International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2019): 7.583

# Remote Sensing Studies for Certain Karstic Features of Sonadih Limestone Mining Area in District Baloda Bazaar [CG]

**Dr. P K Gupta[1], Rishi Kumar Gupta[2], Ritika Jayaswal[3]**

[1]Professor, Department of Civil Engineering, Dr. C V Raman Institute of Science & Technology Raman University, Kota, Bilaspur, Chhattisgarh, India
Corresponding Author: *premkg14[at]gmail.com*

[2]Founder, Chartered Engineers, Bilaspur, Chhattisgarh, India

[3]Chartered Engineers, Bilaspur, Chhattisgarh, India

**Abstract:** ***Limestone deposit of Baloda Bazaar [CG] has dual socio-economic importance due to its karstic nature. Firstly, it has been renewable resource for potable ground-water as "Aquifer" from hydro-geological point of view since its formation. Secondly, it has been non-renewable resource for cement grade limestone [having Ca O content = 42+/- 2 % & Mg O content = 4%], occurring as surfaced outcrop with great attraction for quarrying activity since the past thirty years. It is likely to be continued in future for sake of localization of cement plants and subsequently clinker production. An attempt has been made in the area of study for scientific identification cum documentation of karstic features through developing Remote Sensing methodology-comparatively advance approach in Geology/Mining Engineering/Civil Engineering discipline. Nine major karstic features have been authentically recorded on the basis of their relationship to geology, hydrology, geo-morphology, vegetation, tectonic and hydro-geology besides quarrying activity, along-with digital interpretation of IRS LISS II data. The evolved methodology has better scope for overall conservation cum optimum extraction of renewable and non-renewable resources in the studied area with full proof example as well as future mile- stone for Indian karstic limestone mining scenario for cement production and related evergreen Construction Industry.***

**Keywords:** Remote Sensing, Sonadih Limestone, Mining

## 1. Introduction

The word 'Karst" has been derived from German language in late nineteenth centenary. It is originated from "deer karst"- the name of limestone region in Slovenia. Karstic features have origin through karstification [3]. The mode of occurrence for karstification is governed by geo-morphology, vegetation, hydrology, litho-logy and structural geology in limestone terrain under the influence of ground-water. The favorable conditions for formation of karstic features are as follows [12]:

- Presence of large stretch of water soluble rock on the ground surface and sub-surface like limestone.
- Limestone solvent is to be formed as weak Carbolic acid [H 2 CO 3] on account of rock water chemistry.
- Dense channel network at sub-surface.
- Perennial source of surface water.
- Occurrence of moderate rainfall.

Sonadih limestone mine has been opened on 12 December 1989 [4]. Sink-hole and spring as prominent karstic features in the area of study has been reported, first time as old quarry pond and lust green vegetation patch respectively along eastern portion of mining area in 1996 [8]. The solution cavity has been reported later on in 2014 [2]. The disappearance of intermittent stream within middle portion of mining area has been reported in 2019 [10].

## 2. Area of Study

The mining lease portion has an area of about 4.5 Sq. Km with geographic coordinates as: Latitude N 21° 43' 31" to N 21° 44' 25" & Longitude E 82° 11' 47" to E 82° 12' 36". It has been bounded in all directions by hydrological boundaries. The perennial Sheonath river with west to east direction flow is in northern side. The canal as Mudhyardih distributory No. 19 & 20 is in southern side. The Jamunia nadi with south to north direction flow is in western side. The intermittent stream [of disappearance nature] with south to north direction flow is in middle portion. The Khorsi nalla with south to north direction flow with little bit away of eastern portion. It has been surrounded by villages; Khapri [in east], Rasera & Raseda [in south], Dhabadih & Sonadih [in west]. It is at the distance of 13 Km in north of Baloda Bazaar, on Raipur-Belha Road-State Highway 130 B. Baloda Bazaar has rail connection to nearest railway station Bhatapara on Raipur –Howrah route connecting Jojobera. The location map for area of study is illustrated as **Fig.1.**

**Evolved methodology & Objectives**

The evolved methodology has two approaches namely: Conventional and Advance. The conventional approach is based upon relevant literature review with field observation. The advance approach is based upon developing different methodologies of Remote Sensing including digital analysis. The desired objectives are as follows:

- Spectral characterization of prominent mining features for area of study.

