

Contamination of Groundwater Quality Due to Municipal Solid Waste Disposal – A GIS Based Study in Perungudi Dump Yard

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Abstract: The leachate produced by waste disposal sites contains a large amount of substances which are likely to contaminate ground water. The impact of such sites upon ground water can be judged by monitoring the concentration of potential contaminants at a number of specific monitoring points. Perungudi in Chennai is one such open dump yard with capacity of 2450 tonnes of garbage dumping every day. The disposal causes hazards to ground water quality in and around the dumpsite. In this study the intensity of ground water contamination around the Perungudi dump yard is examined using Geospatial Technology. Physico Chemical analyses were carried out on water samples collected at various radial distances from the boundary of the dumping yard, at intervals of 250m and 500m. The study has revealed that the ground water quality around the dump yard especially in areas like Ramnagar south, Soundharya Nagar, Saibaba Nagar, Thangam Avenue and Sri Sowdeshwari Nagar were severely polluted especially the concentration of Dissolved oxygen is far too lower and parameters like Sulphates, Phosphates, Iron and Specific conductance exceeds the Stipulated limits of Indian standards of Drinking water (BIS 1500:991) and the World Health Organization. Furthermore, ground water in and around the landfill sites shall not be used for drinking purposes unless it meets specific standards. Indiscriminate dumping of wastes in developed areas without proper solid waste management practices should be stopped.

Keywords: Geo-Spatial technology, Solid waste management, Physico-chemical parameter, Landfill, Ground water contamination.

1. INTRODUCTION

Rapid growth of population, changing life style, and developing industrialisation are the root causes of increasing solid waste generation in developing countries. In India, about 0.15 million tons of solid waste are generated daily due to human activities. Landfill has been consider as one of the major cause of Groundwater pollution and it is believed as one of the common method to dispose municipal solid waste due to its favourable economics[1].

Open dump yard creates unhygienic environment and foul smell. Hence the landfill has to be managed efficiently as it creates major threats to human lives as well as the environment. This threat is all over the world including India. This is because 90% of wastes are dumped directly into the landfill. [2] The landfill consists of municipal solid wastes and these wastes are known as trash or garbage. The waste dump constituents include wastes from domestic such as kitchen wastes, clothes, cardboards, plastic, glass, paper etc. Municipal solid wastes also include construction wastes such as bricks, concrete, sand and adding on wastes from fish markets and vegetable markets. [3]

Overall dumping rate all over the world is found to be 1.3 billion tons per year and are expected to increase to approximately 2.2 billion tons per year by 2025 and Metro cities in India generate about 30,000 tonnes of waste per day and Class I cities about 50,000 tonnes per day. [4] The dumped wastes when coming in contact with the moisture tends to extract organic and inorganic substances from trash into liquid which is known as leachate. [5] In this study, it is found that the percolation of leachate leads to pollution of ground water quality which is caused due to unlined landfill site at Perungudi dump yard, Velacherry, Chennai district, Tamil Nadu, India.

In the present work, the influence of physio-chemical parameters of the ground water are studied thoroughly by collecting the water samples around the dump yard at 250m and 500m boundaries and testing them for various parameters such as Turbidity, Total dissolved solids, Calcium, Magnesium, Total Hardness, Chloride, Fluorides, Ammonia, Dissolved

Oxygen, pH, Sulphates, Phosphates, Iron and Specific Conductance. The water samples are collected at equal intervals to obtain accurate results.

2. STUDY AREA

Chennai is a major Indian city with a population of about 67.27 Lakhs at a density of 26,902 persons per square kilometer. The city is lying at latitude 13.04° N and longitude 80.17° E. [6] There are two designated landfills, Perungudi in the south and Kodungaiyur in the north currently being used as open dumps for disposal of municipal solid waste from the Chennai city area. It has many harmful effects on residents nearer to the dump yard, in violation of MSW Rules framed by Ministry of Environment and Forests. [7] These sites are operated by the municipal corporation and accept wastes from Chennai only. The daily generation of waste in Chennai is 4,800 tons and is expected to reach 6,000 tons by the year 2010. The average minimum and maximum temperature of the city is 21°C and 38°C respectively. The Perungudi dump site is located towards the northern limit of a large topographic depression termed as the Pallikaranai Depression and covers an area of 228 acres. The dump yard is lying accurately at 12°97'N and 80°25'E at an elevation of 9metres above the sea level. The dump yard is in use since 1992 and stand at a height of a two storey building. MSW generated in Chennai includes 68 % of residential waste, 16 % commercial waste, 14 % institutional waste and 2 % industrial waste.[8]

Physical analysis of wastes shows that there are a large portions of Green wastes (32.25%) and Inert (34.65%). Remaining composition is of Plastic, Steel, Paper, Food, Textiles and Rubber wastes. Chemical analysis of wastes shows that there are huge compositions of Moisture (27.60%), Organic (39.06%) and Carbon (21.53%) contents and traces of pH, Nitrogen content, Phosphorus and Potassium. (Chennai corporation official website) [9]

