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Mining and its Impacts on Environment and Health with Special Reference to Ballari District, Karnataka, India

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***Abstract*— Mining has played a significant role in the development of a country. The financial progress of various nations depends on the production and use of minerals which leads to the expansion of mining activities. Ballari district has rich mineral resources and is known for iron ore deposits. As iron ore is an essential raw material for the iron and steel industry, many Iron and Steel plants are established in Ballari district. In this study, the impacts of iron ore mining on environmental issues such as air, water, soil, and health on the population are reviewed. The review reports that the concentrations of NO_2, SO_2, PM_{10} and $PM_{2.5}$ are greater in the core zone of Subbarayanahalli iron ore mine located in Hospet-Ballari sector. The PM_{10} level exceeds the NAAQS limits of 100 µg/m^3 at different locations of 10kms radius of Ballari city. The surface water bodies around Sandur, Torangallu and Taranagar are silted and contaminated by mining waste. The airborne dust produced during mining activities decreased crop productivity and affected human health. The main conclusion from the review is that more research should be needed to assess the environmental impacts and emphasize sustainable mining operations in association with Government and mining research activities.*

I. INTRODUCTION

Mineral resources play an essential role in the economic development of a nation. This is vital, particularly for developing countries like India. These resources are base for increased industrialization and generate many employment opportunities for the people of the mining regions [1]. The increase in mining activities results from the fact that the financial progress of various nations is dependent on the production and use of minerals, including fuel minerals [2].

With the rapid industrialization due to mining, society also gets the benefits such as the establishment of schools, hospitals, hotels, construction, transportation, communication, and other infrastructure facilities. In India, mining activities bring huge revenues to the State Governments and thus enable the Governments to use the revenue for the welfare and well-being of people in the society [1].

Thus, minerals are an indispensable part of the economy of a nation. Fortunately, India is blessed with huge deposits of mineral resources. It is estimated that more than 0.8 million hectares of land are under mining, however, a major portion lies in the forest area. There are 20,000 known mineral deposits in India and as many as 89 minerals (4 fuel, 10 metallics, 22 non-metallic and 55 minor minerals. As per the annual report of the Ministry of Mines, 2021-22, the 1st Advanced Estimate of Gross Value Added (GVA) of the mining and quarrying sector during 2021-22 at 2011-12 prices is Rs. 336859 crore, which shows a growth of 14.33% as compared to a provisional estimate of GVA during 2020-21 at Rs. 294644 crores. The States which have indicated a major increase in the value of mineral production are Orissa (93%), Jharkhand (87%) and Karnataka (65%) [3].

II. METHODOLOGY

The Study is based on secondary data published in journals and magazines in the form of articles. It also covers the information provided by the Annual Reports of the Ministry of Mines, Indian Bureau of Mines, Central Pollution Control Board, and other Government organisations. In this study, the impacts of mining iron ore particularly resulting from open-cast mining are covered with special reference to environmental issues (such as Air, Water, Soil), and health hazards on the population of the mining region. The Study area is confined to the Ballari District of Karnataka State.

III. ABOUT BALLARI

The state of Karnataka is abundant in mineral resources. It is said to be one of the most mineral-rich states of India. The mineral belt covers an area of 1.92 lakhs sq. km including 29 districts of the state. Karnataka is also endowed with the green stone belt with valuable mineral resources such as gold, silver, copper, iron ore, manganese, limestone, dolomite, asbestos, bauxite, chromite, kaolin, and granite rock. The Ballari district is enriched with a wide variety of Major and Minor minerals. Major minerals include Iron ore, Manganese, Red Ochre, and Yellow Ochre (as per schedules 11 of MM(RD)1957 and minor mineral includes Building stone such as Granitic gneiss, Gneises and steatite (soapstone), Quartz and Granite. Ballari District has 125 Mining leases of Major minerals of which 30 leases are working and 92 quarry leases of minor minerals [4].

