Section A -Research paper

APPRAISE THE SUITABILITY OF GROUND WATER FOR DRINKING AND IRRIGATION PURPOSE OF USING WATER QUALITY INDEX AND USSL DIAGRAM IN AND AROUND RAMANATHAPURAM DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

Groundwater quality of Tamilnadu in Ramanathapuram District needs attention for alternative source of water for domestic and agricultural purposes because it is one of the coastal region. Groundwater totally thirty samples were collected from different locations in and around Ramanathapuram District for the period of November 2021 (Monsoon) and analyzed for their physic**oc**hemical parameters. The water quality assessment has been carried out by evaluating the physic**oc**hemical parameters such as Hydrogen ion concentration (pH),Electrical Conductivity (EC), Total dissolved solids (TDS), Dissolved Oxygen (DO)), Biological oxygen demand (BOD), Chemical oxygen demand (COD), Sulphate (SO_4), carbonate (CO_3), Bicarbonate (HCO_3), Nitrate (NO_3), Phosphate (PO_4), Total Hardness, Calcium (Ca), Magnesium(Mg), Sodium (Na), Potassium (K), Chloride (Cl) and Fluoride. The main objectives are to study about by using the water quality index and USSL diagram whether it is suitable for drinking and irrigation or not.

Keywords: Groundwater, Physico-chemical, Parameters, WQI,USSL.

Introduction

Water is the most abundant resource on the planet earth[1], however its scarcity affects more than 40% of the people around the world [2]. Natural water is an important material for the life of both animals and plants on the earth [3]. Consequently, access to safe drinking water is essential for health and a basic human right that is integral to the United Nations Resolution 64/292 of 2010 [4].The United Nations set 2030 as the timeline for all countries and people to have universal access to safe drinking water; this is a Sustainable Development Goal (SDG) 6 of the 17SDGs [5].

In recent years, the growth of industry, technology, population and water use has increased the stress upon both our land and waterresources. Locally, the quality of ground water has been degraded. Municipal and industrial wastes, chemicalfertilizers, herbicides and pesticides have entered the soil, infiltrated some aquifers and degraded the ground-waterquality (6,7).

Globally, waterborne diseases such as diarrheal are responsible for more than two million deaths annually. The majority of these deaths occur among children under-5 years of age [8].Given the importance of the water physicochemical parameters, in order to ensure that they are within the acceptable limits, the WHO recommends that they are monitored regularly [9].

Water quality analyses are an integral part of an environmental monitoring program for touristic beaches, and in general, present important information for the management of the coastal zone [10].In several coastal cities, groundwater serves as one of the freshwater sources for drinking, domestic, irrigation,and industrial needs. Seawater intrusion is considered a common problem in most coastal aquifers worldwide [11 - 15].

Materials and Methods

Study Area

The district of Ramanathapuram is an urban district in southern India in Tamil Nadu. The area of the district is 4123 km^2 and was populated in the 2011 census by 1,353,445 people. The district lies between $9^o05'$ and $9^o50'$ North Latitude and $78^o10'$ and 79^o 27' East Longitude. The Gulf of Mannar borders the south and the district of Thoothukudi to the west.

Ramanathapuram district comprises the Pamban Bridge, an eastern-west chain of elevated and medium coral islands extends between India and Sri Lanka, dividing Palk Straits from Mannar Gulf. Marine formation consists of varying proportions of coastal flat deposits of sand and clay. Marine hardpan calcareous occurs as small terraces and platforms, with admixture of quartz, limonite and garnet concentration

Results and Discussion

Table – 1

Physico- Chemical concentration of Groundwater collected in the month of November 2021 (Monsoon)