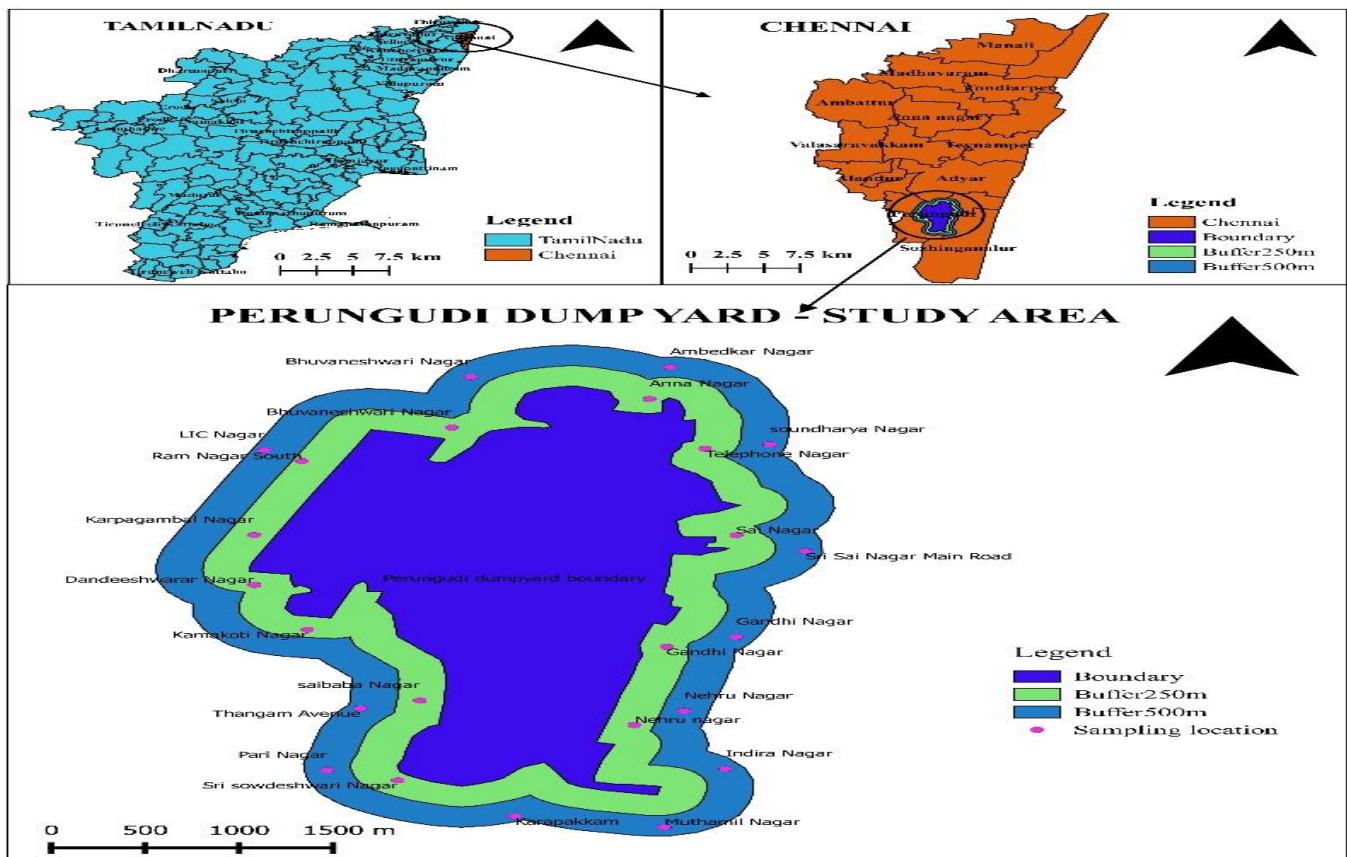


Fig-1: Study area map of Perungudi Dump yard

3. METHODOLOGY

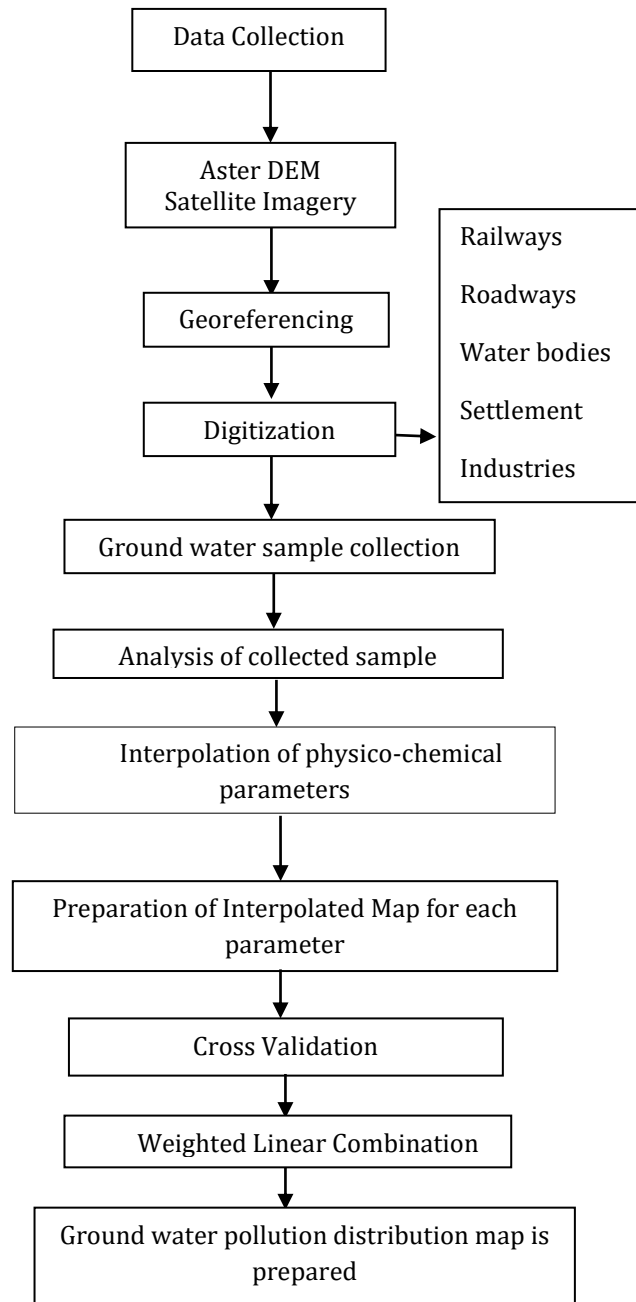


Fig-2: Methodology flow diagram

3.1 Data Collection

Data collection is the first and foremost work in GIS Database creation. Based on the quality of the data used, the standard of GIS data varies. The data that has been acquired in this study is ASTER DEM (Digital Elevation Modelling) and Satellite imagery. Collected data were Geo-referenced by uniform coordinate reference system (WGS 84 UTM Zone 44N). [10]

