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ABSTRACT: Despite government's repeated assertions for the sustainable mining extraction and development of rural and tribal communities living near the vicinity of mining areas, these have not been converted into implementable solutions. The natural resources from rural and tribal areas are being exploited to meet the ever-increasing requirements and aspirations of the affluent groups. With the above background, this article, taking both experimental and control villages into account, tried to explore the impact of coal mining on local environment. Although dealing with local environment, it has mostly focused on sociological impact of mining in air, water, and noise pollution. The data collected show that the suspended particulate matter concentration is alarmingly high in few sampling locations, whereas respirable suspended particulate matter concentration which once used to be within acceptable limits is now gradually approaching its standard acceptable value of 300 µg/m^3. Along with uncovered coal transportation, lack of water spraying system and movement of heavy vehicles have brought an addition to air pollution to the locality. The extraction of mining has influenced the water table. The data collected from State Pollution Control Board, Bhubaneswar, show that suspended sediments and chemical oxygen demand in most of the mining areas and biological oxygen demand in few cases have crossed the specific standard. Along with this, household survey was conducted by covering 6 villages and 600 households. The study was undertaken by following experimental design where 450 households were taken from experimental, ie, mining villages, and 150 households have been selected from nonmining areas. Of the 450 households, around 96.44% villagers responded that Mahanadi Coalfields Limited is not taking any mitigation measures to apprehend the pollution caused by mining operations.

KEYWORDS: Pollution, biodiversity, livelihoods

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Introduction

Since independence, improvement in the health status of the population by raising the access to and utilization of health, family welfare, and nutrition services has remained one of the major thrust for social development in India. But the development projects which have been initiated to reckon the country in the threshold of economic development have always proven to be injurious.[1] At the same time, the drive to accomplish quick economic development both developed and developing countries are utterly harnessing the natural resources. Of the development activities, mining plays an important role in improving the economic aspects of a country.[2] As the obvious reason of mining, diverse range of challenges is occurring. Despite voluminous growth, both in the fields of medical science and health, since some decades, environmental factors remain a major cause of disease and death globally. Even the continuous release of several pollutant particles is causing climate change in a wider aspect.[3] Ecological imbalance is also adding one more feather in the aspect of environmental pollution.[4] Hence, it can be stated that the economic cannot be fortified in its truest sense, whereas the broader impact of mining is on environment.[5]

Background

Indian mineral sector is playing a vital role not only to generate employment opportunities and improved livelihoods but also to provide sufficient space for environmental degradation. Moreover, the central impact of mining is long term and devastating as it shades negative impacts on local air and water quality, depletion of natural resources, decrease in rainfall, loss of cultivable land, etc.[6] As per the official confirmation of Ministry of Mines, the country is bestowed with 87 minerals. Of them, the prime contributors are mica, coal, lignite, iron ore, bauxite, manganese, aluminum, and crude steel.[7] Among these mineral reserves, coal has occupied a vital place by fulfilling around 55% of India's energy requirements.[7]

To meet the energy need of the country, the excavation of coal is becoming commercialized, and at the same time, various coal-extracting industries have been established. Through the customary practice of mining coal, the country is earning good revenues, but at the same time, it has resulted in serious health and environmental issues within its gamut.[8–10]

Extractive industries, mainly the coal mining, generate negative impacts in the local ecological conditions, which adversely affect the local economy and threaten the sustainability of local livelihood systems. Postmining phase of the Ib Valley has broadened the realm of cost-effective industry, but the study based on raw materialistic approach also suggests that impacts of coal mining must be conceptualized through the perspective of resource curse/blessing; in addition, it is important to note

that the scale and dimension of mining are always in question. Exploitation of natural resource endowment shows the negative social and ecological outcomes. Study of Ramsay[11], Rossi,[12] and Williams[13] shows the several negative impact of resource extraction in global scenario. Study of Hota and Behra[14] also suggested that there is need to reinvest some part of resource rents in regeneration of natural capital of the region, but the results of their study also show that rural households in the mining area experience both positive and negative outcomes from the coal mining activities. The study by Deonandan and Dougherty[15] of mining impacts in Latin America raised a range of questions about the practices of mining companies on the ground, and the impacts of mining on host communities in terms of livelihood and capabilities are very critical. They mention that century of mining operations is the reason for the disappearance of the forest, river, and lake. Nielsen and Oskarsson[16] shed light on crucial political and social dynamics that unfold today as India seeks to accelerate industrial growth. They show that how state stimulated the rural land for the mining and ignored the assets of natural capital. Their study shows that the destruction of the natural resource base, more generally, is one of the regions for resistance.

Starting from its excavation to loading and unloading, coal produces dusts and radiation which have a direct negative impact on the ecology, biodiversity, and health of the surrounding communities.[17] During drilling, blasting, sizing, and transportation, the release of total suspended particulate (TSP) matter and inhalable particulate matter (PM_{10}) is the reason of air pollution in and around the mining zone.[18] To check the air quality of the coal mining regions in India, a study was being undertaken by Ministry of Environment & Forests (MoEF), Government of India. According to the report prepared by MoEF, the critically polluted areas of India due to coal mining are Korba, Anugul, Talcher, Hazaribagh-Chatra, Singrauli, Chandrapur, Raigarh, and Jharsuguda.[19] The Central Pollution Control Board (CPCB) has developed a Comprehensive Environmental Pollution Index (CEPI). Central Pollution Control Board has done a nationwide environmental assessment of industrial clusters based on CEPI, and 43 such industrial clusters having CEPI greater than 70, on a scale of 0 to 100, have been identified as critically polluted. In Odisha, 3 clusters—Angul-Talcher, Jharsuguda, and Ib Valley—came under the category of critically polluted. Among these 3 regions, Angul-Talcher secured the highest position acquiring 82.09 CEPI score (SPCB, 2016).[20] Even recently, CPCB has claimed Angul-Talcher region as critically polluted area in Odisha. In the Angul-Talcher region, pollution is caused primarily due to Bhushan Energy, Nalco Smelter, Bhushan Steel along with the Mahanadi Coalfields Limited's (MCL) Bharatpur and Bhubaneswari mines (The Pioneer; June 17, 2017). The central reason behind the pollution of air is the release of suspended particulate matter (SPM).[21]

