# GEOCHEMICAL INVESTIGATION FOR GROUND WATER QUALITY AND IT'S SUITABILITY FOR DRINKING AND AGRICULTURAL USE OF SHIRPUR TALUKA IN DHULE DISTRICT, MAHARASHTRA STATE, INDIA

S. N. Patil[1], N. P. Marathe[2], S. T. Ingle[3]
School of Environmental and Earth Sciences, North Maharashtra University, Jalgaon, (M.S) India.

**Abstract**

**Water is major source for irrigation in the study area and it has extensive irrigation network. Groundwater is an important component of water resources for human existence and financial development in any regions of the world. Anthropogenic activities and environmental change have entailed considerable risk for groundwater quality. Thus the present studies were carried out for physico-chemical quality of groundwater with reference to their suitability for drinking and irrigation use. Total fifty four groundwater samples were collected and analyzed their physico-chemical characteristics such as pH, EC, TDS, alkalinity, total hardness, $Ca_2$+, $Mg_2$+, Na+, K+, Cl- , $SO_4$, $HCO_3$- and $NO_3$ to understand the sources of contaminant. Majority of water samples for irrigation suggesting low sodium and medium salinity hazards. The groundwater from the study area, few locations are not suitable for drinking purpose with suggestion to the concentrations of total dissolved solids, total hardness, Alkalinity, Ca and Mg; while most of the groundwater samples classify for suitable irrigation. In general, alkalinity, hardness, calcium and magnesium in the groundwater samples from the study area is exceed the permissible limit given by bureau of Indian standards. The permeability index of (94%) waters samples are considered to be good and suitable for irrigation. Based on the irrigation parameters (Sodium Adsorption Ratio, Permeability Index and Exchangeable Sodium Percentage), the groundwater quality is assessed and the overall irrigation qualities of wells are demarcated as suitable for irrigation except few locations.**

**Keywords: Groundwater, Water resources, Geochemistry, Irrigation, Drinking water.**

## 1. INTRODUCTION :

Ground water is an important resource on the planet earth for the survival of the human being and also for other variable uses. But last few decades the contamination of ground water increases day by day due to anthropogenic activity, so this is major problem for the society and therefore the related study of water contamination has become significant for mankind groundwater is contaminate due to excess use of chemical fertilizers, septic tank effluent, municipal waste, dumping ground, irrigation return flow. The number of worker in different environments in India has been carried out the water quality studies. However, no systematic study was assay to determine the groundwater quality in the shirpur taluka of Dhule district. The assessment of water resources and monitoring is very useful for sustainable development.

The present study is situated in northern part of Dhule district of Maharashtra State. The Tapi river bank site recognized for rich farming bestowal with Banana, Sugarcane and vegetables due to fertile alluvial soil, perennial water availability and suitable climate. The study area covers about 2364.53 $Km^2$. The major part of the study area is covered under Tapi basin. The area is bounded between Latitude 21° 17' N to 21° 24' N and Longitude 74° 42'E to 75° 09 E. The water sampling location map shown in fig.1 and water sampling locations are tabulated in table 1.

Geologically, major part of the study area is covers Deccan traps except a few strips of alluvium land on both the sides Tapi River (Marathe et. al., 2015). Deccan basalt covers 65 percent of the study area. These trap rocks are the result of outpouring of enormous lava flows which spread over hundreds of kilometers of Western, Central and Southern India to form a major part of the Deccan Plateau at the end of Mesozoic era.

Age of the Deccan trap is Upper Cretaceous to Lower Eocene. Alluvium layers are composed of yellowish brown sand, silt and clay with intercalation of gravel and with “kankar”. Alluvium covers an about 30 percent of the study area and is occupied by thick alluvium. It consist alternate layers of clay, silt, sand, gravels and boulders etc. Piedmont zone consists mainly of boulders admixed with pebbles, cobbles, gravels, sand, silt and clay in loose form. Piedmont zone covers 5 percent area under study.

Table 1: Stratigraphic succession of the study area (Source: Geological Survey of India, 2001)

| **Stratigraphic Status** | **Formation** | **Age** | **Lithology** |
|---|---|---|---|
| | | Recent | Black cotton soil, |
| | | Quaternary | River alluvium sands, gravels, silts and calcareous kankar. |
| | Dyke | | Basaltic, Doleritic and Gabbroic |
| **Satpura Group** (Deccan Trap) North of Tapi River | ---------- | Late Cretaceous to Palaeogene | Dark grey, medium grained, hard and compact, non porphyritic to porphyritic in nature with olivine phenocryst-- highly porphyritic with large plagioclase laths |
| **Sahyadri Group** (Deccan Trap) South of Tapi River | Upper Ratangarh | Late Cretaceous to Palaeogene | Dark grey, medium grained, hard and compact, non porphyritic to porphyritic in nature with olivine phenocryst |
| | Lower Ratangarh | | Dark grey, medium grained, hard and compact, highly porphyritic with large plagioclase laths 3-5 cm. |
| | Salher | | Dark grey, medium grained, hard and compact, highly porphyritic with large plagioclase laths upto5 cm – non porphyritic to porphyritic in nature. |

