Ground Water Quality Analysis and Mapping Using ArcGIS : A Case Study Near Mandur Dumping Site, Bangalore

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Abstract

Ground water is very much needed and greatest in amount among all the natural resources for maintaining ecological balance and there is chance of it getting polluted directly or indirectly due to anthropogenic activities. Due to the waste set down at the landfill, ground water contamination can emerge on the porous ground surface and the associated aquifer unreliable for domestic water supply and other uses from the percolation of leachate. In the current study, investigation is conducted on the quality of ground water due to Mandur waste dumping yard (latitude 77°43'E longitude 13°45'N) in Bangalore East, District, Karnataka, India is considered. Water quality parameters such as pH, acidity, alkalinity, dissolved oxygen, chlorides, and hardness were considered for the study. The water samples were collected from bore-wells in and around the dumping site with a radius of 3 km with dumping yard as the centre point. The parameters analyzed were compared with Bureau of Indian Standards and WHO standards to understand the suitability for drinking purpose. ArcGIS is considered an effective tool for mapping of ground water quality and evaluates groundwater vulnerability to pollution. After the water analysis, results obtained are shown in the maps using ArcGIS, which gives a good judgement of present water quality of the current study area. The IDW maps showing the spatial distribution of the above mentioned physical-chemical parameters were done using ArcGIS, which were helpful to the people in identifying the zones of drinking water quality.

Keywords : ArcGIS, dumping site, groundwater quality

I. INTRODUCTION

Ground water is considered essential for humans as it is a source of consumption for agriculture, irrigation, industrial purposes etc. Due to increase in birth rate (population), increase in shift of people from rural to urban areas due to increase in industrial growth and also due to increase in agricultural works, ground water sources are likely to become critically scarce. Nowadays, ground water is considered as the major source for drinking in urban and rural areas since surface water is polluted to the extreme due to anthropogenic activities. The evaluation of groundwater quality and establishing database is an important step for future water resources development strategies [1]. Due to urban, industrial activities, and modern agricultural practices there is an increasing number of soluble or dissolved chemicals in water sources [2]. Major chemical elements such as Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, and SO_4^{2-} play a significant role in assessing the quality of groundwater [3]. Groundwater contamination has become a major issue in developing countries due to improper management of industrial, agricultural, and domestic waste. There is lack of productive solid waste management system and no proper dumping of municipal solid waste (MSW) [4, 5]. Open landfills affect the quality of surface water and ground water [6]. Poor management of landfills creates contamination of soil, air, and groundwater. The major

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danger to human health from these landfills is the polluting of groundwater by leachate from these dumping sites [7].

ArcGIS is considered an effective tool for managing and getting solutions for water resources problems to assess ground water quality, availability of resources, and understanding the natural environment. From GIS, spatial distribution mapping for various pollutants can be done. The resulting information which is obtained is very useful for policy makers to take remedial measures [8]. Thematic maps are used for linking features of ground water quality using GIS techniques. It is considered the best method for groundwater potential prediction zoning [9]. GIS is considered an integrated system which facilitates recording, management, analysis, and reporting of information in different areas of science over the last decades [10, 11]. It is a database system with specific capabilities for synthesizing spatial formation and non-spatial data within the GIS framework [12]. The Inverse Distance Weighting (IDW) method for the generation of water quality surface data is considered more intuitive and efficient. IDW methodology which is used in water quality index zonation and in the production of spatial distribution maps of water quality parameters [13].

II. STUDY AREA

The study area is Mandur dumping yard (latitude $77^{o}43'$E longitude $13^{o}45'$N) in Bangalore East District, Karnataka, India. It is situated in the eastern part of Bangalore East District. Mandur dumping yard is taken as the center point and water sample is collected from the surrounding 3 km (Fig.1). It experiences severe droughts frequently with weather with 20^{o}C to 30^{o}C temperature. More than 65 % of the population sustains on agro-based economy. The study area of samples located points images.

Bangalore has been dumping its garbage in nearby villages causing irreversible damage to people and the environment. From 2005 onwards, Mandur, a tiny village 20 km north of Bangalore's center has turned into one of the city garbage open dumping yard (Fig. 2). At Mandur, about 30 km from the city center, about 25 lakh to over 30 lakh tons of waste is being dumped. Even though dumping was stopped in December 2014, people are still facing problems due to smell as well as leachate ponds which affect water quality.

