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APPENDICES

Appendix-A.1

Table A.1. Analysis of physical parameters in groundwater during pre-monsoon season

| S. No | Sites | Latitude | Longitude | pH | EC | TDS |
|-------|-------|------------|-----------|------|------|------|
| 1. | GW-1 | 22.355514 | 82.5265 | 6.68 | 219 | 147 |
| 2. | GW-2 | 22.371595 | 82.52132 | 7.12 | 324 | 215 |
| 3. | GW-3 | 22.361964 | 82.49582 | 6.37 | 845 | 558 |
| 4. | GW-4 | 22.334916 | 82.48852 | 6.84 | 475 | 314 |
| 5. | GW-5 | 22.33275 | 82.50858 | 7.78 | 688 | 481 |
| 6. | GW-6 | 22.373734 | 82.53445 | 6.29 | 512 | 344 |
| 7. | GW-7 | 22.304122 | 82.49255 | 6.74 | 954 | 631 |
| 8. | GW-8 | 22.307831 | 82.51542 | 6.89 | 385 | 261 |
| 9. | GW-9 | 22.307115 | 82.5273 | 6.85 | 390 | 256 |
| 10. | GW-10 | 22.28639 | 82.51951 | 6.71 | 1366 | 897 |
| 11. | GW-11 | 22.318646 | 82.54161 | 6.88 | 169 | 114 |
| 12. | GW-12 | 22.312221 | 82.54929 | 6.93 | 237 | 157 |
| 13. | GW-13 | 22.310383 | 82.57747 | 6.69 | 267 | 177 |
| 14. | GW-14 | 22.298111 | 82.60419 | 6.97 | 469 | 342 |
| 15. | GW-15 | 22.300627 | 82.6205 | 6.9 | 58 | 39 |
| 16. | GW-16 | 22.311703 | 82.60981 | 6.92 | 1880 | 1266 |
| 17. | GW-17 | 22.321711 | 82.60628 | 6.88 | 584 | 392 |
| 18. | GW-18 | 22.342156 | 82.62397 | 6.78 | 329 | 207 |
| 19. | GW-19 | 22.361737 | 82.57711 | 6.87 | 395 | 262 |
| 20. | GW-20 | 22.372027 | 82.57059 | 6.82 | 171 | 115 |
| 21. | GW-21 | 22.368166 | 82.6185 | 6.29 | 317 | 208 |
| 22. | GW-22 | 22.3706103 | 82.63626 | 6.41 | 242 | 160 |
| 23. | GW-23 | 22.380998 | 82.653 | 6.47 | 313 | 206 |
| 24. | GW-24 | 22.34756 | 82.65545 | 6.42 | 331 | 222 |
| 25. | GW-25 | 22.362824 | 82.67161 | 6.58 | 111 | 74 |
| 26. | GW-26 | 22.351409 | 82.6763 | 6.54 | 884 | 592 |
| 27. | GW-27 | 22.348766 | 82.69613 | 6.95 | 741 | 492 |
| 28. | GW-28 | 22.337723 | 82.70906 | 6.57 | 369 | 245 |
| 29. | GW-29 | 22.355568 | 82.63618 | 7.69 | 223 | 149 |
| 30. | GW-30 | 22.356015 | 82.59811 | 6.74 | 142 | 95 |
| 31. | GW-31 | 22.359209 | 82.56636 | 6.77 | 147 | 99 |
| 32. | GW-32 | 22.34635 | 82.5424 | 6.68 | 571 | 380 |
| 33. | GW-33 | 22.332723 | 82.63503 | 6.05 | 504 | 339 |
| 34. | GW-34 | 22.310044 | 82.63481 | 6.68 | 589 | 395 |
| 35. | GW-35 | 22.315807 | 82.66115 | 6.94 | 127 | 83 |
| 36. | GW-36 | 22.299632 | 82.66788 | 6.52 | 183 | 126 |
| 37. | GW-37 | 22.313832 | 82.68492 | 6.98 | 123 | 84 |
| 38. | GW-38 | 22.324969 | 82.69116 | 6.71 | 409 | 271 |
| 39. | GW-39 | 22.314707 | 82.69799 | 6.41 | 685 | 458 |
| 40. | GW-40 | 22.284815 | 82.58316 | 6.84 | 255 | 169 |
| 41. | GW-41 | 22.289902 | 82.54711 | 6.68 | 145 | 93 |
| 42. | GW-42 | 22.345766 | 82.48384 | 6.89 | 296 | 197 |
| 43. | GW-43 | 22.349923 | 82.64822 | 6.37 | 338 | 228 |

Table A.2. Analysis of physical parameters in groundwater during post-monsoon

| S. No | Sites | Latitude | Longitude | pH | EC | TDS |
|-------|-------|-----------|-----------|------|------|------|
| 1. | GW-1 | 22.355514 | 82.5265 | 6.32 | 322 | 213 |
| 2. | GW-2 | 22.371595 | 82.52132 | 6.81 | 370 | 247 |
| 3. | GW-3 | 22.361964 | 82.49582 | 6.13 | 909 | 498 |
| 4. | GW-4 | 22.334916 | 82.48852 | 7.17 | 502 | 336 |
| 5. | GW-5 | 22.33275 | 82.50858 | 7.75 | 606 | 403 |
| 6. | GW-6 | 22.373734 | 82.53445 | 6.47 | 248 | 169 |
| 7. | GW-7 | 22.304122 | 82.49255 | 7.16 | 787 | 523 |
| 8. | GW-8 | 22.307831 | 82.51542 | 5.82 | 360 | 238 |
| 9. | GW-9 | 22.307115 | 82.5273 | 5.98 | 263 | 176 |
| 10. | GW-10 | 22.28639 | 82.51951 | 6.89 | 1053 | 702 |
| 11. | GW-11 | 22.318646 | 82.54161 | 5.63 | 231 | 153 |
| 12. | GW-12 | 22.312221 | 82.54929 | 5.86 | 250 | 166 |
| 13. | GW-13 | 22.310383 | 82.57747 | 5.96 | 256 | 171 |
| 14. | GW-14 | 22.298111 | 82.60419 | 6.78 | 561 | 373 |
| 15. | GW-15 | 22.300627 | 82.6205 | 5.82 | 81 | 54 |
| 16. | GW-16 | 22.311703 | 82.60981 | 7.04 | 1736 | 1156 |
| 17. | GW-17 | 22.321711 | 82.60628 | 6.33 | 571 | 384 |
| 18. | GW-18 | 22.342156 | 82.62397 | 6.44 | 311 | 199 |
| 19. | GW-19 | 22.361737 | 82.57711 | 6.15 | 413 | 281 |
| 20. | GW-20 | 22.372027 | 82.57059 | 7.31 | 266 | 178 |
| 21. | GW-21 | 22.368166 | 82.6185 | 6.43 | 321 | 213 |
| 22. | GW-22 | 22.370610 | 82.63626 | 6.97 | 207 | 142 |
| 23. | GW-23 | 22.380998 | 82.653 | 5.88 | 282 | 188 |
| 24. | GW-24 | 22.34756 | 82.65545 | 5.32 | 255 | 172 |
| 25. | GW-25 | 22.362824 | 82.67161 | 6.82 | 150 | 100 |
| 26. | GW-26 | 22.351409 | 82.6763 | 6.95 | 858 | 570 |
| 27. | GW-27 | 22.348766 | 82.69613 | 6.75 | 836 | 498 |
| 28. | GW-28 | 22.337723 | 82.70906 | 6.26 | 369 | 247 |
| 29. | GW-29 | 22.355568 | 82.63618 | 5.97 | 250 | 166 |
| 30. | GW-30 | 22.356015 | 82.59811 | 5.73 | 146 | 98 |
| 31. | GW-31 | 22.359209 | 82.56636 | 6.36 | 124 | 82 |
| 32. | GW-32 | 22.34635 | 82.5424 | 8.11 | 440 | 296 |
| 33. | GW-33 | 22.332723 | 82.63503 | 5.77 | 207 | 138 |
| 34. | GW-34 | 22.310044 | 82.63481 | 6.93 | 721 | 482 |
| 35. | GW-35 | 22.315807 | 82.66115 | 6.46 | 155 | 103 |
| 36. | GW-36 | 22.299632 | 82.66788 | 7.13 | 249 | 166 |
| 37. | GW-37 | 22.313832 | 82.68492 | 6.28 | 126 | 83 |
| 38. | GW-38 | 22.324969 | 82.69116 | 5.8 | 277 | 183 |
| 39. | GW-39 | 22.314707 | 82.69799 | 6.36 | 639 | 426 |
| 40. | GW-40 | 22.284815 | 82.58316 | 6.62 | 301 | 184 |
| 41. | GW-41 | 22.289902 | 82.54711 | 6.61 | 186 | 98 |
| 42. | GW-42 | 22.345766 | 82.48384 | 6.47 | 367 | 243 |
| 43. | GW-43 | 22.349923 | 82.64822 | 6.07 | 284 | 189 |

