



River Water Quality In The Coastal Environment – A case study on “ Status of Ponniayar, Gadilam and Uppanar river water quality near the coast of Cuddalore, Cuddalore district, TN – India ”

Arul P

Department of Geology, Presidency College, Chennai

Francis Lawrence J

Department of Geology, Presidency College, Chennai

Gowtham B

Department of Geology, Presidency College, Chennai

Anitha R

Guest Faculty/Geology, Govt Arts College, Tindivanam

Abstract:

Coastal environment is facing the hazards like flood, cyclone, erosion, storm surge and tsunami. Ingress of sea into the land and nearby surface water bodies is also another major threat to coastal environment. In this scenario, the rivers Ponniayar, Gadilam and Uppanar flowing in the heart of the Cuddalore town have been chosen to study the effect of coastal environment on river water quality. The water samples have been collected from the both rivers during pre-monsoon and post-monsoon periods and they were analyzed in the laboratory by adopting standard procedure (APHA, 1998). The chemical analysis results were fed into HYCH software to understand the water quality type. From the study it is revealed that all the three rivers were facing sea water intrusion problem during pre-monsoon and post-monsoon periods. The level of COD, BOD and E.Coli of Ponniayar river water is comparatively higher than the Gadilam river water. The Uppanar river water is showing concentration of heavy metals like Lead (Pb) and Zinc (Zn). Therefore, immediate steps to be taken to save all the three rivers from problems like sea water intrusion, sewage and industrial pollution. The strategies like construction of check dams, embankment across rivers, avoiding sand quarrying from river beds, prohibiting the entering of sewage and effluent into stream and monitoring of river water quality are essential to overcome the above problems. Creating awareness to public through various mass-media and implementing strict environmental laws are also to be needed to safe guard the coastal environment of this region.

Key words : River, Coast, Quality, Sample and Pollution

1. Introduction

The coastal zone – the transition between the land and the sea, is one of the most fragile, complex and productive ecosystem. There are millions of people depending upon the coastal region for their daily livelihood. The coastal regions are facing the problems like discharge of municipal waste, industrial effluents, waste generated from recreation and tourism activities, etc. Apart from the anthropogenic activities the coastal zones also facing natural hazards like coastal flood, cyclone, coastal erosion and storm surge. The ground water contamination by sea water is a major threat faced by many coastal areas of the world (Goldburg, V.M, 1973). Over exploitation of ground water in the coastal areas leads to the phenomenon of sea water intrusion (Kumaraswamy K, Unnikrishnan K and Kamaraj M., 1995). Ground water is sometimes polluted naturally by the encroachment of seawater into the coastal aquifer (Arul P, 2000). Saline water in aquifers may be derived from : Encroachment of sea water in coastal area, sea water that entered aquifers during past geologic time and some other sources. (Todd D.K., 1995)

Therefore, the coastal zone is one of the most critical areas under the pressure of modern society. In this scenario, a study has been carried out to know the status of the Ponnaiyar, Gadilam and Uppanar river water quality near the coast of Cuddalore, Cuddalore district, Tamilnadu – India.

2. Study Area

The coastal zone of Tamilnadu is endowed with varied landscape such as sandy beaches, beach ridges, back-water, estuaries, dunes, cliffs, deltas, lagoons, mangrove forest and coral reef eco-systems (Singarasubramanian S.R, Mukesh M.V, Sujatha K and Manoharan K., 2009). The study area, part of north east coastal plain of Tamilnadu is considered as an emerging one and which is confined between the North latitude of 11° 40' to 11° 48'; East longitude of 79° 40' to 79° 48' and lies in the Survey of India toposheet nos. 58M/9, 58M/13, 58M/10 and 58M/14.

The SIPCOT industrial complex, Silver beach (tourist spot) and Harbour are the important places found in this coast. The Ponnaiyar, Gadilam and Uppanar are the major rivers flowing in this region and they finally confluences with the Bay of Bengal. The river Ponnaiyar forms the northern boundary to Cuddalore town, river Gadilam flowing central region of Cuddalore town and Uppanar river flowing in the

southern side of the Cuddalore town. The rivers Ponnaiyar and Gadilam receives water from Eastern Ghats and river Uppanar receives water from Perumal lake. The area is comprises of Cuddalore Sandstone of Tertiary age, Quaternary marine sediments and Recent Alluvium (WRO, 2000). The area is experiencing tropical climate, the average annual rainfall is 1160 mm.

