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Occupational Hazards and Environmental Consequences of Sandstone Mining: A Case Study from Soorsagar, Jodhpur, Rajasthan

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ABSTRACT

Mining plays a crucial role in the economic growth and supports national development. However, it also raises significant concerns due to its environmental impact and health risks, particularly in the nearby areas. In India's sandstone mines, both mechanical and manual methods are employed. Mining operations rely heavily on equipment such as trucks, dumpers, compressors, drills for blasting, and cranes for lifting heavy blocks. These activities generate large amounts of dust containing high levels of silica, which poses severe health risks. Prolonged inhalation of silica dust can lead to silicosis, a preventable but serious disease characterized by dyspnoea (shortness of breath) and persistent cough, and is sometimes associated with lung cancer and tuberculosis. Silicosis is one of the most common occupational diseases globally and has a significant impact on workers' health in developing countries like India. The use of heavy machinery and vehicles also creates high levels of noise and vibration in the surrounding. Prolonged exposure to noise can result in occupational hearing loss due to neurosensory deafness. Additionally, continuous exposure to whole-body vibrations leads to degenerative spinal conditions, including chronic back pain. Although stone quarrying near Soorsagar, Jodhpur, contributes to both the rural and national economies, its environmental consequences are considerable. Unplanned and haphazard quarrying has resulted in environmental degradation, and unauthorized mining activities have further worsened the local ecological balance.

Keywords: Sandstone quarrying, Environmental Pollution, Occupational Health Hazard, Silicosis, Dust pollution, Noise pollution

Introduction

In today's world, in most countries, mining involves initial mineral exploration, mineral extraction, and processing, including the extracted material's crushing, grinding, and washing. Exploration, mine development, mine operation, decommissioning, and land rehabilitation comprise a mine area's life cycle. Mining is a multidisciplinary sector that utilizes a variety of trades and professions. Because the term "miner" is somewhat ambiguous, it is crucial to ascertain the specifics of mining tasks in order to guarantee accuracy in clinical and epidemiological studies.

One of the most common types of sedimentary rocks, sandstone is found in sedimentary basins all over the world [1]. The aerial extent of sandstone deposits in India is about 1.79 million sq. km [2]. Sandstone rocks are made up of varying percentages of 'so-called' framework grains, comprising of minerals, rock fragments, organic compounds, with cement and matrix in the interstitial spaces between them. Quartz is by far the most common framework grain for siliciclastic sandstones, along with feldspar. The most prevalent mineral on Earth's surface is quartz, which comes in a variety of hues including white, grey, purple, yellow, brown, black, pink, green, and red. Sandstone with predominant quartz grains is considered a texturally mature rock, compared to feldspar-dominated sandstone [1]. The Indian states of Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Madhya Pradesh, Meghalaya, Mizoram, Karnataka, Odisha, Punjab, Rajasthan, Uttar Pradesh, Tamil Nadu, and West Bengal are among those where sandstone occurs. Rajasthan produces about 90 % of the total sandstone extracted from India. The sandstone mines of Rajasthan are spread over the districts of Bharatpur, Dholpur, Kota, Sawai-Madhopur, Karauli, Bundi, Jhalawar, Chittorgarh, Jodhpur, Bikaner, Nagaur and Jaisalmer. Due to rapidly growing infrastructural development, the importance of mining is also increasing, especially to meet the demand for metals, minerals and building stones. Sandstone is one of the most important building materials. Roofing, flooring, pavement, paneling, beams, pillars, arches, door and window sills, wall-facings, fence posts, milestones, and many other applications are among the various uses for it. As a building stone, sandstone is acid resistant, alkali resistant as well as thermally resistant. On sandstone, the impact of salty winds is minimal and sandstone is appropriate for carving and making windows and decorative and ventilatory friezes (jallis). So sandstone is useful for covering the exterior of coastal buildings. It is also suitable for flooring, wall fixing & lining in chemical industries due to its acid and alkali resistant properties. Humans have used sandstone as building material for centuries. Therefore, many historical structures and monuments are composed of sandstone like the Buddhist Stupas of Sarnath, Red Fort, Sansad Bhawan, Rashtrapati Bhawan, the National Museum, Chhitar Palace, Jodhpur, etc. [3].