III. METHODOLOGY

A. Geodata Base of samples

A total of 18 samples were selected in and around the

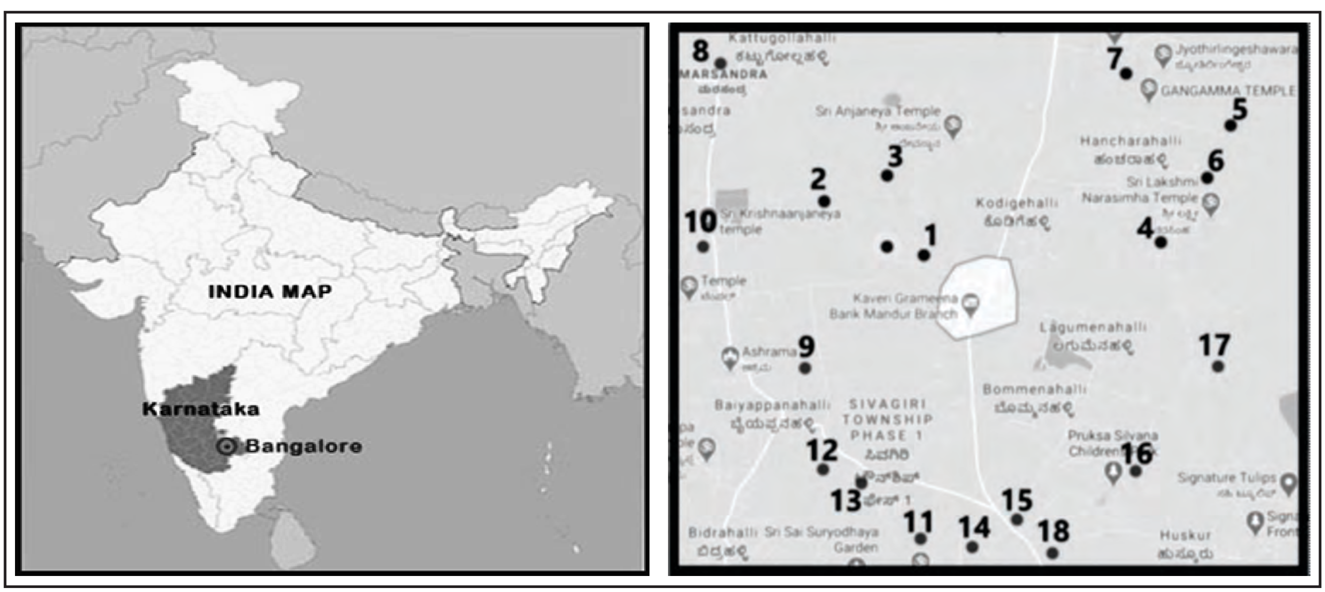

Fig. 1. Location Map of Study Area

Fig. 2. Heap of Legacy Waste in Mandur Landfill That is Lying Untouched Since 2014

Mandur waste dumping site as in Fig. 1. The water samples were collected during post-monsoon season for the period 2019-2020 and location survey was carried out. The collected samples were analyzed and the values are compared with WHO Standards [14]. The sampling stations were the bore wells which are used for drinking, irrigation, and other domestic purposes. The details of all the sampling points which are collected from the field are shown in Table I with depth of the bore wells. Samples were tested for water quality parameters and compared with permissible limits.

TABLE I.

SAMPLE LOCATION DETAILS

Sample No.	Latitude	Longitude	Borehole Depth (m)
S-1	77.7380674	13.0375957	800
S-2	77.735257	13.0358555	1200
S-3	77.7312212	13.0381745	1150
S-4	77.7247387	13.0440329	760
S-5	77.7185417	13.0582394	840
S-6	77.7141979	13.0531933	250
S-7	77.7105096	13.0364818	660
S-8	77.7194816	13.0281111	720
S-9	77.7380674	13.0375957	470
S-10	77.735257	13.0358555	950
S-11	77.7312212	13.0381745	390
S-12	77.7247387	13.0440329	580
S-13	77.7185417	13.0582394	700
S-14	77.7141979	13.0531933	900
S-15	77.7105096	13.0364818	530
S-16	77.7194816	13.0281111	840
S-17	77.9076	13.0685564	280
S-18	77.68298	13.0668925	960

B. Concept of IDW Interpolation Method

In GIS, spatial interpolation is used to create a raster surface with data used for all raster cells. The results of interpolation analysis can be further used for analysis which covers the entire study area. In this current study Inverse Distance Weighting (IDW) has been used for the interpretation of data. The locations of sampling stations were captured as latitude/longitude data in degrees, minutes, and seconds and were converted into decimal degrees. This data were sorted in an excel file, exported as text file structure, and were considered for analysis. Spatial analysis tools in GIS were used for interpretation of this data. So, obtained results are stored as raster files after the analysis. Steps of IDW method employed in Arc Map 10.1 software are as follows:

Steps

(1) Go to Arc map table of contents, click on the point layer where IDW method has to be performed.

(2) Next click on the Geostatistical Analyst Wizard.

(3) Next click on attribute drop down arrow, choose input data method. Once dialog box opens, now start performing IDW method. Click next.

(4) Choose the right parameters required for the IDW Method.

(5) Examine the results on the dialog box and click finish.

IV. RESULTS AND DISCUSSION

Water analysis is done for the all 18 samples for parameters such as pH, total hardness, Calcium hardness, Magnesium hardness, alkalinity, chlorides, and dissolved Oxygen. The results are tabulated in Table II [15,16]. These results are represented as GIS maps using ArcGIS software in Fig. 3 (i, ii, iii, iv, v, vi, vii). Ground water quality maps are evaluated in order to check the quality of water used for various purposes like drinking, agriculture etc. The permissible amount of alkalinity in potable water is 200 mg/L. In all the 18 samples collected, alkalinity was found to be within the limits as per BIS standards. It was found that pH values for the tested samples was within the desired limit of 6.5 to 8. Chlorides present in ground water impart characteristic taste to it. Out of the 18 samples, three were having value higher than permissible limit of 250 mg/L in the current study area.

