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THE IMPACT OF MINING ACTIVITIES ON LAND AND WATER QUALITY THROUGH GEO-ENVIRONMENTAL MAPPING IN NOAMUNDI BLOCK, JHARKHAND, INDIA

Kunal Kanti Maiti[1*], Jatisankar Bandyopadhyay[1], Subha Das[1], Debashish Chakravarty[2]

[1]Department of Remote Sensing and GIS, Vidyasagar University, Midnapore-721102, West Bengal, India,

[2]Department of Mining Engineering, Indian Institute of Technology Kharagpur, Kharagpur-721302, West Bengal, India

[*]E-mail: kunal.rs.gis@gmail.com

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ABSTRACT:

Mining operation causes many adverse impacts on land and water due to the extractive as well as destructive nature of the operations. Land and water is very important to health, well-being, food security and socio-economic development of mankind. This study depicts analysis of the impact of mining on land use/ land cover (LU/LC) and water quality in the Noamundi block, Jharkhand, India. In this area three images of the Landsat missions of 2003, 2011 and 2017have been used which were classified by the supervised image classification techniques (8 classes) for retrieving the absolute and relative change of LU/ LC. The water quality analysis has been done with the sample of 18 points which were taken from different location in the study area. The water quality parameters like pH, Electrical Conductivity, Total Dissolved Solid, Dissolved Oxygen, Suspended Solid, Alkalinity, Chemical Oxygen Demand (COD), Iron, Turbidity and Sulphate have been measured. It has been observed that the most of the study area has poor water quality except some places of Saranda forest, Meghahatuburu and Hatichak. The need for regular monitoring of water quality is very essential before using the water for drinking purpose.

1. INTRODUCTION

Mining has the potential to have severely adverse effects on the environment including loss of biodiversity, land use/land cover(LU/LC), erosion, contamination of surface water, ground water, and soilin mining buffer zone (Mondal et al., 2013; Kumar and Reddy 2016; Mondal et al., 2016). In the world, Noamundi and surrounding areas are one of the most prospective areas of iron ore (Maiti et al., 2019). Water is a prime natural resource and very precious as like national assets which forms the principal constituent of ecosystem. Water resources play a vital role in various functions such as drinking, agriculture, livestock production, forestry, industrial activities, hydropower generation, fisheries etc. Surface and ground water availability and quality have been deteriorated due to some important factors like increasing population, industrialization, urbanization etc. (Tyagi et al., 2013). Different mining operations like mineral processing, metal recovery, dust control and meeting the requirements of workers on site water is needed in mines (Naik and Sahu 2015). Water quality of any specific area or specific source can be assessed using physical, chemical and biological parameters. The values of these parameters are harmful for human health if they occurred more than defined limits. Therefore, the suitability of water sources for human consumption has been described in terms of water quality index (WQI), which is one of the most effective ways to describe the quality of water. This study investigate the impact of mining on land use/ land cover (LU/LC) and water quality, and its significant impacts on geo-environment.

2. MATERIALS AND METHODS

2.1. Study area

Noamundi block is the part of the chota Nagpur plateau. In this block have different topographical features, such as hills, creeks, river, low land etc. The block is full of open forests and deep forests on the mountain slopes. In Noamundi block has two small rivers named as Karo and Koina River. Karo river flows divided Chaibasa and Saranda forest divisions. The geographical location of the study area is between 22°00'35"N to 22°21'28"N latitude and 85°12'10"E to 85°38'44"E longitude (Figure 1).

