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Original Research Paper

Estimation of Surface and Groundwater Pollution Due to Mining Activity by Geo-chemical Methods and Re-vegetation Site Selection Using Remote Sensing and GIS Techniques in the Parts of Sandur Schist Belt, South India

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ABSTRACT

Assessment of surface and groundwater quality has been carried out in the parts of the Sandur schist belt, Bellary district, Karnataka, South India. Sandur schist belt is well known for iron ore deposits. Rigorous and unplanned mining methods causes intensive natural hazards like water pollution, air pollution, noise pollution, dust pollution, etc. Water quality of the study area has been studied for sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), chloride (Cl), fluoride (F), sulphate (SO_4), nitrate (NO_3) and total hardness. Results show gradual decrease in groundwater quality and surface water pollution in and around the parts of Sandur Schist belt. Mapping of re-vegetation site selection at regional scales is essential for a wide range of applications including landslide, erosion, land planning, global warming, LU/LC alterations (especially on human activities), effect of climate, natural hazard and socio-economic dynamics in global and local scale. In this study, re-vegetation site selection has been carried out by using remote sensing and Geographic Information System (GIS) in Sandur schist belt in Bellary District. Identification potential sites for replantation within the mining pit is a complicated thing using change detection comparison (pixel by pixel).

INTRODUCTION

The mining activity, which causes damage to environment, needs to be regulated properly so that its effect on environment is minimal. There is lack of proper legislation on mining. However, there is a specific mandatory provision for the industry to prepare and submit to the concerned authority for a suitable environmental impact assessment before the location is chosen for approval.

Environmental Impact Assessment (EIA) is a tool used for decision making regarding developmental projects and programmers, and it may be defined as a formal process used to predict the environmental consequences of any developmental project. EIA, thus, ensures that the potential problems are foreseen and addressed at an early stage in the project planning and design. Growth in population, urbanization and living standards has led to multi-fold increase in demand of water for diverse purposes of irrigation, domestic and industrial uses. Simultaneously, the water quality has been showing continuous deterioration.

Analytical quality control (AQC) is one of the main components of a quality assurance system, wherein the quality of analytical data being generated in any laboratory is controlled through minimizing or controlling errors to achieve target accuracy. A particular water quality study or any organized water quality monitoring programme involves the collection, comparison and interpretation of analytical data, which leads to a decision for the management and use of the water resource. Groundwater and surface water analysis indicate that there is enough scope for groundwater development through suitable abstraction structures. In order to maximize agricultural production and overall improvement of socio-economic conditions of the people, there is a need for optimal utilization of groundwater resource of the study area. Environmental impact due to mining manifest as water pollution, land degradation, loss of biodiversity, air pollution, increase in health related problems, occupational noise pollution, vibrations, land subsidence and land slides. Karnataka is one of the mineral rich states of the country. Of the total area of 1,92,000 sq. km, more than 40,000 sq. km of green stone belts are known to contain vast mineral deposits of gold, silver, platinum, copper, diamond, iron, manganese, chromite limestone, dolomite, etc. At present 20 varieties of major minerals and five varieties of minor minerals are being exploited in the State. Five hundred sixty eight mining leases of major minerals covering an area of 211.47 hectares and 5650 quarry leases covering an area of 4526 hectares have been sanctioned in the State till December 31, 2004.

These environmental problems are often related to LU/LC changes. And available data on LU/LC changes can pro-

