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Impacts of Coal Mining on Vegetation and Water Quality

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Abstract:
Coal is the prime source of energy in India and plays an important role in development of the national economy. This research explains the use of remote sensing (RS), Global positioning system (GPS), and GIS technology for the detection of land use/ land cover changes. In this work LU/LC changes was detected using remotely sensed images during the period from 1992 to 2011, using Landsat-TM image. Ground truthing for the LU/LC classification accuracy assessment was done using ground truthing and Google Earth. An image analysis operation has been carried out using Erdas Imagine software. Various changes due to coal mining activities on land use and land cover has been highlighted. The results show increase in the mining area and settlements. Surface and ground water pollution in mining area is growing concern today. The study was undertaken to assess the quality of surface and ground water. The coal mining industry has to dispose of millions of liters of water everyday. This water forms main source of various water supplies in the thickly populated coalfields. In this study water sample of major area were collected and analyzed in an attempt to reflect the impact of mining on water quality of the study area. Total 12 water samples were collected and analyzed to assess water quality and suitability for domestic, industrial, livestock and irrigation usage. Though the water body was not suffered much change but the forest area was drastically decreased.

Key words: *Lc /Lc map, Landsat (TM), Mining Area, Water Sample, Seasonal Variation, Water Quality*

1. Introduction

India is highly dependent on coal for meeting its commercial energy requirements. India ranks the third largest coal producer of the world next only to China and USA. Coal mining in India was started in the year 1774 in the state of West Bengal. At the beginning of 20th century, the total production of coal was just about 6 million tonnes per year. The production was 154.30 million tonnes in 1985-86 and it reached 298 million tonnes in the year 1997-98. The expectation to reach the production of coal by 2000 A.D. was 417 million tonnes (Coal India, 1997).

About 70% of India's annual coal production is used in about 72 power generating plants and produce more than 90 million tons of coal ash per year. It is likely that it may cross over 100 million tons during 2001–2010 AD (Muraka *et al.*, 1987). The impact of coal ash leachates on receiving waters, apart from increased elemental concentrations cause changes in water pH with implications for trace element mobility (Carlson and Adriano, 1993). Prakash and Gupta (1998) studied the impact of coal mining on the land use changes by using temporal remote sensing data. Change detection analysis method was conducted in their study. Remotely sensed data are a useful tool and have scientific value for the study of human environment interactions, especially land use and land cover changes (Dale et al., 1993 cited in Codjoe, 2007).

Coal mining causes' extensive degradation to natural ecosystems such as forests and can scar the landscape irreparably. Damage to humans, animals and plants, occurs due to habitat destruction and environmental contamination. Mining tends to make notable impacts on the environment Major environmental issues include erosion, loss of biodiversity and contamination of soil, ground water and surface water by chemicals from mining processes. Besides creating environmental damage, the contamination resulting from leakages of chemicals and vibration form blasting /drilling operations also affect the health of local population.

1.1. Ground for selecting this topic

- Several empirical studies have already been conducted to study the impact of coal mining in India for different mining area.
- My study focuses on the impact of coal mining on vegetation and water quality, which has seen drastic change near mining area.
- Despite continuous growth of coal mining area, such study has great relevance in planning for reducing the impacts.

2. Study Area

Dakra project is situated at a distance of about 65 km from Ranchi. The mine falls under the North Karanpura Area of Central Coalfields Limited, a subsidiary of Coal India Limited. Dakra Project falls in the toposheet no. 73 EI of Geological Survey of India and encompassed by the latitude of 23°–39° N to 23°-41° N and longitude 85° E to 85-01° E. The location of the study area is shown in fig 1.1.