- Correction of IRS LISS II with creation of Sub-scene along-with synchronization with Field observation.
- Selection cum developing digital interpretation tools for identification of karstic features through digital analysis of Satellite data.
- Comparison of temporal Satellite data for documentation of newly formed karstic feature due to extensive mining activity.

## 3. Result & Discussion

The systematic understanding for karstic features in area of study has been carried out on the basis of its governing parameters namely: Geology, Geo-morphology, Vegetation, Hydrology and Hydro-geology. [5]

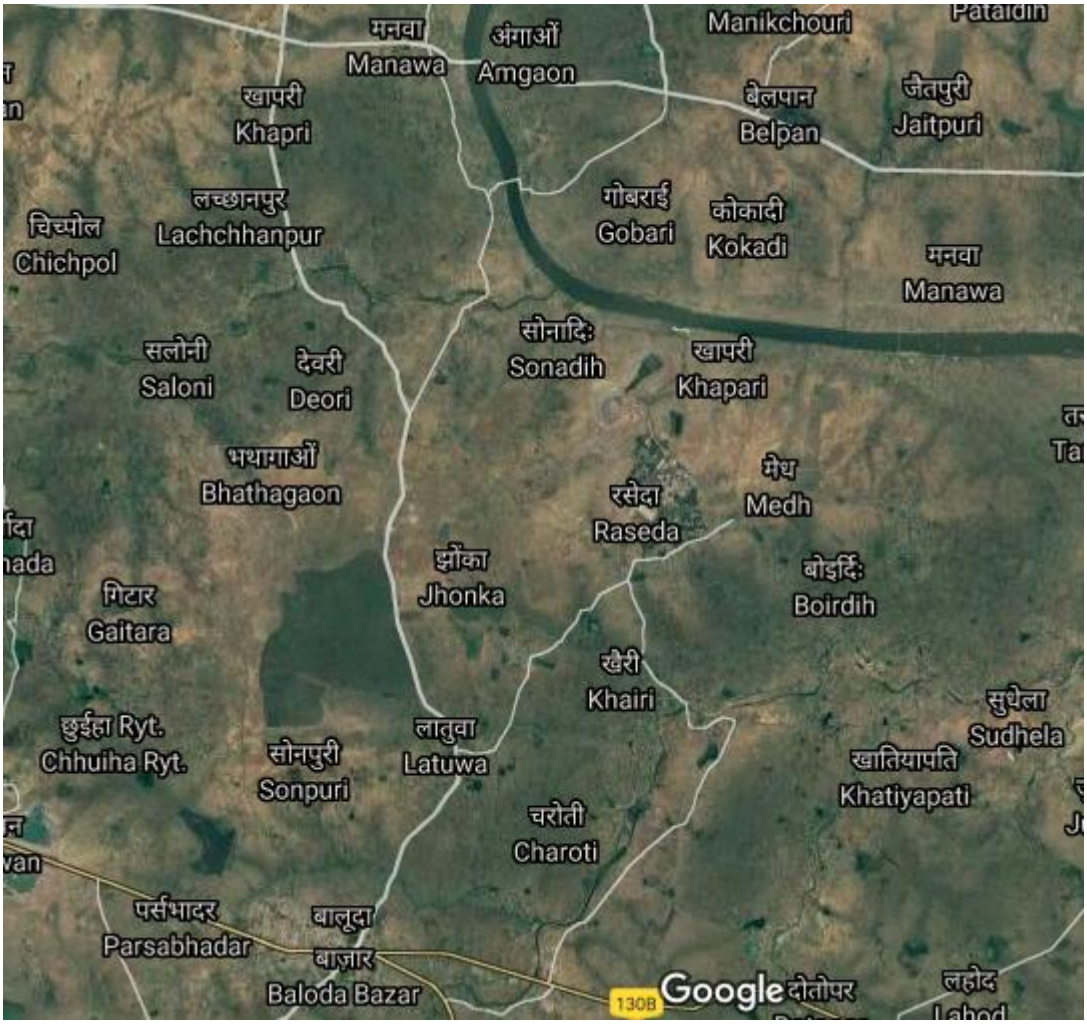


**Figure 1:** Location map for Area of Study

**Geologically,** the area belongs to Chandi limestone formation of Raipur group of Chhattisgarh basin, a typical Proterozoic sedimentary terrain. It has been dominated with three carbonate-shale cyclothem.[1] The limestone deposit in association with TERRA ROSSA has been horizontally bedded with local dip of 2 -6 ° in north west direction and strike trend in north- east to south-west direction.[4,11]

