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Assessment of Water Quality in North-Eastern Jharia Coalfield-Jharkhand by WQI and GIS Mapping

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Abstract

A study was undertaken in the north-eastern Jharia coalfield of Jharkhand to access the quality of surface water around the mines. In this study, elevenwater samples were collected from seepages from coalmine and streams around the coal deposit. These samples were used for analysing the physicochemical parameters by using a geographical information system GIS (spatial analysis) and raster maps are created. In addition to this Water Quality Index (WQI) was calculated to analyse the overall water quality of various sampling locations.

Results show that surface water at mine sites is contaminated and many parameters like Total Hardness, Total Dissolved Solids and Total Suspended Solids exceed the limit prescribed by IS: 10500, 1991 which make the water unfit for use in cooling and various other domestic purposes. This needs an immediate attention of the concerned authorities to restore the water quality in the area.

Keywords

WQI; GIS; North-eastern Jharia coalfield; IDW

Introduction

Water is the most precious gift of nature, the most crucial for sustaining life and is required in almost all the activities of man for drinking and municipal use, irrigation to meet the needs of growing food, industries, power generation, navigation, and recreation [1]. The surface water bodies, which are the most important source of water for human activities are unfortunately under severe environmental stress and are being threatened as a consequence of developmental activities.

The coal mining in Jharia started in 1894. It is well known that mining threatens the quality and quantity of surface water resources, pre-dominantly in the mineral rich regions. Being the primary source of energy, coal is essential to meet the energy demand of a country.

There is no proper water management plan at most of the mines in India. Water from coal treatment plants is often discharged without any treatment or beneficial use [2]. The inhabitants depend solely on surface water for human consumption and other domestic needs since there are no functional boreholes. There has been great fear among the dwellers on their dependence on the surface water due to the presence of the coal deposit.

Keeping in view of the prevailing conditions the study was conducted to determine the quality of water. In this study, a geographical information system (GIS) was used, in order to compare water quality data and related information collected for water quality around the coal mines, and display the distribution of contamination of the surface water bodies in easily viewed maps that can be used by the public and decision makers.

Study Area

The north-eastern Jharia coalfield is situated in the Dhanbad district of Jharkhand, India. The Jharia coalfield is the largest coal producer and the only source of coking coal in the country. The study area lies between latitudes $23^0$44′4.74″N-$23^0$46′50.2″N and longitudes $86^0$22′57.7″E-$86^0$26′37.3″E, at the Northern Hemisphere of Zone 45. The annual rainfall of the area is 1400mm and the elevation ranges from a minimum altitude of 142 meters to a maximum altitude of 214 meters above the mean sea level. The area is accessible through trucks. In addition rural feeder roads and paths enhance accessibility to the surface water and coalmine. Most of the roads are haul roads.

Materials and Methods

Sample Collection and Chemical Analysis

A total of eleven (11) water samples were obtained from seepages from the coalmines and the streams around the coal deposit for physicochemical analysis. The sampling locations are shown in Figure 1 and their details in Table 1. The samples were collected spatially over a period of three months from January- March, 2015 to represent a comprehensive database for the community. The samples from the mine were used as guide for correlation. Each sample was collected in a polyethylene bottle after proper rinsing with de-ionized water. The analysis was carried out within 48 hours in order to maintain the integrity of the samples. A total of six (6) water quality parameters like pH, electrical conductivity, salinity, total dissolved solid (TDS), total hardness (TH) and total suspended solids (TSS) were calculated as per CPCB guidelines [3].