Sample Station	Temp	pH	EC	TDS	DO	BOD	COD	SO_4	CO_3	HCO_3	NO_3	PO_4	TH	Ca	Mg	Na	K	Cl	F
01	26.4	7.7	2995	1319	6	6	13	78	ND	211	6	0.15	432	100	40	50	7	858	0.85
02	26.2	7.6	4567	2012	4	7	13	49	ND	118	6	0.14	783	98	118	81	9	698	0.56
03	26.5	7.9	3879	1543	5	6	14	910	ND	345	19	0.26	550	113	145	75	31	547	1.13
04	26.2	8.2	342	200	7	8	15	421	ND	900	29	0.29	226	57	38	11	1	300	2.15
05	26.6	8.1	1810	784	4	7	13	342	ND	395	11	0.15	589	145	59	49	7	542	1.31
06	26.3	7.8	912	412	5	9	18	765	ND	450	10	0.17	395	95	43	20	2	412	1
07	26.5	8.0	3230	1456	7	10	20	256	ND	780	21	0.25	445	103	74	43	21	601	0.92
08	26.7	8.3	3450	1390	6	7	14	467	ND	988	23	0.11	356	134	68	41	24	567	1.41
09	26.0	8.6	3981	1710	6	6	14	111	ND	312	29	0.13	645	110	102	71	29	945	0.75
10	26.2	7.5	2900	1234	7	8	16	81	ND	635	23	0.25	578	95	87	48	30	487	2
11	26.4	8.2	4231	2101	5	7	13	379	ND	453	9	0.29	298	97	41	78	3	875	0.73
12	26.6	7.6	1892	901	6	10	19	600	ND	988	6	0.11	205	78	50	29	1	450	2.53
13	26.2	8.3	2123	875	4	8	16	77	ND	179	8	2.75	404	134	45	67	2	534	1.6
14	26.4	7.5	600	398	5	9	18	89	ND	461	4	0.13	158	87	59	20	1	367	0.65
15	26.5	8.0	5010	2219	6	7	13	55	ND	199	3	0.22	463	109	72	65	1	921	1.91
16	26.4	7.9	3800	1718	7	8	15	513	ND	402	14	0.21	270	78	87	83	35	799	2.45
17	26.2	8.3	4986	2302	4	9	19	378	ND	432	18	0.14	452	134	155	75	ND	479	0.68
18	26.6	8.0	1491	714	5	10	19	217	ND	435	1	0.25	170	56	38	63	3	512	2.67
19	26.7	7.5	4210	1919	6	8	18	134	ND	213	1	0.11	260	67	72	50	1	876	1.97
20	26.2	8.0	1325	613	7	7	15	256	ND	453	29	0.23	373	45	30	48	17	603	0.7
21	26.5	7.9	2989	1321	5	8	17	67	ND	267	9	0.18	352	98	104	61	7	502	0.89
22	26.2	8.3	5015	2245	5	9	18	157	ND	300	5	0.21	464	77	95	87	15	945	0.57
23	26.4	8.6	4500	1982	7	10	19	93	ND	214	7	0.18	680	107	178	123	10	895	1.15
24	26.5	7.6	3334	1429	5	6	13	435	ND	391	17	0.26	340	85	84	45	ND	890	1.98
25	26.6	8.3	4892	2312	4	7	15	76	ND	115	7	0.18	672	69	154	65	14	750	1.38
26	26.1	7.9	752	376	7	9	19	185	ND	500	1	0.11	279	59	58	114	11	300	0.67
27	26.0	8.0	2099	790	6	7	15	276	ND	550	4	0.23	185	45	89	190	7	512	1.78
28	26.4	8.1	2150	871	5	9	19	78	ND	367	1	0.19	562	69	105	212	35	443	1.19
29	26.2	8.5	378	195	6	6	14	56	ND	187	7	0.25	253	25	78	23	11	199	0.75
30	26.7	8.1	2145	876	4	8	20	867	ND	403	12	0.19	423	101	55	156	18	400	1.9

Water Quality Index

Water Quality index (WQI) is defined as a technique of rating which provides the composite influence of individual water quality parameter on the overall quality of water. It is calculated from the point of view of human consumption. The **concentration** of the thirtyphysico-chemical parameters (Table -1) such as pH, EC, TDS,DO,BOD, COD, SO_4, CO_3, HCO_3, NO_3, PO_4, TH, Ca, Mg, Na, K,Cl and F was used for the calculation of WQI.

