Groundwater Suitability for Drinking and Agricultural usage in MIDC Area Chakan, Pune

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Abstract - *The aim of this research is to carry out quality of water groundwater source as irrigation and drinking purpose. Ground water were collected from different location from bore well, hand pump and for drinking water different parameters like pH, TH, TDS, Cl^-, SO_4^{2+}, Fe, As, BOD, MPN, Cr_6^+, Cd, Hg, and F^-. After checking parameter, quality for irrigation suitability used for method like Sodium Adsorption Ratio (SAR), Soluble Sodium Ratio (SSR), Residual Sodium Carbonate (RSC). The result indicate that the groundwater is not ready for direct drinking with respect to TH, TDS, Cl^-, SO_4^{2+}, Fe and F^-. In some of the samples collected, the consolidation of these component increasing the permissible limits of the Standards for Drinking Water Quality of India. Based on TDS, 80% of water samples are good for drinking purpose and 75% of samples are ready for drinking purpose based on TH. Heavy metals such as, $Cr6^+$, Hg and Cd are well below the permitted limits. With these tests TDS, SAR, SSP, MAR, KR, Residual Mg^{2+}/Ca^{2+}ratio will find out the samples are suitable for irrigation and also Impact of polluted groundwater on plant and soil, animals and birds.*

***Key Words*: Groundwater quality, physic-chemical parameter, groundwater quality assessment, MIDC area Chakan.**

1. INTRODUCTION

Ground water is the major source of water for drinking, agricultural, and industrial desires. The availability of water find the location and activities of humans in an area and our increasing population is placing great demands upon natural fresh water resources. In recent year's humidity change and government regulation, the surface water applicable for drinking and irrigation is decreasing in MIDC area Chakan, and hence, groundwater is becoming more and more important for human and agriculture. Groundwater estimate for drinking and irrigation has become a needed and important project for present and future groundwater quality management. Groundwater is about 25% of the world resource of fresh water and widely used for various purposes. Only about 1% of all of fresh water is available from rivers, ponds, lakes. The quality of water depends upon various chemical constituents and their concentration generated by fertilizers, industrial waste, garbage or domestic waste. The groundwater analysis for physical and chemical properties is very important for Public Health Studies. These studies are also main part of pollution studies in the environment. According to WHO organization, about 80% of all the diseases in human beings are caused by water. The aim of this study is to determine the physico-chemical analysis of groundwater sources of MIDC area Chakan as compare with levels obtained from WHO drinking water directive.

2. MATERIALS AND METHODS

Sample collection and analysis-

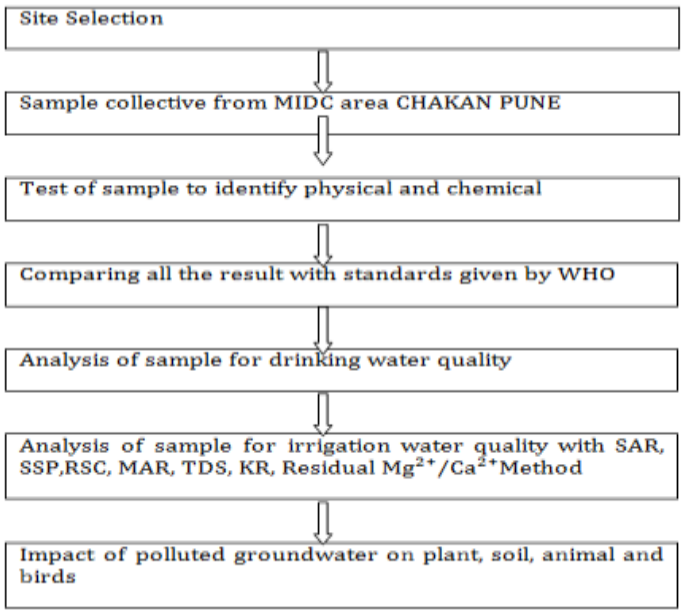
Chakan is situated in Pune district in Indian state of Maharashtra. Its co-ordinates are 18.75°N 73.85°E. It has an average elevation of 646 meter (2119feet) and lies at the bank of the Chakan River. Groundwater sample are randomly collected from areas around MIDC area Chakan. Total of 12 ground water sample were collected from bore well, hand pump. The groundwater sample were collected in cleaned and washed bottles and brought to the laboratory for analysis. The samples were analyzed for various water quality parameter viz. pH, Total Hardness, Fluoride, Chloride, Sodium, Carbonate, Bicarbonate, Phosphate, Sulphate, Iron, cadmium, Mercury, Chromium, Arsenic. The results were compared with WHO (world health organization)

