ASSESSMENT OF IMPACT OF COAL MINING ON GROUNDWATER WITH REFERENCE TO SINGRAULI COALFIELD

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Doctor of Philosophy

By

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CHAPTER 7

CONCLUSIONS AND FUTURE SUGGESTIONS

7.1 Conclusion

The generalized conclusions of the research work derived from different objective are as follows:

- A total of eighty-six dug-wells were selected for the monitoring of groundwater level around different coal mining blocks of Singrauli coalfields for pre and post-monsoon for the season 2016. The pre-monsoonal and post-monsoonal groundwater level (mbgl) data has been recorded in the month of April and November. Five vital hydrogeological parameters viz. soil, geology, drainage, elevation and slope of the study area has been considered. The thematic maps of various hydrogeological parameters were prepared to assess the impact of hydrogeological parameters on groundwater level fluctuation.
- The groundwater level in the study area varied between 0.83 and 25 mbgl during pre-monsoon season.
- The groundwater level varied from 1 to 25 mbgl during post-monsoon season.
- The groundwater level is observed is very high (>20 mbgl) at few locations such as Khadia Tola (490 m) and Mukhiya Tola (482 m), this may be due to the elevation at that point is very high.
- Based on GIS maps comparative analysis, it has been found that south-west and few portions of the north-east region of the study area have shown a higher level of water level fluctuation (WLF >1.5m) whereas, north-west, south-east and central areas have shown lower water level fluctuation (WLF < 1.5m).
- The slope, drainage, elevation and geology of the study area were more significant parameters that affected the groundwater fluctuation as compared to soil. The

groundwater level of the study region has also been affected by coal mining and industrial activities.

- Demarcating the groundwater potential zones in Singrauli coalfield using combined application of remote sensing, GIS and MIF techniques.
- Satellite images, topographic maps and conventional data were used to make the thematic layers of lineament, land-use, geology, drainage, slope, and soil. These thematic layers are assigned appropriate weightage using the MIF technique and then integrated in the GIS software to prepare the groundwater potential zone map of the study region.
- The obtained groundwater potential zones has been divided into four classes namely very good, good, very poor and poor zones.
- The groundwater potential zone map have been showed that very good and good groundwater potential found in the plains as it comprises cropland, gentle slope, pediplains,whereas poor and very poor groundwater potential was found in and around the mining area as it covers forest/hilly area with a steep slope, metamorphic and built-up area.
- A comparative analysis has been done by comparing the WLF map with the groundwater potential zone map, it was found that the maximum water level fluctuation area shows very good groundwater potential zone whereas the lowest water level fluctuation area shows poor groundwater potential zone.
- The results of the present research can help as guidelines for planning future artificial recharge projects in the study area in order to ensure sustainable groundwater utilization.

- To assess the groundwater quality of the study region, a systematic sampling of groundwater was carried out during dry seasons in the month of May, 2018.A total of forty-six (46) groundwater samples were collected from different locations of the Singrauli coalfields and analyzed for thirteen major physicochemical parameters (pH, EC, TDS, total hardness, bicarbonate, Cl^-, F^-, NO_3^-, SO_4^{2-}, Ca^{2+}, Na^+, Mg^{2+}, K^+) and seven heavy metals (Fe, Cu, Pb, Cd, Cr, Ni, Zn).
- The analytical results indicate the slightly acidic to slightly alkaline nature of the groundwater in the study region.
- Bicarbonate and chloride were dominant anions and representing on average 43% and 28% of the total anions. The order of mean abundance of major anions was $HCO_3^- > Cl^- > SO_4^{2-} > NO_3^-$.
- Calcium and sodium were dominant ion among all the cations and representing on average 40% and 38% of the total cations. The order of mean abundance of major cations was $Ca^{2+} > Na^+ > Mg^{2+} > K^+$.
- The correlation matrix indicated that the strong positive correlation coefficients were observed between TDS and EC (r=0.999), SO_4^{2-} and EC (r=0.872), SO_4^{2-} and TDS (r=0.871), SO_4^{2-} and Cl^-(r=0.817), TH and Ca^{+2} (r=0.807), while strong negative correlation coefficients were observed between K^+ and F^-(r=-0.316), Fe^{2+} and pH (r=0.311).
- The Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) index was used to reflect the overall and ongoing condition of the water. The WQI of groundwater samples was found in the range of 64.90 to 96.52. Almost 56% of the total water samples were found in the range good category, 35% were found in

fair category, 7 % were found in excellent category and 2 % were found in the marginal category, respectively.