3.1 Iron Ore

The Geological Survey of India (GSI) has estimated a reserve of about 1876 million tonnes of iron ore with about 63% of total iron in the Sandur belt. Large deposits of lateritoid haematitic iron ore in association with manganese ore are from prominent ridges of the Sandur schist belt. There are six ranges carrying iron ore deposits viz., Donimalai, Kumaraswamy, Ramandurga, Yeshavanthanagar, Devagiri and Thimmappanagudi. The Ramandurg deposit is about 10,400 m long and 150 m wide with 62.3 to 62.6% Fe. In Donimalai, six ore bodies with sizeable reserves of 65.2% Fe have been estimated. In Kumaraswamy, the Geological Survey of India has estimated iron ore over a strike length of 2.5 km and width of 465 m [4].

3.2 Manganese Ore

The bimetallic (Fe-Mn) low-phosphorus manganese ore deposits as discontinuous bodies occur all along the western and southern margin of the Sandur schist belt over a strike length of about 40 km with an average width of about 500m. The deposits in Deogiri hill are the largest. The manganese horizon is stratigraphically confined to Deogiri Formation whose thickness varies from 975 to 1000 m consisting of metagreywacke, carbonates with minor interbeds of quartzites, arkose, meta-chert, basic and acid volcanic rocks.

Exploration by large-scale mapping and drilling carried out by GSI has identified three distinct manganese horizons over a strike length of 15 km viz., (i) top lateritoid horizon (ii) middle reef-like manganese ore and (iii) bottom clay mixed zone. Pyrolusite, cryptomelane, and psilomelane are the principal ore minerals. Hausmanite, hollandite and mangano-magnetite have also been recorded. The probable reserves of manganese ore in the entire belt are estimated to be 107.36 million tonnes [4].

IV. SIGNIFICANCE OF IRON ORE MINING AND ITS OPERATIONS

Iron ore is an essential raw material for the Iron and Steel Industry. It is significant among all mining activities and influences largely the economic status of the country. India is one of the leading producers of iron ore with a total reserve of over 33.276 billion tonnes of haematite (Fe_2O_3) and magnetite (Fe_3O_4). About 79% of haematite ore deposits are found in Assam, Bihar, Chhattisgarh, Jharkhand, Odisha and UP and 93% of magnetite ore deposits occur in Andhra Pradesh, Goa, Karnataka, Kerala, and Tamil Nadu. Interestingly, Karnataka alone contributes 72% of the magnetite deposit in India.

The production of iron ore constituting lumps, fines and concentrates was 246.08 million tonnes in the year 2019-20 and is given in table-1.

Table 1: State-wise Production of Iron Ore

Sl.No.	State	Production (in million tonnes)	Percentage
1.	Odisha	146.77	59.64
2.	Chhattisgarh	34.72	14.11
3.	Karnataka	31.40	12.76
4.	Jharkhand	26.89	10.92
5.	Other States	6.30	2.57
	Total	246.08	100.00

Source: Indian Minerals Year Book 2020

From the above table, it is evident that Karnataka stands in third place in terms of the production of iron ore with 12.76 per cent of the total production in the country. The other states in the above table include Andhra Pradesh, Goa, Madhya Pradesh, and Telangana [5].

4.1 Iron ore operations

Depending on the mode of extraction of minerals, mines can be surface mines, underground mines, or a combination of both [6]. Iron ore mining is carried out by open cast method through manual, semi-mechanised and mechanised operations. Generally, mining is done by digging the ore with pick axes, crowbars, chisel, and spades. The mined material is screened manually to separate +10mm float ore which is stacked separately. The waste is backfilled into the pits. In some cases, 150-200 gm of gunpowder or special gelatine cartridges are filled and blasted. The blast tonnage per kg of gunpowder is 2.5 to 3 tonnes. On the other hand, in the case of mechanised mining, hydraulic excavators, Ripper Dozers, Shovels, Dumpers and heavy machines are used. They also use explosives such as Ammonium nitrate–fuel oil (ANFO), Site Mixed Slurry (SMS) and emulsion explosions for blasting the mines.

