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Assessment of Ground water Quality around Adayar River, Chennai, Tamil Nadu, India

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Abstract: **In the current study 5 borewell water samples are collected around Adayar river, Chennai, Tamilnadu, India to assess the ground water quality by analyzing the major cations (Ca^{2+} , Mg^{2+}, and Fe^{2+}) and anions (SO_4^{2-}, HCO_3^-, F^-, NO_3^{2-} and Cl^-). Physicochemical parameters such as pH, Turbidity, Electrical conductivity, Total Dissolved Solids were also analyzed. Geographic Information System based on ground water mapping in the form of visually communicating contour maps were developed using ArcGIS 9.3.1 to delineate spatial physico-chemical characteristics of ground water samples. Different parameters of water samples are analyzed. Some of the parameters are found be in adherence and a few parameters are above the Bureau of Indian Standard Permissible limits (IS: 10500:2012). The study reveals that the bore well water in Adayar river basin is polluted and therefore needs proper treatments before human consumption. The paper discusses sampling area, analytical methods and groundwater quality maps in detail.**

Key words: Ground water, Physicochemical parameters, Geographic information systems, Adayar river, Potable water.

1. INTRODUCTION

Adyar river starts from Malaipattu tank (12.93°latitude and 80.00°longitude) near Manimangalam village in Sriperumbudur Taluk at about 15 kilometres west of Tambaram near Chennai. It starts to appear as a stream from the point where water from Chembarambakkam lake joins the river. It flows through Kancheepuram, Tiruvallur and Chennai district for about 42.5 kilometres before joining the Bay of Bengal in Adyar, Chennai. The river has varying depth of approximately 0.75 meters in its upper reaches and 0.5 metres in its lower reaches. The catchment area of the river is 530 square kilometers. Bed width ranges from 10.5 to 200 meters. It flows for 24 kilometres in the Chennai Metropolitan Area including about 15 kilometres within the Chennai District before draining into the sea of Bay of Bengal.

The average water content of human body is 50-60% water. About 75% of the total available water is found be sea water. The other 25% is from various sources like ground water, river and lake etc[1]. But it has been confirmed that only about 0.2% of the total available water is fresh water and useful for domestic purposes without any treatment. The ground water is also used for potability, agriculture and industrial applications [2]. Ground water dissolves various solids and rock minerals through the action of chemical weathering. Hence it contains predominant ions. These ions are classified as major cations(Ca^{2+}, Mg^{2+}, Na^+) and major anions (HCO_3^-,$SO4^{2-}$ and Cl^-) with higher concentrations. Many other ions are also present in lower concentrations (K^+,$Fe^{2+}NO_3^{2-}$ and CO_3^{2-}).These ionic species added together and account for the salinity that is commonly called as Total Dissolved Solids (TDS)[3].Water quality assessment is useful to find the suitability of ground water by many researchers as an assessment tool [4].Therefore an attempt has been made in the current study to assess the ground water quality and their variation by defining the physicochemical nature of the ground water around adayar river Chennai, Tamilnadu.

2. MATERIALS AND METHODS

Groundwater samples were collected from five hand pumps in 1000ml polyethylene bottles during premonsoon season (April-June 2015).The water samples are collected from various locations (Table 1) around Adayar river in Chennai starting from Adayar, Saidapet, Kasi Theatre (Ekkatuthangal), Beasantnagar and Ambalnagar (Guindy). The sampling bottles at the time of sampling were thoroughly rinsed three times using ground water to be sampled. The chemical parameters viz., pH, Total Dissolved Solids(TDS) and Electrical Conductivity(EC) were measured using digital instruments immediately after sampling. The bottles were labeled, tightly packed, transported immediately to laboratory and stored at 4ºC for chemical analysis. The specific methods [5] used for Physicochemical analysis of ground water samples as per IS 3025 are given in Table 2.