Appendix A.3

Table A.3. Analysis of Anions in groundwater during pre-monsoon season

| S. No. | Sites | Lat. | Long. | F ⁻ | Cl ⁻ | NO ₃ ⁻ | SO ₄ ²⁻ | HCO ₃ ⁻ |
|--------|-------|-----------|----------|----------------|-----------------|------------------------------|-------------------------------|-------------------------------|
| 1. | GW-1 | 22.355514 | 82.5265 | 0.389 | 11.902 | 7.024 | 12.274 | 62 |
| 2. | GW-2 | 22.371595 | 82.52132 | 0.311 | 46.012 | 51.029 | 8.82 | 75 |
| 3. | GW-3 | 22.361964 | 82.49582 | 0.306 | 194.799 | 123.612 | 21.184 | 123 |
| 4. | GW-4 | 22.334916 | 82.48852 | 0.765 | 21.164 | 3.938 | 17.925 | 80 |
| 5. | GW-5 | 22.33275 | 82.50858 | 0.98 | 66.01 | 0.53 | 4.154 | 138 |
| 6. | GW-6 | 22.373734 | 82.53445 | 0.374 | 60.407 | 16.21 | 30.601 | 118 |
| 7. | GW-7 | 22.304122 | 82.49255 | 0.695 | 115.52 | 0.673 | 27.65 | 165 |
| 8. | GW-8 | 22.307831 | 82.51542 | 0 | 62.918 | 85.572 | 5.433 | 72 |
| 9. | GW-9 | 22.307115 | 82.5273 | 0.333 | 58.859 | 8.984 | 14.616 | 69 |
| 10. | GW-10 | 22.28639 | 82.51951 | 0.806 | 175.168 | 66.277 | 162.07 | 292 |
| 11. | GW-11 | 22.318646 | 82.54161 | 0 | 25.753 | 49.226 | 0.589 | 34 |
| 12. | GW-12 | 22.312221 | 82.54929 | 0 | 38.958 | 29.543 | 6.237 | 65 |
| 13. | GW-13 | 22.310383 | 82.57747 | 0.27 | 35.83 | 68.205 | 4.267 | 72 |
| 14. | GW-14 | 22.298111 | 82.60419 | 0.173 | 26.89 | 1.228 | 31.54 | 112 |
| 15. | GW-15 | 22.300627 | 82.6205 | 0.362 | 1.794 | 0.34 | 0.588 | 22 |
| 16. | GW-16 | 22.311703 | 82.60981 | 0.764 | 22.523 | 25.68 | 35.241 | 311 |
| 17. | GW-17 | 22.321711 | 82.60628 | 0.302 | 92.281 | 4.746 | 135.79 | 192 |
| 18. | GW-18 | 22.342156 | 82.62397 | 0.623 | 36.251 | 21.327 | 58.351 | 86 |
| 19. | GW-19 | 22.361737 | 82.57711 | 0.276 | 65.945 | 52.227 | 19.15 | 149 |
| 20. | GW-20 | 22.372027 | 82.57059 | 0.309 | 20.675 | 4.203 | 5.41 | 55 |
| 21. | GW-21 | 22.368166 | 82.6185 | 0.396 | 14.153 | 0.351 | 59.518 | 89 |
| 22. | GW-22 | 22.370610 | 82.63626 | 0.785 | 9.787 | 1.031 | 28.667 | 93 |
| 23. | GW-23 | 22.380998 | 82.653 | 0.288 | 71.19 | 23.965 | 17.512 | 131 |
| 24. | GW-24 | 22.34756 | 82.65545 | 0.619 | 43.248 | 51.867 | 17.555 | 89 |
| 25. | GW-25 | 22.362824 | 82.67161 | 0.489 | 3.398 | 0.81 | 9.686 | 36 |
| 26. | GW-26 | 22.351409 | 82.6763 | 0.628 | 142.551 | 0.333 | 16.735 | 125 |
| 27. | GW-27 | 22.348766 | 82.69613 | 0.37 | 102.672 | 69.769 | 62.995 | 113 |
| 28. | GW-28 | 22.337723 | 82.70906 | 0.345 | 40.933 | 26.839 | 52.972 | 103 |
| 29. | GW-29 | 22.355568 | 82.63618 | 1.099 | 12.153 | 1.439 | 30.312 | 52 |
| 30. | GW-30 | 22.356015 | 82.59811 | 0.27 | 19.352 | 13.294 | 4.748 | 48 |
| 31. | GW-31 | 22.359209 | 82.56636 | 0.382 | 2.036 | 0.369 | 1.365 | 43 |
| 32. | GW-32 | 22.34635 | 82.5424 | 0.903 | 29.297 | 1.117 | 17.934 | 181 |
| 33. | GW-33 | 22.332723 | 82.63503 | 0 | 108.412 | 63.176 | 20.695 | 119 |
| 34. | GW-34 | 22.310044 | 82.63481 | 0.878 | 18.102 | 6.928 | 14.971 | 146 |
| 35. | GW-35 | 22.315807 | 82.66115 | 0.28 | 17.949 | 14.936 | 0.421 | 41 |
| 36. | GW-36 | 22.299632 | 82.66788 | 0.432 | 15.241 | 9.254 | 10.352 | 46 |
| 37. | GW-37 | 22.313832 | 82.68492 | 0.306 | 13.604 | 15.063 | 1.174 | 39 |
| 38. | GW-38 | 22.324969 | 82.69116 | 0 | 64.896 | 38.776 | 0.73 | 126 |
| 39. | GW-39 | 22.314707 | 82.69799 | 0.372 | 90.573 | 48.564 | 73.025 | 146 |
| 40. | GW-40 | 22.284815 | 82.58316 | 0.812 | 61.351 | 28.652 | 25.351 | 110 |
| 41. | GW-41 | 22.289902 | 82.54711 | 0.521 | 54.351 | 21.541 | 16.584 | 36 |
| 42. | GW-42 | 22.345766 | 82.48384 | 0.333 | 38.158 | 34.37 | 12.297 | 96 |
| 43. | GW-43 | 22.349923 | 82.64822 | 0.757 | 27.766 | 0.734 | 35.689 | 121 |

Table A.4. Analysis of Anions in groundwater during post-monsoon season

| S. No. | Sites | Lat. | Long. | F ⁻ | Cl ⁻ | NO ₃ ⁻ | SO ₄ ²⁻ | HCO ₃ ⁻ |
|--------|-------|------------|----------|----------------|-----------------|------------------------------|-------------------------------|-------------------------------|
| 1. | GW-1 | 22.355514 | 82.5265 | 0.296 | 49.128 | 20.871 | 7.471 | 73 |
| 2. | GW-2 | 22.371595 | 82.52132 | 0.285 | 55.283 | 44.49 | 7.358 | 79 |
| 3. | GW-3 | 22.361964 | 82.49582 | 0.341 | 234.44 | 114.35 | 45.255 | 163 |
| 4. | GW-4 | 22.334916 | 82.48852 | 0.726 | 34.289 | 4.664 | 33.683 | 83 |
| 5. | GW-5 | 22.33275 | 82.50858 | 1.103 | 69.56 | 2.201 | 1.348 | 116 |
| 6. | GW-6 | 22.373734 | 82.53445 | 0.344 | 25.976 | 9.152 | 16.906 | 65 |
| 7. | GW-7 | 22.304122 | 82.49255 | 0.623 | 92.09 | 0.98 | 25.99 | 155 |
| 8. | GW-8 | 22.307831 | 82.51542 | 0.279 | 73.625 | 65.38 | 14.845 | 69 |
| 9. | GW-9 | 22.307115 | 82.5273 | 0.335 | 35.61 | 8.742 | 7.545 | 56 |
| 10. | GW-10 | 22.28639 | 82.51951 | 0.751 | 133.211 | 83.732 | 139.657 | 245 |
| 11. | GW-11 | 22.318646 | 82.54161 | 0.275 | 39.334 | 71.125 | 0.19 | 42 |
| 12. | GW-12 | 22.312221 | 82.54929 | 0.275 | 49.099 | 26.487 | 9.827 | 68 |
| 13. | GW-13 | 22.310383 | 82.57747 | 0.273 | 36.481 | 67.37 | 7.587 | 68 |
| 14. | GW-14 | 22.298111 | 82.60419 | 0.834 | 25.428 | 0.391 | 28.885 | 142 |
| 15. | GW-15 | 22.300627 | 82.6205 | 0.383 | 2.105 | 2.306 | 1.295 | 34 |
| 16. | GW-16 | 22.311703 | 82.60981 | 0.87 | 37.283 | 2.98 | 273.996 | 298 |
| 17. | GW-17 | 22.321711 | 82.60628 | 0.304 | 80.341 | 4.241 | 38.351 | 183 |
| 18. | GW-18 | 22.342156 | 82.62397 | 0.209 | 12.381 | 5.381 | 48.421 | 72 |
| 19. | GW-19 | 22.361737 | 82.57711 | 0.296 | 68.093 | 26.436 | 40.02 | 142 |
| 20. | GW-20 | 22.372027 | 82.57059 | 0.417 | 30.451 | 4.286 | 19.646 | 68 |
| 21. | GW-21 | 22.368166 | 82.6185 | 0.402 | 19.991 | 0.427 | 66.392 | 102 |
| 22. | GW-22 | 22.3706103 | 82.63626 | 0.734 | 11.803 | 0.294 | 29.369 | 72 |
| 23. | GW-23 | 22.380998 | 82.653 | 0.286 | 62.847 | 37.563 | 18.401 | 105 |
| 24. | GW-24 | 22.34756 | 82.65545 | 0.275 | 45.125 | 57.692 | 4.692 | 59 |
| 25. | GW-25 | 22.362824 | 82.67161 | 0.676 | 4.647 | 0.223 | 12.697 | 39 |
| 26. | GW-26 | 22.351409 | 82.6763 | 0.707 | 151.049 | 1.861 | 20.837 | 121 |
| 27. | GW-27 | 22.348766 | 82.69613 | 0.369 | 115.501 | 171.111 | 67.082 | 119 |
| 28. | GW-28 | 22.337723 | 82.70906 | 0.35 | 45.037 | 29.126 | 64.737 | 111 |
| 29. | GW-29 | 22.355568 | 82.63618 | 0.308 | 43.733 | 60.756 | 3.517 | 55 |
| 30. | GW-30 | 22.356015 | 82.59811 | 0.27 | 24.079 | 15.598 | 5.258 | 52 |
| 31. | GW-31 | 22.359209 | 82.56636 | 0.485 | 3.394 | 1.673 | 10.698 | 39 |
| 32. | GW-32 | 22.34635 | 82.5424 | 0.606 | 13.254 | 3.597 | 176.59 | 142 |
| 33. | GW-33 | 22.332723 | 82.63503 | 0 | 48.447 | 26.539 | 0.927 | 48 |
| 34. | GW-34 | 22.310044 | 82.63481 | 1.083 | 42.224 | 2.046 | 29.192 | 161 |
| 35. | GW-35 | 22.315807 | 82.66115 | 0.291 | 22.022 | 19.202 | 0.291 | 44 |
| 36. | GW-36 | 22.299632 | 82.66788 | 0.936 | 41.257 | 0.345 | 156.178 | 53 |
| 37. | GW-37 | 22.313832 | 82.68492 | 0.405 | 2.578 | 2.486 | 0.881 | 36 |
| 38. | GW-38 | 22.324969 | 82.69116 | 0 | 46.222 | 39.062 | 0.25 | 79 |
| 39. | GW-39 | 22.314707 | 82.69799 | 0.38 | 92.938 | 48.915 | 74.489 | 139 |
| 40. | GW-40 | 22.284815 | 82.58316 | 0.561 | 25.051 | 42.35 | 29.384 | 119 |
| 41. | GW-41 | 22.289902 | 82.54711 | 0.481 | 36.842 | 39.51 | 27.354 | 42 |
| 42. | GW-42 | 22.345766 | 82.48384 | 0.301 | 43.921 | 43.51 | 23.482 | 112 |
| 43. | GW-43 | 22.349923 | 82.64822 | 0.334 | 26.038 | 24.346 | 43.041 | 81 |