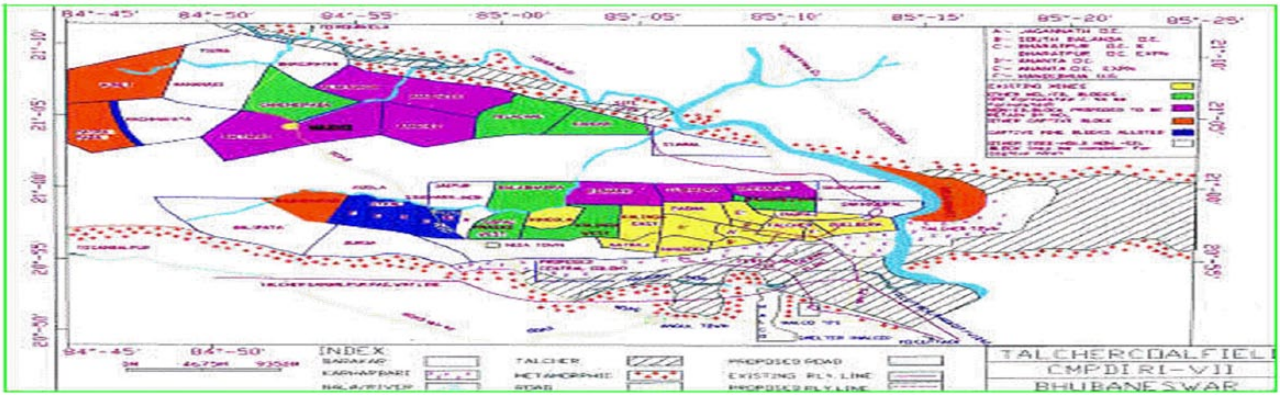
In India, the central producer of coal is Coal India Limited (CIL) which operates in 8 different stations. They are excavating coal through both opencast and underground techniques. However, the opencast mines are the major producer of fugitive dust to the air which ultimately pollutes the air environment.[22] Sometimes, the assessment of air quality shows that the air quality of both the residential and industrial areas is surpassing the National Ambient Air Quality Standards (NAAQS) protocol. Study done by Chaulya[23] in the Ib Valley coalfield region of MCL shows that the 24-hour average of TSP and PM_{10} is much more than the prescribed limit of NAAQS. Even the study done by Central Institute of Mining and Fuel Research, Dhanbad, during 2012 to 2013 concluded that the emission of total particulate matter at the mines of MCL is because of the release of contaminating dust.[24]

The long-term and continuous mining of coal deteriorates the natural environment as it sheds negative influences on the nearby water bodies and soil.[10] However, the regular disposal of millions of wastewater into the nearby water bodies is the main cause of pollution of water.[25] More specifically, the release of chemical particles with the wastewater is the reason behind alteration of water regimes.[26] Above all the chemical particles, contamination of water through acid mine drainage is the reason behind the alteration of pH balance. Even the low pH balance is the reason behind the hazardous condition of aquatic life.[27] Furthermore, the metallic materials which comprise iron (Fe), copper (Cu), manganese (Mn), and nickel (Ni) are hindering the domestic use of water.[21]

Pollution of both surface water and groundwater is becoming rampant due to coal mining activity. During the initial period, the release of obnoxious substances such as ash, oil, phosphorus, ammonia, urea, and acids are contaminating the surface water quality of the mining regions.[26] Studies have found that the groundwater quality is also getting contaminated due to the release of manganese (Mn), cadmium (Cd), and lead (Pb). The concentration of these metallic particles was found beyond the maximum permissible limits.[28] Similarly, the presence of these metallic substances in water resulting in various health hazards such as rheumatism, speech and hearing disability, euphoria, impotency, high blood pressure, high cholesterol, diabetes, kidney stones, and cancer.[29,30] Sometimes, overexploitation of water from the nearby water bodies is becoming the major cause of water scarcity.[31]

Noise pollution is quite evident while discussing about coal mining and pollution. As mining activity is taking place throughout the day, the noise coming out at the time of blasting, drilling, and transportation is polluting the entire environment. Mostly because of opencast mines, the noise comes out at the time of blasting and overburden (OB) removal.[32] Even the workers are working in the polluted environment where they have continuous exposure to noise, humidity, unhealthy ventilation, smell of chemical explosion, etc. and are becoming the adverse sections because of mining.[33]

However, all these issues can be tackled by formulating and implicating the appropriate policies for the project-affected communities. Time and again, some policies have been formulated,



Map 1. Talcher coalfield. Adapted from http://mahanadicoal.nic.in.

but the improper distribution of resettlement and rehabilitation (R & R) measures underpinned varied distress among the affected communities. In receipt of the above-mentioned consequences of mining, this article is being devoted to observe major environmental issues that are being encountered by the project-affected people of Talcher coalfield. Here, we have tried to explore the impact of mining on local environment. While exploring the impact, we have looked it from sociological perspectives.

Objectives

This article is an attempt to discuss the following environmental aspects of coal mining at Talcher coalfield region:

- The reasons behind environmental degradation.
- The impact of coal mining on local environment including air and water.

