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Impact of Groundwater Contamination in Cuddalore by Flood

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Abstract: *Groundwater Quality and Contamination study was carried out in Cuddalore Urban, Tamil Nadu. The objective of this study is to identify the quality and contamination of groundwater. Five groundwater samples were collected from different Bore wells in the study area and were analyzed for major ions. This analysis result was compared with the World Health Organization (WHO) standards of drinking water quality parameters with the following water quality parameters namely pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Total Alkalinity (TA), Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride (Cl), Sulphate (SO^4), Fluoride (F). The usefulness of these parameters in predicting ground water quality characteristics were discussed. The groundwater quality depends upon geological, meteorological and topographical conditions. This study reveals that the domestic activities, geological formation and local environmental conditions control the groundwater quality. Groundwater suitability for domestic and other purposes was examined using WHO, Indian standards which indicate that groundwater in a few locations.*

Keywords: *Infiltration, Groundwater, Contamination, Cuddalore, Flood*

1. INTRODUCTION

Groundwater is one of the most valuable natural resources, which supports human health, socio-economic development, and functioning of ecosystems (Eg. Zektser 2000; Humphreys 2009; Steube et al. 2009). Of the 37 Mkm^3 of freshwater estimated to be present on the earth, about 22% exists as groundwater, which constitutes about 97% of all liquid freshwater potentially available for human use (Foster 1998). However, the worldwide groundwater overdraft, declining well yields, drying up of springs, stream flow depletion and land subsidence due to overexploitation of groundwater as well as the growing degradation of groundwater quality by natural and or anthropogenic pollutants is threatening our ecosystems and even the lives of our future generations. Groundwater is a precious and the most widely distributed resource of the earth and unlike any other mineral resource, it gets its annual replenishment from the meteoritic precipitation. Groundwater is the largest source of fresh water on the planet excluding the polar icecaps and glaciers. The amount of groundwater within 800m from the ground surface is over 30 times the amount in all fresh water lakes and reservoirs, and about 3,000 times the amount in stream channels at any one time.

1.1 Need for the Study

Groundwater is a major source of public water supply because it is assumed to be free from surface pollutants compared to surface water. Groundwater is an important source of drinking water for many people around the world, especially in rural areas. Groundwater can become contaminated from natural sources or numerous types of human activities. Residential, municipal, commercial, industrial, and agricultural activities can all affect groundwater quality. Contamination of groundwater can result in poor drinking water quality, loss of water supply, high cleanup costs, high costs for alternative water supplies, and or potential health problems. The quality of ground water depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region. Ground water occurs in weathered portion, along the joints and fractures of the rocks. In fact, industrial waste and the municipal solid waste have emerged as one of the leading cause of pollution of surface and ground water. In many parts of the country available water is rendered non-potable because of the presence of heavy metal in excess. The situation gets worsened during the summer season due to water scarcity and rain water discharge. Contamination of water resources available for household and drinking purposes with heavy elements, metal ions and harmful microorganisms is one of the serious major health problems. As a result huge amount of money is spent for chemical treatment of contaminated water to make it potable. Thus there is a need to look for some useful indicators for both chemical and physical, which can be used to monitor both drinking water operation and performance.

The quality of groundwater depends on a large number of individual hydrological, physical, chemical and biological factors. Generally higher proportions of dissolved constituents are found in groundwater than in surface water because of greater interaction of ground water with various materials in geologic strata. The water used for drinking purpose should be free from any toxic elements, living and nonliving organism and excessive amount of minerals that may be hazardous to health. Some of the heavy metals are extremely essential to humans, for example: Cobalt, Copper, etc., but large quantities of them may cause physiological disorders.

The contamination of groundwater by heavy metals has assumed great significance during recent years due to their toxicity and accumulative behavior. These elements, contrary to most pollutants are not biodegradable and undergo a global eco-biological cycle in which natural waters are the main pathways. The determination of the concentration levels of heavy metals in these waters, as well as the elucidation of the chemical forms in which they appear is a prime target in environmental research today. A vast majority of groundwater quality problems are caused by contamination, over-exploitation, or combination of the two. Most groundwater quality problems are difficult to detect & hard to resolve. The solutions are usually very expensive, time consuming and not always effective.

