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Environment Impact Assessment of Gypsum Mining in Nagaur District of Rajasthan

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A B S T R A C T

Assessment of environmental impact and sustainable index of gypsum mining activity in Nagaur district of Rajasthan is discussed in this paper. Mining is one of the important activities for the economic growth of a country. It also provides valuable minerals for fulfilling fundamental human needs. Mining is considered as a negative activity from the environment point of view but as it is necessary and cannot be stop. Therefore, a rigorous assessment is required to evaluate the impact of mining on environment. In this case study, the assessment of impact of gypsum mining on the environment were assessed by rapid impact assessment matrix (RIAM). Result of this study revealed both negative and positive effects. Negative impacts were observed on physical, chemical, ecological, biological, sociological and cultural component of environment while positive impact was assessed on economic operational component. The sustainable index of gypsum mining activity in Nagaur district were also assessed and sustainable index was found -0.05 which shows that present mining activities are not sustainable. The present study also suggested that some new guidelines may be introduced to achieve sustainable development goals.

***Key words*:** Gypsum, Mining, Environment, RIAM, Sustainability

Earth is mother of abiotic factor like mineral and biotic factor like animals and plants. Minerals are hidden treasure under the surface of earth while the same surface provide the base for plants to germinate and grow and along with this it gives space for animals to living. Both minerals and living organisms are separated by the surface of earth and majorly both are not inter-related in any manner. Minerals are explored from earth through mining and plants are cultivated on earth by plantation. Both plantation and mining are different activity and not related to each other. However, it is observed that in some of the diverse areas both activities (mining and plantation) are done and therefore, due to their coupled nature through the surface they may have impact on each other. Mining is absolutely a fruitful and necessary activity and have a positive impact on economy and adversely impact on ecology. The mining activity impact negatively on the environment and increase soil, water, air and noise pollution [1]. Interestingly, ecology is being neglected only due to economic benefits by mining activity [2].

Increasing in population and resources are limited, sustainable development is the major goals of the developing countries such as India. Rajasthan is the largest (area wise) state of India situated in northern-western part of country. The state is also leading state in mineral production and all category of minerals like Metallic (copper, zinc, silver etc.), Non-metallic (China clay, gypsum sandstone etc.) and fuel minerals (coal, fuel oil) are available. Rajasthan produces more than 95% gypsum of the India and it also export the gypsum across the world. Gypsum has a chemical composition of $CaSO_4.2H_2O$ and widely used as fertilizer and as construction/building material. Due to the growing population, the requirement of the gypsum in both of the section (farming and construction) is also increasing. To fulfil the demand, gypsum mining is also increased in the same proportion. Currently, in the Rajasthan Bikaner, Barmer, Nagaur and Jaisalmer are major gypsum producing district.

A lot of work has been done separately by geologist, environmentalist, ecologist, botanist, and zoologist on various mining sites and environment. There is still a requirement of combined study of all aspects related to mining and environment simultaneously. In the present study, the assessment of impact of gypsum mining on nearby environment is done with taking some parameters to find out the result. Along with the environment impact assessment of gypsum mining, sustainability index is also determined in the present study. The mining or quarrying impact on the environment is not permanent, it can be mitigated or reverse with highly efforts with proper management by government and at individual level [3]. Result of this study creates a framework for successfully achieving the sustainable development goals in gypsum mining area in future. Various studies are presented in the past which shows the significant role of gypsum in agriculture. However,

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during the processing and mining of the gypsum, the dust of the gypsum is deposited on the surfaces of the soil and propagated through the wind. In this study, the impact of the passive circulation of the gypsum dust is addressed and geographically focused on western Rajasthan especially gypsum mining area of Nagaur district.