Materials and Methods

This study was conducted in MCL region of Odisha, India. Mahanadi Coalfield Limited, a subsidiary of CIL, is divided into 3 parts as per its functioning areas, such as Talcher, Ib Valley, and Vasundhara. However, this study is confined to the opencast mining areas of MCL, Talcher (Map 1).

Talcher coalfield, bounded by latitudes 23*53′N and 21*12′N and longitudes 84*20′E and 85*23′E, covers an area of about 1800 km^2. It has 8 opencast and 3 underground coal mines in its 5 coal areas, namely, Jagannath area, Bharatpur area, Lingaraj area, Hingula area, and Talcher area.

In this study, the targeted population consists of those who bear the negative costs of mining. In the first stage, a list of all those villages which are near the mines was undertaken. Given the choice of a target population, the next step was to put together a list of the target population, known as the sample frame population, from which, ultimately, the sample was drawn. Second, a list of 6 villages was undertaken according to stratified random sampling procedure. The strata were decided on the basis of the distance from the mine. The significance of selection of the villages in this particular way is to capture the variations in the impact of livelihood due to mining activities.

The closer a village is to the mines, the more is the probability that is affected by the mining. Since mines have started operation 20 years ago, it is difficult to go for a before and after analysis. Instead, with and without comparison will be conducted. For the purpose of with and without comparison, 2 more villages are selected that are not affected by mining, but belong to the same district, as control villages. In the last stage, from each sample village households were selected on the basis of circular random sampling methods for final study (Table 1).

To fulfil the objectives of the study, data were collected from both primary and secondary sources. For primary data collection apart from quantitative techniques, this study used qualitative anthropological tools. As part of qualitative data collection, the techniques such as observation (both participants and nonparticipants), case study, key informant interview, formal and informal interviews, and some of the participatory rural appraisal techniques such as focused group discussions, resource maps, and seasonal analysis were used. For gathering quantitative data, household survey was conducted using the pretested schedules. The secondary data were collected from official records, policy documents, published reports of similar projects, journals, and literature from social science discipline.

Coal Mining and Environment

With due course of time, many environmentalists agreed that burning coal is the most polluting method for producing electricity and is causing huge environmental damage. The worst thing that occurs during this process is of course the production of greenhouse gases (mostly carbon dioxide emissions) by burning coal, but carbon emissions are not the only negative thing in this process, as it also involves varied harmful compounds that released during burning of coal. Besides burning process, environmental problems are also associated with transportation, storage and disposal, loading and unloading, blasting, etc. Because coal is predominantly mined from the surface of earth, this often causes damage to nearby ecosystems as many of the ecosystems above are degraded or sometimes even

Table 1. Sample villages.

SAMPLES	NO. OF VILLAGES	DISTANCE FROM VICINITY	NO. OF SAMPLES HOUSEHOLDS	TOTAL SAMPLE
Affected by mining (experimental group)	2	3	75@2	150
	2	6	75@2	150
	2	9	75@2	150
Nonmining affected (control group)	2		75@2	150
Total				600

Adapted from Field study.

completely removed. Coal is usually transported by diesel trains over great distance, which means that it releases extra carbon dioxide and other harmful particles. And there is also coal dust that once produced contributes to particulate matter in the air which ultimately causes air pollution.

The trace factors contained in coal (and others formed during combustion) are a large group of various pollutants with a number of health and environmental effects. As a result, it disturbs ecosystem and endangers human health as well. Some cause cancer, others impair reproduction and the normal development of children, and still others damage the nervous and immune systems. Many are also respiratory irritants that can worsen respiratory conditions such as asthma. There is an environmental concern because they are often damaging ecosystems.

Coal mining and air pollution

In the era of 21st century, this belt has become an industrial hub. Along with MCL, a good number of coal-based thermal power plants, several heavy industries, coal washeries, and a large number of subsidiary industrial units have come up in the area. All these mining and industrial activities have caused rapid degradation of environmental quality. Although, on one hand, the natural resources available are degrading very first, on the other hand, the demand for resources have risen in this locality because of rise in industries and inflow of outsiders.

Across the globe, mining activities have either direct or indirect association with air pollution.[34] Although the effect of mining, ie, opencast and underground, varies, the negative impact of opencast coal mining is much higher than that of underground mines. The activities such as drilling, blasting, and transportation are the central cause behind air pollution.[21,35] Even the release of fugitive dust into the air is also responsible for air pollution.[22] In this study, it is observed that in the mining-affected villages, due to the release of particulates and poisonous gases, the atmosphere has created havoc and panic among the villagers. As a result, all the opencast mines have directly or indirectly are contributing to the air pollution. Even the associated activities of opencast mines such as unloading and loading of coal, transportation of coal, poor condition of roads, and huge quantities of open air coal burning by the villagers are the causes responsible for air pollution.

In all the affected villages and the nearby areas, it was observed that airborne emissions occurs during each stage of the mine cycle, but especially during exploration, development, construction, and operational activities. Mining operations generally mobilize large amounts of material, and waste piles containing small size particles are easily dispersed by the wind. The largest sources of air pollution in mining operations are as follows: particulate matter transported by the wind as a result of excavations, blasting, and transportation of materials; wind erosion fugitive dust from tailings facilities; stockpiles; waste dumps; and haul roads. Exhaust emissions from mobile sources (cars, trucks, heavy equipment) also raise these particulate levels. In the roads, it was observed that the movement of heavy vehicles, which had tons of coal meant for transportation to other places, was seen creating air pollution. It was also noticed that during transportation, the coal-loaded vehicles were normally uncovered. Even the trains which transport coal from the source point to the designated place pose serious threats as the loads are literally uncovered. Mahanadi Coalfields Limited authorities are not at all concerned to monitor the uncovered vehicles. In a discussion, MCL officials blamed the State authorities for not monitoring these issues. They claimed that around 85% of coal is being transported through train, and only 15% coal is transported by truck to local industries because of the Memorandum of Understanding (MoU) with State Government. They also claimed that till the MCL gate they used to monitor and are giving clearance certificate, but the truck drivers used to remove the cover once they cross the MCL gate.