1.2 Study Area

The study area, viz., Cuddalore district in the part of Tamil Nadu State lies on the East Coast of Southern India. Cuddalore district Bounded on the north, south and west by Villupuram, Nagapattinam and Perambalur districts and on the east by Bay of Bengal. River Vellar and River Coloroon flows in the southern boundary of this region. The district lies between 78° 42'and 80° 12' east latitude and 12° 27' 30" and 11° 10' 45" north longitude. The principal river of the region is the Pennar or the Ponnaiyar. The river flows across the boundary between Cuddalore and Villupuram taluks and empties itself into the Bay of Bengal. Keeping in view of the industrial and urbanization expansion of the region as well as the groundwater potential, the region is chosen as the study area.

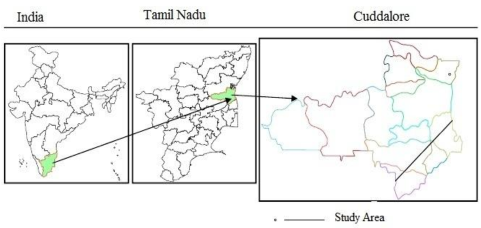

Fig 1: *Study Area*

1.3 OBJECTIVES OF THE STUDY

- To assess the preliminary investigation and interpretation of the ground water quality at Cuddalore.
- Find out the suitability of ground water for domestic, agricultural and other purpose.
- Assessing the impacts on agricultural, domestic purpose and people for this ground water contamination.

2. LITERATURE REVIEW

Abdul qadir et al,. have explained about the information regarding the spatial distribution of important physical-chemical parameters and heavy metals which affect water chemistry. The spatial distribution maps will also be produced using GIS for important physiochemical variables to understand groundwater quality and ecological status of the groundwater systems. The identification of the possible sources of groundwater contamination and will offer a valuable tool for reliable management of groundwater.

Allan et al,. have studied the groundwater quality is defined based on a set of health and safety regulations for domestic use. Similarly, the quality of groundwater is analyzed and evaluated for other uses. Groundwater used for public domestic supply must adhere to a more rigorous set of regulatory objectives for health and safety than groundwater used strictly for irrigation needs. The quality of public water systems must fall below the maximum contaminant levels (MCL's) for a standard set of constituents. No adverse human health effects are known to exist at the recommended MCL's. Presently, MCL's have been determined and recommended for: inorganic chemicals such as arsenic, mercury, and nitrate; for optimal fluoride levels; natural and manmade radioactive substances; man-made, volatile organic carbon compounds typically associated with industrial activities; non-volatile, synthetic organic chemicals associated with past or present agricultural and urban pesticide use; and for other parameters such as color, odor, corrosion, turbidity, bacteria and salinity.

Wen-Qing Lu has briefed the Industrial effluent and domestic sewage were the two principal causes of water pollution in China. The Ministry of Water Resources disclosed that the total quantity of wastewater discharge across the country in 2006 amounted to 73.1 billion tons, of which 2/3 was from industrial sectors and 1/3 was from tertiary industry as well as urban domestic sewage .The major pollutants in industrial wastewater and domestic sewage include heavy metals (Hg, Cd, Cr, Pb, Zn, etc), non-heavy metals (As, CN, F, S, Se, etc), organs (alkanes, substituted benzenes, PAHs, phthalate acid esters, etc), inorganic compound (P) and microorganisms (enteric pathogenic bacterium, virus, parasites, etc).

3. METHODOLOGY

3.1. Sample Collection

For the present study, Cuddalore district was selected. The selected areas were categorized into five zones. There are:

zone 1 (Thevanaampattinam);

zone 2 (Vannaarapalayam);

zone 3 (Cuddalore NT [New Town]);

zone 4 (Selankuppam);

zone 5 (Cuddalore OT [Old Town]).