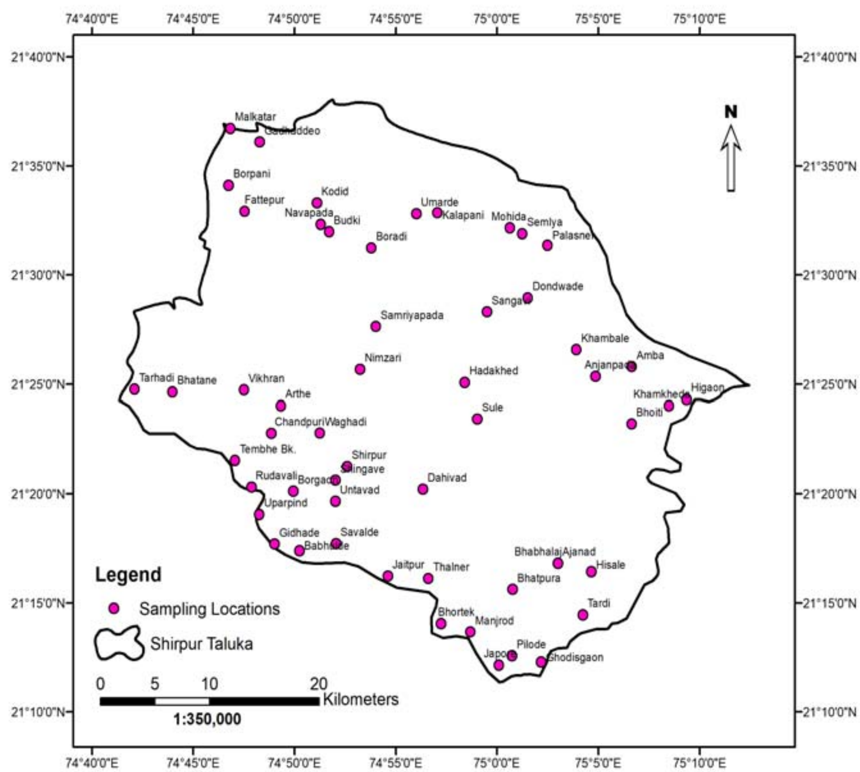
Table: 2. Water sampling locations of the study area

| Sr. No | Village | Source | Latitude | Longitude | Elevation in (M) |
|---|---|---|---|---|---|
| 1 | Babhulde | BW | N $21^0$17.39 | E $74^0$50.236 | 167 |
| 2 | Gidhade | BW | N $21^0$17.69 | E $74^0$49.018 | 155 |
| 3 | Uparpind | BW | N $21^0$19.053 | E $74^0$48.252 | 160 |
| 4 | Rudavali | BW | N $21^0$20.304 | E $74^0$47.881 | 155 |
| 5 | Chandpuri | BW | N $21^0$22.770 | E $74^0$48.852 | 150 |
| 6 | Arthe | BW | N $21^0$24.034 | E $74^0$49.325 | 167 |
| 7 | Tembhe Bk. | BW | N $21^0$21.53 | E $74^0$47.06 | 155 |
| 8 | Bhatane | BW | N $21^0$24.65 | E $74^0$43.98 | 156 |
| 9 | Tarhadi | BW | N $21^0$24.771 | E $74^0$42.095 | 146 |
| 10 | Vikhran | BW | N $21^0$24.74 | E $74^0$47.50 | 173 |
| 11 | Sangavi | DW | N $21^0$28.31 | E $74^0$59.51 | 235 |
| 12 | Hadakhed | DW | N $21^0$25.09 | E $74^0$58.40 | 215 |
| 13 | Fattepur | DW | N $21^0$32.918 | E $74^0$47.543 | 384 |
| 14 | Borpani | DW | N $21^0$34.122 | E $74^0$46.737 | 350 |
| 15 | Malkatar | DW | N $21^0$36.73 | E $74^0$46.831 | 321 |
| 16 | Sule | DW | N $21^0$23.42 | E $74^0$59.03 | 219 |
| 17 | Navapada | BW | N $21^0$32.335 | E $74^0$51.292 | 341 |
| 18 | Budki | DW | N $21^0$31.985 | E $74^0$51.714 | 321 |
| 19 | Boradi | DW | N $21^0$31.246 | E $74^0$53.798 | 308 |
| 20 | Umarde | BW | N $21^0$32.810 | E $74^0$56.009 | 334 |
| 21 | Gadhaddeo | BW | N $21^0$36.10 | E $74^0$48.28 | 338 |
| 22 | Untavad | BW | N $21^0$19.657 | E $74^0$52.013 | 166 |
| 23 | Shingave | BW | N $21^0$20.617 | E $74^0$52.015 | 168 |
| 24 | Borgaon | BW | N | E $74^0$49.934 | 147 |

| | | | | | |
|---|---|---|---|---|---|
| | | | $21^0$20.119 | | |
| 25 | Waghadi | BW | N $21^0$22.776 | E $74^0$51.255 | 168 |
| 26 | Shirpur | BW | N $21^0$21.250 | E $74^0$52.599 | 162 |
| 27 | Nimzari | BW | N $21^0$25.675 | E $74^0$53.235 | 226 |
| 28 | Samriyapada | DW | N $21^0$27.639 | E $74^0$54.013 | 240 |
| 29 | Bhoiti | BW | N $21^0$23.195 | E $75^0$06.651 | 267 |
| 30 | Khamkheda | DW | N $21^0$23.842 | E $74^0$08.660 | 266 |
| 31 | Higaon | BW | N $21^0$24.314 | E $75^0$09.351 | 265 |
| 32 | Amba | BW | N $21^0$25.796 | E $75^0$06.650 | 294 |
| 33 | Khambale | BW | N $21^0$26.40 | E $74^0$04.08 | 299 |
| 34 | Anjanpada | BW | N $21^0$25.360 | E $75^0$04.862 | 308 |
| 35 | Dondwade | BW | N $21^0$28.958 | E $75^0$01.519 | 269 |
| 36 | Kodid | BW | N $21^0$33.31 | E $74^0$51.11 | 343 |
| 37 | Dahivad | BW | N $21^0$20.21 | E $74^0$56.34 | 180 |
| 38 | Kalapani | DW | N $21^0$32.855 | E $74^0$57.056 | 346 |
| 39 | Mohida | DW | N $21^0$32.160 | E $75^0$00.632 | 294 |
| 40 | Semlya | DW | N $21^0$31.897 | E $75^0$01.243 | 297 |
| 41 | Palasner | BW | N $21^0$31.368 | E $75^0$02.497 | 292 |
| 42 | Ghodisgaon | BW | N $21^0$12.29 | E $75^0$02.18 | 165 |
| 43 | Savalde | BW | N $21^0$17.228 | E $75^0$52.958 | 155 |
| 44 | Jaitpur | BW | N $21^0$16.230 | E $74^0$54.603 | 160 |
| 45 | Thalner | BW | N $21^0$16.115 | E $74^0$56.600 | 161 |
| 46 | Bhortek | BW | N $21^0$03.869 | E $74^0$58.483 | 164 |
| 47 | Manjrod | BW | N $21^0$13.659 | E $74^0$58.689 | 165 |
| 48 | Japore | BW | N $21^0$12.918 | E $74^0$49.868 | 167 |
| 49 | Pilode | BW | N $21^0$12.569 | E $75^0$00.736 | 169 |