However, during the field study, it was observed that almost all coal-loaded trucks were uncovered. Interestingly, when the drivers were asked whether they were directed to cover the coal loads at the time of transportation, they replied as no such directions were given at the time of loading neither they have paid any penalty for the same. Although there was an agreement that a separate coal corridor road will be built, it is not yet ready. Villagers in the study area revealed that sprinkling of water to prevent dust from flying never occurs and they have to take in

the polluted air which is fatal for their health. Mahanadi Coalfields Limited has openly flouted the Pollution Control Board's norms by allowing overloading of coal through vehicles which in turn generate large amount of dust particles due to spillage, and the authorities have not made any provision for the collection of spilled over coal materials which have become a source of pollution. This clearly violated the Environment (Protection) Act 1986.

The data collected from field reflected in Table 2 show that around 95.33% households reveal that mining has polluted their local environment. As there is no much variance in responses, the reliability of the questionnaire shows high reliability.

During summer, the temperature in Talcher remains between 42°C and 48°C which is unbearable and at the same time mine fire also adds to an extreme summer condition. The release of huge stocks of coal from Lingaraj, Bharatpur, and Ananta mines is causing mine fires regularly. Simultaneously, the failure of MCL authorities to pacify the fire has worsened the situation. The constant fire has soared up the atmospheric heat and is polluting the whole environment. Although there is no moisture in the air, it is necessary to disperse the produced coal. It should not be stored. The coal should not take to stocks, which lead to combo stone, fire, and smoke. Coal dispatch facilities have to be developed to avoid a chance of fire. Mahanadi Coalfields Limited authorities are also well aware about the fact that the dust particles which arise out of blasting, loading, unloading, and transportation of coal are lethal, but the authorities are inactive in terms of paving the way for a permanent and strategic method for countering the menace of dust-related hazards. From the available official data of MCL, they claim that varieties of measures were taken to encounter air pollution. Such measures include using blast-less mining technology which eliminates the dust-generating operations, such as drilling, blasting, and crushing, completely while sprinkling water at the same time, but hardly there is blast-less mining technology which is eliminating dust particles nor there is any consistency in water sprinkling. Another mitigation measure as claimed by the MCL includes mist type water spraying system along the conveyor belts/bunkers in the major coal handling plants, but hardly the mist type water system was found during the field study.

To reduce the fugitive dust emission, the MCL has started using Surface Miner Machine. Earlier it used to completely depend on the method of normal mining. However, MCL Talcher is not totally depending on Surface Miner. Most of its mining activities are still depending on conventional method. Coal-transported roads are not much equipped with water spray system. Maintenance of fixed and mobile water sprinklers on roads, railway sidings, stockyards, etc, is also not done by the MCL in a regular fashion. It should be a compulsion that both the road sides should have sufficient number of water sprinklers which are not seen in Talcher coalfield. Occasionally some tanks are moving on roads to sprinkle water. The seriousness of MCL regarding the installation and strengthening of existing dust collectors and dust extractors in drill raises serious concerns.

Table 2. Respondents' response on pollution.

NAME OF THE VILLAGE	YES	NO	TOTAL
Balanga Khamar	73 (97.33)	2 (2.67)	75
Langijoda	59 (78.67)	16 (21.33)	75
Hensamul	75 (100.0)	0	75
Naraharipur	75 (100.0)	0	75
Danara	72 (96)	3 (4)	75
Jambu Bahali	75 (100)	0	75
Total	429 (95.33)	21 (4.67)	450 (100)

Crushed coal from coal handling plant or directly from Surface Miner face is transported through tippers which unload the coal on the platform. Then, pay loaders load the coal in the wagon. Due to the unloading, loading, and movement of number of tippers, railway sidings become a major source of fugitive dust emission. Although water sprinkling through mobile and fixed sprinklers and good housekeeping through plying of wheel dozers are used to control the dust at railway sidings, still pollution is a major challenge here. Even the mining-affected villagers reported that MCL has openly cut around lakhs of trees and has never planted a single plant in their villages. Trees not only yielded fruits for them but also purified the atmosphere. This demonstrates that how MCL has openly disobeyed the environmental laws and is not serious in abiding to any afforestation programs for the betterment of the environment.

Table 3 reveals that around 96.44% villagers responded by saying that MCL is not taking any mitigation measures to apprehend the pollution caused by mining operations. Villagers also added that the mitigation measures which MCL claims that are implemented in the affected villages such as use of blast-less technology and use of water sprayer are nothing but white lies, and MCL is violating the environment laws and its mitigation claims are totally baseless. However, during fieldwork, it was observed that although MCL has taken lots of initiation to control pollution, it failed in reaching at complete solution.

To examine the existing air pollution scenario, this study has taken the 10-year air ambient quality data measured by State Pollution Control Board (SPCB), Odisha. As per the study conducted by Goswami,[36] SPM had reached an alarming level of 1848 kg/km^2 in Talcher region in Odisha. The data collected from Odisha Pollution Control Board show that nitrogen dioxide (NO2) and sulfur dioxide (SO2) levels for most of the coal mining areas are within the prescribed limits; however, high concentration of SPM and dust levels is

a major problem in and around the mining areas of Talcher. Fugitive dust emissions, in particular, have been a major cause of concern.

