WATER POLLUTION DUE TO COAL MINING AND ITS MANAGEMENT WITH SPECIAL REFERENCE TO THE GOVIND BALLABH PANT RESERVOIR

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By

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CHAPTER 7

CONCLUSIONS AND FUTURE SUGGESTIONS

7.1 Conclusions

The study has been conducted in a coal mining complex and nearby reservoir. The objective of the study was to assess the impact of mining on Govind Ballabh Pant reservoir in terms of quality and volume of the water of the reservoir. The management of water pollution caused by mining has also been assessed and phytoremediation technique was used to lessen the impact of mining. As a result of this study, the following important conclusions have been drawn.

1) The water samples collected during the study were mostly alkaline in nature. The pH of water samples located in different locations varied from 8.8 to 6.3 and 8.5 to 7.5 respectively with a mean value of 7.3 and 7.9 respectively during pre and post-monsoon season.

2) The TDS and TSS of the water samples ranged from 574 mg/L to 107 mg/L and 697 mg/L to 227 mg/L respectively with a mean value of 239.6 mg/L and 348.2 mg/L respectively during pre-monsoon season. In post-monsoon season, it ranged from 616 mg/L to 177 mg/L and 719 mg/L to 271 mg/L with a mean value of 286.3 mg/L and 431.8 mg/L respectively. These values were well within the permissible limit of 500 mg/L and 500 mg/L respectively as suggested by BIS/WHO.

3) The EC of water samples ranged between 1148 µS/cm to 214 µS/cm with a mean value of 477.4 µS/cm during pre-monsoon monsoon while it ranged from 1231 µS/cm to 354 µS/cm with a mean value of 573.6 µS/cm. However, most of the samples revealed moderate higher conductivity values than the permissible limit of 300 µS/cm as recommended by BIS/WHO.

4) The cations like magnesium and sodium ranged from 37.9 mg/L to 10.1 mg/L and 49.9 mg/L to 11.9 mg/L respectively with a mean value of 19.2 mg/L and 27.1 mg/L

respectively during pre-monsoon season. In post-monsoon season, it ranged from 33.5 mg/L to 8.1 mg/L and 59.2 mg/L to 20.9 mg/L with a mean value of 14.8 mg/L and 31.6 mg/L respectively. These values were well within the permissible limit of 50 mg/L and 50 mg/L respectively as suggested by BIS/WHO.

5) The concentration of calcium and potassium in the region ranged from 95.2 mg/L to 11.1 mg/L and 26.2 mg/L to 10.6 mg/L with a mean value of 36.3 mg/L and 13.6 mg/L respectively during pre-monsoon season. Whereas in post-monsoon season, it ranged from 98.8 mg/L to 13.7 mg/L and 25.1 mg/L to 7.5 mg/L with a mean value of 41.6 mg/L and 12.0 mg/L respectively. These values were higher than the permissible limit of 75 mg/L and 15 mg/L respectively for most of the samples during both the seasons.

6) The hardness of the surface water calculated from the cations analysed ranged from 206.4 mg/L to 82.2 mg/L and 202.3 mg/L to 95.4 mg/L respectively with a mean value of 123.6 mg/L and 128.3 mg/L respectively during pre and post-monsoon season respectively, depicting that it was well under the desirable limit of 500 mg/L as per BIS/WHO guidelines.

7) The heavy metals such as iron, copper, zinc, nickel, chromium, cadmium and lead were also analysed. These ranged from 2.1 mg/L to 0.1 mg/L, 1.8 mg/L to 1.0 mg/L, 5.8 mg/L to 1.4 mg/L, 0.29 mg/L to 0.01 mg/L, 0.08 mg/L to 0.01 mg/L, 0.26 mg/L to 0.01 mg/L and 0.48 mg/L to 0.01 mg/L respectively with a mean value of 0.8 mg/L, 1.1 mg/L, 2.5 mg/L, 0.07 mg/L, 0.02 mg/L, 0.05 mg/L and 0.12 mg/L respectively during pre-monsoon season. However, during post-monsoon season, the heavy metals ranged from 2.1 mg/L to 0.1 mg/L, 1.8 mg/L to 1.0 mg/L, 5.8 mg/L to 1.4 mg/L, 0.26 mg/L to 0.01 mg/L, 0.07 mg/L to 0.01 mg/L, 0.23 mg/L to 0.01 mg/L and 0.45 mg/L to 0.01 mg/L respectively with a mean value of 0.7 mg/L, 1.1 mg/L, 2.4 mg/L, 0.07 mg/L, 0.01 mg/L, 0.04 mg/L and 0.09 mg/L respectively. These metals exceeded the desirable limit of 1.0 mg/L, 1.5

mg/L, 5.0 mg/L, 0.20 mg/L, 0.01 mg/L, 0.10 mg/L and 0.15 mg/L respectively as suggested by BIS/WHO in many samples for both the seasons.