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Table -1.Sampling Locations with Latitude and Longitude

S.No	Sampling places	Latitude	Longitude	Sample Codes
1	Adayar	13°00'63"N	80°15'05"E	S1
2	Saidapet	13°00'47"N	80°13'40"E	S2
3	Kasi theater(Ekkatuthangal)	13° 00' 29"N	80°14'06"E	S3
4	Beasantnagar	12°59'43"N	80°16'02"E	S4
5	Guindy	13°0'29"N	80°13'09"E	S5

Table -2.Methods used for Physicochemical parameters analysis(IS 3025)

Parameters	Methods
SO_4^{2-}	Turbidity Method
HCO_3^-	Volumetric titration
Ca^{2+}	EDTA Titration method
Mg^{2+}	EDTA Titration method
Cl^-	Volumetric titration
TDS	TDS Meter
NO_3^{2-}	UV-Visible spectrophotometer UV1601PC/Shimadzu)
F^-	UV-Visible spectrophotometer (UV1601PC/Shimadzu)
Fe^{2+} & Fe^{3+}	UV-Visible spectrophotometer (UV1601PC/Shimadzu)

The results were evaluated for the suitability of drinking water and compared with the water quality guidelines of Bureau of Indian Standards (IS 10500: 2012).[6]

3. GEO-DATABASE CREATION-GIS MODEL

The various physico-chemical parameters obtained from analyses are created as attribute database in generating the spatial distribution maps. These attribute data then transferred in to a point layer for GIS analysis. Each sample point was assigned by a unique code and stored in the point attribute table. The database file contains the values of all Physico-chemical parameters in separate columns along with a sample code for each sampling station. The attribute data were linked to the spatial data and maps showing the spatial distribution were prepared to model the variation in concentrations of the physico-chemical parameters using Inverse Distance Weighted(IDW) raster interpolation technique of spatial analyst TM module in ArcGIS 9.3.1 software. IDW is an algorithm for spatially interpolating or estimating values between measurements. Each value estimated in an IDW interpolation is a weighted average of the surrounding sample points. Weights are computed by taking the inverse of the distance from an observation location to the location of the point being estimated[7]. In a comparison of several different deterministic interpolation procedures [7and8] found that using IDW with a squared distance term yielded results most consistent with original input data. In the present study the geospatial attributed data were utilized for the generation of spatial distribution maps of selected water quality parameters.

Table-3.Results of Physicochemical analysis of samples collected from different locations

Parameter/Location	Adayar	Saidapet	Kasi theatre (Ekattuthangal)	Beasant Nagar	Guindy
pH	7.26	6.28	7.45	6.92	6.85
Turbidity(NTU)	Less than 0.5	Less than 0.5	Less than 0.5	Less than 0.5	Less than 0.5
Conductivity µmhos/cm	1376	1332	1890	1392	1180
TDS mg/l	771	746	1058	779	661
Total Hardness as $CaCO_3$ mg/l	358	442	432	222	386
Calcium mg/l	89.7	76.2	117	60.1	94
Magnesium mg/l	32.5	61.2	34	17.5	37
Chloride mg/l	203	147	261	170	132
Total Alkalinity mg/l	331	314	449	344	353
Sulphate mg/l	56.5	76	89.1	68.8	64.2
Nitrate mg/l	22	23	8.92	11.7	27.1
Iron mg/l	0.10	0.02	0.02	0.17	0.06
Flouride mg/l	0.29	0.35	0.27	0.88	0.39

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Table -4. Statistics of the analytical results

Parameter(s)	N	Minimum	Maximum	Mean	SD ±
pH	5	6.3	7.5	6.9	0.5
Turbidity (NTU)	5	0.5	0.5	0.5	0
Conductivity µmhos/cm	5	1180	1890	1434	268.3
TDS mg/l	5	661	1058	803	150
Total Hardness mg/l	5	222	442	368	88.5
Calcium mg/l	5	60.1	117	87.4	21.2
Magnesium mg/l	5	17.5	61.2	36.4	15.8
Chloride mg/l	5	132	261	182.6	51.4
Total alkalinity mg/l	5	314	449	358.2	52.8
Sulphate mg/l	5	56.5	89.1	70.9	12.4
Nitrate mg/l	5	8.9	27.1	18.5	7.8
Iron mg/l	5	0	0.2	0.1	0.1
Fluoride mg/l	5	0.3	0.9	0.4	0.3

