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Research Article

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Spatial Interpolation of Groundwater Quality for Drinking and Irrigation Purpose from Degloor Tahsil Maharashtra, India

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ABSTRACT

Degloor Tahsil is situated on Lendi River, Manjra River and Mannyar River and also it is a largest tahsil in Nanded District. In this tahsil most of the population is dependent on agriculture and use groundwater as source for drinking and irrigation purpose. In this region there are three forms of rocks like granite, basalt and intertrappen also have geological features like dyke, fault and fracture.

The attempt has been made to understand the groundwater quality for drinking and irrigation use by using water quality index and different irrigation water suitability indices from Degloor region. Total 35 representative groundwater samples have been collected from borewells on monthly basis during August 2017 to July 2018. To evaluate groundwater pollution physico-chemical parameter were analyzed. The physico-chemical parameters pH, EC, TS, TH, Ca, Mg, Na, K, TA, Cl, NO_3 *and* SO_4 *have been analysed. The obtained results were compared with BIS (2012). After evaluation of groundwater samples it was observed that the contents EC, TS, TH, Ca and* NO_3 *show its majority in groundwater samples but according to water quality index (WQI) 97.15% of groundwater samples fall in suitable category for drinking. Majority of groundwater samples using SAR, %Na, RSC, MH and PI method from study area fall in suitable category for irrigation purpose.*

Keywords: *Groundwater Hydrochemistry, Water quality index, Drinking Suitability, Irrigation Suitability, BIS.*

INTRODUCTION

Groundwater is most important natural resource for drinking and irrigation purpose (Kumar & Ahmad, 2003). Water available in ground, surface and spring are the main source for people. Environmental factors and climatic condition affects the quality and quantity of water which is an essential resource for domestic, agriculture and commercial use (Bansal & Dwivedi, 2018, Patil et al., 2018, Patil & Bhosle, 2018, Patil & Bhosle, 2018). The precipitation is the major source of groundwater which gets infiltrate in ground and maintains groundwater table (Patel et al., 2016, Raju, 2007).

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Groundwater contains more mineral composition than surface water. Human activities, improper waste disposals and poor agricultural land use management are the reasons to increasing threats in groundwater contamination (Shigut et al., 2017, Sharma & Chhipa, 2013, Achary, 2014). Excess use of chemical fertilizers and pesticides in irrigation after precipitation which percolate in aquifers and lead to groundwater contamination (Abdul et al., 2012, Mukate et al., 2015).

The aim of present study is to determine the groundwater quality for drinking purpose by using BIS standard limit and water quality index (WQI) and groundwater quality for irrigation by using SAR, %Na, RSC, MH and PI methods. The different spatial distribution of maps is prepared to evaluate the spatial variations in groundwater (Paliwal, 1972, Richard, 1954, Wilcox, 1955).

MATERIALS AND METHODS

Study Area:

It is discussed that the Degloor tahsil is one of the biggest tahsil in Nanded District, Maharashtra. Study area lies between $18^0$20'0" N to $18^0$40'0" N latitude and $77^0$20'0" E to $77^0$20'0"E longitude (Fig 1). The total population in this tahsil is about 173,369. In this tahsil irrigation is an economical source where many type of grains are produced. Due to change in environmental condition there is no proper precipitation in this region so people in this region use groundwater as direct source for drinking and irrigation purpose. The geological conditions revel that the granite is found in northeast region, basalt is found in south region and intertrappen bed is covered about 0.3 percent and also in this region three types of soil patterns are seen like shallow, moderate and deep soil.

Groundwater Sampling:

Random sampling method is used for groundwater sampling. Total 35 groundwater samples were collected from different sites that cover maximum study area (Fig 1). Groundwater sampling was done on monthly basis for one year from August-2017 to July-2018 to observe monthly variations in groundwater as shown in (Fig 2). The samples were collected in pre-cleaned polyethylene bottles with systematic labeling and precaution was taken to avoid other contaminations. After sampling samples were transferred to laboratory for chemical analysis.