| | | | | | |
|---|---|---|---|---|---|
| 50 | Tardi | BW | N $21^{0}14.45$ | E $75^{0}04.230$ | 177 |
| 51 | Hisale | BW | N $21^{0}16.432$ | E $75^{0}04.658$ | 205 |
| 52 | Bhabhalaj | BW | N $21^{0}16.814$ | E $75^{0}03.002$ | 213 |
| 53 | Ajanad | BW | N $21^{0}16.814$ | E $75^{0}03.002$ | 213 |
| 54 | Bhatpura | BW | N $21^{0}15.612$ | E $75^{0}00.765$ | 178 |

Fig: 1. Location map of Water Sampling stations




## Methodology:

Analysis and processing of water sampling data by using standard techniques and procedures (APHA, 1998). Sampling of ground water is an important aspect in hydro chemical investigations. The selection of water sampling from wells by using random sampling techniques considering to present lithology, possible sites of contamination and shallow and deep aquifers. Total 54 water sampling sites are selected including 13 dug wells sites; 41 bore wells sites from the study area. The water samples collected in the month of April 2013 for analysis of various physico-chemical parameters. Plastic cans of 1 liter capacity were used for water samples collection, these plastic cans are first thoroughly washed with the water being sampled and then were filled, after that all water samples handled carefully to avoid the contamination. Sampling site locations are fixed by using Global Positioning System (GPS). The samples were brought to the laboratory for analysis of various water quality parameters.

The pH, EC and TDS of the samples was analysed by digital water analysis kit (Micro processor based ESICO make, Model no. 1160). Alkalinity and Total Hardness was determined by simple acid base titration method (APHA, 1998). In this method, hydroxyl ions represent in the sample as a result of dissociation or hydrolysis are determined by titration with strong acid like HCL using phenolphthalein and methyl orange as indicators used for respectively determination of phenolphthalein alkalinity and total alkalinity. Total Hardness (TH) and Ca++ is determined by standard EDTA Titrimetric method, $AgNO_3$ was used to estimate $Cl^-$ and magnesium determined by difference in total hardness and calcium titration by calculation method. Sulphate was analyzed by spectrophotometric method using ammonium molybedate and barium chloride solution at 420 nm. Concentration of Na and K present in water was determined by using Flame photometer, (APHA, 1998). Piper and USSL diagram were plotted using Aquachem (Version 2014.2) geo-scientific software.

**Results and Discussions:**

**Quality for drinking water:**

The comparison of water quality of the samples from the study area with the standards (BIS, 2003) is shown table 3. The data shows most of the water quality parameters are within the prescribed limits.

The BIS limit for pH, ranges from 6.5 to 8.5 for drinking water (Table.3), the water would affect the mucous membrane when the pH beyond this limit (Rao et.al, 2012). The pH values range from 6.8 to 8.2 collected samples area under study. All the water samples are potable for drinking. The TDS concentration in the study area range from 187 to 1071 mg/L. All water sample, 19 (35%) are not potable for drinking because cross the desirable limit 500 mg/L. (BIS, 2003). The Total Hardness of all water samples in the study area range from 94 to 573 mg/L. The desirable limit for drinking water of total hardness is 300 mg/L. As per results, 15 (28%) water samples are not suitable for drinking purpose. Calcium and Magnesium ions and their compounds account to the hardness of water.

The desirable limit of BIS for alkalinity is 200 mg/L. as per results, 42 (78%) water samples are beyond this limit, this water samples are not potable for drinking. The alkalinity values of water samples range from 61 to 579 mg/L.

