ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Assessment of groundwater contamination due to improper sanitation using visual mod flow

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ABSTRACT

Increase in population and improper infrastructure facilities for sanitation leads to ground water contamination due to sullage and sewage infiltration. Alandur which is located in the Southern part of Chennai was taken for the study. This study aims to find out the prevailing groundwater contamination issues due to improper disposal of domestic waste. For this study, groundwater samples were analyzed for its chemical and biological parameters. The visual Modflow was used to find out the flow direction and contaminant transport model, the flow direction was observed from north to south towards Adambakkam Lake and some flow towards east. Nitrate was taken as the pollutant parameter. The nitrate pollution was more in unserved area of Alandur. Then the social survey was conducted to study the people opinion about the water quality deterioration. Awareness was created among the people through Self Help Group (SHG) and Non-Government Organization (NGO) to prevent the groundwater contamination. Through this study the people acquired knowledge about the proper disposal of waste water and how to use the recycled water for domestic purposes like gardening and sanitation etc.

KEY WORDS: Contamination, improper, SHG.

1. INTRODUCTION

Groundwater is the most reliable source of supply for potable water and supports a wide array of economic and environmental services. Estimates of global groundwater abstraction between 1950 and 2000 increased to 1000 km^3 of water in 2000 with more than 2 billion people depending on groundwater for their daily supply. Not only have population increases and economic growth laid claim to an ever larger share of groundwater, but the quality of the resource is also increasingly under strain. The occurrence of ground water contamination and the quality of ground water have become major issues since the discovery of numerous hazardous waste sites in the late seventies.

Groundwater hydrology is of great importance because of the use of aquifer systems for water supply and because of the threat of contamination from leaking hazardous waste sites, which occur at or below the ground surface. Recently, more attention has been given to the connection between the unsaturated zone and shallow aquifers just below the water table as it relates to migration of contaminants from the surface or from buried tanks, pipes or waste ponds. Properties of the porous media and subsurface geology govern both the rate and direction of ground water flow in any aquifer system. The injection or accidental spill of hazardous wastes into an aquifer or the pumping of the aquifer for water supply may alter the natural hydrologic flow patterns.

Over the last two decades, the use of groundwater flow models is common in the field of hydrogeology and the environmental related aspects. Groundwater flow and transport models have been applied to investigate a wide variety of hydrologic conditions (Mandle, 2002). These models are used to estimate the rate and direction of movement of groundwater and pollutants through aquifer, and tracing the impacts of pollutants (artificial and natural) within the different zones downwards using empirical equations and formulae. Groundwater flow models are used to calculate the rate and direction of movement of groundwater through aquifers and confining units in the subsurface. These calculations are referred to as simulations (Mandle, 2002)

One of the thrust areas of this project is to estimate the extent of contamination by studying the rate of movement of contaminants present in groundwater in the Alandur area. Community participation in water and sanitation projects is a necessary strategy in sustainable development. The main advantage of following such an approach is that if participation can encourage a sense of ownership in managing the water quality of the area, the benefits are more likely to extend over the long term. The project at hand focuses on the challenges faced to solve an environmental and public health problem in the Alandur study area. The main objectives are,

a. To assess the groundwater contamination in unsewered area.
b. To estimate the groundwater contaminant movement using visual Modflow.
c. To evaluate the people participation in management of drainage network

2. MATERIALS AND METHODS

Alandur is a southern suburban of Chennai, a city situated on the east coast of the southern India, and a municipality in Kancheepuram district in the state of Tamil Nadu.Alandur has a mixed population with a notable number of Anglo-Indians.Alandur is located at 13.03°N 80.21°E. It is a mix of residential development, educational institutions and small scale industries. The index map of Alandur municipality Figure 1. The weathered data used for this study was taken from Indian Metrological Department(IMD)Meenambakkam.Chennai city enjoys a tropical climate with a mean annual temperature of 24.3˚C(minimum) to 32.9˚(maximum).The hottest month of

the year is April and May; temperature raises upto 41.2˚C.(Seasons and Crop report Tamil nadu, 2005, 2006).The rainfall taken for this study was average of 1980 to 2006.

Figure.1.Index Map of Alandur

The terrain is almost flat, gently sloping towards the east, Chennai city is underlain by various geological formations from the ancient Archaean's to recent alluvium. Based on the hydrological soil classification, soil group-B was found to be in study area. The characteristic of the soil group-B was moderately deep well drained with moderately fine to coarse texture. In this study, water quality analysis is carried out. The groundwater contamination migration has been studied by using groundwater flow model and contaminant transport model. Then social survey was conducted using participatory rural appraisal tools like focus group discussion and questionnaire survey. People's perceptions towards participation were gathered through this survey. The results from the survey and groundwater flow model can help to give suggestion to the people on ways to improve the groundwater condition within their locality. The detailed methodology are shown in Figure 2.