Table-5. Comparison of test results with Indian standards (IS: 10500: 2012)

Parameters(s)	IS:10500:2012		No of samples exceeding the acceptable limit (Max)	No of samples exceeding permissible limit
	Acceptable limit	Permissible limit		
pH	6.85-8.5	No relaxation	0	0
Turbidity (NTU)	1	5 NTU	0	0
Conductivity µmhos/cm	-	-	0	0
TDS mg/l	500	2000	5	0
Total Hardness mg/l	200	600	5	0
Calcium mg/l	75	200	4	0
Magnesium mg/l	30	100	4	0
Chloride mg/l	250	1000	1	0
Total alkalinity mg/l	200	600	5	0
Sulphate mg/l	200	400	0	0
Nitrate mg/l	45	No relaxation	0	0
Iron mg/l	0.3	No relaxation	0	0
Fluoride mg/l	1.0	1.5	0	0

4. RESULTS AND DISCUSSION

The results of physicochemical analysis of samples collected from different locations are showed in Table 3. The statistics of the analytical results are presented in Table 4. Comparison of test results with Indian standards (IS:10500: 2012) are given in Table 5. Some of the parameters are found be in adherence and a few parameters are above the Permissible limits. The spatial distribution maps using ArcGIS 9.3.1 namely Sample location, pH, TDS, EC, Calcium, Total Hardness, Chloride, Sulphate, Total alkalinity, Nitrate, Flouride, Iron, Magnesium are given. (Fig. 1,2,3,4,5,6,7,8,9,10,11,12and 13).

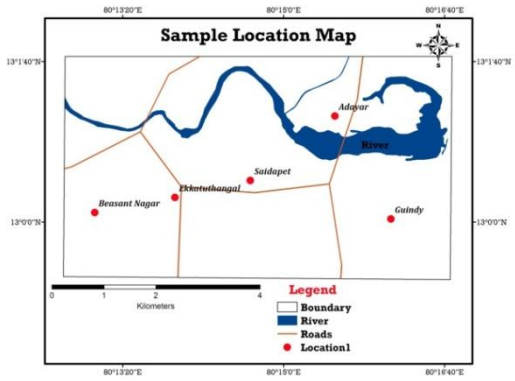

Fig.1. Spatial distribution of Sample Location

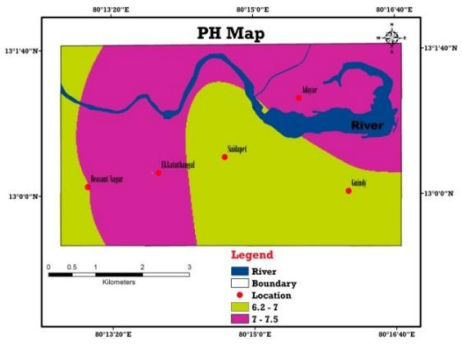

Fig. 2. Spatial Distribution of PH

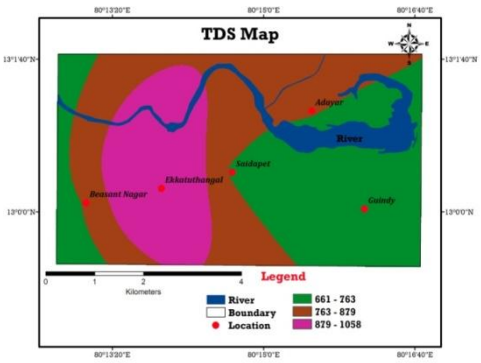

Fig. 3. Spatial distribution of TDS

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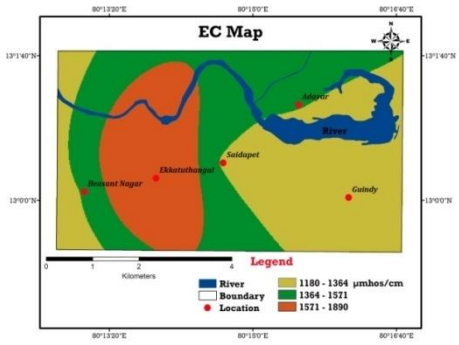