Table 3: Physicochemical parameter of water samples from the area under study

| Sr No | pH | EC | TDS | TH | TA | Ca | Mg | Na | K | Cl | SO4 | CO3 | HCO3 | $NO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/L | | | | | | | | | | | |
| 1 | 7.7 | 604 | 386 | 249 | 334 | 46 | 34 | 59 | 0.3 | 32 | 1.41 | 51 | 283 | 9 |
| 2 | 7.9 | 498 | 318 | 247 | 278 | 50.3 | 29.1 | 26.7 | 0.4 | 27.4 | 2.74 | 37 | 241 | 6.2 |
| 3 | 7.6 | 887 | 564 | 362 | 387 | 45.7 | 59.3 | 65.4 | 0.2 | 76.2 | 8.3 | 102 | 285 | 9.7 |
| 4 | 8.2 | 1220 | 839 | 573 | 579 | 42.3 | 113.1 | 107.3 | 1.3 | 138.3 | 18.4 | 108 | 471 | 25.3 |
| 5 | 7.9 | 969 | 618.4 | 179 | 281.3 | 25.6 | 26.7 | 87.6 | 2.1 | 60.8 | 8.4 | 76 | 205.3 | 11.3 |
| 6 | 7.7 | 704 | 452 | 267 | 289 | 79.2 | 19.2 | 56.5 | 0.4 | 62.7 | 4.45 | 72 | 217 | 4.9 |
| 7 | 7.5 | 774 | 502 | 247 | 136 | 50 | 28 | 45 | 0.8 | 148 | 38 | 32 | 104 | 31 |
| 8 | 7.45 | 1632 | 1060 | 523 | 285 | 83 | 76 | 167 | 1.4 | 358 | 89 | 57 | 228 | 40 |
| 9 | 8.1 | 1098 | 708 | 196 | 435.6 | 35.2 | 14.9 | 34.8 | 1.8 | 29.2 | 8.3 | 124 | 311.6 | 9.2 |
| 10 | 7.8 | 1043 | 669 | 398 | 494 | 51.5 | 65.8 | 107.4 | 0.3 | 87.6 | 14.9 | 84 | 410 | 18.2 |
| 11 | 7.4 | 591 | 385 | 182 | 265 | 36 | 23 | 72 | 0.5 | 82 | 30 | 26 | 239 | 27 |
| 12 | 7.5 | 907 | 589 | 263 | 239 | 38 | 40 | 112 | 2.3 | 152 | 42 | 35 | 204 | 58 |
| 13 | 7.4 | 336 | 227 | 99 | 61 | 31 | 8.1 | 28 | 0.1 | 68 | 30 | 21 | 40 | 4 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 7.9 | 587 | 315.9 | 274 | 349.2 | 74.8 | 21.9 | 57.2 | 0.5 | 39.8 | 1.8 | 18 | 331.2 | 3.89 |
| 15 | 7.7 | 646 | 412 | 279 | 301.2 | 48.2 | 34.6 | 41 | 1 | 49.1 | 1.26 | 51 | 250.2 | 4.28 |
| 16 | 7.8 | 534 | 347 | 216 | 273 | 53 | 20 | 94 | 3.8 | 110 | 18 | 42 | 231 | 24 |
| 17 | 7.4 | 630 | 409 | 160 | 121 | 36 | 17 | 89 | 0.1 | 106 | 21 | 22 | 99 | 78 |
| 18 | 7.9 | 502 | 321 | 249 | 279.8 | 51.6 | 32.9 | 25.9 | 0.2 | 26.8 | 9.2 | 32 | 247.8 | 8.7 |
| 19 | 7.45 | 1645 | 1071 | 535 | 356 | 120 | 56 | 256 | 65.1 | 406 | 30 | 24 | 332 | 84 |
| 20 | 7.45 | 752 | 486 | 210 | 98 | 56 | 19 | 89 | 0.1 | 183 | 31 | 19 | 79 | 28.2 |
| 21 | 7.8 | 1023 | 665 | 297 | 203 | 63 | 31 | 107 | 0.1 | 208 | 67 | 24 | 179 | 38 |
| 22 | 7.6 | 597 | 380 | 298 | 284 | 61 | 32 | 34 | 0.2 | 51.1 | 6.8 | 38 | 246 | 6.8 |
| 23 | 7.3 | 957 | 608 | 278 | 365 | 39.9 | 42.7 | 61.5 | 0.1 | 45.8 | 5.3 | 67 | 298 | 6.1 |
| 24 | 7.5 | 963 | 614 | 283 | 344 | 41.8 | 42.3 | 61.7 | 0.9 | 45 | 7.9 | 47 | 297 | 14.3 |
| 25 | 7.7 | 754 | 490 | 235 | 206 | 57 | 23 | 90 | 0.2 | 140 | 63 | 26 | 180 | 6 |
| 26 | 6.8 | 290 | 187 | 94 | 221 | 17 | 14 | 56 | 3 | 26 | 16 | 30 | 191 | 10 |
| 27 | 7.34 | 381 | 247 | 115 | 92 | 22 | 16 | 30 | 0.1 | 58.2 | 27 | 26 | 66 | 35 |
| 28 | 7.7 | 471 | 300.1 | 259 | 260.2 | 57.9 | 27.1 | 21.9 | 0.4 | 38.1 | 1.68 | 21 | 239.2 | 5.8 |
| 29 | 7.6 | 689 | 439.6 | 387 | 391 | 64.8 | 34.1 | 36.2 | 0.4 | 50.1 | 4.6 | 103 | 288 | 5.3 |
| 30 | 7.2 | 472 | 308 | 161 | 93 | 37 | 20 | 51 | 0.1 | 105 | 27 | 18 | 75 | 53 |
| 31 | 7.4 | 623 | 403 | 214 | 115 | 38 | 29 | 49 | 0.1 | 123 | 34 | 23 | 92 | 16 |
| 32 | 7.6 | 1530 | 997 | 374 | 358 | 120 | 20 | 126 | 4.9 | 290 | 36 | 69 | 289 | 27 |
| 33 | 7.3 | 627 | 403 | 236 | 122 | 39 | 34 | 50 | 1.3 | 119 | 37 | 27 | 95 | 40 |
| 34 | 7.9 | 590 | 376.1 | 240 | 296.4 | 63.8 | 17.9 | 46.9 | 0.1 | 41.1 | 3.9 | 50 | 246.4 | 8.3 |
| 35 | 7.8 | 496 | 321 | 281 | 270.2 | 51.2 | 32.4 | 22.9 | 0.5 | 33.7 | 8.7 | 41 | 229.2 | 6.32 |
| 36 | 7.5 | 545 | 353 | 165 | 136 | 38 | 18 | 72 | 0.1 | 104 | 31 | 17 | 119 | 43 |
| 37 | 7.4 | 626 | 405 | 215 | 285 | 49 | 24 | 63 | 3 | 73 | 35 | 32 | 253 | 39 |
| 38 | 7.8 | 651 | 496 | 308 | 280 | 52.1 | 28.3 | 25.1 | 0.4 | 27.1 | 37 | 38 | 242 | 6.7 |
| 39 | 7 | 1092 | 706 | 340 | 207 | 63 | 42 | 109 | 0.1 | 223 | 67 | 28 | 179 | 35 |
| 40 | 7.9 | 500 | 313 | 251 | 281.1 | 52.4 | 28.7 | 25.4 | 0.4 | 26.1 | 21 | 36 | 245.1 | 5.2 |
| 41 | 7.3 | 1479 | 962 | 485 | 426 | 61 | 79 | 215 | 77 | 300 | 22 | 59 | 367 | 82 |
| 42 | 8 | 574 | 371 | 154 | 122 | 35 | 18 | 70 | 0.1 | 101 | 27 | 19 | 103 | 25 |
| 43 | 7.5 | 820 | 545 | 405 | 331 | 60.1 | 61.4 | 69.7 | 0.1 | 81.1 | 8.1 | 49 | 282 | 15 |
| 44 | 7.7 | 903 | 580 | 534 | 345 | 51.6 | 54.3 | 41.2 | 0.2 | 37.2 | 13.3 | 41 | 304 | 10.2 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | 7.8 | 706 | 530 | 270 | 381 | 76 | 29 | 48 | 0.1 | 105 | 22.6 | 71 | 310 | 41 |
| 46 | 7.5 | 673 | 483 | 391 | 375.6 | 86 | 22 | 30.1 | 0.3 | 24.2 | 11.7 | 67 | 308.6 | 9.1 |
| 47 | 7.2 | 497 | 338 | 351 | 280.1 | 51.1 | 19 | 37.4 | 0.2 | 40.3 | 9.3 | 43 | 237.1 | 6.4 |
| 48 | 7.7 | 536 | 398 | 235 | 269 | 49.7 | 23 | 41 | 0.4 | 59.6 | 7.4 | 52 | 217 | 5.8 |
| 49 | 7.5 | 636 | 533 | 358 | 345 | 42.5 | 41.9 | 58.3 | 0.2 | 46.3 | 6.4 | 45 | 300 | 13.3 |
| 50 | 7.7 | 596 | 387 | 198 | 87 | 52 | 19 | 63 | 0.1 | 139 | 32.4 | 37 | 50 | 41 |
| 51 | 7.6 | 470 | 300 | 256 | 269.2 | 58.2 | 26.4 | 22.3 | 0.4 | 38.1 | 1.68 | 28 | 241.2 | 5.8 |
| 52 | 7.6 | 421 | 268.3 | 276 | 282.8 | 52.4 | 33.5 | 21.4 | 0.2 | 30.9 | 2.38 | 63 | 219.2 | 5.2 |
| 53 | 8.1 | 723 | 469 | 245 | 194 | 58 | 26 | 72 | 0.1 | 167 | 53 | 23 | 171 | 19 |
| 54 | 7.8 | 500 | 323 | 249 | 273.8 | 52.5 | 33.1 | 23.8 | 0.5 | 34.5 | 22.4 | 43 | 230.8 | 6.3 |
| **Min** | **6.8** | **290** | **187** | **94** | **61** | **17** | **8.1** | **21.4** | **0.1** | **24.2** | **1.26** | **17** | **40** | **3.89** |
| **Max** | **8.2** | **1645** | **1071** | **573** | **579** | **120** | **113.1** | **256** | **77** | **406** | **89** | **124** | **471** | **84** |
| **Avg.** | **7.609** | **740.2** | **484.7** | **280.4** | **270.9** | **53.1** | **32.975** | **66.15** | **3.31** | **97.674** | **21.939** | **45.074** | **225.91** | **21.79** |
| **Des.Limit** | **6.5-8.5** | **1400** | **500** | **300** | **200** | **75** | **30** | **250** | **10** | **250** | **200** | **0** | **300** | **45** |