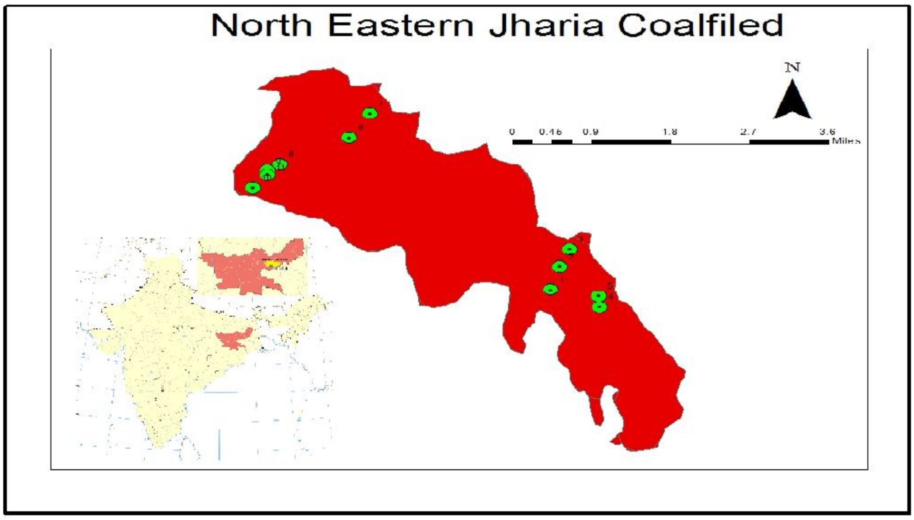


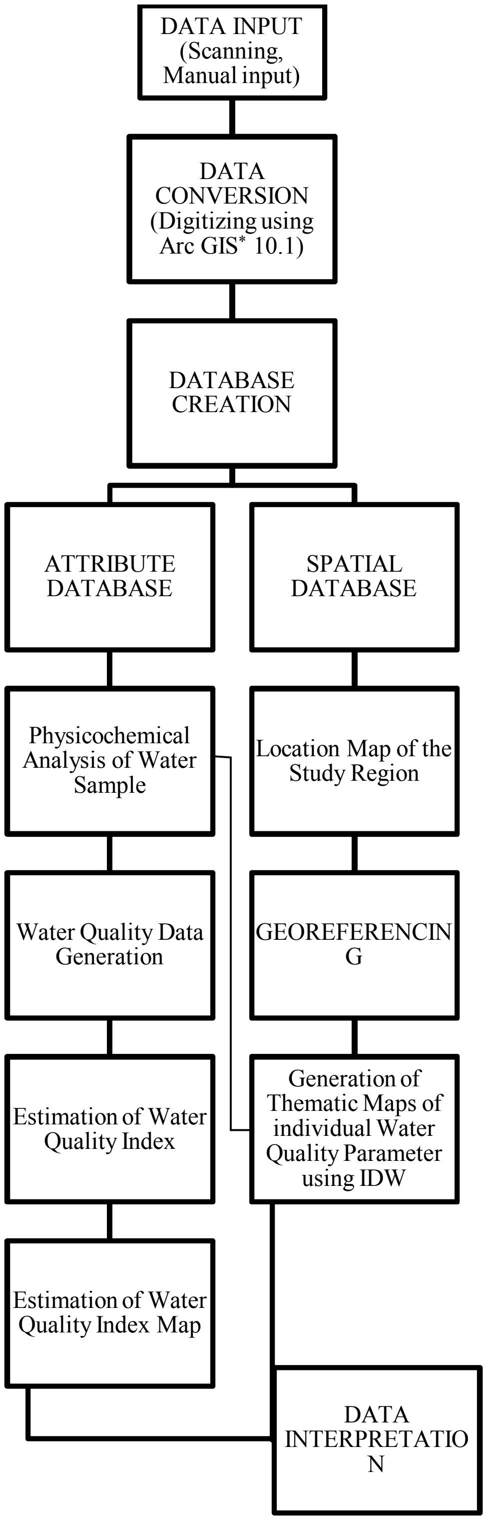
Figure 1: The sampling sites at the north-eastern Jharia coalfield, Jharkhand

Sample code	Latitude (N) (meter)	Longitude (E) (meter)	Elevation (in meter)
1	2625438.0	442413.9	214
2	2626013.0	442604.7	207
3	2626460.0	442818.8	212
4	2624960.0	443300.4	187
5	2625239.0	443286.2	142
6	2629477.0	438918.0	183
7	2630065.0	439322.4	202
8	2628851.0	437629.8	194
9	2628690.0	437391.3	202
10	2628266.0	437097.4	185
11	2628596.0	437379.0	200

Table 1: Geographical Location of sampling sites

Geographic Information System (GIS)

A geographic information system (GIS) is a computer-based technology which lets us visualize, question, analyze, and interpret data in digital form to understand relationships, patterns, and trends [4,5,6]. Coordinates of sampling points were recorded by a mobile Geographic Position System (GPS). The results of the physicochemical analysis were then used as input data in ArcGIS 10.1. The sampling locations were integrated with the water data for the generation of spatial distribution maps. The present study used the Inverse Distance Weighted (IDW) method for spatial interpolation of water parameters. To predict a value for any unmeasured location, IDW will use the measured values surrounding the prediction location. Those measured values closest to the prediction location will have more influence on the predicted value than those farther away [7]. The flowchart of the entire procedure is shown in Flowchart 1.