**Geo-morphologically,** the area has depositional features namely; Pediplain [Surface] & Paleo-drainage [Surface to subsurface] along Jamunia nadi [west] and Khorsi nalla [east] respectively.

**Vegetation** observation reveals the presence of bade Jhar ka jungle, lust green vegetation [SPRING], mixed species of trees, afforestation, paddy cultivation, fallow land and water loving vegetation along HFL and natural levees of Sheonath river.

**Hydrological,** the area is controlled by drainage characteristic of Jamunia nadi [west] and Khorsi nalla [east]**, superimposed by dendritic drainage of Sheonath** river. PALEO-DRAINAGE along Jamunia nadi basin has been activated locally by KARTISFICATION. The quarry portion has annual rainfall of 1350-1450 mm during middle June to Middle September months. About 15-20 % of it percolates down-word into sub-surface along joints for natural recharge of local aquifer. Sheonath river has flood cycle at interval of ten years and previously occurred in 1993, 2003 & 2013 so far, as per Central Water Commission discharge site at Kotni, nearest to mine site. [7]

**Hydro-geologically,** the area has two types of aquifer namely: unconfined and confined. The unconfined aquifer occurs up to average depth of 6 m, underlined by shale and overlain by marginal soil cover. It belongs to vadose zone under the influence of geochemical weathering. It is recharged through open rectangular joint pattern as per field observation and illustrated as **FIG.2.** It has been disturbed

by first bench of mining having same thickness of 6 m. The confined aquifer occurs in depth range of 8 m to 25-30 m. It has been influenced by karstification, tectonic as well as remaining three benches of mining activity of 6 m each. There are three types of groundwater discharge namely: SPRING, seepage and resurgence. The primary porosity of limestone is negligible to 2-3 % due to compact nature. The secondary porosity varies in accordance with mining activity and presence of fractures. The hydraulic conductivity as per pumping test has been 3-4 m per day. The transmissivity has higher range of 202 cubic m per day due to presence of probable CAVITY.

Mining design has maximum depth of 30 m for bottom of last [forth] working bench in area of study.

**Figure 2:** Geo-chemical Weathering with Rectangular Joint Pattern

The extent of karstification has been revealed up-to the depth range 35-40 m as per Resistivity investigation. The karstic features of the central India have been grouped into two categories namely: True karst and Fluvial karst [12]. True karst is developed by karstification process at moderate depth. Fluvial karst is produced by either fluvial activity or karstification confining to shallow depth. Nine karstic features in the study area of have been identified through evolved methodology. Two karstic features namely spring and solution cavity has been documented through field observation due to their small size and shape and illustrated as **FIG.3 & FIG.4** respectively. The cavity has been also inferred through resistivity investigation, without any further validation. One karstic feature of newly developed through extensive mining activity new sinkhole has been documented through temporal satellite data analysis. The remaining six karstic features have been documented through developing image interpretation tools through digital analysis of IRS LISS II data with field validation. The details of nine karstic features have been summarized in Table1.

**Field Observation**

The purpose of field observation has been the collection of field data in synchronization with the passing of IRS LISS II Satellite [ 23 January 1994] over the area of study, followed with major ground truth information during the period pre-monsoon, monsoon [repeating of one successive year] and post-monsoon season. Thus the duration of field work has been from January 1993 to January 1996 including developing Remote Sensing methodologies, with understanding the details of mining activities- arrangement of pumping test and Resistivity investigation.