Methodology:

The pH value of samples were analysed by using pH meter, Total Solids (TS) and Electrical Conductivity (EC) value was analysed by using EC and TS meter by calibrating 1413 standard. Total Hardness (TH), Calcium (Ca), Magnesium (Mg), Total Alkalinity (TA) and Chloride (Cl) were analysed by using titration method. Sodium and potassium was analysed by using flame photometer. Nitrate was analysed on UV Spectrophotometer using multiwavelength of 220 and 275 and Sulphate was also analysed on UV Spectrophotometer by precipitate method using 420 wavelength (Achary, 2014). The suitability of groundwater for drinking is based in standard limits given by (BIS) water quality index (WQI) and suitability of groundwater for irrigation is based on the concentration of cations and anions present in groundwater (BIS, 2012). The SAR, %Na, RSC, MH and PI plays vital role to determine groundwater suitability for irrigation (Paliwal, 1972, Richard, 1954, Wilcox, 1955).

RESULT AND DISCUSSION

It is necessary to understand the quality and quantity of groundwater used by humans for different purposes. Samples were collected from different locations from study area to evaluate hydrochemical characteristics (Table 1).

Groundwater quality for drinking purpose:

pH: The pH value of groundwater range from 7.3 to 7.8 with mean value that indicates the most of the samples show its alkaline nature. According to the standard limit given by BIS all samples are within permissible limit. pH values have no direct effect on health but it effects chemical constituents present in water (Fig 3).

EC: The EC value of groundwater ranged from 2167.2 to 2947.6 μS/cm with mean value that indicates most of the samples show their presence in above permissible limit. EC signify the amount of total dissolved salts in groundwater which indicates the inorganic load of water (Fig 4).

TS: The TS value of groundwater ranged from 1603.9 to 3213.5 mg/L with mean value that indicates majority of the sample show its presence in above permissible limit and some of the samples show its presence within permissible limit. TS are the sum of all cations and anions present in water (Fig 5).

TH: The TH value of groundwater ranged from 445.9 to 866.3 mg/L with mean value that indicates majority of the samples are above permissible limit and few sample shows its presence within permissible limit. The measurement of hardness is very necessary for domestic and industrial application point of view because it causes lather formation in boilers (Fig 6).

Ca and Mg: The Ca value of groundwater ranged from 262.1 to 370.9 mg/L with mean value which are above permissible limit. Calcium has on harmful effect on human health. Mg value of groundwater ranged from 2.8 to 11.6 mg/L with mean value which are within permissible limit (Fig 7, Fig 8).

Na and K: The Na value of groundwater ranged from 43.3 to 64.0 mg/L with mean value and the K value of groundwater ranged from 2.3 to 8.5 mg/L with mean value which indicate that Na and K are within permissible limit. The higher concentration of sodium and potassium increases due to the leaching of fertilizers applied to crops (Fig 9, Fig 10).

TA: The TA value of groundwater ranged from 241.3 to 398.8 mg/L with mean value show its presence within permissible limit. The total alkalinity is basically dissolved minerals in the water that help neutralize the water we drink (Fig 11).

Cl: The Cl value of groundwater ranged from 319.7 to 782.3 mg/L with mean value show its presence within permissible limit. Chloride in surface and groundwater sources from both natural and anthropogenic sources such as run off containing road de-icing salts, the use of inorganic fertilizers, landfill leachate, septic tank effluents, animal feeds, industrial effluents and irrigation drainage (Fig 12).

NO_3^-: The NO_3^- value of groundwater ranged from 60.8 to 122.2 mg/L with mean value most of the samples show its presence within permissible limit and few samples show its presence in above permissible limit. In natural groundwater nitrate is very low but its concentration increases due to human activities such as agricultural, industry, domestic effluents and emissions from combustion engines (Fig 13).

SO_4^{-2}: The SO_4^{-2} value of groundwater ranged from 48.7 to 78.8 mg/L with mean value show its presence within permissible limit. Sulphate is a naturally occurring ion in almost all kinds of water bodies and plays important role in total hardness of water (Fig 14).