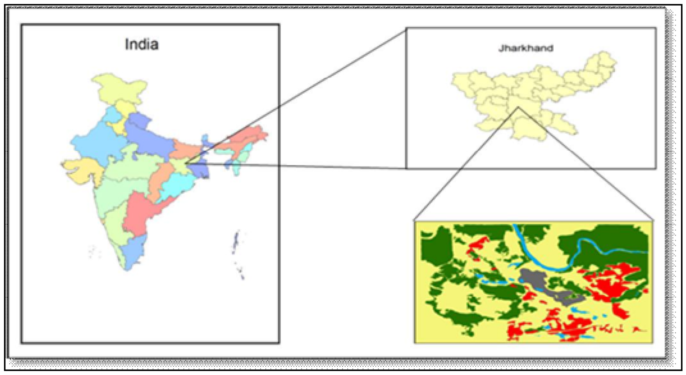


Figure 1.1

3. Material and Method

The methodology is divided in to two parts:

- To create land use / land cover map to analyze change in vegetation by using remote sensing data.
- To carry out the chemical and biological analysis of surface water and ground water using standard method.

3.1. Analysis of change in vegetation

In order to analyze the change in vegetation over the study area, specific data was acquired. For carrying out the study, satellite images of Dakra coalfields were obtained for the two years namely, 1992 and 2011. For keeping all atmospheric criteria same all the images chosen are of the same month that is November. The toposheet number of my study area is 73E/2 and the study area is covered by two toposheets – 73E/2, 73A/14. Topohseets of the year 2011 was used, which was updated for major details from satellite imagery of 2007 during 2008-09. Software used in image classification were ERDAS IMAGINE 9.2, Arc GIS 10.1, Quantum GIS 1.8.0, Google earth, Ms Word and Ms Excel

The methodology step adopted in the project to reach the results to analyze change in vegetation is shown in the Fig 1.2

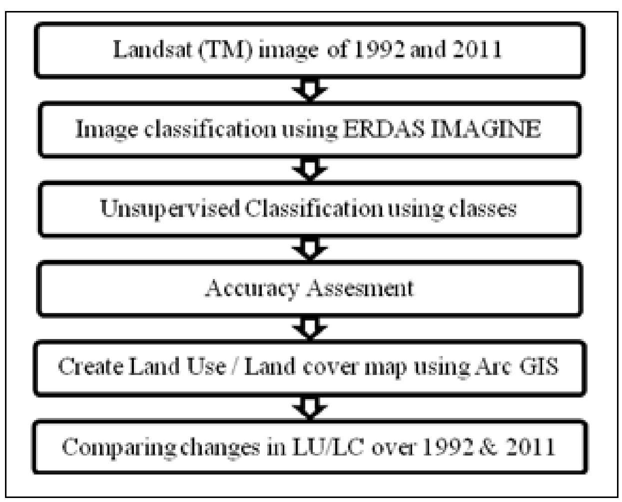


Figure 1.2

SI. No	Data type	Period	Scale	Source
01	Landsat (TM)	Nov,1992	30 m	http://earthexplorer.usgs.gov/
02	Landsat (TM)	Nov, 2011	30 m	http://earthexplorer.usgs.gov/
03	Toposheet	2011	1:50,000	Survey of India, Ranchi.

Table 1: shows data type and their sources

3.1.1. Image Interpretation

The two different year satellite data of which image interpretation and analysis is done are shown in fig 1.3 & 1.4.

Figure 1.3

Figure 1.4

The image is classified into six classes - Mining area, Water bodies, Sand dunes, Non forest area, Forest cover, Settlement. After determination of the major land use and land cover classes to be included, a natural cluster comprised of twenty classes was created using the unsupervised classification operator of ERDAS imagine. This software uses the ISODATA (Iterative Self-Organizing Data Analysis Technique) algorithm to perform an unsupervised classification. It performs an entire classification (with a thematic raster layer as an output) repeatedly and recalculates statistics by locating the clusters that are inherent in the data using the minimum spectral distance formula to form clusters. This was revised using supervised class technique.

For checking the accuracy of image classification ground-thruthing is done with the help of Google Earth and taking GPS reading of the study area. Finally; the classified images were exported to Arc GIS for creating the land use and land cover map. Then the boundary is set of study area on classified image for easy interpretation. After that different color ramps and the entire map making element are given i.e. title, date of map preparation, author, arrow, scale, legend, etc. By seeing the classified land use and land cover map we can easily determine the changes in the land use pattern of two different years.

