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Assessing the Impacts of Coal Mining Activities on the Environment Using Remote Sensing and GIS Data

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A B S T R A C T

Mining is that the process of excavating minerals of economics value from the earth's crust for advantage of mankind. Mining excavation process like digging, blasting causes massive damage to landscape and biological communities. Primary industries like mining form the backbone of developing economies throughout much of the planet. A century of production driven, environmentally insensitive policies however, are resulting in massive soil degradation and contamination, toxic vegetation, groundwater (surface and subsurface) pollution, mine dump disposal and landscape defacement around the mining areas. A systematic and multidisciplinary approach of mapping, monitoring and controlling the impact caused by the mining activities is important so understand the character and magnitude of those hazardous events in an area. Environmental impact assessment is now an integral part of mining operations. Remote sensing satellite imageries data enables the identification, delineating, and monitoring of pollution sources and affected areas, including derelict land, and changes in surface land use and land cover and in water bodies. Using high resolution satellite remote sensing data and state of the art GIS techniques with parallel development of a totally integrated geospatial database system provided monitoring and feedback at appropriate spatial scales; therefore, such data are often used for long-term environmental management and monitoring of reclamation and rehabilitation of mining areas.

Keywords: Mining, Environmental Impacts, Land use/Land cover, Remote sensing, GIS.

1. Introduction

Primary industries such as mining form the backbone of developing economies throughout much of the world. A century of production driven, environmentally insensitive policies however, are leading to massive soil degradation and contamination, toxic vegetation, groundwater (surface and subsurface) pollution, mine dump disposal and landscape defacement around the mining area1. The exploitation of mineral resources has brought serious land problems.

A large number of land resources are excavated, exploited and at times left unattended after mining2.Main applications of GIS are mapping, storing, modification of environmental data and afterwards analysis and visualization3.A quick review of the literature shows that satellite-based remote sensing is a widely accepted and utilized technique in many scientific disciplines to monitor and evaluate the impact of natural processes and human activity onthe environment4.The basic data used for environmental appreciation about mining areas usually include the location of pollution sources and the areas influenced by these pollution resources. Some of these data can be directly acquired from the satellite image, but another data should be

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made certain by incorporated the satellite image and fieldwork[5]. Field work was conducted to identify places of special interest and to calibrate the results of the analysis[6]. Field studies were conducted from time to time, Data and literature were gathered from various sources[7]. The data used in this research paper was environmental impact assessment of limestone mining in the Ariyalur district was analyzed using Landsat 8 and 7 data[8.] Remote sensing satellites provide timely, accurate and reliable data on degraded lands at definite time intervals in a cost effective manner[9].The Proposed KTK OC - 2 (kakatiya khani opencast mine) Project study area is a part of Singareni collieries company limited. This is located at Jayashankar Bhupalpally Telangana State [10.]

2. Study Area

3. The mine is covered in Bhupalpalli Village, Jayashankar Bhupalpalli District, and Telangana tate. The location of the Mine area falls under Survey of India Topos heet No.(56N/15). The 15 km buffer Zone of the Kakatiya Khani Opencast -II Coal Mining Project is falling in (56 N/14), (56 N/15) and (56 N/11) Survey of India Toposheets. The geographical coordin ats of the study area as follows: left side corner 79°49'44.978"E 18°27'42.624"N, right side corner79°52'4.04E 18°26'57.114" N,top side corner79°51'36.424"E 18°27'50.3 5"N & bottom side corner 79°51'5.586"E 18°26'36.789"N. It Covers 6Mandals(Malha lrao,Ghanpur,Bhupalpally,Chitya, Kataram, Mahadevpur)