Periodic sampling of air quality in MCL region is being done by the Regional office of State Pollution Control Board, Angul, Odisha. A brief comparison is made using their sampling results for Jagannath Opencast Project which is presented in Tables 4 and 5 and can be considered as a representation for the other opencast mining works in the surrounding region of Talcher coalfield. The highest concentrations of particulate matter are found within the mine with concentrations gradually diminishing with increasing distance from the mine,[37] and hence, the expected concentration within the Jagannath Opencast Project is much higher than the values reported in the above tables.

From tables, it is also observed that the concentration of these particulate pollutants is consistently increasing throughout the last decade. The SPM concentration is alarmingly high at all the sampling locations, whereas respirable suspended particulate matter (RSPM) concentration which once used to be within acceptable limits is now gradually approaching its standard acceptable value of 300 µg/m^3. In some cases, it was observed that RSPM has crossed the standard limits. The rise in SPM in Jagannath colony, that is, residential area, is a matter of serious concern. The SPCB data of other mining areas show that both the SPM and respirable particulate matter (RPM) levels have crossed the minimum level even in most of the residential areas. The 2014 data collected from Hensamul village and coal transport of city road of Bhubaneswari mine and Kumuda village of Lingaraj mine show that both the SPM and RPM levels have crossed the minimum level in all the villages.

Figure 1 shows the trend of RSPM and SPM concentration in the Jagannath Opencast Mining. The values of RSPM and SPM recorded show a fluctuating trend from 2012 to 2014 and then with a steep rise in the values of RSPM and SPM, respectively, in March 2014.

Table 3. Respondents' response toward MCL's initiation to mitigate the pollution caused by mining.

NAME OF THE VILLAGE	MCL TAKING INITIATIVES TO MITIGATE POLLUTION		TOTAL
	YES	NO	
Balanga Khamar	6 (8)	69 (92)	75 (100)
Langijoda	5 (6.67)	70 (93.33)	75 (100)
Hensamul	5 (6.67)	70 (93.33)	75 (100)
Naraharipur	0	75 (100)	75 (100)
Danara	0	75 (100)	75 (100)
Jambu Bahali	0	75 (100)	75 (100)
Total	16 (3.56)	434 (96.44)	450 (100)

Abbreviation: MCL, Mahanadi Coalfields Limited.

Water pollution

Another ill effect of coal mining is its impact on the water resources which perhaps is the most important aspect as far as the existence of the villagers is concerned. Villagers in the affected villages claimed that coal-related waste and coal sludge are often injected in the nearby water bodies which makes the water unfit for domestic use. The ponds which the villagers earlier used as a bathing *ghat* no more exist as either water has dried up or the water bodies have been clearly dominated by the coal-associated waste materials. During the field study, it was found that mining operations have exploited huge acres of lands. Few learned villagers also exclaimed that erosion normally causes loading of sediments which has chemical pollutants that cause varieties of environmental issues. In each and every mining-affected villages, it was witnessed that waste heap which consists of waste rocks may have coal-associated waste which can enter the groundwater through leaching and may cause contamination of groundwater. Villagers also expressed that they have also experienced a change in the taste of drinking water.

Table 4. RSPM (PM_{10}) and SPM concentration in µg/m^3 (Jagannath Opencast Project).

SITE NAME	MARCH 2004	APRIL 2005	FEBRUARY 2006	APRIL 2006	MARCH 2007	MARCH 2012	FEBRUARY 2013	OCTOBER 2013	JANUARY 2014	MARCH 2014
Time office	ND	ND	ND	ND	ND	225	210	215	340	229
Project office	ND	180	295	275	171	ND	ND	ND	ND	ND
Colony	ND	ND	ND	ND	ND	135	195	163	209	266
Central nursery	144	83	ND	140	ND	ND	ND	ND	ND	ND
Field canteen	ND	ND	ND	ND	ND	ND	215	220	369	243
RSPM standard: 300 µg/m^3										

Abbreviations: ND, no data; PM_{10}, particulate matter; RSPM, respirable suspended particulate matter; SPM, suspended particulate matter.
Source: Regional Office of State Pollution Control Board, Angul, Odisha.

Table 5. SPM concentration in μg/m³ (Jagannath Opencast Project).

SITE NAME	MARCH 2004	APRIL 2005	FEBRUARY 2006	APRIL 2006	MARCH 2007	MARCH 2012	FEBRUARY 2013	OCTOBER 2013	JANUARY 2014	MARCH 2014
Time office	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Project office	ND	307	991	699	616	ND	ND	ND	ND	ND
Colony	ND	ND	ND	ND	ND	455	583	505	455	734
Central nursery	352	162	ND	398	ND	ND	ND	ND	ND	ND
Field canteen	ND	ND	ND	ND	ND	ND	594	551	766	458
SPM standard: 600 μg/m³										

Abbreviations: ND, no data; SPM, suspended particulate matter.
Source: Regional Office of State Pollution Control Board, Angul, Odisha.

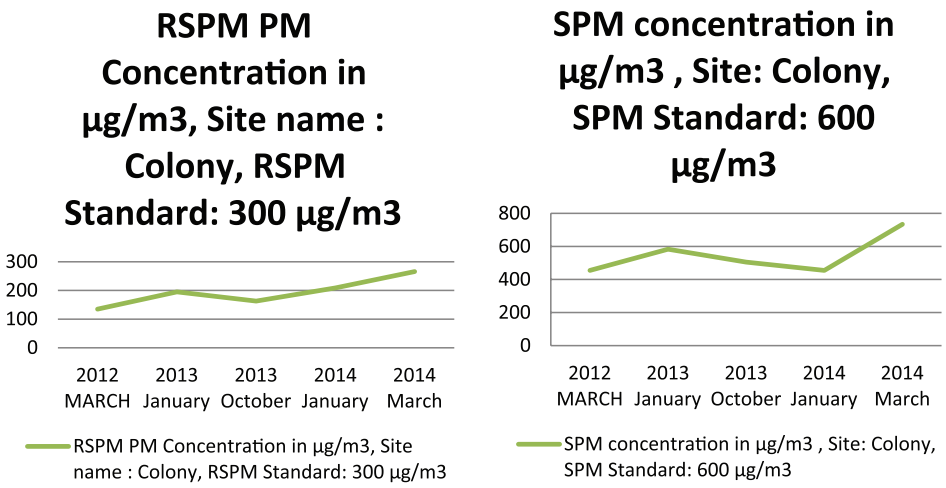


Figure 1. Trend of the RSPM and SPM concentration in the Jagannath Opencast Mining.
Source: Regional Office of State Pollution Control Board, Angul, Odisha.