Mining has consistently been one of the riskiest professions [4]. The hazards and hazardous working conditions in mines were brought to light by the Second National Commission on Labor. Workers in mines face significant health hazards that shorten their lives. Due to inadequate protection and care, both on and off site, the miners get affected by the biggest health threats like silicosis, pneumoconiosis and tuberculosis [5]. A large amount of fine dust is generated due to quarrying and crushing of stones. This fine particulate matter contains free silica in the range of 20 to 70% [6]. Breathing in fine crystalline silica dust can cause cancer, bronchitis or

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silicosis. As the silica dust enters in the lungs, annoying them ceaselessly, lung capacities will reduce [7, 8]. Apart from silicosis, accidents are frequent in mine areas, especially when miners work without any safety gear. Sometimes workers lose their limbs due to these accidents. In India, 20% of on-site deaths take place due to falling objects [9]. Apart from these, noise and vibration are created due to heavy machinery, blasting, transport vehicles, hammering and chiseling; these are also very hazardous for the mine worker. Mining is one of the most common jobs in India, despite being a dangerous one. Mining employs a sizable portion of the labor force and will continue to expand in the future [4, 10].

Social well-being and economic development of any modern society depend on the mineral resources of that society or nation [11]. The importance of mining has been advanced greatly due to the rapidly rising need for all types of minerals and metals. As a result, global mining industries have been booming since the early 20th Century and these industries not only produce jobs at national, state and regional levels but also increase the earning of tax revenues and foreign currency for the nation [12]. However, mining has detrimental effects on society and the environment. The majority of the detrimental impacts of mining operations have a significant impact on the nearby communities that reside near the mining sites [12-15]. Mining has been practiced across the world and is not confined within a single country [16-18]. Additionally, mining has developed best practices to lessen related problems. Conflicts between developmental works of any nation and environmental degradation of that nation are the obvious outcome due to any unplanned and haphazard human involvement in the ecological sphere. Moreover, though mining may be fulfilling the necessity of resources and thus contributing in the direction of the regional economy, the unverifiable practice of mining deeply affects the local environment. Examples of these human involvements are the rigorous agriculture, industrialization, extension of roadways as well as railways, construction of dams etc. that accompany development. An essential component of the growth of the human socioeconomic system is mining. Excavation of minerals, stones and coal have yielded a footing for local economy across the globe. Local bodies are engaged in the extraction procedure almost everywhere. The social web of a region experiences unexpected changes due to mining [19]. Above Around 20 million people worldwide rely on the unregulated mining of mineral resources as their primary source of income, which is much more in terms of numbers than workers employed in formal mining industries [20]. A considerable portion of Indian rural households to subsist, these non-farm occupations as their primary source of income [21]. Among the mining workers and their families, a few significant social problems are found, such as illiteracy, child marriage, child labor, and loneliness etc.

Geological background

The End-Proterozoic geological events in the north-western submerged continental shelf of Indian plate is represented by the Marwar basin [22, 23]. The Marwar Supergroup, also known as the Trans-Aravalli Vindhyans, overlies Malani Rhyolites of Neoproterozoic age [24-26]. The more or less horizontal, unmetamorphosed and undeformed Marwar Supergroup is subdivided into the Jodhpur Group, Bilara Group and Nagaur Group in order of superposition [27, 28]. Three formations namely the Pokaran Boulder Bed at the bottom, the Sonia Sandstone at the middle and the Girbhakar Sandstone, at the top, make up the Jodhpur Group [28-30] (Table 1: Stratigraphic Succession, Fig. 1). Around 60 m thick, undeformed, unmetamorphosed, arenaceous Sonia Sandstone Formation commonly overlies the acid volcanic rocks of the Malani Rhyolite and the argillaceous sedimentary strata of the Girbakhar Formation are uncomfortably layered atop it [28].

Table 1: Generalized Stratigraphic Succession of the Marwar Supergroup (after [28, 31])

Age	Supergroup	Group	Formation	Lithology
Permo-Carb.	Bap Boulder Bed			Subrounded, ellipsoidal cobbles and pebbles
——— Unconformity ———				
Ediacaran to Middle Cambrian	Marwar Supergroup	Nagaur Group (75 – 500 m)	Tunklian Sandstone	Brick red sandstone, siltstone & red claystone
			Nagaur Sandstone	Brick red sandstone, siltstone & red and green clay beds
		Bilara Group (100 – 300 m)	Pondlo Dolomite	Cherty dolomitic limestone
			Gotan Limestone	Interbedded dolomite & limestone
			Dhanapa Dolomite	Dolomitic limestone with cherty lenses, sandstone with cherty lenses
		Jodhpur Group (125 – 240 m)	Girbhakar Sandstone	Brick-red sandstone, siltstone and shale, pebbly to gritty near top
			Sonia Sandstone	Maroon siltstone and shale, cream sandstone with sedimentary structures. Banded chert-jasper, subordinate dolomite and sandstone
			Pokaran Boulder Bed	Sub-rounded, ellipsoidal cobbles, pebbles and sandstone
——— Unconformity ———				
779 – 681 Ma	Malani Igneous Suite			