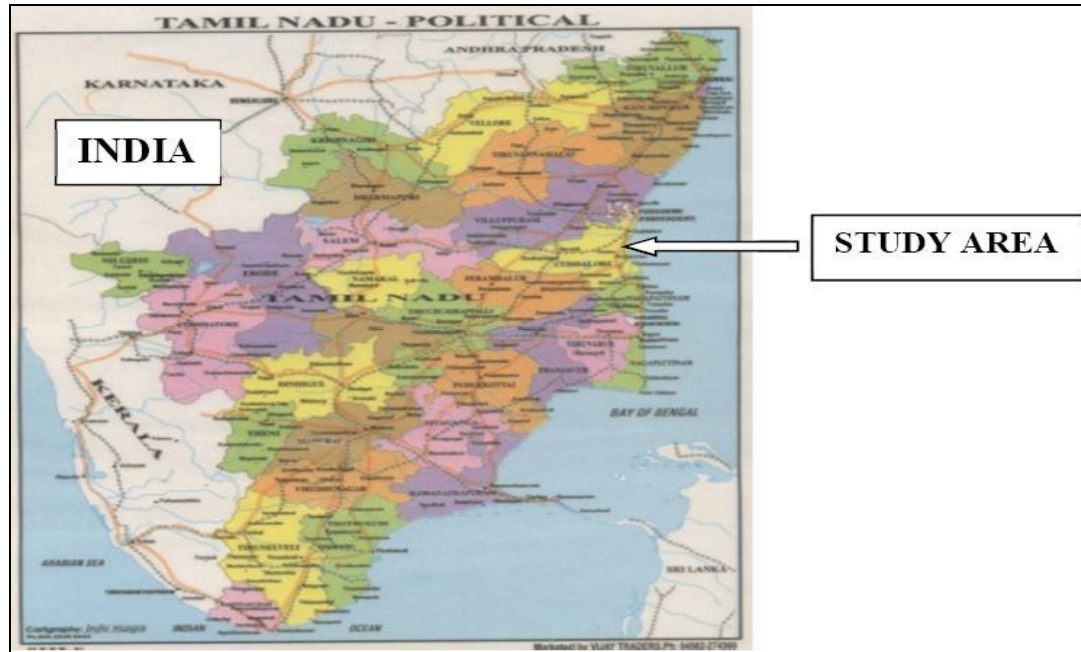


Figure 1: Study Area

3. Methodology

The base map of the study area has been prepared by using the Survey of India toposheets of 1:50,000 scale. In the base map the sampling sites were marked and from each river the surface river water samples were collected during pre-monsoon and post-monsoon periods. The water samples of Ponnaiyar and Gadilam were collected nearer to urban area to know the level of sewage pollution and the water sample of Uppanar river were collected very near to industrial area to understand the industrial heavy metal pollution.

By adopting standard procedures (APHA, 1996), 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 analysis results were run into HYCH programme to classify the water type (Balasubramaian et al, 1986). The river water samples also tested for microbiological

and heavy metal study. The MS Excel software also used to show the concentration of heavy metals in the form of graph.