Flowchart 1: Procedure for analysis using GIS

Water Quality Index (WQI)

Water Quality Index (WQI) is a very useful and efficient method for assessing the suitability of water quality. It is also a very useful tool for communicating the information on overall quality of water [8, 9] to the concerned citizens and policy makers. Thus, WQI becomes an important parameter for the assessment and management of water quality. It reflects the combined influence of different water quality parameters and is calculated from the point of view of the suitability for human consumption. WQI is a dimensionless number that combines multiple water-quality factors into a single number by normalizing values to subjective rating curves [10]. In the current study, Water Quality Index (WQI) was calculated by using the Weighted Arithmetic Index method as described by [11]. In this model, different water quality components are multiplied by a weighting factor and are then aggregated using simple arithmetic mean. Weighted arithmetic water quality index method classifies the water quality according to the degree of purity by using the most commonly measured water quality variables.

The calculation of WQI was made by using the following equation:

WQI = ∑ (Qi Wi) / ∑ (Wi)

The quality rating scale (Qi) for each parameter was calculated by using this expression:
Qi = {[(Vi– Vo) / (Si– Vo)] * 100}

Where,
Vi is the estimated concentration of i^{th} parameter in the analyzed water
Vo is the ideal value of this parameter in pure water
Vo = 0 (except pH =7.0 and DO = 14.6 mg/l)
Si is the recommended standard value of i^{th} parameter.

The unit weight (Wi) for each water quality parameter was calculated by using the following formula:

Wi = K/ Si

Where
K = proportionality constant and can also be calculated by using the following equation:

K=$1/\sum_{1}^{n}(1/Si)$

The rating of water quality according to this WQI is given in Table 2.

WQI Value	Rating of Water Quality	Grading
0-25	Excellence	A
26-50	Good	B
51-75	Poor	C
76-100	Very Poor	D
>100	Unsuitable for drinking	E

Table 2: Water Quality Rating as per Weight Arithmetic Water Quality Index Method

Results and Discussions

From the physicochemical analysis of the various water samples, the following results of the six water quality parameters were found. It had been found out that the pH value ranges from 3.795-8.757 as shown in Figure 2. The pH values here, in general, ranges from slightly acidic to basic. In the sampling location 5, the value is found to be very less, which indicates very high acidity. This may be due to the acid mine drainage.

The ranges for other parameters are the following: for conductivity 845 μS/m-3150 μS/m, for salinity 0.42 psu-1.58 psu, for TDS 422 ppm-1478 ppm, for TH 90 mg/l-996 mg/l and for TSS 18 mg/l-7420 mg/l as shown in Figures 3, 4, 5, 6 and 7 respectively.

In case of Water Quality Index, the unit weights of the six water quality parameters were calculated on the basis of their corresponding Indian standards, as shown in Table 3.

Parameters	IS Standards	Wi = K/Si
pH	5.5-9.0	0.79933
Total Suspended Solids (mg/l)	100	0.07194
Total Dissolved Solids (ppm)	500	0.01439
Total Hardness (mg/l)	300	0.02398
Conductivity (mS/m)	80	0.08992
Salinity	-	-

Table 3: Unit weight of different Water Quality Parameters

Then the Water Quality Indices for different sampling locations were calculated. The corresponding Water Quality Indices of various locations are shown in Table 4 as well as Figure 8.

As we can see from the figure, the quality of water is very poor. They are in extremely poor conditions that they may not be suitable for any domestic use. The water quality in sampling locations 1 and 3 are relatively better. But, as they are in poor to very poor conditions, they need proper treatment before their use for any domestic purpose.

An immediate attention from the side of the concerned authorities is very much essential to bring the situation under control. Moreover the mines should be fully mechanized as well as the water treatment should be adopted before being released to the streams. The public should in turn be well aware of the current situation and demand for their basic rights to get good water. They should remind the concerned authorities timely so that they are brought to their attention. In addition to this, before the starting of any new mines during the time of Public Hearing process the public should be very well aware of the policies of the lease holder regarding their actions towards the environment. They should give a positive nod for mining and other industrial activities only when their activities are environment-friendly.