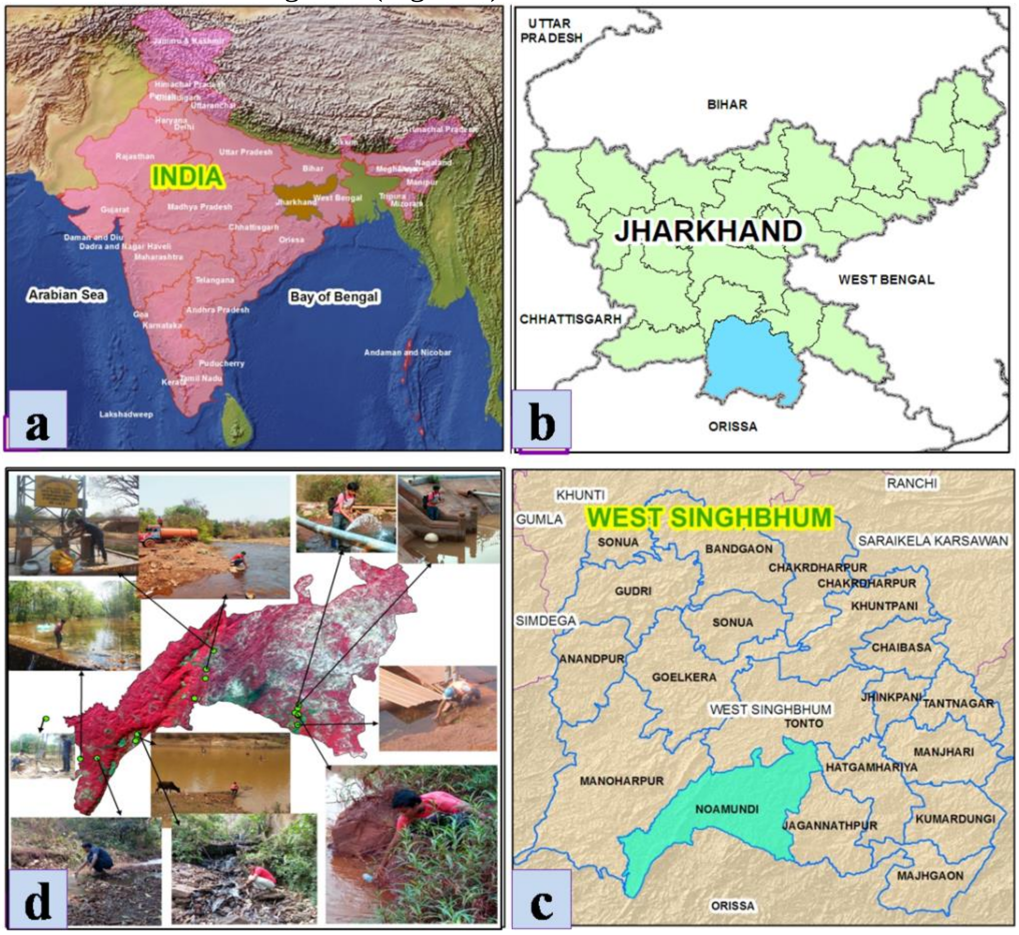

Figure 1: Location map - a) India**; b)** Jharkhand state**; c)** Noamundi block in West Singhbhum district**; d)** Water sample collection from different places in field location.

2.2. Data Used

The monitoring of LU/LC has been done using three Landsat images which were taken in the year of 2003, 2011 and 2017. First of all some signatures was taken from satellite images based on their spectral signature and then supervised classification which was performed by using the maximum likelihood method.The Survey of India (SOI) Topographical maps 73F/4, 73F/7, 73F/8, 73F/11 and 73F/12 on a scale of 1:50,000 were used to prepare a base map. The water quality analysis has been done with the sample of 18 points which were taken from different location in the study area.

2.3. Methodology

Three images of the Landsat data of 2003, 2011 and 2017 have been classified by the supervised image classification techniques (8 classes) for change detection of LU/ LC. Weighted arithmetic water quality index (WQI) method(Horton,1965; Brown,1970) classified the water quality according to the degree of purity by using the most commonly measured water quality variables. The methodologies flowchart of the analysis has been shown in Figure 2.