3.2 Georeferencing

Georeferencing of Raster data is an important process in most GIS projects. The process of Georeferencing involves assigning real world co-ordinates to each pixel of raster. The aerial photo image or the internal co-ordinate system of a map can be related to geographic co-ordinates of the Earth. These co-ordinates could be obtained by performing field surveys (i.e.) collecting co-ordinates with a GPS device for some easily identifiable features in the map or image. In Georeferencing, WGS 1984 geographic coordinate system was used. The co-ordinate system that has been projected is WGS_84_UTM_zone_43N which is followed for Raster as well as vector data in the study for maintaining unity. The obtained coordinate transforms are stored typically in the form of image file[11].

3.3 Digitization

Digitization is one of the crucial step in data processing, storage and transmission because it is used for carrying information of all kinds in all formats with same efficiency and also for intermingling. The land use features such as Industrial area, Water body, Railway lines, Road network that are around the study area were digitized and are stored in a vector type spatial database. The digitized data are finally maintained in uniform co-ordinate system (WGS 84, UTM zone 43N) for both vector and raster layer. The Maximum benefits could be obtained by using QGIS tool for digitizing road areas, some parameters need to be determined. Through digitization, raster file are converted into vector file for calculating the areas. [11]

Digitization is done by representing different features in different forms such as polygons, lines etc. and in different colors[12]. Digital data is mostly preferred by many organizations around the world over analog data as the latter suffers loss of quality during each time it is copied or transmitted. In digital form, data can be propagated indefinitely with absolutely no degradation. Digitization helps in easy understanding of the study area for the users.[13] The digitized image of the study area is shown in figure given below.

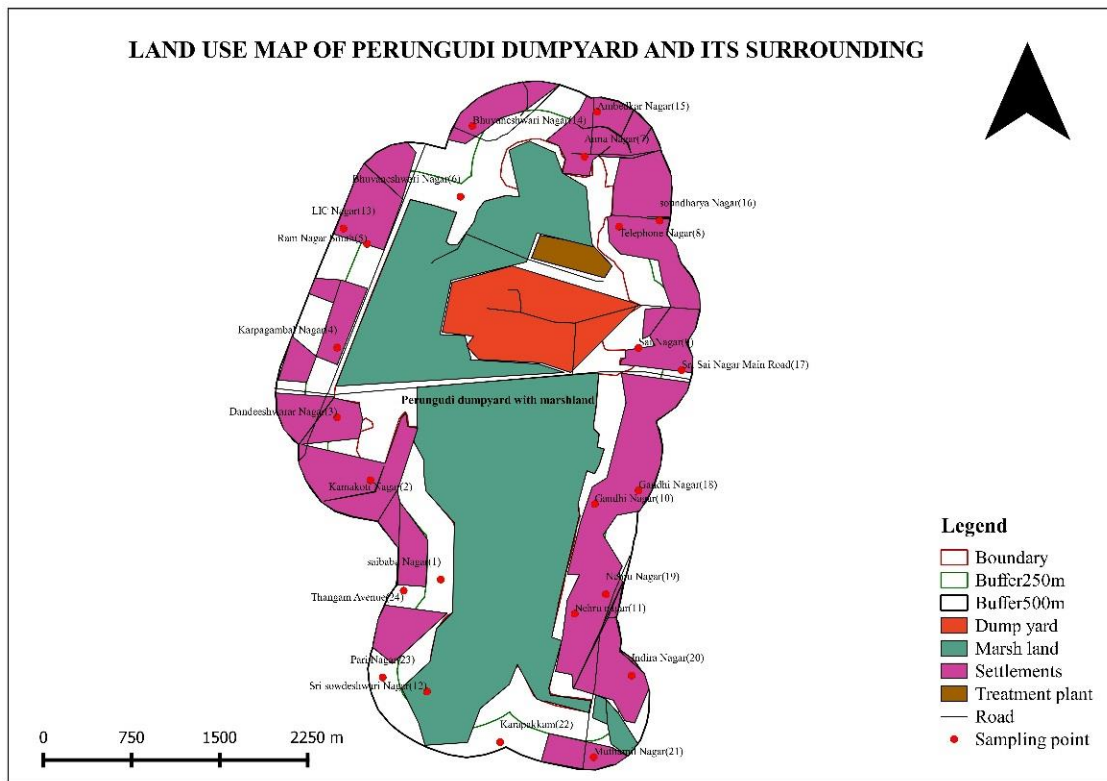


Fig-3: Landuse map of Perungudi dump yard

3.4 Ground Water Sample Collection

To study the quality of the groundwater around Perungudi dump yard, totally Twenty four groundwater samples are collected as twelve samples are located around 250m buffer distance and another twelve samples are located around 500m buffer distance.

It is important that the sampling points are well distributed around the dump yard and are equidistant between adjacent points in order to obtain high accuracy. All the sampling points are reached by navigating to the noted co-ordinates using satellite maps. Ground water samples are collected using polythene containers of two liters capacity which are cleaned and sterilized well before using for the sample collection. [14] During sample collection utmost care was taken to avoid any kind of contamination.[15] The sample collection points are represented in the below figure.