The concentration of Ca in the study area range from 17 to 120 mg/L. (11%) of the water samples exceed limit of 75 mg/L. The major source of Ca in the water is due to weathering of silicate minerals such as plagioclase in basalt and ion exchange of minerals from the rocks in this study area. The concentration of Mg range from 8.1 to 113.1 mg/L. Mg concentration in most of the water samples (43%) are exceeds the desirable limit of 30 mg/L. (BIS, 2003). The concentration of Na+ ions vary from 21.4 to 256 mg/L. The concentration of Na+ in all water samples are within the limit except, 01 water samples are beyond the limit. The BIS standard for Na is 250 mg/L. Na is one of the naturally occurring cation in water. It occurs as Na+ ion in dilute water with total dissolve solid values below 1000 mg/L. (Karanth, 1987). The concentration of K+ ions in ground water is very low as compared to Na. K is contributed in the water through excess use of mineral matter and fertilizers (potash) in agricultural land (Ravikumar and Venkatesharaju, 2010).

Concentration increases in the polluted water due to disposal of waste water (Murhekar, 2011). The $HCO_3^-$ concentration ranges from 40 to 471 mg/L. with an average of 225 mg/L. $HCO_3^-$ are exceeds in (16%) water samples than desirable limit. The BIS limit of $HCO_3^-$ is 300 mg/L. The $SO_4$ concentration range from 1.26 to 89 mg/L, with an average value of 21.9 mg/L. The BIS limit for $SO_4$ is 200 mg/L. and all water samples within the limit. The $Cl^-$ concentration range from 24.2 to 406 mg/L, averaging 65 mg/L. All the water samples have $Cl^-$ concentration within the limit of 250 mg/L, except 4 samples (Sample Id- 8, 19, 32 and 41). $Cl^-$ in water may be due to agricultural runoff, septic tank effluents, animal feeds and industrial effluents.

### Quality for Irrigation Purposes:

Water is major source to the irrigation. Crop cultivation is thoroughly depending on the water, for this the quality of water is analyzed to ascertain whether the water can be used for irrigation purpose or not. The irrigation water quality parameters are representing in Table 4.

The water quality for irrigation depends on soil, cropping practices, runoff, topography and climate. Important chemical parameters that affect the suitability of water for irrigation are total dissolved solids, relative proportion of Na and Mg, Ca, salinity and alkalinity (Golekar et. al., 2017).

The assessment of ground water quality to irrigation purpose is very useful in the future for water resources management. Different parameters have been used to assess suitability of water for as irrigation such, SAR (Sodium Adsorption Ratio), KR (Kelly's ratio), Na % (Sodium Percent), RSC (Residual Sodium Carbonate), PI (Permeability Index), SSP (Soluble Sodium Percentage) and ESP (Exchangeable Sodium Percentage). There are several methods for irrigation water quality assessment. Sodium Adsorption Ratio (SAR) is probably the most popular one used over the world. It is calculated from the ratio of sodium to calcium and magnesium. The equation is expressed as follows (Richards, 1954).

**Sodium Absorption Ratio (SAR):**

SAR is express as,

$$SAR = \frac{Na}{\sqrt{(Ca+mg)/2}}$$

Where, all the ions are expressed in meq/L

Classification of water and soil with reference to the SAR (Raghunath, 1987), all samples of the study area range from 0.56 to 4.83 for (pre monsoon 2013) suggests that the all water falls under excellent category because if ratio less than 10 it is very good quality of irrigation purposes and which indicate that, the irrigation with these water could not induce high sodium hazard. The calculated SAR values have been depicted in Table 4.