3.2. Water Quality Analysis

The water samples were collected from both surface and groundwater (from wells, bore well & pond) resources in surrounding areas of Dakra coal mine (latitude of 23^o–39^o N to 23^o-41^o N and longitude 85^o E to 85-01^o E) in an attempt to reflect the impact of mining on water quality. Total 12 surfaces and ground water sample were collected in which 7 samples were from bore-wells, 2 were of pond and 3 of open dug wells. Total 12 samples were taken for study for each monsoon and post monsoon season. Analysis of collected water samples are carried out to determine pH, Turbidity, Hardness, Calcium, Magnesium, Chloride, Alkalinity, Ferrous, Nitrate, Total dissolve solids, Fluoride and MPN. All the parameter are tested by standard procedure APHA 1998 (American Public Health Association) which is standard methods for the examination of water and wastewater.

4. Result and Discussion

4.1. Classified Lu/Lc map of study area

Land use and land cover map is created to identify the impact on vegetation causes due to coal mining of two different year i.e. November 1992 and 2011. On comparing the fig 1.5 & 1.6 we easily find the impact of mining on vegetation in various year and we also find what changes occurs in Lu/Lc pattern in different year as is shown in graph 1.1. The graph shows that as mining activity and settlement increased, forest cover area has been decreased but there is no effect on water bodies. Due to mining activity the forest area are changing in to non forest area. So we can say that mining is causing impact on vegetation because in year 1992 forest cover is 58% in the study area but in year 2011 forest cover comes to 48% which show great decline in growing of tress in forest area due to mining activity.

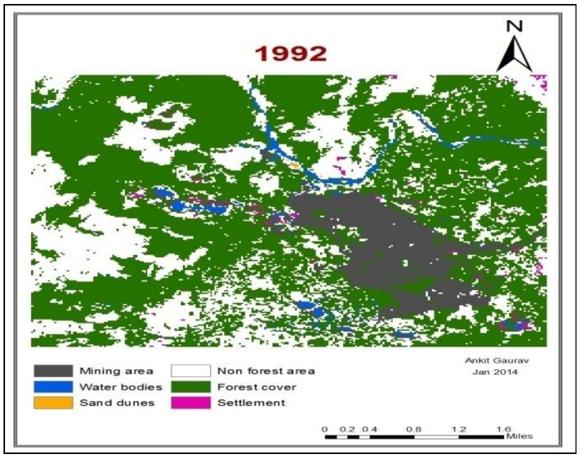


Figure 1.5

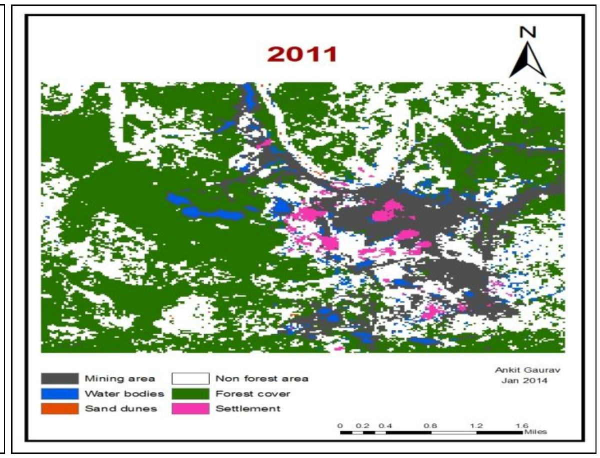
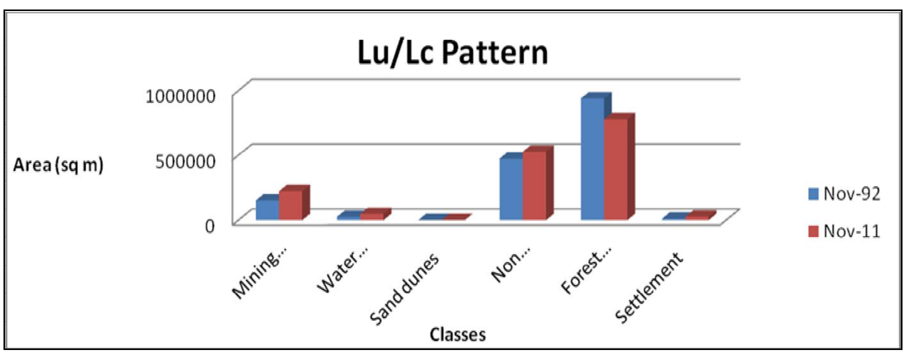