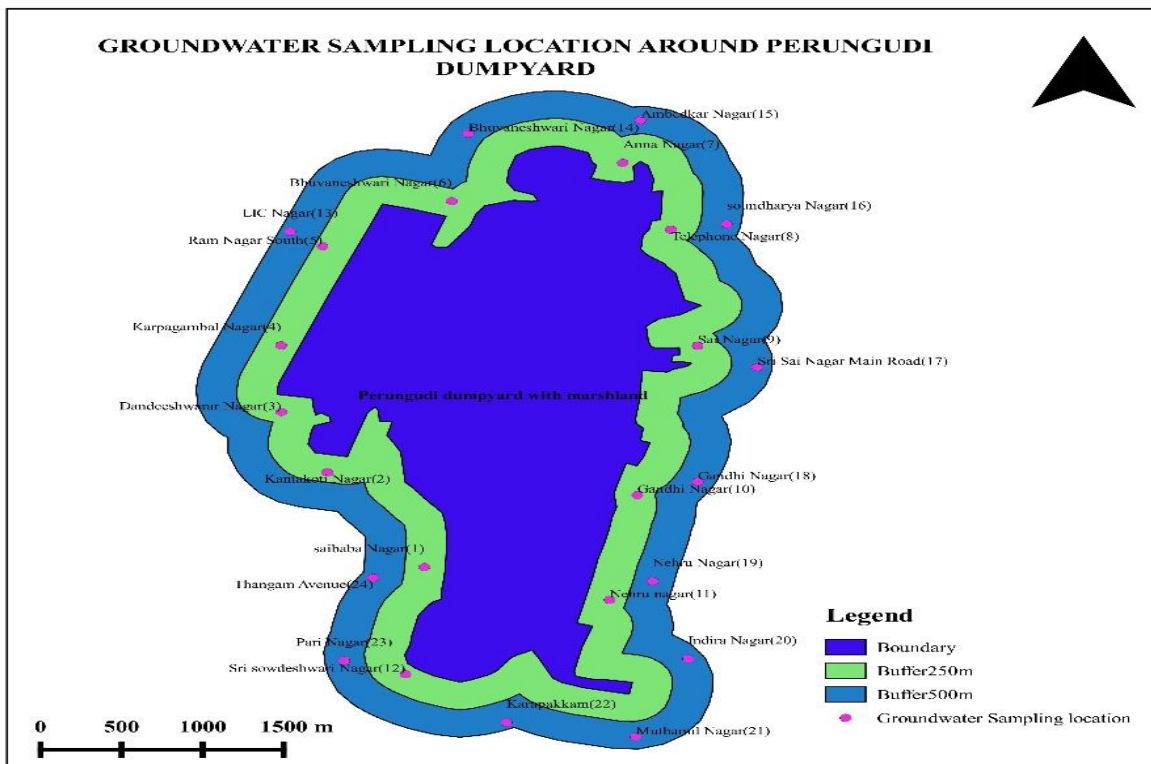


Fig-4: Groundwater sample collection location around study area

4. Results and Conclusion

The Quality of ground water plays an important role in determining its suitability for various purposes such as Drinking, Domestic, Agriculture and Industry. Totally Twenty-Four groundwater samples were collected and analyzed for 14 different Physico-Chemical parameter such as Turbidity, TDS, Calcium, Magnesium, Total Hardness, Chlorides, Ammonia, Dissolved Oxygen, pH, Sulphates, Phosphates, Iron, Fluorides and Electrical Conductivity.

4.1 Physico-chemical Characteristics of Groundwater:

Groundwater water samples are collected and analyzed for the various physico-chemical parameters such as Turbidity, Hardness, Magnesium, Ammonia, Chloride, Calcium, Dissolved Oxygen, Fluoride, Iron, Phosphate, Sulphate, pH, Specific conductance and Total Dissolved Solids. Analyzed Physico-chemical parameters of different groundwater samples are tabulated in Table.1

S.No	Turbidity (NTU)	TDS (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Total Hardness (mg/l)	Chlorides (mg/l)	Ammonia (mg/l)	DO (mg/l)	pH	Sulphates (mg/l)	Phosphates (mg/l)	Iron (mg/l)	Fluorides (mg/l)	EC (µS/Cm)
1	7.5	53000	2400	1944	14000	37000	0.22	0.3	7.1	11000	0.05	0.3	0.8	77900
2	1	810	68	29	290	380	0.03	0.57	8.7	150	0.04	0.2	0.1	1250
3	0.5	1370	104	32	390	420	0.11	1.71	8.3	190	0.4	0.15	0.1	2100
4	4	1490	124	53	530	500	0.56	1.74	8.2	160	0.2	0.5	0.1	2290
5	9	41750	1600	2673	15000	25000	0.22	1.35	7.8	14000	0.04	2	0.8	61400
6	0.1	890	68	19	250	300	0.03	0.75	8.6	170	0.04	0.1	0.1	1370
7	47	2150	76	53	410	610	5.6	2.58	8.3	360	0.05	5	0.2	3310
8	1.5	1070	60	24	250	330	0.03	0.75	8.6	60	0.2	0.2	0.1	1650
9	0.8	2360	92	68	510	900	0.04	1.47	8.5	480	0.04	Trace	0.1	3630
10	3	1260	80	49	400	580	0.04	0.84	8.5	190	0.02	0.5	0.1	1940
11	3	1430	68	51	380	470	2.4	0.93	8	190	0.04	0.3	0.1	2200
12	0.1	25800	2000	3888	21000	13000	0.22	0.54	8	10000	0.02	0.25	0.4	38000
13	0.8	1330	100	41	420	580	0.1	3.15	8.4	130	0.5	0.15	0.1	2050
14	0.3	1320	72	34	320	500	0.04	0.63	7.1	240	0.015	1.5	0.1	2030
15	4	1330	116	53	510	490	0.03	0.81	7.1	180	0.2	1.5	0.15	2050
16	2	20400	800	972	6000	9000	0.03	1.11	8.1	10000	0.04	0.3	0.3	30000
17	2	1700	116	41	460	860	0.1	3	8.4	180	0.2	0.15	0.3	2620
18	3	665	48	51	330	360	0.08	0.24	8.5	160	0.015	2	0.15	1025
19	0.1	3270	120	73	600	1480	0.19	1.83	8.9	480	0.04	0.5	0.1	5030
20	28	13340	1200	972	7000	7000	0.05	0.63	7.7	1540	0.015	2.5	0.2	19600
21	1	2330	80	90	570	970	0.03	0.39	7.4	400	0.015	0.1	0.1	3580
22	0.2	1755	140	51	560	650	0.04	0.75	8	230	0.4	0.25	0.1	2700
23	0.4	2050	120	53	520	790	0.1	2.55	8.1	180	0.4	0.4	0.1	3150
24	0.4	2430	124	68	590	740	0.04	1.11	8.3	400	1	0.3	0.1	3740