Table 2.1: Sampling location and Sampling point

Sr.	Sampling location	Type of water	Sampling point
1	Phase I	Bore well	S1
2	Phase I	Bore well	S2
3	Phase I	Bore well	S3
4	Phase I	Bore well	S4
5	Phase II	Bore well	S5
6	Phase II	Hand pump	S6
7	Phase II	Bore well	S7
8	Phase II	Bore well	S8
9	Phase III	Hand pump	S9
10	Phase III	Bore well	S10
11	Phase III	Bore well	S11
12	Phase III	Bore well	S12

Methods-

Methodology flowchart



The important parameter for determination of soil alkalinity or alkali hazards in the use of ground water for agricultural function are:

SAR(Sodium Adsorption Ratio):

Irrigation water including large amount of sodium is special things due to sodium's effects on the soil and causes sodium hazard. Sodium hazard is usually show in terms of SAR (Sodium Adsorption Ratio). The two ions are important since they tend to counter the effect of sodium. For water containing significant amount of bicarbonate, the adjusted sodium adsorption ratio

(SAR_{adj}) is same time used. Continued use of water having a high SAR leads to reduce in the physical structure of the soil. The soil then becomes hard and compact when dry and more impervious to water penetration. SAR calculated from the ratio of sodium to calcium and magnesium. SAR expressed as follows:

$$SAR\text{-}\frac{Na^{2+}}{\sqrt{(Ca^{2+}+Mg^{2+})/2}}$$

Where all the ionic are expressed in meq/L.

SSP(Soluble Sodium Percent):

It is also evaluate sodium hazard. SSP is define as the ration of sodium in epm to the total cation epm multiplied by 100. SSP greater than 60 percent may result in sodium quantity that will cause reducing in the soil's physical properties. SSP expressed as follows:

$$SSP\text{-}\frac{\text{Soluble } Na^{2+} \text{concetration}}{\text{Total cation concetration}} x100$$

MAR(Magnesium Adsorption Ratio):

Generally, alkaline earths are in equilibrium state in surface water. If soils have more alkaline earths, they lower a crop yield.

$$MAR = \frac{Mg \times 100}{Ca + Mg}$$

Where all the ionic are expressed in meq/L.

KR (Kelly's ratio) :

Kelly's ration with values greater than 1 shows excess concentration of sodium; groundwater is suitable for irrigation with Kelly's ratio less than 1.Kelly's ratio is calculated using the following formula.

$$KR=Na+/(Ca^{2+} + Mg^{2+})$$

Where all the ionic are expressed in meq/L.

Residual Mg^{2+}/Ca^{2+}ratio:

It is very useful to find the suitability of groundwater for irrigation; groundwater can be classified as suitable or unsuitable on the basis of this residual ratio. The residual ratio was calculated using the following relation:

Residual Ratio = Mg^{2+}/Ca^{2+}

Where all the ionic are expressed in meq/L.

3. RESULTS AND DISCUSSIONS

Quality assessment for drinking:

All the water quality parameter will be checked in laboratory.

TDS is usually affected by topography, lithology of aquifer, recharge, runoff and discharge conditions of groundwater. It is an important parameter for determine groundwater quality.

According to WHO for Drinking Water Quality, the permissible value of TDS for drinking water is 500 mg/L. In this study, TDS in ranges 423-1264mg/L.

It can be seen from the below analysis that the groundwater in the region is moderately unsuitable for drinking without pretreatment. A graph was drawn to illustrate the distribution of TDS which is shown in Figure3.1.

Table 3.1: Methods used to determine physicochemical parameters along with WHO standards.