The calculation involves the following steps
First, the calculation of weightage of ithparameter.
Second, the calculation of the quality rating for each of the water quality parameters.
Third, the summation of these sub-indices in the overall index.
The weightage of ith parameter
W i = k/Si (1)
Where
Wi is the unit of weightage,
Si them recommended standard for ith parameter (I =1-6) and
k is the constant of proportionality.
Individual quality rating is given by the expression
Qi=100V/Si (2)
Where
Qi is the sub index of ith parameter,
Vi is the monitored value of the ith parameter in mg/l and
Si the standard or permissible limit for the ith parameter.
The Water Quality Index (WQI) is then calculated as follows
WQI = Σin= 1(QiWi)/ Σin= 1Wi (3)
Where,
Qi is the sub index of ith parameter,
Wi is the unit weightage for ith parameter and
n is the number of parameters considered.
Generally, the critical pollution index value is 100.

Table - 2

Calculation of WQI Values For Groundwater Samples Collected In November (Monsoon) 2021.

Parameters	Mean value in ppm (vi)	Highest permitted value (WHO) (si)	Unit weightage (Wi)	Wi X Qi
pH	8.0	8.5	0.117	11.011
EC	2866	500	0.002	1.146
TDS	1273	500	0.002	0.508
DO	5.53	5	0.2	22.12

BOD	7.86	10	0.1	7.86
COD	16.1	15	0.066	7.084
SO_4	282	250	0.004	0.451
HCO_3	421	500	0.002	0.168
NO_3	11	50	0.02	0.44
PO_4	0.27	12	0.083	0.187
TH	408.7	500	0.002	0.163
Ca	89	200	0.005	0.222
Mg	80.76	150	0.006	0.322
Na	71.43	200	0.005	0.178
K	12.60	20	0.05	3.15
Cl	606.96	250	0.004	0.971
F	1.34	1.5	0.666	59.47

$WQI = \Sigma_i^n{}_{=1}(QiWi)/\Sigma_i^n{}_{=1}WiWQI = 86.54$

Table - 3	
Categorisation of WQI status	
WQI	**QUALITY OF WATER**
0-25	Very Good
26-50	Good
51-75	Poor
Above 75	Very Poor (Unsuitable for Drinking)

In the present study, categorisation of water quality index as shown in Table 3. The WQIcomputed value is 86.54. Thisvalue is found to be above 75 as per WQI (Table: 3) which shows the nature of the water quality of the areas seemsto be very poor. It is clearly understood that the groundwater of our study area is not recommended for **drinking purposes as per the WQI standard values.**

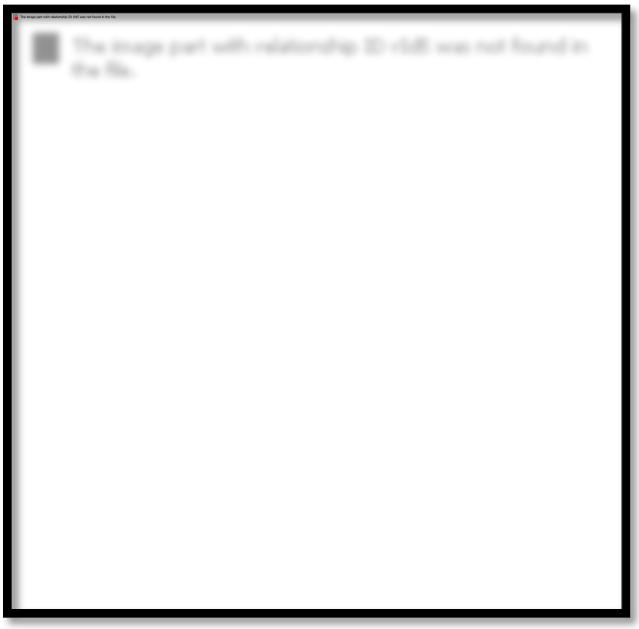
Wilcox Diagram

Percent Sodium vs. EC Plot (Na %)

Wilcox [14] plotted the percent Na value against the EC value to determine the suitability of groundwater for irrigation. According to his plot, he categorized groundwater as (1) excellent to good, (2) good to permissible, (3) permissible to doubtful, (4) doubtful to unsuitable, and (5) unsuitable as shown in figure - 1.