**Residual Sodium carbonate (RSC):**

The values for RSC is calculated as per Eaton, (1950)

$$RSC= (CO_3 + HCO_3) - (Ca+ Mg)$$

All values expressed in meq/L.

The water having excess of CO3- and HCO3- concentration over the Ca++ and Mg++ in excess of limits and there are unfavorable effects on agriculture (Raghunath, 1987; Eaton, 1950). Lloyd and Heathcote (1985) have classified irrigation water based on RSC as suitable (<1.25), marginal (1.25 to 2.5) and not suitable (> 2.5). The RSC values from study area ranges from - 4.75 to 6.25 for pre monsoon 2013 suggesting that the 34 of the water samples fall under suitable type, 15 water sample fall under the suitable to marginal type and 5 water samples have crossed RSC values of 2.5 are not suitable may be due to intense chemical weathering.

**Kelly's ratio (KR):**

Kelly's ratio is expressed as

$$\text{Kelly's Ratio} = \frac{Na}{Ca+mg}$$

The Kelly's ratio (Kelly et. al, 1940) is calculated and if the ratio more than 1 the water is not suitable for irrigation and it is because of alkali hazards. The Kelley's ratio values also could be seen in Table 4, from the table it could be seen that, the KR values of water samples in the area under study ranges from 0.17 to 1.21. Most of the water samples of the study area show ratio values less than 1 suggesting suitable for the agricultural except, at location Chandpuri (5), Navapada (17), Boradi (19) and Shirpur (26).

**Sodium percentage (Na %):**

Sodium concentration is an important measure for defining the type of irrigation. The Sodium percentage is calculated as per Doneen (1961),

Sodium Na % = (Na × 100) / (Ca + Mg)

$$\frac{Na \times 100}{ca+mg}$$

Where all ionic concentration expressed in meq/l

Sodium Percentage (Na %) is also a useful indicator for determining the suitability of water for agricultural uses. (Na %) is defined as the ratio of sodium to the total cations in meq/L. Water with % Na greater than 60 may result in sodium accumulations that will cause a breakdown in the soil's physical properties (Golekar et al., 2014). Sodium percentage in pre monsoon (2013) varies from 14.75 % to 54.75 %. According to Na % groundwater has classified as excellent (< 20%), good (20%-40%) and permissible (40% - 60%) some doubtful (60%-80%). The Na % in 11 samples (<20%) category, which are fall under Excellent quality. 28 water samples (20%-40%) category, which fall under good quality, except 15 water samples (40%-60%) category, were belongs to permissible quality.

**Soluble Sodium Percentage (SSP):**

The soluble sodium percentage calculated by using following formula, where the concentration is expressed in meq/l.

$$SSP = \frac{Na \times 100}{Ca + Mg + Na}$$

The values of SSP less than 50 indicate good quality of water and higher values suggest unsatisfactory quality of water for irrigation (USDA, 1954). It is observed that, the SSP values are more than 50 in samples number 5, 17, 19 and 26 are unsatisfactory water quality for irrigation. Remaining all water samples values have less than 50, which suggest good quality of water for irrigation.

**Permeability Index (PI):**

The soil permeability is affected by long term use of irrigation water and is influenced by sodium, calcium, magnesium and bicarbonate contents of the soil. The Permeability Index (PI) was calculated according to Doneen (1961) employing the following equation, Where all ionic concentration expressed in meq/l

$$PI = \frac{Na + \sqrt{HCO3}}{Ca + Mg + Na} \times 100$$

The classification of the PI is suggested as (Doneen, 1961):

(i) The permeability index of the water from the study area ranges between 44.8 and 94.8.

(ii) Class I (>75%): waters are considered to be excellent and suitable for irrigation.

(iii) Class II (25-75 %): waters are considered to be good and suitable for irrigation.

(iv)Class III (<25%): water is unsuitable for irrigation.

According to PI values, 51 waters samples (94%) falls under class II category (PI 25-75%) and remaining 3 water samples belongs to class I (PI >75%). It is suggests that the majority of samples exhibit there is no permeability hazard. Therefore, the water considered to be good and excellent for suitable irrigation.

**Exchangeable Sodium Percentage (ESP):**

The Exchangeable sodium percentage is most important parameter for irrigation. Higher values of ESP are generally associated with soils, so there is slow permeability loss, which is a major problem with the crop productions (McNeal, 1981). The ESP is calculated by using following equation, (USDA, 1954).

$$ESP = \frac{100\,(-0.0126+0.01475.SAR)}{1+(-0.0126+0.01475.SAR)}$$

Higher values of ESP indicates that, cation-anion of soil are not in steady state. This is due to concentration of salts by evaporation of water from root zone and selective precipitation of Ca+Mg salts during evapo-transpiration. The ESP values for pre-monsoon season range from 0.122 to 1.029. The ESP values less than 15 are used as a boundary between saline and non-saline soil (USDA, 1954). All the water samples ESP values are less than 15.