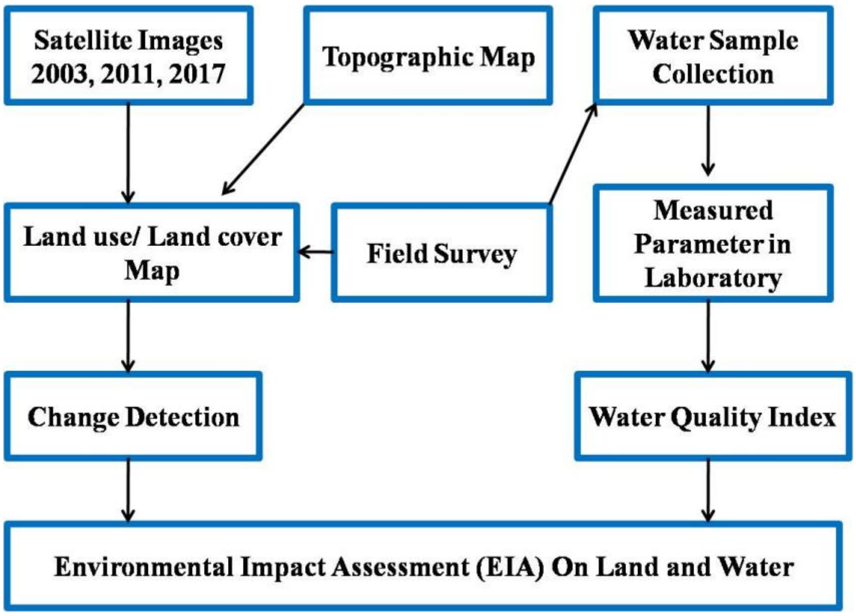

Figure 2: Methodology Flow chart

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

$$WQI = \frac{\sum Q_i W_i}{\sum W_i}$$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$Q_i = 100 * \left[\frac{(V_i - V_O)}{(S_i - V_O)}\right]$$

Where,

V_i is estimated concentration of i^{th} parameter in the analyzed water

V_O is the ideal value of this parameter in pure water

V_O = 0 (except pH =7.0 and DO = 14.6 mg/l)

S_i is recommended standard value of i^{th} parameter.

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

$$W_i = \frac{K}{S_i}$$

Where,

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

$$K = \frac{1}{\sum\left(\frac{1}{S_i}\right)}$$

The rating of water quality according to this WQI (Tyagi et al., 2013) is given in Table 1.

Table 1: Water Quality Rating as per Weight Arithmetic Water Quality Index Method

WQI Value	Rating of Water Quality	Grading
0-25	Excellent water quality	A
26-50	Good water quality	B
51-75	Poor water quality	C
76-100	Very Poor water quality	D
Above 100	Unsuitable for drinking purpose	E

3. RESULTS AND DISCUSSION

3.1.Impact of mining on Land use/ land cover

The land use/ land cover (LU/LC) map prepared by the analysis of remotely sensed satellite imagery and it validated the collected ground control point from field survey. The estimates of the analysis show eight categories of land use/ land cover types (figure 3). The results of analysis are used for land use/ land cover change monitoring in Noamundi Block of west Singhbhum district (Maiti et al., 2019). In the Table 2 depict that the open forest decreased 20.33 Sq. Km from the year 2003-2011 and 29.93 Sq. Km from 2011-2017 and the dense forest was decreased 25.08 sq. km from the years 2003-2011 and 12.72 sq. km from 2011-2017. Very little increase was found in the river and water bodies and on the other side, built-up land was increased by 11.16 sq. km from the year 2003-2017 and 7.7 sq. km from 2011-2017 for the reason of population growth. Agricultural land was increased 18.56 sq. km from the year 2003-2011 and then increased by 51.25 sq. km from 2011-2017 and fallow land also relatively got increased by 9.94 sq. km from 2003-2011, but between 2011 to 2017 it decreased by 13.5 sq. km. The increase in the mining area is observed by 6.14 sq. km from the year of 2003 to 2011, but from 2011 to 2017 a decrease of 2.33 sq. km area is observed. In 2003 the mining area has 14.60 sq. km. but in 2011 it was increased by 20.74 sq. km and in the year 2017 it was decreased to 18.41 sq. km. Figure 4 depicts the changing scenario of mining area between the year of 2003, 2011 and 2017.