Figure 1.6

SI. No.	Class	1992		2011	
		Area (Sq. m)	Percentage	Area (Sq. m)	Percentage
1	Mining area	153570	10%	223920	14%
2	Water Bodies	26070	2%	48450	3%
3	Sand dunes	990	0%	1200	0%
4	Non forest area	474030	29%	527490	33%
5	Forest Cover	940320	58%	779220	48%
6	Settlement	12060	1%	26760	2%

Table 2: Shows different classes, area covered with their percentage of classified image



Graph 1.1

4.2. Water Quality Parameters

- ***pH:*** pH is important parameter, which determines the suitability of water for various purposes. In the study area pH level of water varies from 6.9 to 7.9 in monsoon and 6.25 to 7.5 in post monsoon, which comes under desirable limit i.e., 6.5 to 8.5 as specified by IS 10,500. W1 is showing high pH i.e. 7.6 and 7.25 in both monsoon and post monsoon and the other all sample are slightly neutral in nature.
- ***Calcium:*** The desirable limit and permissible limit of calcium for drinking water as specified by IS: 10,500 is to be within 75 mg/l to 200 mg/l. Calcium in the groundwater and surface water of the study area, ranges from 70.4 mg/l to 312 mg/l in monsoon and 72 mg/l to 193 mg/l in post monsoon. The entire post monsoon water samples are under limits but W2 and W7 are beyond the limit in monsoon.
- ***Magnesium:*** The desirable limit and permissible limit of magnesium for drinking water as specified by IS: 10,500 is, 30 mg/l to 100 mg/l. Magnesium in the groundwater and surface water of the study area, ranges from 126.5 mg/l to 478 mg/l in monsoon and 444.2 mg/l to 198.5 mg/l in post monsoon. All the water samples contain high amount of magnesium concentration in both monsoon and post monsoon. The concentrations are exceeding the limit.
- ***TDS (Total Dissolved Solid):*** Total dissolved solids in the groundwater and surface water of the study area, which ranges from 150 mg/l to 610 mg/l in monsoon and 130 mg/l to 735 mg/l in post monsoon. W6 has low amount of TDS in both monsoon and post monsoon.