Appendix A.5

Table A.5. Analysis of Cations in groundwater during pre-monsoon season

| S. No. | Sites | Lat. | Long. | Ca ²⁺ | Mg ²⁺ | Na ⁺ | K ⁺ | TH |
|--------|-------|------------|----------|------------------|------------------|-----------------|----------------|--------|
| 1. | GW-1 | 22.355514 | 82.5265 | 36.32 | 10.224 | 6.173 | 3.061 | 50.95 |
| 2. | GW-2 | 22.371595 | 82.52132 | 25.47 | 8.04 | 34.211 | 2.642 | 160.96 |
| 3. | GW-3 | 22.361964 | 82.49582 | 68.447 | 23.173 | 64.989 | 10.351 | 325.49 |
| 4. | GW-4 | 22.334916 | 82.48852 | 34.37 | 26.918 | 24.044 | 5.214 | 166.23 |
| 5. | GW-5 | 22.33275 | 82.50858 | 44.36 | 20.641 | 53.632 | 6.631 | 272.40 |
| 6. | GW-6 | 22.373734 | 82.53445 | 40.371 | 13.748 | 30.689 | 9.215 | 160.71 |
| 7. | GW-7 | 22.304122 | 82.49255 | 64.448 | 43.592 | 41.223 | 10.025 | 278.61 |
| 8. | GW-8 | 22.307831 | 82.51542 | 39.23 | 11.905 | 23.283 | 2.214 | 125.61 |
| 9. | GW-9 | 22.307115 | 82.5273 | 29.463 | 26.206 | 24.334 | 2.014 | 165.64 |
| 10. | GW-10 | 22.28639 | 82.51951 | 82.36 | 74.026 | 76.819 | 11.014 | 501.18 |
| 11. | GW-11 | 22.318646 | 82.54161 | 20.46 | 8.795 | 13.129 | 1.351 | 76.03 |
| 12. | GW-12 | 22.312221 | 82.54929 | 24.451 | 8.513 | 20.508 | 1.264 | 105.71 |
| 13. | GW-13 | 22.310383 | 82.57747 | 27.417 | 6.548 | 17.566 | 1.024 | 88.69 |
| 14. | GW-14 | 22.298111 | 82.60419 | 34.47 | 11.742 | 31.041 | 3.214 | 157.15 |
| 15. | GW-15 | 22.300627 | 82.6205 | 68.457 | 2.405 | 2.072 | 17.015 | 14.54 |
| 16. | GW-16 | 22.311703 | 82.60981 | 72.43 | 21.358 | 31.024 | 9.214 | 181.09 |
| 17. | GW-17 | 22.321711 | 82.60628 | 31.32 | 22.244 | 38.591 | 2.152 | 214.46 |
| 18. | GW-18 | 22.342156 | 82.62397 | 26.357 | 19.351 | 27.365 | 1.641 | 161.01 |
| 19. | GW-19 | 22.361737 | 82.57711 | 40.357 | 10.764 | 30.87 | 0.152 | 154.00 |
| 20. | GW-20 | 22.372027 | 82.57059 | 21.73 | 6.945 | 13.529 | 2.314 | 73.05 |
| 21. | GW-21 | 22.368166 | 82.6185 | 26.357 | 11.659 | 16.524 | 1.321 | 97.16 |
| 22. | GW-22 | 22.3706103 | 82.63626 | 27.46 | 9.628 | 13.424 | 1.681 | 79.32 |
| 23. | GW-23 | 22.380998 | 82.653 | 24.457 | 6.962 | 38.847 | 2.314 | 177.36 |
| 24. | GW-24 | 22.34756 | 82.65545 | 28.47 | 7.462 | 29.177 | 16.321 | 138.78 |
| 25. | GW-25 | 22.362824 | 82.67161 | 54.427 | 9.351 | 27.581 | 7.261 | 136.93 |
| 26. | GW-26 | 22.351409 | 82.6763 | 92.37 | 28.097 | 76.95 | 2.314 | 387.04 |
| 27. | GW-27 | 22.348766 | 82.69613 | 24.64 | 30.109 | 75.933 | 1.325 | 387.87 |
| 28. | GW-28 | 22.337723 | 82.70906 | 29.36 | 9.771 | 29.535 | 6.014 | 146.02 |
| 29. | GW-29 | 22.355568 | 82.63618 | 22.447 | 6.876 | 15.314 | 5.651 | 80.23 |
| 30. | GW-30 | 22.356015 | 82.59811 | 35.457 | 3.3 | 12.763 | 12.014 | 60.80 |
| 31. | GW-31 | 22.359209 | 82.56636 | 33.42 | 5.883 | 2.645 | 3.241 | 25.58 |
| 32. | GW-32 | 22.34635 | 82.5424 | 48.367 | 28.333 | 17.266 | 1.624 | 141.85 |
| 33. | GW-33 | 22.332723 | 82.63503 | 49.34 | 14.913 | 40.512 | 8.321 | 204.07 |
| 34. | GW-34 | 22.310044 | 82.63481 | 52.727 | 39.836 | 23.914 | 1.021 | 197.95 |
| 35. | GW-35 | 22.315807 | 82.66115 | 58.46 | 3.136 | 7.304 | 0.684 | 37.91 |
| 36. | GW-36 | 22.299632 | 82.66788 | 23.457 | 4.621 | 12.512 | 1.621 | 63.06 |
| 37. | GW-37 | 22.313832 | 82.68492 | 44.347 | 4.316 | 4.452 | 1.034 | 29.11 |
| 38. | GW-38 | 22.324969 | 82.69116 | 26.357 | 6.058 | 32.16 | 1.651 | 147.56 |
| 39. | GW-39 | 22.314707 | 82.69799 | 48.457 | 19.356 | 35.46 | 1.624 | 194.36 |
| 40. | GW-40 | 22.284815 | 82.58316 | 26.727 | 29.571 | 31.521 | 0.861 | 203.64 |
| 41. | GW-41 | 22.289902 | 82.54711 | 42.448 | 22.314 | 36.014 | 6.251 | 204.02 |
| 42. | GW-42 | 22.345766 | 82.48384 | 25.46 | 7.796 | 22.118 | 2.351 | 110.55 |
| 43. | GW-43 | 22.349923 | 82.64822 | 30.364 | 11.989 | 18.791 | 3.214 | 107.32 |