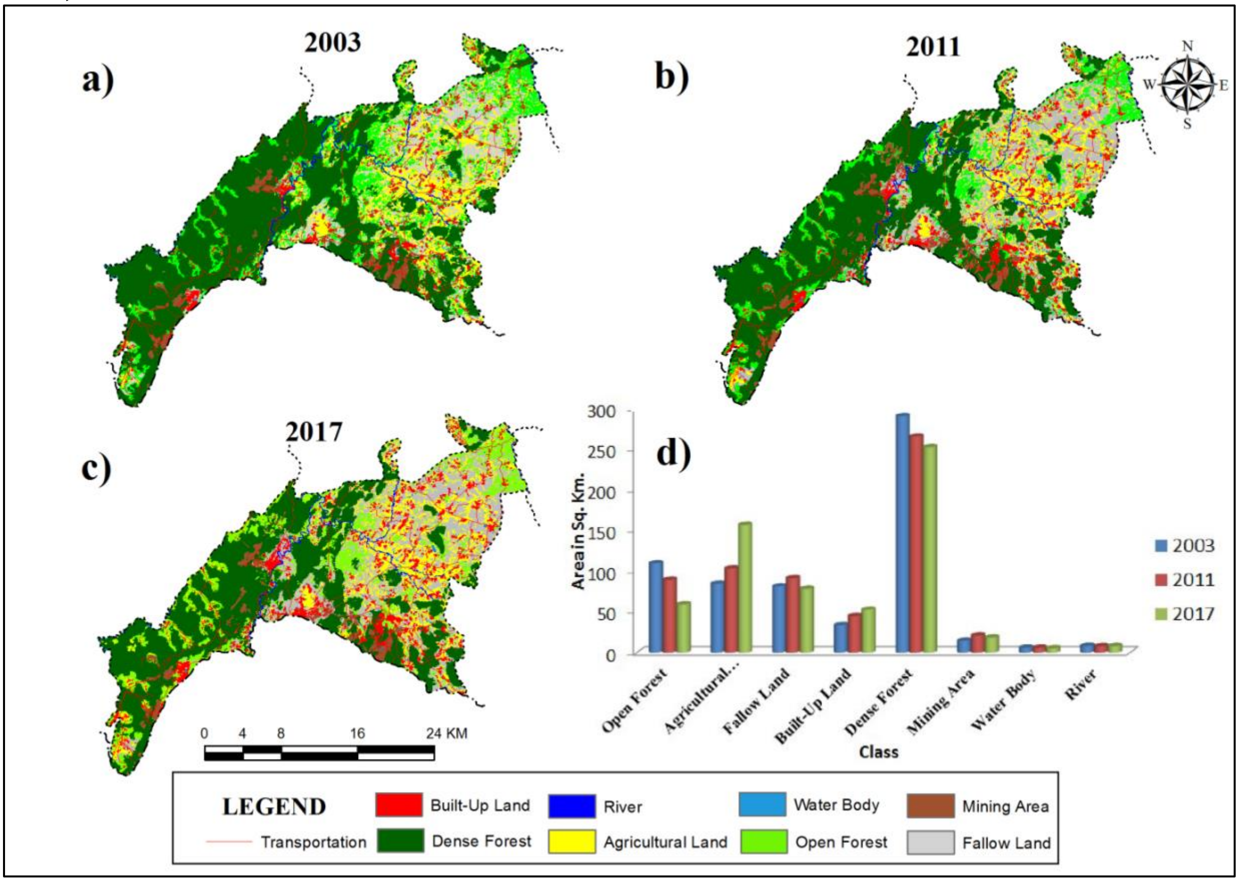

Figure 3: Land Use/Land Cover map a) 2003, b) 2011, c) 2017, d) Bar graph represents the comparative status.

Table 2: Land use / land cover area calculation in different classes

Sl. No.	Class	LU/LC (2003) Area (Sq. Km)	LU/LC (2011) Area (Sq. Km)	LU/LC (2017) Area (Sq. Km)
1	Open Forest	109.20	88.87	58.94
2	Agricultural Land	84.21	102.77	154.02
3	Fallow Land	80.86	90.80	77.30
4	Built-Up Land	33.48	44.64	52.34
5	Dense Forest	288.95	263.87	251.15
6	Mining Area	14.60	20.74	18.41
7	Water Body	5.88	5.86	5.24
8	River	8.07	7.70	7.85
		625.25	**625.25**	**625.25**

Mining is the primary source of mineral produce that all countries find essential for maintaining and improving their living standards. Mining is the dynamic process of extracting of valuable minerals. It changes any time. In Noamundi block year of 2003, Gua mines were 1.88 sq. km, Kiriburu and Meghahatuburu mines was 1.91 sq. km, Noamundi mines was 2.09 sq. km. In year of 2011, Gua mines were 1.87 sq. km, Kiriburu and Meghahatuburu mines was 2.26 sq. km, Noamundi mines was 3.04 sq. km. In Noamundi block year of 2017, Gua mines were 2.06 sq. km, Kiriburu and Meghahatuburu mines was 2.42 sq. km, Noamundi mines was 3.53 sq. km.

