Groundwater and Soil Quality parameters Assessment in vicinity of Landfill for Alternate Site selection using Fuzzy-based Geo-informatics

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Abstract - *Solid waste management is a worldwide ecological issue at present. There is an expansion in commercial, residential and infrastructure improvement because of the populace development and this negatively affects the environment. One of these effects is because of area of dumping sites developed in unsuitable regions. The present study was focused on assessing the groundwater and soil quality parameters in and around the existing landfill by using GIS techniques. Groundwater quality and soil Quality contours were plotted with respect to distance from the landfill. Most of the results shows that distance from the landfill play a major role in the level of contamination in most area around the landfill. There is a gradual increase in deterioration of water and soil quality in almost every locations under study.*

Key Words*: *Solid waste, fuzzy, GIS, Water quality, Contours

1. INTRODUCTION

The landfilling is an attractive technique for the municipal solid waste management due to economic considerations (Gupta, 2003), so it is particularly in developing countries like India. The major problem of landfill site selection is complex and time-consuming process. Planning for solid waste management requires an assessment of much complex process, eg. Among transportation systems, land use patterns, public health considerations, etc., Because of these interactions and interdependencies; attention has focused on systems analysis and mathematical modelling techniques. A suitable site for a proper landfill territory for Perambalur area is controlled by utilizing geographic data framework (GIS) as an tool to help the decision making process. GIS has exceptionally distinguishing, powerful capacities and can assume a vital part in decision-making and planning process. In this study, the main aim is to assess the role of Landfill in deterioration of the physical, chemical, and bio-chemical parameters of groundwater around the study area, water and soil quality contours were generated for dominant parameters

GIS applications can help in deciding/figuring out the (place where garbage and trash is dumped) location (going along with/obeying) the technical needed things, with overlay the (related to underlying messages and morals in a story) map to get the right/the proper (place where garbage and trash is dumped). Sener et.al. (2006) utilized GIS for multicriteria decision analysis (MCDA) to help the (find out where waste and junk is dumped) site selection issue and built up a positioning of the conceivable (spot where garbage is dumped) territories in light of an assortment of judging prerequisites. Kao et.al. (1996) pointed out that large amount of (related to space or existing in space) data can be processed using GIS and so, it possibly saves time that would (usually/in a common and regular way) be spent in selecting the right/the proper site. Geographic Information Systems (GIS) technology is used to identify candidate places/locations for a solid waste dumping. In this research focused on various thematic layers are used to generate the vulnerability map for the area and the result was compiled to the buffer zones around sensitive areas.

1.1 Significance of the study

One of the significant issues in waste management is deals with the determination of proper site for waste disposal. Through (place where garbage and trash is dumped) is the least expensive, (related to surrounding conditions or the health of the Earth) safe and cost effective; it still faces the problem of selecting good locations, which (related to surrounding conditions or the health of the Earth), socially and (money-based)/cheaply doable/possible. Hence site selection becomes a tedious and difficult process. The site selection process depends upon various thematic factors. The most important concern is the environmental impact. Leakages of leachate from landfill pits contain toxic contaminants such as ammonias, nitrate, chlorite and metals which may reach ground water bodies. The developing environmental awareness and diminished measure of legislative and municipalities fiscals are the key concerns which need to be adhered to while taking decisive measures for landfill site selection (Kao & Lin, 1996). Some studies have revealed that under Indian conditions, a volume of 9 x 105 m3 is adequate to take care of 100 tons of refuse per day for 25 years (Indian standard 9533, 1980). Kao and Lin (1996) proposed a siting model that was researched for use with raster-based GIS. Siddiqui et al., (1996) used GIS and the analytical hierarchy process (AHP) to aid in preliminary site selection. (Suresh, 2001) studied the multi-objective decision support system using GIS for siting sanitary landfills. Gupta et al., (2003) utilized fuzzy logic, considering the uncertainty during the process of the environmental impact assessment of landfill siting and the frequency of impact occurrence. Padmaja et.al. (2006) identified solid waste disposal site in Hyderabad city using analytical hierarchy process and GIS. The landfill selection problems have often been tackled using MCDA where few data are Present.

1.2 Study area

The study area is Perambalur taluk of the district of Perambalur. It has an area of 293 km^2 located between latitudes 11.11.23 N and 11.18.23N and longitudes 79.47.52 E and 79.55.12 E. The study area map is shown in Figure.1.Perambalur district comprises of three major agro-climatic sub-zones. The major part comes under Cauvery delta zone and the other two zones are Northeastern zone and Northwestern zone. The district lies in the southern (flat land/stop getting better (or worse)) and Slope zone of agro-climate (identified with an expansive territory) planning with semi-dry climate. It is a dry sub humid coastal plain of Tamil Nadu including Cauvery delta zone with a growing period of 150-180 days and moderately large moisture availability. The total normal rainfall in the district is about 908 mm. The present study has been an effort towards the direction, principally reveals the deteriorations of groundwater and soil quality around the municipal solid waste landfill. GIS have been utilized to recognize the extent of contamination influenced by landfill-siting selection.