Water Quality Index:

The standards prescribed by BIS have been considered for calculation of WQI. WQI is classified in three steps. Assigned the weight (wi) to each parameters such as pH, EC, TS, TH, Ca, Mg, Na, K, TA, Cl, NO_3^- and SO_4^{-2} according to its relative importance in overall quality of water for human consumption. Compute the relative weight (Wi) of each parameter using Eq.1. A quality rating scale (qi) for each parameter is computed by dividing its concentration in each water sample by its respect standard according to the guidelines given by BIS (2012) and the obtained result was multiplied by 100 using Eq. 2 (BIS, 2012). (Table 2).

$$W_i = \frac{w_i}{\sum_{n=1}^{n} w_i}$$ ……………Eq.1

$$q_i = \left(\frac{C_i}{S_i}\right)100$$ ……………Eq.2

Where, Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters.

Where, qi is quality rating, Ci is concentration of each chemical parameter in each water sample in mg/L.

$$\mathrm{SI} = \mathrm{Wiqi}$$ ……………Eq.3

$$\mathrm{WQI} = \sum_{i=1}^{n} \mathrm{SI}_i$$ ……………Eq.4

Where, SIi is the sub-index of ith parameter; qi is the rating based on concentration of ith parameter and n is the number of parameters.

After using WQI method it is revealed that all 97.15 samples shown their presence in good category and suitable for drinking purpose and 2.85 % samples show its presence in poor category (Table 3).

Groundwater quality for irrigation purpose:

SAR: SAR is an important parameter to determine groundwater suitability for irrigation purpose. A sodium hazard is briefly expressed as SAR which determines the sodium, calcium and magnesium concentration from groundwater. As the ratio increases, it affects the cationic exchange capacity of soil where the replacement of Ca and Mg is done by sodium which harms the structure of soil and makes compact and impervious soil. The value of SAR ranged from 3.10 to 5.01 meq/L. obtained results shows that all samples are suitable for irrigation. According to the Richards classification water shows its suitability for irrigation is showed in (Paliwal, 1972). (Table 4).

%Na: It is also one of the important method to determine the groundwater suitability for irrigation. Because if there is increase in sodium concentration then there is increase in hardness and decreases the soil permeability. In this study area %Na value ranged from 11.35 to 17.93 are in suitable category for irrigation. According to Wilcox classification all samples shows its suitability for irrigation (Trivedi, & Goel, 1998). (Table 5).

RSC: Residual sodium carbonate is an index of to determine water suitability for irrigation which indicates alkalinity hazards in soil. When dissolved sodium in comparison with dissolved calcium and magnesium is high in water, clay soil swells which reduce the infertility capacity of soil. Obtained results indicate that ranged from -88.87 to 65.80 meq/L which indicates that 51.43% of samples are in good category, 2.58% samples are in doubtful category and 45.72% of samples are in unsuitable category (Trivedi, & Goel, 1998). (Table 6).

MH: The magnesium hazards from study are ranged from 0.19 to 3.91 that shows 100% of samples are suitable for irrigation. This method is to determine magnesium hazards from groundwater (Patel et al., 2016). (Table 7).

PI: Longtime use of groundwater affects the permeability of soil. If calcium, total solids, magnesium, sodium and bicarbonates are in higher concentration then it effects the permeability of soil. The obtained results revel that all samples in suitable category (Doneen, 1948). (Table 8).