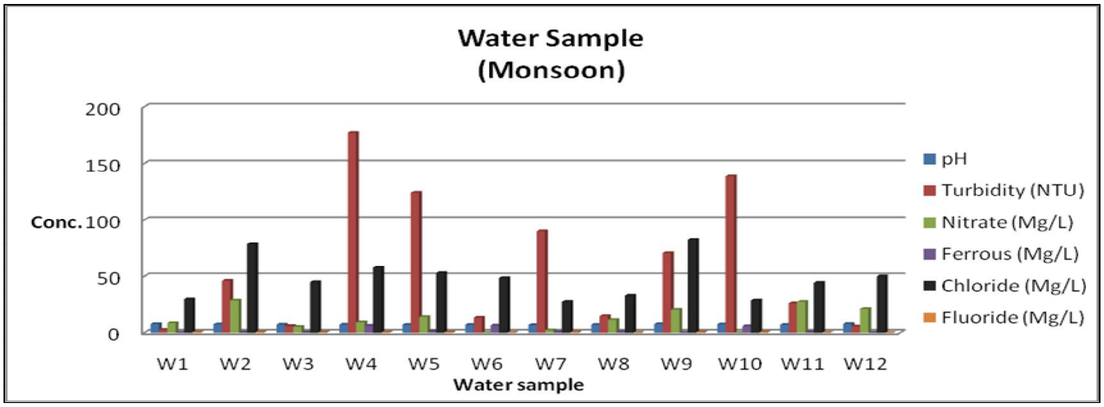
- ***Alkalinity:*** The standard desirable limit of alkalinity of potable water is 120 mg/l and the maximum Permissible level is 600 mg/l for drinking water as specified by IS: 10,500. Total Alkalinity in the study area varies from 75 mg/l to 370 mg/l in monsoon and 100 mg/l to 260 mg/l in post monsoon. All the samples of monsoon and post monsoon are under the standard limit.
- ***Hardness:*** The desirable limit and permissible limit of total hardness value for drinking water as specified by IS: 10,500 is to be within 300 mg/l to 600 mg/l. In the study area total hardness of water varies from 267 mg/l to 790mg/l in monsoon and 290 mg/l to 620 mg/l in post monsoon.
- ***Nitrate:*** According to Is 10,500 the desirable and permissible limit for nitrate in drinking water is 45 mg/l and 100 mg/l. In the study area Nitrate concentration varies from 5.2 mg/l to 27 mg/l in monsoon and 2.3 mg/l to 23.8 mg/l in post monsoon.
- ***Fe (Iron):*** The desirable and permissible limit of Fe for drinking water as specified by IS: 10,500 is to be within 0.3 mg/l to 1 mg/l. Iron concentration in the groundwater and surface water of the study area, which ranges from 0.25 mg/l to 6.25 mg/l in monsoon and 0.23 mg/l to 6.45 mg/l in post monsoon. W4 and W10 have high concentration of Iron in monsoon and post monsoon which is beyond the limit of IS 10,500.
- ***Turbidity:*** The desirable limit and permissible limit of Turbidity for drinking water as specified by IS: 10,500 is to be within 5 NTU to 10 NTU. Amount of turbidity found in the groundwater and surface water of the study area, which ranges from 2.7NTU to 177 NTU in monsoon and 0.5NTU to 232.3NTU in post monsoon. Most of the water samples are beyond the standard limit in both monsoon and post monsoon.
- ***Fluoride:*** The desirable limit and permissible limit of Fluoride for drinking water as specified by IS: 10,500 is to be within 1 mg/l to 1.5 mg/l. Fluoride concentration in the groundwater and surface water of the study area, which ranges from 0.6 mg/l to 2.15 mg/l in monsoon and 0.1 mg/l to 6.8 mg/l in post monsoon. W4, W9, W10 has high concentration of fluoride in monsoon.
- ***MPN (Most Probable Number):*** There is no bacterial coliform found in the samples of the study area. So MPN/100 ml in water sample is nil.