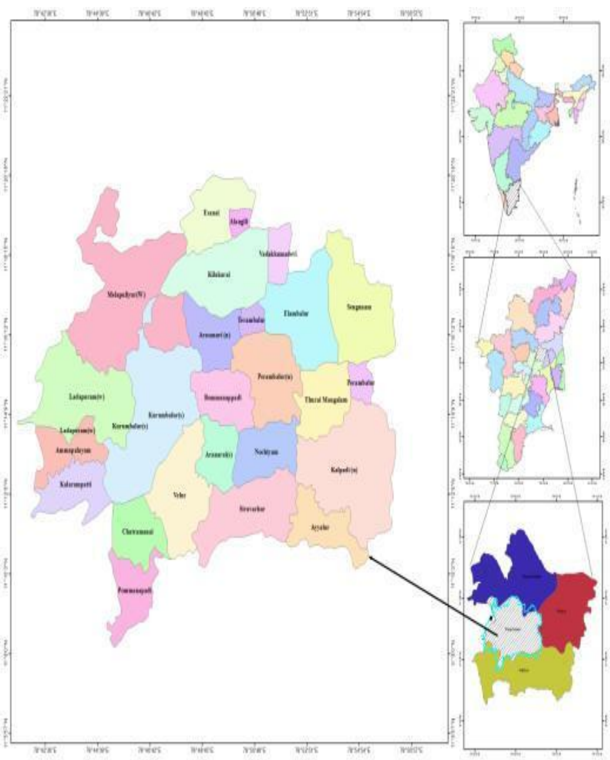

Fig -1: Location map

2. Methodology

Landfill leachates have the potential of slowly moving downwards and eventually reaching the aquifer used by the city for its water supply, thus contaminating this precious resource. Groundwater samples have been collected in and around the Landfill Site around 10km radius. The samples were gathered as such and the water quality parameters, such as pH, EC, TDS, Salinity, Alkanity, Ca, Mg, Na, K, Fe, Zn, Cl, F, SO4, No2 and NO3 were analyzed. The results for each parameter were given in plots with respect to its locations. The locations were listed as 1 to 15.

The location details were as follows 1. *Thuraimangalam (N)* 2. *Thuraimangalam (S)* 3. *Dheeran Nagar (N)* 4. *Dheeran Nagar (S)* 5. *Neduvasal (N)* 6. *Neduvasal (S)* 7. *Min Nagar* 8. *Eraiyasamuthiram* 9. *Avvaiyar Nagar* 10. *MM Nagar* 11. *Sangupettai* 12. *Perambalur (N)* 13. *Perambalur (S)* 14. *Kalpadi* 15. *Siruvachur.*

The location of soil sample details were as follows 1. *Landfill (L1)* 2. *Thuraimangalam (L2) 3. Neduvasal (31) 4. Dheeran Nagar (L4) 5. Perambalur (L5)*

In this section, a membership function was determined for each criterion. The standardization process is described as a relative grade of belonging to a fuzzy set. The suitability of map was made for every suitability paradigm and a last composite guide was at last delivered by straight forward overlaying of the individual maps. The dominant parameters selected from both water and soil samples by PCA has been plotted with their respective distances from the landfill in order to analyses the relationship between distance and sampling points. It is observed that both concentration and slope shows an increase trend in case of organic carbon and cadmium with each increasing year, whereas available nitrogen and pH with respect to concentration shows increase over year although slope shows a decreasing trend. Different patterns are observed in case of Pb (i.e., both concentration and slope shows a decrease), Mg, (i.e. concentration decreases and slope increases), Ca (increase in concentration over years although there is no clear cut trend) and Na (there is a trend in slope but concentration do not show any distinct variation).

Table 1 Descriptive Statistics for Water

	Mean	Std. Deviation	No. of Samples
pH	7.3051	.23258	90
EC	525.4333	68.75997	90
TDS	327.7222	44.09388	90
sal	3.2400	.47518	90
Alk	470.6222	66.61420	90
Ca	162.3556	23.55787	90
Mg	35.6889	6.06823	90
Na	508.1444	392.91242	90
K	7.5444	2.09419	90
Fe	.4622	.18334	90
Zn	1.8926	.27047	90
Cl	144.6889	17.60723	90
F	1.1708	.18087	90
SO4	145.2333	26.95983	90
No2	.4711	.17562	90
NO3	11.6000	2.87883	90

Table 1 Descriptive Statistics for Soil

	Mean	Std. Deviation	No. of Samples
pH	7.6180	.16183	15
density	1.5320	.17280	15
WHC	35.8720	2.81693	15
Cond	.4241	.05579	15
OrgMat	.8453	.04190	15
AvailN	215.7913	19.94553	15
P2O5	17.5720	4.36471	15
K	510.3520	45.13361	15
Ca	1536.2667	235.52236	15
Mg	160.1387	37.80277	15
Cl	168.9393	13.93892	15
Na	137.2555	25.74762	15
Mn	291.1067	41.42160	15
Cu	34.5333	4.25133	15
Pb	16.9933	2.61519	15
Cr	42.4067	3.35612	15

3. Results and Discussions

For the water sample collection, fifteen bore well locations were identified. These locations were identified in such a way that the bore wells were evenly distributed over the study area. The water samples were collected for periods between March 2012 and December 2016. The water from these bore wells were used for drinking, house hold utilities and bathing by the residents. The Laboratory tests were conducted on these samples for 16 different physical and chemical potable water quality parameters.