Table A.6. Analysis of Cations in groundwater during post-monsoon season

| S. No. | Sites | Lat. | Long. | Ca ²⁺ | Mg ²⁺ | Na ⁺ | K ⁺ | TH |
|--------|-------|------------|----------|------------------|------------------|-----------------|----------------|--------|
| 1. | GW-1 | 22.355514 | 82.5265 | 23.214 | 7.818 | 26.673 | 1.907 | 90.16 |
| 2. | GW-2 | 22.371595 | 82.52132 | 12.364 | 14.996 | 33.311 | 1.488 | 92.63 |
| 3. | GW-3 | 22.361964 | 82.49582 | 35.341 | 24.98 | 27.769 | 8.197 | 191.11 |
| 4. | GW-4 | 22.334916 | 82.48852 | 21.264 | 28.981 | 27.812 | 3.06 | 172.44 |
| 5. | GW-5 | 22.33275 | 82.50858 | 31.254 | 17.97 | 54.33 | 4.477 | 152.04 |
| 6. | GW-6 | 22.373734 | 82.53445 | 27.265 | 9.771 | 13.241 | 7.061 | 108.32 |
| 7. | GW-7 | 22.304122 | 82.49255 | 51.342 | 41.925 | 32.823 | 7.871 | 300.85 |
| 8. | GW-8 | 22.307831 | 82.51542 | 26.124 | 12.344 | 25.845 | 1.354 | 116.06 |
| 9. | GW-9 | 22.307115 | 82.5273 | 16.357 | 10.395 | 21.62 | 1.024 | 83.65 |
| 10. | GW-10 | 22.28639 | 82.51951 | 69.254 | 67.976 | 72.599 | 8.86 | 452.85 |
| 11. | GW-11 | 22.318646 | 82.54161 | 7.354 | 10.195 | 21.439 | 2.361 | 60.35 |
| 12. | GW-12 | 22.312221 | 82.54929 | 11.345 | 10.383 | 24.947 | 3.251 | 71.09 |
| 13. | GW-13 | 22.310383 | 82.57747 | 14.311 | 6.936 | 18.306 | 1.234 | 64.30 |
| 14. | GW-14 | 22.298111 | 82.60419 | 21.364 | 37.531 | 30.335 | 1.06 | 207.90 |
| 15. | GW-15 | 22.300627 | 82.6205 | 55.351 | 3.923 | 2.485 | 9.351 | 154.37 |
| 16. | GW-16 | 22.311703 | 82.60981 | 72.324 | 14.234 | 28.842 | 10.06 | 239.21 |
| 17. | GW-17 | 22.321711 | 82.60628 | 18.214 | 19.354 | 31.361 | 1.341 | 125.18 |
| 18. | GW-18 | 22.342156 | 82.62397 | 13.251 | 4.384 | 20.654 | 2.014 | 51.14 |
| 19. | GW-19 | 22.361737 | 82.57711 | 27.251 | 11.77 | 35.232 | 2.341 | 116.51 |
| 20. | GW-20 | 22.372027 | 82.57059 | 8.624 | 9.74 | 28.585 | 1.021 | 61.64 |
| 21. | GW-21 | 22.368166 | 82.6185 | 13.251 | 12.972 | 19.053 | 2.641 | 86.51 |
| 22. | GW-22 | 22.3706103 | 82.63626 | 14.354 | 9.516 | 13.572 | 1.324 | 75.03 |
| 23. | GW-23 | 22.380998 | 82.653 | 11.351 | 7.009 | 37.802 | 2.014 | 57.21 |
| 24. | GW-24 | 22.34756 | 82.65545 | 15.364 | 6.259 | 25.656 | 14.167 | 64.14 |
| 25. | GW-25 | 22.362824 | 82.67161 | 41.321 | 6.852 | 8.62 | 5.107 | 131.40 |
| 26. | GW-26 | 22.351409 | 82.6763 | 79.264 | 30.346 | 78.783 | 1.364 | 322.89 |
| 27. | GW-27 | 22.348766 | 82.69613 | 11.534 | 42.482 | 80.506 | 2.14 | 203.74 |
| 28. | GW-28 | 22.337723 | 82.70906 | 16.254 | 10.517 | 31.258 | 3.86 | 83.90 |
| 29. | GW-29 | 22.355568 | 82.63618 | 9.341 | 10.291 | 14.956 | 3.497 | 65.70 |
| 30. | GW-30 | 22.356015 | 82.59811 | 22.351 | 3.545 | 14.231 | 9.86 | 70.41 |
| 31. | GW-31 | 22.359209 | 82.56636 | 20.314 | 7.714 | 3.074 | 1.087 | 82.49 |
| 32. | GW-32 | 22.34635 | 82.5424 | 35.261 | 28.61 | 12.587 | 2.014 | 205.86 |
| 33. | GW-33 | 22.332723 | 82.63503 | 36.234 | 5.174 | 10.63 | 6.167 | 111.78 |
| 34. | GW-34 | 22.310044 | 82.63481 | 39.621 | 49.225 | 44.25 | 1.641 | 301.64 |
| 35. | GW-35 | 22.315807 | 82.66115 | 45.354 | 3.682 | 8.806 | 1.864 | 128.41 |
| 36. | GW-36 | 22.299632 | 82.66788 | 10.351 | 81.01 | 48.362 | 2.541 | 359.45 |
| 37. | GW-37 | 22.313832 | 82.68492 | 31.241 | 6.393 | 2.548 | 1.652 | 104.34 |
| 38. | GW-38 | 22.324969 | 82.69116 | 13.251 | 4.752 | 24.146 | 1.364 | 52.66 |
| 39. | GW-39 | 22.314707 | 82.69799 | 35.351 | 18.537 | 33.837 | 2.021 | 164.61 |
| 40. | GW-40 | 22.284815 | 82.58316 | 13.621 | 21.684 | 28.482 | 2.341 | 123.31 |
| 41. | GW-41 | 22.289902 | 82.54711 | 29.342 | 27.841 | 21.541 | 4.097 | 187.92 |
| 42. | GW-42 | 22.345766 | 82.48384 | 16.354 | 11.196 | 20.723 | 1.451 | 86.94 |
| 43. | GW-43 | 22.349923 | 82.64822 | 17.258 | 15.558 | 16.371 | 1.06 | 107.16 |

Appendix A.7**Table A.7.** Analysis of physical parameters in surface water during pre-monsoon season

| S. No. | Sites | Lat. | Long. | pH | EC | TDS |
|--------|-------|----------|----------|------|-----|-----|
| 1. | SW-1 | 22.35414 | 82.51663 | 8.35 | 256 | 172 |
| 2. | SW-2 | 22.3616 | 82.49478 | 6.78 | 298 | 202 |
| 3. | SW-3 | 22.33282 | 82.50842 | 8.6 | 363 | 244 |
| 4. | SW-4 | 22.30262 | 82.4942 | 8.2 | 204 | 139 |
| 5. | SW-5 | 22.30597 | 82.53274 | 6.56 | 575 | 389 |
| 6. | SW-6 | 22.30666 | 82.57948 | 6.81 | 424 | 286 |
| 7. | SW-7 | 22.29502 | 82.60928 | 8.23 | 342 | 228 |
| 8. | SW-8 | 22.31709 | 82.60657 | 6.82 | 550 | 365 |
| 9. | SW-9 | 22.37801 | 82.56934 | 5.55 | 98 | 64 |
| 10. | SW-10 | 22.36784 | 82.63339 | 6.25 | 316 | 211 |
| 11. | SW-11 | 22.34914 | 82.67577 | 8.04 | 250 | 165 |
| 12. | SW-12 | 22.3415 | 82.68958 | 7.81 | 409 | 275 |
| 13. | SW-13 | 22.35607 | 82.58254 | 6.66 | 962 | 643 |
| 14. | SW-14 | 22.35099 | 82.55361 | 6.79 | 395 | 261 |
| 15. | SW-15 | 22.31589 | 82.65367 | 6.46 | 219 | 144 |
| 16. | SW-16 | 22.30934 | 82.6892 | 6.81 | 365 | 242 |
| 17. | SW-17 | 22.29223 | 82.54957 | 6.68 | 265 | 145 |

Appendix A.8**Table A.8.** Analysis of physical parameters in surface water during post-monsoon

| S. No. | Sites | Lat. | Long. | pH | EC | TDS |
|--------|-------|----------|----------|------|-----|-----|
| 1. | SW-1 | 22.35414 | 82.51663 | 7.25 | 157 | 106 |
| 2. | SW-2 | 22.3616 | 82.49478 | 7.89 | 175 | 116 |
| 3. | SW-3 | 22.33282 | 82.50842 | 7.31 | 342 | 231 |
| 4. | SW-4 | 22.30262 | 82.4942 | 7.31 | 101 | 67 |
| 5. | SW-5 | 22.30597 | 82.53274 | 7.96 | 326 | 215 |
| 6. | SW-6 | 22.30666 | 82.57948 | 7.34 | 216 | 144 |
| 7. | SW-7 | 22.29502 | 82.60928 | 7.29 | 188 | 125 |
| 8. | SW-8 | 22.31709 | 82.60657 | 8.22 | 529 | 351 |
| 9. | SW-9 | 22.37801 | 82.56934 | 7.47 | 82 | 63 |
| 10. | SW-10 | 22.36784 | 82.63339 | 7.31 | 293 | 195 |
| 11. | SW-11 | 22.34914 | 82.67577 | 7.12 | 179 | 119 |
| 12. | SW-12 | 22.3415 | 82.68958 | 6.35 | 217 | 145 |
| 13. | SW-13 | 22.35607 | 82.58254 | 7.24 | 712 | 465 |
| 14. | SW-14 | 22.35099 | 82.55361 | 7.41 | 408 | 273 |
| 15. | SW-15 | 22.31589 | 82.65367 | 7.96 | 211 | 173 |
| 16. | SW-16 | 22.30934 | 82.6892 | 7.14 | 246 | 131 |
| 17. | SW-17 | 22.29223 | 82.54957 | 6.52 | 275 | 154 |