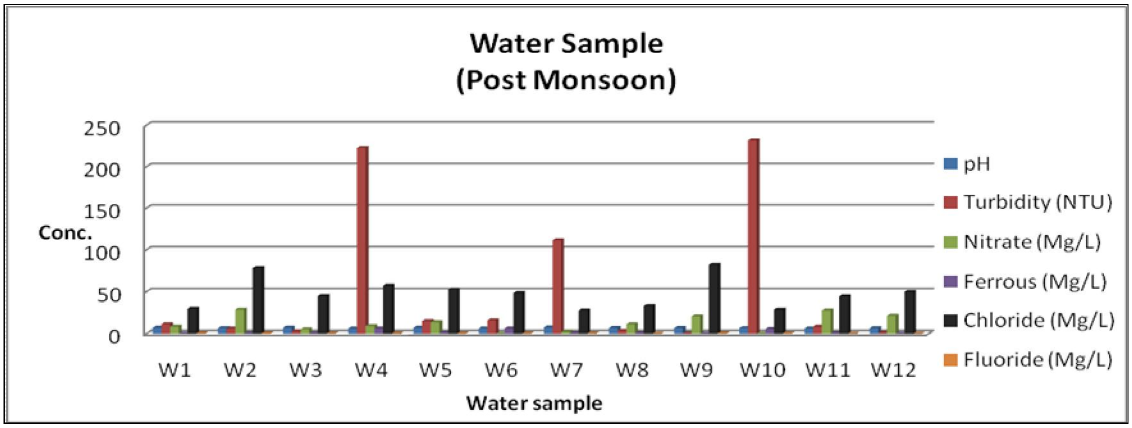
Sample	pH		Turbidity (NTU)		Alkalinity (mg/l)		Hardness (mg/l)		Magnesium (mg/l)		Chloride (mg/l)		Fluoride (mg/l)		Calcium (mg/l)		Nitrate (mg/l)		TDS (mg/l)		Fe (mg/l)		MPN/100ml	
	M	P M	M	P M	M	P M	M	P M	M	P M	M	P M	M	P M	M	P M	M	P M	M	P M	M	P M	M	P M
W1	7.6	7.25	2.7	11.5	370	230	550	410	448	275	45	29.8	0.75	0.68	102	135.6	13.5	8.5	445	345	0.4	0.23	NIL	NIL
W2	7.4	6.8	46.2	6.3	190	260	675	620	464	444.2	27	78.5	0.53	0.65	210.8	175.8	5.2	28.7	331	735	0.77	0.35	NIL	NIL
W3	7.2	7.2	6	2.9	100	130	280	290	162.8	198.5	38.5	45	0.8	0.42	117.2	91.5	BDL	5.3	165	240	0.42	0.46	NIL	NIL
W4	7.25	6.35	177	223	130	145	350	570	205	424.4	35	57.6	1.9	0.45	145	145.6	BDL	9.2	250	538	6.3	6.3	NIL	NIL
W5	7	7.25	124	15.2	110	125	790	490	478	334.7	42	52.8	1.08	0.48	312	155.3	19.6	13.8	610	452	6.45	1.2	NIL	NIL
W6	7.1	6.3	13.2	16	120	110	610	550	420	402	35	48.5	0.22	0.3	190	148	BDL	BDL	240	130	0.35	6.45	NIL	NIL
W7	6.9	7.5	90	112	210	160	580	610	360	417	12	27.5	0.73	0.54	220	193	7.4	2.3	390	287	0.66	0.6	NIL	NIL
W8	7.15	7.1	14.7	3.7	75	115	440	460	396.6	303	23.2	33	0.62	0.17	70.4	157	27	11.3	167	247	0.37	0.84	NIL	NIL
W9	7.75	6.9	70.5	0.5	97	150	267	480	126.5	318	21.5	82.5	2	0.62	140.5	162.8	12.7	20.7	310	430	1.25	0.23	NIL	NIL
W10	7.5	6.85	138.5	232.3	170	135	340	290	179.2	218	19.5	28.7	2.15	0.58	160.8	72	BDL	BDL	175	175	6.52	5.85	NIL	NIL
W11	7.1	6.25	26.3	8.5	95	100	390	400	329	260.2	30	44.5	0.53	0.2	151	139.8	18.5	27.5	280	298	0.5	0.63	NIL	NIL
W12	7.9	6.7	5.7	1.3	80	130	485	450	312.5	317.5	15.3	50	0.42	0.1	172.5	132.5	BDL	21.3	150	395	0.25	0.25	NIL	NIL

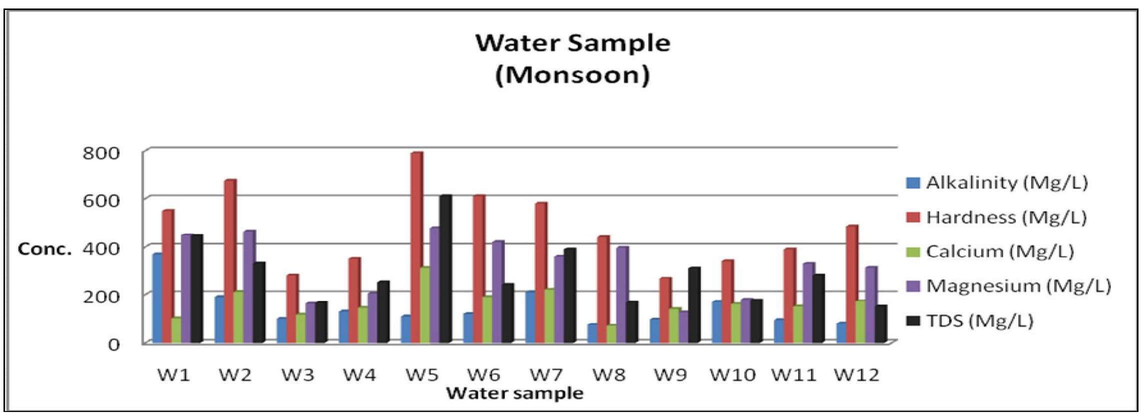
Fe – Iron, BDL – Below detection level, NIL – No Coliforms found, M – Monsoon, P M - Post Monsoon, W- Sample Stations

