



# HYDROCHEMISTRY OF GROUND WATER IN AND AROUND CUDDALORE DISTRICT TAMIL NADU, INDIA

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## Abstract

The present work has been carried out to study the groundwater quality in Cuddalore district, sixty two groundwater samples were collected in year 2017. The Hydro-chemical parameters analysed were based on their clinical significance. Parameters like p<sup>H</sup>, Electrical conductivity, Total dissolved solids, Total hardness, COD, Calcium, Magnesium, Sodium, Potassium, Carbonate, Bicarbonate, Chloride, nitrate, and sulphate were analysed using standard methods. Based on the TDS classification 87% of samples are fresh water type and 18% of samples are saline water type, based on the EC classification, 14 samples are not permissible in drinking purpose and 5 ground water Samples are hazardous in nature. Based on the water quality index most of samples are unsuitable for drinking purpose.

**Key Words:** Water quality, Groundwater classification, Hydro-chemical, Cuddalore district.

## 1. Introduction

The usage of ground water increases day by day for the various purposes, but ground water qualities are affected by sewage water disposal and industries. Now- a- days the level of groundwater has gone at least 250-500 m depth for good water quality<sup>1-5</sup>. Generally ground water is considered as a source of safe drinking water<sup>6</sup>. Ground water is contaminated in so many ways such as use of fertilizer in farming<sup>7</sup>,

seepage from effluent bearing water body<sup>8</sup> etc...

The study of quality of water body alone is not sufficient to solve the problems of water management, because its uses for various purpose depends on its quality. Hence the hydro chemical characters of ground water in different aquifers over space and time have proven to be important in solving the problems<sup>9-13</sup>. To identify the ground water contamination various water samples were collected from different parts of Cuddalore district and analysed to get various parameters pH, Electrical conductivity, Total dissolved solids, Total hardness, Calcium, Magnesium, Sodium, Potassium, Chloride, Carbonate, bicarbonate, Nitrate, sulphate and COD. The obtained values were compared with WHO and CMR

## 2. Methodology

A total of 62 ground water samples were collected in 186 place of Cuddalore district during post monsoon 2017. The ground water samples were collected after 10 minutes of pumping and stored in washed polyethylene bottles. EC and p<sup>H</sup> measured in the field by using portable water TDS were measured by evaporation methods. The volumetric titration methods used to determine the total hardness, chloride, and alkalinity. Sodium and Potassium was analysed using flame photometer. Sulphate and nitrate were measured by using UV visible spectrometer. EDTA complexometric titration method used to determine the Calcium, and Magnesium. Heavy metals were analysed by using AAS

Table-1: Location of sample site

Sam ple Code	Sample location	p H	EC	TD S	T H
NI	Cuddalore OT	7.3	39 70	17 10	29 0
N2	Cuddalore NT	8.1	38 9	19 7	65
N3	Ramapuram	7.3	59 7	30 0	90
N4	Karaikadu	8.1	12 19	60 9	16 0
N5	Kumara puram	7.7	75 6	39 1	12 5
N6	Alappakkam	8.1	15 90	76 7	11 0
N7	Vadalur	7.7	59 4	29 6	80
N8	Kurinjipadi	8	13 16	67 5	18 0
N9	Kullanchavadi	7.8	11 73	58 3	13 0
N10	Manthara kuppam	7.9	99 4	49 9	12 5
NI1	U.Mangalam	8.0	45 7	22 1	90
NI2	Vridhachalam	7.8	13 09	66 4	14 5
NI3	Erumanur	7.8	12 98	64 9	20 0
NI4	Paravalur	8.4	96 0	48 7	10 0
NI5	A.Chithur	8.7	23 10	10 80	25
NI6	Thiruvandhipu ram	7.8	13 31	67 5	23 5
S1	Orathur	8.3	10 56	53 1	85
S2	Sethiyathoppu	8.1	73 0	36 8	90
S3	Dharma nallur	7.8	17 47	82 3	14 0
S4	Kammapuram	8.1	11 43	57 7	12 0
S5	Ko.Athanur	8.0	77 7	38 7	10 0
S6	Vilangattur	8.5	19 00	85 9	11 5
S7	Naraiyur	7.3	37 90	15 20	70 0
S8	Nallur	7.9	72 60	24 50	82 5

