**A comprehensive assessment of groundwater for seasonal variation in hydro-geochemistry, quality, contamination and human health risk from Deccan Basaltic region, Western India**

Environmental Science and Pollution Research (Ref.:  Ms. No. ESPR-D-20-15721)

**Author response to Editor Comments**

**Editor's Comments:**1. The writing of the manuscript is very poor. There are a number of grammar mistakes throughout the manuscript.

Response: Thanks for the comments/suggestions which are very useful to strengthen the manuscript quality in more scientific way. Also, Grammar mistakes have been corrected in the manuscript.
2. Too many figures and tables in your manuscript, and many of them could be put in supporting information. For example, it appeared to me that figure 12 and table 6 are presenting the same results. If so, they should only appear once in the manuscript (I would suggest to move table 6 to supporting information).

Response: Thanks for the comments/suggestions. Now in revised manuscript only 4 tables are included. However table 3 and 6 are removed in the manuscript and provided as supplementary material. Moreover 2 figures (Fig. 13a and 13 b) are removed from manuscript and provided as supporting information.
3. The resolution of figures is low, especially for those GIS pictures.

Response: Thanks for your comments. Now in revised manuscript all the figures have been revised with more DPI.
4. The caption of figures were too simple, which is not the scientific way to present figure captions. In addition, captions for Fig. x(a) or x(b) should not be separated.

Response: Thanks for the suggestions. The captions for all the figures have been modified.
5. Discussion section is very weak. It appeared to me that the authors only present the results of the study without discuss them in-depth.

Response: Thanks for the suggestions. The result and discussion section has been revised in depth in the revised manuscript.
6. Many of the paragraphs in results and discussion should be moved to methods (e.g., Line 475-491, Line 512-533, etc.).

Response: Thanks for the suggestions. Now in revised manuscript these line numbers are moved to material and methods section.
7. Conclusion section: too long. In general, this section should be very brief and short, only summarizing key findings of your study.

Response: Thanks for the suggestions. The conclusion section has been revised and summarized with only key findings.
8. The format of reference list is in chaos. Please at least uniform the format of reference before submitting your manuscript to any journal.

Response: Thanks for the suggestions. All the references have been cross checked and rearrange them according to journal guidelines.

9. Please include continuous line numbers in your manuscript to facilitate editorial handling and reviewing.

Response: Thanks for your suggestion, now in revised manuscript continuous line number are included