Overall, 5 samples were collected for monitoring the physico-chemical analysis of the ground water.

3.2 Physico-Chemical Analysis

The collected samples were analyzed for major physical and chemical water quality parameters like:

1) pH
2) Electrical Conductivity (EC)
3) Total Dissolved Solids (TDS)
4) Total Hardness (TH)
5) Total Alkalinity (TA)
6) Calcium (Ca)
7) Magnesium (Mg)
8) Sodium (Na)
9) Potassium (K)
10) Chloride (Cl)
11) Sulphate (SO^4)
12) Fluoride (F)

As per the methods described in "Standard methods for the examination of water and wastewater", American Public Health Association (APHA).The parameters present in the water samples can be calculated by using various methods. The pH of the samples was determined using a pH electrode. Electrical conductivity was measured using conductivity meter and Sulphate by turbidimetric method. The Chloride, total hardness and total alkalinity were estimated by the standard methods of water and waste water. Calcium and Magnesium are calculated by titration method. Sodium and Potassium are analyzed by flame photometry. The groundwater locations were selected to cover the entire study area, and attention was been given to the area where contamination is expected. The expected groundwater contaminants were Chloride, TDS, etc. The results were evaluated in accordance with the drinking water quality standards given by the World Health Organization (WHO) 1993.

Table 1: *WHO standard values for physico chemical parameters of water*

S. No.	Parameters	ISI Standard
	Physical Parameters	
1	Electrical Conductivity	-
2	TDS	1500-3000 (ICMR)
	Chemical Parameters	
1	pH	6.5 to 8.5*
2	Total Alkalinity	600
3	Total Hardness	600
4	Calcium	200
5	Magnesium	100
6	Sodium	-
7	Potassium	-
8	Chloride	1000
9	Fluoride	1.5
10	Sulphate	400

* Except pH the values for all the Chemical parameters are given in mg/L, Electrical Conductivity Unit is MicroMho/cm, TDS (Total Dissolved Solids) unit is mg/L.

3.3 Groundwater Quality Assessment

⇒ Geochemical analysis shows that the seasonal effect does change the concentration of various ions present in the groundwater.

⇒ This Assessment was carried out to identify the sources responsible for the change in quality of groundwater as well as to evaluate the suitability of water to various applications.

3.4 Groundwater Contamination

⇒ Groundwater contamination due to the lack of concrete collapse and drainage system failure by Flood. Imperative to regularly monitor the quality of groundwater and to protect it.

⇒ Pollution control measures and strict Law enforcement have been recommended to avoid Groundwater contamination.

Pollutants Removal Some Mechanisms:

Sedimentation, Volatilization, Photolysis, Bio-Degradation, Bio-Transformation, Bio-Accumulation, Filtration.

3.5 Saline Water Intrusion

- Cuddalore coastal areas, fresh water zones are bordered by saline zones.
- Seawater intrusion develop a direct artificial access between ground water and seawater.

4. RESULTS AND DISCUSSIONS

The values of various parameters were furnished in the Table 2 and 3. The results indicate that the quality of water considerably varies from location to location.

pH

The pH doesn't vary much in the study area. The underground water is characterized by a relatively constant pH of around 7.2 to 7.7 for the samples collected area. The allowable limit set by WHO is 7.0 to 8.5.

Electrical conductivity (EC)

Electrical conductivity of groundwater in study area is given in Table 1 and is found that all the samples (1280-2374 MicroMho/cm) above permissible limit. They are marginally poor in quality according to the WHO standard. The hazardous quality is due to the chemicals used for the various processing in the study area. The occurrence of high EC values in the study area might also be due to addition of some salts through the prevailing agricultural activities.

Total Dissolved Solids (TDS)

The study shows that all the samples are high TDS which can be used for any purpose, it is risk. Higher content of TDS can be attributed to the contribution of salts from the thick mantle of soil and the weathered media of the rock and further due to higher residence time of groundwater in contact with the aquifer body. TDS value range from 896 to 1662 mg/l in this study area. It's very high TDS compare with WHO standard.