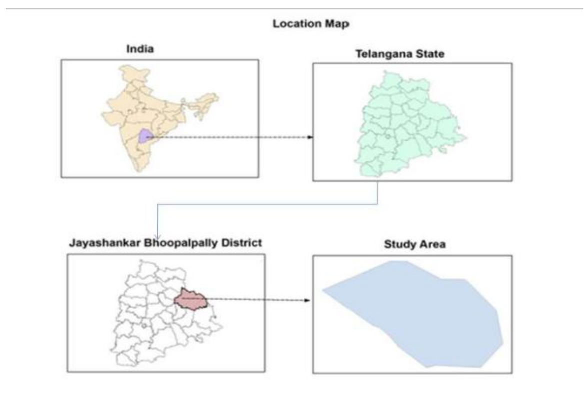

Fig.1 Location map of study area

3. Methodology

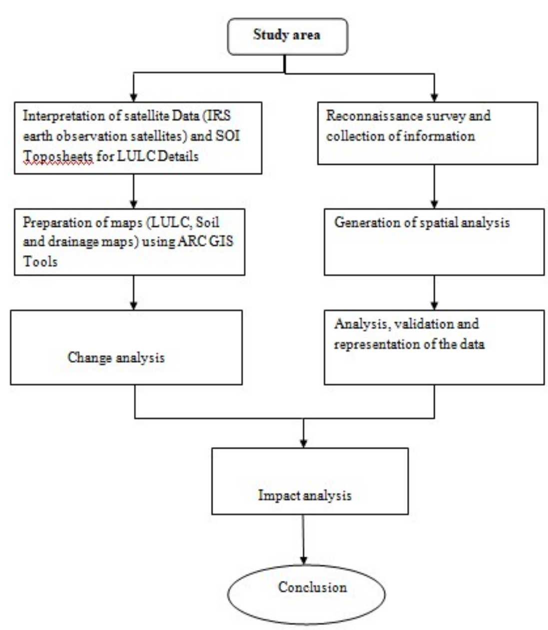

Figure 2 : Methodology

The proposed methodology of study area involved various activities such as base map preparation, LU/LC and soil map preparation using Arc GIS software tools. The field survey was carried out in the study area for analysis of water, air, noise and socio economic environment. The first stage involves Interpretation of various satellite imageries and survey of India Toposheets for analysis of LU/LC, soil and other maps. In the second stage, collection of information from the field survey was carried out for analysis of the environmental impacts on the study area due to coal mining activities. In the third stage, change analysis, geospatial analysis represen tation and validation of the data was carried out. All the above processing and interpretation of the data is used for impact analysis.

4. Results

While comparing the land use/land cover changes of years 2016 and 2019The land required for the project will be initially put in use for quarry(mine), Overburden dumping, mine yard, coal yard, sand dump ,water treatment plant ,infrastructure, approach roads, etc. But the same will be progressively reclaimed to economic and social use at the end of mining operation. In the core zone the total area is 1671.44 acres. Out of these the changes observed are the settlements would not change, and the percentage of roads was increased from 0.8 to1.2.and the main changes are observed in increasing the area of the mine because the given mine is underground mine previously and then it was converted to open cast. The mine area is increased from 12% to 20%.The overburden area is completely vanished in the year of 2019, why because the plantation of trees on the overburden was takes place by management. So it comes under the plantation. While the water bodies or tanks percentage is decreased from 2 % to 1.5%.crop land of the area is decreased to 5%.The coal yard of the area remains same. **The water environment** was assessed by studying the quality of ground water and surface water bodies within the study area. The result of such sample survey is the surface water consists of different types of elements such as dissolved solids and oxygen are 610 mg/L and 5.8 mg/L presents respectively. According to TDS standard levels between 1000 is fair for dissolved solids and the Dissolved oxygen percentage is also good by comparing standards. Chlorides, sulphates copper and nitrates are present in acceptable limit. While in ground water samples collected at two locations, the color, pH value and odor are agreeable and the presence of lead, cyanide, nickel etc. are at below detection level. The study area consists of different types of soils which are Loamy to clayey deep Reddish brown soils 300.251 sq km .Clayey to gravelly clayey moderately deep dark brown soils 22 sq.km and Moderately deep calcareous moist clayey soils 25.070 sq km Deep black clayey soils 21.582sqkm.

Ambient air quality at core zone it is observed that PM 10 value is 176 and pm 2.5 concentration is 67.4, sulphur dioxide concentration is 11.7 as well as NO2 is observes as 16.6.while comparing these values with air quality standards. The PM 10 concentration is 100 but here it is observed that 176 and PM 2.5 standard concentration is 60 and the observed value at core zone is 67.4 and that of SO2 and NO2 standard concentrations are 80 and the observed concentrations are 11.7 and 16.6 respectively. The ambient air quality samples are collected at four locations in Buffer zone. The locations are Kashimpalli village, Gaddi ganipalli village, Peddakuntapalli village an d Jangedu village. By comparing these values with the standard values of Air quality at mines, it is observed that the PM10 concentrations of these locations are below 100 a nd PM 2.5 concentrations are below 60, the SO2 and NO2 observed concentrations at buffer zone are below 80, less than its standard value. The ambient Noise Levels data generated at two locations of core zone and buffer zone during the certain periods of the study area which are presented in Table 6.1. Out of two locations, one location is in core zone (KTKOC –II mine) and other location is at buffer zone of Kashimpalli village. The details of Leq (day) and Leq (night) are presented in Table 6.2. Generally the noise level is high at core zone due to vehicular sound, moving of heavy earth machineries and operating of excavating machines like shovel, dumper etc., and the most important operation of mining is blasting practice. However by analysis of data at these locations it is observed that the noise levels were well within the limits.