**Table 1** Physico-chemical analysis of groundwater samples of pre monsoon season (PRM) of 2015

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **pH** | **EC** | **T** | **TDS** | **TH** | **Ca2+** | **Mg2+** | **Na+** | **K+** | **PA** | **HCO3-** | **Cl-** | **SO42-** | **NO3-** | **PO42-** | **B3+** | **F-** |
| 1 | 7.52 | 1070 | 27 | 593 | 352 | 96.19 | 27.3 | 33.95 | 0.4 | 50 | 280 | 128 | 26.88 | 10.2 | 0.03 | 5.6 | 1.2 |
| 2 | 7.58 | 910 | 30 | 470 | 284 | 65.73 | 29.2 | 29.08 | 0.3 | 50 | 210 | 92.4 | 43.54 | 9.6 | 0.03 | 1.5 | 1.0 |
| 3 | 7.77 | 750 | 30 | 437 | 256 | 43.29 | 36.1 | 28.05 | 0.5 | 50 | 200 | 64.1 | 64.98 | 11.1 | 0.03 | 1.8 | 0.4 |
| 4 | 7.48 | 885 | 30 | 595 | 372 | 73.75 | 45.8 | 30.19 | 1.3 | 100 | 280 | 129.1 | 34.72 | 10.2 | 0.03 | BDL | 0.8 |
| 5 | 7.46 | 942 | 32 | 833 | 604 | 120.2 | 74.1 | 32.7 | 0.2 | 50 | 250 | 248.5 | 106.9 | 15.3 | 0.03 | 1.1 | 1.0 |
| 6 | 7.87 | 832 | 28 | 521 | 304 | 88.18 | 20.5 | 35.87 | 1.2 | 0 | 210 | 124.9 | 40.68 | 12.7 | 0.04 | 1.0 | 1.3 |
| 7 | 7.61 | 540 | 27 | 294 | 128 | 53.67 | 10.7 | 17.93 | 0.3 | 50 | 150 | 43.9 | 17.54 | 9.5 | 0.05 | 4.3 | 0.6 |
| 8 | 7.97 | 542 | 31 | 548 | 324 | 59.32 | 42.9 | 40.13 | 0.4 | 50 | 250 | 113.6 | 42.05 | 14.0 | 0.06 | 1.2 | 1.0 |
| 9 | 7.84 | 390 | 26 | 296 | 124 | 44.04 | 15.6 | 19.1 | 0.2 | 50 | 150 | 49.7 | 17.52 | 14.5 | 0.02 | BDL | 0.9 |
| 10 | 7.58 | 658 | 27 | 492 | 316 | 51.3 | 45.8 | 19.08 | 0.5 | 50 | 320 | 42.6 | 12.32 | 14.4 | 0.06 | 0.5 | 0.6 |
| 11 | 7.78 | 501 | 28 | 341 | 164 | 41.68 | 14.6 | 46.03 | 0.5 | 70 | 150 | 63.9 | 24.28 | 14.0 | 0.05 | 1.6 | 0.3 |
| 12 | 7.78 | 540 | 27 | 263 | 148 | 35.27 | 14.6 | 19.01 | 0.2 | 50 | 140 | 35.5 | 17.89 | 14.5 | 0.03 | BDL | 1.2 |
| 13 | 8.15 | 322 | 28 | 223 | 136 | 19.24 | 21.4 | 14.37 | 0.6 | 0 | 100 | 49.7 | 17.79 | 9.5 | 0.03 | BDL | 1.6 |
| 14 | 7.69 | 476 | 28 | 266 | 144 | 33.67 | 14.6 | 19.54 | 7.3 | 0 | 120 | 53.9 | 16.44 | 11.6 | 0.1 | BDL | 1.1 |
| 15 | 7.73 | 446 | 30 | 338 | 244 | 38.48 | 36.1 | 13.36 | 0.6 | 50 | 120 | 84.8 | 44.72 | 11.7 | 0.04 | BDL | 0.5 |
| 16 | 7.93 | 524 | 28 | 264 | 112 | 24.05 | 12.7 | 37.69 | 0.7 | 50 | 100 | 43.6 | 45.03 | 14.6 | 0.08 | 0.9 | 1.0 |