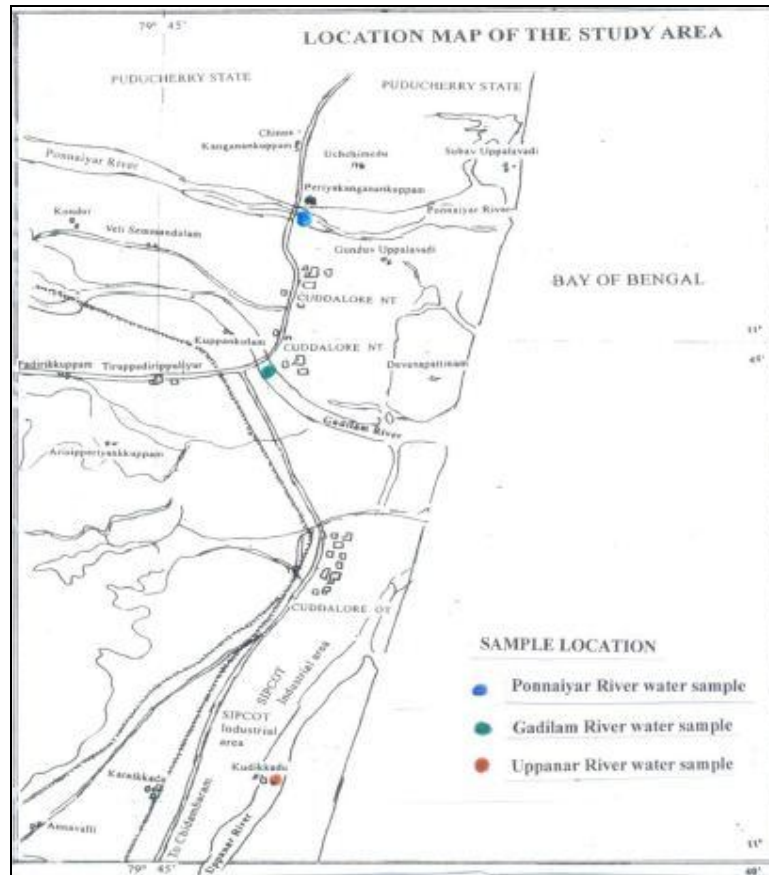


Figure 2

4. Result And Discussion

The chemical analysis results and output of HYCH programme of river water samples of Ponnaiyar, Gadilam and Uppanar during pre-monsoon and post-monsoon periods were shown in the tables 1, 2, 3 and 4. The result of micro-biological analysis of the river water samples were represented in the table no. 5. The presence of heavy metals in the Uppanar river water were listed in the table no. 6.

No.	Sample Location	pH	EC	Ca	Mg	Na + K	HCO ₃ + CO ₃	Cl	SO ₄	TDS	Na%	Cl/HCO ₃ + CO ₃
1	Ponnaiyar River water	7.5	40,827	44	209	8,941	165	12,780	45	38,078	95.2	77.6
2	Gadilam River water	7.7	32,535	55	164	7,107	317	10,082	1707	30,337	95	31.8
3	Uppanar River water	8	56,708	89	287	12,395	207	17,750	3006	52,770	95.1	85.7

Table 1: Chemical analysis result & HYCH data of the River water samples (Pre-monsoon) EC value unit : μ mhos/cm @ 25°C; All other values expressed in mg/L

No.	Sample Location	SAR	RSC	NCH	CR (Corrosivity Ratio)	Gibb's Plot (Mechanism)	SWT (Schoeller's Type)	SWC (Stuyfzand Classification)	USSL
1	Ponnaiyar River water	124.8	-16.7	834.7	122.9	Evaporation	IV	Salt	CSS4
2	Gadilam River water	108.4	-10.8	542.1	50.4	Evaporation	IV	Salt	CSS4
3	Uppanar River water	143.8	-24.2	1212.9	135.9	Evaporation	IV	Salt	CSS4

Table 2: Chemical analysis result & HYCH data of the River water samples (Pre-monsoon)

No.	Sample Location	pH	EC	Ca	Mg	Na+ K	HCO ₃ + CO ₃	Cl	SO ₄	TDS	Na%	Cl/HCO ₃ + CO ₃
1	Ponnaiyar River water	8	97,050	50	48	22,172	158	30,487	5,163	58,079	99.3	192.7
2	Gadilam River water	8.7	36,942	58	78	8,282	536	11,347	1,921	22,223	97.5	21.1
3	Uppanar River water	8	1,05,840	100	51	24,131	170	33,252	5,629	63,334	99.1	195.1

Table :3 Chemical analysis result & HYCH data of the River water samples (Post-monsoon) EC value unit : μ mhos/cm @ 25°C; All other values expressed in mg/L

No.	Sample Location	SAR	RSC	NCH	CR (Corrosivity Ratio)	Gibb's Plot (Mechanism)	SWT (Schoeller's Type)	SWC (Stuyfzand Classification)	USSL
1	Ponnaiyar River water	534.9	-3.5	174.7	305.4	Evaporation	IV	Hyperhaline	CSS4
2	Gadilam River water	167	1.1	-5.3	33.5	..	IV	Salt	CSS4
3	Uppanar River water	489.3	-5.9	299.8	309.2	..	III	Hyperhaline	CSS4

Table 4 Chemical analysis result & HYCH data of the River water samples (Post-monsoon)