Hardness indicates the presence of soluble carbonates, bicarbonates, chlorides, and sulfates of calcium and magnesium present in water. From all the tested water samples, total hardness value was found to be normal. Two water samples in the study area had higher than 300mg/L indicating very hard water. The permissible calcium present in drinking water samples has to be 75mg/L according to BIS standards [17]. Seven samples showed higher values than permissible. The permissible range of Magnesium present in drinking water is 30 mg/L, only five samples fall in this range and others show high Magnesium content. Dissolved oxygen (DO) of the water sample collected from the study area falls in the range of 7-8.1 mg/L indicating the potability of water.

TABLE II.

VARIOUS PARAMETERS OF WATER SAMPLE ANALYZED

Samples	pH Value	Alkalinity (mg/l)	Total Hardness (mg/l)	Dissolved Oxygen (mg/l)	Chlorides (mg/l)	Calcium Hardness (mg/l)	Magnesium Hardness (mg/l)
S-1	7.5	36	334	8.1	204.93	198	136
S-2	7	34	630	7.5	484.84	382	248
S-3	7.5	34	996	7.3	629.80	676	320
S-4	7	36	706	7.2	480.35	592	114
S-5	7.5	14	184	7.3	70.97	102	82
S-6	6.5	30	598	7.4	208.93	262	336
S-7	7.5	10	336	7.6	106.96	134.3	202
S-8	7.5	16	222	7.8	76.47	156	66
S-9	7.5	30	286	7.9	36.98	270	16
S-10	7.5	14	226	7.6	64.97	122	104
S-11	6.5	30	462	7.9	80.97	258	204
S-12	7.7	30	536	7.6	95.47	284	252
S-13	6.5	16	226	7.7	70.97	134	92
S-14	7.5	24	370	7.8	119.96	166	204
S-15	7.5	30	318	7.9	154.95	190	128
S-16	6.5	20	280	7.8	155.95	84	196
S-17	7.6	18	220	7.8	75.98	162	58
S-18	7.5	14	338	7.6	106.96	140	198

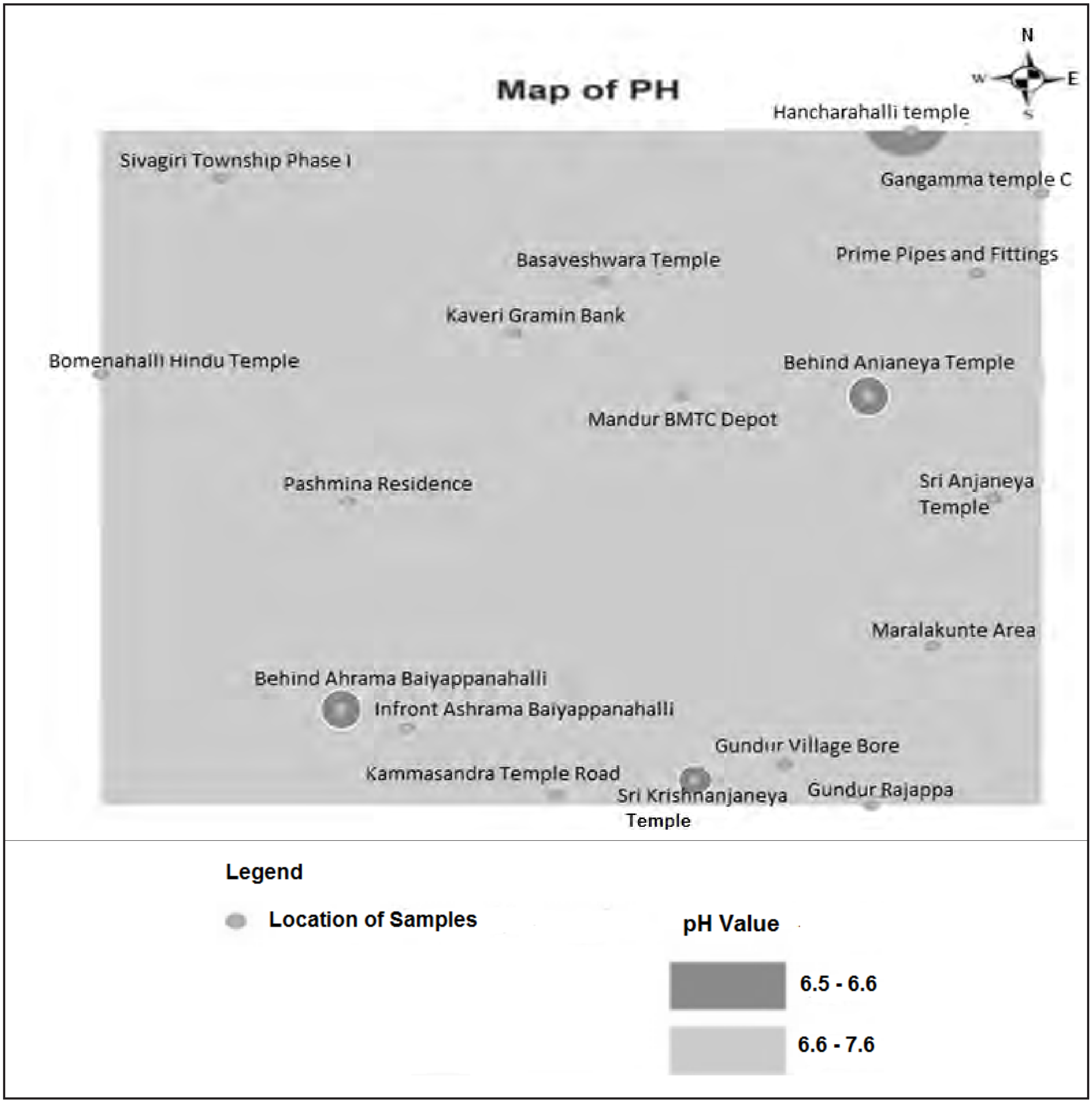

Fig. 3(i). Map of pH

Location number and Location for Fig. 3 (ii) to (vii)