However, the processing of iron ore involves crushing, screening, washing and in some cases beneficiation and agglomeration. Dry and Wet grinding is also carried and this processed ore is mainly used for manufacturing pig iron, sponge iron and steel and is also used in cement, coal washers, ferro alloys, foundry, vanaspati and glass industries [5]. In the present day, nearly all industrial establishments consume at least one of the minerals in their process of production. This speaks about the significance of mines and minerals in the world [7]. Rapid industrialisation has led to an ever-increasing demand for iron ore resources. The unabated exploitation of iron ore resources led to the ecological imbalance in the natural ecosystem and has caused environmental deterioration [8].

There are 266 iron ore mines in Karnataka, out of which 134 are in forest areas. In the Bellary District, 148 mines (out of which 98 are in forest areas) cover 10,598 hectares of land. The Indian Bureau of Mines in 2005 estimated the total iron ore mineral reserves to be about 1148 million tonnes [9]. The Supreme Court Central Empowered Committee has assessed that even at conservative estimates, at the present rate reserves in the State will be exhausted in about 20 years. Iron ore mining in Bellary took off in 1999, paved by the 1993 National Mineral Policy that began encouraging private players to participate in iron ore mining [10,11]. It received a further push when the Karnataka State Mining Policy in the year 2000 outlined a policy of “Export Oriented Development”. Finally, in March 2003, the state government de-reserved 11,620 square km for private mining that was formerly marked for mining by state entities alone [12]. The changes in mining policy went hand in hand with increasing demand from China due to the Beijing Olympics which caused iron ore prices to soar from around Rs. 1,300 per tonne in 2000 it crossed Rs. 4,500 per tonne in 2005-06 [13].

V. IMPACTS OF IRON ORE MINING

Mineral resource extraction and mining often have a significant negative influence on the environment, including the land, water, air, and biological resources as well as the socioeconomic situation of the local population [14]. The degree of impact depends on the methods, scale, and concentration of mining activities, as well as the geological and geomorphological environment [15].

Mining activities certainly affect all the components of the environment. The ill effects may be permanent or temporary, beneficial, or harmful, repairable, and sometimes go irreparable. In this paper, the study area is chosen as the Ballari District of Karnataka State. In recent years, there has been increased production of iron ore due to the usage of heavy machinery and equipment, particularly in open-cast mining. This open-cast mining results in the dumping of a huge volume of unmined land in addition to a pit-scarred landscape.

The major problem of iron ore mining is the disposal of tailings and other deleterious silica minerals and phosphorus. The mining regions are highly prone to the siltation of agricultural fields, nallahs, riverbeds, and creeks due to the wash off from iron ore dumps in rainy seasons. Apart from loss in crop yield and reduction in fish population in streams are caused by silting. It also results in dust concentration (suspended particulate matter) which poses environmental problems.

The iron ore mining activities in Ballari District threaten severe impact on the community and environment in one of the highly exploited iron ore belts of Karnataka State i.e., Sandur-Hospect-Ballari Belt [16]. Sandur -Hospet region has abundant reserves of Iron ores from which many fines are generated during mining, crushing, and screening processes. Nearly 50-60% of the total burden removed from the surface is below 10mm in size and these fines are dumped at mine sites as waste. During the rainy seasons, these fines, carried by runoff water, spread to the surrounding agricultural land thereby reducing the fertility of the soil and productivity of the pedosphere and leading to deforestation. The dissolved constituents from the mining process pollute the surface and groundwater of the region [17].