**Remote Sensing Studies**

**Spectral characterization** of prominent mining features for area of study as available on the ground surface is the basis for Remote Sensing and its application. IRS LISS II has four spectral bands with ground resolution of 36.5 m. The Digital Number recorded in all spectral bands has range 0-80 and pronounced as DN value. The precise discrimination of individual surface object depends upon maximum co-variance of corresponding DN value in all bands. The eight major surface objects for area of study namely: surface

water [pond], quarry, limestone outcrop, Sheonath river, sand, vegetation, fallow land, shrub and cropped land have been selected for spectral characterization with plotting their respective spectral curve, as illustrated **Fig 5**.

**Correction of Indian Remote Sensing Satellite- Linear Image Scanning Sensor [IRS LISS II] with creation of Sub-scene along-with synchronization to Field observation** for area of study has been carried out for 23 January 1994 data with path and row 23/53. It contains data for much large geographic region including area of study. So, a sub-scene of 512x512 pixels has been extracted out for further it's preprocessing and digital analysis towards our area of concerned. Two sub-scenes of same path, but different adjacent rows have been merged to each other for data of same date in order to applying radiometric correction. The geo-reference for geometric correction has been carried out by superimposing Survey of India topo-sheet no. 64/K1 & 64/K2.

**Figure 3:** Spring as per Field Observation

**Figure 4:** Solution Cavity as per Field Observation

**Table 1:** Status of major karstic features in area of study

| S N | Name of Karstic feature | Type | Typical Characteristics | Demarcation tool | Remark |
|---|---|---|---|---|---|
| 1 | Spring | Fluvial | Part of karst hydrological cycle | Field observation | Out flow of groundwater with green vegetation cover |
| 2 | Pedi-plain | Fluvial | Hydro-geo-morphological deposit | Field & Digital observation | Western portion of quarry |
| 3 | Solution cavity | True | Geochemical weathering | Field observation | Along intermittent stream |
| 4 | Terra rossa | True | Physical weathering | Field & Digital observation | Surface outcrop |
| 5 | Plaeo-karst | True | Semi-circular hole with wide joint | Field & Digital observation | Eastern portion of quarry |
| 6 | Paleo-drainage | True | Impression of sub-surface drainage on | Digital observation | Along Jamunia nadi |

| | | | | | |
|---|---|---|---|---|---|
| | | | surface outcrop of limestone | | |
| 7 | Lineament | True | Regional tectonic | Digital observation | Along Khorasi nalla |
| 8 | Old sink hole | True | Influence of solution activity along surface depression | Field & Digital observation | Dumping of mine rejects along eastern portion of quarry |
| 9 | New sink hole | True | Remnant of last worked bench with mine pit water in ML-1 | Goggle Image observation [20 March 2020] | Heavy blasting with fractured shale |

**Selection cum developing adequate interpretation tools to identification of karstic features through digital analysis of Satellite data** for area of study has been carried out at Regional Remote Sensing Center [RRSC], Nagpur. Twenty five Ground Control Points [GCP] have been recorded with their precise location as per detailed field work pertaining to major eight surface features for generation of training sets.