Appendix A.9

Table A.9. Analysis of anion in surface water during pre-monsoon season

| S. No. | Sites | Lat. | Long. | F ⁻ | Cl ⁻ | NO ₃ ⁻ | SO ₄ ²⁻ | HCO ₃ ⁻ |
|--------|-------|-----------|----------|----------------|-----------------|------------------------------|-------------------------------|-------------------------------|
| 1. | SW-1 | 22.355514 | 82.5265 | 0.609 | 46.311 | 14.563 | 7.36 | 69 |
| 2. | SW-2 | 22.371595 | 82.52132 | 0.643 | 34.413 | 2.743 | 29.044 | 81 |
| 3. | SW-3 | 22.361964 | 82.49582 | 0.578 | 52.228 | 3.342 | 282.092 | 119 |
| 4. | SW-4 | 22.334916 | 82.48852 | 0.65 | 14.937 | 5.409 | 14.691 | 59 |
| 5. | SW-5 | 22.33275 | 82.50858 | 0.789 | 131.961 | 7.862 | 19.028 | 131 |
| 6. | SW-6 | 22.373734 | 82.53445 | 0.608 | 17.172 | 3.745 | 115.044 | 135 |
| 7. | SW-7 | 22.304122 | 82.49255 | 0.755 | 28.399 | 0.811 | 11.317 | 119 |
| 8. | SW-8 | 22.307831 | 82.51542 | 0.552 | 63.459 | 0.432 | 105.694 | 181 |
| 9. | SW-9 | 22.307115 | 82.5273 | 0.417 | 10.836 | 0.358 | 4.193 | 29 |
| 10. | SW-10 | 22.28639 | 82.51951 | 0.385 | 41.219 | 0.388 | 55.173 | 102 |
| 11. | SW-11 | 22.318646 | 82.54161 | 1.031 | 15.294 | 2.104 | 27.518 | 108 |
| 12. | SW-12 | 22.312221 | 82.54929 | 0.882 | 16.641 | 10.757 | 105.159 | 124 |
| 13. | SW-13 | 22.310383 | 82.57747 | 0.676 | 31.685 | 4.557 | 166.948 | 193 |
| 14. | SW-14 | 22.298111 | 82.60419 | 0.471 | 16.626 | 0.528 | 30.12 | 76 |
| 15. | SW-15 | 22.300627 | 82.6205 | 1.098 | 12.898 | 0.382 | 4.9 | 53 |
| 16. | SW-16 | 22.311703 | 82.60981 | 0.836 | 36.061 | 0.378 | 12.77 | 129 |
| 17. | SW-17 | 22.321711 | 82.60628 | 0.515 | 12.564 | 4.256 | 22.324 | 78 |

Appendix A.10

Table A.10. Analysis of anion in surface water during post-monsoon season

| S. No. | Sites | Lat. | Long. | F ⁻ | Cl ⁻ | NO ₃ ⁻ | SO ₄ ²⁻ | HCO ₃ ⁻ |
|--------|-------|-----------|----------|----------------|-----------------|------------------------------|-------------------------------|-------------------------------|
| 1. | SW-1 | 22.355514 | 82.5265 | 0.455 | 26.678 | 3.47 | 5.374 | 38 |
| 2. | SW-2 | 22.371595 | 82.52132 | 0.503 | 19.692 | 0.282 | 11.675 | 49 |
| 3. | SW-3 | 22.361964 | 82.49582 | 0.605 | 33.932 | 0 | 26.182 | 79 |
| 4. | SW-4 | 22.334916 | 82.48852 | 0.505 | 5.365 | 7.29 | 7.26 | 32 |
| 5. | SW-5 | 22.33275 | 82.50858 | 0.432 | 28.504 | 124.731 | 12.754 | 97 |
| 6. | SW-6 | 22.373734 | 82.53445 | 0.568 | 10.83 | 0 | 23.397 | 121 |
| 7. | SW-7 | 22.304122 | 82.49255 | 0.653 | 14.045 | 0 | 6.607 | 53 |
| 8. | SW-8 | 22.307831 | 82.51542 | 0.628 | 51.711 | 0 | 53.488 | 110 |
| 9. | SW-9 | 22.307115 | 82.5273 | 0.418 | 5.749 | 0 | 3.756 | 26 |
| 10. | SW-10 | 22.28639 | 82.51951 | 0.475 | 17.091 | 0.645 | 34.82 | 89 |
| 11. | SW-11 | 22.318646 | 82.54161 | 0.92 | 13.332 | 0 | 22.757 | 93 |
| 12. | SW-12 | 22.312221 | 82.54929 | 0.682 | 7.744 | 1.302 | 37.052 | 68 |
| 13. | SW-13 | 22.310383 | 82.57747 | 0.631 | 14.36 | 0 | 128.942 | 89 |
| 14. | SW-14 | 22.298111 | 82.60419 | 0.384 | 37.208 | 0.224 | 88.344 | 73 |
| 15. | SW-15 | 22.300627 | 82.6205 | 0.716 | 4.435 | 0 | 5.044 | 62 |
| 16. | SW-16 | 22.311703 | 82.60981 | 0.475 | 2.811 | 2.48 | 7.628 | 83 |
| 17. | SW-17 | 22.321711 | 82.60628 | 0.412 | 10.851 | 3.214 | 8.341 | 86 |

Appendix A.11**Table A.11.** Analysis of Cations in surface water during pre-monsoon season

| S. No. | Sites | Lat. | Long. | Ca ²⁺ | Mg ²⁺ | Na ⁺ | K ⁺ | TH |
|--------|-------|-----------|----------|------------------|------------------|-----------------|----------------|--------|
| 1. | SW-1 | 22.355514 | 82.5265 | 25.47 | 9.678 | 19.55 | 12.351 | 104.67 |
| 2. | SW-2 | 22.371595 | 82.52132 | 26.362 | 8.823 | 17.07 | 3.014 | 92.33 |
| 3. | SW-3 | 22.361964 | 82.49582 | 39.475 | 48.709 | 33.199 | 2.324 | 258.34 |
| 4. | SW-4 | 22.334916 | 82.48852 | 20.958 | 3.436 | 15.008 | 3.365 | 70.38 |
| 5. | SW-5 | 22.33275 | 82.50858 | 48.427 | 5.891 | 46.65 | 13.351 | 206.81 |
| 6. | SW-6 | 22.373734 | 82.53445 | 32.47 | 26.022 | 16.16 | 3.264 | 131.52 |
| 7. | SW-7 | 22.304122 | 82.49255 | 30.421 | 11.277 | 24.577 | 1.654 | 129.37 |
| 8. | SW-8 | 22.307831 | 82.51542 | 44.362 | 23.06 | 35.356 | 4.621 | 203.18 |
| 9. | SW-9 | 22.307115 | 82.5273 | 28.448 | 3.288 | 10.334 | 4.257 | 50.77 |
| 10. | SW-10 | 22.28639 | 82.51951 | 23.447 | 12.6 | 17.751 | 2.351 | 104.56 |
| 11. | SW-11 | 22.318646 | 82.54161 | 35.47 | 6.581 | 16.213 | 4.261 | 83.20 |
| 12. | SW-12 | 22.312221 | 82.54929 | 74.64 | 19.968 | 17.435 | 5.214 | 121.66 |
| 13. | SW-13 | 22.310383 | 82.57747 | 29.448 | 81.429 | 24.457 | 4.62 | 304.04 |
| 14. | SW-14 | 22.298111 | 82.60419 | 22.451 | 12.153 | 30.938 | 4.251 | 157.75 |
| 15. | SW-15 | 22.300627 | 82.6205 | 34.747 | 7.088 | 16.874 | 10.354 | 87.19 |
| 16. | SW-16 | 22.311703 | 82.60981 | 23.454 | 10.263 | 38.389 | 5.321 | 183.71 |
| 17. | SW-17 | 22.321711 | 82.60628 | 38.427 | 19.089 | 19.351 | 2.251 | 127.35 |

Appendix A.12**Table A.12.** Analysis of Cations in surface water during post-monsoon season

| S. No. | Sites | Lat. | Long. | Ca ²⁺ | Mg ²⁺ | Na ⁺ | K ⁺ | TH |
|--------|-------|-----------|----------|------------------|------------------|-----------------|----------------|--------|
| 1. | SW-1 | 22.355514 | 82.5265 | 12.364 | 6.374 | 11.734 | 10.197 | 57.12 |
| 2. | SW-2 | 22.371595 | 82.52132 | 13.256 | 6.562 | 9.386 | 2.014 | 60.12 |
| 3. | SW-3 | 22.361964 | 82.49582 | 38.261 | 9.487 | 21.537 | 1.321 | 134.61 |
| 4. | SW-4 | 22.334916 | 82.48852 | 7.852 | 7.987 | 5.255 | 1.211 | 52.50 |
| 5. | SW-5 | 22.33275 | 82.50858 | 35.321 | 40.449 | 21.94 | 11.197 | 254.77 |
| 6. | SW-6 | 22.373734 | 82.53445 | 19.364 | 11.083 | 9.428 | 1.11 | 93.99 |
| 7. | SW-7 | 22.304122 | 82.49255 | 17.315 | 6.935 | 12.066 | 1.354 | 71.79 |
| 8. | SW-8 | 22.307831 | 82.51542 | 41.256 | 17.035 | 27.729 | 4.021 | 173.17 |
| 9. | SW-9 | 22.307115 | 82.5273 | 15.342 | 2.353 | 4.608 | 2.103 | 48.00 |
| 10. | SW-10 | 22.28639 | 82.51951 | 10.341 | 14.446 | 15.84 | 0.197 | 85.31 |
| 11. | SW-11 | 22.318646 | 82.54161 | 22.364 | 5.115 | 13.49 | 2.107 | 76.91 |
| 12. | SW-12 | 22.312221 | 82.54929 | 78.356 | 10.574 | 11.482 | 3.06 | 239.20 |
| 13. | SW-13 | 22.310383 | 82.57747 | 21.214 | 30.792 | 11.467 | 2.466 | 179.77 |
| 14. | SW-14 | 22.298111 | 82.60419 | 9.345 | 13.186 | 28.418 | 2.097 | 77.63 |
| 15. | SW-15 | 22.300627 | 82.6205 | 21.641 | 3.794 | 5.504 | 8.2 | 69.66 |
| 16. | SW-16 | 22.311703 | 82.60981 | 10.348 | 1.999 | 2.635 | 3.167 | 34.07 |
| 17. | SW-17 | 22.321711 | 82.60628 | 25.321 | 5.621 | 9.254 | 1.025 | 86.37 |