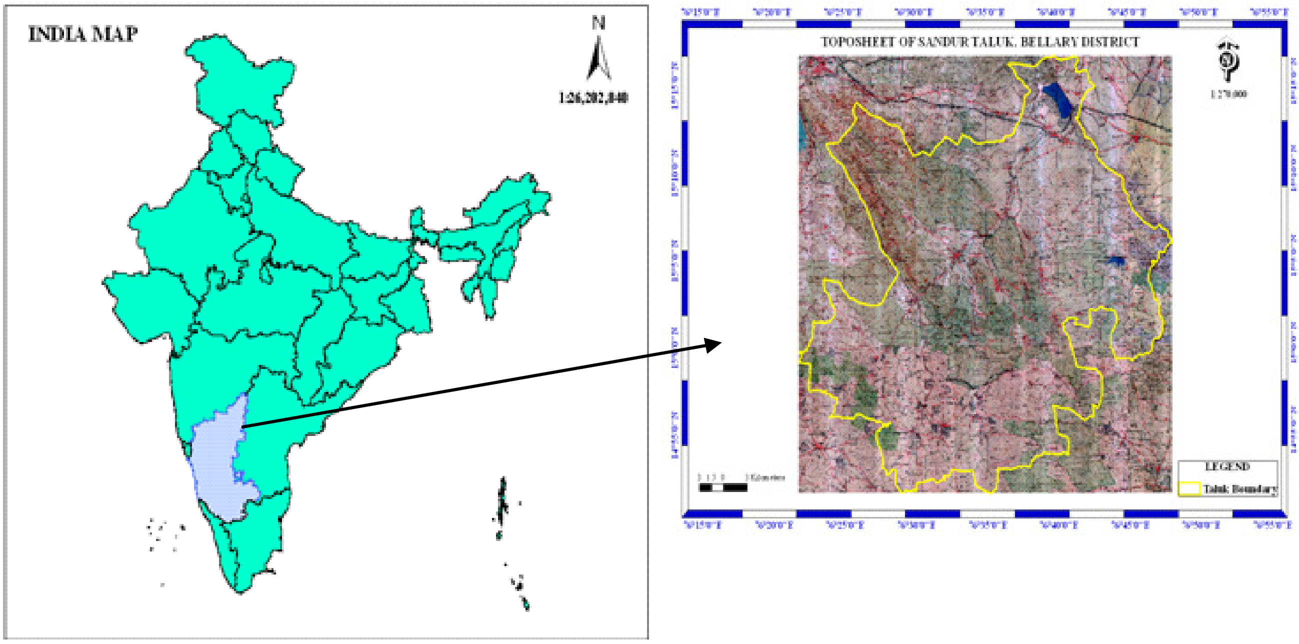


Fig. 1: Sandur schist belt.

vide critical input to decision-making of environmental management and planning of the future (Prenzel et al. 2004). The growing population and increasing socio-economic necessities create a pressure on land use/land cover. This pressure results in unplanned and uncontrolled changes in LU/LC. The LU/LC alterations are generally caused by mismanagement of agricultural, urban, range and forest lands. Deforestation leads to severe environmental problems such as landslides, floods, etc. Remote sensing and Geographical Information Systems (GIS) are powerful tools to derive accurate and timely information on the spatial distribution of land use/land cover changes over large areas (Carlson et al. 1999, Guerschman et al. 2003, Rogana et al. 2004).

Karnataka has a great history of mining activity that dates back to prehistoric times. In 1991 annual production of iron ore was between 2.75-4.5 million tones, and manganese ore between 0.13 -0.3 million tones. Now it has reached up to 150 million tones per annum by means of mechanized methods.

In the natural ecosystems of Sandur schist belt, the Sandur taluk is extremely sensitive to human interference. Open pits, mining dumps and tailing dams cause severe degradation of the environment. Due to the specific climatic and topographic conditions in the environment, nature's self healing capabilities are considerably reduced. As the economy in the area relies to a considerable extent on tourism, human support is needed to minimize the negative effects of mining activities and to speed up the process of mining site re-naturation.

STUDY AREA

The Sandur schist belt is a cone shaped amphitheatre hill formation and covered by dense vegetation and has an area of 960 sq km. The lowest elevation is 625 m above the MSL, and the highest elevation 997 m above the MSL. The belt is bound by geo-coordinates 15°00' to 15°15' N and 76°15' to 77°00' E within the Dharwar craton (Fig. 1).

Geology: Geologically, this area falls under the Dharwar Super Groups of Sandur Schist belt. However, this Schist belt is dominantly mineralized by iron and manganese.

The Sandur schist belt exposes different varieties of granites and gneisses of different ages and tectonic histories. Structural features like faults, folds, synclines and anticlines, and lineaments, etc. in tern indicate the underlying subsurface geometry of rock units and the amount of crustal deformation and stress experienced by delineating the structures and identifying the associated lithology.