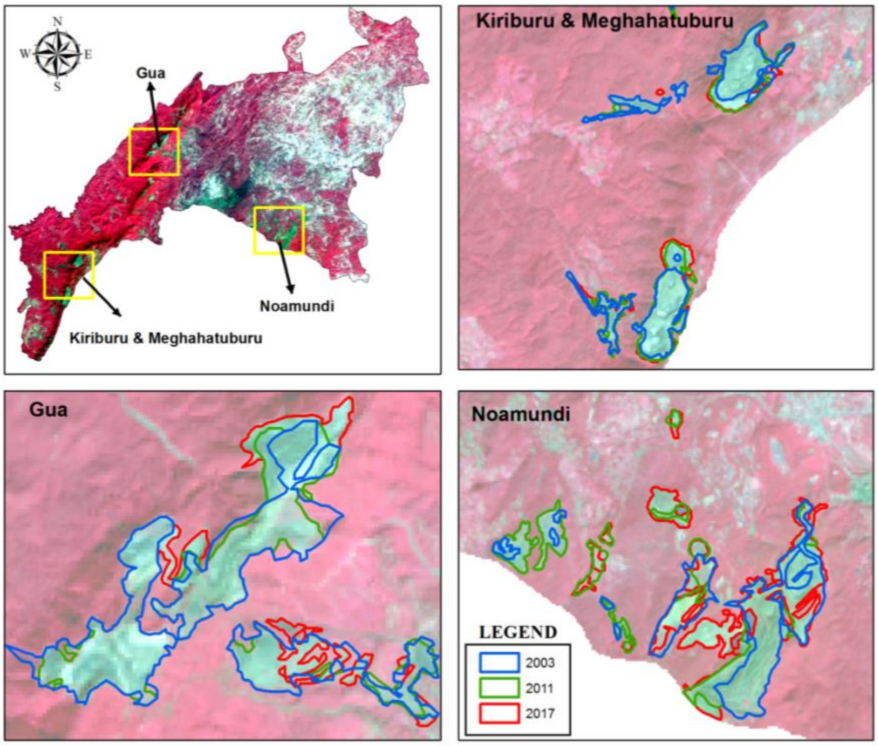

Figure 4: Changing scenario of mining area.

3.2 Water quality index (WQI)

The water is a prime natural resource forms the major element of ecosystem. Mining has the potential to effects on the contamination of surface water, ground water. The availability and quality of surface or ground water have been deteriorated due to some important factors like increasing population, industrialization, urbanization etc (Tyagi et al., 2013). Table 3 gives the observed values (vi) of the ten (10) selected physico-chemical parameters of water standard drinking water values (S_i) according to World Health Organisation (WHO, 1993), BIS, ICMR unit weights (Q_i), water quality rating (Q_i) and W_iQ_i.

Table 3: Drinking water standards, recommending agencies and unit weight

Sl. No.	Parameter	Standard values (s_i)	Recommended by	Unit weights (w_i)
1	**pH**	6.5-8.5	ICMR/BIS	0.219
2	**Electrical Conductivity (µS)**	300	ICMR	0.371
3	**Total Dissolved Solid (mg/l)**	500	ICMR/BIS	0.0037
4	**Dissolved Oxygen (mg/l)**	5	ICMR/BIS	0.3723
5	**Suspended Solid (mg/l)**	500	WHO	0.0037
6	**Alkalinity (mg/l)**	120	ICMR	0.0155
7	**Sulphate (PPM)**	150	ICMR/BIS	0.01236
8	**Turbidity**	10	ICMR	0.3333
9	**Iron (PPM)**	0.3	ICMR	0.1515
10	**COD**	5	ICMR	0.372

Table 4 shows that the Water Quality Index (WQI) of 18 samples collected from different points from different location in the study area.