Table A.13. Analysis of heavy metals in groundwater during pre-monsoon season

| S. No. | Sites | Lat. | Long. | Al | Ba | Cd | Cr | Cu |
|--------|-------|---------|---------|---------|---------|-------|-------|--------|
| 1. | GW-1 | 22.3555 | 82.5265 | 0 | 78.695 | 1.488 | 2.351 | 0 |
| 2. | GW-2 | 22.3620 | 82.4958 | 2.351 | 41.241 | 0.016 | 1.021 | 0.081 |
| 3. | GW-3 | 22.3349 | 82.4885 | 0 | 69.625 | 0.018 | 0 | 0 |
| 4. | GW-4 | 22.3328 | 82.5086 | 41.049 | 245.22 | 0.069 | 0 | 0 |
| 5. | GW-5 | 22.3737 | 82.5345 | 7.364 | 214.364 | 0.004 | 2.621 | 0.276 |
| 6. | GW-6 | 22.3041 | 82.4925 | 2.532 | 183.521 | 0.038 | 1.021 | 0 |
| 7. | GW-7 | 22.3078 | 82.5154 | 11.012 | 116.814 | 0.137 | 0.981 | 0.522 |
| 8. | GW-8 | 22.2864 | 82.5195 | 3.658 | 38.941 | 0.081 | 0 | 0 |
| 9. | GW-9 | 22.3186 | 82.5416 | 0 | 199.952 | 0.215 | 0 | 0 |
| 10. | GW-10 | 22.3122 | 82.5493 | 21.621 | 46.581 | 0.087 | 1.351 | 1.063 |
| 11. | GW-11 | 22.3104 | 82.5775 | 0 | 68.241 | 0.281 | 2.351 | 0.604 |
| 12. | GW-12 | 22.2981 | 82.6042 | 13.241 | 185.014 | 0.078 | 2.021 | 0.034 |
| 13. | GW-13 | 22.3217 | 82.6063 | 17.95 | 278.651 | 0.015 | 0 | 6.354 |
| 14. | GW-14 | 22.3422 | 82.6240 | 0 | 92.357 | 0.131 | 0 | 7.381 |
| 15. | GW-15 | 22.3720 | 82.5706 | 1.088 | 41.199 | 0.064 | 2.614 | 5.306 |
| 16. | GW-16 | 22.3682 | 82.6185 | 0 | 64.352 | 0.006 | 2.314 | 0 |
| 17. | GW-17 | 22.3706 | 82.6363 | 12.062 | 88.674 | 0.231 | 2.021 | 0 |
| 18. | GW-18 | 22.3476 | 82.6554 | 7.391 | 72.651 | 1.024 | 0.871 | 11.024 |
| 19. | GW-19 | 22.3628 | 82.6716 | 4.627 | 141.354 | 0.061 | 2.324 | 13.054 |
| 20. | GW-20 | 22.3514 | 82.6763 | 0 | 88.461 | 0.022 | 0 | 50.71 |
| 21. | GW-21 | 22.3488 | 82.6961 | 0 | 174.367 | 0.101 | 0 | 4.681 |
| 22. | GW-22 | 22.3377 | 82.7091 | 9.075 | 145.624 | 0.042 | 2.612 | 0 |
| 23. | GW-23 | 22.3556 | 82.6362 | 0 | 93.687 | 0.112 | 1.251 | 7.024 |
| 24. | GW-24 | 22.3560 | 82.5981 | 13.013 | 513.915 | 0.264 | 2.014 | 0 |
| 25. | GW-25 | 22.3592 | 82.5664 | 5.247 | 220.146 | 0.049 | 0.835 | 0 |
| 26. | GW-26 | 22.3464 | 82.5424 | 0 | 193.671 | 0.012 | 0.812 | 2.057 |
| 27. | GW-27 | 22.3327 | 82.6350 | 1.548 | 660.385 | 0.231 | 0 | 0 |
| 28. | GW-28 | 22.3100 | 82.6348 | 6.257 | 70.621 | 0.073 | 1.524 | 0.218 |
| 29. | GW-29 | 22.3158 | 82.6612 | 176.566 | 135.256 | 0.015 | 0 | 0 |
| 30. | GW-30 | 22.2996 | 82.6679 | 11.624 | 89.67 | 0.009 | 1.864 | 3.571 |
| 31. | GW-31 | 22.3138 | 82.6849 | 29.571 | 134.594 | 0.011 | 1.364 | 14.354 |
| 32. | GW-32 | 22.3250 | 82.6912 | 0 | 184.019 | 0.269 | 2.641 | 36.433 |
| 33. | GW-33 | 22.2848 | 82.5832 | 16.573 | 71.354 | 0.011 | 0.892 | 0 |
| 34. | GW-34 | 22.2899 | 82.5471 | 11.672 | 221.654 | 0.002 | 0.861 | 0 |
| 35. | GW-35 | 22.3458 | 82.4838 | 7.061 | 620.812 | 0.031 | 1.254 | 12.354 |

Appendix A.14**Table A.14.** Analysis of heavy metals in groundwater during post-monsoon season

| S. No. | Sites | Lat. | Long. | Al | Ba | Cd | Cr | Cu |
|--------|-------|---------|---------|---------|---------|-------|-------|--------|
| 1. | GW-1 | 22.3555 | 82.5265 | 0 | 64.652 | 0.864 | 1.962 | 0 |
| 2. | GW-2 | 22.3620 | 82.4958 | 2.012 | 32.654 | 0.022 | 0.632 | 0.077 |
| 3. | GW-3 | 22.3349 | 82.4885 | 0 | 53.235 | 0.013 | 0 | 0 |
| 4. | GW-4 | 22.3328 | 82.5086 | 35.164 | 241.354 | 0.051 | 0 | 0 |
| 5. | GW-5 | 22.3737 | 82.5345 | 11.982 | 193.652 | 0.022 | 2.232 | 0.248 |
| 6. | GW-6 | 22.3041 | 82.4925 | 7.164 | 176.321 | 0.031 | 0.632 | 0 |
| 7. | GW-7 | 22.3078 | 82.5154 | 9.842 | 98.364 | 0.121 | 0.592 | 3.381 |
| 8. | GW-8 | 22.2864 | 82.5195 | 6.045 | 36.351 | 0.027 | 0 | 0 |
| 9. | GW-9 | 22.3186 | 82.5416 | 0 | 178.652 | 0.024 | 0.251 | 0 |
| 10. | GW-10 | 22.3122 | 82.5493 | 17.651 | 39.365 | 0.061 | 0.962 | 2.964 |
| 11. | GW-11 | 22.3104 | 82.5775 | 0 | 52.341 | 0.164 | 1.962 | 1.381 |
| 12. | GW-12 | 22.2981 | 82.6042 | 11.652 | 163.521 | 0.062 | 1.632 | 0 |
| 13. | GW-13 | 22.3217 | 82.6063 | 16.982 | 243.321 | 0.012 | 0.124 | 5.248 |
| 14. | GW-14 | 22.3422 | 82.6240 | 0 | 81.621 | 0.089 | 0 | 6.158 |
| 15. | GW-15 | 22.3720 | 82.5706 | 0 | 50.621 | 0.058 | 2.225 | 4.671 |
| 16. | GW-16 | 22.3682 | 82.6185 | 0 | 61.321 | 0.012 | 1.925 | 0 |
| 17. | GW-17 | 22.3706 | 82.6363 | 11.562 | 76.654 | 0.198 | 1.632 | 0 |
| 18. | GW-18 | 22.3476 | 82.6554 | 7.067 | 53.251 | 0.862 | 0.482 | 9.246 |
| 19. | GW-19 | 22.3628 | 82.6716 | 4.167 | 99.351 | 0.054 | 1.935 | 11.541 |
| 20. | GW-20 | 22.3514 | 82.6763 | 0 | 71.365 | 0.022 | 0 | 34.351 |
| 21. | GW-21 | 22.3488 | 82.6961 | 0 | 146.321 | 0.089 | 0.341 | 2.651 |
| 22. | GW-22 | 22.3377 | 82.7091 | 7.364 | 126.351 | 0.031 | 2.223 | 0 |
| 23. | GW-23 | 22.3556 | 82.6362 | 0 | 84.365 | 0.079 | 0.862 | 5.624 |
| 24. | GW-24 | 22.3560 | 82.5981 | 10.348 | 218.214 | 0.167 | 1.625 | 0 |
| 25. | GW-25 | 22.3592 | 82.5664 | 10.064 | 189.351 | 0.039 | 0.446 | 0 |
| 26. | GW-26 | 22.3464 | 82.5424 | 0 | 165.354 | 0.008 | 0.423 | 1.294 |
| 27. | GW-27 | 22.3327 | 82.6350 | 0 | 235.621 | 0.197 | 0 | 0 |
| 28. | GW-28 | 22.3100 | 82.6348 | 4.362 | 84.521 | 0.059 | 1.135 | 0.108 |
| 29. | GW-29 | 22.3158 | 82.6612 | 153.214 | 109.358 | 0.012 | 0 | 0 |
| 30. | GW-30 | 22.2996 | 82.6679 | 8.651 | 75.365 | 0.018 | 1.475 | 3.164 |
| 31. | GW-31 | 22.3138 | 82.6849 | 21.305 | 126.245 | 0.009 | 0.975 | 9.641 |
| 32. | GW-32 | 22.3250 | 82.6912 | 0 | 146.235 | 0.193 | 2.252 | 28.641 |
| 33. | GW-33 | 22.2848 | 82.5832 | 13.62 | 64.384 | 0.018 | 0.503 | 0 |
| 34. | GW-34 | 22.2899 | 82.5471 | 11.052 | 198.358 | 0.021 | 0.472 | 0 |
| 35. | GW-35 | 22.3458 | 82.4838 | 5.365 | 198.624 | 0.028 | 0.865 | 8.654 |

