit, shown in Figure-22.

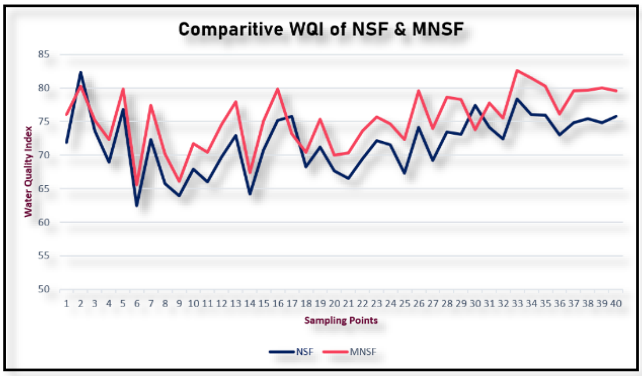

Figure-22. Comparative chart of NSF-WQI and MNSF-WQI.

CONCLUSION

This study indicates that GIS techniques and WQI methods provide valuable information to assess Surface and ground water quality of Udumalpet Taluk, Tamil Nadu. From the results, 72% of the samples belong to good category and 28% belong to medium category. The water quality parameters like chlorides, TDS, total hardness, calcium and magnesium are higher compared to the standard recommended by the WHO, may be due to household, agricultural and industries. Total hardness was found to be high in S10, S14, S21, S27, S30 and S37, while other areas were found to have hardness with allowable limitations. The TDS values from S4, S8, S10, S14, S21, S27 and S36 sampling points are high and Chloride content is found to be high in S25 sampling point only. The analysis revealed that the water in the polluted area should be treated before it is consumed and to develop appropriate management practices for the protection of water resources.

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