

A study on status of ground water quality in and around coastal town of cuddalore, cuddalore DT-TN, India

P. ARUL, J. FRANCIS LAWRENCE and B. GOWTHAM

Department of Geology, Presidency College, Chennai – 5 (INDIA)

(Acceptance Date 2nd November, 2012)

Abstract

About 14 water samples have been collected from 10 different locations to know the status of the ground water quality in and around Cuddalore, Cuddalore district, Tamilnadu. The collected water samples were chemically analyzed by adopting standard procedures and the results were run into HYCH software to classify the water. The results show that whether it is shallow or deep aquifer systems the salt concentrations are increasing during post-monsoon period due to leaching of salts from the surrounding rocks. The deep aquifer water quality is better and its water quality parameters were within the permissible limits of WHO standard. It is suggested that the utilization of deep aquifer water is better than using shallow aquifer water to meet the water demand of people living in and around the Cuddalore town.

Key words: Coastal area, Aquifer, Cuddalore, Analysis, Pre-monsoon and Post-monsoon.

Introduction

It is known fact that water is one of the most precious natural resource and it is essential for sustaining all form of life in this world. Our country population is estimated as 20% of world population but possesses only 5% the world's water wealth. Water problem is not a local problem but there are many interstate water disputes and intrastate water conflicts. The federal structure of the country is under threat for the sharing of the scarce water resource among people. In this existing scenario a study

has been carried out to understand the status of ground water quality in and around coastal town Cuddalore, Cuddalore district, Tamilnadu, India¹.

Experiments

The study area lies in the north eastern part of Tamilnadu, confined between latitudes of 11°40'2" N - 11°48'2" N and longitude of 79°40'2" E - 79°48'2" E and lies in the parts of toposheets of 58 M/9, 58 M/13, M/10 and M/14 and covering an area of approximately 150

km². The rivers Ponnaiyar, Gadilam and Uppanar are flowing through this town and finally confluence with the Bay of Bengal. In general the area is plain, but the western side is elevated and sloping towards eastern side. The plants like paddy, sugarcane, pulses, groundnut, coconut, cashew nut, jack fruit tree, casuarina, etc. are growing well in the red soil, alluvial soil and loamy soil. The area is experiencing the average annual rainfall of 1160mm.

The study area comprises of Tertiary Cuddalore Sandstone and Quaternary sediments. The geological history of the region reveals that the area have been experienced several times marine transgression and regression. The marine transgression is noticed by the evidence of transformation of some of the coastal areas into lagoons; subsidence and uplift of land cause sea regression. The existing terrain evolved as a result of prolonged geological processes happened in the geological past²⁻⁷.

The base map is prepared by using the Survey of India toposheets of 1:50,000 scale. To estimate the water quality of the region, there were about 9 shallow aquifer and 5 deep aquifer water samples have been collected during pre-monsoon and post-monsoon periods.

By adopting standard procedures (APHA, 1998), the collected samples were chemically analyzed – the calcium, magnesium, chloride, carbonate and bi-carbonate ions by titration; sodium and potassium by flame photometer and sulfate by spectrophotometer. By using portable instruments the pH and EC values were measured in the field itself. The water analysis results were run into 'HYCH software' to classify and to understand the