Total Hardness (TH)

The classification of groundwater based on Total Hardness (TH) as Calcium Carbonate ($CaCO_3$) shows that a majority of the ground water samples fall in the very hard water category. The hardness values ranges from 242 to 354 mg/l. The maximum allowable limit of TH for drinking purpose is 500 mg/l and the most desirable limit is 100 mg/l as per the WHO international standard. Groundwater exceeding the limit of 300 mg/l is considered to be very hard (Sawyer et al. 2003).

Total Alkalinity (TA)

The TA values ranges from 240 mg/l to 360 mg/l. The maximum allowable limit of TA for drinking purpose is 500 mg/l and the most desirable limit is 100 mg/l as per the WHO international standard. Groundwater exceeding the limit of 300 mg/l is considered to be very hard (Sawyer et al. 2003).

Calcium (Ca)

In this study area calcium ranges from 60-89 mg/l. As per WHO (1993), the maximum allowable limit for Calcium is 75 mg/l. Calcium was exceeding this permissible limit in all the samples.

Magnesium (Mg)

Magnesium ranges in the samples was 22-32 mg/l. the maximum allowable limit for Magnesium is 30 mg/l. Magnesium was exceeding this permissible limit in all the samples.

Sodium (Na)

Sodium range in the study area is 140-340 mg/l. The ground water samples values are high and are not suitable for irrigation purpose.

Potassium (K)

As per WHO (1993), the maximum allowable limit for Potassium is 12 mg/l. From the analysis of water samples of the study area, is 16-32 mg/l. All the samples exceed this permissible limit.

Chloride (Cl)

Chloride concentrations ranging from 188-530 mg/l have been found in shallow groundwater, and its possible source in industries where Sodium Chloride is used as a raw material. The Chloride ion concentration in groundwater of the study area exceeds the BIS acceptable limit of 250 mg/l in some locations.

Sulphate (SO4)

The concentration of Sulphate is likely to react with human organs if the value exceeds the maximum allowable limit of 400 mg/l. Sulphate concentration in groundwater of the study area is 41-92 mg/l within the maximum allowable limit in all the sample locations.

Fluoride (F)

As per BIS acceptable limit for Fluoride is 1 mg/l.. From the analysis of water samples of the study area, is 0.2-0.3 mg/l. All the samples below of BIS Acceptable limit.

Physical Examination of Samples

Table 2: *Physical Examination of Samples*

Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
EC (Micromho/cm)	2374	1835	1970	1305	1280
TDS (mg/l)	1662	1285	1379	914	896

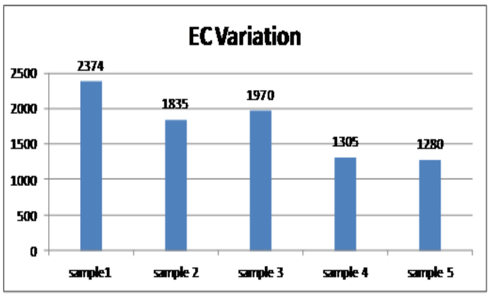

Figure 2: *Electrical Conductivity (EC) variation*

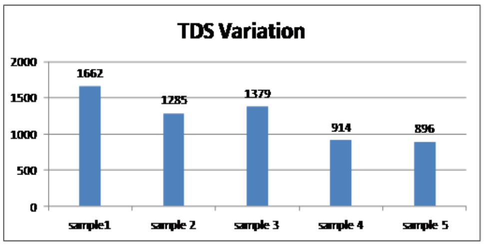

Figure 3: *Total Dissolved Solids (TDS) variation*

Chemical Examination of Samples

Table 3: *Chemical Examination of Samples*

Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
pH	7.2	7.6	7.4	7.2	7.7
TH (mg/l)	354	275	303	242	283
TA (mg/l)	304	240	360	292	320
Ca (mg/l)	89	68	74	60	69
Mg (mg/l)	32	25	28	22	26
Na (mg/l)	340	260	280	164	140
K (mg/l)	32	24	28	16	16
Cl (mg/l)	530	392	382	212	188
SO_4 (mg/l)	89	92	79	41	43
F (mg/l)	0.3	0.2	0.2	0.3	0.2