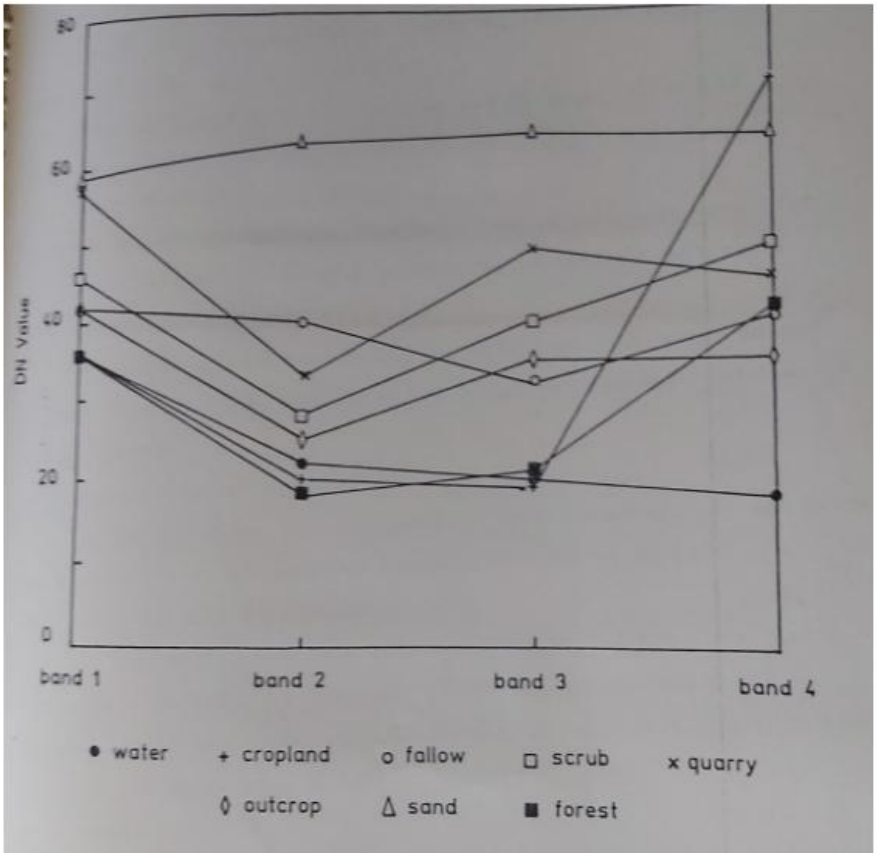


**Figure 5:** Spectral Characteristics of Eight major Surface Objects

The digital analysis has been carried out through interpretation tools as Band Ratio, False Color Composite [FCC], and Edge Enhancement, Edge Enhancement, Principal Component Transformation [PCT] and supervised classification of various band combinations for delineation of six karstic features. The details have been summarized as follows:

a) **Band ratio:** The Band Ratio of 4/2 has provided the occurrence of Pediplain along the confluence of Jamuniya nadi with Sheonath river and illustrated as **Fig.6.** It has been confirmed with field validation, as illustrated **Fig.7**.
b) **False Color Composite [FCC]:** The standard FCC with band combination of 12 &3 has provided the occurrence of Terra rossa at and surrounding of main quarry and illustrated as **Fig.8.** It has been confirmed with field validation, as illustrated **Fig.9.** Standard FCC band combination of 2, 3 &4 has provided the occurrence of Paleo-karst along the confluence of khorsi nalla with Sheonath river and illustrated as **Fig.10.** It could not be confirmed in field, since the occurrence has been beyond the area of study.
c) **Edge Enhancement:** The DN value of band 2, 3 &4 has been linearly stretched with their supervision to each other. It has provided the occurrence of Paleo-drainage at northern and eastern portion of mining area and illustrated as **FIG.11.** It could not be confirmed in field, since it has been sub-surface feature.
d) **Principal Component Transformation [PCT]:** The standard PCT of band of 2, 3 &4 has provided regional Lineament with trend north to south, controlled by drainage configuration and illustrated as **Fig.12.**
e) **Supervised classification:** It has provided the occurrence of Old Sinkhole along the eastern boundary of mining lease area and illustrated as **Fig. 13.**

**Comparison of temporal Satellite data for documentation of newly formed karstic feature due to extensive mining activity** has been observed in ML-1 along the bottom of fourth and final worked out bench through Google Image of 20 March 2020. It was not present during

1993-96 field investigation, as second bench had been operation. It has been developed due to excessive mine water pumping through working of each bench and sufficiently drawdown of groundwater accordingly. It is illustrated as **Fig.14.**

## 4. Summary & Conclusion

The open cast mining activity in area of study has been continued since 1990, as captive mine with change of ownership from Tata steel to Lafarge and Shri Jai Kumar Krishnaswami [with effect from November 2018]. It has been producing clinker material [Nodule Ball] for local cement plant [12-15%] towards Portland Pozzolana Cement manufacturing, with remaining portion to Jojubera Grinding plant, near Tata- nagar [Jharkhand] for manufacture of Portland Slag Cement.