S9	Veppur	8.2	35 90	13 90	18 5
S10	Sirupakkam	8.9	30 80	13 60	50
S11	Tholudur	8.1	12 40	60 6	18 0
S12	Tittakudi	8.3	13 59	66 7	16 0
S13	Avinangudi	8.2	13 01	65 1	16 0
S14	Pennadam	7.9	12 87	62 4	17 0
S15	Karuveppilank uruchi	7.7	87 7	41 7	80
S16	Sri mushnam	7.4	10 52	51 6	17 0
C1	Nellikuppam	8.4	11 67	55 1	22 5
C2	Paloor	8.2	10 63	53 7	10 0
C3	Panruti	8.3	15 37	73 7	75
C4	Annagramam	8.2	89 3	44 6	11 0
C5	Melpattam pakkam	8.3	10 82	55 3	10 5
C6	Muthandi kuppam	7.8	14 0	75	30
C7	Kattukudalur	7.7	22 2	11 4	30
C8	Kotteri	7.9	26 0	13 6	55
C9	Aladi	7.5	14 57	72 7	27 0
C10	Palakollai	7.6	17 0	86	40
C11	Mathur	7.7	24 10	10 80	35 5
C12	Mangalampet	8.2	15 87	77 5	14 5
C13	M.Parur	8.3	81 8	41 3	85
C14	Pudhupet	8.2	11 24	57 1	12 5
C15	Redichavadi	8.0	10 86	54 2	19 0
C16	Thokkamnam pakkam	8.4	72 2	36 5	85
W1	Pudhuchatthira m	7.9	46 3	23 0	80
W2	Kothattai	8.0	10 25	53 0	14 5

W3	Parangipettai	7. 8	15 74	73 7	17 0
W4	Vilayanallur	7. 9	99 4	43 6	95
W5	Killai	7. 9	22 10	10 70	15 0
W6	Bhuvanagiri	8. 3	19 52	94 2	14 0
W7	Manampadi	7. 9	21 10	10 10	95
W8	Chidambaram	8. 2	21 60	10 80	18 0
W9	Annamalainagar	7. 7	17 67	89 5	22 0
W10	Komaratchi	8. 3	19 13	92 4	11 5
W11	Kattumannarkoil	7. 6	12 59	62 5	17 5
W12	Sozhatharam	7. 6	91 7	46 0	15 0
W13	Pannalur	7. 3	95 9	47 9	11 0
W14	Lalpuram	8. 4	22 60	11 20	15 0

### 3. Study Area

The study area viz., Cuddalore district lies on East Coast of Southern India, bounded on the North by Villupuram district, on the East by Bay of Bengal, and on the West by Perambalur district, and lie between latitude 11° 75' North and longitude 79° 75' East. It has an average elevation of 6M (20Ft). The land is completely flat with large deposits of black and alluvial soil inland and coarse sand near the seashore. The district has an area of 3564 km<sup>2</sup>. The district is drained by Gadilam and Pennaiyar River in the North, Vellar and Kollidam River in South. According to 2011 census, Cuddalore district had a population of 2605914. The normal annual rainfall over the district varies from about 1050 mm to about 1400 mm. The average annual temperature is 28.2°C. The map of study area has been shown in figure 1



**Fig 1: Map of study area and sampling locations**

### 4. Result and discussion

Ground water quality is important to understand the suitability for drinking, agricultural, and industrial Purpose. Table-1 Shows various Physical and chemical Parameters including statistical data such as maximum, minimum, average and standard deviation analyzed in ground water samples from the study area. According to World Health Organization Two samples (N15 and S10) are above the allowable Limits of pH (>8.5), Four Samples (N1, S7, S8 and S9) are electrical conductivity (>3125), Three Samples (N1, S7 and S8) are TDS (>1500), 27 samples are above allowable limit of potassium and above the allowable limit of sodium in Two Samples.

**Table-2: Descriptive statistics of groundwater samples in Cuddalore district**

Parameters	Minimum	Maximum	Average	SD
p <sup>H</sup>	7.3	8.9	7.8	0.34
EC	140	7260	1447	1102
TH	25	825	152	129
TDS	75	2450	674	410.8
COD	7.8	194	60	41.6
CO <sub>3</sub>	0	320	33.7	50.6
HCO <sub>3</sub>	20	4150	247.6	524.1
Cl	13.8	1198.7	189.0	188.1
SO <sub>4</sub>	4.8	82.4	34.5	17.0
NO <sub>3</sub>	1.4	62.4	20.9	15.5
Ca	4	146	26	22.6
Mg	1.2	179	21.2	24.4
Na	9.2	456.4	74.6	68.4
K	0.4	28.8	9.9	8.1