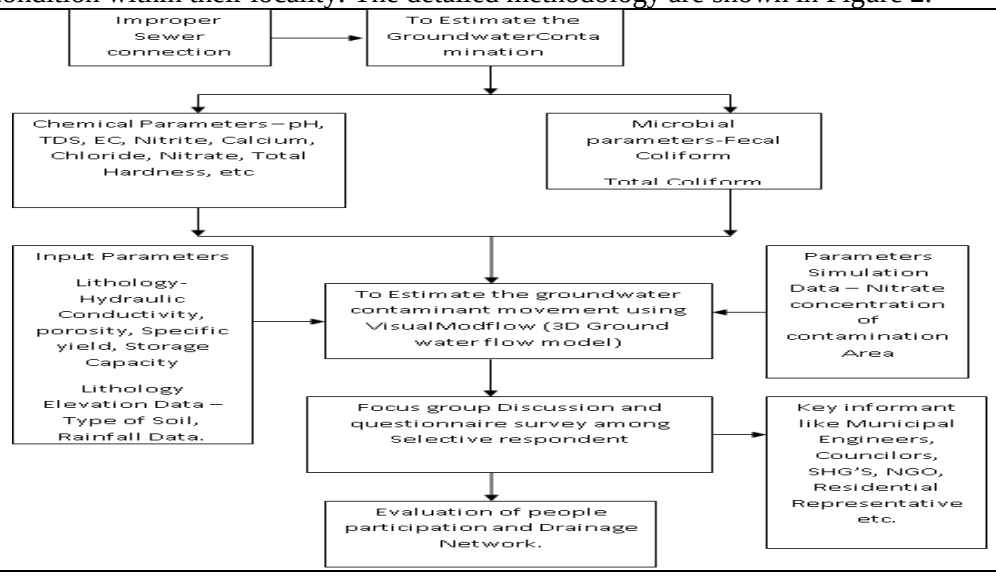

Figure.2.Methodology

The survey is conducted with the people and by the analysis, the problem in that area is mainly due to the disposal of domestic waste water directly to the ground without treating. The problem also caused due to the improper maintenance of sanitation in Alandur area. Because of this problem groundwater quality has been degraded. Based on the preliminary survey of the study area, appropriate sampling points are identified as shown in Figure 3 for the collection of groundwater samples. Ten groundwater samples were taken from the residential bore holes like unserved areas. The parameters such as PH, Nitrate, Total Dissolved solids, Chloride, Fecal coliform and E.Coli were analyzed.

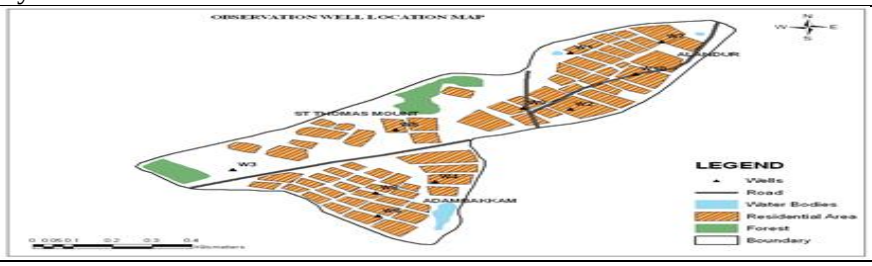

Figure.3.Location of sampling point

MT3D is a model for the simulation of pollutant transport. MT3D stands for "Mass Transport in 3 Dimensions". The model was developed by the US Environmental Protection Agency (EPA) as an extension of MODFLOW. Using simulation results of MODFLOW, MT3D will predict the fate of chemicals dissolved in the groundwater in function of advection, dispersion, absorption and decay. Hence, the model uses output files from MODFLOW as input for obtaining the groundwater flows.Boundary conditions for transport can be added together

with dispersive and absorptive properties of the ground layers, as well as chemical reaction characteristics. The following transport equation is subsequently solved:

$$\frac{\partial(nD+\rho A)}{\partial t} = \nabla(nD\nabla C) - \nabla(qC) - \lambda nC - \lambda_A \rho A$$

Where, C = Solute concentration [M/L^3], A = Absorbed amount [M/M], ρ = Dry density of the soil material [M/L^3], λ_c and λ_A = First order decay rates of the chemical in dissolved and absorbed form [T^{-1}].

3. RESULTS AND DISCUSSION

The main social goal of this project is to gather people's opinion about the water quality deterioration in study area of Alandur. Questionnaire survey was conducted among 48 respondents. The inference made on analysis of the data collected shows the following. The household people depend upon the following drinking water sources, 75% of the households depends on the public water supply mostly through pipe connections and 15% of the people depend on the packaged drinking water. About 10% of the households depend on the own wells and bore wells. The amount of water which is supplied in that area may be sufficient due to the factors which include the quantity of the water delivered, the continuity of the drinking-water service, the seasonal availability of water, and the affordability of the services. About 55% of the people are not getting sufficient amount of water and thus they are forced to use the packaged drinking water. Poor people are mostly affected by this problem.