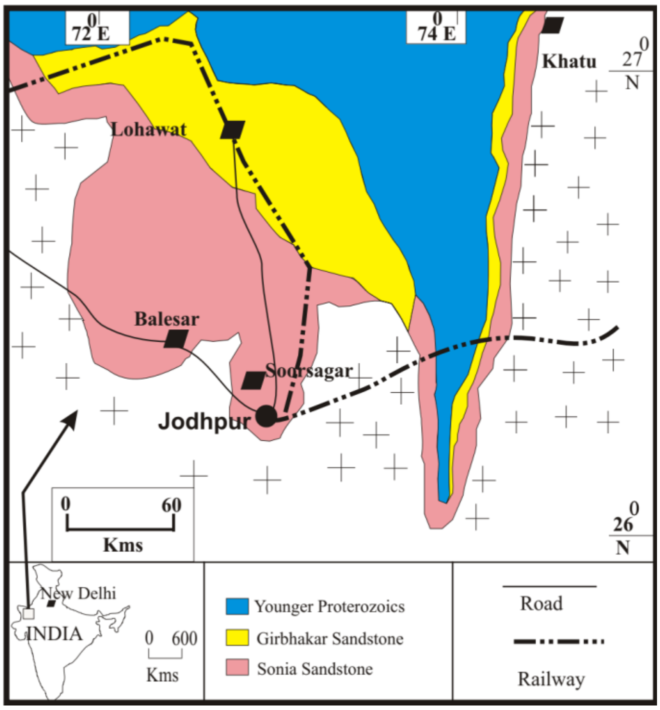

Fig. 1: Location and geological context of the research area: an outcrop map illustrating the spread of the several formations that make up the Marwar Supergroup (after [32]).

Combining the Sonia Sandstone and Girbhakar Sandstone, as per Pareek [28], into the Jodhpur Sandstone, Chauhan et al. [31] subdivided the Jodhpur Group into the Pokaran Boulder Bed and Jodhpur Sandstone Formation. The lowermost Pokaran Boulder Bed Formation of the Jodhpur Group is developed in the Northern part of the basin, is about 4 m thick, and is followed by the Jodhpur Sandstone Formation. Exposed in an elongated area, the Marwar Supergroup is bounded by basin-margin fault systems trending roughly NNW–SSE and N–S [32]. Sag basins or intracratonic rifts are the places where the Marwar Supergroup was deposited [22, 32].

This present paper deals with the sandstone mining from the deposits within the shallow marine interval of the Marwar Supergroup's unmetamorphosed and undeformed Sonia Sandstone Formation, that are exposed ~7 km north-west from Jodhpur town, Rajasthan, India [27, 31] (Fig. 1).

Discussion

Humanity started mining and quarrying from the 'Stone Age', before they started to use fire. Humans were used to use rocks and stone for hunting animals for their food. Even in this era, the necessity of obtaining materials like stone, metals and ceramics has been increasing with time due to tremendous population growth. As a result, the mining and quarrying sectors are growing tremendously, in terms of extents of mining areas and intensity of this activity, for the past few years. In terms of quality and quantity, India has an abundance of minerals and rocks available across the country. At present, India produces 27% of the total stone of the World. One of the major sandstone production centres and a craftsmanship centre in India is Jodhpur, Rajasthan. According to the Indian Bureau of Mines [33], Rajasthan used to produce about 90 % of the sandstone of India. Considering the favorable color and texture of the sandstone, Jodhpur produces a vast variety of sandstone. Sandstone from Rajasthan has been widely used because of its high quality, which includes regular bedding, consistent grain size, acceptable character, and durability (Fig. 2). It is even exported, to Canada, Japan and the Middle Eastern countries [34].

Fig. 2: Use of Sandstone as building materials – from quarried raw material i.e., slabs of sandstone (left side) to finished building of sandstone (right side).