Table 4: WQI of different samples

Sample	Place	WQI	Quality
1	Sump area in Noamundi Mines	74.36150426	Poor
2	Near Aqua Park, Noamundi	74.18025165	Poor
3	Outside Aqua Park, Noamundi	75.28788944	Very Poor
4	Inside Aqua park, Noamundi	56.20359573	Poor
5	Rest House-3, Noamundi	41.62160594	Good
6	Rain Water Harvesting, Noamundi	60.83145978	Poor
7	Near SBI bank, Noamundi	59.14591194	Poor
8	Tube well (Kiriburu)	49.93940449	Good
9	Lake Garden, Meghahatuburu	77.9404644	Very Poor
10	Near Forest Guest House, Meghahatuburu	61.3713684	Poor
11	Sankajor Nala, Saranda Forest	43.76517338	Good
12	Koina River Check Dam, Saranda Forest	40.6381607	Good
13	forest guest house, Tholkabad	131.0891969	Unsuitable
14	Hatichak	48.26823906	Good
15	Tube well (Gua)	113.9728791	Unsuitable
16	Gua	108.2561823	Unsuitable
17	Karo River, Gua	92.02129947	Very Poor
18	Guest House, Meghahatuburu	47.75868767	Good

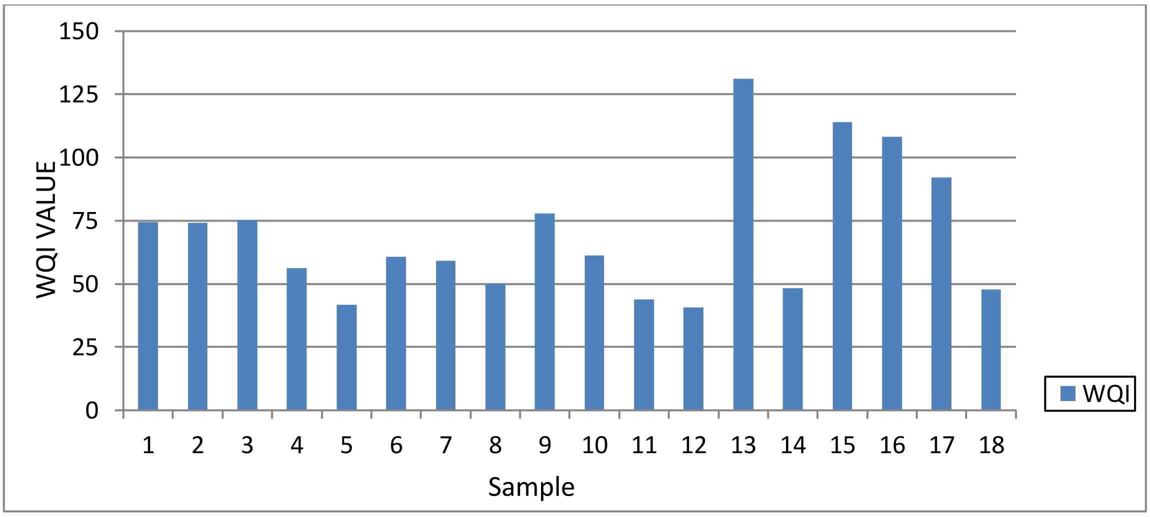

Figure 5: WQI of 18 samples in Noamundi block and surroundings

Figure 5 depicts the samples wise WQI distribution. From the above table it would be observed that six samples have good WQI. Drinking water used by village peoples in Kiriburu, Sankajor Nala inside Saranda forest, water of Koina River inside Saranda forest, Drinking water in Hatichak, and domestic water in Meghahatuburu forest village has a good water quality. But the water quality is bad in Tholkabad forest guest house, ground water and drinking water in Gua. WQI value of these areas was above 100 that indicate unsuitable for drinking. The spatial variation of Water Quality Index are shown in Noamundi block and surrounding area using Kriging Interpolation method which was applied in GIS environment. The Kriging is a geostatistical interpolation technique that considers both the distance and the degree of variation between known data points when estimating values in unknown areas. A kriged estimation is a weighted linear combination of the known sample values around the point to be estimated.