Coal mining has not only disturbed the water quality in the villages but also resulted in water scarcity. As mining activities require large quantities of water, the availability of water is a big question mark. According to Reza and Singh,[26] an average of 86.26 million cubic meters per annum is drawn from the river for industry/mining activity in Angul-Talcher region of Odisha. Many coal mining regions are reported to confront the problem of overexploitation of groundwater resources which in turn decreased the water table.[21] Villagers are very much skeptical of the MCL's role for the preservation of water resources in their respective regions. Few villagers have also reported that MCL is continuously exploiting the groundwater resources in a continuous manner which has affected the water table in their area. They cited the example of their existing tube well. They claimed that the tube well now gives out water after 15 minutes of pumping which has a big variation than earlier. The villagers claimed that the wells, tube wells, ponds, and streams in the mining-affected villages are at first getting dried up due to the intense exploitation of water for mining operations. They claimed that before mining activities started in this area, they used to get the water 0.75 m below the ground. Even almost all the borewells remained functional during summer. The extraction of mining has reduced the water table. Especially in the summer season, they are facing loads of issues in getting safe drinking water. Almost all the tube wells are becoming dysfunctional during summer.

Mahanadi Coalfields Limited is quite low as compared with other industrial activities. Although we did not get premining water table data, the present data reveal that water table has gone down in comparison with the people's claim. During premonsoon period, the water table is falling down around 7/9 m (Table 6).

The investigator has taken 450 household opinions about the sources of water pollution in the mining-affected villages. Around 41.34% of the households stated that dumping ash is the major source of water pollution in the area and 22% of the households had given that the mining water discharged into existing water sources cause water pollution in the area, but it was not found in the control villages because the control villages are far from the mines. When asked about any mitigation measures such as adding bleaching powder in the water sources by the MCL to purify water, more than 80% of the villagers explained that MCL has never made any provision of

Table 6. Water table data for the year 2014 (Angul-Talcher belt).

LOCATION	LONGITUDE	LATITUDE	PREMONSOON (m bgl)	POSTMONSOON (m bgl)	FLUCTUATION (m bgl)
Ghantapada	85.1690	20.9293	7.95	3.15	4.80
Balanda	**85.1555**	**20.9230**	**7.75**	**3.28**	**4.47**
Santhaparha	85.2222	20.9036	8.45	5.15	3.30
Talcher	**85.2305**	**20.9472**	**9.65**	**4.45**	**5.20**
Gorumara	85.2130	20.8548	8.85	3.85	5.00
Kularha	85.1671	20.8399	6.35	2.35	4.00
Turanga	85.1241	20.8483	6.45	2.75	3.70
Barha Singarha	85.1347	20.9198	7.80	2.65	5.15
Danara	**85.0961**	**20.9439**	**6.35**	**2.77**	**3.58**
Raghunathpur	85.1537	20.9899	4.75	2.65	2.10
Sendhogram	85.2331	20.9259	7.45	5.25	2.20
Bhogabereni	85.2139	20.8917	8.65	5.15	3.50
Kukurhanga	85.1485	20.8948	7.75	2.45	5.30
Tentulia	85.1728	20.9191	7.85	3.46	4.39

Adapted from Central Ground Water Board, Bhubaneswar.
"m bgl" indicates meters below ground level.

adding bleaching powder to the water resources. More than 80% of the villagers claimed that MCL is not at all complying with the water recycling norms nor is bothered to look into the condition of the water that has emerged due to the constant generation of dust and ash, which settle in the water sources of the villages and completely deteriorate the water condition (Table 7).

Drainage water pumped out of the mine as well as the water flowing out from OB dumps is discharged into settling ponds before being discharged into the rivers and other water bodies to settle the sediments and prevent silting of rivers and other water bodies. The villagers further added that often the oily sludge which comes out during mining operations mixes with the water resources. Water effluents are not properly treated and no water recycling is done by MCL. It was also found that there are tankers which supply water to the villagers, but the amount as well as the frequency of water supply by the MCL is questionable, and during summer, few households do not get even a bucket of water for domestic purpose as other water sources have completely dried up due to the exploitation caused by the MCL. During transportation of coal, the spillage of coal often comes in contact with the water bodies and drains which are major sources of pollution in the area. Mahanadi Coalfields Limited lauds itself that they are the trendsetters in terms of mitigation of pollution, but hardly any such things were found during the field study and the responses of the villagers completely prove the alleged inaction of the MCL in terms of controlling water pollution in the area. It also came to light that several kinds of demonstrations as well as several complaints have been written seeking the interventions of MCL authorities against the backdrop of water menace, but MCL is completely ignorant of the just demands of the villagers. The voice of the villagers is always suppressed when they try to go against the MCL authorities.

Table 7. Sources of water pollution.

SOURCES OF WATER POLLUTION	FREQUENCY	PERCENTAGE
Mining water going to existing water sources	101	22.4
No recycling	60	13.33
Dumping ash	186	41.3
All	103	22.9
Total	450	100.0

Adapted from Field study.