The area of study belongs to typical karstic limestone terrain, which has not been paid any attention so far towards documentation and scientific study of karstic features. The restoration of karstic watershed belonging to Jamunia nadi and Khorsi nalla under the influence of ongoing mining activity envisages for conservation of karstic limestone aquifer and related environmental issues through following considerations:

- Water quality study for local agricultural area through evaluation of rock-water chemistry.[3]
- Water appraisal of spring, intermittent stream in relation to mine-water pumping strategy and related draw dawn characteristics.

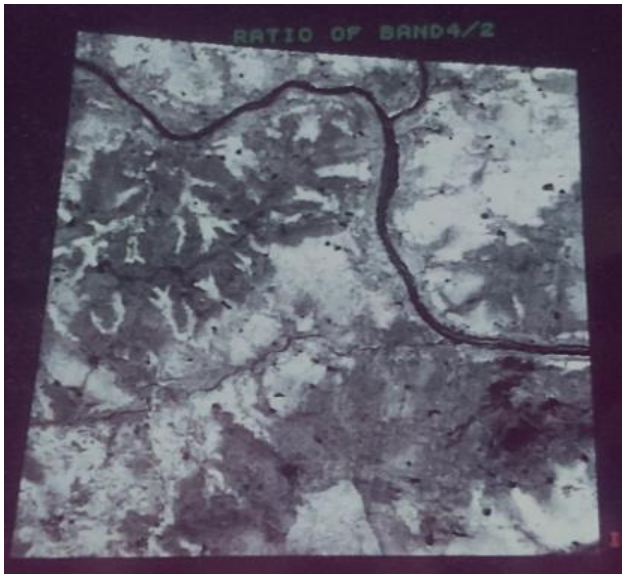


**Figure 6:** Pediplain Occurrence near the Confluence of Jamuniya nadi & Sheonath river as per Band Ratio 4/2

**Figure 7:** Pediplain Occurrence near the Confluence of Jamuniya nadi & Sheonath river as per Field Observation

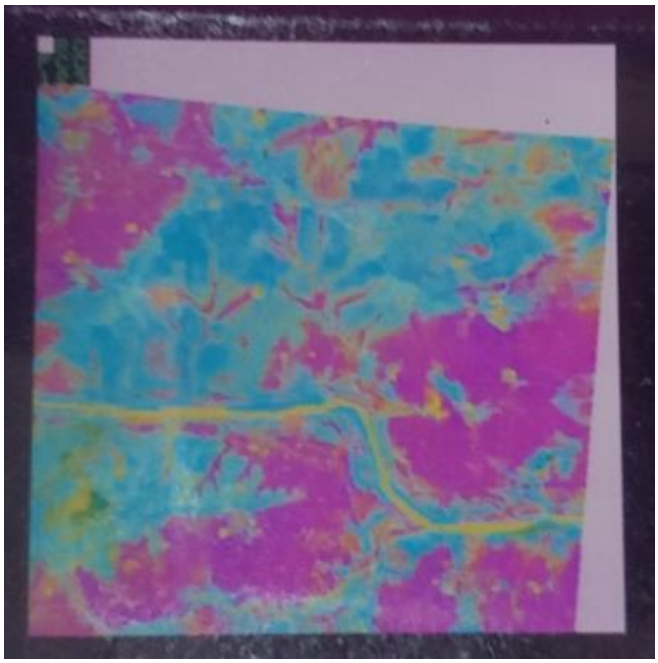

**Figure 8:** Terra rossa near the Confluence of Khorsi nalla and Sheonath River as FCC # 1, 2 &3

**Figure 9:** Terra rossa near the Confluence of Khorsi nalla and Sheonath River as per Field Observation

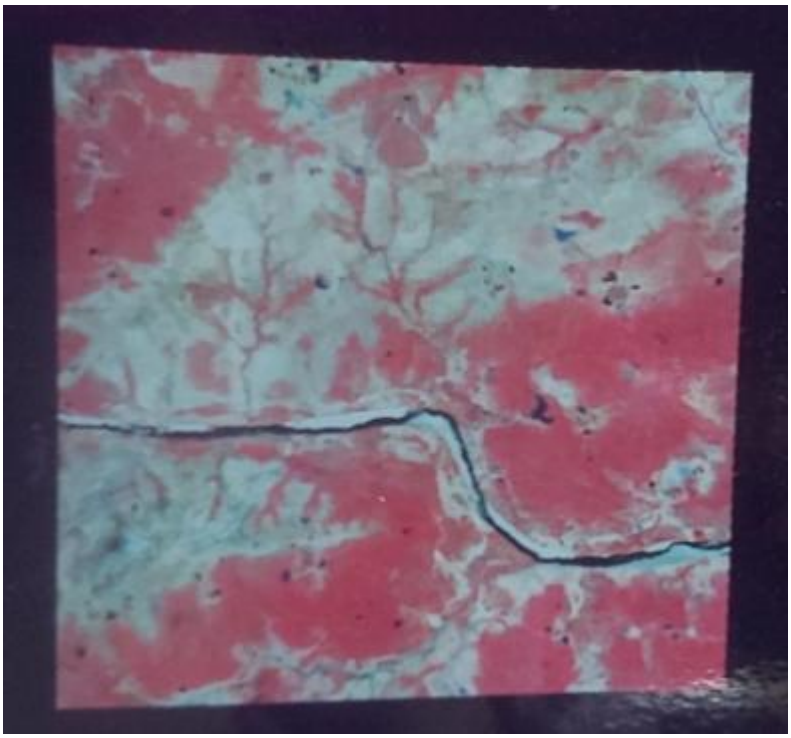

**Figure 10:** Paleo-karst near the Confluence of Khorsi nalla and Sheonath River as per Standard FCC 2, 3 & 4

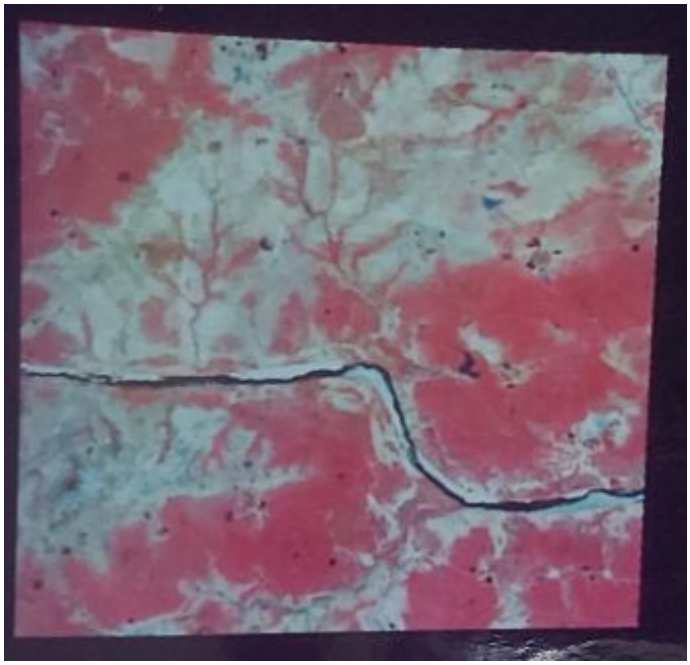

**Figure 11:** Paleo-drainage near North Eastern portion of mining area through Edge Enhancement

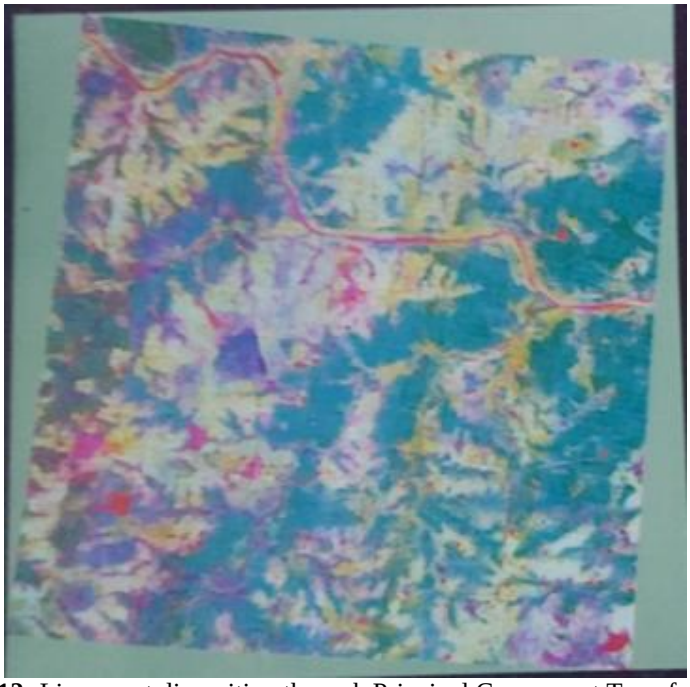