Table-1: Result of Analyzed Physico-chemical Parameters of Collected Groundwater Sample

4.2 Interpolation

Interpolation is the process of estimating values of unknown points using known points. By using spatial analysis tool from the GIS software, the data is interpolated. Inverse Distance Method is the easiest method to interpolate various physical chemical parameters of water samples. In this study Quantum GIS software is used to prepare spatial variation of various parameters. The spatial variability of different parameters are listed below.

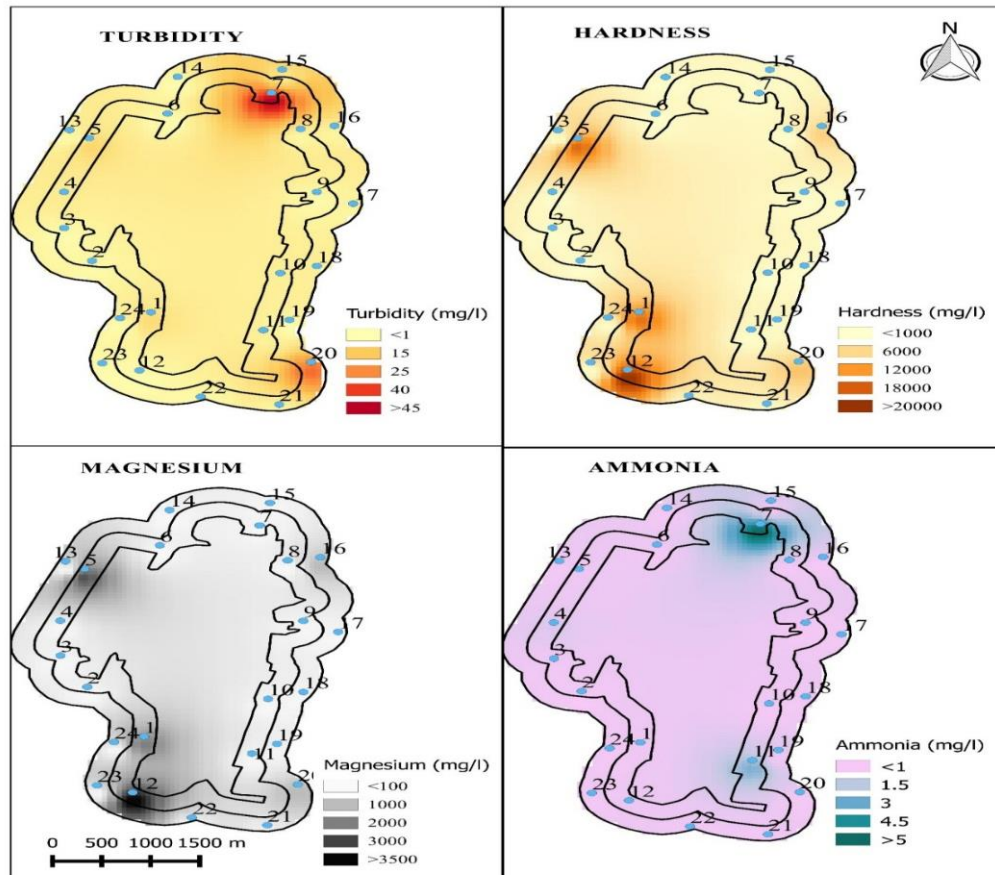


Fig-5: Spatial variability map of Turbidity, Hardness, Magnesium, Ammonia