On the contrary, the control villages, namely, Saradhapur and Deraguda, represent a different picture from that of affected villages. During field investigation in the control villages, 96% of the villagers responded that there is no water pollution in their locality and they have still got access to clean and pure water. The ponds in their area have good amount of water which is fit for bathing. Water for domestic purpose is in abundance as there are number of tube wells which give out good amount of water even during extreme summers, the villagers exclaimed. Also, activities such as the cleaning the ponds are done in a regular fashion, and the villagers are very happy about

Table 8. Water effluent quality data in MCL region of Talcher.

NAME OF MINE	SAMPLING DATE	SAMPLING POINT	PARAMETERS, MG/L				
			PH	SS	BOD	COD	O&G
Bhubaneswari OCP	October 30, 2013	(a) Outlet of sedimentation tank discharged into Bangaru Nallah	7.3	28	4	27	—
		(b) Outlet of ETP discharged into underground tank	7.4	1266	8	32	—
		(c) Outlet of O&G trap	7.0	44	4	11	5
		(d) Bangaru Setu near BCML workshop	8.1	28	4	11	—
	July 22, 2014	Outlet of sedimentation tank discharged into Bangaru Nallah	6.8	155	4	24	—
Lingaraj OCP	December 30, 2014	(a) Treated workshop effluent discharged into outside Nallah	6.4	136	27	—	12.8
		(b) Final effluent discharged into outside Nallah	6.6	122	22	—	10.4
Bharatpur OCP	February 1, 2013	(a) Outlet of workshop ETP	7.6	26	8	64	—
		(b) Outlet of ETP, village Nallah and Balram pipe leakage to Bangaru Nallah	7.8	28	16	224	—
		(c) Outlet of STP	6.8	24	24	160	—
		(d) Outlet of railway siding runoff discharge into Bangaru Nallah	6.8	1826	12	288	—
	March 14, 2012	(a) Treated workshop effluent discharged on outside land	6.6	146	82	22	14.2
		(b) Outlet effluent of STP discharged on outside land	7.2	43	163.8	32.4	—
Jagannath colliery Balanda	February 1, 2013	(a) Workshop ETP outlet	6.1	76	20	288	—
		(b) Outlet of mine drainage treatment plant	7.3	24	8	128	—
Standard			6.5–9.0	100	30	250	10

Abbreviations: MCL, Mahanadi Coalfield Limited; SS, suspended solids; BOD, biochemical oxygen demand; COD, chemical oxygen demand; O&G, oil and grease; ETP, effluent treatment plant; STP, sewage treatment plant.
Adapted from State Pollution Control Board, Odisha.

the fact that their water sources for bathing, washing, and other domestic purpose are not polluted and are in the position of status quo since time immemorial.

To strengthen the argument and finding out the impact of mining on local environment the existing water, tested data on Talcher coalfield were collected from SPCB, Bhubaneswar, Odisha (Table 8).

Both the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) tests are a measure of the relative oxygen-depletion effect of a waste contaminant. Both have been widely adopted as a measure of pollution effect. The BOD test measures the oxygen demand of biodegradable pollutants, whereas the COD test measures the oxygen demand of biodegradable pollutants plus the oxygen demand of nonbiodegradable oxidizable pollutants. The data presented above show that suspended sediments and COD in most of the mining areas and BOD in few cases have crossed the specified standard. Aquatic life will be disturbed due to reduction in photosynthesis, high suspended sediments, COD, and BOD. However, the recent initiation taken by MCL for zero discharge of mining water will solve most of the water related problems.

Drainage water from the mines discharged into various streams and rivers has affected the aquatic life. Many wildlife species are highly dependent on vegetation growing in natural drainages. This vegetation provides essential food, nesting sites, and cover for escape from predators. The development of mining projects destroys vegetation near ponds, reservoirs and reduces the quality and quantity of habitat essential for waterfowl, shore birds, and many terrestrial species. The loss of habitat requirements for many animals did not permit them to adjust to changes created by land disturbance. As a result, it has reduced wildlife.

Noise pollution

Coal mining is a loud, daylong, and nightlong process that includes blasting, drilling, and continuous movement of heavy vehicles. These mining-related activities have resulted in emission of loud noise which has disrupted the lives of those in the surrounding communities and has reduced the quality of life.[32] During field investigation, there was clear evidence that the ill effects of mining affected not only the environment but also

the human habitats as well. Blasting which is done for the coal extraction shakes the ground for some distance around the blast site. Residential properties around the quarry have experienced significant increases in the effects of blasts. Villagers were very sad about the fact that they had invested astronomical amount of money for their houses, but the vibration which emerges out due to mining has given the villagers a big jolt. More than 60% of the villagers expressed that blasting-related operations are making the children terrified and have brought disturbance in their studies. According to some residents, they could not sleep at night because of the blasting and the fact that heavy-duty trucks operate virtually all night to cart coal to the company's plant.

Villagers as a whole have complained a number of times to the Area General Managers and the Project Officers regarding the widespread house cracking, but according to the villagers, the MCL officials do not address their issues and express their helplessness in this regard. Few officials have even threatened the villagers to leave the village instead of paying for the loss. Truck traffic makes varying noise levels. Haul trucks and loaders within the quarry are moving continuously during daytime and nighttime. Transport trucks arrive empty and are filled. Filling often results in loud crashes and thumps as empty metal bins are loaded. All trucks and mobile plants have loud and penetrating reversing beepers that are a constant nuisance to local residents.

Table 9 represents that around 91% of the households reported blasting as the major cause of noise pollution and 9% of the households replied that the movement of heavy vehicles in the mining area creates a noise pollution which was not found in the control villages. Due to noise pollution, the households faced a lot of problems, ie, hearing, mental disturbance, disturbance in students' studies, and house cracking, which are clearly shown in Table 10.