5. Discussion

Land use/Land cover

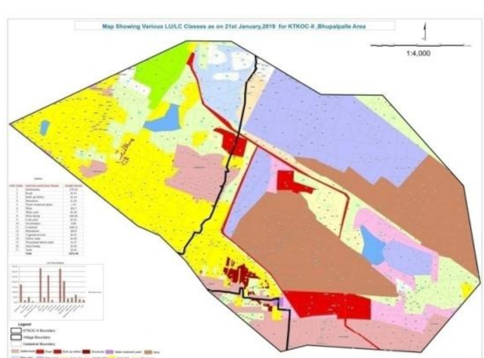

Fig 3. Land use/Land cover map of core zone (2019)

Table 1. Land use/Land cover statistics of core zone (2019)

Land use/Land cover category	Area in (Acres)	% area
Settlements	174.10	10.4
Road	20.72	1.2
Built up others	52.14	3.11
Structures	11.32	0.6
Water treatment Plant	1.74	0.14
Mine	331.7	19.8
Mine yard	45.18	2.7
Mine dump	264.04	15.7
Coal yard	25.22	1.5
Overburden	0.00	0
Crop land	328.12	19.6
Plantations	206.9	12.37
Vegetation-trees	36.55	2.18
Fallow land	43.49	2.6
Waste land – barren land	73.77	4.41
Sand dump	32.03	1.91
Tank	24.42	1.46
Total	**1671.44**	

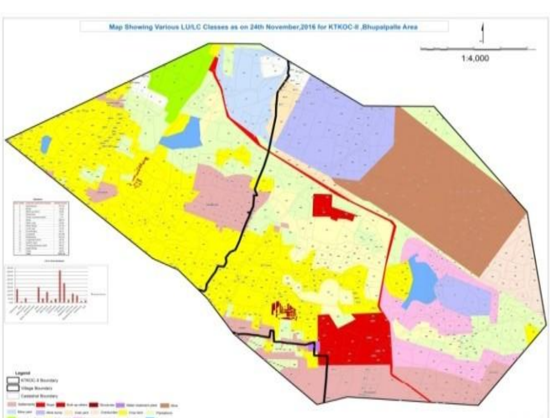

Fig 4. Land use /Land cover map of core zone (2016)

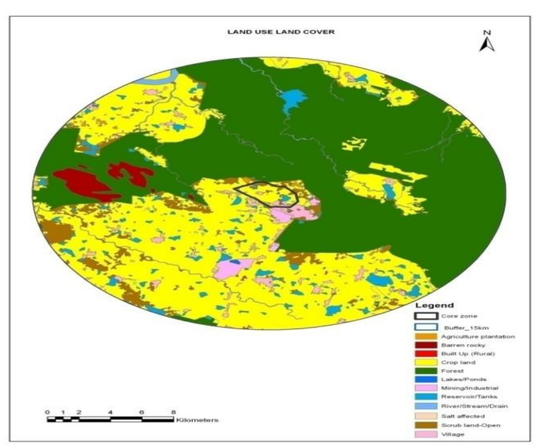

Fig 5. Land use/Land cover Map of Buffer zone (2019)

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Table 2. Land use/Land cover statistics of core zone (2016)

Land use/Land cover category	**Area in (Acres)**	**% area**
Settlements	175.22	10.4
Road	14.69	0.8
Built up others	56.83	3.4
Structures	3.52	0.21
Water treatment Plant	1.74	0.1
Mine	200.27	11.98
Mine yard	53.80	3.2
Mine dump	137.57	8.23
Coal yard	25.36	1.51
Overburden	46.12	2.7
Crop land	415.98	24.88
Plantations	250.10	14.96
Vegetation-trees	36.39	2.1
Fallow land	115.75	6.9
Waste land – barren land	89.41	5.34
Sand dump	20.65	1.23
Tank	28.05	1.67
Total	**1671.44**	