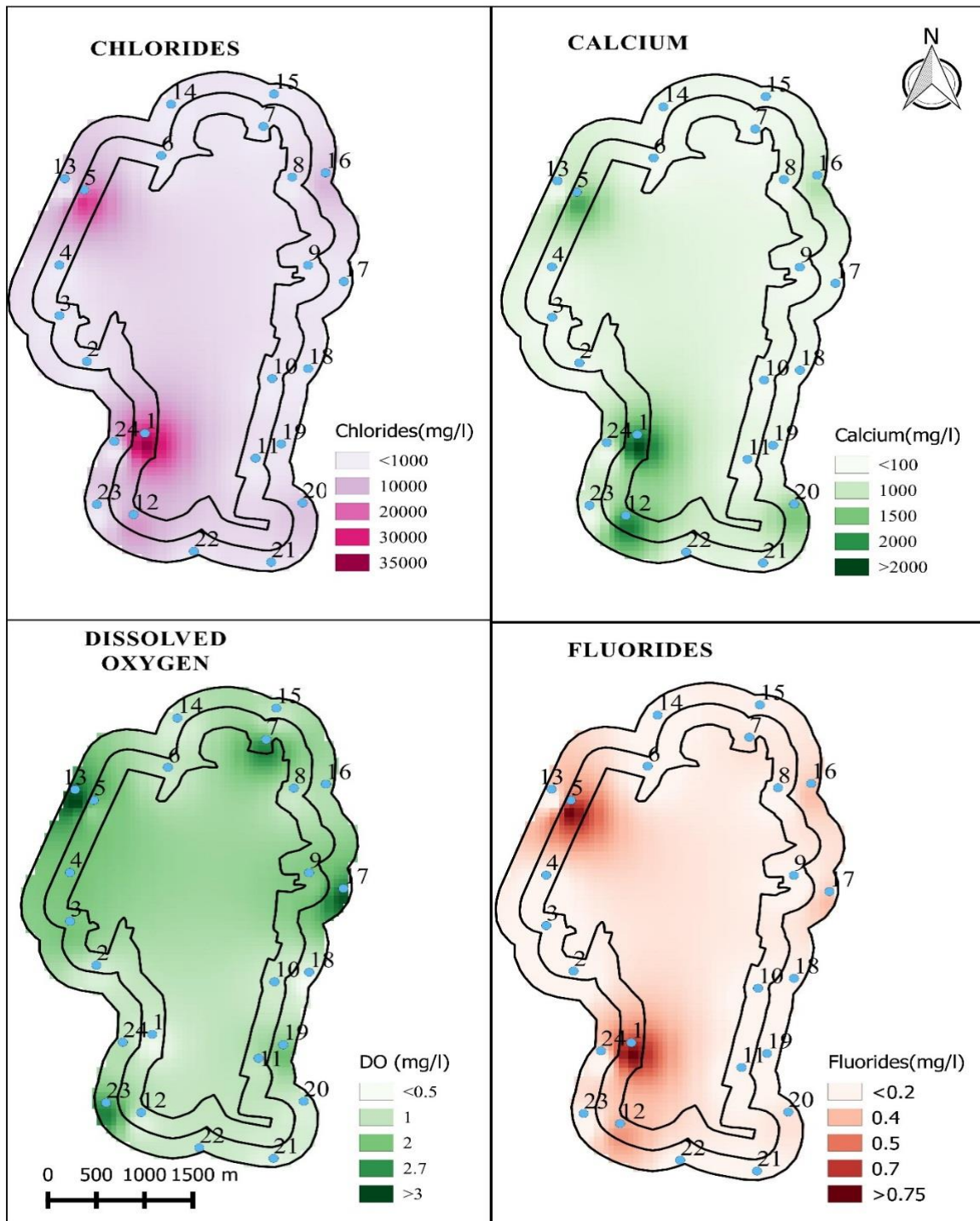


Fig-6: Spatial variability map of Chloride, Calcium, Dissolved Oxygen, Fluorides

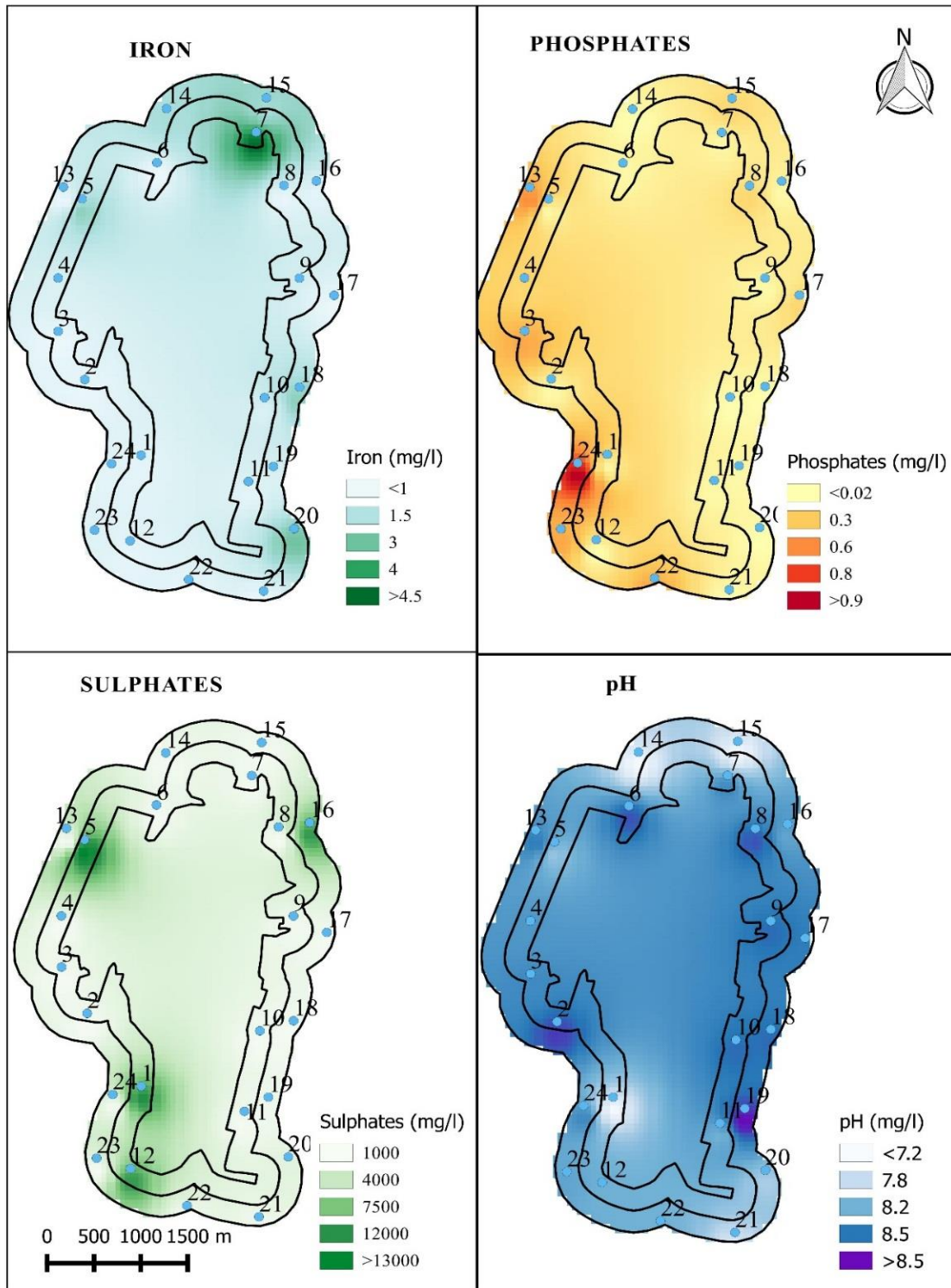


Fig-7: Spatial variability map of Iron, Phosphate, Sulphate and pH

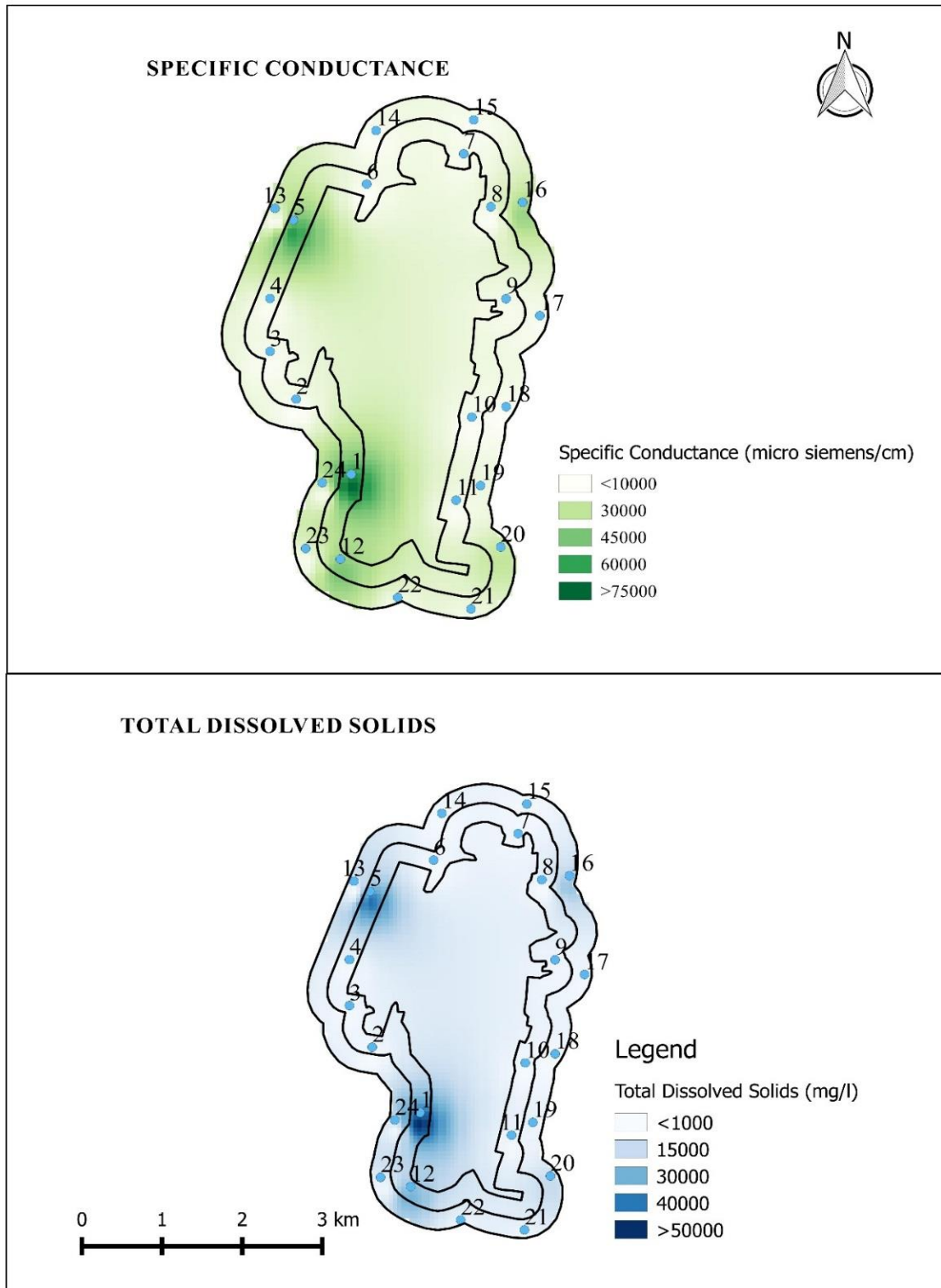


Fig-8: Spatial variability map of Specific conductance and Total Dissolved Solids

4.3 Weighted Linear Combination

Weighted Linear Combination is one of the method used for decision making when various parameter are taken into consideration [16]. The suitable weightage is assigned for each parameter based on its relative importance. The weights of relative importance is directly assigned to each attribute map layer by the decision maker. The total score for each alternative is obtained by summing the products of scaled value given for each attribute to the alternative and the importance weight assigned to each attribute. The highest overall score among all the calculator alternatives is chosen. The method can be executed using any GIS software with overlay analysis, and allows the evaluation criterion map layers to be combined in order to determine the composite map layer which is output.[17][18] The weights assigned to various parameters are shown in table.2