Jodhpur city is situated in the eastern margin of the 'Thar Desert' in Rajasthan. As per the available literature, the sandstone quarrying in the region started sometime in 16th century. Most of the historical buildings of the city, the Jodhpur Palace, the Meharangarh Fort and Royal Tombs at Mandore Garden are made up of this sandstone. The sandstone mining activity lies very close to Jodhpur city within a distance of 8–10 km in the north [35]. Two and half million people are employed in and around the 30,000 mines present in Rajasthan. Out of these 30,000, 1300 are sandstone mines engaging around 71,000 workers [34]. These approximately 71,000 sandstone workers in the mines do a variety of tasks, including as drilling, blasting, breaking down larger stones into smaller ones and loading & unloading of slabs from trucks. These tasks expose mine employees to high concentrations of silica dust for extended periods of time [36] (Fig. 3). The Jodhpur district in Rajasthan is composed of several geological elements such as sandstone, limestone, granite, rhyolite, schist, phyllite, and slate [37]. One of the main hubs for the quarrying and artisanal production of sandstone in India is Jodhpur, where miners extract a diverse range of sandstone types in terms of color and texture. Jodhpur and the surrounding areas have seen a rise in the number of sandstone quarrying and processing operations as a result of a boost in exports over the past 20 years. Currently, one of the most significant economic sectors in Jodhpur is the quarrying and processing of sandstone [35]. The largest industry of Jodhpur district is the sandstone quarrying. Government earns about 12 crores annually through taxes [35]. Among the large numbers of quarries in the area, the major ones include Fedusar, Keru, Soduki Dhani, Pabu Magra, Barli, Chaina ka Bariya, Brahmno ka Tanka, Mandore, Kali Beri, Ghora Ghati, Balsamand, Old Fort, Magji ki Ghati, Palri and Soorsagar. Among these mining areas, Keru, Fedusar, Soorsagar and Mandore are the biggest blocks and are extensively quarried [35].

There are 2.5 million workers engaged in mining in Rajasthan [38]. Unfortunately, most of these mines are from an unorganized economic sector [36]. Workers in the majority of the unorganized sector face dangers to their bodily and mental health due to their line of work [39] and carries an increased risk of exposure to harmful chemicals [40].

Fig. 3: Silica dust generated due to different types of mining activities. This dust reduces the lung's ability to function by causing silicosis, or the fibrosis of lung tissues.

Silicosis is a lung ailment that is commonly encountered by miners and employees in related industrial and construction sectors. This avoidable sickness is brought on by breathing in silica-containing dust that is produced during various mining operations. There are two types of silica: amorphous and crystalline. Crystalline silica is more harmful than the amorphous silica. Polymorphs of crystalline silica include tridymite, cristobalite, and quartz. The crust of the Earth is covered with an abundance of silica, composed mainly of quartz [41]. Crystalline silica emits free silica into the mine area during various mining operations, such as drilling, cutting, and crushing of rocks. Workers in mines breathe in and deposit silica dust particles, which results in chronic inflammation and the development of granulomas. Additionally, silica dusts induce lung tissue fibrosis, which lowers the lungs' ability to function [41-43]. In addition to this, mine workers who are exposed to crystalline silica dust may develop silicosis, pulmonary TB, and chronic obstructive pulmonary disease (COPD) [44]. Based on the duration of silica exposure and radiological results, three types of silicosis can be distinguished: accelerated, chronic, and acute [45]. Because silicosis is linked to a number of illnesses, including lung cancer and tuberculosis, it increases occupational morbidity and death [46].

Mechanized operations like drilling, crushing, screening, blasting, and so forth cause noise levels to be far higher than the suggested noise threshold of 90 dB(A). Consequently, neurosensory deafness causes occupational hearing loss in mine workers exposed to high noise levels. There have been reports of noise levels during drilling reaching 115–122 dB or higher (Fig. 4). Extremely high noise levels and explosive blasts have the potential to rupture the tympanic membrane, impairing hearing at all frequencies and perhaps causing hemorrhaging into the middle or inner ear.

Fig. 4: Due to automated procedures including drilling, crushing, screening and blasting, etc., noise level is much higher than the recommended limit. Moreover, Workers who use pneumatic tools like drills can get vibration illnesses.

To save time, heavy earth moving machines have been introduced in the mining operation in the Soorsagar quarry, Jodhpur (Fig. 4). Consequently, there is now a greater risk of whole body vibrations for operators. Chronic whole-body vibration exposure leading to degenerative spinal diseases, including back pain. After a few months to several years, pneumatic instruments like drills cause vibration disorders in workers. The most prevalent vibration disorder is Raynaud's phenomenon i.e., vasospasm, which is characterized by the spasmodic contraction of finger blood vessels that briefly causes the fingers to turn white and numb.