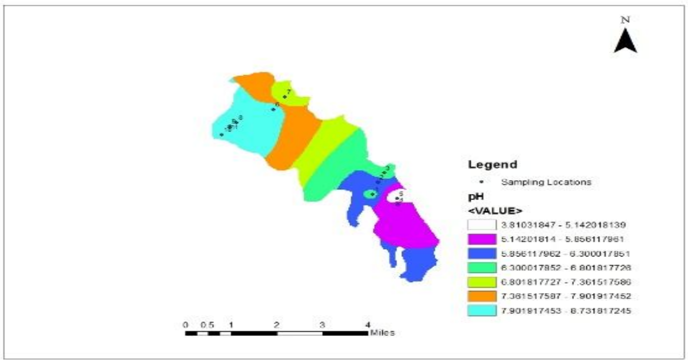


Figure 2: Average pH values in the water samples

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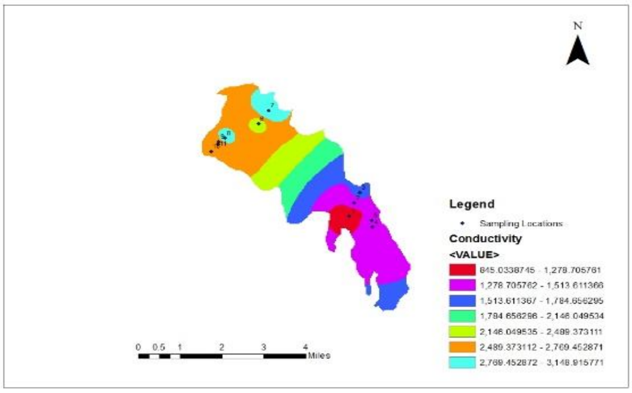

Figure 3: Average conductivity (µS/m) values in the water samples

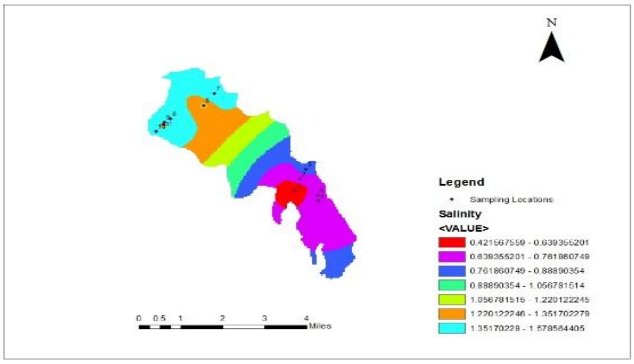

Figure 4: Average salinity (psu) values in the water samples

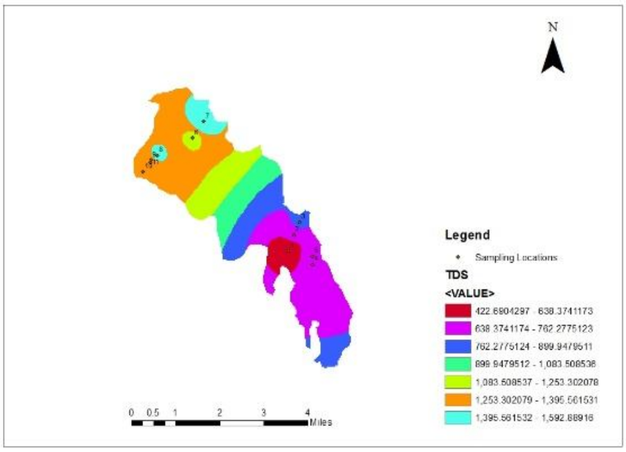

Figure 5: Average TDS (ppm) values in the water samples

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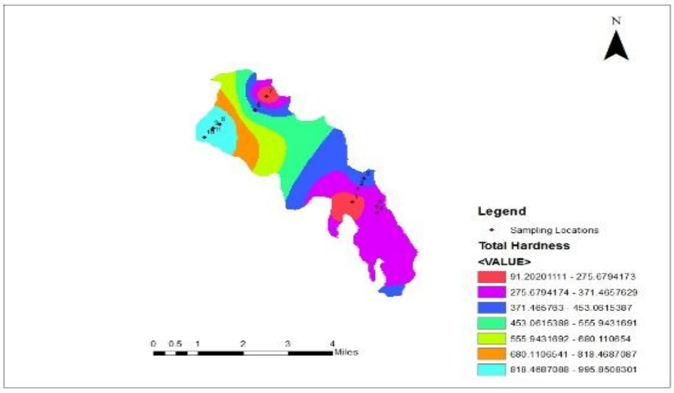

Figure 6: Average TH (mg/l) values in the water samples

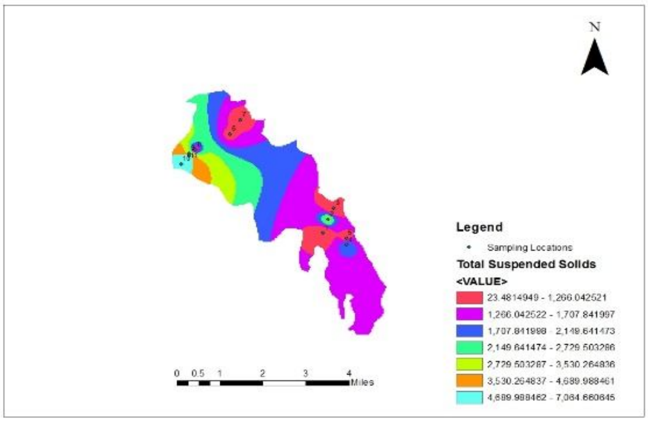

Figure 7: Average TSS (mg/l) values in the water samples

Sample code	WQI Value	Description
1	82.58	Very poor
2	272.40	Extremely poor
3	66.46	Poor
4	215.23	Extremely poor
5	104.26	Extremely poor
6	159.52	Extremely poor
7	133.24	Extremely poor
8	145.77	Extremely poor
9	218.06	Extremely poor
10	522.47	Extremely poor
11	618.47	Extremely poor