Table 1: Geographical locations of groundwater samples

Sr. No	GW Sampling Sites	Latitude	Longitude	Village Name
1	**S1**	18°39'13.28"N	77°42'23.81"E	Shevala
2	**S2**	18°36'52.98"N	77°43'33.72"E	Shelgaon
3	**S3**	18°38'19.48"N	77°40'17.70"E	Alur
4	**S4**	18°35'22.23"N	77°43'1.36"E	Tamlur
5	**S5**	18°33'44.68"N	77°43'10.76"E	Sangvi Umar
6	**S6**	18°33'55.34"N	77°39'56.63"E	Narangal Bk
7	**S7**	18°36'27.56"N	77°38'2.15"E	Shahapur
8	**S8**	18°33'11.65"N	77°37'57.66"E	Hanuman Hipparga
9	**S9**	18°34'57.80"N	77°36'47.37"E	Chainpur
10	**S10**	18°35'41.65"N	77°35'54.26"E	Antapur
11	**S11**	18°37'27.09"N	77°35'34.08"E	Wannali
12	**S12**	18°39'1.23"N	77°33'40.27"E	Sugaon
13	**S13**	18°36'7.07"N	77°34'22.69"E	Khanapur
14	**S14**	18°33'30.46"N	77°34'44.52"E	Degloor
15	**S15**	18°35'30.22"N	77°30'59.01"E	Tadkhel
16	**S16**	18°32'54.34"N	77°30'30.20"E	Kavalgadda
17	**S17**	18°31'2.44"N	77°31'13.74"E	Kavalgaon
18	**S18**	18°30'20.25"N	77°32'26.97"E	Ballur
19	**S19**	18°29'43.50"N	77°35'6.27"E	Bhaktapur
20	**S20**	18°28'44.78"N	77°33'47.85"E	Hottal
21	**S21**	18°31'37.38"N	77°28'21.28"E	Bhokaskheda
22	**S22**	18°29'27.63"N	77°27'56.79"E	Amdapur
23	**S23**	18°28'39.36"N	77°29'40.73"E	Karadkhed
24	**S24**	18°27'3.64"N	77°33'50.88"E	Yergi
25	**S25**	18°24'46.84"N	77°31'54.04"E	Malegaon
26	**S26**	18°25'56.81"N	77°28'19.95"E	Markhel
27	**S27**	18°22'47.29"N	77°31'7.56"E	Martoli
28	**S28**	18°23'14.90"N	77°27'9.89"E	Loni
29	**S29**	18°21'32.37"N	77°27'25.11"E	Hanegaon
30	**S30**	18°19'31.39"N	77°23'42.72"E	Wazar
31	**S31**	18°19'51.27"N	77°26'12.88"E	Kamajiwadi
32	**S32**	18°19'44.96"N	77°29'19.07"E	Somur
33	**S33**	18°18'35.58"N	77°32'0.36"E	Manur Bk
34	**S34**	18°17'11.88"N	77°29'20.51"E	Yedur
35	**S35**	18°17'18.00"N	77°27'19.16"E	Bijalwadi

Table 2: Weight (wi) and calculated Relative Weight (Wi) for each parameter

Sr. No	Parameters	BIS Permissible limit	Weight (wi)	Relative Weight (Wi)
1	**pH**	8.5	3	0.089
2	**EC**	2000 μS/cm	5	0.122
3	**TDS**	2000 mg/L	3	0.093
4	**TH**	600 mg/L	4	0.117
5	**Ca**	200 mg/L	4	0.120
6	**Mg**	100 mg/L	1	0.028
7	**Cl**	1000 mg/L	3	0.078
8	**Na**	200 mg/L	2	0.054
9	**K**	30 mg/L	1	0.027
10	**TA**	600 mg/L	3	0.075
11	**SO_4**	400 mg/L	2	0.054
12	**NO_3**	100 mg/L	3	0.088
Total			**∑wi = 35**	**∑Wi = 1.00**

Table 3: Groundwater quality for drinking purpose using WQI

WQI Values	Category	Sample Numbers	Percentage
Below 50	**Excellent**	NIL	NIL
50 - 100	**Good**	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,26,27,28,29,30,31,32,33,34,35.	97.15
100 - 200	**Poor**	25	2.85
200 - 300	**Very Poor**	NIL	NIL
Above 300	**Unsuitable**	NIL	NIL

Table 4: Groundwater suitability for irrigation based on SAR

Rank	SAR	Quality	No. of Samples Aug-2017 to July-2018	% of Samples
1	**0 - 10**	**Excellent**	1 to 35	100 %
2	**10 - 20**	**Good**	Nil	Nil
3	**18 - 26**	**Fair**	Nil	Nil
4	**>26**	**Poor**	Nil	Nil