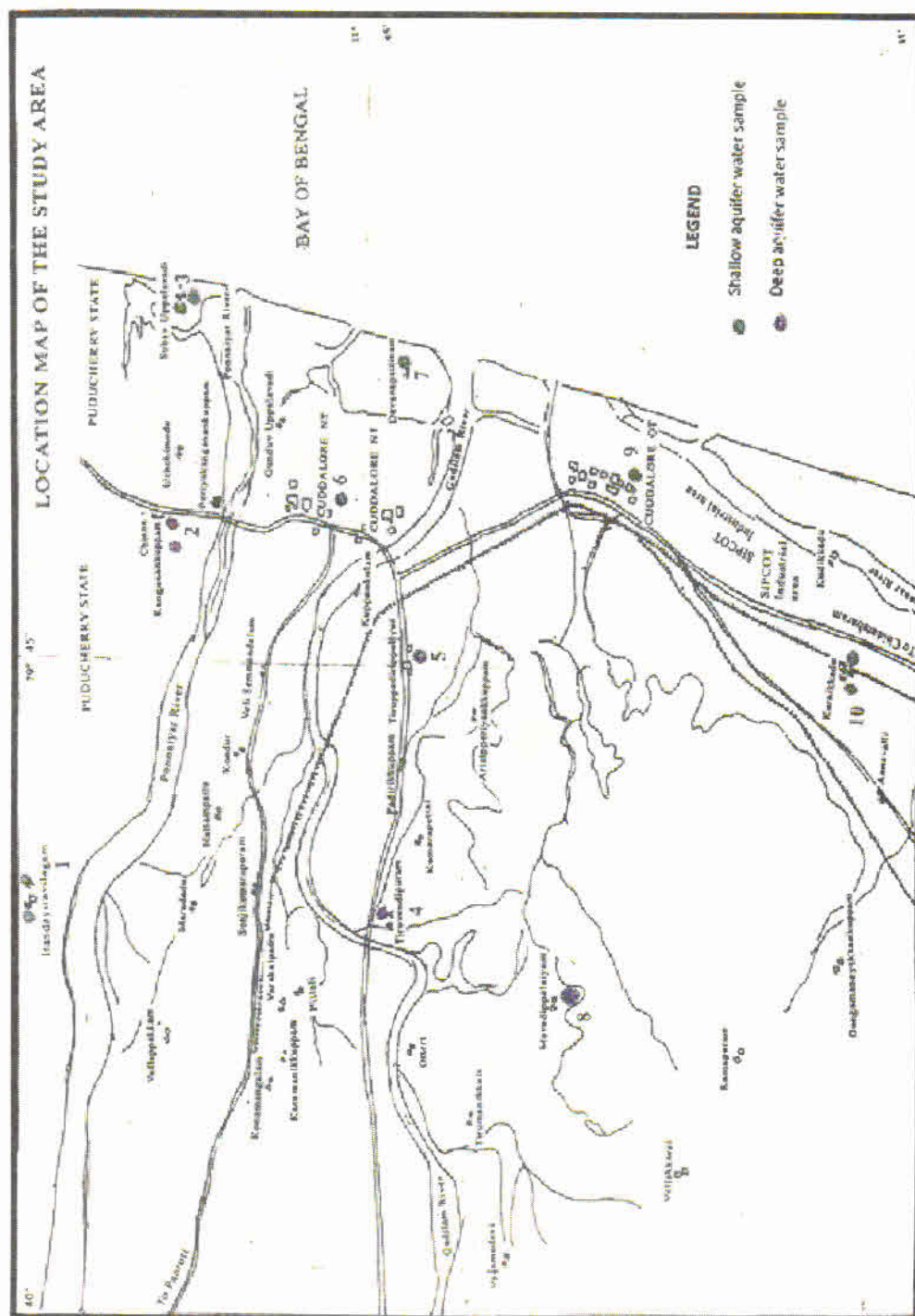
suitability of the water quality for various purposes⁸⁻¹⁵.

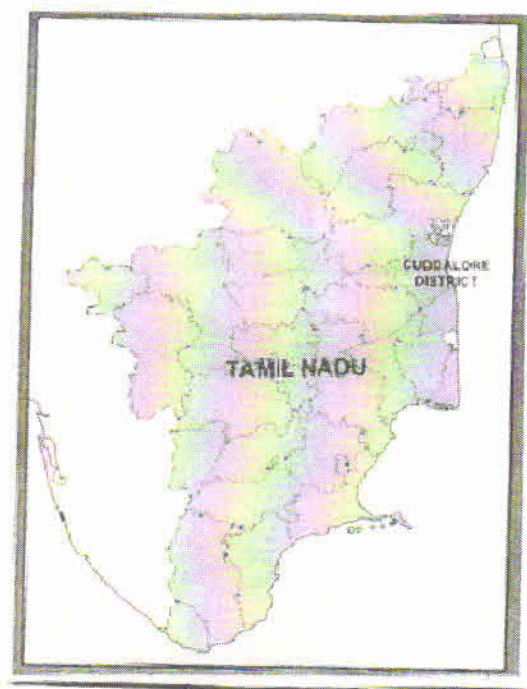
Observations

The EC values of shallow aquifer water lies between 685 – 2070 $\mu\text{mho/cm}$ at 25°C and 1260 – 8214 $\mu\text{mho/cm}$ at 25°C in pre-monsoon and post-monsoon periods respectively. In the case of deep aquifer water samples the EC value lies from 200 to 1090 $\mu\text{mho/cm}$ at 25°C and 420 – 1840 $\mu\text{mho/cm}$ at 25°C during pre-monsoon and post-monsoon periods respectively.