5.1 Air Pollution

The deterioration of air quality is a significant problem in mining areas [18,19,20]. The primary causes of air pollution in mining regions include drilling, blasting, loading, and unloading of minerals, transportation, as well as dust generation by wind at stockyards. Many meteorological factors such as wind speed, wind direction, temperature, amount of rainfall, and atmospheric stability in mining areas have a great impact on the environment [21]**.** The National Ambient Air Quality Standard was developed in India in 1994 to evaluate and compare the degree of air pollution in various places (CPCB, 1998) **[**14]**.** Particulate matter is one of the major pollutants released during different operations (drilling, blasting, loading, transporting, and unloading of ore) in open-cast mining [22,23]. The levels of NO_2 and SO_2 produced due to mining activities generally remain within the standard limit. Thus, controlling dust emission is crucial for every mining location, as it contains free silica and respirable particulate matter that can lead to respiratory illnesses [21].

Jaswanth Gowda (2016) reported that the activities of the Subbarayanahalli iron ore mine located in Hospet-Ballari sector contribute to air pollution in and around the mine areas. The pollutant concentrations, namely Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Suspended Particles (PM_{10}), and Respirable Suspended Particulate Matter ($PM_{2.5}$), observed in the mining region are greater in the core zone and within the National Air Quality Standards in the buffer zone. Due to variations in rainfall, humidity, temperature, wind speed and direction, the values are quite high in the summer and very low in the rainy season [24].

The particulate matter released at the mining site is carried from their place of production to a long distance by winds and upper-level circulation in the atmosphere. Patel et al. (2017) studied the impact of mining and associated industries on the Air Quality of the Bellary region. The study reported that the PM_{10} levels exceed the National Ambient Air Quality Standards (NAAQS) limits of $100 \mu g/m^3$ at different locations of 10kms radius of Bellary city. This was due to the transportation of vehicles on unpaved roads and the contribution from industries [25].

5.2 Water Pollution

Over 98% of the fresh water on the earth lies below its surface. The remaining 2% is what we see in lakes, rivers, streams and reservoirs. Of the freshwater below the surface, about 90% satisfies the description of "groundwater". This groundwater contamination is generally irreversible i.e., once contaminated, it is difficult to restore the original water quality. Unfortunately, the mining operations result in wastes containing oil, grease, and toxic metals, and are run-offs during the rainy season which causes pollution in the ground water . The residual material of mines is dumped into water bodies and as a result of which the colour of the water bodies becomes reddish and the depth of water bodies decreases [26].

Nayak (2016), measured the colour and siltation of water bodies which are located within a radius of 5 and 10km of mining area which lies in the part of Bellary, Hospet and Sandur taluks. The study reported that the impact on any components decreases with an increase in distance from the mining area. The area of the water bodies got silted within a radius of 10 km [27].

Kumar et al. (2012) studied the surface and groundwater quality in the parts of the Sandur Schist belt, Bellary district. The study reported that nitrate, fluoride, magnesium, sodium, and total hardness are high in Narihalla Stream and are polluted and not suitable for drinking or agriculture. Most of the surface water bodies around Sandur, Torangallu and Taranagar are silted and contaminated by the mining waste [28].

5.3 Soil Pollution

Life on earth relies directly on the soil and aquatic ecosystem of rivers. Food would not grow, objects would not decompose, and nutrients would not be recycled if there was no fertile soil and microbial fauna to occupy it. Without fertile soil and microbial fauna that inhabit it, food would not grow, dead things would not decay and nutrients would not be recycled. A significant contributing cause to soil pollution is the disposal of industrial waste as a result of mining operations. The chemical and biological characteristics of soil are affected by these pollutants. The sludges resulting from surface mining which contains several toxic chemicals if untreated pollute the soil. Near the mining region, soil fertility has been negatively impacted. In a few instances, agricultural yield also falls [26].

There have been devastating environmental consequences of the unbridled iron ore mining in Bellary – the largest hit being to agriculture, with once-fertile lands turning red with iron ore silt and bore wells drying up across the entire region. The Supreme Court CEC report also states that nearly 45% of the forest cover in the region has been lost to mining – "As a result of mining and associated activities, what was once an area with green, scenic, undulating hilly terrain, today presents a barren and dismal picture akin to a war-ravaged zone with huge ugly scars" [29].