Table 5: Groundwater suitability for irrigation based on % Na

Rank	% Na	Quality	No. of Samples Aug-2017 to July-2018	% of Samples
1	**< 20**	**Excellent**	1 to 35	100 %
2	**20 - 40**	**Good**	Nil	Nil
3	**40 - 60**	**Permissible**	Nil	Nil
4	**60 - 80**	**Doubtful**	Nil	Nil
5	**80 - 100**	**Unsuitable**	Nil	Nil

Table 6: Groundwater suitability for irrigation based on RSC

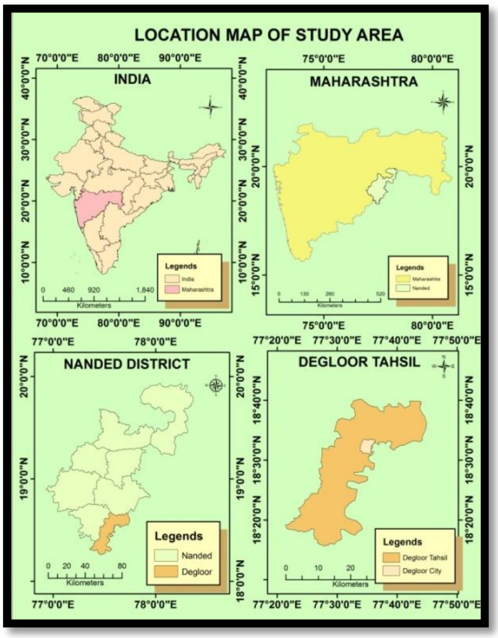
Rank	RSC	Quality	No. of Samples Aug-2017 to July-2018	% of Samples
1	**< 1.25**	**Good**	2,3,6,7,9,10,11,12,15,23,24,25,26,27,30,31,34,35 = 18	51.43 %
2	**1.25-2.50**	**Doubtful**	19 = 1	2.85 %
3	**>2.50**	**Unsuitable**	1,4,5,8,13,14,16,17,18,20,21,22,28,29,32,33 = 16	45.72 %

Table 7: Groundwater suitability for irrigation based on MH

Rank	MH	Quality	No. of Samples Aug-2017 to July-2018	% of Samples
1	**< 50**	**Suitable**	1 to 35	100 %
2	**>50**	**Unsuitable**	Nil	Nil

Table 8: Doneen classification of groundwater for irrigation purpose

Rank	PI	Quality	No. of Samples Aug-2017 to July-2018	% of Samples
1	**< 80**	**Good**	1 to 35	100 %
2	**80-100**	**Moderate**	Nil	Nil
3	**100-200**	**Poor**	Nil	Nil