**Figure 12:** Lineament disposition through Principal Component Transformation


**Figure 13:** Old Sinkhole along eastern boundary of mining area through Supervised Classification


**Figure 14:** New Karstic feature [Sink hole] in mining area as on 20 March 2020, as per Google

- Monitoring on pollution aspects of Industrial effluent through Cement plant.[6]
- Utility of evolved methodology with incorporating Carto-sat data for preparation of EIA/EMP for group of small mines.[9]
- Inventory of land-use & water-use at specific time interval [preferably of three years] for quarry watershed through Remote Sensing.
- Karst limestone aquifer is asset for potable water cum renewable resource and to be protected for human welfare, vegetation and ecology along-with optimization of limestone as non-renewable resource.[13]

## 5. Acknowledgement

The authors would like to acknowledge the financial support from Tata Steel, Raipur [SLM/01/1126/92-93] to CMRI [CSIR Lab], now CIMFR Dhanbad [Jharkhand]. The authors thank to authorities of Dr. C V Raman University, Kota, Bilaspur for rendering the necessary assistance. The views expressed in the paper are the views of the authors and do not of the organization, to which they belong.

## References

[1] Adyalkar P G [1984]: Hard rock hydro-geology in Indian Scenario, 71 Session of Indian Science Congress, Ranchi, Presidential address.
[2] Deb P K [2014]: Introduction to mining hydrogeology, Pub. Springer, 54p.
[3] Derik Ford & Paul William [2002]: Karst hydrogeology & geomorphology, Pub. John Willey & Sons, 578p.
[4] Das R K & Devangan V P [2019]: Inspection report for Sonadih Limestone Mine, No. I MCDR, Pub. I B M Nagpur, 8p.