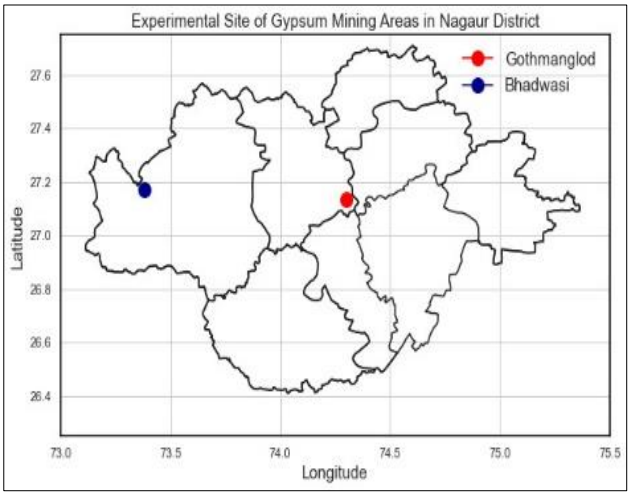

Fig 1 Selected gypsum mining area in Nagaur district for RIAM The maps and spatial data of following are provided by GADM and a python code was used for plotting [4]

MATERIALS AND METHODS

(a) *Environmental scenario*

The study area is situated in Nagaur district situated in central western Rajasthan and shown in (Fig 1). Bhadwasi mining area of Nagaur block and Goth Manglod mining area of Jayal block in Nagaur district is being selected for this study. The location of study area is located between 27° 17 ' 41" N to 27° 21' 19 " N latitude and 73° 38 ' 48.79 " E to 73° 48' 11.50 " E longitude in Nagaur block and 27° 13 ' 22 " N to 27° 14 ' 56 " N latitude and 74° 3'24 "E to 74° 4' 11.8 "E longitude in Jayal block. The complete area is lied in arid zone. A huge variation is seen in temperature of the area in a year. It experiences a maximum temperature of 50°C in summer to minimum temperature of 12°C in winter as shown in Figure 2. No river is found in the study area. near the gypsum mining sites.

(b) *Assessment of mining activity*

Gypsum is mined by open cast mining method. Primary data of gypsum mining and its impact on different factors is record by frequent on-site survey and observation of mining area. secondary data such as mineral reserves in the area, total mineral production and some other data is collected from different reports published by the government (central and state), data published by RSMML, Annual report of mineral department of India, etc.

(c) *Rapid environmental impact assessment (RIAM)*

The gypsum deposited in a very large area and therefore, it is very difficult to assess the impact of mining on each component of environment individually in a limited time. There are many assessment tools and methods are available for environment impact assessment but for this case study, rapid impact assessment matrix (RIAM) proposed by Pastakia and Jenson [5] is selected due to its reliability, transparency, accuracy, easy to use and decision-making tool for assessment in a larger site. The elemental matrix components can be easily obtained and easy to understand. The assessment criteria divided into two group as Group A and Group B. Group A is the criteria for the importance of condition whereas Group B represents value of situation.

Group A further classified in $\alpha 1$ and $\alpha 2$ while Group B is classified in $\beta 1$, $\beta 2$ and $\beta 3$ as in table 1. Environmental score for study area is calculated as follow,

$$\alpha_t = \alpha 1 \times \alpha 2$$
$$\beta_t = \beta 1 + \beta 2 + \beta 3$$
$$ES = \alpha_t \times \beta_t$$

Where, result of multiplication of all group A score is given by α_t, result of summation of all group B score are defined by β_t and finally, Environmental score of the condition is defined by ES. The Environment components are divided in following four categories in RIAM technique. Value of each component is determined by the given criteria in Table 1. The component PC, BE, SC and EO is the Physical/chemical component, Biological/ecological component, sociological/cultural component, and economic/operational component, respectively. For each above component, the value of given criteria is filled up and after completing the matrix, environmental score is resulted as the calculation of matrix.

Table 1 Criteria and description of group A and Group B [4]

Criteria	Scale	Description
$\alpha 1$ Importance of condition	+4	Importance to national or international interests
	+3	Importance to regional or national interests
	+2	important to areas immediately outside the local condition
	+1	only local condition
	0	No importance
$\alpha 2$ Magnitude of effect	+3	Major positive benefit
	+2	significant improvement in status quo
	+1	Improvement in status quo
	0	No change
	-1	Negative change in status quo
	-2	Significant negative change
	-3	Major negative change
$\beta 1$Permanence	+1	No change
	+2	Temporary
	+3	Permanent
$\beta 2$Reversibility	+1	No change
	+2	Reversible
	+3	Irreversible
$\beta 3$Cumulative	+1	No change
	+2	Non-cumulative
	+3	Cumulative

Environmental score between +72 to 108 is considered in +E range band and major positive impact. Significant positive is between +36 to +71 with range band +D and moderately positive is between +19 to +35 with range band +C. positive and slightly positive impact is +10 to +18 with range band +B and +1 to +9 with range band +A respectively. ES=0 indicates no change. ES between -1 to -9 is considered as slightly negative impact with range band -A. ES= -10 to -18 with range band -B and ES= -19 to -35 with range band -C is considered as negative impact and moderately negative impact respectively. ES= -36 to -71 with range band -D and ES= -72 to -108 with range band -E is considered as significant negative impact and major negative impact respectively.