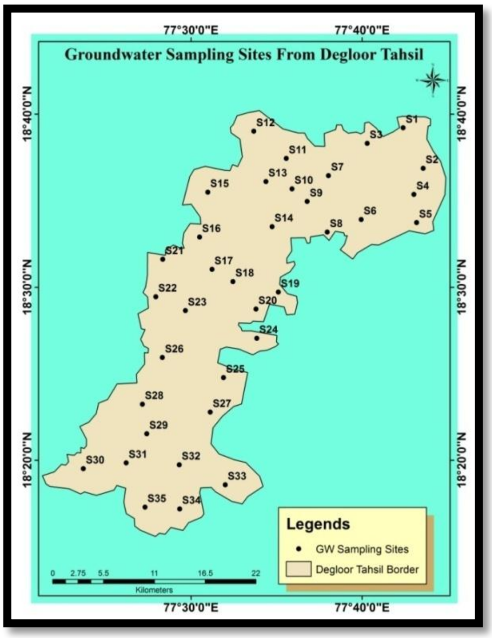
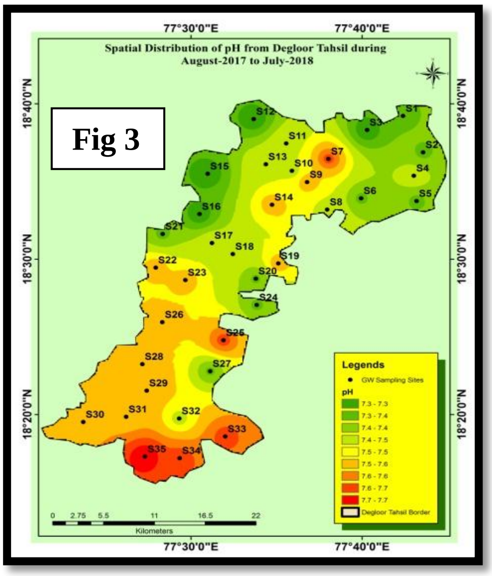
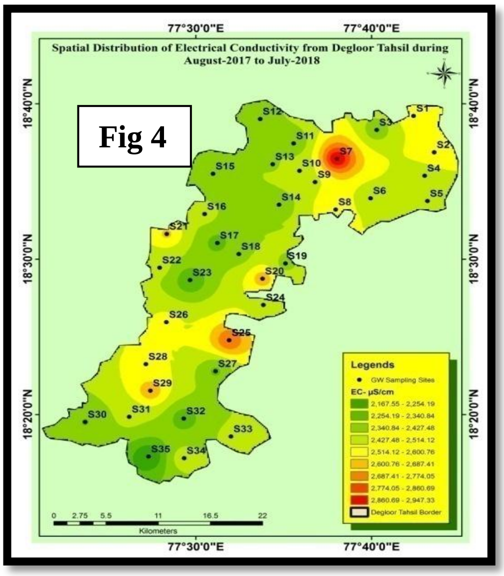
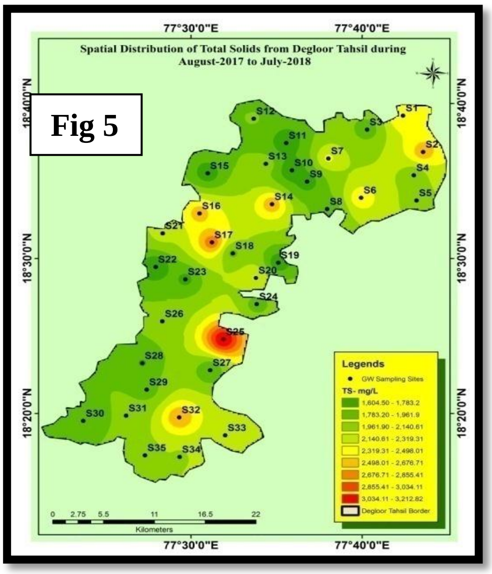
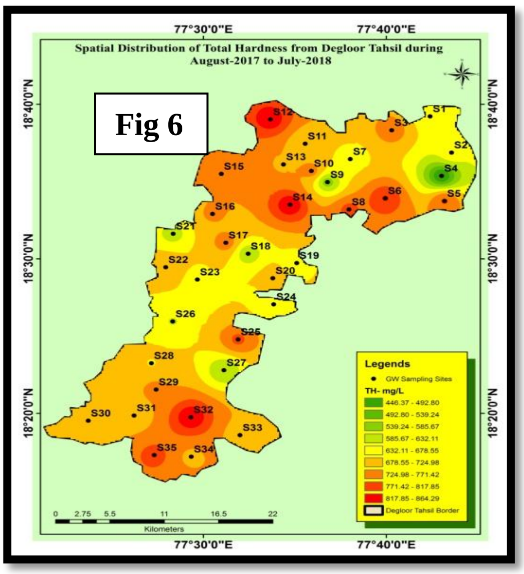