Table 10 represents the data about problems faced by the mining-affected households. Noise pollution is one of the leading nuisances generated by the mining activities. Around 81.3% of the households described that due to blasting in the mining sites their houses are being cracked and 13% of the households specified that they are having mental disturbances. The noise pollution occurs due to noise by the vehicles, bulldozers, and excavators. But the central cause of noise pollution is the form of blasting using explosive material to get the rocks from mines. Noise has serious implications for the workers working in the area in general and the local dwellers in particular. Mahanadi Coalfields Limited authorities when contacted during field investigation replied that they are the trendsetters in introducing blast-free technology of winning coal in opencast mine by Surface Miner.

So far, noise pollution is a concern; it is due to heavy machineries and blasting operations. So, workers in mines should be provided with hearing protection devices and duration of exposure should be reduced to minimize the adverse health effects. It was noticed that the company is providing sufficient hearing protection materials (earplugs and earmuffs) to operators and workers to reduce health hazards from noise. But it is seen that operators are not following the norms. Although officials from MCL said that blasting time is very much limited and its effect is minimized using electronic delay detonators, the villagers claimed that they are highly victimized due to blasting, and during fieldwork, most of the households have also visualized cracks in their walls.

Table 9. People's Perception towards Causes of Noise Pollution.

CAUSES OF NOISE POLLUTION	FREQUENCY	PERCENTAGE
Movement of heavy vehicle	42	9.3
Blasting	408	90.7
Total	450	100.0

Adapted from Field study.

Table 10. Issues associated with noise pollution.

PROBLEMS FACED DUE TO NOISE POLLUTION	FREQUENCY	PERCENTAGE
Hearing	23	5.1
Mental disturbance	58	12.89
Student study disturb	3	0.7
House cracking	366	81.3
Total	450	100.0

Adapted from Field study.

Impact on local biodiversity

The development of coal mines has led to the loss of forest cover and simultaneously affected biodiversity and wildlife corridors in these forest areas. According to the Ministry of Coal (MoC), about 60% of coal resources are located in the forest areas (MoC, 2005). Most coal blocks allocated in the last few years have been in or adjoining forest areas. Of all the coal leases acquired by CIL, 28% lay under forest region, ie, out of which 2 00 000 ha are coal leases and 55 000 ha lay under forest cover (Greenpeace Report, 2012).

The MoC estimated that given the rising demand the need for forestland for mining will increase from about 22 000 ha in 2005 to 75 000 ha by 2025. In Angul-Talcher region in Odisha, for instance, forest cover has reduced by 11% between 1973 and 2007 due to coal mining (Singh, 2010). Coal mining, especially opencast mining and the evacuation of coal, requires large tracts of land for extraction processes, industrial purposes such as thermal power plants and captive plants, as well as ancillary processes such as OB dumps, pipelines, railway lines, and public works. It destroys not only the standing forests but also animal corridors, which diverted the streams.

Mining has affected the local environment and associated biota through the removal of vegetation and topsoil, the displacement of fauna, the release of pollutants, and the generation of noise. Mining of coal, both surface and subsurface, causes enormous damage to the flora, fauna, hydrological relations, and soil biological properties of the systems. Destruction of forests during mining operation is invariably accompanied by an extensive damage and loss to the system. The OB of coal mines when dumped in unmined areas creates mine spoils which ultimately affects the surrounding vegetation.

The destruction of ecosystem in postmining period has brought a great loss to the wildlife and their habitat. Both directly and indirectly it has damaged the wildlife. These animals live in communities that depend on each other. Survival of these species can depend on local ecosystem, soil conditions, local climate, altitude, and other features of the local habitat. The impacts stem primarily from disturbing, removing, and redistributing the land surface. Some impacts are short term and confined to the mine site; others may have far-reaching, long-term effects. The most direct effect on wildlife is destruction or displacement of species in areas of excavation and heaping of mine wastes. As per villagers view, most of the wildlife species are extinct. Mobile wildlife species, such as game animals, birds, and predators, have left these areas. More sedentary animals, such as invertebrates, many reptiles, burrowing rodents, and small mammals, are severely affected. The fragmentation of habitats due to mining activities has made difficult for some animals for their ecological move. In some cases, the isolation has led to local decline of species or genetic effects such as inbreeding. Species that require large patches of forest simply disappeared.

Conclusions

Environmental degradation is inevitable while it is associated with developmental activities such as coal mining. In this study, it was observed that in comparison with control villages, the mining-affected villages witnessed varied environmental issues. With increased production of coal, the environment of mining-affected villages is degrading hurriedly. Although the mining authorities claimed that they have taken varied precautionary measures to control the level of pollution, it still is responsible for air-related, water-related, and noise-related pollutions. Although the concentration of SPM and RSPM in some areas is going beyond the permissible limits, this ultimately is responsible for numerous respiratory diseases. Even it has decreased the average life span of project-affected persons. Similarly, the groundwater quality in Talcher-Anugal industrial complex has crossed more than 100 which is not at all suitable for drinking. The rise in suspended sediments, COD in most of the mining areas and BOD in few cases, has crossed the specified standard in mining drainage water. This may disturb the aquatic life in local areas. The ill effect of noise pollution is not only increasing the household repairing cost but it is also responsible for some sort of hearing as well as mental disturbances. From the existing air, water, and noise quality data; personal observation; interactions; and through photographic collection of the study area, it can be concluded that a major initiation is required to control the environmental degradation by minimizing several aspects of pollution.

Author Contributions

NM conducted the fieldwork, analyzed the data and wrote report; ND helped in analyzing and writing report.

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