Table A.15. Analysis of heavy metals in groundwater during pre-monsoon season

| S. No. | Sites | Lat. | Long. | Fe | Mn | Pb | Ni | Zn |
|--------|-------|---------|---------|---------|---------|-------|--------|----------|
| 1. | GW-1 | 22.3555 | 82.5265 | 0 | 242.19 | 4.963 | 2.467 | 3712.512 |
| 2. | GW-2 | 22.3620 | 82.4958 | 17.241 | 30.214 | 0 | 0 | 39.651 |
| 3. | GW-3 | 22.3349 | 82.4885 | 64.261 | 137.214 | 2.341 | 3.3541 | 81.354 |
| 4. | GW-4 | 22.3328 | 82.5086 | 0 | 27.992 | 1.022 | 0 | 0 |
| 5. | GW-5 | 22.3737 | 82.5345 | 51.354 | 139.267 | 2.347 | 11.354 | 12.364 |
| 6. | GW-6 | 22.3041 | 82.4925 | 0 | 20.842 | 0.089 | 4.651 | 13.051 |
| 7. | GW-7 | 22.3078 | 82.5154 | 71.354 | 45.574 | 0 | 2.364 | 0 |
| 8. | GW-8 | 22.2864 | 82.5195 | 19.741 | 204.57 | 0 | 18.354 | 21.025 |
| 9. | GW-9 | 22.3186 | 82.5416 | 0 | 24.911 | 0.37 | 4.279 | 0 |
| 10. | GW-10 | 22.3122 | 82.5493 | 41.351 | 37.541 | 0.371 | 0 | 0 |
| 11. | GW-11 | 22.3104 | 82.5775 | 63.512 | 84.254 | 0 | 8.354 | 8.671 |
| 12. | GW-12 | 22.2981 | 82.6042 | 0 | 33.124 | 1.182 | 0 | 13.021 |
| 13. | GW-13 | 22.3217 | 82.6063 | 12.354 | 69.542 | 0 | 6.354 | 0 |
| 14. | GW-14 | 22.3422 | 82.6240 | 0 | 52.567 | 0.671 | 16.354 | 31.024 |
| 15. | GW-15 | 22.3720 | 82.5706 | 104.027 | 17.528 | 0 | 0 | 29.641 |
| 16. | GW-16 | 22.3682 | 82.6185 | 88.354 | 21.524 | 1.412 | 4.351 | 0 |
| 17. | GW-17 | 22.3706 | 82.6363 | 17.257 | 32.257 | 0.754 | 9.514 | 0 |
| 18. | GW-18 | 22.3476 | 82.6554 | 9.572 | 28.364 | 0.871 | 19.354 | 68.351 |
| 19. | GW-19 | 22.3628 | 82.6716 | 120.571 | 62.541 | 1.341 | 11.215 | 83.541 |
| 20. | GW-20 | 22.3514 | 82.6763 | 340.828 | 162.035 | 0 | 0 | 110.701 |
| 21. | GW-21 | 22.3488 | 82.6961 | 138.242 | 111.647 | 1.654 | 2.354 | 42.357 |
| 22. | GW-22 | 22.3377 | 82.7091 | 0 | 87.243 | 0.814 | 1.024 | 0 |
| 23. | GW-23 | 22.3556 | 82.6362 | 35.624 | 28.641 | 0 | 24.321 | 32.354 |
| 24. | GW-24 | 22.3560 | 82.5981 | 0 | 351.02 | 1.665 | 69.872 | 84.999 |
| 25. | GW-25 | 22.3592 | 82.5664 | 0 | 60.564 | 0.724 | 20.131 | 0 |
| 26. | GW-26 | 22.3464 | 82.5424 | 32.254 | 39.587 | 0.196 | 0 | 0 |
| 27. | GW-27 | 22.3327 | 82.6350 | 0 | 74.706 | 0 | 58.45 | 213.181 |
| 28. | GW-28 | 22.3100 | 82.6348 | 0 | 108.624 | 0 | 27.351 | 310.214 |
| 29. | GW-29 | 22.3158 | 82.6612 | 0 | 34.078 | 0 | 3.818 | 0 |
| 30. | GW-30 | 22.2996 | 82.6679 | 71.351 | 37.054 | 0.864 | 0 | 6.357 |
| 31. | GW-31 | 22.3138 | 82.6849 | 56.841 | 108.241 | 2.574 | 7.654 | 116.381 |
| 32. | GW-32 | 22.3250 | 82.6912 | 2892.06 | 367.681 | 7.368 | 54.262 | 11766.92 |
| 33. | GW-33 | 22.2848 | 82.5832 | 42.651 | 88.351 | 3.571 | 6.354 | 109.354 |
| 34. | GW-34 | 22.2899 | 82.5471 | 39.541 | 68.354 | 6.514 | 0 | 68.357 |
| 35. | GW-35 | 22.3458 | 82.4838 | 63.248 | 35.045 | 0 | 0 | 0 |

Appendix A.16

Table A.16. Analysis of heavy metals in groundwater during post-monsoon season

| S. No. | Sites | Lat. | Long. | Fe | Mn | Pb | Ni | Zn |
|--------|-------|---------|---------|---------|---------|-------|--------|---------|
| 1. | GW-1 | 22.3555 | 82.5265 | 0 | 183.651 | 3.364 | 5.031 | 2896.51 |
| 2. | GW-2 | 22.3620 | 82.4958 | 13.651 | 21.3651 | 0 | 0 | 28.632 |
| 3. | GW-3 | 22.3349 | 82.4885 | 59.671 | 106.251 | 2.151 | 3.164 | 73.459 |
| 4. | GW-4 | 22.3328 | 82.5086 | 0 | 19.325 | 0.589 | 0 | 0 |
| 5. | GW-5 | 22.3737 | 82.5345 | 38.351 | 111.026 | 1.864 | 10.321 | 10.359 |
| 6. | GW-6 | 22.3041 | 82.4925 | 0 | 16.351 | 0 | 4.003 | 11.352 |
| 7. | GW-7 | 22.3078 | 82.5154 | 63.521 | 32.561 | 0 | 1.681 | 0 |
| 8. | GW-8 | 22.2864 | 82.5195 | 18.364 | 124.256 | 0 | 13.28 | 17.562 |
| 9. | GW-9 | 22.3186 | 82.5416 | 0 | 21.581 | 0.261 | 4.279 | 0 |
| 10. | GW-10 | 22.3122 | 82.5493 | 32.451 | 36.521 | 0.214 | 0 | 0 |
| 11. | GW-11 | 22.3104 | 82.5775 | 51.624 | 69.351 | 0 | 6.621 | 8.015 |
| 12. | GW-12 | 22.2981 | 82.6042 | 0 | 28.653 | 0.795 | 0 | 9.561 |
| 13. | GW-13 | 22.3217 | 82.6063 | 8.254 | 53.258 | 0 | 13.321 | 0 |
| 14. | GW-14 | 22.3422 | 82.6240 | 0 | 41.357 | 0.492 | 11.235 | 27.324 |
| 15. | GW-15 | 22.3720 | 82.5706 | 89.654 | 15.025 | 0 | 0 | 23.563 |
| 16. | GW-16 | 22.3682 | 82.6185 | 69.521 | 17.654 | 1.061 | 7.622 | 0 |
| 17. | GW-17 | 22.3706 | 82.6363 | 12.651 | 23.254 | 0.359 | 6.651 | 0 |
| 18. | GW-18 | 22.3476 | 82.6554 | 0 | 23.514 | 0.628 | 17.624 | 53.456 |
| 19. | GW-19 | 22.3628 | 82.6716 | 108.651 | 42.364 | 0.862 | 12.326 | 65.265 |
| 20. | GW-20 | 22.3514 | 82.6763 | 289.621 | 97.657 | 0 | 0 | 102.324 |
| 21. | GW-21 | 22.3488 | 82.6961 | 108.541 | 89.624 | 1.264 | 6.164 | 39.562 |
| 22. | GW-22 | 22.3377 | 82.7091 | 0 | 74.651 | 0.641 | 9.003 | 0 |
| 23. | GW-23 | 22.3556 | 82.6362 | 29.571 | 23.681 | 0 | 19.651 | 29.562 |
| 24. | GW-24 | 22.3560 | 82.5981 | 0 | 106.254 | 1.341 | 52.364 | 75.367 |
| 25. | GW-25 | 22.3592 | 82.5664 | 0 | 48.681 | 0.421 | 15.349 | 0 |
| 26. | GW-26 | 22.3464 | 82.5424 | 31.054 | 32.651 | 0.046 | 0 | 0 |
| 27. | GW-27 | 22.3327 | 82.6350 | 0 | 61.358 | 0 | 43.456 | 194.351 |
| 28. | GW-28 | 22.3100 | 82.6348 | 0 | 88.657 | 0 | 21.147 | 267.435 |
| 29. | GW-29 | 22.3158 | 82.6612 | 0 | 31.264 | 1.452 | 3.068 | 0 |
| 30. | GW-30 | 22.2996 | 82.6679 | 61.561 | 32.658 | 0.614 | 0 | 5.268 |
| 31. | GW-31 | 22.3138 | 82.6849 | 51.256 | 92.651 | 2.681 | 6.164 | 109.624 |
| 32. | GW-32 | 22.3250 | 82.6912 | 110.351 | 96.336 | 2.351 | 42.354 | 9866.35 |
| 33. | GW-33 | 22.2848 | 82.5832 | 32.264 | 69.564 | 3.051 | 5.692 | 89.458 |
| 34. | GW-34 | 22.2899 | 82.5471 | 31.264 | 56.265 | 5.261 | 0 | 57.264 |
| 35. | GW-35 | 22.3458 | 82.4838 | 52.354 | 26.625 | 0 | 0 | 0 |