No.	Sample Location	COD (Chemical Oxygen Demand) Mg/L	BOD (Biological Oxygen Demand) Mg/L for 5 days @ 20°C	E.Coli MPN /100ml
1	Ponnaiyar River water	240	105	26
2	Gadilam River water	224	44	21
3	Uppanar River water	192	5.1	4

Table 5: Micro-biological Examination of River Water samples

Element present	Concentration level mg/L
Chromium (Cr)	BDL
Copper (Cu)	BDL
Nickel (Ni)	BDL
Zinc (Zn)	.07
Arsenic (As)	BDL
Cadmium (Cd)	BDL
Lead (Pb)	.32
Mercury (Hg)	BDL

Table 6: Heavy Metal Concentration in Uppanar River (Kudikkadu) water samples
BDL-Below Detectable Limit

4.1 Quality of Ponnaiyar river water

The chemical analysis results of the Ponnaiyar river water sample show that the maximum pH value is 8 and minimum is 7.5 during post-monsoon and pre-monsoon periods respectively. The pH limits set for irrigation is 5.5 to 9.0 and for domestic use 7.0 to 9.0 (ICMR, 1975). The potable limit of pH range is 7.0 to 8.5, which is a safe range for drinking purpose (WHO, 1993).

The maximum EC value is 97,050 during post-monsoon and minimum value is 40,827 μ mhos/cm @ 25°C during pre-monsoon period. Conductivity is an important criterion in determining the suitability of water for irrigation (Shrivastava and Patil, 2002). The average TDS value between pre-monsoon and post-monsoon period is 48,078 mg/l. The average Na% is more than 60% and the average SAR (Sodium Adsorption Ratio) exceeds 100, indicate the water is unfit for irrigation.

Stuyfzand (1989) has proposed a method of classification of ground water and identified 8 main types on the basis of Cl. It is used for identification fresh water flow zone from the zone of salt-water intrusion. The Ponnaiyar river water samples belong to salt - hyperhaline type of Stuyfzand water classification and lies in the category of C5S4 USSL classification - indicate high salinity and high sodium water. According to Rengarajan et.al, 1990 the ground water with corrosivity ratio more than 1 are considered to be corrosive water and it cannot be transported through the metal pipes.

In both the seasons the corrosivity ratio is very high (> 100), indicate the water is corrosive in nature. In pre-monsoon and post-monsoon periods the Cl/HCO₃+CO₃ is exceeds more than 20, indicate the mixing of sea water with the river water. The presence of chloride in large amounts may be due to natural processes such as the passage of water through natural salt formations in the earth or it may be an indication of pollution from sea water or industrial or domestic waste discharge water (Renn C.E., 1970). In both the seasons the Na+K ion concentration is higher than Mg and Ca ion.

As the Ponnaiyar river is flowing very near to Cuddalore town the micro-biological examination of river water were also carried out to understand the level of the pollution. BOD to COD ratio indicates the proportion of the biodegradable organic matter in the waste water. The less the value, the less is the biodegradability. For normal domestic waste water, the ratio of BOD to COD may range from 0.5 to 0.9 (Gohil M.B, 2000). The Ponnaiyar river water shows the BOD to COD ratio is about 0.44.

4.2

Quality of Gadilam river water

The pH range of Gadilam river water is between 7.7 – 8.7 and the EC value is between 32,535 to 36,942 μ mhos/cm @ 25°C. The average TDS value is about 26,280 mg/l. The average Na% is more than 60% and the average SAR (Sodium Adsorption Ratio) exceeds 100, indicate the water is unfit for irrigation.

The Gadilam river water belong to salt type of Stuyfzand classification and lies in the category of C5S4 USSL classification - indicate high salinity and high sodium water. In both the seasons the Corrosivity Ratio is very high (more than 30), indicate the water is corrosive in nature. Both in pre-monsoon and postmonsoon periods the Cl/HCO₃+CO₃ exceeds more than 20, indicate the mixing of sea water with the river water. In both the seasons the Na+K ion concentration is higher than Mg and Ca ion.

The river Gadilam is flowing in the heart of the Cuddalore town, hence, the microbiological examination of river water is also carried out to understand the level of the sewage pollution. BOD to COD ratio of Gadilam river water is about 0.19

4.3

Quality of Uppanar river water

The pH value of Uppanar river water during pre-monsoon and post-monsoon is 8, average EC value is 81,274 μ mhos/cm @ 25°C and the average value of TDS is 58,052 mg/l. The values of Na% and SAR were above the permissible limits indicate the water is unfit for irrigation.