Table.1.Water Quality Analysis Results

		Samples									
Parameters	**Seasons**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
pH	**Before Monsoon**	6.9	7.8	6.7	7.2	7.4	8.25	7.7	6.7	7.2	7.38
	After Monsoon	7	7.1	7.8	7.5	7	8.08	7.72	7.7	7.83	7.7
Nitrate (Mg/ml)	**Before Monsoon**	30	28	10	19	21	28	34	25	34	32
	After Monsoon	47	45	40	26	29	141	84	46	62	56
FC (MPN)	**Before Monsoon**	8	40	36	68	16	44	12	16	65	42
	After Monsoon	20	110	120	40	120	360	60	110	160	150
TDS (mg/ml)	**Before Monsoon**	670	710	610	550	455	865	630	660	888	932
	After Monsoon	635	700	545	565	450	865	665	660	1501	985
Chloride (mg/L)	**Before Monsoon**	176	200	180	135	130	255	300	252	235	145
	After Monsoon	160	165	120	125	120	175	150	146	185	125

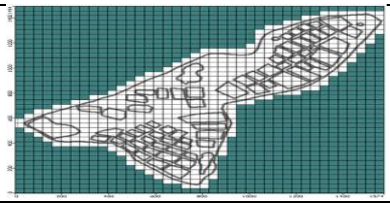

Figure.4.Model Area with Active and Inactive Cells

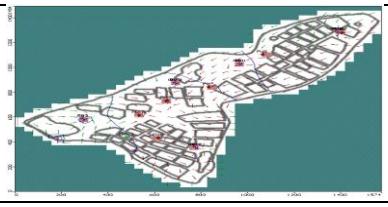

Figure.5.Groundwater Flow Direction in Layer

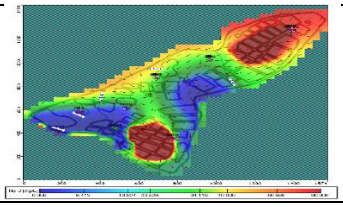

Figure.6.Concentration Contour in Layer2

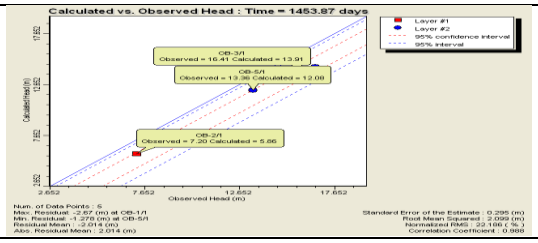

Figure.7.Model calibration Chart for head and Concentration

Figure 7 shows the minimized deviation between these values for the same year after the calibration process. The standard error was found to be 0.295 and 1.216 for flow and concentration. The expected Root Mean Square (RMS) value was found to be 2.099m for flow and 3.194 mg/L for concentration. In this case, an awareness program should be conducted to provide awareness to public on the importance of saving the ground water with proper drainage even though they are not directly dependent on ground water now. The long term benefit of both cost and health should be educated to the public.

The survey is done to identify the various drainage facilities available in the area. Proper drainage should be ensured in all houses in that area. This will help in taking measures to check the pollutant level across the project area. Even as the underground sewerage project of Alandur rolled on to provide sewerage connections to slum households, many poor households that could not afford to pay for these services were left out of this program. The

water quality analysis and model results helps to identify the problem of pollution of groundwater. Through this result awareness program was conducted by the support of self-help group and non-governmental organization. The weekly meetings are conducted in the Alandur area. Now the people got an idea about to how to save the groundwater resources.

4. CONCLUSION

The threats of groundwater pollution in Alandur is mainly due to improper drainage facility and the domestic waste are directly discharge into the ground, so this condition pollutes the groundwater resources.

The flow direction was simulated by using visual Mod flow. The flow direction was observed from north to south reach to Adambakkam Lake. Some portion of flow towards east. Nitrate was taken as pollutant parameter to study the groundwater contamination. The nitrate pollution is more in unserved areas of Alandur. Nitrate concentration in the groundwater in Alandur area range from 60ppm of NO_3 component.

During the survey and the analysis, unserved area groundwater quality has deteriorated and also the open drainage system is not properly maintained. The outcome of awareness program shows that the people were willing to discharge their effluents into the common treatment plant. And also people shows their willingness to work together with government to implement proper drainage and to construct water treatment plant in their area.

This condition requires social and institutional measures to prevent the groundwater contamination.

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