[5] Gautam P K, Narayan A C, Ramesh R, Yadava M G & Panigrahi C P [2014]: Origin and evolution of limestone caves of Chhattisgarh & Orissa, India- role of geomorphic, tectonic & hydro-geological processes, Poster ID, FP 216, 3552, 16 December 2014, 2p.
[6] Gunn John, Bailey D & Handley J [1997]: The reclamation of limestone quarries using landforms-replication, Pub. Department of Environment, Transport regions, London.
[7] Gupta P K, Singh T N, Singh P K, Gupta J P & Dhar B B [1996]: Hydrological study for adequate dewatering system at Sonadih Limestone Mine, Un-pub. Report, Central Mining Research Institute [now CIMFR] Dhanbad, 81p.
[8] Gupta P K & Singh T N [1996]: Documentation of land-use in Karstic mining area through digital analysis of IRS data, Proceeding- Indo-US Symposium/Workshop on Remote Sensing applications, 6-9 October.1996, I I T Bombay, [ed. by M G Srinivas] pp 463-468.
[9] Gupta P K [1998]: Remote sensing methodologies for Indian small scale mining Industry, Pub. Remote Sensing in geosciences, I I T Kanpur, [Ed. By Tripathi N K & Bajpai V N], pp 31-38.
[10] Raj Promoda [2017]: Chhattisgarh ka basin/karst topography, dated 11/12/2017 and 18/04/2019 on Internet.
[11] Saha Shalab [2017]: Mine plan of Sonadih Limestone deposit ML-3, Submitted to D G M, C G Government, 191p.
[12] Singh Yamuna [1985]: Hydrogeology of karstic area around Rewa, Proceeding Karst water Resource, July 1985, IAHS Pub. pp 407-415.
[13] Victor R Baker [1973]: Geomorphology & Hydro-geology of Karst drainage basin & cave channel network in east central New-York, Water Resources Research, Vol. 7, Issue 3, July 1973, pp 695-706.