During pre-monsoon the minimum and maximum values of TDS in shallow aquifer water sample is 513 mg/l and 2011 mg/l respectively; for post-monsoon periods the values are 769 and 5154 mg/l respectively. During pre-monsoon the minimum and maximum values of TDS for deep aquifer water sample is 138 mg/l and 969 mg/l respectively; during post-monsoon the values are 254 mg/l and 1125 mg/l respectively. Sodium Absorption Ratio (SAR) value for shallow aquifer ranges between 2.5 - 26.5 during pre-monsoon and 4.2 - 31.3 during post-monsoon periods. For deep aquifer water the value is 1.5 - 7.9 in pre-monsoon; 2.0 - 9.1 in post-monsoon periods.

In shallow aquifer for about 8 water samples lies in the category of $C_3S_1 - C_3S_4$ and only one sample lies in the category of C_2S_1 USSL classification during pre-monsoon period; during post-monsoon about 4 samples belongs to $C_4S_3 - C_5S_4$ category and remaining 5 samples belongs to $C_3S_1 - C_3S_2$ category of USSL classification.





In deep aquifer - only one water sample lies in the C_3S_2 category and the remaining 4 samples lie in the category of C_2S_1 USSL classification during pre-monsoon period. During post-monsoon 3 samples lie in the category of C_2S_1 and the remaining 2 samples lie in the category of $C_3S_1 - C_3S_2$ of USSL classification.

The results of chemical analysis of shallow and deep aquifer water samples and the output of HYCH software were presented in the form of tables from 1 to 8.

Discussion

In the shallow aquifer water samples, 4 locations (sample no. 3,4,7 and 10) show medium range of EC values and remaining 5

locations (sample no. 1,2,5,6 and 9) show higher range of EC values. In deepaquer except one water sample (sample no.1) all the other water samples (sample no. 2,3,8 and 10) show EC and TDS values within the permissible limit¹⁶⁻¹⁹.

The higher EC and TDS values in shallow aquifer in both seasons *i.e.* in pre-monsoon and post-monsoon indicate the shallow aquifer water quality is medium - poor quality throughout the year. The EC and TDS values of deepaquer water samples were within the permissible limit both in pre-monsoon and post-monsoon periods, which indicate that the deepaquer water is suitable for drinking purposes¹⁻¹⁷.

In both shallow and deep aquifer the samples showing lesser EC and TDS values in pre-monsoon and higher EC and TDS values in post-monsoon periods, indicate that the leaching of the salts from the enclosing sediments. The presence of Quaternary marine sediments in the shallow depth is the reason to have higher salt concentration in shallow aquifer water²⁻⁶.

The quality of shallow aquifer water in locations 4 and 10 is good, it is mainly due to Quaternary fluvial sediments present in that area. The shallow aquifer water sample locations 3 and 7 are very close to coast but shows moderate - good quality, indicate the presence of floating or perched aquifer. The water analysis results also reveal that the north and central region of the study area is much affected by the palaeomarine transgression (upto 10 - 12 km) compared to the south side. In the southern side the Tertiary formations stand up as small hill like landforms, hence, the marine transgression is not much affected in this region⁸⁻¹⁵.

Table 1. Hydro-chemical analysis results of shallow aquifer
water samples (**Pre-monsoon**)

| Sample Location | pH | EC (micro mhos/cm) | Ca | Mg | Na + K | HCO ₃ + CO ₃ | Cl | SO ₄ | TDS |
|---------------------|-----|-----------------------|----|----|--------|---------------------------------------|-------|-----------------|--------|
| Irundayiravilagam | 8.3 | 1640 | 20 | 22 | 310 | 396.3 | 344 | - | 1475.5 |
| Chinakanganankuppam | 8.8 | 1900 | 7 | 7 | 414 | 670 | 173.8 | 100.9 | 2011.7 |
| SubavUppalavadi | 8.6 | 1067 | 16 | 9 | 207 | 274 | 159.6 | 56.2 | 991.7 |
| Tiruvendipuram | 8.4 | 1020 | 25 | 36 | 137 | 359.7 | 145.4 | - | 819.6 |
| Tiruppadirippuliyur | 8.3 | 1875 | 40 | 37 | 314 | 432.7 | 358.1 | 55.2 | 1570 |
| Cuddalore NT | 8.8 | 2070 | 23 | 25 | 401 | 524 | 407.8 | - | 1892.3 |
| Devanampattinam | 8.7 | 1130 | 72 | 40 | 98 | 334.8 | 180 | - | 795.5 |
| Cuddalore OT | 8.5 | 1668 | 49 | 40 | 249 | 371.8 | 287.2 | 104.7 | 1338.1 |
| Karaikkadu | 8.3 | 685 | 37 | 20 | 75 | 164.6 | 106.4 | 50.4 | 513.3 |