1	Sivagiri Township Phase 1	10	Sri Krishnanjaneya Temple
2	Bomanahalli Hindu Temple	11	Hancharahalli Temple
3	Pashmina Residence	12	Behind Anjaneya Temple
4	Behind Ashrama Baiyappanahalli	13	Gundur Village Bore
5	Infront Ashrama Baiyappanahalli	14	Gangamma Temple Opp
6	Basaveshwara Temple	15	Prime Pipes and Fittings
7	Kaveri Gramina Bank	16	Sri Anjaneya Temple
8	Mandur BMTC Depot	17	Maralukunte Area
9	Kammasandra Temple Road	18	Gundur Rajappa

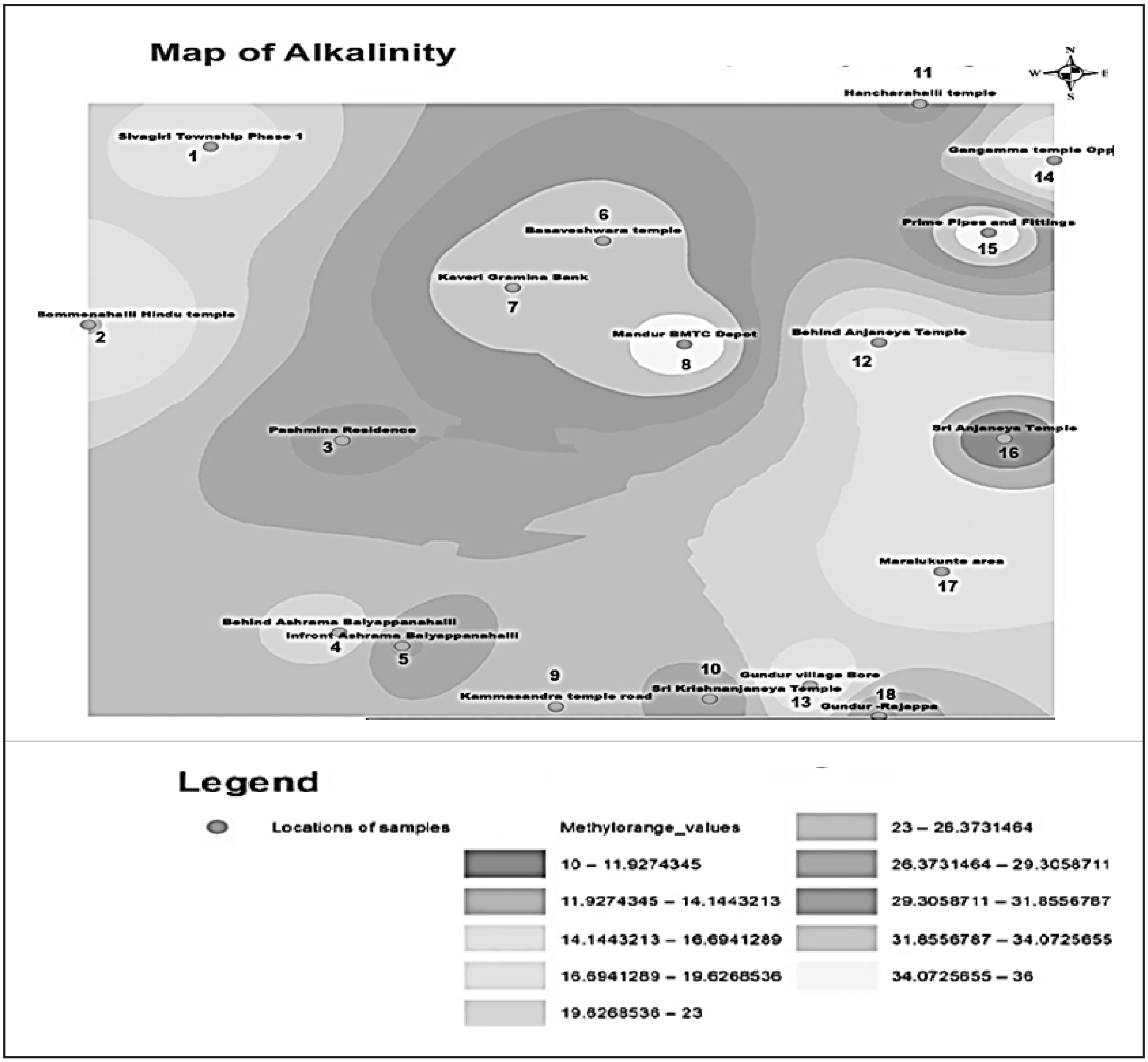