Table 4: Irrigation water quality parameters from the area under study

| Sr. No | KR | SAR | SSP | Na% | ESP | PI | RSC |
|---|---|---|---|---|---|---|---|
| | | meq/L | % | | % | | |
| 1 | 0.504 | 1.608 | 33.503 | 33.470 | 0.344 | 61.631 | 1.247 |
| 2 | 0.237 | 0.741 | 19.144 | 19.112 | 0.159 | 51.918 | 0.280 |
| 3 | 0.397 | 1.503 | 28.433 | 28.419 | 0.322 | 50.044 | 0.914 |
| 4 | 0.409 | 1.953 | 29.018 | 28.958 | 0.418 | 46.300 | -0.093 |
| 5 | 1.097 | 2.890 | 52.304 | 51.921 | 0.618 | 77.494 | 2.425 |
| 6 | 0.444 | 1.477 | 30.755 | 30.716 | 0.317 | 54.365 | 0.425 |
| 7 | 0.408 | 1.263 | 28.968 | 28.881 | 0.271 | 48.298 | -2.027 |
| 8 | 0.699 | 3.185 | 41.132 | 41.049 | 0.680 | 52.083 | -4.755 |
| 9 | 0.507 | 1.239 | 33.662 | 33.321 | 0.266 | 83.938 | 6.258 |
| 10 | 0.585 | 2.338 | 36.912 | 36.890 | 0.500 | 57.403 | 1.538 |
| 11 | 0.849 | 2.305 | 45.913 | 45.827 | 0.493 | 74.940 | 1.096 |
| 12 | 0.939 | 3.024 | 48.429 | 48.147 | 0.646 | 66.613 | -0.676 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | 0.550 | 1.157 | 35.489 | 35.462 | 0.248 | 59.092 | -0.858 |
| 14 | 0.449 | 1.495 | 31.008 | 30.959 | 0.320 | 60.057 | 0.495 |
| 15 | 0.340 | 1.100 | 25.346 | 25.254 | 0.236 | 54.138 | 0.550 |
| 16 | 0.953 | 2.791 | 48.792 | 48.232 | 0.596 | 72.021 | 0.896 |
| 17 | 1.211 | 3.062 | 54.779 | 54.759 | 0.654 | 72.811 | -0.839 |
| 18 | 0.213 | 0.693 | 17.577 | 17.563 | 0.149 | 49.034 | -0.153 |
| 19 | 1.051 | 4.836 | 51.237 | 47.589 | 1.029 | 61.975 | -4.352 |
| 20 | 0.888 | 2.622 | 47.039 | 47.024 | 0.561 | 60.870 | -2.429 |
| 21 | 0.817 | 2.757 | 44.970 | 44.959 | 0.589 | 61.526 | -1.959 |
| 22 | 0.260 | 0.878 | 20.665 | 20.650 | 0.188 | 48.733 | -0.377 |
| 23 | 0.486 | 1.612 | 32.703 | 32.693 | 0.345 | 59.731 | 1.615 |
| 24 | 0.482 | 1.608 | 32.528 | 32.438 | 0.345 | 59.280 | 0.870 |
| 25 | 0.826 | 2.543 | 45.244 | 45.218 | 0.544 | 65.103 | -0.919 |
| 26 | 1.218 | 2.435 | 54.907 | 53.973 | 0.521 | 94.806 | 2.131 |
| 27 | 0.540 | 1.187 | 35.083 | 35.059 | 0.255 | 63.057 | -0.465 |
| 28 | 0.186 | 0.595 | 15.687 | 15.660 | 0.128 | 48.306 | -0.497 |
| 29 | 0.261 | 0.906 | 20.678 | 20.650 | 0.194 | 49.221 | 2.115 |
| 30 | 0.635 | 1.678 | 38.845 | 38.827 | 0.360 | 58.267 | -1.662 |
| 31 | 0.498 | 1.456 | 33.229 | 33.215 | 0.312 | 52.381 | -2.007 |
| 32 | 0.718 | 2.804 | 41.784 | 41.389 | 0.599 | 58.384 | -0.596 |
| 33 | 0.458 | 1.412 | 31.433 | 31.283 | 0.303 | 49.475 | -2.285 |
| 34 | 0.438 | 1.337 | 30.459 | 30.447 | 0.287 | 60.476 | 1.049 |
| 35 | 0.191 | 0.616 | 16.020 | 15.988 | 0.132 | 47.205 | -0.096 |
| 36 | 0.927 | 2.409 | 48.110 | 48.091 | 0.515 | 69.572 | -0.860 |
| 37 | 0.620 | 1.843 | 38.268 | 37.862 | 0.395 | 66.716 | 0.794 |
| 38 | 0.221 | 0.695 | 18.133 | 18.102 | 0.149 | 51.224 | 0.306 |
| 39 | 0.718 | 2.609 | 41.804 | 41.794 | 0.558 | 56.912 | -2.731 |
| 40 | 0.222 | 0.700 | 18.166 | 18.135 | 0.150 | 51.134 | 0.242 |
| 41 | 0.980 | 4.280 | 49.490 | 44.817 | 0.912 | 62.474 | -1.559 |
| 42 | 0.943 | 2.396 | 48.539 | 48.519 | 0.513 | 69.260 | -0.905 |
| 43 | 0.377 | 1.511 | 27.354 | 27.348 | 0.324 | 46.759 | -1.793 |
| 44 | 0.254 | 0.955 | 20.283 | 20.271 | 0.205 | 45.557 | -0.691 |
| 45 | 0.338 | 1.188 | 25.253 | 25.246 | 0.255 | 52.528 | 1.270 |
| 46 | 0.215 | 0.749 | 17.663 | 17.645 | 0.161 | 48.016 | 1.190 |
| 47 | 0.395 | 1.134 | 28.337 | 28.312 | 0.243 | 62.689 | 1.207 |
| 48 | 0.408 | 1.206 | 28.967 | 28.919 | 0.259 | 59.611 | 0.918 |
| 49 | 0.455 | 1.519 | 31.289 | 31.269 | 0.326 | 58.660 | 0.850 |
| 50 | 0.659 | 1.900 | 39.719 | 39.704 | 0.407 | 52.845 | -2.105 |
| 51 | 0.191 | 0.609 | 16.040 | 16.013 | 0.131 | 48.932 | -0.189 |
| 52 | 0.173 | 0.568 | 14.769 | 14.757 | 0.122 | 44.854 | 0.323 |
| 53 | 0.622 | 1.974 | 38.351 | 38.339 | 0.423 | 58.859 | -1.463 |
| 54 | 0.194 | 0.633 | 16.228 | 16.196 | 0.136 | 46.729 | -0.126 |
| **Min** | **0.173** | **0.568** | **14.769** | **14.757** | **0.122** | **44.854** | **-4.755** |
| **Max** | **1.218** | **4.836** | **54.907** | **54.759** | **1.029** | **94.806** | **6.258** |
| **Average** | **0.549** | **1.741** | **33.341** | **33.099** | **0.372** | **58.228** | **-0.157** |