Sr. no	Physicochemical Parameters	Method/Instrument Used	WHO Standards (1993)
1	pH	pHmeter	6.5 to 8.5
2	Electrical Conductivity	Conductometer`	250
3	Total hardness	Titration	300
4	TDS	Digital meter	500
5	Fluoride	Titration	1.5
6	Sulphate	Titration	250
7	Chloride	Titration	250
8	Iron	Atomic abortion Spectrophotometer	0.3
9	BOD	Titration	5.0
10	Arsenic	Atomic abortion Spectrophotometer	0.01
11	Chromium	Atomic abortion Spectrophotometer	0.05
12	Mercury	Atomic abortion Spectrophotometer	0.001
13	Cadmium	Atomic abortion Spectrophotometer	0.003

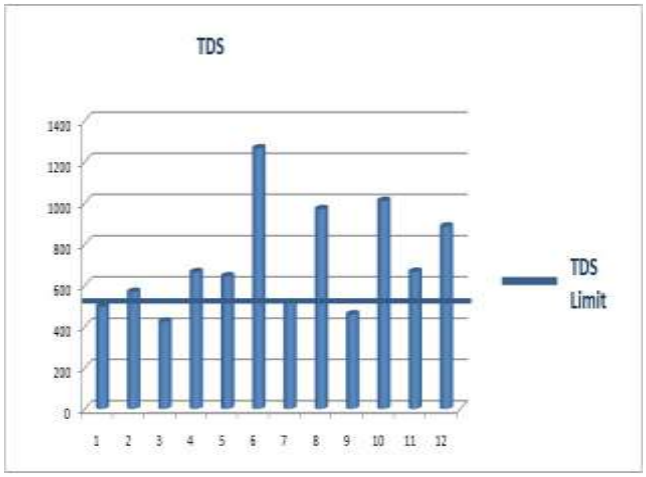


Fig.3.1: TDS distribution in study area.

Total hardness of water is a part of dissolved Ca and Mg in water expressed as CaCO3. According to the classify standards of TH, groundwater can be divided into soft water (61mg/L), moderately hard water (61-120mg/L), hard water (121-180mg/L), extremely hard water (180mg/L).

The permissible value of TH for drinking water is 200 mg/L. In this study, TDS in ranges 260-479 mg/L. A graph was drawn to the distribution of TH which is shown in Figure.3.2.

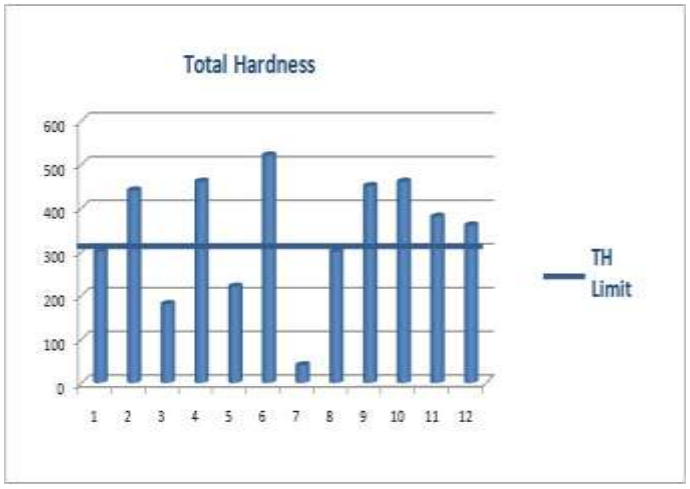


Fig.3.2: TH distribution in study area.

The permissible limit for Cl^- and SO_4^{2+} is 250mg/L. It can also been from the Table 1 that the combination of Cl^- and SO_4^{2+} are to degree beyond the permissible limits for drinking water. The Cl^- concentration varies from 192.2 to 410.1 mg/L water.

The SO_4^{2+} concentration for phreatic water varies from 236 to 372.4 mg/L. A graph was drawn to the distribution of Cl^- and SO_4^{2+} which is shown in Figure3.3. and Figure 3.4.