| 17 | 7.86 | 568 | 27 | 278 | 172 | 28.86 | 24.4 | 18.05 | 0.7 | 100 | 100 | 45.1 | 60.98 | 15.7 | 0.05 | 1.0 | 0.8 |
| 18 | 7.98 | 531 | 27 | 349 | 232 | 51.3 | 25.3 | 18.92 | 0.3 | 50 | 150 | 85.2 | 18.23 | 17.1 | 0.05 | 5.6 | 1.3 |
| 19 | 7.91 | 543 | 28 | 330 | 188 | 38.48 | 22.4 | 25.64 | 3.8 | 0 | 120 | 74.9 | 44.32 | 9.7 | 0.06 | 8.7 | 0.6 |
| 20 | 7.57 | 814 | 28 | 312 | 176 | 33.67 | 22.4 | 24.39 | 0.3 | 0 | 150 | 66.5 | 14.28 | 12.1 | 0.04 | 12.5 | 1.3 |
| 21 | 7.48 | 857 | 28 | 511 | 328 | 78.56 | 32.2 | 30.71 | 0.3 | 0 | 250 | 95.2 | 24.36 | 13.0 | 0.06 | 2.1 | 0.6 |
| 22 | 7.71 | 766 | 27 | 499 | 336 | 97.8 | 22.4 | 26.25 | 0.6 | 0 | 150 | 103.6 | 97.86 | 13.2 | 0.04 | BDL | 0.8 |
| 23 | 7.82 | 763 | 27 | 457 | 288 | 81.76 | 20.5 | 23.24 | 0.2 | 0 | 250 | 56.8 | 24.58 | 14.9 | 0.04 | 6.0 | 0.2 |
| 24 | 7.69 | 821 | 29 | 463 | 284 | 73.75 | 24.4 | 23.6 | 0.2 | 0 | 206 | 99.4 | 35.91 | 10.0 | 0.05 | 7.0 | 1.0 |
| 25 | 7.55 | 673 | 27 | 367 | 208 | 51.3 | 19.5 | 24.4 | 0.4 | 50 | 180 | 71 | 20.23 | 8.1 | 0.04 | 7.9 | 0.8 |
| 26 | 7.71 | 296 | 27 | 196 | 52 | 8.02 | 7.8 | 9.51 | 1.3 | 0 | 30 | 19.1 | 20.36 | 6.4 | 0.04 | 4.7 | 1.1 |
| 27 | 7.44 | 534 | 27 | 226 | 144 | 28.86 | 17.5 | 18.41 | 0.7 | 0 | 60 | 45.2 | 54.98 | 8.7 | 0.04 | 1.8 | 0.1 |
| 28 | 7.84 | 531 | 28 | 593 | 192 | 30.46 | 28.3 | 108.5 | 0.4 | 0 | 200 | 74.5 | 151.2 | 14.4 | 0.03 | 4.1 | 1.8 |
| 29 | 7.89 | 437 | 27 | 389 | 232 | 48.1 | 27.3 | 25.46 | 0.6 | 0 | 150 | 63.4 | 74.52 | 13.4 | 0.04 | 2.9 | 0.5 |
| 30 | 8.38 | 689 | 28 | 349 | 216 | 57.72 | 17.5 | 25.16 | 0.4 | 0 | 100 | 85.2 | 63.08 | 18.7 | 0.02 | 0.1 | 0.2 |
| 31 | 7.57 | 672 | 27 | 277 | 244 | 43.29 | 33.1 | 18.44 | 0.3 | 0 | 100 | 43.9 | 17.41 | 12.3 | 0.02 | 11.6 | 0.9 |
| 32 | 7.46 | 475 | 29 | 362 | 180 | 38.48 | 20.5 | 17.08 | 0.5 | 0 | 180 | 85.2 | 20.33 | 12.3 | 0.04 | BDL | 0.5 |
| 33 | 7.84 | 724 | 31 | 460 | 288 | 60.92 | 33.1 | 27.76 | 0.3 | 0 | 200 | 120.7 | 16.79 | 13.5 | 0.03 | BDL | 0.5 |
| 34 | 7.61 | 578 | 30 | 573 | 168 | 30.46 | 22.4 | 26.71 | 7.8 | 0 | 120 | 34.9 | 101 | 15.1 | 0.32 | BDL | 1.1 |