MATERIALS AND METHODS

Standard samples: The list of parameters covered under the AQC exercise is as follows: calcium (Ca), chloride (Cl), total hardness (TH), sodium (Na), fluoride (F), sulphate (SO_4), nitrate (NO_3), potassium (K) and magnesium (Mg).

The tests were carried out in the laboratory for charac-

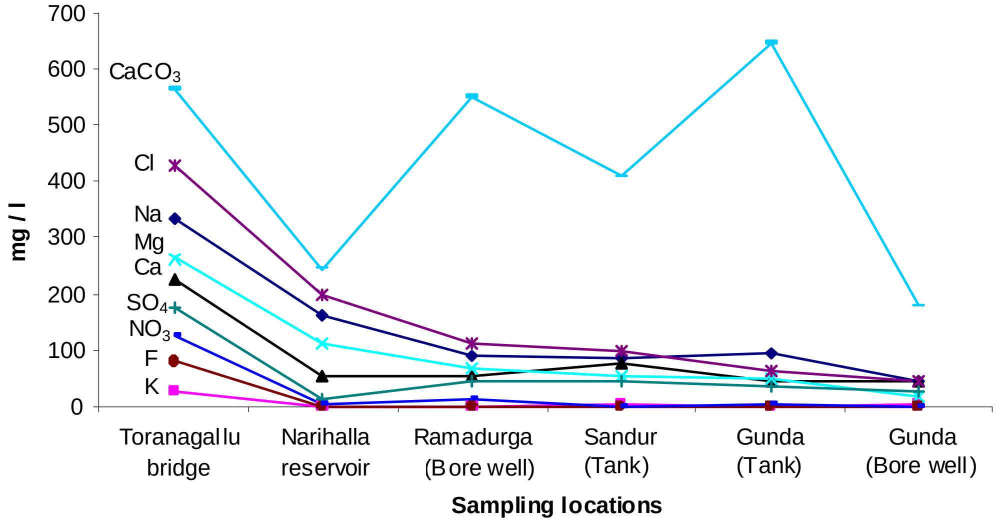


Fig. 2: Variation diagram of Sample location Vs. different parameters for June 2011.

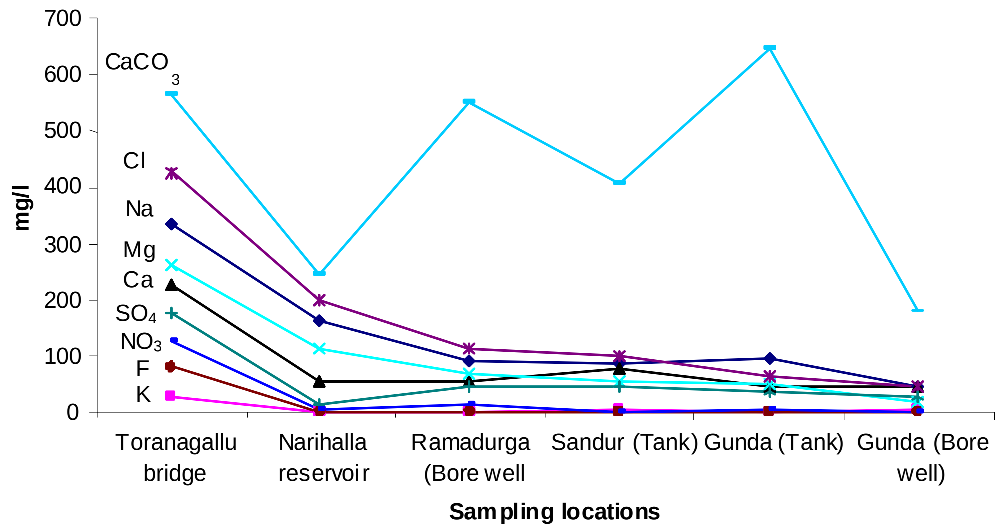


Fig. 3: Variation diagram of Sample location Vs. different parameters for July 2011.