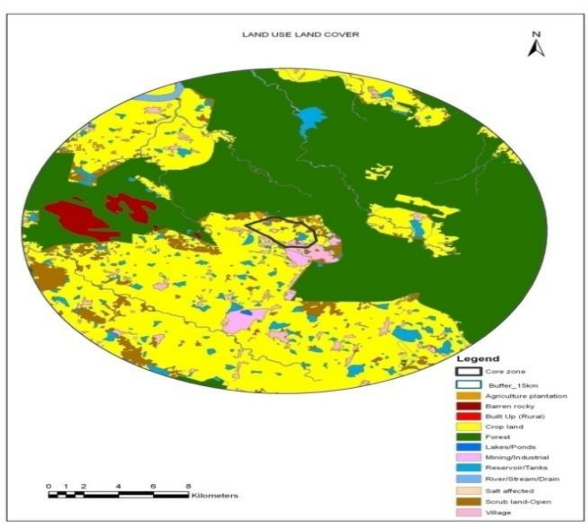

Fig 6. Land use/Land cover Map of Buffer zone (2016)

Table 3. Land use/Land cover statistics of buffer zone

LULC Categ ories	Year -2016		Year -2019	
	Area in Ha	% Area	Area in Ha	%Area
Double crop	2009.35	4.7	5391.14	10.91
Single crop	10047.23	23.5	15917.78	32.28
Quarry (mine area)	654.749	1.6	329.39	0.66
Water bodies	971.320	2.2	3359.39	6.8
Plantation	119.497	1.1	2164.20	4.38
Fallow land	1052.46	2.5	2818.84	5.7
Barren land	291.578	0.7	6.96	0.01
Built up land	877.17	1.9	1965.02	3.97
Open forest	9052.03	21.1	3004.68	6.08
Dense forest	15784.7	37.3	10239.85	20.72
Land with /with out scrub	1012.6	2.4	1686.35	3.4
Total area	**69,947**		**69,947**	

Water Environment

Table 4.Physico-Chemical Characteristics of Surface water

Parameters	Acceptable limit	Permissibe limit	Result	
			Jangedu village	Gaddigaipalli village
Colour	Agreeable	Agreeable	Agreeable	Agreeable
Odour	Agreeable	Agreeable	Agreeable	Agreeable
pH	6.5 to 8.5	No relaxation	7.2	7.2
Taste	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity	1	5	1.2	1.3
Total dissolved solids	500	2000	1360	716

Table 5. Physico-Chemical Characteristics of Ground water

Parameter	Unit	Standard value(CPCB	Observed value(Result
pH	-	6-9	7.6
TDS	mg/L	1000	610
DO	mg/L	4-6	5.8
BO	mg/L	5	3
COD	mg/L	-	20
Total Coli forms	MPN/10 mL	50-5000	350
Chlorides	mg/L	45	44
Nitrites	mg/L	-	BDL
Nitrates	mg/L	150	18
Sulphates	mg/L	5.9	26
Iron as Fe	mg/L	-	0.18
Copper	mg/L	-	BDL
Odour	-	-	No odour observed
Boron	mg/L	-	0.07
Total Phosphates	mg/L	-	BDL
Oil & Grease	mg/L	-	<1

Table 6.Parameters Concerning Toxic Substances

Parameters in mg/L	Acceptable limit	Permissible limit	Result	
			Jangedu village	Gaddiganipalli village
Cadmium	0.03	No relaxation	BDL	BDL
Cyanide	0.05	No relaxation	BDL	BDL
Lead	0.01	No relaxation	BDL	BDL
Nickel	0.02	No relaxation	BDL	BDL
Molybdenum	0.07	No relaxation	BDL	BDL
Chromium	0.05	No relaxation	BDL	BDL

The impact of the proposed project on the water environment was assessed by studying the quality of ground water and surface water bodies within the study area. To analyze for various Physico-Chemical parameters the water samples are required from surface and ground water bodies during the study period. A Total of 3 water samples i.e., 1 sample from surface and 2 sample from groundwater were collected and analyzed for various physico-chemical and bacteriological parameters

Soil Environment

Greatest Impact of mining on the soil resources is due to opencast mining, which is much having a much potential for the deterioration of soil quality than underground operations. Topsoil is an important component for land reclamation in coal mining areas. The study area consists of different types of soils which are Loamy to clayey deep Reddish brown soils 300.251 sq km .Clayey to gravelly clayey moderately deep Dark brown soils 22 sq.km .Moderately deep calcareous moist clayey soils 25.070 sq km Deep black clayey soils 21.582sqkm. Shallow gravelly.