Based on the TDS classification<sup>14</sup>87% of samples are fresh water type (<1000mg/l) and 18% of samples (N1, N15, S7, S8, S9, S10, C11, W4, W7, W8 and W14) are saline water type, where 30 samples (N4, N6, N8, N9, N12, N13, N16, S1, S3, S4, S6, S11, S12, S13, S14, S16, C1, C2, C3, C5, C9, C12, C14, C15, W2, W3, W6, W9, W10 and W11) are permissible for drinking (500-1000mg/l) and 11 samples (N1, N15, S7, S8, S9, S10, C11, W4, W7, W8, W13 and W14) are useful for irrigation<sup>15</sup> (1000-3000mg/l). In the study area EC value range from 140 to 7260 µs/cm with average 1447, based on the EC classification, 41 ground water sample are permissible for drinking purpose (<1500 µs/cm), 14 samples (N6, N15, S6, C3, C11, C12, W3, W4, W6, W7, W8, W9, W10 and W14) are not permissible for drinking

purpose(1500-3000 µs/cm) and 5 ground water Samples( N1, S7,S8, S9 and S10) are hazardous in nature (>3000 µs/cm).

**Table-3: Classification of groundwater based on TDS**

TDS	Classification	Number of samples	Percentage
<1000	Fresh water type	51	82.2%
1000-10,000	Brackish water type	11	17.7%
10,000-100,000	NIL	NIL	NIL
>100,000	NIL	NIL	NIL

**Table-4: Groundwater classification based on electrical conductivity**

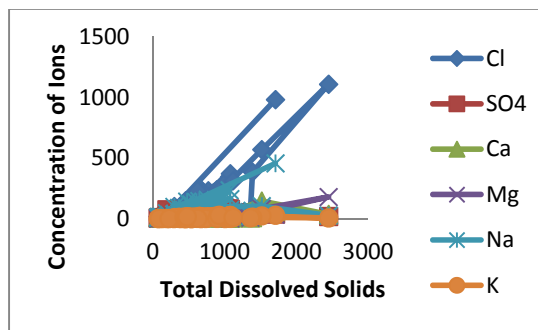
Electrical conductivity	Classification	Number of samples	Percentage
<1500	Permissible	41	66%
1,500-3,000	Not Permissible	14	23%
>3,000	Hazardous	5	8%

Total hardness varies from 25 to 825 ppm with the average 153, based on hardness classification<sup>16</sup> 7samples (N2, N15, S10, C6, C7, C8 and C10) are soft, 32 Samples are moderate high, 20 samples(N1, N4, N8, N13, N16, S9, S11, S12, S14, S16, C1, C9, C15, W3, W4, W8, W9, W11, W12 and W14) are hard and 3 samples (S7, S8 and C11) are very hard. Chloride is the most dominating anion, varied from 13 to 1103 with average 189 mg/l, sulphate is the another important anion range from 4.8 to 82.4 mg/l with average 34.5 mg/l, bicarbonate range from 20 to 4150 mg/l with average 248 mg/l, 11 samples (N15, N16, S3, S4, S6, S7, S9, S10, S14, W6 and, W9) are above the maximum allowable limit (>300 MG/L). The study area shows Nitrate range from 1.4 to 62.4 mg/l with average 20.9 mg/l, 8 ground water samples (N1, S6, S7, C11, W4, W6, W8, and W10) are above the allowable limit (>45mg/l).The Nitrate concentration of drinking water is higher than 45mg/l is toxic and cause blue baby disease in children and also gastric cancer. In the order of anion concentration are HCO<sub>3</sub><sup>-</sup>> Cl<sup>-</sup>> SO<sub>4</sub><sup>2-</sup>> NO<sub>3</sub><sup>-</sup>.