- The results of Hierarchical cluster analysis are given as a dendrogram was indicating the sampling stations have mainly grouped into three Clusters: cluster I, II and III. Cluster I consist of 26 sampling stations whereas cluster II consist of 17 sampling stations and Cluster III consists of only three sampling stations (GW-3, GW-46, and GW-44).
- From Piper trilinear diagram, the diamond-shaped part of the plot reveals that nearly 48% of the groundwater samples collected from the study area laid under the Ca-Mg-HCO_3 category indicating the percolation and dissolution of minerals. However, approximately the same percentage of samples i.e. 46% of the samples fall under the Ca-Mg-Cl-SO_4 group representing the presence of anthropogenic activities. Apart from this, only 4% and 2% of the groundwater samples appeared under NaCl-SO_4 and NaK-HCO_3 groups respectively showing the process of dissolution of minor minerals present in the area.
- The Gibbs diagram indicated that the majority of the water samples fall under the rock water dominance field for both ratios (cations & anions) and only few samples were placed under the evaporation dominance zone.
- Based on sodium adsorption ratio (SAR), sodium percentage (Na %), Kelly's ratio (KR) and magnesium hazard (MH). The computed SAR values of the groundwater in the study area ranged from 0.40 and 7.20 meq/l with an average value of 1.36 meq/l. Majority of groundwater samples fall under the higher to medium salinity and low alkali category, which can be used for irrigation purposes.
- The soluble sodium percentage (%Na) of the examined groundwater samples of the study region varies from 10.31% to 78.24% with an average value of 32.27 %. Based

on wilcox classification, about 76.08% of the water samples come under very good to good and 19.56 % of the samples come under good to permissible class, which may be used for irrigation purposes, whereas the rest of water samples (GW-15, 16) fall under the range of good to permissible.

- Kelly's ratio was calculated in the study region which ranges from 0.11 to 3.40. Based on KI classification, about 91.30% of water samples were suitable and 8.70% of water samples are unsuitable for irrigation purposes.
- The magnesium hazard values ranged from 10.97 to 82.84 meq/l with the mean value of 41.33 meq/l. Approx. 23.91% of the groundwater samples were not appropriate for irrigation purposes.
- As per the classifications of groundwater for irrigation using the SAR, Na%, KI and MH, the majority of the groundwater samples were found to be appropriate for irrigation purposes.
- The remote sensing and GIS application have been utilize to examine land use/land cover changes in the study region. Six major land use /land cover classes such as built-up area, mining area, forest/hilly area, crop land, water body and fallow land have been clearly identified. The results of the present research provided the trend of major changes in the land use/land cover classes of study region during the 1990-2019.
- The maximum positive change (352.61%) is observed in the mining area during 1990–2019, whereas maximum negative change is recorded in the forest/hilly area (-37.36%) and fallow land (-30.17%) area in the same period.
- The area of forest/hilly and fallow land has reduced during 1990-2019. This reduction was due to the conversion of forest/hilly areas and fallow land into coal mining area.

- The area of built-up has increased from 3.20 km^2 to 9.24 km^2 during 1990-2019. This increase of 6.04 km^2 in the built-up area has taken place mainly due to the industrialization in the region.
- It is observed there is a direct impact of mining on forest/hilly area and fallow land due to the expansion of mining areas during the study period. The rapid expansion of coal mine and industrial activities had been responsible for drastic changes in the land use/land cover change in the last 3 decades in the study region.
- The effective management techniques that can be suggested for the study region are rainwater harvesting, artificial recharge, plantations and treatment of available water resources.

7.2 Suggestions for future work

- There is need to study the impact of blasting on geo-hydrological properties of aquifer and adjoining rocks.
- There is essential to study the groundwater flow modeling for development and management of groundwater resources.
- Prediction of water inflows into a surface mine excavation is also essential to study the impact of mining on surrounding groundwater resources.
- Water management plans should be developed on a regional basis.