Nearly all human activities have an adverse effect on the ecosystem, ecology, and terrain. But due to the mining activities, local environments are degraded due to stripping of topsoil, destruction of the vegetation, altering soil properties and thus disturbing nearby ecosystems. As a result, the existing landscape and environment are being ruined [35, 47, 48, 49]. Mine dumps and tailings, one of the major problems in the mining industry, are also the cause of degraded environment [50, 51] (Fig. 5). Adverse environmental changes due to unsystematic disposal of the mining waste will affect the agricultural land, forest land, surface & subsurface drainage, flora & fauna etc. The fact that the visible negative effects of environmental degradation are so evident as a result of developmental activity is concerning. Thus, the best course of action for improving the situation is to develop the area sustainably by extracting its mineral wealth while also protecting the ecosystem. One of the major sources of pollution during quarrying and transporting stone is the waste stone dust. It directly jeopardizes the health of the mining employees, because stone dust is the cause of life threatening breathing problems among the mine workers like silicosis, tuberculosis, and chest pains [34, 52- 54]. Due to wind and surface runoff, the stone dust is being deposited on the soil and crop lands. As a result, the soil quality and crop production are decreasing [49, 55].

Fig. 5: The environment is affected by the mine dumps and tailings

Conclusions

Millions of people are employed globally in the mining industry. Mining can be carried out on a large, medium, or small scale under extremely hazardous working conditions, or it can be done on a high tech level in large mines with adequate working conditions and safety for the miners. With an average of one million people employed every day and an annual turnover of over 40 billion US dollars, India boasts a unique blend of large and small, manual and mechanized, opencast and underground mines that contribute to roughly 2.5% of the country's GDP [63]. The most common occupational lung disease among mine workers is still silicosis, a condition linked to dust. Over a century of accident data and safety experience in Indian mines demonstrate a decline in both mortality and accidents over time. The fatality rate per 1000 mine workers, however, has been averaging 0.30 in both the non-coal and coal industries; following a period of steady decline, fatal accident trends increased once more in the 1980s and 1990s. The efficacy of the current, traditional method of enforcing occupational safety and health laws in mines through statutory investigations, inspections, and other means has reportedly reached its limit. It is necessary to develop a strategy that combines “strategic” and “systems” thinking in order to get the mining sector ready to meet higher requirements for the health and safety of mine workers. Together with hazard control, analysis to foresee hazards, and engineering solutions to prevent accidents and occupational diseases, the new thinking must take into account behavioral, cultural, and organizational systems.

Mining activity has increased many fold in the last 10-15 years and caused different degrees of damage to drainage systems, canals, agricultural land, groundwater, vegetation and cultural objects like roads and rail networks, buildings etc. As a result, there is a reduction of the flow of rainwater to the existing tanks and several artificial water bodies are created in the mined-out areas. For mining to grow responsibly in India and around the world, there are a number of factors that must come together, including legislation, mine supervision and control, accurate data on accidents and occupational illnesses, the creation of safety programs, and a safety culture. From the present study, it can be concluded that the health shape of the miners as well as the near-by inhabitants is in critical situations. Improper and unsupportable mining and mining-related wastes are the main culprits for such situations. Through a variety of educational programs and practical training programs, local Government Officials and various Non-Governmental Organizations (NGOs) should take the initiative to raise awareness about potential health effects linked with sandstone quarrying and accompanying dust.

Many steps can be taken to address the unwanted quarrying functions. These are as follows:

By providing the right tools and machinery, miners can reduce the production of excess waste and dust emissions due to mining as the first and most crucial measuring step. Sandstone miners of Soorsagar are still using old-school hand-held chisels and hammers for cutting the blasted stone, without any kind of safety gear. As a result, dust created due to hammering and blasting is spreading across the area which is affecting the miners as well as the local residents. Due to inadequate safety gears, the maximum number of injuries and illnesses is taking place among the miners. Therefore, the mine owners should provide safety gears like helmets, masks, safety goggles, rubber boots and mine workers should use these equipments. Miners can use this water for wet drilling and cutting. They can also spread this water around the mining area to reduce the suspended dust in the area. As the second most important strategy, recycle the generated wastes or turn them into building materials that are useful. Lastly, secure disposal of the trash generated due to mining.

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References

[1] F.J. Pettijohn, P.E. Potter and R. Siever, “Sand and Sandstone (Second Edition)," Springer, vol. 559, no. 1-2, 1987.

[2] A. Ahmad, “Socio-economic and health status of sandstone miners: a case study of Sorya village, Karauli, Rajasthan,” Int. J. Res. Med. Sci., vol. 3, no. 5, pp. 1159–1164, 2015.

[3] P. Gupta and A. Laddha, "Jodhpur Sand Stone'–A Splendid Architectural Building Material," Journal of Emerging Technologies and Innovative Research (JETIR), vol. 5, no. 11, pp. 755–761, 2018.

[4] K.S. Cho and S.H. Lee, "Occupational health hazards of mine workers," Bull World Health Organ., vol. 56, no. 2, pp. 205–218, 1978.