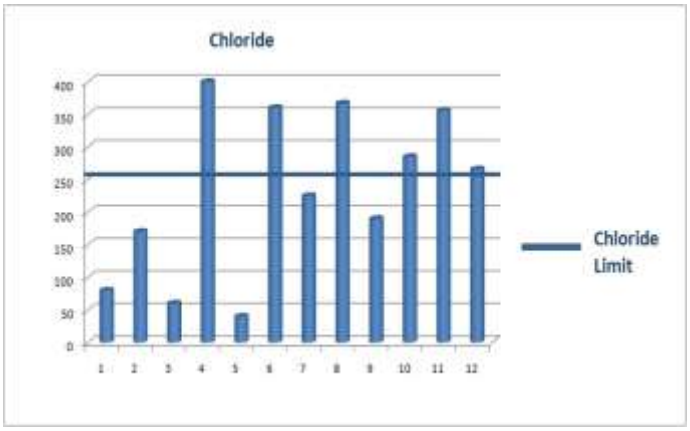


Fig.3.3:Cl^- distribution in study area.

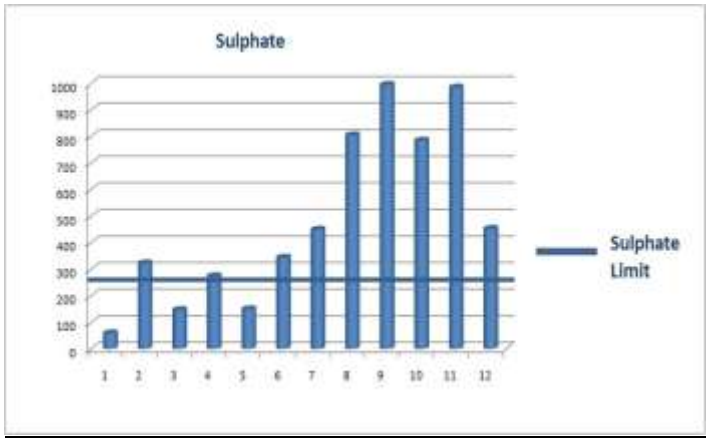


Fig.3.4:SO_4^{2+} distribution in study area.

Heavy metals, such as As, Cr^{6+}, Cd and Hg important roles in determining the groundwater quality. Many heavy metals are harmful to human body and can cause many serious diseases. well, all the heavy metals studied in the area are well below the

permissible limits which may not likely to cause those heavy metal induced diseases. The above analyses show that TDS, TH, Fe, F^-,Cl^- and SO_4^{2+} are the main chemical parameters affect the groundwater quality. This may be apply to the chemical plants and waste residue sites in the area. The wastes from these type of pollution sources infiltrate into groundwater with rainfall and the polluted the groundwater.

Parameter	WHO standers	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
PH	6.5 to 8.5	7.67	7.60	7.73	7.47	7.87	7.0	7.87	7.52	7.78	7.43	7.89	7.5
EC	250	93	590	375	827	411	891	398	616	366	628	213	525
TH	300	300	440	180	460	220	520	40	300	450	460	380	360
TDS	500	496	567.3	423	663	643	1264	516	969	458	1009	665	885
F	1.5	2.0	1.4	1.9	1.2	2.2	1.3	1.8	2.1	1.4	1.6	2.6	2.3
SO	250	60	323.3	147.5	275	150.2	344.5	450	805	995	785	985	453
CI	250	80	170	60	400	40	360	225	367	190	285	356	266
Fe	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
BOD	5.0	11.8	9.8	10.2	5.4	8.7	15.6	4.5	12.8	6.5	18.5	13.6	15
MPN	-	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800	>1800
As	0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cr	0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Hg	0.001	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Cd	0.003	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Analysis results of different chemical constituents of collected samples used for drinking usage were presented in **Table3.2:**

Quality assessment for Irrigation:

The irrigation water quality depends on the part of the minerals present in the groundwater. The concentration of dissolved salts, magnesium and relative proportion of sodium to calcium are the important chemical constituents, which affect the water quality for irrigation.

In this study, important irrigation water quality parameters, namely sodium adsorption ratio (SAR), soluble sodium percent (SSP), Kelly's ratio (KR), Total dissolve solids(TDS), magnesium adsorption ratio (MAR) and residual Mg^{2+}/Ca^{2+} ratio. The calculation of all these parameters was carried by ionic concentration (meq/l). The calculated values of all parameter are given below the Table 3.3.

Sodium adsorption ratio (SAR):

The calculated values of SAR are given in Table 4.2.4.SAR varied from 0.29 to 1.05. According to the classification of SAR in the study area, Table 4.2.4 showed that all the samples of SAR had excellent water class and it is acceptable for irrigation in the study area.