Fig. 4. Spatial Distribution of EC

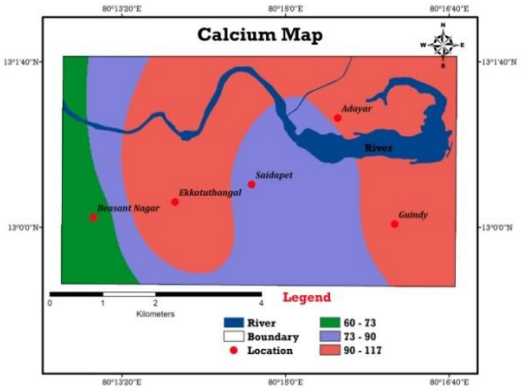

Fig. 5. Spatial distribution of Calcium

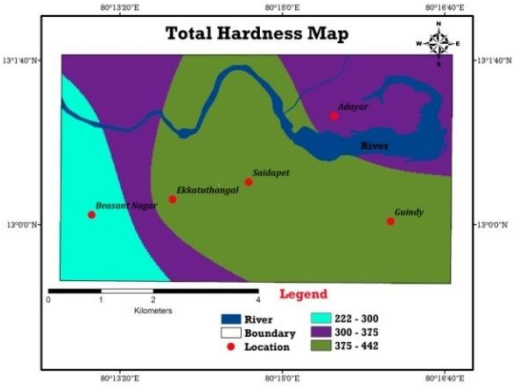

Fig. 6. Spatial distribution of TH

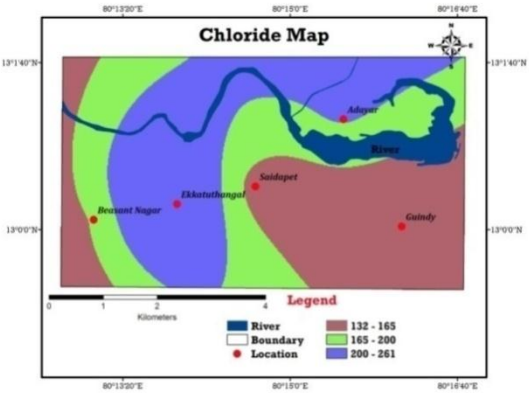

Fig. 7. Spatial Distribution of Chloride

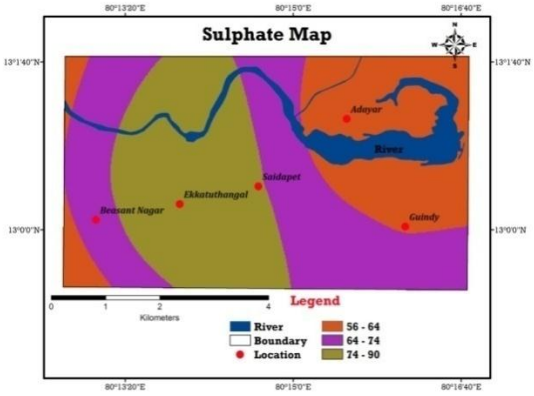

Fig. 8. Spatial distribution of Sulphate

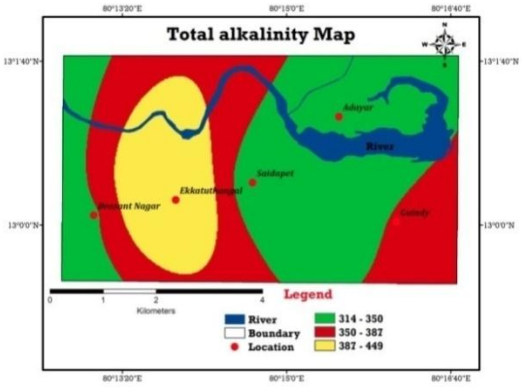

Fig. 9. Spatial Distribution of Spatial Alkalinity

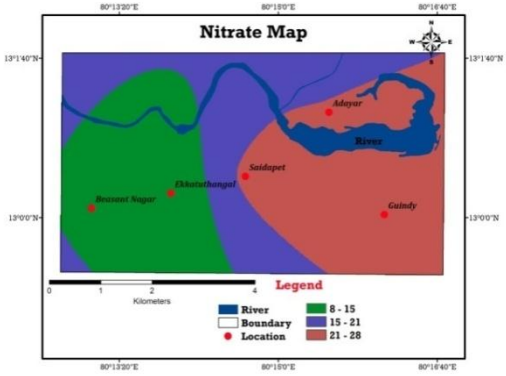

Fig. 10. Spatial distribution of Nitrate

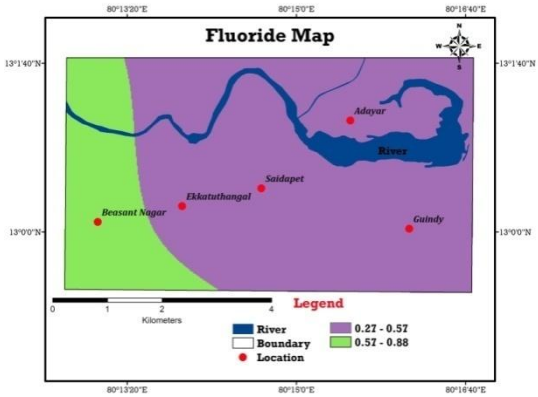

Fig. 11. Spatial distribution of Fluoride

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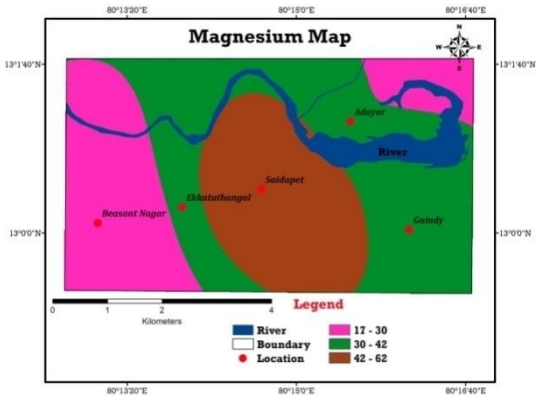

Fig. 12. Spatial distribution of Iron

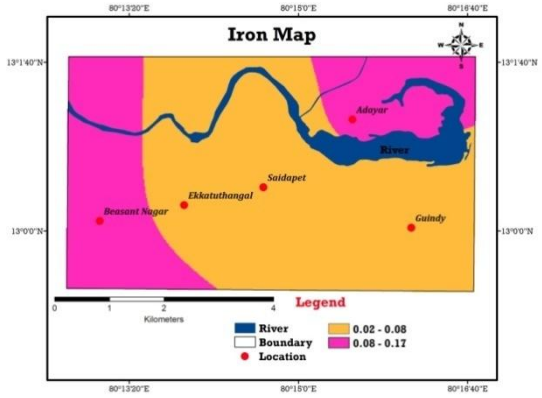

Fig. 13. Spatial distribution of Magnesium

4.1.pH

Generally pH of ground water sample is dependent on the relative quantities of calcium carbonates and bicarbonates. The change is also governed by the amount of free CO_2 and HCO_3. In the study area, the pH level varied from 6.28 to 7.45 respectively. The maximum level of pH is noticed at Ekkatuthangal and Adayar and minimum pH value was observed at Saidapet. The spatial distribution of pH is given in the Fig. 2. The values were within the limits as specified as 6.5 to 8.5 in WHO standards [9] for drinking.

4.2. Total Dissolved solids (TDS)

The total dissolved solids in the groundwater varying from 661mg/l to 1058 mg/l where minimum value was noticed at Guindy and Saidapet and maximum value observed at Ekkatuthangal. The possible reason for increased total dissolved solids is from dissolution or weathering of the rock and solids and dissolving nature of lime, gypsum and other salts, when the source water passed over or percolates through them. The spatial distribution of TDS is presented in the Fig.3.