[5] M. Shafiei, A. Ghasemian, M. Eslami, F. Nojoomi & H. Rajabi-Vardanjani, "Risk factors and control strategies for silicotuberculosis as an occupational disease," New Microbe and New Infect. vol. 27, pp. 75–77, 2019.

[6] M.I. Greenberg and J. Waksman, "Silicosis: a review". Disease-a-Month," vol. 53, pp. 394–416, 2007.

[7] R. Merget, T. Bauer, H.U. Küpper, S. Philippou, H.D. Bauer, R. Breitstadt & T. Bruening, "Health hazards due to the inhalation of amorphous silica," Arch Toxial, vol. 75, no. 11–12, pp. 625–634, 2002.

[8] D. Macallan, "Malnutrition in tuberculosis," Diagn. Microbiol. Infect. Dis., vol. 34, no. 2, pp. 153–157, 1999.

[9] S. Verma and S. Chaudhari, "Safety of Workers in Indian Mines: Study, Analysis, and Prediction," Safety and Health at Work. vol. 8, pp. 267–275, 2017.

[10] S.S. Nandi, S.V. Dhatrak, D.M. Chaterjee and U.I. Dhumne, "Health Survey in Gypsum Mines in India," Indian J. Community Med. Off Publ. Indian Assoc. Prev. Soc. Med., vol. 34, no. 4, pp. 343–345, 2009.

[11] L. Mancinia and S. Sala, "Social impact assessment in the mining sector: review and comparison of indicators frameworks," Res Policy, 57, pp. 98–111, 2018.

[12] P.P. Mishra, "Coal mining and rural livelihoods: a case of the IB Valley Coalfield, Orissa," Econ. Polit. Wkly., vol. 44, no. 44, pp. 117–123, 2009.

[13] P. Hota and B. Behera, "Opencast coal mining and sustainable local livelihoods in Odisha, India," Miner Econ., vol 29, pp. 1–13, 2016.

[14] A.G.N. Kitula, "The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: a case study of Geita Districts," Cleaner Production, vol. 14, pp. 405–414, 2006.

[15] A. Sincovich, T. Gregory, A. Wilson and S. Brinkman, "The social impacts of mining on local communities in Australia," Rural Soc., vol. 27, no. 1, pp. 18–34, 2018.

[16] C.D. McCullough and M.A. Lund, "Opportunities for sustainable mining pit lakes in Australia," Mine Water Environ., vol. 25, pp. 220–226, 2006.

[17] A. Sincovich, T. Gregory, A. Wilson & S. Brinkman, "The social impacts of mining on local communities in Australia," Rural Society, 2018.

[18] B. Dold, "Sustainability in metal mining: from exploration, over processing to mine waste management," Rev. Environ Sci. Biotechnol., vol. 7, no. 4, pp. 275–285, 2008.

[19] S. Petrova & D. Marinova, "Social impacts of mining: Changes within the local social landscape," Rural Society, vol. 22, no. 2, pp. 153–165, 2013.

[20] L. Wang, J.-L. Zhang and L.M. Liu, "Diversification of rural livelihood strategies and its effect on local landscape restoration in the Semiarid Hilly Area of the Loess Plateau, China," Land Degrad. Develop., vol. 21, no. 5, pp. 433–445, 2010.

[21] A. Das, R. Raj & N.M. Patnaik, "Status, Impact, and Factor Determining Rural Non-farm Economy of India: A Review," Indian Journal of Economics and Development. vol. 16, no. SS, pp. 68–76, 2020.

[22] D.S. Chauhan, "Tectonic and sedimentary evolution of the Marwar basin: A Neoproterozoic–Early Cambrian intracratonic sag basin," In: Proceedings of the Seminar on Geology of Rajasthan – Status and Perspective (A.B. Roy Felicitation Volume) Geology Department, MLSU, Udaipur, pp. 111–125, 1999.

[23] K.S. Valdiya, "Marwar's connection with the Himalayas; In: Geological Evolution of Northwestern India," B.S. Paliwal (ed). Scientific Publishers India, pp. 1–18, 1999.

[24] S.S. Rathore, T.R. Venkatesan and R.K. Srivastava, "Rb–Sr and Ar–Ar systematics of Malani volcanic rocks of southwest Rajasthan: Evidence for a younger postcrystallization thermal event," Proc. Indian Acad. Sci. (Earth Planet. Sci.)., vol. 105, pp. 131–141, 1996.

[25] S.S. Rathore, T.R. Venkatesan and R.K. Srivastava, "Rb–Sr isotope dating of Neoproterozoic (Malani Group) magmatism from southwest Rajasthan, India: Evidence of younger Pan-African thermal event by 40Ar–39Ar studies," Gondwana Res. vol. 2, no. 2, pp. 271–281, 1998.