Table 2. Hydro-chemical analysis results of shallow aquifer
water samples (**Post-monsoon**)

| Sample Location | pH | EC (micro mhos/cm) | Ca | Mg | Na + K | HCO ₃ + CO ₃ | Cl | SO ₄ | TDS |
|---------------------|-----|-----------------------|----|------|--------|---------------------------------------|--------|-----------------|--------|
| Irundayiravilagam | 8.6 | 2270 | 50 | 47.4 | 374.9 | 365.6 | 577.8 | - | 1415.7 |
| Chinakanganankuppam | 8.3 | 1337.90 | 42 | 51.1 | 340.4 | 492.8 | 354.5 | 57.6 | 1337.9 |
| SubavUppalavadi | 7.5 | 1320 | 36 | 42.6 | 181.7 | 389.8 | 212.7 | 9.6 | 872.4 |
| Tiruvendipuram | 8.4 | 1260 | 28 | 24.3 | 211.6 | 158.4 | 347.4 | - | 769.7 |
| Tiruppadirippuliyur | 7.6 | 6450 | 70 | 51.1 | 1294.9 | 121.8 | 1198.2 | 1368.8 | 4104.8 |
| Cuddalore NT | 7.3 | 5960 | 38 | 65.7 | 1202.9 | 304.4 | 1134.4 | 1056.7 | 3802.1 |
| Devanampattinam | 7.8 | 1640 | 76 | 51.1 | 193.2 | 304.2 | 375.8 | - | 1000.3 |
| Cuddalore OT | 7.5 | 8214 | 70 | 85.1 | 1646.8 | 158.2 | 1701.6 | 1493.7 | 5154.9 |
| Karaikkadu | 7.3 | 1690 | 20 | 60.8 | 250.7 | 97.6 | 538.8 | 4.8 | 972.7 |

Table 3. Hydro-chemical analysis results of deep aquifer
water samples (**Pre-monsoon**)

| Sample Location | pH | EC (micro mhos/cm) | Ca | Mg | Na + K | HCO ₃ + CO ₃ | Cl | SO ₄ | TDS |
|---------------------|------|-----------------------|----|----|--------|---------------------------------------|-------|-----------------|--------|
| Irundayiravilagam | 8.18 | 1090 | 13 | 20 | 197 | 317 | 195 | - | 969.39 |
| Chinakanganankuppam | 8.42 | 380 | 13 | 12 | 48 | 158.6 | 42.5 | - | 315.13 |
| SubavUppalavadi | 8.55 | 630 | 13 | 15 | 101 | 213.5 | 99.3 | - | 543.63 |
| Mavadippalayam | 7.74 | 200 | 11 | 4 | 23 | 61 | 35.4 | - | 138.4 |
| Karaikkadu | 8.39 | 630 | 22 | 26 | 69 | 140.1 | 102.8 | 43.2 | 455.21 |

Table 4. Hydro-chemical analysis results of deep aquifer water samples (**Post-monsoon**)

| Sample Location | pH | EC (micro mhos/cm) | Ca | Mg | Na + K | HCO ₃ + CO ₃ | Cl | SO ₄ | TDS |
|---------------------|-----|--------------------|----|------|--------|------------------------------------|-------|-----------------|--------|
| Irundayiravilagam | 8.4 | 1840 | 36 | 34 | 317.4 | 255.6 | 482.1 | - | 1125.1 |
| Chinakanganankuppam | 7.1 | 440 | 10 | 12.2 | 66.7 | 115.8 | 85.1 | - | 289.8 |
| SubavUppalavadi | 7.3 | 540 | 14 | 15.8 | 78.2 | 158.4 | 92.2 | - | 358.6 |
| Mavadippalayam | 7.7 | 420 | 18 | 14.6 | 48.3 | 67 | 106.3 | - | 254.2 |
| Karaikkadu | 6.5 | 890 | 28 | 19.4 | 135.7 | 54.9 | 283.6 | - | 521.6 |