Fig. 1. Location map of study area. **Fig. 2. Groundwater sampling Locations.**









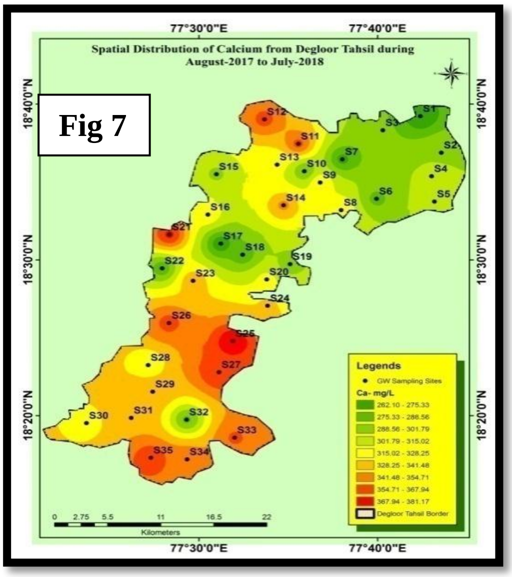


Fig 7

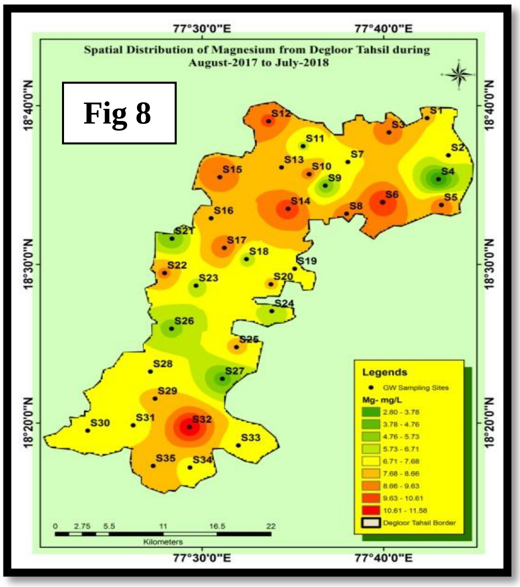


Fig 8

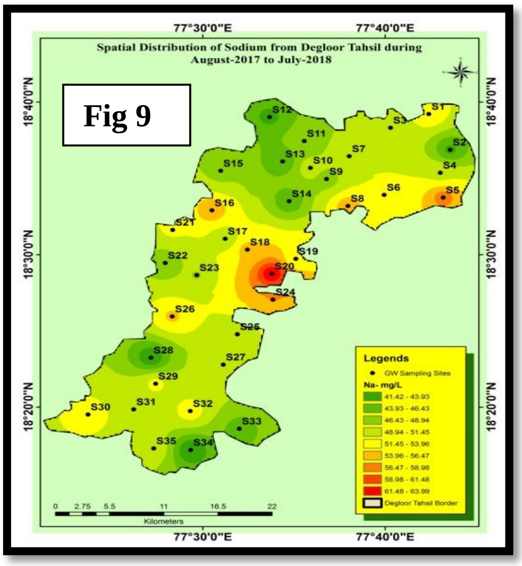


Fig 9

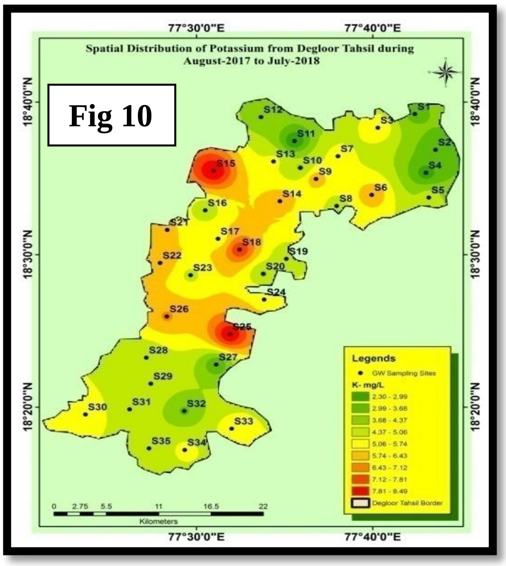
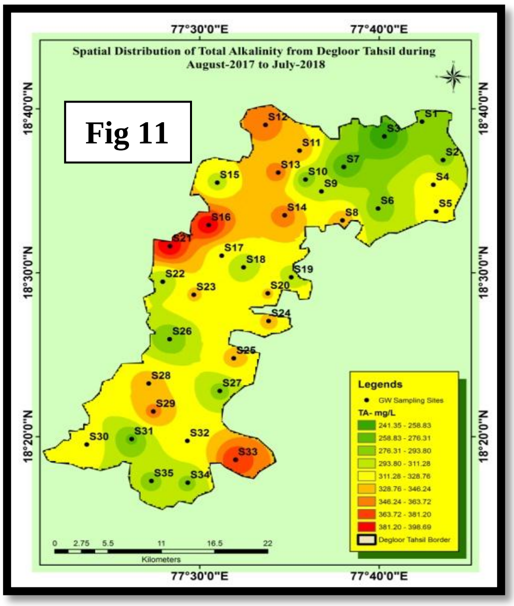