[26] S.J. Malone, J.G. Meert, D.M. Banerjee, M.K. Pandit, E. Tamrat, G.D. Kamenov, V.R. Pradhan and L.E. Sohl, "Paleomagnetism and Detrital Zircon Geochronology of the Upper Vindhyan Sequence, Son Valley and Rajasthan, India: A ca. 1000 Ma age for the Purana Basins," Precamb. Res., vol. 164, pp. 137–159, 2008.

[27] H.S. Pareek, "Basin configuration and sedimentary stratigraphy of Western Rajasthan," J. Geol. Soc. Ind., vol. 22, pp. 517–527, 1981.

[28] H.S. Pareek, "Pre-Quaternary geology and mineral resources of north-western Rajasthan," Geol. Surv. India Memoir., vol. 115, pp. 1–95, 1984.

[29] S.K. Das Gupta and S.S. Bulgauda, "An overview of the geology and hydrocarbon occurrence in western part of Bikaner–Nagaur basin," Indian J. Petrol. Geol., vol. 3, no. 1, pp. 1–17, 1994.

[30] S.K. Das Gupta, "Marwar Supergroup evaporates, Rajasthan. In Recent advances in Vindhyan Geology (ed A. Bhattacharyya)," Geol. Soc. India Memoir., vol. 36, pp. 49–58, 1996.

[31] D.S. Chauhan, R. Bhanwara and R. Narayanan, "Jodhpur sandstone: A gift of ancient beaches to Western Rajasthan," Journal of the Geological Society of India, vol. 64, pp. 265–276, 2004.

[32] S. Sarkar, P. Samanta, S. Mukhopadhyay and P.K. Bose, "Stratigraphic architecture of the Sonia Fluvial interval, India in its Precambrian context," Precamb. Res., vol. 214–215, pp. 210–226, 2012.

[33] M. Vishwanath & A. Singh Rathore, "A Study of Market Scenario of Sand Stone Industry of Rajasthan," Ijfans International Journal of Food and Nutritional Sciences. vol. 11, no. 12, 2022.

[34] A. Ahmad, "Socio-economic and health status of sandstone miners: a case study of Sorya village, Karauli, Rajasthan," Int. J. Res. Med. Sci., vol. 3, no. 5, pp. 1159–1164, 2015.

[35] B.K. Bhadra, A.K. Gupta, J.R. Sharma and B.R. Choudhary, "Mining activity and its impact on the environment: Study from Makrana marble and Jodhpur sandstone mining areas of Rajasthan," Journal of Geological Society of India, vol. 70, no. 4, pp. 557–570, 2007.

[36] P.K. Sishodiya, "Silicosis Detection and Relief Programme: A Case Study of Rajasthan, India. In: Medical Geology in Mining: Health Hazards Due to Metal Toxicity (Eds: K. Randive, S. Pingle, A. Agnihotri)," 2022, Springer Geology.

[37] M. Shafiei, A. Ghasemian, M. Eslami, F. Nojoomi and H. Rajabi-Vardanjani, "Risk factors and control strategies for silicotuberculosis as an occupational disease," New Microbes New Infect., vol. 27, pp. 75–77, 2018.

[38] A. Ahmad, "Awareness of workplace hazards and preventive measures among sandstone mineworkers in Rajasthan, India: a cross-sectional study," J. Health Soc. Sci., vol. 2, no. 1, pp. 69–82, 2017. DOI 10.19204/2017/wrns6

[39] A.M. Donoghue, "Occupational health hazards in mining: an overview," Occup. Med., vol. 54, pp. 283–289, 2004.

[40] N.E. Adler and K. Newman, "Socioeconomic disparities in health: pathways and policies," Health Aff., vol. 21, pp. 60–76, 2002.

[41] D. Rees and J. Murray, J., "Silica, silicosis and tuberculosis," Int. J. Tuberc. Lung Dis., vol. 11, pp. 474–484, 2007.

[42] C.R. Thomas and T.R.A. Kelley, "A brief review of silicosis in the United States," Environ. Health Insights., vol. 4, pp. 21–26, 2010.

[43] H.A. Kawasaki, "A mechanistic review of silica-induced inhalation toxicity," Inhal. Toxicol., vol. 27, pp. 363–377, 2015.

[44] K.M. Pollard, "Silica, silicosis, and autoimmunity," Front Immunol., vol. 7: 97, 2016.