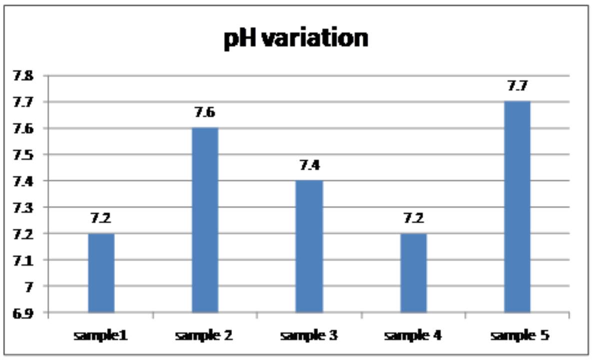

Figure 4: *pH variation*

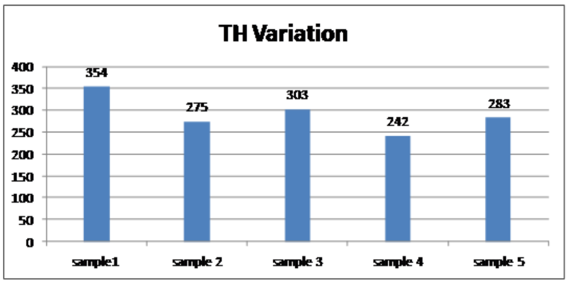

Figure 5: *Total Hardness (TH) variation*

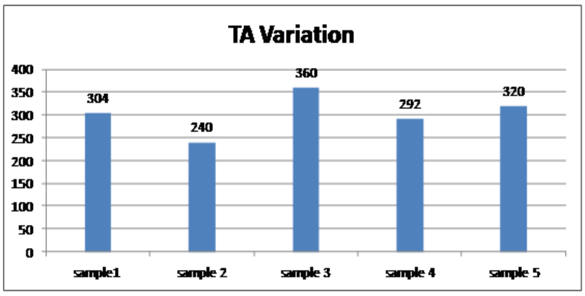

Figure 6: *Total Alkalinity (TA) variation*

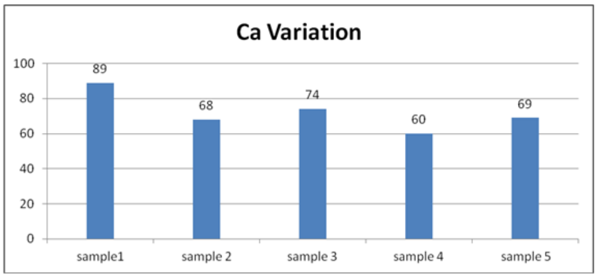

Figure 7: *Calcium (Ca) variation*

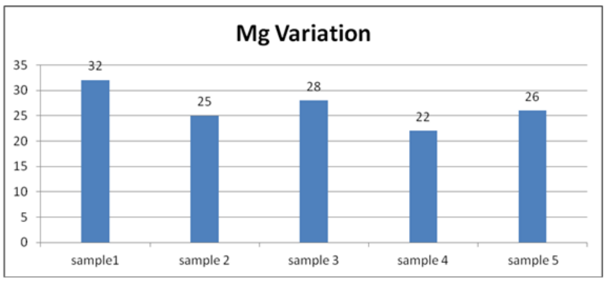

Figure 8: *Magnesium (Mg) variation*

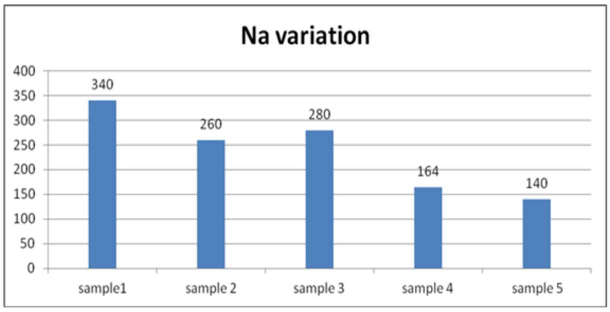

Figure 9: *Sodium (Na) variation*

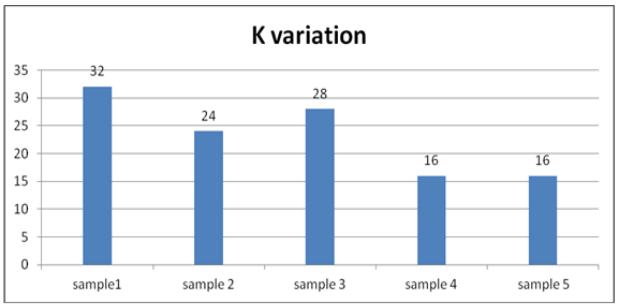

Figure 10: *Potassium (K) variation*

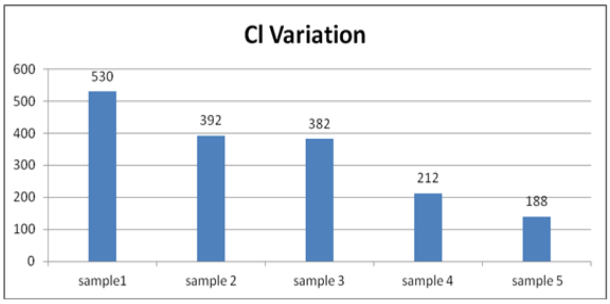

Figure 11: *Chloride (Cl) variation*

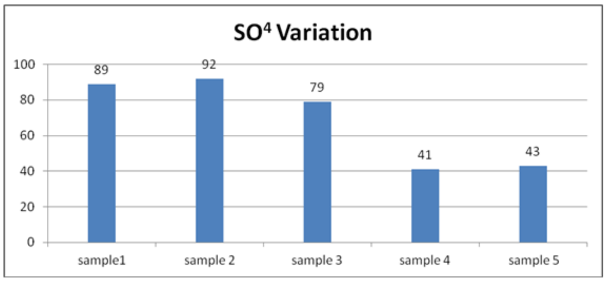

Figure 12: *Sulphate (SO^4) variation*

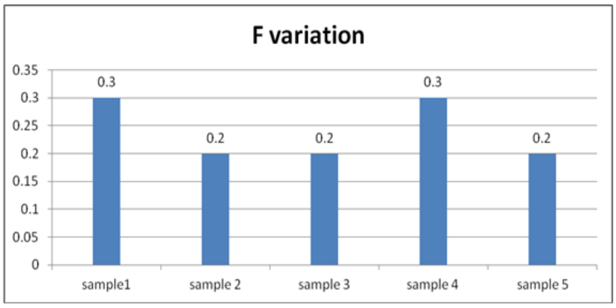

Figure 13: *Fluoride (F) variation*

5. CONCLUSIONS

The Ground water which were taken from the various places in Cuddalore area were analyzed and the analysis reports that the water quality parameters like pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Total Alkalinity (TA), Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride (Cl), Sulphate (SO^4) and Fluoride (F).

Except few parameters, others are maximum not permissible limit prescribed by WHO. These values have more impact for the water to use for domestic purpose. According to this report, the ground water in Cuddalore in some zone is not suitable for domestic purposes, agricultural utilization and industrial purposes and also generally it is harmful to human beings. So, Water treatment techniques must apply for before use the water.

The present study has been carried out in order to identify the effect of the flood as especially agriculture damages, settlement damages, transport damages, communication damages and biological damages due to flood affected places.

Dynamic use of GIS integrated with hydrodynamic model provides useful measures towards disaster preparedness and planning. It can help to promote public awareness in disaster management activities as a part of focusing dissemination of forecast at grass-root level.

New flood control or management schemes based on dynamic model can be implemented for important disaster management aspects like prevention, mitigation, preparedness, response and recovery and also planning for operational activities as before, during and after flood immediately.

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