**Table-5: Groundwater classification based on Hardness**

Total Hardness	Classification	Number of samples	Percentage
<75	Soft	7	11%
75-150	Moderately high	32	52%
150-300	Hard	19	31%
>300	Very Hard	3	5%

The most dominating ion is Sodium which range from 9.2 to 456 mg/l with average 74. 6 mg/l. Two samples (N1 and W4) are the maximum allowable limits (>200 mg/l). The concentration of potassium varies from 0.4 to 28.8 mg/l with average 9.9 mg/l, Twenty Seven groundwater samples (N1, N4, N6, N12, N13, N14, N15, S4, S6, S7, S9, S12, S13, S14, S16, C9, C11, C13, C14, C15, C16, W5, W4, W6, W10, W13 and W14) are above the maximum allowable limit (> 10 mg/l). The presence of calcium and magnesium in ground water cause hardness in nature, the range of calcium and magnesium are 4 to 146 mg/l with average 26 mg/l and 1.7 to 179 mg/l with average of 21.2 mg/l respectively. In the order of cations are Na<sup>+</sup>> Ca<sup>2+</sup>> Mg<sup>2+</sup>> K<sup>+</sup>. The figure 2: shows variations of TDS with sodium and potassium increases with TDS and decrease and the further increase. This happens similar to calcium and magnesium but the sodium and potassium concentration is higher than calcium and magnesium, it indicates major cation in Sodium and major anion in chloride.



**Fig 2: Variation of TDS versus with Ions**

**5. Water Quality Index**

The assessment of water quality index<sup>17</sup> is calculated using the following formula

$$WQI = \sum (Q_i W_i) / \sum W_i$$

W<sub>i</sub> is a unit weight factor and it is a constant for all nine parameters.

The quality rating  $q_i$  is determined by

$$q_i = 100 (v_i - v_{io}) / (s_i - v_{io})$$

Where,  $v_i$  = Estimated value of  $n^{\text{th}}$  parameter

$S_i$  = standard value of  $n^{\text{th}}$  parameter

$V_{io}$  = ideal value of  $n^{\text{th}}$  parameter

Based on the water quality index, in the study area 16 samples (N1, S3, S6, S7, S8, S9, S10, S15, C11, W4, W6, W7, W8, W9, W10 and W14) are unsuitable for drinking (WQI>300), 21 samples (N4, N6, N8, N9, N12, N13, N16, S4, S11, S12, S13, S14, C1, C3, C5, C9, C12, C14, C15, W3, and W11) are very poor (WQI value is 200-300), 18 samples (N3, N5, N7, N14, S1, S5, S15, S16, C2, C4, C16, W5, W12 and W13) are poor (WQI value is 100-200), five samples (N2, N11, C7, C8 and W1) are good (WQI value is 50-100) and only one sample (C6 and C10) is excellent (WQI<50) and represent the water quality index in pie diagram in Figure 3.

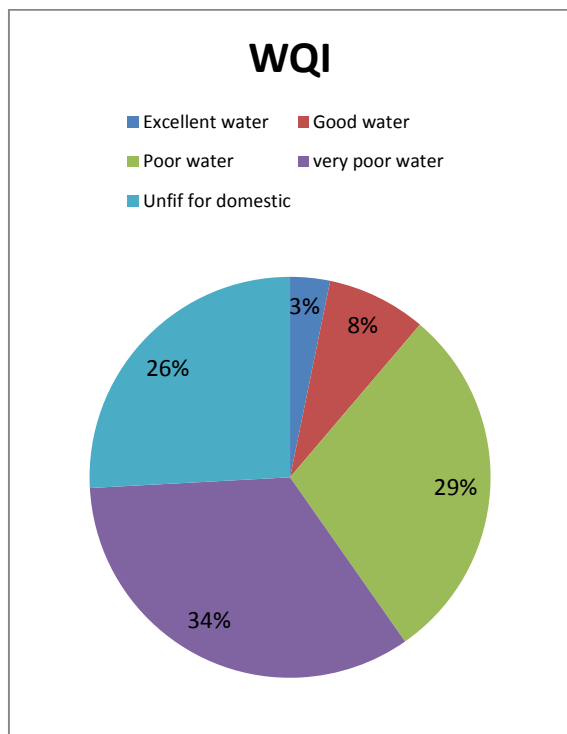


Figure 3: Pie Diagram to Analysis the Water

## 6. Conclusions

Based on the TDS & EC 87% of samples are fresh water and 18% of samples are saline water type, 14 SAMPLES (N6, N15, S6, C3, C11, C12, W3, W4, W6, W7, W8, W9, W10 and W14) are not permissible for drinking purpose and 5 ground water Samples (N1, S7, S8, S9 and S10) are hazardous in nature. The analysis indicates that the most dominating cation was sodium and anion was chloride. The Nitrate

concentration of 8 ground water samples (N1, S6, S7, C11, W4, W6, W8, and W10) are above the allowable limit which cause blue baby disease in children and also gastric cancer. Based on water quality index most of groundwater samples are unsuitable for drinking purpose.

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