4.3. Electrical Conductivity (EC)

Electrical conductivity is the measure of concentration of electrolyte in water in the form of ions (Karanth, 1987)[10]. In the study area, EC is varied from 1890 to 1180 µmhos/cm respectively. The higher value was noticed at Ekkatuthangal, the low EC was observed at Guindy and Saidapet respectively. The high conductivity was observed due to chloride concentrations in ground water. The spatial distribution of EC is presented in the Fig. 4. The maximum limit of EC for drinking is prescribed as 1500 microsimns/cm [9].

4.4. Calcium

The Ca ionic concentration was found low as 60.1& 76.2 mg/l in Beasantnagar and Saidapet, high concentration of 94, 117 mg/l was observed in Gundy, and Ekkatuthangal. The concentration of Ca is due to interaction of minerals like Feldspar and the weathering process. Moreover, it is a major constituent of most igneous, metamorphic and sedimentary rocks. The spatial distribution of Ca is presented in Fig. 5.

4.5. Total Hardness (TH)

The water hardness is primarily due to the result of interaction between water and geological formations. The permissible limit of TH in drinking water is specified as 100 mg/l. (WHO, 1993).In the study area, TH varied from 222 to 442 mg/l where maximum at Saidapet and Ekkatuthangal and minimum at Beasantnagar. The spatial distribution of TH is presented in the Fig. 6.

4.6. Chloride

The Cl concentration varied from 132 mg/l to 261 mg/l. Low concentration was observed at Guindy and Saidapet and high concentration was observed at Ekkatuthangal and Adayar. The limit of chloride concentration for drinking water is specified as 600 mg/L. The spatial distribution of Cl is presented in the Fig. 7. High chloride in ground water samples may be due to the pollution from chloride rich effluents of sewage and municipal waste[11]

4.7. Total Alkalinity

The total alkalinity concentration varied from 314mg/l to 449mg/l. Low concentration was observed at Saidapet and high concentration was observed at Ekkattuthangal. The spatial distribution of Total alakalinity is presented in the Fig. 8**.**

4.8. Sulphate

The Sulphate concentration varied from 56.5 mg/l to 89.1 mg/l where the maximum concentration of 89.1 mg/l was observed at Ekkatuthangal and the minimum concentration of 56.5 mg/l was observed at Adayar. The limit of sulphate concentration for drinking water is specified as 250 mg/l. The spatial distribution of $SO_4^{2-}$is presented in the Fig.9.

4.9. Nitrate

The nitrate concentration varied from 8.92 mg/l to 27.1 mg/l. The low concentration was observed in Ekkattuthangal and high concentration was observed in Saidapet and Guindy. The limit of nitrate concentration for drinking water is specified as 45mg/l. The spatial distribution of Nitrate is presented in the Fig. 10.

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4.10. Fluoride

Fluoride concentration is observed in the study area ranges from 0.27 to 0.88 mg/l. The low concentration was found in Ekkattuthangal and high concentration was observed in Beasantnagar. The spatial variation map of Fluoride is presented in Fig. 11. Fluoride initiated from the weathering of fluoride-containing minerals and blends with surface waters, with run-off and ground waters through direct interaction.

4.11. Iron

Iron concentration was observed in the study area ranging from 0.02 to 0.17 mg/l. The low concentration was found in Ekkatuthangal, Saidapet and high concentration was observed in Beasantnagar. The spatial variation map of Iron is presented in Fig. 12. Iron is naturally released into the environment from weathering, it may also be released into the aquatic environment through human activities, sewage, and iron related industries.

4.12. Magnesium

Magnesium is the important cations in groundwater. In the study area the magnesium concentration is varied from 17.5 mg/l to 61.2 mg/l. The low concentration of magnesium was observed in Beasantnagar and higher concentration was observed at Saidapet. The spatial distribution of Mg is presented in the Fig. 13. Magnesium is an essential ion for functioning of cells in enzyme activation,but at higher concentration it can cause laxative effect upon people after consumption[12].

5. CONCLUSION

From the analysis it is clear that the majority of ground water quality parameters around Adayar river are exceeding the acceptable limits of BIS (2012). It is generally concluded that ground water quality is not good for drinking purposes. Further research should be conducted in both wet and dry seasons to obtain more information pertaining to physico-chemical parameters in many ground water samples within the study area so as to determine the effect of seasonal variations.

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