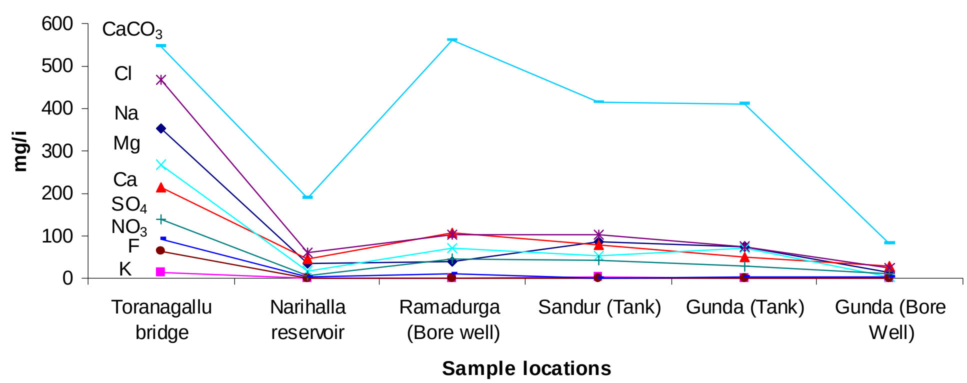


Fig. 4: Variation diagram of sample location Vs. different parameters for August 2011.

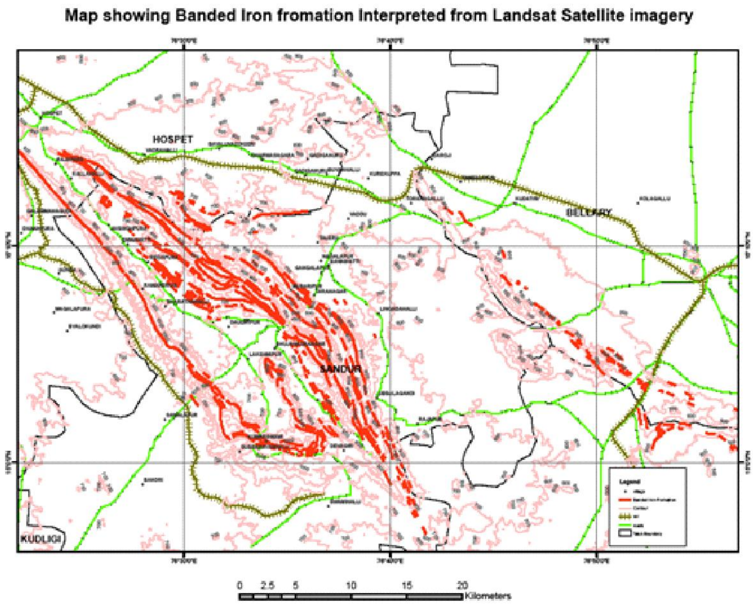


Fig. 5: BIF from Landsat imagery.

Table 1: Analysis data for the month of June 2011.

Sample Location	Sodium (Na)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Chloride (Cl)	Fluoride (F)	Sulphate (SO_4)	Nitrate (NO_3)	Total hardness ($CaCO_3$)
Toranagallu bridge	333	28	226	264	428	80	176	128	566
Narihalla reservoir	162	1.5	56	111	199	0.42	12	2.9	245
Ramadurga (Bore well)	88	0.5	56	67.94	111	0.5	46.5	10.8	552
Sandur (Tank)	85.4	2.6	76.95	52.42	99.97	0.42	43	0.2	408
Gunda (Tank)	92.6	0.9	45.69	48.06	64.06	0.92	34	4.35	650
Gunda (Bore well)	42.6	1.9	43.29	16.98	41.25	0.58	24	0.35	178

Table 2: Analysis data for the month of July 2011.

Sample Location	Sodium (Na)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Chloride (Cl)	Fluoride (F)	Sulphate (SO_4)	Nitrate (NO_3)	Total hardness ($CaCO_3$)
Toranagallu bridge	155.3	0.8	56.91	98.57	343.6	1.1	28.5	11.2	548
Narihalla reservoir	37.3	0.5	44.89	18.43	61.15	0.57	6	1.95	188
Ramadurga (Bore well)	39.4	0.3	107.41	70.86	105.31	0.54	48	10.95	560
Sandur (Tank)	86.8	2.4	78.56	53.38	102.4	0.46	42	0.3	416
Gunda (Tank)	75.3	0.2	48.9	69.91	75.71	0.92	30	4.3	410
Gunda (Bore Well)	12.5	1.4	28.86	2.41	23.29	0.66	9	2.6	82

Table 3: Analysis data for the month of August 2011.