All values are in mg/L, pH on scale, EC in uS/cm, Temperature in 0C, BDL stands below detectable level

**Table 2** Physico-chemical analysis of groundwater samples of post monsoon season (POM) of 2015

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **pH** | **EC** | **T** | **TDS** | **TH** | **Ca2+** | **Mg2+** | **Na+** | **K+** | **PA** | **HCO3-** | **Cl-** | **SO42-** | **NO3-** | **PO42-** | **B3+** | **F-** |
| 1 | 7.08 | 800 | 26 | 417 | 352 | 57.7 | 28.7 | 20.9 | 0.2 | 20 | 240 | 21.23 | 48.28 | 9.84 | 0.02 | BDL | 0.64 |
| 2 | 7.1 | 670 | 27 | 388 | 336 | 56.1 | 28.8 | 14.6 | 0.1 | 20 | 220 | 18.64 | 49.6 | 6.24 | 0.02 | 3.02 | 0.39 |
| 3 | 6.99 | 650 | 29 | 512 | 368 | 57.7 | 54.6 | 14.2 | 0.2 | 20 | 260 | 40.21 | 85.2 | 2.9 | 2.90 | 0.54 | 0.71 |
| 4 | 7.1 | 830 | 28 | 591 | 332 | 70.5 | 38.0 | 14.1 | 0.2 | 0 | 340 | 42.52 | 85.2 | 6.96 | 0.02 | 0.34 | 0.51 |
| 5 | 7.13 | 980 | 29 | 478 | 348 | 55.0 | 33.1 | 24.4 | 0.3 | 20 | 300 | 19.56 | 45.44 | 0.6 | 0.01 | BDL | 1.02 |
| 6 | 7.11 | 640 | 27 | 467 | 312 | 51.3 | 44.8 | 17.6 | 0.2 | 20 | 280 | 9.56 | 63.6 | 3.94 | 0.01 | 0.96 | 0.86 |
| 7 | 7.14 | 560 | 26 | 384 | 280 | 52.9 | 26.1 | 11.8 | 0.1 | 40 | 240 | 10.02 | 42.72 | 2.98 | 0.01 | 0.95 | 0.51 |
| 8 | 7.11 | 510 | 26 | 432 | 268 | 64.1 | 26.3 | 13.1 | 0.4 | 40 | 240 | 62.12 | 25.56 | 0.64 | 0.05 | BDL | 0.66 |
| 9 | 7.21 | 380 | 25 | 374 | 220 | 60.9 | 16.6 | 12.4 | 0.2 | 20 | 260 | 9.23 | 14.2 | 0.34 | 0.02 | 1.47 | 0.73 |
| 10 | 7.25 | 480 | 28 | 370 | 232 | 51.3 | 25.3 | 11.5 | 0.3 | 40 | 260 | 4.56 | 17.04 | 1.12 | 0.02 | 2.2 | 0.18 |
| 11 | 7.08 | 380 | 27 | 261 | 160 | 35.3 | 17.5 | 9.1 | 0.1 | 40 | 180 | 5.21 | 14.2 | 0.23 | 0.03 | 2.3 | 0.25 |
| 12 | 7.09 | 480 | 28 | 318 | 192 | 60.9 | 9.8 | 8.1 | 0.1 | 20 | 220 | 4.59 | 14.2 | 0.89 | 0.02 | BDL | 0.42 |
| 13 | 6.85 | 380 | 26 | 292 | 184 | 41.7 | 19.5 | 6.6 | 0.4 | 20 | 210 | 4.12 | 10.2 | 2.54 | 0.02 | BDL | 0.46 |
| 14 | 7.34 | 380 | 26 | 266 | 152 | 51.3 | 5.9 | 7.2 | 3.2 | 40 | 180 | 3.85 | 14.2 | 1.45 | 0.04 | BDL | 0.27 |
| 15 | 7.04 | 360 | 28 | 279 | 176 | 56.1 | 8.8 | 5.9 | 0.4 | 20 | 180 | 4.58 | 22.72 | 0.4 | 0.03 | BDL | 0.69 |