Table 4: Water Quality index of different sampling stations

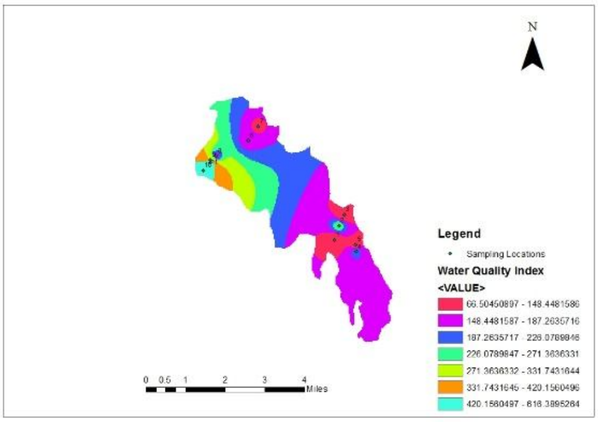

Figure 8: WQI of sampling locations

Conclusions

Most of the water quality parameters exceed the Indian Standard. As the total hardness of water is very high, this will result in clog formation in filters, reduced circulation through piping and decreasing heating efficiency.

These untreated water, sometimes, flows through streams resulting in the deterioration of downstream water quality. In addition, as the rainfall of the area is very low, people solely depend on these streams for use in various domestic purposes.

The pollution control boards should be very vigilant of the effluents released to the water bodies and necessary remedial steps should be taken up as early as possible. And the concerning mine owners must be very careful while releasing effluents and they must employ proper treatment systems at all levels of mining activities. If these two bodies work in full co-ordination these problems can be minimized to a great extent, benefitting both the public as well as the environment.

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References

[1] Kannan, K. S., and Ramasubramanian, V. Assessment of Fluoride contamination in Ground Water Using GIS, Dharmapuri District, Tamilnadu, India. International Journal of Engineering Science and Technology (IJEST), Vol. 3, No. 2, 2011, p. 1077.

[2] Singh, A.K., Mondal, G.C., Singh, S., Singh, P.K., Singh, T.B., Tewary, B.K. and Sinha, A. 2007.Aquatic geochemistry of Dhanbad district, coal city of India: Source evaluation and quality assessment. Journal of Geological Society of India, 69: 1088-1102.

[3] Guide manual: Water and Wastewater Analysis. Retrieved from http://cpcb.nic.in/upload/NewItems/NewItem_171_guidemanualw&wwanalysis.pdf

[4] The Power of Mapping. Retrieved from http://www.esri.com/what-is-gis

[5] Singh, V. P., and Fiorentino, M. Geographic Information System in Hydrology. Kluwer Academic Publishers, Dordrecht, 1996.

[6] Saeedrashed, Y., and Guven,A. Estimation of Geomor- phological Parameters of Lower Zab River-Basin by Using GIS-Based Remotely Sensed Image. Water Resources Management, Vol. 27, No. 1, 2013, pp. 209-219. http://dx.doi.org/10.1007/s11269-012-0179-x

[7] How inverse distance weighted interpolation works. Retrieved from http://resources.arcgis.com/en/help/main/10.2/index.html#//00310000002m000000

[8] Asadi, S.S., Vuppala, P., Anji, R.M. 2007. Remote sensing and GIS techniques for evaluation of groundwater quality in Municipal Corporation of Hyderabad (Zone-V), India. International Journal of Environmental Research and Public Health, 4, 4552.

[9] Buchanan, S., Triantafilis, J. 2009. Mapping water table depth using geophysical and environmental variables. Groundwater, 47, 80.

[10] Miller, W. W., Joung, H. M., Mahannah, C. N. and Garrett, J. R. 1986. Identification of water quality differences Nevada through index application. Journal of Environmental Quality 15, 265-272.

[11] Pesce, S. F., and Wunderlin, D. A. 2000. Use of water quality indices to verify the impact of Córdoba city (Argentina) on Suquía River. Water Research, 34, 2915–2926.