(d) *Determination of sustainability index*

By using RIAM, environmental score can be known after calculating the matrix. For knowing the sustainability index for selected study area, Sustainable development model [6] is

selected for determining the sustainability index of the selected area. According to this model-

$$SI = ES - H_n$$

Where, SI is sustainability index, ES is environmental score and H_n is human needs. The optimal value of SI ranging from 0 to 1 the sustainability and can be summarized in (Table 3).

Table 3 Vale of SI indicating sustainability

Value of SI	Sustainability
SI is less than 0	Not sustainable
SI = 0.001 to 0.25	Very weak
SI = 0.251 to 0.50	Weak
SI = 0.501 to 0.75	Strong

In RIAM, the total environmental score is negative after putting the original values. The sustainable development model makes an erroneous result when using negative total environmental score. For removing this error, relative environmental score is calculated with adding 108 to each component's environmental score. Hence the capacity for each component is 216 so the relative environmental score is between 0 to 216, Environmental score (E) and human needs (H_n) is calculated by following formulas:

$$E = \frac{\sum PC + \sum BE}{PC_{max} + BE_{max}}$$

$$H_n = \frac{(SC_{max} - \sum SC) + (EO_{max} - \sum EO)}{SC_{max} + EO_{max}}$$

Where, PC, BE, SC and EO are the relative environmental score for Physical/Chemical, Biological/Environmental, Sociological/ Cultural and Economical/ Operational, respectively. PC_{max} is the maximum capacity of Physical/Chemical component, EO_{max} is the capacity of the economic component, BE_{max} is capacity of Biological/Ecological component and SC_{max} is capacity of sociological/ Cultural component.

RESULTS AND DISCUSSION

Nagaur district contributes a major part in gypsum production at national level. Gypsum is mined in only two blocks Nagaur and Jayal. Total 16 mining sites with an area of 2660 hectare are permitted by government. Out of 16, Two mining sites are operating by RSMML and remaining 14 mining sites are in private sector. Out of 16 mining sites, 8 are situated in Jayal block's kherat and Manglod villages while remaining 8 mining sites are situated in Nagaur block's Golsar, Makori, Jeevanbera, Bhadwasi and Ganthilasr villages. Gypsum is found in sedimentary formations in all site exceptionally in Goth manglod site, it is found as transparent crystal associated with clays [6]. Government assesses the estimated value of gypsum production per year and production per mining site and record the data as for economic purpose. this economic activity impacts each component of environment directly or indirectly. This study is attempting to assess the environment impact in these mining areas. the result of this study is discussed in this section.

Physical / chemical

Gypsum mining has some direct and indirect impacts on physiochemical properties of surrounding area. the intensity of impact depends on the rate of mining and distance from the mining site. Soil properties is changed due to the spreading of gypsum particles near mining site. Gypsum impact in soil property not only for a short term but also it changes soil properties for a long term after gypsum application on land. It changes the pH of soil, increase exchangeable Sulphur and calcium while decrease in exchangeable aluminium and magnesium in soil [7].

Gypsum powder and gypsum particles reach to the open water sources and storage during the gypsum mining. It changes the chemical composition of water. While close water resources and water supply system is not affected due to pipelines. Rainy water is main sources for agriculture so it is considered that gypsum mix up with rainy water and reach to the agriculture land. Increasing in waste dumps in mining areas is very normal but waste dumps in gypsum mining area is very less than other minerals mining sites. A large amount of gypsum particles is being released in surroundings of mining area. The released gypsum dust by mining area changed the air quality of surrounding and increase the air pollution. Along with this, gypsum crushing machines and transport vehicles also release pollutants and disturb the air quality [8].