8) The concentration of anions, such as chloride and phosphate ranged from 96.3 mg/L to 43.8 mg/L and 18.1 mg/L to 0.1mg/L respectively with a mean value of 60.8 mg/L and 1.8 mg/L respectively during pre-monsoon season. In post-monsoon season, it ranged from 91.0 mg/L to 31.6 mg/L and 16.8 mg/L to 0.1 mg/L respectively with a mean value of 51.1 mg/L and 1.5 mg/L respectively. These were well within the desirable limits of 250 mg/L and nil respectively as prescribed by BIS/WHO.

9) The concentration of fluoride, sulphate, nitrate and bicarbonate ranged from 1.7 mg/L to 0.6 mg/L, 735.5 mg/L to 60.5 mg/L, 97.2 mg/L to 10 mg/L and 362 mg/L to 122 mg/L respectively with a mean value of 1.3 mg/L, 115.7 mg/L, 19.3 mg/L, and 172.2 mg/L respectively during pre-monsoon season. However, during post-monsoon season, the anions ranged from 1.6 mg/L to 0.4 mg/L, 728.7 mg/L to 14.9 mg/L, 93.4 mg/L to 7.3 mg/L and 389 mg/L to 145 mg/L respectively with a mean value of 1.1 mg/L, 106.2 mg/L, 14.4 mg/L and 194.3 mg/L respectively. These exceeded the permissible limit of 1.5 mg/L, 150 mg/L, 45 mg/L and 200 mg/L respectively as recommended by WHO at few of the locations.

10) The WQI during pre-monsoon season determined that 55% of the samples were under the good category, 26.67% under excellent, 13.33% under fair, 1.67% in marginal, and 3.33% in the poor category as per the classification. While during the post-monsoon season, 71.67% of water samples fell under the good category, 5% under the excellent category, 13.33% in the fair category, 3.33% in marginal, and 6.67% under the poor category for all the samples collected from the area under study. It may be observed from the above conclusions that there was no significant impact of coal mining on the water quality of the reservoir.

11) The statistical approach for grouping the water samples concluded that during pre-monsoon, positive correlation was observed between TDS with EC (+0.997), K^+ with Hardness (+0.939) and Cd^{2+} with HCO_3^- (+0.864). While during post monsoon season, TDS with EC (+0.989), Na^+ with Hardness (+0.906) and Cd^{2+} with HCO_3^- (+0.875). The Box Plot analysis envisaged the quartiles distribution of various water quality parameters for estimating the water quality of the area.

12) Hierarchical Cluster Analysis revealed that the water quality index was divided into 4 groups and 3 groups during pre and post monsoon seasons respectively. The hydro-geo-chemical facies analysis indicated Ca-Mg-Cl-SO_4 as the dominant type during pre and post-monsoon seasons showing the predominance of anthropogenic activities along with geological settings.

13) The Land Use/ Land Cover pattern study concluded that the hills/forest and water body in the area showed a decreasing trend from 1998 to 2018. The decrease was 4.57% for hills/forest and 3.06% for water body.

14) The change in volume of the reservoir was marginally affected by the activities occurring in and around the reservoir. The decrease in volume of the reservoir from 30.72 km^3 in 1998 to 25.12 km^3 in 2018 has been observed. Probably, this may be due to increase in mining area as exhibited by the study of Land Use/ Land Cover maps of the area or due to discharge and deposition of insoluble suspended solids and other fine particles into the reservoir.

15) Lastly, the laboratory experimental setup for mitigating the concentration of pollutants through phytoremediation and sandstone filtration technique concluded that there was marginal to significant decrease in the concentration of pollutants while keeping the flow of Balia Nala stagnant for a particular duration i.e. 15 days.

7.2 Suggestions for Future Work

1. Mine water is an asset for society but unfortunately, it is considered a hindrance for mining operations. The future work related to this thesis is the conversion of mine water into potable water under Jal Shakti Abhiyan of the country.
2. Another area of research can be the utilization of mine water for the local population and water-based industries during the mining activities.
3. In the study area, the concentration of mercury and arsenic is insignificant in a few places. Hence, new techniques may be developed by future researchers to minimize such toxic pollutants in bulk volumes of water. New techniques should be adopted to adsorb such metals.
4. For the execution of phytoremediation processes in the future, phytoremediation reactors can be designed and constructed. Besides this, aquatic macrophytes having better potential can be explored for faster removal of pollutants.
5. A combination of remote sensing, GIS, and traditional in-situ sampling can be used for designing a better performing monitoring program for water quality parameters in the area under study.
6. To minimize the impact of mining on Govind Ballabh Pant reservoir, the construction of siltation pond and good plantation may be adopted to decrease the problem of siltation of this important reservoir.
7. The proposed work in the thesis is field applicable for management of water pollution in streams and nalas. The streams and nalas carrying mine effluents from workshops may be treated by adoption of phytoremediation technique in combination with sandstone filtration system.