By using Weighted Linear Combination method, the weightage are calculated assigned for each and every parameter using raster calculator in QGIS. Final Pollution distribution map is shown in Figure 9

Table-2 Assigned weightage for various physico-chemical parameters using WLC Method

S.No	Parameters	Mean RMSE 1	Mean RMSE 2	Mean RMSE 3	Mean RMSE 4
1	Turbidity	0	0	0.23	0.04
2	Total Dissolved Solids	0.003	0.005	0.007	0.016
3	Calcium	0	0.0013	0.005	0.007
4	Magnesium	0.049	0.002	0.008	0.056
5	Total Hardness	0.0031	0.008	0.003	0
6	Chlorides	0.05	0.001	0.02	0.006
7	Ammonia	0	0	0.001	0.039
8	Dissolved Oxygen	0	0	0	0
9	pH	0	0	0	0
10	Sulphates	0.0054	0.0062	0.0046	0.007
11	Phosphates	0.008	0.0076	0.0067	0.0043
12	Iron	0.001	0.0082	0	0.004
13	Fluorides	0	0.0045	0.078	0.0019
14	Specific Conductance	0	0	0	0

5. Conclusion

From the study it has been found that the areas such as Sai baba Nagar, Sri Sowdeshwari Nagar, Ram Nagar south, Thangam Avenue, Soundharya Nagar are heavily contaminated. The results shows that Dissolved oxygen is far too lower than the stipulated limits given by the Indian Standards of Drinking Water (BIS 1500:991) and World Health Organization and parameters like Sulphates, Iron, Phosphates and Specific conductance is present in higher concentration and exceeds the limits of standards. So, it's not recommended for drinking purpose. Counter measures such as provision of clay liners, Monitoring wells can be placed to reduce the further contamination of Ground Water around the dump yard.

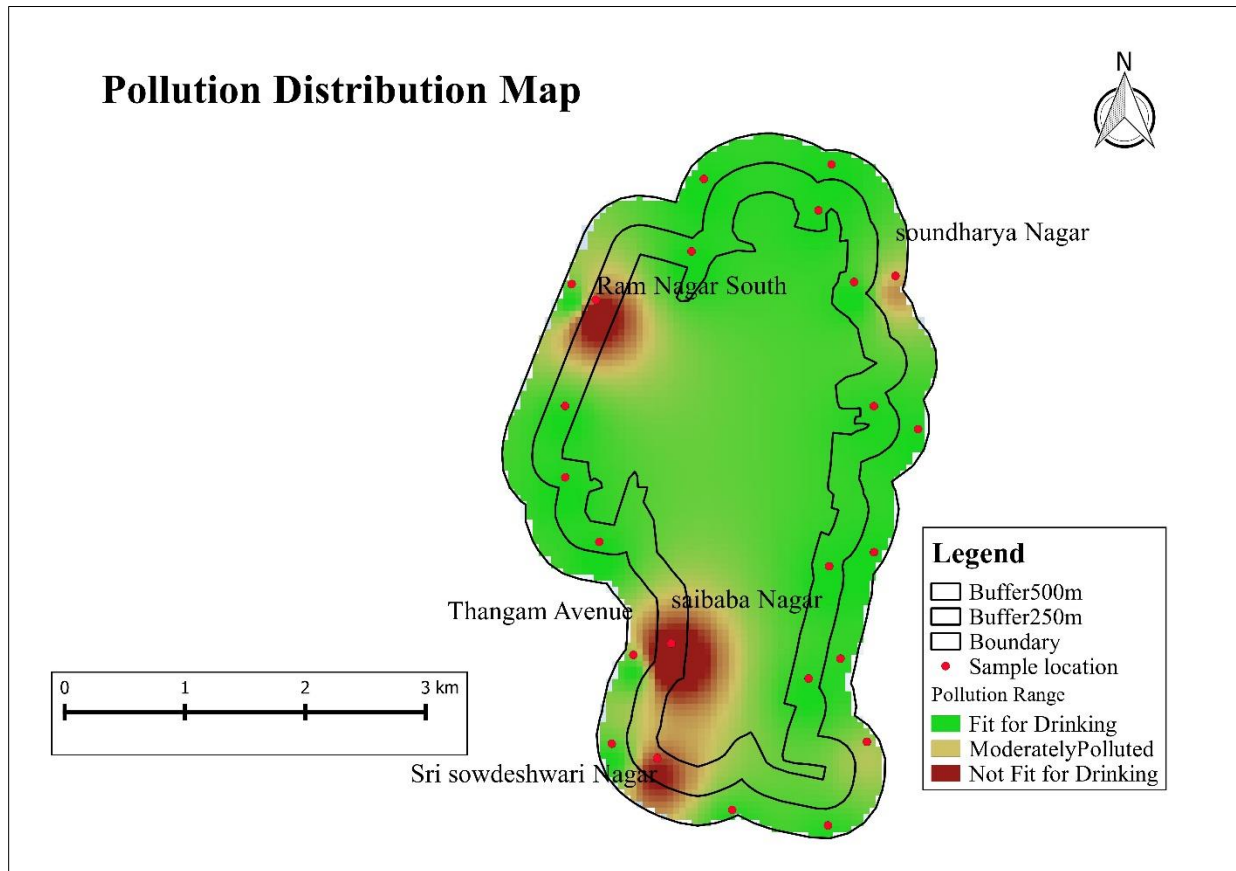


Fig-9: Pollution Distribution Map of Perungudi dump yard

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