Figure - 1

Wilcox classified groundwater for irrigation



USSL diagram

Richards [16] modified the Wilcox diagram by including the SAR value as a sodium hazard and the EC value as a salt hazard and proposed the diagram as a USSL diagram for evaluating the quality of irrigation water, shown in the Table - 4. He also classified the water quality as low, medium, high and very high for sodium and salinity hazards with respect to the SAR and EC values [17-19]. The November 2021 (Monsoon) groundwater quality as shown in Figure**2**) according to the USSL diagram was distributed as follows: **3** samples in **S1C2 (low sodium–medium salinity), 2**samples in **S1C3 (low sodium–high salinity),4**samples in **S2C3 (medium sodium–high salinity) and 12**samples **in S2C4 (medium sodium–very high salinity), 1** sample **in S3C2 (highsodium– medium salinity),5** samples **in S3C4 (highsodium–very high salinity) and 3**samples **in S4C3 (**very high sodium–high salinity) for irrigation as shown in Table - 5.

Table -4			
Classification of USSL diagram			
Alkali Hazards		**Salinity Hazards**	
Sub zones	S1-Low sodium hazard	**Sub zones**	C1- low salinity hazard
	S2-Medium sodium hazard		C2-medium salinity hazard
	S3-High sodium hazard		C3-high salinity hazard
	S4-very high sodium hazard		C4-very high sodium hazard

Figure –2

Classification of USSL diagram plotted in the month of November 2021 (Monsoon)

Table-5			
Classification of USSL diagram plotted in the month of November 2021 (Monsoon)			
S.No	**Zones**	**Suitability of water sample**	**Water sample in percentage**
1	S1C1	No sample	-
2	S1C2	3 sample	10
3	S1C3	2 sample	6.7
4	S1C4	No sample	-
5	S2C1	No sample	-
6	S2C2	No sample	-

7	S2C3	4 sample	13.3
8	S2C4	12 sample	40
9	S3C1	No sample	-
10	S3C2	1 sample	3.3
11	S3C3	No sample	-
12	S3C4	5 sample	16.7
13	S4C1	No sample	-
14	S4C2	No sample	-
15	S4C3	3 sample	10
16	S4C4	No sample	-

Conclusion

The calculatedWQI showed the quality of drinking water and also irrigation water quality indices shows in the graphs Na% versus EC an USSL diagram showed the quality of the irrigation of the water in the study area during monsoon 2021 seasons.

The WQI calculated values ranged very poor category, whichshows that the water quality of the study area is unsuitablefor drinking purpose. In this research paper theapplications of WQI and **USSL** diagram approach togroundwater quality in Ramanathapuram District**had the purpose of providing a simple, valid method for expressing the results of several parameters in order toassess the groundwater quality.** Monitoringof groundwater quality should be undertaken regularly toidentify the sources of principal contaminants and other inhibitory compounds that affect the potability of waterand also to identify the wells which are safe for drinkingwater as well as irrigation water and protecting them from further contamination.

References

1. Godfrey Bwire , David A. Sack, AtekKagirita, TonnyObala, Amanda K. Debes, Malathi Ram2, Henry Komakech1, Christine Marie George2 and Christopher GarimoiOrach (2020). The quality of drinking and domestic water from the surface water sources (lakes,rivers, irrigation canals and ponds) and springs in cholera prone communities of Uganda: an analysis of vitalphysicochemical parameters. BMC Public Health,20 ,1-18.

2. UNDP. Sustainable Development GOALS 2030. 2015.

3. Nikanorov AM, Brazhnikova LV. Water chemical composition of Rivers, lakesand wetlands. Encycl Life Support Syst. 2009;2:42–80 https://www.eolss.net/Sample-Chapters/C07/E2-03-04-02.pdf.