**Hydrochemical Classification:**
**Piper Trilinear Diagram: (Piper 1944)**

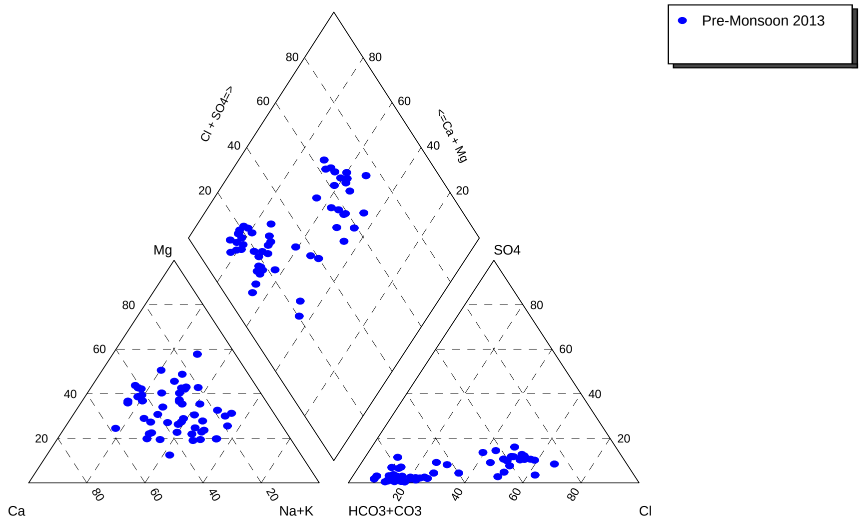



***Fig 2: Piper Trilinear Diagram for pre monsoon 2013.***

The importance of Piper Trilinear diagram has been widely recognized in water studies. The diagram consisting three distinct fields - two triangular fields and one diamond shaped field. The equivalent per million values of different constituents of water are represented by three points in which cation and anions grouped separately and are plotted in lower left and right triangles respectively then the anions and cation are combined to show a single point diamond shape fields, which throws light on the hydrochemical facies classification. The Piper Trilinear diagram shows the water type in the study area (Fig. 2).

In order to understand hydro chemical facies, the chemical data of water for both pre and post monsoon seasons were plotted on various trilinear diagrams. The changes in hydro chemical facies have been attributed to factors such as mineral composition of parent material, climate conditions, Physiography of the area, nature of groundwater circulation and vegetation (Pawar, 1986). Water type in the study area of pre monsoon seasons shows mixed type with majority of samples as Ca-Mg for cation and Cl-SO4 for anion type.

**US Salinity Hazard Diagram (USDA 1954):**

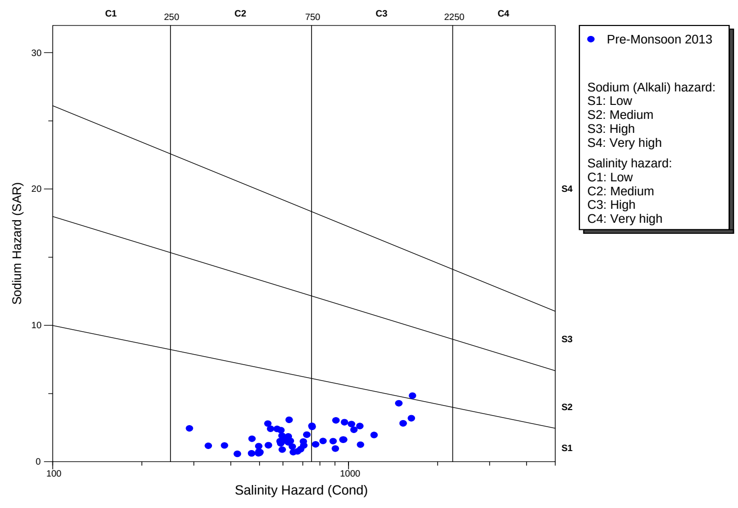



Fig 3: USSL diagram of the water samples

SAR (Sodium Adsorption Ratio) is an important parameter for determining suitability of groundwater to irrigation because it is a measure of alkali/sodium hazards to crops (Richard, 1954; Kumaresan and Riyazuddin, 2006).

The Sodium Hazard Diagram (USDA, 1954) drawn with the help of Electrical conductance and SAR values, different areas as follow.

C1 = Low salinity water: Good.

C2 = Moderate salinity water: Good for soils of medium permeability and the most Plants.

C3 = Medium High salinity water: Satisfactory for plants having moderate salt tolerance and soils of moderate permeability and leaching.

C4 = High salinity water: Satisfactory for salt tolerant crops on soil of good permeability with special leaching.

S1 = Low sodium water: Good.

S2 = Medium sodium water: Good for coarse-grained permeable soils, unsatisfactory for highly clayey soils with low leaching.

S3 = High sodium water: Suitable only with good drainage, high leaching and organic material addition.

S4 = Very high sodium water: Unsatisfactory.

The data plotted on the USSL diagram (Fig. 3) indicates the type of salinity hazards. It is observed that, 01 samples fall under category C3S2 suggest that medium sodium and high salinity hazards conditions. 15 samples plots in C3S1 category suggesting low sodium and high salinity hazards and 38 samples fall in C2S1 type suggesting low sodium and medium salinity hazards.

## CONCLUSION:

Analytical results of 54 water samples indicate that the hydrochemistry in the study area based on role of lithology and anthropogenic activities. According to quality of drinking water standards, the groundwater from the study area at few locations are not suitable for drinking with reference to the concentrations of total dissolved solids, total hardness, alkalinity, Ca and Mg. Based on the irrigation parameters (Sodium Adsorption Ratio, Permeability Index and Exchangeable Sodium Percentage) most of the groundwater samples fall into the classification of suitable for irrigation. The RSC, KR and Na % shows at few locations the ground water is not suitable for irrigation. The weathering of country rocks mainly controls the natural chemistry of waters in the study area. The sulphate concentration is very low in country rock of the study area, the excessive sulphate may be comes from anthropogenic activities.

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