The Uppanar river water samples belong to salt – hyperhaline type of Stuyfzand water classification and lies in the category of C5S4 USSL classification -indicate high salinity and high sodium water. In both the seasons the Corrosivity Ratio is very high (more than 100), indicate the water is corrosive in nature. In pre-monsoon and post-monsoon periods the Cl/HCO₃+CO₃ exceeds more than 20, indicate the mixing of sea water with the river water. In both the seasons the Na+K ion concentration is higher than Mg and Ca ion.

As the river Uppanar is flowing very near to SIPCOT industrial area the heavy metal studies of river water also carried out to understand the effect of industrial activities on the river system. The analysis results shows that the heavy metals like Lead (Pb) and Zinc (Zn) were present in the water sample. The concentration of Pb is 0.32 mg/L and the concentration of Zn is 0.07 mg/L (Fig No. 3).

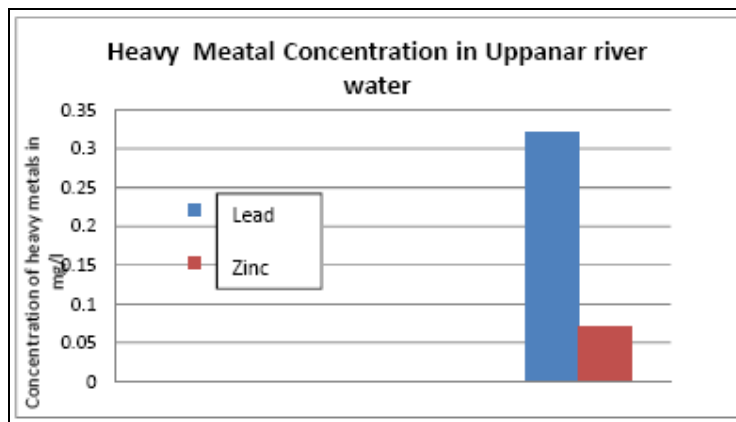


Figure 3

5. Conclusion And Recommendation

The coastal regions are facing the problems like discharge of municipal waste, industrial effluents, waste generated from recreation and tourism activities, etc. Apart from the anthropogenic activities the coastal zones also facing natural hazards like coastal flood, cyclone, coastal erosion, storm surge and sea water intrusion. In this scenario, a study has been carried out to know the status of the Ponnaiyar, Gadilam and Uppanar river water quality near the coast of Cuddalore, Cuddalore district, Tamilnadu – India.

The study area, part of north east coastal plain of Tamilnadu is considered as an emerging one and which is confined between the North latitude of $11^{\circ} 40'$ to $11^{\circ} 48'$; East longitude of $79^{\circ} 40'$ to $79^{\circ} 48'$ and lies in the Survey of India toposheet nos. 58M/9, 58M/13, 58M/10 and 58M/14. The Ponnaiyar, Gadilam and Uppanar are the major rivers flowing in this region and they finally confluences with the Bay of Bengal.

With the help of Survey of India toposheets of 1:50,000 scale the base map has been prepared. The water samples of Ponnaiyar, Gadilam and Uppanar rivers were collected during pre-monsoon and postmonsoon periods and by adopting standard procedures (APHA, 1998) the collected samples were chemically analyzed. The analysis results were run into HYCH programe to classify the water type (Balasubramaian et al, 1986). The river water samples also tested for microbiological and heavy metal study. The MS Excel software were also used to show the concentration of heavy metals in the form of graph.

The maximum pH of Ponnaiyar river water is 8; maximum EC value is $97,050 \mu$ mhos/cm @ 25°C and the maximum TDS value is 58,079 mg/L. Higher values of Na% and SAR (Sodium Adsorption Ratio) indicates the water is unfit for irrigation. The water

is high salinity and high sodium in nature and belongs to C5S4 type of USSL classification. The water shows high Corrosivity Ratio and the higher values of $Cl/HCO_3 + CO_3$ indicates the mixing of sea water with the river water. The BOD to COD ratio is about 0.44