Fig 10



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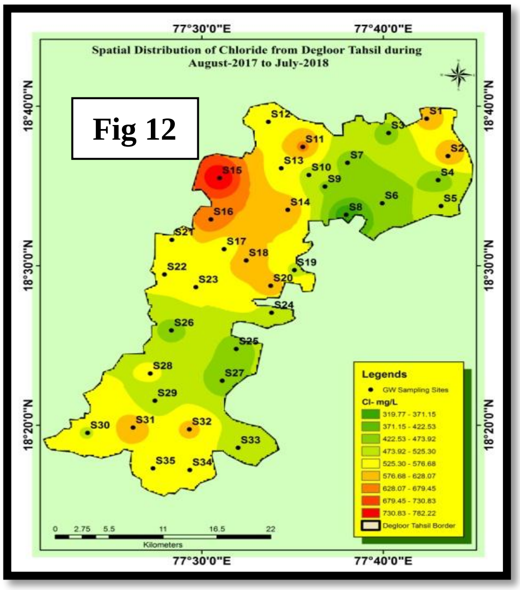

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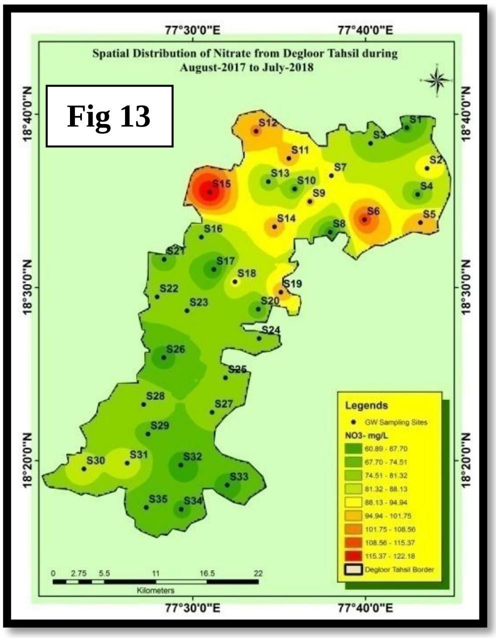

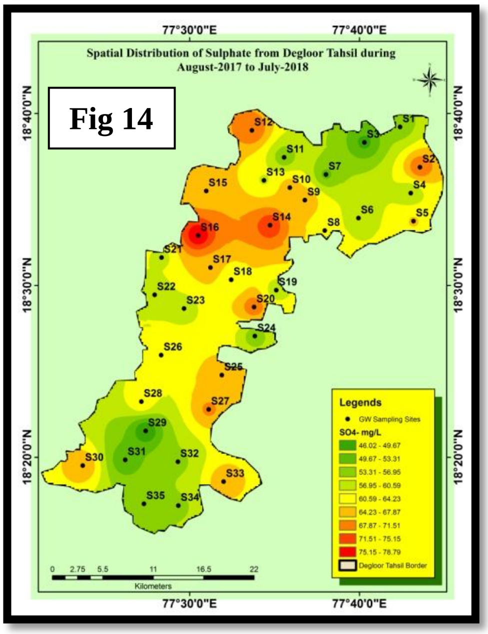

Figure 3 to 14. Showing Spatial distributio of physico-chemical parameters pH, EC, TS, TH, Ca, Mg, Na, K, TA, Cl, NO_3^- and SO_4^{-2}

CONCLUSION

The obtained results which are correlated with standard limit given by BIS (2012) which show that the groundwater quality inDegloor tahsil is suitable for drinking. But some of the patameter TDS, TH, Ca and NO_3^- show there higher concentration so somewere it indicate the way towards contamination. For irrigation suitability different methods used to show its suitability ane that revel that the groundwater is suitable for irrigation but still it is necessary to avoil contamination to protect groundwater pollution.

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