| 16 | 7.41 | 490 | 29 | 356 | 220 | 49.7 | 23.4 | 10.9 | 0.3 | 40 | 240 | 14.52 | 17.04 | 3.41 | 0.02 | 14.33 | 1.1 |
| 17 | 7.37 | 590 | 26 | 357 | 220 | 60.9 | 16.6 | 11.4 | 0.4 | 40 | 240 | 4.88 | 22.72 | 0.94 | 0.04 | 3.43 | 1.03 |
| 18 | 7.2 | 520 | 25 | 389 | 224 | 64.1 | 15.6 | 14.8 | 0.2 | 40 | 260 | 8.86 | 25.56 | 2.89 | 0.02 | 2.71 | 0.27 |
| 19 | 7.51 | 550 | 26 | 400 | 232 | 67.3 | 15.6 | 13.5 | 1.9 | 40 | 280 | 4.58 | 17.04 | 0.6 | 0.04 | BDL | 0.88 |
| 20 | 7.18 | 800 | 26 | 468 | 376 | 67.3 | 28.7 | 19.5 | 0.2 | 40 | 280 | 24.12 | 48.28 | 10.8 | 0.00 | 7.43 | 0.39 |
| 21 | 7.24 | 920 | 25 | 441 | 248 | 65.7 | 20.5 | 22.6 | 0.3 | 20 | 260 | 22.56 | 49.64 | 2.02 | 0.04 | BDL | 0.28 |
| 22 | 7.35 | 660 | 26 | 299 | 176 | 33.7 | 22.4 | 14.9 | 0.1 | 20 | 180 | 19.24 | 28.4 | 3.23 | 0.02 | BDL | 1.35 |
| 23 | 7.23 | 690 | 29 | 274 | 140 | 51.3 | 2.9 | 17.6 | 0.1 | 20 | 160 | 9.54 | 32.6 | 2.47 | 0.02 | 5.58 | 0.77 |
| 24 | 7.35 | 810 | 28 | 212 | 120 | 30.5 | 10.7 | 12.7 | 0.0 | 20 | 100 | 31.56 | 26.92 | 3.96 | 0.03 | 3.08 | 0.77 |
| 25 | 7.39 | 490 | 25 | 164 | 96 | 12.8 | 15.6 | 9.6 | 0.0 | 20 | 100 | 5.62 | 19.88 | 0.42 | 0.02 | 0.66 | 0.29 |
| 26 | 7.45 | 240 | 23 | 193 | 120 | 25.7 | 13.6 | 4.8 | 0.5 | 20 | 130 | 4.12 | 14.2 | 1.36 | 0.03 | 1.09 | 0.86 |
| 27 | 7.14 | 640 | 25 | 414 | 304 | 54.5 | 30.9 | 13.8 | 0.5 | 20 | 280 | 14.24 | 19.88 | 5.86 | 0.02 | BDL | 0.93 |
| 28 | 7.2 | 460 | 26 | 402 | 240 | 67.3 | 17.5 | 12.7 | 0.2 | 40 | 260 | 21.56 | 22.72 | 0.65 | 0.00 | BDL | 0.19 |
| 29 | 7.24 | 550 | 25 | 513 | 384 | 89.8 | 29.0 | 14.3 | 0.2 | 20 | 300 | 17.51 | 62.6 | 14 | 0.04 | 2.07 | 1.4 |
| 30 | 7.29 | 670 | 26 | 531 | 332 | 78.6 | 33.1 | 18.3 | 0.1 | 40 | 320 | 38.46 | 42.56 | 9.93 | 0.04 | BDL | 0.18 |
| 31 | 7.33 | 720 | 25 | 507 | 308 | 72.1 | 31.2 | 14.2 | 0.2 | 20 | 360 | 6.62 | 22.72 | 0.12 | 0.00 | BDL | 0.35 |
| 32 | 7.25 | 530 | 27 | 406 | 240 | 62.5 | 20.5 | 11.8 | 0.1 | 40 | 280 | 14.21 | 17.04 | 2.39 | 0.05 | BDL | 1.48 |
| 33 | 7.35 | 680 | 29 | 491 | 312 | 67.3 | 35.1 | 18.2 | 0.2 | 20 | 300 | 35.65 | 34.08 | 5.46 | 0.03 | 7.27 | 0.71 |
| 34 | 7.32 | 560 | 28 | 386 | 240 | 57.7 | 23.4 | 16.6 | 1.1 | 60 | 230 | 20.52 | 37.04 | 5.21 | 0.09 | 0.38 | 0.02 |