Soluble sodium percent (SSP):

SSP was calculated using above equation and its values are given in Table 4.2.4. It ranged from 14.45 to 31.97. It was observed in Table 4.2.4showed that all the samples of SAR had Suitable water class and it is acceptable for irrigation in the study area.

Magnesium adsorption ratio (MAR):

MAR values were calculated using equation. In the study area, MAR values ranged from 24.78 to 71.8.Table. 4.2.4. Hence, most of water samples are safe for irrigation water inthe study area.

Kelly's ratio (KR):

KR was calculated using equation and values are given in Table 5.2.4. In the study area, KR varied from 0.165 to 0.460 Table 4.2.4.Hence, overall groundwater quality is suitable for irrigation purpose.

Residual Mg^{2+}/Ca^{2+}ratio:

This ratio was calculated and values are given in Table 5.2.4. In the study area, it ranged from 0.329 to 4.938Table 5.2.4. According to the classification of residual ratio as given in Table 5.2.4. Hence, overall groundwater quality is Safe for irrigation purpose.

Total dissolve solid (TDS):

The TDS varies from 423 to 1264. The permissible value of TDS for drinking water is 500 mg/l. So, overall groundwater quality is Safe for irrigation purpose.

Assessment results and grading for irrigation purpose	Sample no.	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
	TDS	495	567.3	423	663	643	1264	561	969	458	1009	665	885
	Grading	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable
	SAR	0.785	0.835	0.731	0.496	0.905	0.452	0.675	0.294	0.899	0.848	0.732	0.706

	Grading	SSP	Grading	MAR	Grading	Mg^{2+}/Ca^{2+}	Grading	KR	Grading
	Excellent	26.47	Suitable	53.09	Suitable	1.132	Safe	0.348	Suitable
	Excellent	29.16	Suitable	50.24	Suitable	1.009	Safe	0.401	Suitable
	Excellent	26.78	Suitable	41.06	Suitable	0.696	Safe	0.362	Suitable
	Excellent	21.24	Suitable	34.11	Suitable	0.517	Safe	0.260	Suitable
	Excellent	31.59	Suitable	46.05	Suitable	0.853	Safe	0.454	Suitable
	Excellent	20.11	Suitable	31.51	Suitable	0.460	Safe	0.240	Suitable
	Excellent	25.79	Suitable	46.51	Suitable	0.869	Safe	0.338	Suitable
	Excellent	14.45	Suitable	24.8	Suitable	0.329	Safe	0.165	Suitable
	Excellent	31.97	Suitable	61.32	Suitable	1.585	Moderate	0.460	Suitable
	Excellent	30.03	Suitable	47.83	Suitable	0.917	Safe	0.424	Suitable
	Excellent	.28.99	Suitable	71.78	unsuitable	2.544	Moderate	0.399	Suitable
	Excellent	29.96	Suitable	83.16	unsuitable	4.938	Unsafe	0.423	Suitable

Analysis results of different chemical constituents of collected samples used for irrigation usage were presented in **Table3.3:**

4. CONCLUSIONS

- The groundwater quality was assessed for its drinking and irrigation suitability. This work has presented the levels of physicochemical parameters pH, TH, TDS, Cl^-, SO_4^{2+}, Fe, As, BOD, MPN, Cr_6^+, Cd, Hg, F, Na^+,Mg^{2+},K^+, and Cl^- in the bore water samples collected from MIDC area Chakan.
- According to the findings of this study, the groundwater in the study area is not ready for direct drinking with respect to TDS, TH, Fe, F ,Cl and SO4.
- The results obtained from the analysis of physico-chemical parameters for drinking purpose show that most of the parameters did not exceed the permissible limit set by the world Health Organization (WHO).
- Heavy metals such as As, Gr, Hg and Cd are well below the permissible limits.
- The study of irrigation water parameters such as sodium adsorption ratio (SAR), soluble sodium (SSP), Kelly's ratio (KR), and magnesium adsorption ratio (MAR), Residual Mg^{2+}/Ca^{2+}ratio show that overall groundwater quality in the study area is good for irrigation.This polluted groundwater impact on plant, soil, animal, birds.

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