Sample Location	Sodium (Na)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Chloride (Cl)	Fluoride (F)	Sulphate (SO_4)	Nitrate (NO_3)	Total hardness ($CaCO_3$)
Toranagallu bridge	149.6	0.9	54.51	97.59	332.44	1	26.5	10.4	538
Narihalla reservoir	41.3	0.4	46.49	20.86	59.21	0.6	5	1.85	202
Ramadurga (Bore well	40.4	0.5	109.02	71.83	108.22	0.56	50	10.2	568
Sandur (Tank)	87.6	2.6	80.96	53.87	104.83	0.48	40	0.6	424
Gunda (Tank)	76.7	0.1	46.49	69.92	73.77	0.89	28	4.5	404
Gunda (Bore well)	20.6	6.1	39.28	16.01	49.02	0.56	3	0.15	164

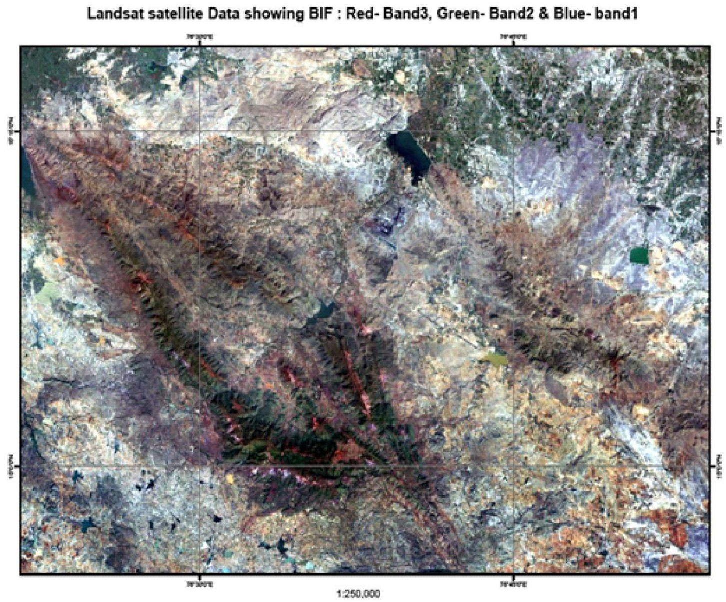
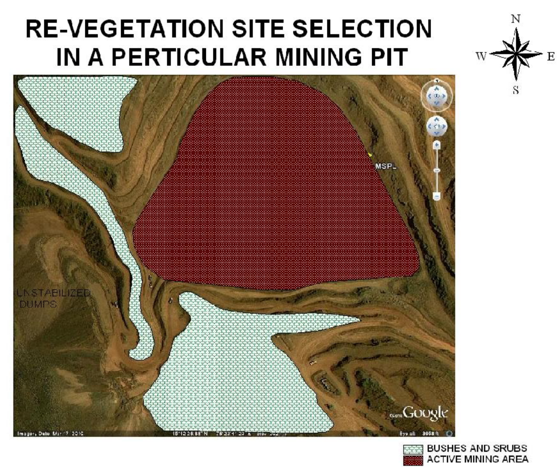


Fig. 6: Landsat imagery showing banded iron formation in different colour combinations.

$15^0$12’32.93”N
$76^0$23’36.66”E

$15^0$12’35.82”E
$76^0$23’50.79”E



$15^0$12’24.13”N
$76^0$23’40.14”E

Fig. 7: Proposed re-vegetation sites.

$15^0$12’26.89”N
$76^0$23’51.81”E

terization of surface waters and groundwater for the month of June, July and August 2011.