Fig. 3(ii). Map of Alkanility

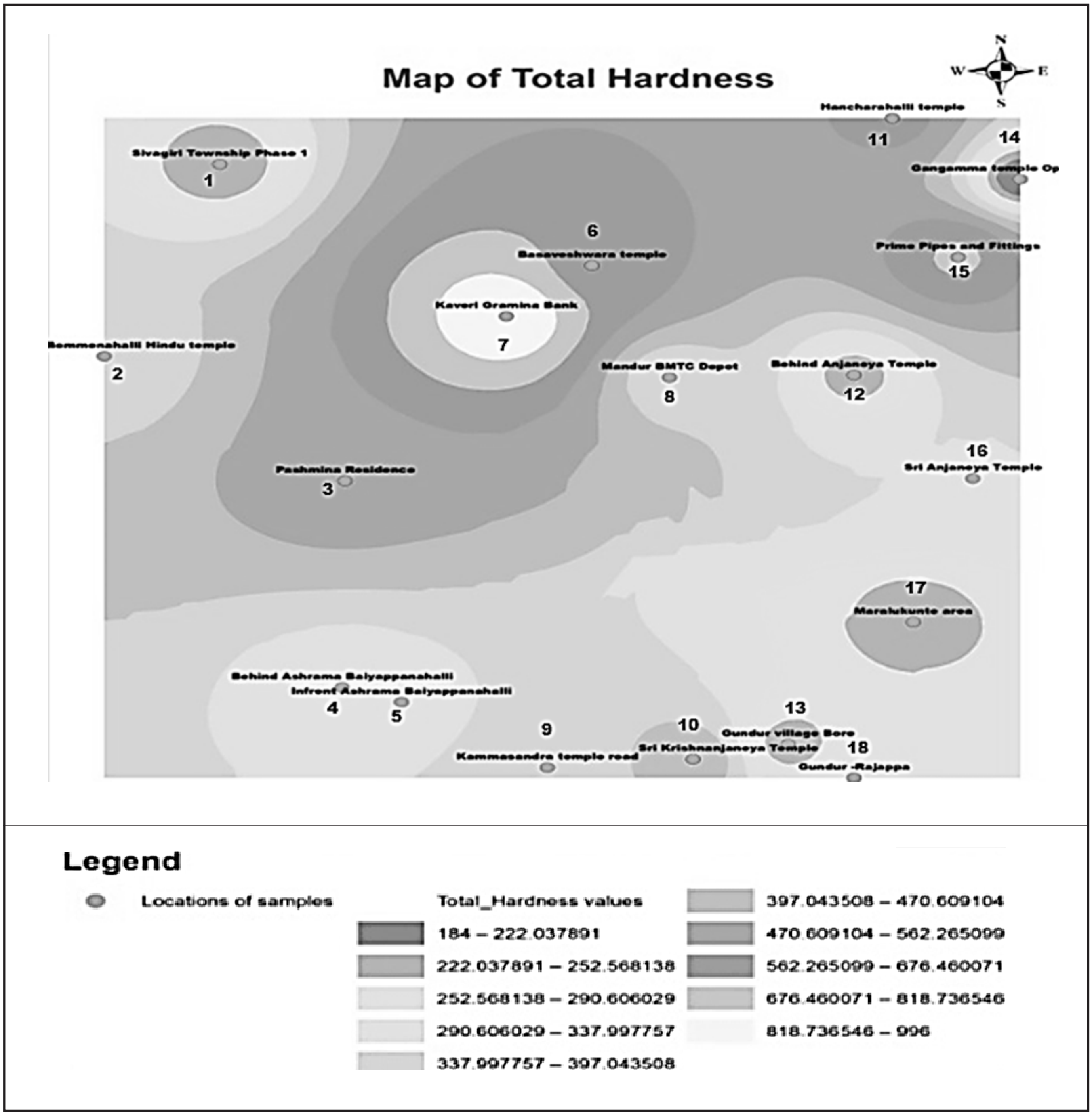

Fig. 3(iii). Map of Total Hardness

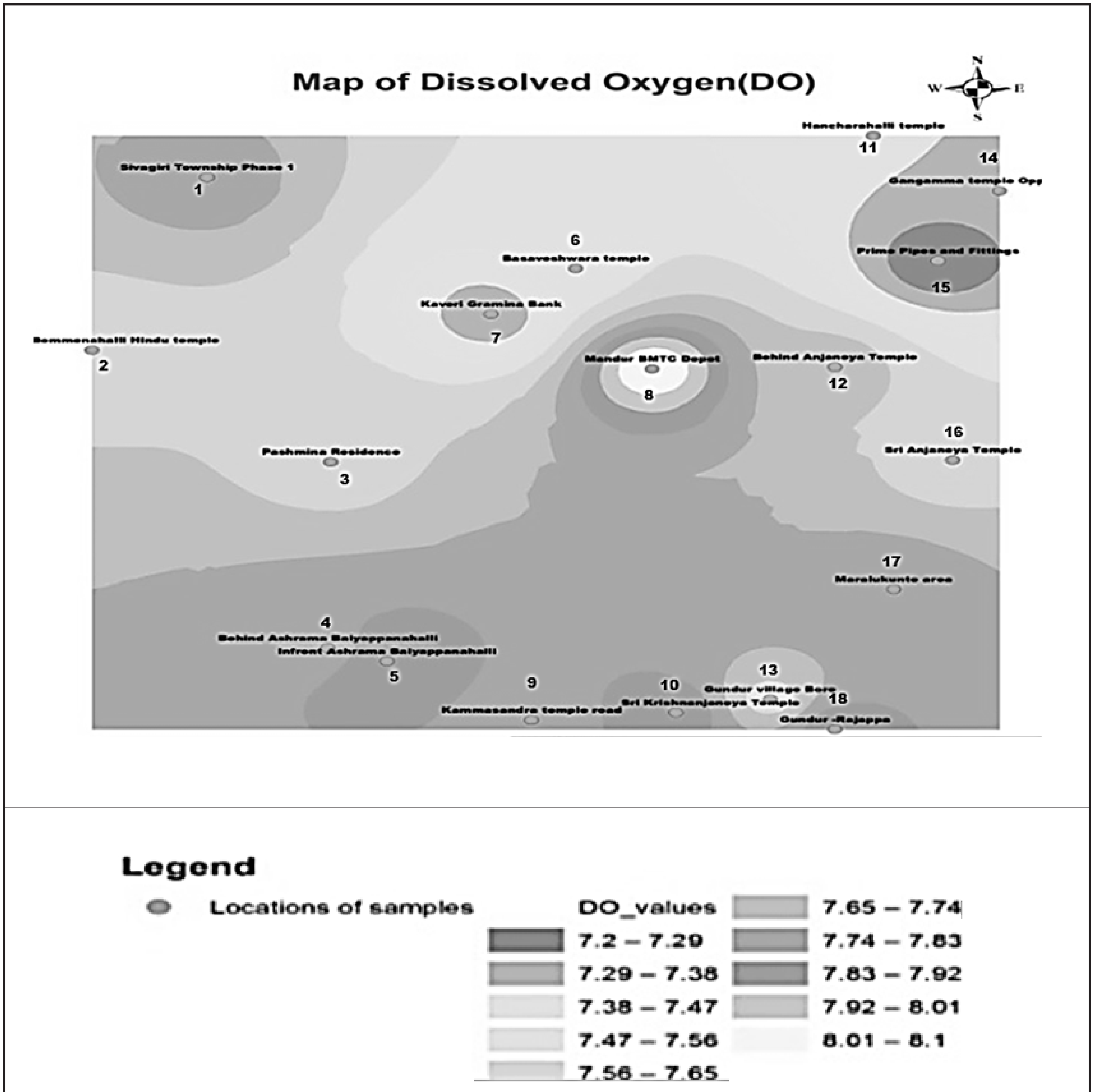

Fig. 3(iv). Map of Dissolved Oxygen

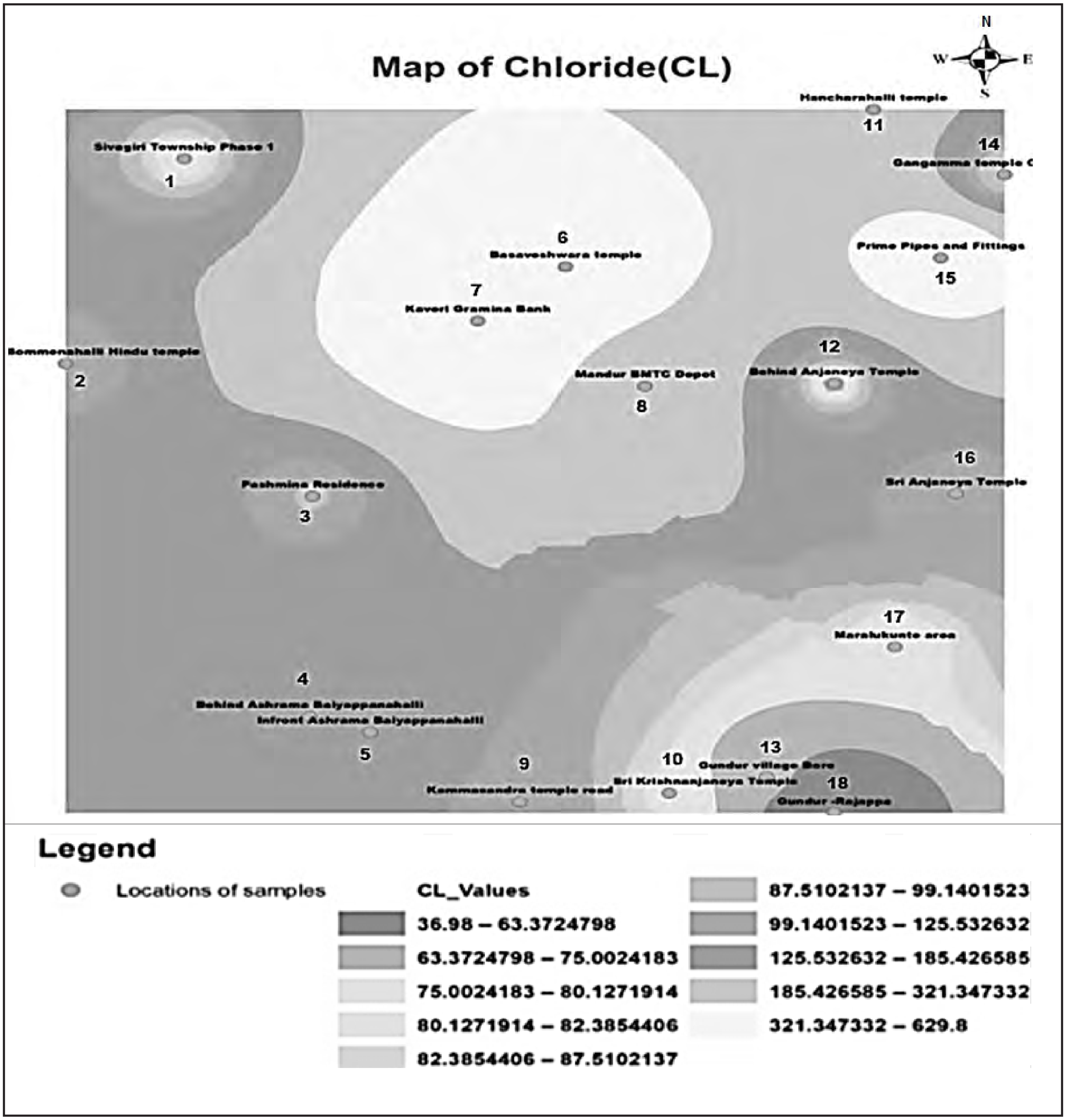

Fig. 3(v). Map of Chloride

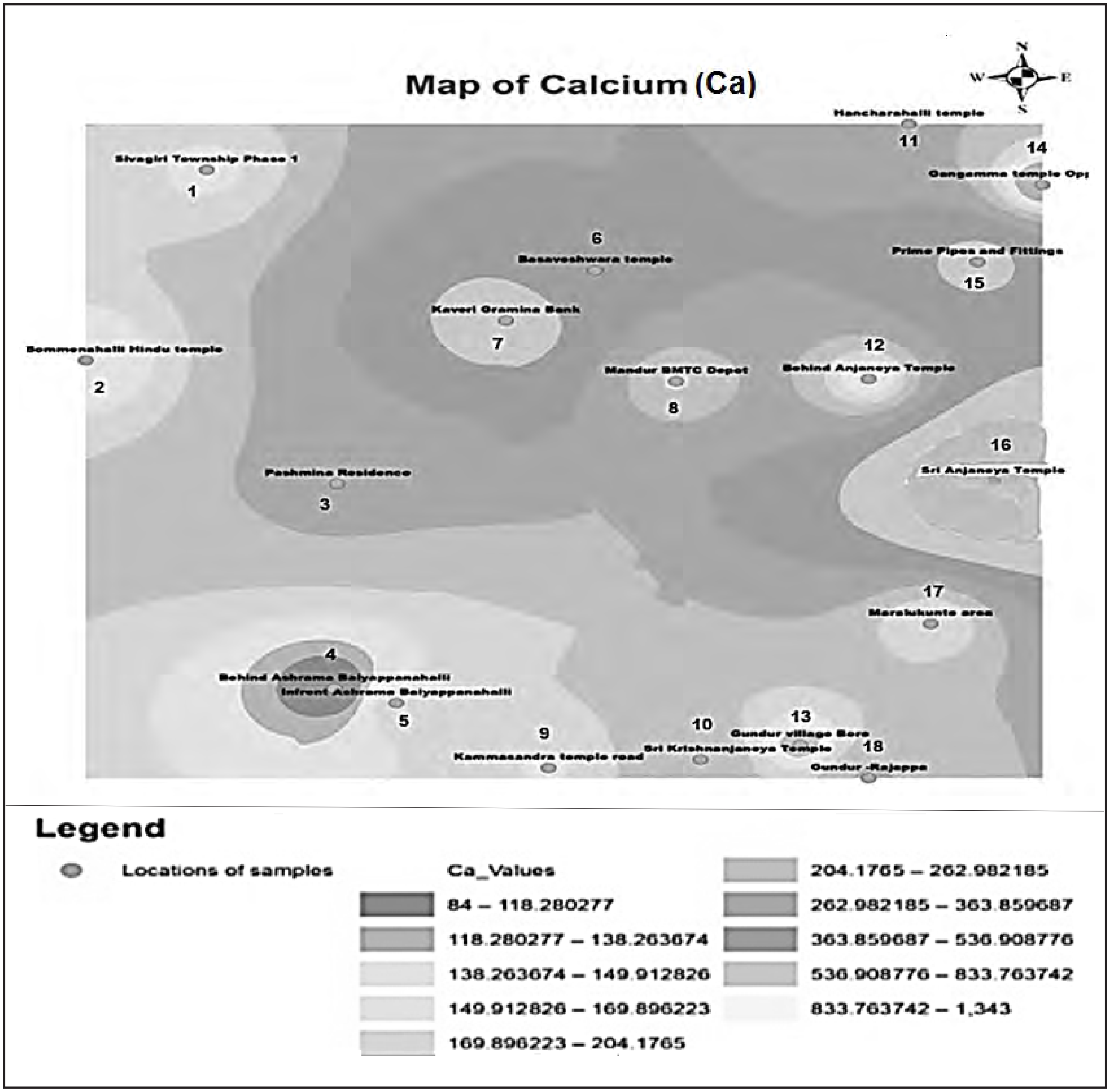

Fig. 3(vi). Map of Calcium

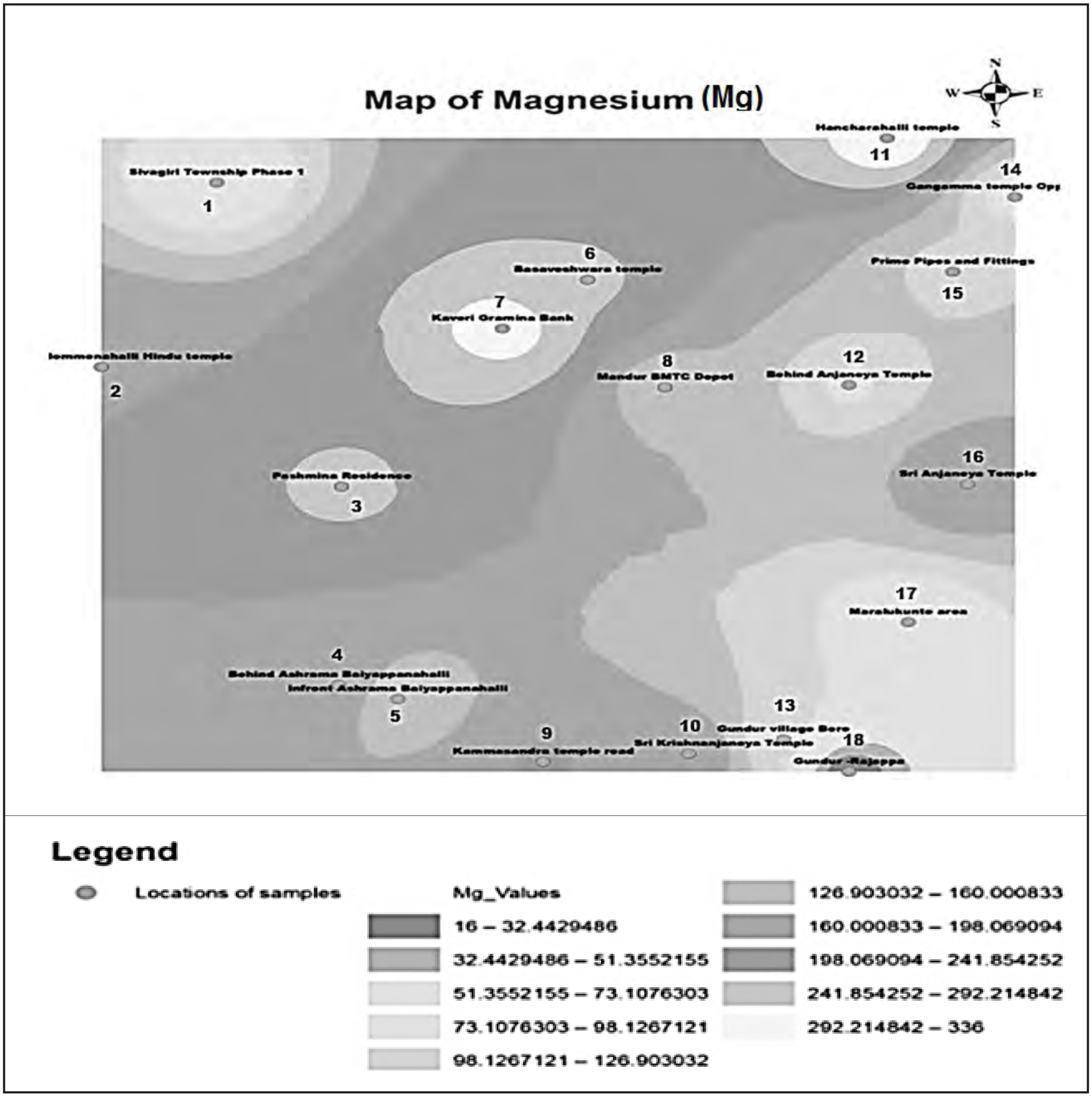

Fig. 3(vii). Map of Magnesium

V. CONCLUSION

In this study, GIS technology is used to analyze water quality and to prepare ground water quality maps in and around Mandur waste dumping site. The water quality parameters are analyzed for better understanding and are represented using spatial analysis tools of ArcGIS software. The spatial distribution of interpolated maps for the parameters pH, alkalinity, dissolved oxygen, calcium, chloride, magnesium, and total hardness during the year 2020 have been discussed in this paper. The Inverse Distance weighted (IDW) maps prepared shows the spatial distribution of water quality parameters considered in the study using GIS techniques which facilitate identifying potential zones of drinking water quality. Out of the 18 samples analyzed only, 7 samples were found to be potable, rest water samples can be used after proper treatment.

AUTHORS' CONTRIBUTION

Professor Geena George and Professor Shobha N. V. developed the idea of conducting water quality analysis near the Mandur Waste Dumping yard and mapping using ArcGIS software. The water quality analysis was carried out by Prof. Geena George and Prof. Shobha N. V. developed the spatial distribution of interpolated maps for the parameters studied. Both the authors worked on the manuscript.

CONFLICT OF INTEREST

The authors certify that they have no affiliations with any organization with any financial or non-financial interest in the subject matter discussed in this manuscript.

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