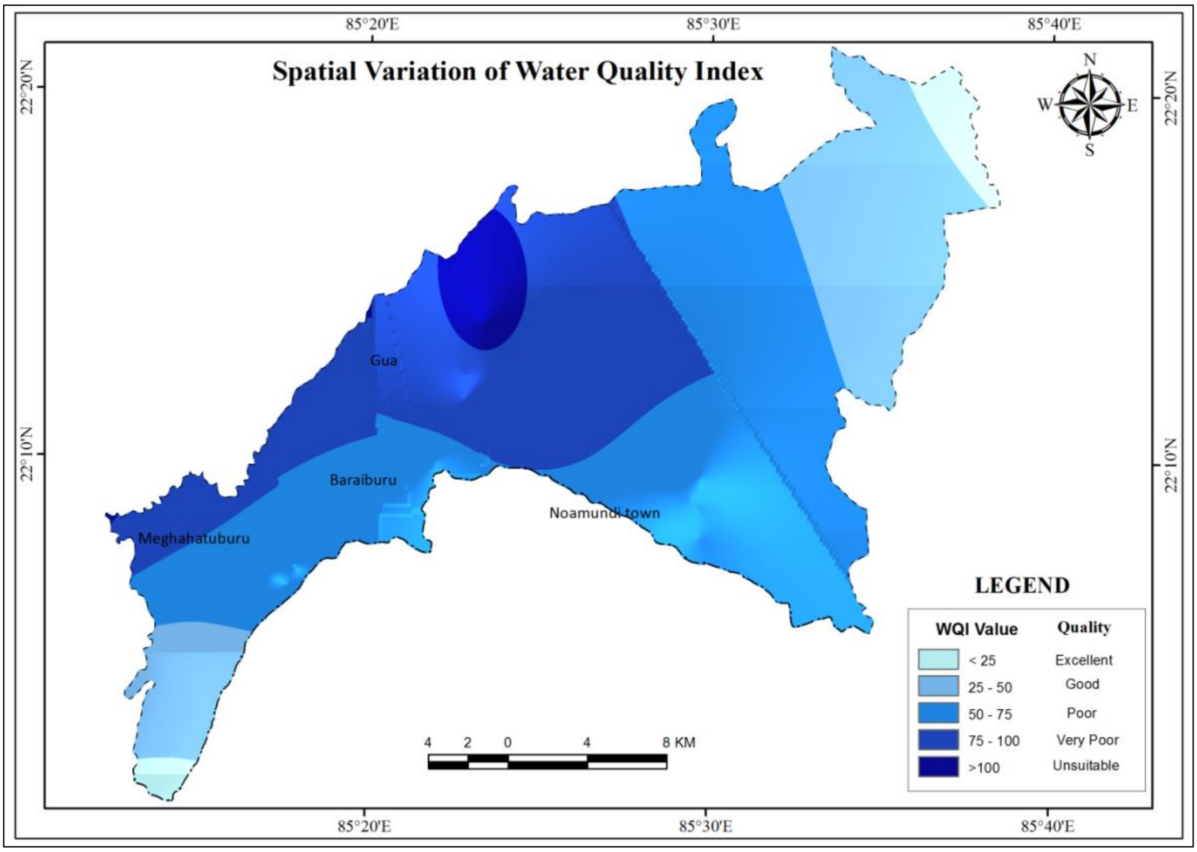

Figure 6: Spatial variation of WQI in Noamundi

In the figure 6, it would be seen that most of the area has poor to very poor water quality except some parts of Baraiburu area and some parts of Saranda forest area. Most of the iron ore mining area was found in this area as a result the dust particles are mixed with rain water and then it mixed with surface water that cause poor water quality.

3.3 Major Geo-environmental Impacts

- Air Quality
- Change in the land use pattern
- Land Degradation
- Soil Erosion
- increase of land surface temperature
- Ecosystems

- Flora and fauna (removal of the forest/vegetation cover are disturbance of wildlife habitats).
- Streams/ water bodies are affected due to Ore- Waste.
- Iron contamination
- pH change
- Groundwater acidification

4. CONCLUSION

Mining activity has adverse effects on the surrounding environment. It is necessary for the mine management to look after the impacts that the mining activities put on the environment. This study depicts analysis of the impact of mining on land (LU/LC) and water quality. The water quality parameters like pH, Electrical Conductivity, Total Dissolved Solid, Dissolved Oxygen, Suspended Solid, Alkalinity, COD, Iron, Turbidity and Sulphate have been measured for showing the spatial variation of water quality index. It has been observed that the most of the study area has poor water quality except some places of Saranda forest, Meghahatuburu and Hatichak. The need for regular monitoring of water quality is very essential before using the water for drinking purpose.

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