Satellite data registration and interpretation: In the second part of the study Landsat TM satellite image and Google Earth 4.5 were used for the study area to interpretation of banded iron formation and re-vegetation site selection. Digital Elevation Model (DEM) was produced from the standard topographic maps with the scale of 1/50,000. DEM was created and re-vegetation site selections have been digitized by using ArcGIS 9.2 GIS software. Slope and elevation maps were generated by using DEM.

It is mandatory to establish controls in dealing with interpretation of satellite digital data. Geo-registration of satellite data was carried out with respect to Survey of India

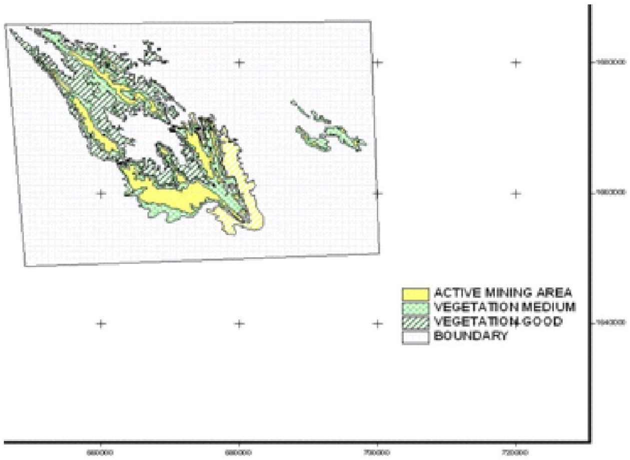


Fig. 8 Re-vegetation site selection map for Sandur Schist belt.

toposheets Nos. 57 A/8, A/12, A/16 and 57 B/9. It was effected through selection of common ground control points (GCP's) on the toposheets and on the image, using nearest neighbour and cubic convolution methods.

RESULTS AND DISCUSSION

Analysis report shows that the total hardness, nitrate, and fluoride contents are high in Narihalla stream and in the parts of Gunda village (Table 1, Fig. 2). The magnesium, nitrate and fluoride contents are high in Narihalla stream and in the parts of Ramandurga village (Table 2, Fig. 3). The total hardness, magnesium, nitrate, fluoride and sodium contents are high in Narihalla, Sandur and Ramandurga villages (Table 3, Fig. 4). The mining activity is continued even below the groundwater table, which is leading to the contamination of groundwater. This is evident from the water quality assessment. The water quality shows continuous deterioration in the parts of Sandur schist belt.

In the second part of the study, deposits of banded iron formation are shown (Figs. 5 and 6). 0.054 sq. km of re-vegetation site has been selected out of 0.8 sq. km of mining area (Fig. 7). Re-vegetation site selection was done using GPS; co-ordinate points have been downloaded and mapped in ArcView 3.2 as shown in Fig. 4. Vegetation status of Sandur schist belt, i.e., good, medium and low is shown in Fig. 5 to support re-naturation.

Brown coloured area is active mining spot (Fig. 7). Green coloured area is re-vegetation site. Within the mining area re-vegetation process is a complicated thing because of absence of top soil, moisture, nutrients and presence of toxic chemicals. In the green coloured buffered area can be planted with bushes and shrubs by providing fertilizers and micro-nutrients. Vegetation is good and medium, and in active mining areas the waste dumping sites and top of the benches are considered to be site for re-vegetation process (Fig. 8).

CONCLUSION

Re-vegetation site selection is complicated in a mining pit because of the absence of top soil and presence of toxic chemicals. In the present investigation, an attempt has been made to evaluate surface and groundwater pollution. Narihalla stream, Ramandurga, Sandur and the parts of Toranagallu are the main affected villages by the mining activity. Water pollution, dust pollution and noise pollution are quite common in these areas. The Narihalla stream is entirely polluted by the mining waste and is not suitable for drinking and agricultural purposes. Majority of the surface water bodies present around the Sandur, Torangallu and Taranagar are contaminated and silted by the mining waste. In any successful re-vegetation program, site assessment and species selection go hand in hand. Species can be chosen for different reasons such as timber production, erosion control or nature conservation. The right plants in the right place for the right purpose with adequate site assessment is necessary.

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