Suresh Kumar et al. (2017) assessed the soil Loss in Sandur Taluk due to Mining Activities in and Around Bellary district. They adopted Geographical Information System (GIS) based on the Revised Universal Soil Loss

Equation (RUSLE) to study the parameters like Land use, Land cover, Soil, Geomorphology, and catchment boundary. The study found that the areas of Ramgad Forest Block, Devagiri Hills, Northern Donimalai Village, North Eastern Block Hills, and Middle Eastern Taluk encompassing Taranagar Village and Bommagatta Village have considerable soil loss. Due to the ongoing sediment deposition in these places, the water tanks are severely affected [30].

Srinivasa Sasdhar Ponnaluru(2019) did an empirical analysis of the impacts of mining dust on crop productivity in the Bellary district in India. The study found that ore transportation and mining produce airborne dust that has an impact on agricultural productivity. It adopted a change in crop productivity modelled by regressing crop productivity on fertilizer consumption, amount of rainfall, and on mining activity over the study period. The study found that mining drastically decreased crop productivity and this decline in crop yield may be due to airborne dusts [31].

Nayak et al. (2015) evaluated the spatial variation in soil contamination by iron ore Mining of Bellary district using linear discriminate analysis and partial correlation analysis. The study reported that different types of acidic chemicals are concentrated in agricultural soil and affected areas of the Bellary district; simultaneously mining eruption damaged the fertility of the soil [32].

5.4 Noise Pollution

Noise has come to be regarded as a major urban pollutant capable of causing annoying hearing loss, and sometimes even adverse physiological and psychological effects. The unwanted sound emanating from the blasting, crushing, and processing of plants in the mining areas results in either temporary or permanent hearing loss. Due to this noise, the workers get tired and the quality of efficiency will come down. Noise also results in an unnecessary interruption in the communication process. Above all, the high incidence of sound invariably causes circulating problems, irregularities in heart rates, lack of concentration, nausea, headache, loss of appetite etc. [33].

5.5 Health Effect

The particulate matter produced during mining activities is of different sizes and is harmful to human health and the environment. The particles of size 30 µm and above (also known as total suspended particulate matter, TSPM) will settle down quickly near the source of emission. The particles between 30 and 10 µm in size are suspended in the air for a short time and they pose no health risk because when they are swallowed after becoming stuck in the mouth or nostrils. The particles of size less than 10 µm (PM_{10}) enter the respiratory tract when inhaled and the particles less than 2.5 µm in size (PM2.5) enter deep into the lungs and results in adverse health effect. The increased level of particulate matter results in diseases such as asthma, black lung disease and cardiovascular diseases. Thus, the study on PM_{10} and $PM_{2.5}$ emissions in the mining area is of more importance as it poses severe health problems [34,35,36].

Veerendra Kumar et al. (2020) studied the health status of mining labourers in the Bellary district by collecting data from the Primary Health Centre (PHC) of Bellary, Hospet and Sandur taluks. The study reported the number of patients treated or registered for diarrhoea, respiratory infections and other diseases [37].

VI. CONCLUSION

India is the leading producer of iron ore in the world. Apart from the basic Iron and Steel industry, sponge iron, pig iron, the ferrous industry and even the cement industry are also considered the major consumer of iron ore. Therefore, a long-term policy is needed to preserve and conserve iron ore deposits for the country's long-term consumption. The Indian steel sector is set to achieve a global benchmark in terms of quality, standard and technology. This requires huge demand for iron ore. To augment this demand, intensive and deeper exploration needs to be promoted. The underground mining techniques with optimum utilisation of iron ore deposits should be eco-friendly. The main conclusion of the review is that further research is required to assess environmental impacts of iron ore mining activities. Thus, the emphasis should be placed on sustainable mining operations in association with Government and mining research institutes.

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