An increase in traffic activities related to mining and mineral transportation, heavy machinery uses in mining activities increase noise level and resulted as noise pollution. Gypsum mining is an open cast mining but during the mining activities, land characteristics is disturbed and it lost its natural value as shown in (Fig 2b). During the mining, land cannot use in other purpose and postmining area of gypsum can be used very well with a proper management and completely following the guidelines of reclaim the land.

Biological / ecological

Mining is considered as a harmful activity for nature and plant but on the other hand gypsum has a good effect on plant growth. Gypsum conserve water by sealing the soil surface and stop entering the oxygen under surface. In this case study, gypsum mining has good impact on surrounding plants while it has an adverse effect on the animal life. Overall effect of gypsum mining on nearby biodiversity is negative. It totally destroyed the habitation for animals. Many reptiles, birds and mammalians are live in this area more than aquatic animals. mostly animal migrant from nearby areas due to very much human interruption and lose of habitant during mining activity. Only human immigration is noticed in these areas for their livelihood and job work. The food chain and food web impact by emigration of local animals directly or indirectly impact regional ecosystem and biodiversity [9].

Sociological / cultural

Social health is also impacted badly in gypsum mining and nearby areas. Gypsum dust and other particles is produced during gypsum mining changed the air quality and climate as shown in (Fig 2a). This gypsum particle and bad air quality directly creates respiratory related problems for peoples engaged in this work. Gypsum dust create skin related disease, and people who used drinking water from open water sources also suffers from stomach related diseases. Living conditions near mining sites are not too good to survive. There are many hurdles for daily life faced by labours and people. Uses of heavy machinery and vehicles for transportation of materials and workers is a part of these sites but accidents are major risk in these areas.

Dust particles and dumps are common things found in mining sites and there is no proper manner or work plan for sanitation it also influences the drainage system sometimes. immigration of other community from different parts of the country, the community structure can be mix up or conflict, it impacts the local social structure and due to lack of a common platform and other problems, it's very difficult to follow regional customs and tradition and culture. The government and companies provide better facilities and education for local children for improving education level for bring them in main

stream. Children and people involve in mining and other activities for earning money and not complete their education due to their self-reliance or responsibility or family problems. Apart from this, government and other NGO also organize social welfare and social awareness programmes and it is very beneficial for local public [10].

Table 2 Data matrix for relative environment score by RIAM

S. No.	Environmental components Physical/Chemical	Criteria for group A		Criteria for group B			ES	RV	Relative environment score
		α1	α2	β1	β2	β3			
1	Soil quality	1	2	2	2	3	14	+B	122
2	Water quality (open sources)	2	-3	3	3	3	-54	-D	54
3	Water quality (close sources)	2	0	1	1	1	6	+A	114
4	Climate	2	-1	2	3	3	-16	-B	92
5	Air quality	2	-3	2	3	3	-48	-D	60
6	Waste dumps	2	-2	2	2	3	-28	-C	80
7	Land characteristics	3	-2	2	2	2	-36	-D	72
8	Land use	1	-3	2	2	2	-18	-B	90
9	Noise level	3	-2	2	2	3	-42	-D	66
10	Aesthetic	3	-3	3	3	1	-54	-D	54
	Biological / ecological								ΣPC=764
1	Plant life	1	1	2	3	2	7	+A	115
2	Animal life	2	-3	2	2	2	-36	-D	72
3	Biodiversity	2	-3	3	3	3	-54	-D	54
4	Crop productivity	3	-1	1	1	1	-9	-A	99
5	Habitation	1	-3	2	2	2	-18	-B	90
6	Migration	2	-3	3	3	2	-48	-D	60
7	Environmental risks	2	-3	2	3	3	-48	-D	60
8	Ecosystem Scenario	1	-3	2	2	2	-18	-B	90
	Sociological / cultural								ΣBE= 640
1	Living condition	1	-2	3	3	3	-18	-B	90
2	Social health	2	-2	3	3	3	-36	-D	72
3	Accidents	2	-1	1	1	2	-8	-A	100
4	Sanitation	2	-2	2	2	2	-24	-C	84
5	Social welfare	2	2	3	1	1	20	+C	128
6	Social awareness	3	2	1	1	1	18	+B	126
7	Social security	2	-1	1	1	1	-6	-A	102
8	Traditions and customs	3	-1	1	1	1	-9	-A	99
9	Education	3	1	3	3	3	27	+C	135
	Economic / operational								ΣSC= 936
1	Investment	3	3	2	2	2	54	+D	162
2	Employment	3	3	2	2	2	54	+D	162
3	Income per capita	3	3	2	2	2	54	+D	162
4	Mineral value	4	3	3	2	2	84	+E	192
5	Land value	3	-2	3	3	2	-48	-D	60
6	Transportation	3	2	2	2	2	36	+D	144
7	Industry development	3	3	2	2	2	54	+D	162
8	Infrastructure development	2	3	3	3	2	48	+D	156
									ΣEO = 1200