GLOSSARY

A glossary provides descriptions of the important terms used in this thesis.

pH- Since pH is the negative logarithm of H^+ ion concentration, it can be used to identify how acidic or alkaline a solution is. The pH scale typically spans from 0 to 14.

Total Dissolved Solid- TDS is a measurement of the dissolved combined content of all inorganic and organic compounds available inside a liquid in molecular, ionized, or micro-granular suspended form.

Electrical Conductivity- The EC scale is used to quantify the electrical current-carrying capacity of water and its ability is directly influenced by the ion content of the water. These conductive ions come from dissolved salts as well as inorganic chemicals like alkalis, chlorides, sulphides, and carbonate compounds.

Hardness- The amount of dissolved both calcium and magnesium in water is measured as water hardness. Hard water has a high level of dissolved minerals, primarily calcium and magnesium.

Physicochemical- It is a branch of chemistry concerned with the physical and chemical properties of substances.

Contaminants- Contamination is the term used to describe a biological, chemical, physical, or radioactive contaminant that has been intentionally or unintentionally added to water and has since harmed people or other living things.

Water Pollution- Water pollution is the polluting of water sources with substances that makes the water unhealthy for drinking, cooking, and other uses. Pollutants include

substances like chemicals, trash, and bacteria. All forms of pollution eventually make their way to water.

Water Quality Index- The water quality index (WQI) is a single value (like a grade) that measures the total water quality at a given location and time using several water quality parameters.

Heavy Metal Pollution- Heavy metal pollution has developed as a result of anthropogenic activity, which is the main cause of pollution. This is primarily because of metal mining, smelting, foundries, and other industries that use metal, as well as the leaching of metals from different sources like landfills, waste dumps, excretion, livestock, and chicken manure.

Heavy Metal Pollution Index- The Heavy Metal Pollution Index (HPI) is a scale that measures the overall impact of dissolved heavy metals.

Heavy Metal Evaluation Index- As an alternative to the HPI index, it is suggested that the HEI index be used to determine the concentrations of heavy metals in water.

Metal Index- The metal index (MI) assesses the extent to which heavy metals harm human health in addition to the overall water quality used for drinking, domestic use, and other uses

Sustainable- it refers to satisfying our own wants while without compromising the ability of subsequent generations to satisfy their own needs.

Geographical Information System- A computer system that evaluates and presents information with a geographic context is known as a Geographic Information System (GIS). It employs information linked to a certain place.

Remote Sensing- It means that observing the earth from a distance and gaining information about it without really touching it. It detects reflected radiation from the earth and are commonly placed on satellites or aircraft.

Image- Images are computer images of the earth's surface that are built using spectral data collected by sensors on specialized satellites.

Band- The term "band" refers to a certain wavelength range in the electromagnetic spectrum.

Resolution- Capability to distinguish between two visible objects. More visual detail translates into better resolution.

Digital Elevation Model- A DEM, commonly referred to as a raster GIS layer, is a digital elevation model. They are vertical datum-referenced raster grids of the Earth's surface, or the surface at zero elevation, to which scientists, insurers, and geodesists use when describing heights.

Electromagnetic Spectrum- It refers to the complete dispersion of electromagnetic radiation by frequency or wavelength. There are seven subgroups that they are commonly categorized into: radio, microwave, infrared, visible, ultra-violet, x-ray, and gamma-ray radiation respectively.

Thermal Infrared Sensor-The Thermal Infrared Sensor (TIRS) uses quantum physics to detect heat and estimate land surface temperature in two thermal bands.

False Color Composite- FCC is a color image that has been artificially created in which the different shades of blue, green, and red have been allocated to wavelength ranges that they do not naturally belong in.

Multispectral Scanner System- A multispectral scanner (MSS) is a scanning device that captures data place at various wavelengths. It is the most popular scanning system. The two main scanning methods for acquiring multispectral image data are across-track and along-track scanning.

Aster- The Advanced Spaceborne Thermal Emission and Reflection Radiometer sensor, or ASTER for short, is the name of the image instrument carried by the Terra satellite, which has been launched on December 1999.

LISS-III- A remote sensing satellite sensor operated by the Indian Space Research Organization (ISRO) that captures multispectral data in four bands is called the Linear Imaging Self-Scanning Sensor 3 (LISS III).

Sentinel- it is a Copernicus Earth observation project that gathers optical imagery over land and coastal waterways with high spatial resolution (10 m to 60 m).

Landsat- Land remote sensing satellite, a series of satellites built to collect data on Earth's resources in a systematic manner, is operated by a US earth observation satellite firm and utilized for: land use inventory, crop/forestry assessment, geological and mineralogical investigations, and cartography.

Land Use Land Cover- Land Use Land Cover (LULC) maps of an area give information to help people to understand the current terrain or landscape in specific time frame.

Land Surface Temperature- The Land Surface Temperature (LST) is the radiative skin temperature of the land surface as measured in the direction of the remote sensor.

Normalized Difference Vegetation Index- The NDVI is a dimensionless metric that quantifies the difference between visible and near-infrared light reflectance in vegetation and can be used to determine the density of green on a piece of land.

Normalized Difference Water Index- The Normalized Difference Water Index (NDWI) is used in satellite imagery to emphasize open water features, allowing a body of water to "stand out" against the land and vegetation.

Spatial Distribution Map- a spatial patterns, also referred to as the study of spatial distribution or a pattern of geographic variation. Or In statistics, a spatial distribution is the distribution of a phenomena across the Earth's surface.

Pearson's Correlation Coefficient- Pearson's correlation coefficient is the covariance of the two variables divided by the product of their standard deviations.

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1. **Dheeraj, V. P.**, Singh, C. S., & Sonkar, A. K. (2022). Land Use Land Cover (LULC) Study with Different Geospatial Indices of Korba Coalfield Region, Chhattisgarh, India. *Indian Journal of Environmental Protection*, IJEP 42(12): 1445-1455: Vol. 42 Issue. 12 (2022).
2. **Dheeraj, V. P.**, Singh, C. S., Kishore, N., & Sonkar, A. K. (2023). Groundwater Quality Assessment in Korba Coalfield Region, India: An Integrated Approach of GIS and Heavy Metal Pollution Index (HPI) Model. *Nature Environment & Pollution Technology*, 22(1).
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4. **Dheeraj, V. P.**, Singh, C. S., Sonkar, A. K., & Kishore, N. (2024). Heavy metal pollution indices estimation and principal component analysis to evaluate the groundwater quality for drinking purposes in Coalfield Region, India. *Sustainable Water Resources Management*, 10(1), 1-16.
5. **Dheeraj, V. P.**, Singh, C. S., Sonkar, A. K., & Barman, S. K. (2024). Assessment of heavy metal contaminants in ground water around mining area by using metal pollution indices multivariate analysis and GIS techniques, *Journal of Chemical Technology and Metallurgy*, 59(4), 1-14.

LIST OF INTERNATIONAL CONFERENCE PAPER

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3. Assessment of Rihand Reservoir water quality using WQI Approach in Sonbhadra district, India. **Vijayendra Pratap Dheeraj**, Ashwani Kumar Sonkar, Ramita Varshney & Dharmendra Kumar Singh, Accepted and published in proceedings of International Conference on Recent advances in science & Engineering, (RASE-2021), REC Sonbhadra, February 26-27, (2021), pp. 63.
4. Assessment of Groundwater Suitability for drinking and irrigation purposes in Singrauli Coalfield Region, Madhya Pradesh. Ashwani Kumar Sonkar, **Vijayendra Pratap Dheeraj**, Aarif Jamal & C.S Singh, Accepted and published in Proceeding of 2th International Conference on Opencast Mining Technology & Sustainability (ICOMS-2019), NCL Singarauli (M.P), December 13-14, (2019), pp.174-179.

5. A Study on the relationship between Normalized Difference Vegetation Index and Land Surface Temperature in Coalfield Region, India: An integrated approach of Remote Sensing & GIS, **Vijayendra Pratap Dheeraj**, C.S Singh & Nawal Kishore, Accepted and published in Proceeding of 2nd International Conference on Geotechnical Issues in Energy, Infrastructure and Disaster Management, January 18-20, (2024), pp.58.