Table 5. Physico-Chemical Parameters of shallow aquifer

Pre-monsoon

| Sample Location | SAR | RSC | NCH | SC | USSL |
|---------------------|----------|-----------|-----------|------------------|------|
| Irundayiravilagam | 11.37431 | 3.889594 | -194.4797 | Brackish | C3S3 |
| Chinakanganankuppam | 26.46324 | 11.07134 | -553.5671 | Fresh - Brackish | C3S4 |
| SubavUppalavadi | 10.25982 | 3.459666 | -172.9833 | Fresh - Brackish | C3S2 |
| Tiruvendipuram | 4.105577 | 1.888266 | -94.41328 | Fresh | C3S1 |
| Tiruppadirippuliyur | 8.599512 | 2.457134 | -122.8567 | Brackish | C3S2 |
| Cuddalore NT | 13.77288 | 5.992447 | -299.6224 | " | C3S3 |
| Devanampattinam | 2.296587 | -6.859326 | 34.29663 | Fresh - Brackish | C3S1 |
| Cuddalore OT | 6.392326 | .6614704 | -33.07352 | " | C3S2 |
| Karaikkadu | 2.467788 | -6.929152 | 34.64576 | Fresh | C2S1 |

Table 6. Physico-Chemical Parameters of shallow aquifer

Post-monsoon

| Sample Location | SAR | RSC | NCH | SC | USSL |
|---------------------|----------|--------------|-----------|------------------|------|
| Irundayiravilagam | 9.115228 | 2.702713E-03 | -1351357 | Brackish | C4S3 |
| Chinakanganankuppam | 8.338394 | 3.597117 | -179.8559 | " | C3S2 |
| SubavUppalavadi (S) | 4.852083 | 1.696206 | -84.81028 | Fresh - Brackish | C3S1 |
| Tiruvendipuram | 7.059411 | -5.975904 | 29.87952 | Brackish | C3S2 |
| Tiruppadirippuliyur | 28.69704 | -5.498506 | 274.9253 | Brackish-Salt | C5S4 |
| Cuddalore NT | 27.3704 | -1.703976 | 85.19878 | " | C5S4 |
| Devanampattinam | 4.200708 | -2.198733 | 109.9367 | Brackish | C3S1 |
| Cuddalore OT | 31.25524 | -7.496424 | 374.8212 | Brackish - Salt | C5S4 |
| Karaikkadu (S) | 6.292551 | -4.401606 | 220.0803 | Brackish | C3S2 |

Table 7. Physico-Chemical Parameters of Deep aquifer

Pre-monsoon

| Sample Location | SAR | RSC | NCH | SC | USSL |
|----------------------|----------|-----------|-----------|------------------|------|
| Irundayiravilagam | 7.996757 | 3.103896 | -155.1948 | Fresh - Brackish | C3S2 |
| Chinnakanganankuppam | 2.307366 | .9629958 | -48.14979 | Fresh | C2S1 |
| SubavUppalavadi | 4.525658 | 1.615838 | -80.79192 | " | " |
| Mavadippalayam | 1.509228 | .1216202 | -6.081012 | " | C1S1 |
| Karaikkadu | 2.358013 | -.7379797 | 36.89898 | " | " |

Table 8. Physico-Chemical Parameters of Deep aquifer

Post-monsoon

| Sample Location | SAR | RSC | NCH | SC | USSL |
|----------------------|----------|-----------|-----------|------------------|------|
| Irundayiravilagam | 9.105212 | .2045999 | -10.22999 | Brackish | C3S2 |
| Chinnakanganankuppam | 3.345389 | .4964945 | -24.82473 | Fresh | C2S1 |
| SubavUppalavadi | 3.401067 | .8004556 | -40.02278 | " | " |
| Mavadippalayam | 2.049585 | -.899935 | 44.99675 | " | " |
| Karaikkadu | 4.822491 | -2.093877 | 104.6939 | Fresh - Brackish | C3S1 |

Conclusion

Totally about 9 shallow aquifer water samples and 5 deep aquifer water samples have been collected from 10 different locations both in pre-monsoon and post-monsoon periods to know the status of ground water quality of the study area. By adopting standard procedures, the samples were chemically analyzed and the results were fed into HYCH software to classify and to find the suitability of water for various purposes.