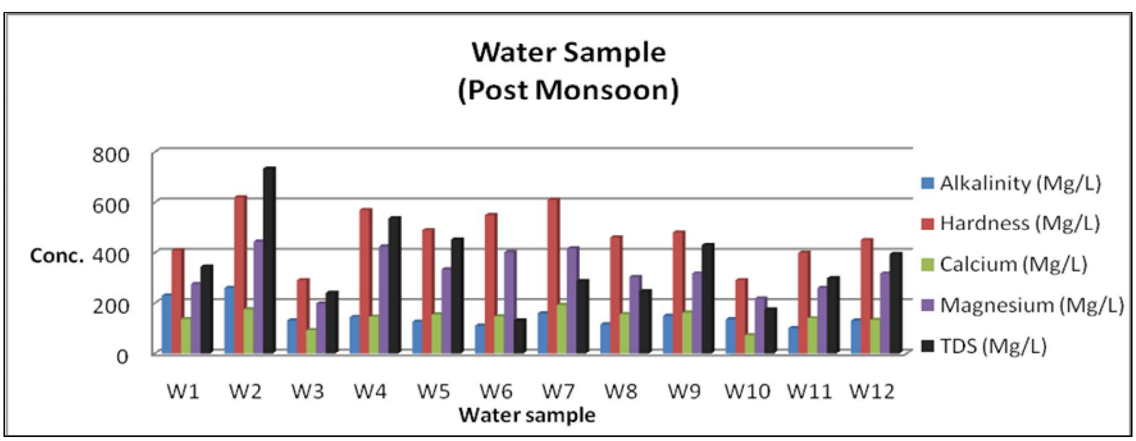
Table 3. Shows observation of monsoon and post monsoon

- The various graph as shown below, shows the concentration of parameter which was analyzed for both Monsoon and Post monsoon.


Water Sample
(Monsoon)
Conc.
200
150
100
50
0
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12
Water sample
pH
Turbidity (NTU)
Nitrate (Mg/L)
Ferrous (Mg/L)
Chloride (Mg/L)
Fluoride (Mg/L)


Water Sample
(Post Monsoon)
Conc.
250
200
150
100
50
0
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12
Water sample
pH
Turbidity (NTU)
Nitrate (Mg/L)
Ferrous (Mg/L)
Chloride (Mg/L)
Fluoride (Mg/L)


Water Sample
(Monsoon)
Conc.
800
600
400
200
0
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12
Water sample
Alkalinity (Mg/L)
Hardness (Mg/L)
Calcium (Mg/L)
Magnesium (Mg/L)
TDS (Mg/L)


Water Sample
(Post Monsoon)
Conc.
800
600
400
200
0
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12
Water sample
Alkalinity (Mg/L)
Hardness (Mg/L)
Calcium (Mg/L)
Magnesium (Mg/L)
TDS (Mg/L)

5. Conclusion

From the study it was found that the total loss in forest cover between 1992 and 2011 is about 10% and mining area has increased by 4%. Though the water body has increased by 1% but still there is not much difference and non forest land has also increased about 4%. The total increase in settlements is about 1%. Thus, it is clear that large scale mining leads to massive deforestation as can be seen near Dakra mining area. The coal dust also settles on leaves of plants which affects the growth of plants. It is concluded from the analysis of ground water and surface water for monsoon and post monsoon season near Dakra coalfield that, the water of that area is slightly contaminated due to mining activities. Some of the parameter like Turbidity, Hardness, Alkalinity and Iron are found beyond the limit as specified by IS 10,500 at some sampling points in both monsoon and post monsoon. High concentration of magnesium found at all sampling point in both season. Hence it is highly essential that use of proper mine closure plan and land reclamation practices must be adopted to bring the area, if not fully at least nearer to its original fauna cover.

6.A cknowledgement

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