For the soil sample collection, five locations were identified. These locations were identified in such a way that the soil profile is evenly distributed over the study area within a particular radius from the landfill. The soil samples were collected for different periods between March 2012 and December 2016. The Laboratory tests were conducted on these samples for 21 different physical and chemical parameters.

The groundwater quality data were used as the hidden layer for the preparation of base maps. These features were the boundary lines between mapping units, other linear features (streets, rivers, roads, etc. or point features like sampling bore well points, etc.). The contours were developed for pH, EC, Cl, Na, Ca, Mg, Zn, and SO_4 values for the period of study and were stored in a grid file. Ca contours has been given as reference below. (Fig 2)

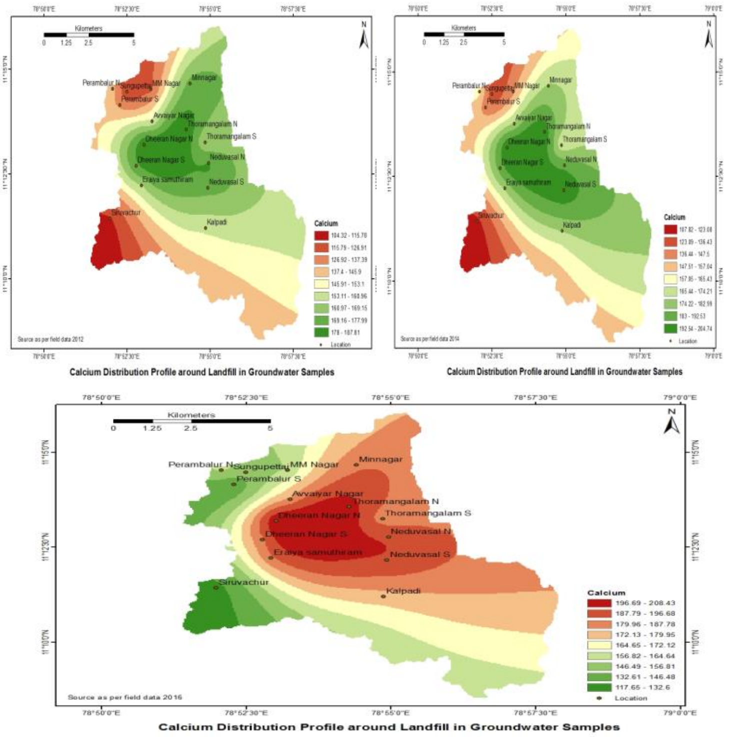

Fig 2. Ca distribution profile (2012-2016)

The contour diagrams show the concentration profile of pH, EC, Na, Ca, Mg, SO_4, Cl and Zn for different water sample at various locations in and around the study area. The collected groundwater samples were analyzed for the above parameters and most of them seems to increase year by year with respect to distance from the landfill. This shows that the leachate intrusion will be an alarming factor in polluting the groundwater resources. There is a common pattern of gradual increase in most of the parameters which is not a good sign.

It was found that the presence of high concentration of Mg (42 mg/L) in groundwater samples nearby dumping site implies that groundwater samples were contaminated by leachate migration from that particular open dumping site. The concentrations of Zn in the collected samples were within the permissible limit. Based on the contour diagrams, the parameters such as Na, Ca, Mg, SO_4, Cl and Zn showed significantly increasing by each passing years, which may exceed the maximum permissible concentration (MPC) as specified by WHO and BIS Standards for drinking water in near future. The results indicated that most of the collected sample locations were rigorously affected by the migration of leachate. Hence, the alternate sites should be proposed based on fuzzy GIS.

4. CONCLUSIONS

GIS could efficaciously be utilized as a management and an analysis implement that facilitates planning process. In this research, GIS software was used to locate the best landfill site for Perambalur taluk by analyzing the current scenario of underground water and soil quality in and around the existing landfills by creating various contour maps.

As discussed in the methodology, contour maps were created for each location with respect to distance from the landfill. The groundwater and soil quality contour maps were generated based on the field data by using GIS fuzzy logic analysis for Perambalur Taluk. The research depended on two components: One is the relationship between the distances of the locations from the existing landfill vulnerable of deteriorating water and soil quality. The other is the buffer areas around sensitive spots and lines in order to find the best location for the landfill site taking wells, springs, natural reserves, road network into consideration. Then by superimposing thematic maps, the result was the best location for a landfill site taking all the mentioned criteria and standards into consideration. The selected site located in areas with low to very low vulnerability which gives a high ability to prevent leachate comes from waste to reach ground water.

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