(a)

(b)

Fig 2 (a) Gypsum dust production by gypsum industry in Nagaur and (b) Open cast mining of gypsum

Economic / operational

The main aim of mining to fulfil the human needs and economic growth. This activity generates the employment at many levels. people directly get jobs in mining sector at different posts, some workers also immigrant from different part of country for different work. Apert from this, local public involve directly or indirectly to find jobs and get opportunity to start some other business. With an increase in employment ratio, per capita income of the regional level also increased [11].

Gypsum is very useful as fertiliser and building material, Nagaur and Bikaner produce quality level gypsum and export it to across the world and this mineral has its value at international level. Transport means have very important role, only two means of transportation is developed here because this is landlock area so water transportation is not available here. Railway station in Bhadwasi and Nagaur are main stations on rail route. Bhadwasi station is specially developed for transportation of gypsum. National highways and other transportation mean like tractor and trucks are mostly used for transportation of gypsum by road. Goth manglod temple and such many other temples and tourist places are impacted indirectly in very minor manner [12].

Infrastructure and industrial development is core for any areas development. Government and companies developed roads, transport means, water facilities, buildings, power supply education health and other facilities, near mining areas. Many gypsum industries have established here for making fertilizer and plaster of paris sheets (POP). Government acquires the land for mining purpose and the remaining land is not useful for residential purpose due to some safety reasons, land value falls down**.**

After fulfilling all data in (Table 2) by following the values described in (Table 1). The summation of the relative environment value and capacity for all component is resulted as below:

ΣPC – 764	PC_{max} – 2160
ΣBE – 640	BE_{max}– 1728
ΣSC – 936	SC_{max}- 1944
ΣEO – 1200	EO_{max} – 1728

Environment (E) and human needs (H_n) is calculated as below:

$$E = \frac{\sum PC + \sum BC}{PC_{max} + \text{BEmax}} = 0.36$$

$$H_n = \frac{(SC_{max} - \sum SC) + (EO_{max} - \sum EO)}{SC_{max} + EO_{max}} = 0.41$$

Hence the result after calculation of environment (E) is 0.36 and human needs (H_n) is 0.41 shows that human needs are more than environment in the study area.

Sustainability index of gypsum mining

The objective of this study to calculate the sustainability index in a mathematical procedure for selected study area for gypsum mining. Environmental score and human needs is calculated based on RIAM. The sustainability index is calculated as following -

$$SI = E - H_n = 0.36 - 0.41$$

$$SI = -0.05$$

This negative sustainability index shows that Human needs are more than environment. The value of SI = -0.05 also indicates unsustainability in gypsum mining area in Nagaur district.

CONCLUSION

This study is an attempt to assess the environmental impact in gypsum mining area in Nagaur district in western Rajasthan. Nagaur district produce good quality gypsum and supply it across the world. Environmental impact assessment is required to know the impact of gypsum mining on various factors. RIAM is used to calculate the environmental score for each component and the result reveals that the sustainable development index is -0.05 which indicates unsustainability in gypsum mining activities. The government prepare a guideline before starting mining at gypsum mining sites but this study concluded that the mining and other related activities are not doing in proper manner and following the guidelines. It is noted that physical/chemical, social/cultural and biological/ecological aspects are neglecting only for economic benefits. The mining activities should be well managed and eco-friendly. A framework is still needed to focus on other facts like training for labours, mitigate unnecessary use of transportation, development of social bonding in local public and other postmining activities for better use of land. A balance is much required between Human needs and environment to get the strong sustainability index for achieving the sustainable development goals and a healthy environment.

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