The result shows that the EC and TDS values of shallow aquifer water in 5 locations-Irundayiravilagam, Chinnakanganankuppam, Tiruppuripuliyur, Cuddalore NT and Cuddalore OT are above the permissible limit. The remaining 4 locations of shallow aquifer water - Subav Uppalavadi, Tiruvendipuram, Devanapattinam and Karaikkadu the water quality parameters were within the permissible limit.

In deep aquifer water, all the 5 locations - Irundayiravilagam, Karaikkadu, Chinnakanganankuppam, SubavUppalavadi and Mavadippalayam- the water quality parameters were within the permissible limit. Further, the deeper aquifer water quality is good during pre-monsoon as well as in post-monsoon periods. Whether it is shallow or deep aquifer, the salt concentrations were increases in the post-monsoon period due to leaching and dissolution of salts from the surrounding sediments.

From the study it is understood that because of the natural leaching of salts from the Quaternary marine sediments the shallow aquifer water quality is degraded. The district headquarter Cuddalore is situated over the Quaternary marine sediments, as there is no other way the people living in this region using salty water for their daily need. It is suggested that the deep aquifer water is more suitable for consumption and it is better to supply water

from locations 2,3,8 and 10 to meet the water demand of the people living in the Cuddalore town.

Acknowledgement

Authors are grateful to Prof. R. Sivakumar, Head, Department of Geology, Presidency College, Chennai for extending all facilities to carry out chemical analysis work in the department laboratory. Our sincere thanks are due to Dr.R.Sabanayagam, Principal, Presidency College, Chennai, for his constant encouragement and guidance to complete this work. Thanks are also due to all the geology department staff members of Presidency College, for their interest shown in this work. We express our sincere thanks to the Principal and Staff members of Thiru.A.Govindasamy Government Arts College, Tindivanam, Tamilnadu.

References

1. APHA, Standard methods for the Examination of water and wastewater, 19th Edition (1996).
2. Arul P., A text book of Ground water, 1st Edition, 105 – 122 (2000).
3. Ballukarya P.N. and Ravi, *Journal of Geological Society of India*, 58, 1- 11 (2001).
4. Brar S.P.S., Dinesh Kumar and Bishnoi S.R., *Indian Journal of Environmental Health*, Vol. 26, 202 ; 209 (1984).
5. Ibrahim Bathusa M. and Saseetharan M.K., *Indian Journal of Environmental Protection*, 26 (6), 508 – 515 (2006).
6. Prasanna M.V., *Journal of Ultra Chemistry*, 2(2), 157 – 172 (2006).
7. Ramesh R. and Anbu M., *Chemical methods for Environmental Analysis*, 1st Edition (1996).
8. Satheesh Herbert Singh D., Evaluation of ground water status and coastal aquifer modeling of Chennai city, Tamilnadu, India., Ph.D. Thesis, (2005).
9. Satheesh Herbert Singh D. and Lawrence J.F., *Mining Engineers Journal*, Volume 5 no. 12, 21 – 26, (2004).
10. Sathyanarayanan M. and Periakali P., IGWC- Sustainable Development and management of ground water resources in semi-arid region with special reference to hard rocks, 215 – 228, (2002).
11. Selvakumar M. and Manoharan R., IGWC– GIS application for ground water quality assessment–A case study at Dindugultaluk., TN, 333–338 (2002).
12. Shantha Kumari D., Srinivasalu S. and Subramanian S., *Research Journal of Environmental Toxicology*, 1(1): 16-26, (2007).
13. Stuyfzand P.J., A new hydrochemical classification of water types with examples of applications, *IAHS*, 184, 89–98 (1989).
14. Subrmaninan K.S. and Selvan T.A., *Journal of Geological Society of India– Geology of Tamilnadu and Pondicherry*, ISBN : 81–85867 – 47 – X, 192, (2001).
15. Suresh Kumar G., Thirumurugan V., Sridharan V. and Vijaya Kumar N., National workshop on water resources, Periyar University, 149 – 157, (2008).
16. The Hindu, Survey of the Environment, 63 – 69 (2009).
17. Trivedi A.R., Ghevaria Z.G., Parikh H.N. and Jain N.M., *Hydrology Journal*, volume XIII, 35 – 43 (1990).
18. WHO, Guidelines for drinking water quality, Volume 1, 1-4 (1993).
19. WRO (Water Resource Organisation) – PWD, Ground water perspective – A profile of Cuddalore District, TN, 13 – 17 (2000).