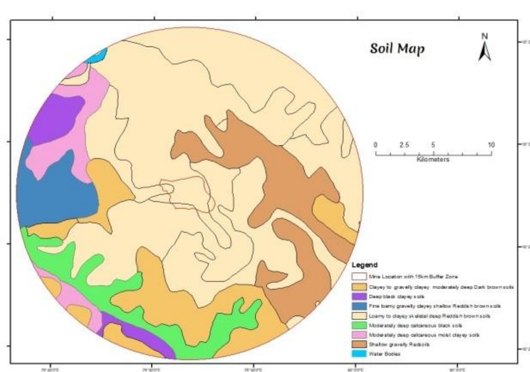

Fig 7: Soil map

Red soils 59.184 sq km. Fine loamy gravelly clayey shallow Reddish brown soils 33.444 sq km. Shallow gravelly Red soils 28.636 sq km .Moderately deep calcareous black soils 45.917 sq km .Clayey to gravelly clayey moderately deep Dark brown soils 68.391sq km. Moderately deep calcareous moist clayey soils 7.609 sq km. Moderately deep calcareous moist clayey soils 1.245 sq km. Water Bodies 1.088 sq km. Loamy to clayey skeletal deep Reddish brown soils 29.325 sq km Loamy to clayey skeletal deep Reddish brown soils 63.172 sq.km.

Air Quality

To quantify the impact of mine on the ambient air quality, it is necessary at first to evaluate the existing ambient air quality of the area. The baseline studies on air environment include identification of specific air pollution parameters and their existing levels in ambient air. The ambient air quality with respect to the study zone 15km radius around the proposed mines forms the baseline information. The sources of air pollution in the region are mostly due to vehicular traffic, dust arising from unpaved village road. The prime objective of the baseline air quality study of the study area.

Table 7: Ambient air quality at core zone

Date of Sampling	Noise Levels in dB(A)	
	Leq Day	Leq Night
11.01.2020	65.0	54.9
30.01.2020	64.6	55.4
13.02.2020	67.7	56.9
11.03.2020	63.6	51.3

Table 8. Ambient air quality at buffer zone

S.No.	PM10 (µg/m3)	PM2.5 (µg/m3)	SO2 (µg/m)	NO2 (µg/m3)
Kashimpalli village				
1	69	41.6	8.0	11.8
Gaddiganipalli village				
1	82	44.8	8.2	11.4
Peddakuntapalli village				
1	71	38.9	12.3	15.8
Jangedu village				
1	78	43.4	8.5	12.7

Noise Environment

A Detailed survey on noise environment was carried in and around the mine site to study the hourly equivalent noise level. This study was necessary as the high noise levels may cause adverse effect on human beings and associated environment, including structures, domestic animals and natural ecological systems. Spot noise levels were measured for 24 hours on hourly basis by using a high precision Sound Level Meter at six locations within the study area.

Table 9. Noise quality at core zone

S.No.	PM10 (μg/m3)	PM2.5 (μg/m3)	SO2 (μg/m)	NO2 (μg/m3)
1	176	67.4	11.7	16.6

Table 10. Noise quality at buffer zone

Name of the Location	Date of Sampling	Noise levels in dB (A)	
		Leq Day	Leq Night
Kashimpalli Village	10.12.2019	48.2	35.4
	10.01.2020	49.2	32.1
	11.02.2020	48.2	37.7
	26.02.2020	46.8	32.0

The ambient noise level data is observed at two locations of study area, i.e, one location at the core zone (KTKOC-II) and one location at the buffer zone (Kashimpalli village)

Socio-economic environment

To Assess the Anticipated Impacts of the proposed activities of the project on the socioeconomic aspects of people, it was necessary to study the existing

Table 11. Demographic profile of the study area

Demographic Information	Jayashankar Bhupalpally District(in lakh)	Census Villages of Study Area
Total Population	3512576	133053
Density of Population (per Sq.km)	273	374
Sex Ration (females per 100 males)	997	988
Sex Ratio Population (<06 yrs)	923	908
Percentage Total Literacy	65.11	64.78
Percentage of Male Literacy	74.58	74.02
Percentage of Female Literacy	55.69	55.5
Percentage of Work Population	48.56	46.82
Percentage of Main Work Population	41.06	87.21

socio- economic status of the local population and to arrive at what is required to be done to deal with the adverse impacts and to improve the quality of life of the population living in the study area. The Human settlements, demography, social strata, literacy levels and Infrastructure facilities available in the area. The economic aspect included the study of occupational pattern of people. The baseline data on distribution of population, density of population, literacy, and work participation was obtained from the census of 2011.

6. Conclusion

Satellite images and aerial ph otos, allow one to monitor mining event during the time of occurance while the forces are in full swing. The Advantage position of satellite images and aerial photos makes it ideal to evaluate areas of historical mining operations as well as active mine sites to the extent of providing more sensitive, cost effective, and timely monitoring potential. Satellite images offer multispectral approach, synoptic view and repetitive coverage. They provide very useful environmental information, on a wide variety of terrain parameters and range of scales.

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