The maximum pH of Gadilam river water is 8.7; maximum EC value is 36,942 μ mhos/cm @ 25°C and the maximum TDS value is 30,337 mg/L. The Na% and SAR (Sodium Adsorption Ratio) values of the river water sample indicates the water is unfit for irrigation. As per Stuyfzand classification the water is salt type and it belongs to C5S4 type of USSL classification. The water is corrosive in nature and sea water is mixing with the river water. The BOD to COD ratio is about 0.19

The pH of Uppanar river water is 8; maximum EC value is 1,05,840 μ mhos/cm @ 25°C and the maximum TDS value is 63,334 mg/L. The Na% and SAR (Sodium Adsorption Ratio) values of the river water sample indicates the water is unfit for irrigation. The water is salt – hyperhaline type of Stuyfzand classification and lies in the category of C5S4 type of USSL classification. The water is corrosive in nature and sea water is mixing with the river water. The heavy metal analysis of river water sample indicates the presence of Lead (Pb) and Zinc (Zn).

μ mhos/cm @ 25°C and the maximum TDS value is 63,334 mg/L. The Na% and SAR (Sodium Adsorption Ratio) values of the river water sample indicates the water is unfit for irrigation. The water is salt – hyperhaline type of Stuyfzand classification and lies in the category of C5S4 type of USSL classification. The water is corrosive in nature and sea water is mixing with the river water. The heavy metal analysis of river water sample indicates the presence of Lead (Pb) and Zinc (Zn).

It is concluded that all the three water samples collected from Ponnayar, Gadilam and Uppanar rivers were unfit for irrigation, domestic and industrial purposes. As per microbiological examination the Ponnayar river water is highly contaminated than the Gadilam river. Due to nearby SIPCOT industrial activities the Uppanar river is facing heavy metal contamination problem. The strategies like construction of check dams, embankment across rivers, avoiding sand quarrying from river beds, prohibiting the entering of sewage and effluent into streams and monitoring of river water quality are essential to overcome the above problems. Creating awareness to public through various mass-media and implementing strict environmental laws are also to be needed to safe guard the coastal environment of this region.

6.Reference

1. APHA (1996), Standard methods for the Examination of water and wastewater
2. Arul P.(2000), A text book of Ground water, Virudhachalam (Tamilnadu), Dhanam Publications
3. Balasubramanian.A. (1986), Hydrological Investigation of Tambraparani River Basin, Tamil Nadu, Unpublished Ph.D. Thesis, University of Mysore, 349p,
4. Gohil M.B (2000), Land Treatment of Waste water, New Delhi, New Age International (P) Limited
5. Goldberg V.M (1973), The movement of Fresh and Salt water towards a water intake in the Coastal areas, Intern. Symp. Development of Ground water Resources, pp. 11 – 22
6. ICMR (1975), Manual of Standards of quality for drinking water supplies, Indian Council of Medical Research, Spl. Rep.Ser.No. 44
7. Kumaraswamy K, Unnikrishnan K and Kamaraj M (1995), Hydrogeochemical Evaluation of Sea water intrusion in the Vaippar Estuary-Tamilnadu, Journal of Applied Hydrology, Vol.VIII, No.1-4, 93-97
8. Rengarajan R and Balasubramanian A (1990), Corrosion and Scale formation Characteristics of ground water in and around Nangavalli, Salem district-Tamilnadu, Journal of Applied Hydrology, Vol.3, no. 2, 15 – 22
9. Renn C.E. (1970), Investigating water problems. Education products division, Maryland, Lamotta Chemical products company
10. Shrivastava V.S., and Patil P.R. (2002), Tapi river water pollution by industrial wastes, A statistical approach, Nature. Env.Poll.Tech. 1(3), 279-283
11. Singarasubramanian S.R, Mukesh M.V, Sujatha K and Manoharan K.(2009), 26th December, 2004 Indian Ocean M9 Tsunami – A general Perspective, National Seminar on Recent Trends in Water Research, 11-18
12. Stuyfzand P.J. (1989), A new hydrochemical classification of water types with examples of applications, IAHS, 184, 89 – 98
13. Todd D.K.(1995), Ground water Hydrology, New York, John Wiley & Sons
14. WHO (1993), Guidelines for drinking water quality, Geneva, Volume 1, 1-4

15. WRO -Water Resource Organisation (2000), PWD, Ground water perspective – A profile of Cuddalore District, TN, 13–17