[45] C. Santos, A. Norte, F. Fradinho, A. Catarino, A.J. Ferreira, M. Loureiro et al., "Silicosis-brief review and experience of a

pulmonology ward," Rev. Port. Pneumol., vol. 16, issue 1, pp. 99–115, 2010.

[46] M. Nasrullah, M., Mazurek, J. M., Wood, K.M. Bang and K. Kreiss, "Silicosis mortality with respiratory tuberculosis in the United States, 1968-2006," Am. J. Epidemiol., vol. 174, no. 7, pp. 839–848, 2011.

[47] N. Al-Joulani, "Soil Contamination in Hebron District Due to Stone Cutting Industry," Jordan Journal of Applied Science, vol. 10, pp. 37–50, 2008.

[48] S.D. Odell, A. Bebbington and K.E. Frey, "Mining and climate change: A review and framework for analysis," The Extractive Industries and Society, vol. 5, no. 1, pp. 201–214, 2017.

[49] S. Zia Khan, W. Spreer, Y.Pengnian, X. Zhao, H. Othmanli, X. He. and J. Müller, "Effect of dust deposition on stomatal conductance and leaf temperature of cotton in northwest China. Water. vol. 7, no. 1, pp. 116–131, 2014.

[50] R.K. Bapna, "Marble waste minimization," Rajasthan Mineral Bulletin., vol. 23, no. 3, pp. 17–19, 2002.

[51] U. Forstner, "Introduction. In: Environmental impacts of mining activities: emphasis on mitigation and remedial measures (ed Azcue, J.M.)," Springer, Heidelberg, pp. 1–3, 1999.

[52] K. Chopra, P. Prakash, S. Bhansali, A. Mathur. and P.K. Gupta, "Incidence and prevalence of silicotuberculosis in western Rajasthan: A retrospective study of three years," National Journal of Community Medicine, vol. 3, no. 1, pp. 161–163, 2012.

[53] J. Solanki, S. Gupta and S. Chand, "Oral health of stone mine workers of Jodhpur City, Rajasthan, India," Safety and health at work, vol. 5, no. 3, pp. 136–139, 2014.

[54] A. Yarahmadi, M.M. Zahmatkesh, M. Ghaffari, S. Mohammadi, Y. Labbafinejad, S.M. Seyedmehdi, M. Nojomi and M. Attarchi, "Correlation between silica exposure and risk of tuberculosis in Lorestan province of Iran," Tanaffos., vol. 12, no. 2, pp. 34–40, 2013.

[55] S.K. Prajapati, "Ecological effect of airborne particulate matter on plants," Environmental Skeptics and Critics., vol. 1, no. 1, pp. 12–22, 2012.

[56] R.E. Mittleman and C.V. Welti, "The fatal café coronary," JAMA, vol. 247, pp. 1285–1288, 1982.

[57] P.C. Elmes, "Inorganic dusts". In: P.A.B Raffle, P.H. Adams, P.J. Baxter, W.R. Lee (Ed.): "Hunter's Diseases of Occupations," Edward Arnold Publications, London, pp. 421–428, 1994.

[58] A.G. Leitch, "Functions of lungs". In: Anthony Seaton, Douglas Seaton, A Gordon Leitch (Eds.): "Rofton and Douglas's Respiratory Disease (5th Edition)," Oxford: Blackwell Science Ltd., vol. 1, pp. 43–46, 2000.

[59] K. Kimura, I. Nakano, Y. Ohtsuka, K. Okamoto, I. Usami, K. Onishi, T. Kishimoto, K. Genma, K. Mizuhashi, M. Sakatani and H. Kaji, "Today's occupational respiratory disease–From our recent investigations," Hokkaido Igaku Zasshi, vol. 85, no. 1, pp. 27–30, 2010.

[60] P.K. Sishodiya, "Silicosis–An Ancient Disease Providing Succour to Silicosis Victims, Lessons from Rajasthan Model," Indian Journal of Occupational and Environmental Medicine, vol. 26, no. 2, pp. 57–61, 2022.

[61] B.K. Sikand and S.P. Pamra, "Preliminary Report on the occurrence of Silicosis among Stone Masons Workers: In: Proceedings of 7th Tuberculosis Conference (1964)," Ind. J. Chest Diseases, vol. 6, no. 1, pp. 37–38, 1964.

[62] M.L. Mathur, "Silicosis among sand stone quarry workers of a desert district Jodhpur," Annals of the National Academy of Medical Sciences (India). vol. 32, pp. 113–118, 1996.

[63] S. Mazumder, "Mine safety analysis with a special focus on accidents due to explosives," Journal of Emerging Technologies and Innovative Research (JETIR), vol. 4, no. 11, pp. 128–133, 2017.