4. United Nations. International Decade for Action "Water for Life" 2005–2015.Focus Areas: The human right to water and sanitation1. UN. InternationalDecade for Action "Water for Life" 2005–2015. Focus Areas: The humanright to water and sanitation [Internet]. United Nati. United Nations. 2014.

5. UNDP. Goal 6: Clean water and sanitation | UNDP. UNDP. 2015. https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-6-clean-water-and-sanitation.html. Accessed 29 Nov 2019.

6. Abdul Jameel, J. Sirajudeen and R. Abdul vahith (2012). Studies on heavy metal pollution of ground water sources between Tamilnadu and Pondicherry, India. Advances in Applied Science Research, 3 (1), 424-429.

7.AhamedSulthan J, Mohamed Sihabudeen M, Sirajudeen J and AsrarAhamed A, Variation in Physicochemical Characteristics of Groundwater Quality Between Taluks of Cuddalore District, Tamil Nadu. International Journal of Recent Scientific Research, 2016; 7(5), 11118-11122.

8. World Health Organization. WHO | Water-related Diseases. https://www.who.int/water_sanitation_health/diseases-risks/diseases/diarrhoea/en/. Accessed9 July 2020.

9.Gorchev HG, Ozolins G. WHO guidelines for drinking-water quality 2011. doi: https://doi.org/10.1016/S1462-0758(00)00006-6.

10.S. Abdul Gafoor, R. Nasar Ali, M. ShahulHameed, S.Sabeena Begum and D. ZunaithurRahman (2020),Identification and Environmental Issues of Polluted Sea Water,International Journal of Engineering and Advanced Technology (IJEAT),9 (4),1528-1533.

11.Dar, I.A.; Sankar, K.; Dar, M.A. Spatial assessment of groundwater quality in Mamundiyar basin (2011), Tamil Nadu, India. Environ. Monit. Assess, 178, 437–447.

12.P.Sivasubramanian, N.Balasubramanian, J.P.Soundranayagam, N.Chandrasekar (2013**)**.Hydrochemical characteristics of coastal aquifers of Kadaladi, Ramanathapuram District, Tamilnadu, India. Appl. Water Sci., 3, 603–612.

13. SivakumarKarthikeyan ,PrabakaranKulandaisamy , VenkatramananSenapathi , Sang Yong Chung , KongeswaranThangaraj, MuruganandhamArumugam , SathishSugumaran and Sung Ho-Na(2022). Hydrogeochemical Survey along the Northern Coastal Region of Ramanathapuram District, Tamilnadu, India. Appl. Water Sci,12.

14. R. Abdul Vahith, A. Mohamed Mahadir, I. Sajitha, J. Sirajudeen, J. MuneerAhamath and

S.S.SyedAbuthahir(2023). Evaluation Of Groundwater Quality In And Around Ramanathapuram District, Tamil Nadu, India By Using HydrogeochemicalFacies Analysis And Wilcox Diagram. European Journal of Molecular & Clinical Medicine, 10 (01), 2681-2689.

15.Wilcox. Classification and Use of Irrigation Waters; US Department of Agriculture: Washington, DC, USA, 1955; p. 969.

16.AhamedSulthan J, Mohamed Sihabudeen M, Sirajudeen J and AsrarAhamed A, Impact of Heavy Metals on Groundwater of Cuddalore District, Tamil Nadu. International Journal of Nano Corrosion Science and Engineering, 2015, 2 (5), 236-244.

17. Richard, L.A. Diagnosis and improvement of saline and alkali soils. USDA Handb. 1954, 60, 160.

18. R.Abdulvahith, J.Sirajudeen and J.MuneerAhamath (2018). Use of WQI and Hydrogeochemicalfacies analyses to assess the suitability of groundwater between Tamilnadu and Pondicherry states, India, International journal of basic and applied research, 8(11), 142-160.

19. S. S. Venkateswaran, S.Karuppannan, R .Vijay Prabhu, S .Kannan, Malar and P .Prabu (2013). Hydro Chemical Characteristics and Groundwater Quality Assessment in Parts of Pambar River Basin, Tamil Nadu, India. International Journal of Innovative Technology and Exploring Engineering (IJITEE), 3: 2278-3075.