 All values are in mg/L, pH on scale, EC in uS/cm, Temperature in 0C, BDL stands below detectable level

**Table 3** Classification for groundwater based on total hardness (Sawyer and McCarty 1967)

|  |  |  |
| --- | --- | --- |
| Total hardness (mg/L) | Water classification | Number of Samples in% |
| PRM 2015 | POM 2015 |
|
| 0 – 75 | Soft | 03 | 00 |
| 75- 150 | Moderately hard | 24 | 12 |
| 150 - 300 | Hard | 49 | 53 |
| > 300 | Very Hard | 24 | 35 |

**Table 6** Groundwater classification based on GWQI and PIG values

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample ID | Pre-monsoon  | Post-monsoon  | Pre-monsoon  | Post-monsoon  |
|  | GWQI values and catergories  | PIG values and catergories |
| 1 | 140.94 | Poor | 70.89 | Good | 1.27 | low pollution  | 0.51 | insignificant pollution  |
| 2 | 79.01 | Good | 91.94 | Good | 0.74 | insignificant pollution  | 0.79 | insignificant pollution  |
| 3 | 77.49 | Good | 90.45 | Good | 0.72 | insignificant pollution  | 0.69 | insignificant pollution  |
| 4 | 76.49 | Good | 80.22 | Good | 0.67 | insignificant pollution  | 0.66 | insignificant pollution  |
| 5 | 115 | Poor | 78.14 | Good | 1.04 | low pollution  | 0.58 | insignificant pollution  |
| 6 | 77.12 | Good | 78.89 | Good | 0.73 | insignificant pollution  | 0.7 | insignificant pollution  |
| 7 | 81.88 | Good | 67.57 | Good | 0.86 | insignificant pollution  | 0.56 | insignificant pollution  |
| 8 | 78.61 | Good | 62.12 | Good | 0.80 | insignificant pollution  | 0.49 | insignificant pollution  |
| 9 | 40.23 | Excellent | 67.88 | Good | 0.46 | insignificant pollution  | 0.6 | insignificant pollution  |
| 10 | 72.14 | Good | 72.09 | Good | 0.67 | insignificant pollution  | 0.65 | insignificant pollution  |
| 11 | 60.19 | Good | 61.43 | Good | 0.57 | insignificant pollution  | 0.58 | insignificant pollution  |
| 12 | 42.14 | Excellent | 47.8 | Excellent | 0.47 | insignificant pollution  | 0.36 | insignificant pollution  |
| 13 | 35.34 | Excellent | 45.34 | Excellent | 0.49 | insignificant pollution  | 0.38 | insignificant pollution  |
| 14 | 42.55 | Excellent | 41.03 | Excellent | 0.48 | insignificant pollution  | 0.32 | insignificant pollution  |
| 15 | 50.14 | Good | 45.34 | Excellent | 0.48 | insignificant pollution  | 0.37 | insignificant pollution  |
| 16 | 47.92 | Excellent | 194.47 | Poor | 0.54 | insignificant pollution  | 2.06 | high pollution  |
| 17 | 55.37 | Good | 91.82 | Good | 0.58 | insignificant pollution  | 0.85 | insignificant pollution  |
| 18 | 105.06 | Poor | 78.58 | Good | 1.17 | low pollution  | 0.7 | insignificant pollution  |
| 19 | 130.02 | Poor | 61.03 | Good | 1.41 | low pollution  | 0.48 | insignificant pollution  |
| 20 | 166.53 | Poor | 143.04 | Poor | 1.87 | moderate pollution  | 1.33 | low pollution  |
| 21 | 90.01 | Good | 62.79 | Good | 0.81 | insignificant pollution  | 0.45 | insignificant pollution  |
| 22 | 69.44 | Good | 57.86 | Good | 0.58 | insignificant pollution  | 0.49 | insignificant pollution  |
| 23 | 121.04 | Poor | 100.97 | Good | 1.13 | low pollution  | 0.97 | insignificant pollution  |
| 24 | 129.9 | Poor | 75.79 | Good | 1.34 | low pollution  | 0.69 | insignificant pollution  |
| 25 | 125.33 | Poor | 38.78 | Excellent | 1.33 | low pollution  | 0.35 | insignificant pollution  |
| 26 | 65.86 | Good | 48.17 | Excellent | 0.85 | insignificant pollution  | 0.47 | insignificant pollution  |
| 27 | 55.58 | Good | 68.43 | Good | 0.51 | insignificant pollution  | 0.54 | insignificant pollution  |
| 28 | 98.76 | Good | 52.86 | Good | 1.22 | low pollution  | 0.4 | insignificant pollution  |
| 29 | 79.91 | Good | 102.28 | Poor | 0.82 | insignificant pollution  | 0.89 | insignificant pollution  |
| 30 | 54.95 | Good | 70.63 | Good | 0.44 | insignificant pollution  | 0.54 | insignificant pollution  |
| 31 | 159.75 | Poor | 68.2 | Good | 1.73 | moderate pollution  | 0.52 | insignificant pollution  |
| 32 | 46.18 | Good | 66.98 | Good | 0.44 | insignificant pollution  | 0.56 | insignificant pollution  |
| 33 | 62.18 | Good | 140.39 | Poor | 0.54 | insignificant pollution  | 1.36 | low pollution  |
| 34 | 56.81 | Good | 57.03 | Good | 0.62 | insignificant pollution  | 0.45 | insignificant pollution  |

**Fig. 13a** The comparison between THI values of Adult, children and infants for PRM season

**Fig. 13b** The comparison between THI values of Adult, children and infants for POM season