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Impact of Mining Activities on Various Environmental Attributes with Specific Reference to Health Impacts in Shatabdipuram, Gwalior, India

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Abstract

Mining and metallurgical activities cause greater perturbation and devastation of both terrestrial and aquatic environments which has large scale ramifications. This piece of work reports the findings of a study undertaken to assess the environmental impacts of the mining activities in the Shatabdipuram mining area in Gwalior city of Madhya Pradesh, India. In addition to assess the environmental impact of the mining activities, community perceptions about the mining activities were also assessed to know the health effects caused by these activities. Marked environmental impacts were observed through the study in the form of air pollution, water pollution, noise pollution and their consequential effect on the health of the persons who got exposed to these pollutants. The concentration of some of the pollutants both in the air and water has reached alarming proportions which are presenting a health hazard, exacerbating various disorders among the people. A comprehensive strategy and appropriate regulations are indispensible to alleviate the negative impacts of the mining activities on the environment to make this practice a sustainable one.

Keywords: Mining activities, community, environmental impacts, health hazards, disorders.

Introduction

Mining is an important economic activity in many countries all over the world. It is an essential human activity to provide rough materials for the society. Operations, whether small or large-scale, are extremely disruptive and damaging to the environment, producing large quantities of waste that can have deleterious impacts for decades[1]. The exploitation and valorification of the mineral resources results in the environmental perturbation with large scale ramifications. Although mining activities directly affects a relatively limited area of terrestrial land, its impacts on the environment, as well as on public health, may be found at greater distances from the source and for a long period[2,3]. Mining is achieved through several activities from exploration through exploitation to processing and finally to the consumer. Through every phase of the mining activity, extensive man-made damage is caused to the environment[4]. Due to improper planning and negligence of regulations, mining activities results in an appreciable damage, degradation and deterioration of the environment and ecological damage to water, air and soil occurs[5]. The problems caused by mining activities are land degradation, disposal of over burden, deforestation, washing rejects, subsidence, water pollution due to wash off, discharge of mine water, acid mine drainage, coal washing operation, air pollution due to release of gases and dust, noise pollution, mine fires, damage to forest flora and fauna, wildlife habitat destruction and occupational health hazards[6]. The degradation of various environmental factors substantially would aggravate the health problems among the workers and the people living in the immediate vicinity of the mining area. In this regard, the aim of this study was to have a preliminary assessment of the possible effects of mining activities on the environment that might be used as a possible indicator in assessing the effect of mining activities on the public health.

Material and Methods

Study area: The present study was carried out in the Shatabdipuram mining area of Gwalior city, which is a historical city of the state of Madhya Pradesh, India. The mining area is located about 12 kilometers away from the city centre. The study was carried out in the months of march-June. The mining area is known for the extraction of black stone. The processing of the Blackstone is carried out in the same mining area by the crushers who convert the stones into gravel and other materials used for the construction purposes. The total area of the land given on lease for mining purposes is 24.66 hectares, but the present land area under mining is more than the lease area. The mining in the area has been going on for last 12 years. The mining activities employ a lot of heavy machineries like bulldozers, excavators and trucks for the transportation of the material product to the users. The reckless mining in the area presents a drastic exploitation of the natural resources. The faulty practice of mining in the area is so serious that extensive pit mining in the area has exposed the ground water which is being poisoned by the pollutants released from the mining activities. The general description of the study area is given in the table 1.

Data collection and Analysis: Data for the study were obtained from both primary and secondary sources. Primary data were obtained using a combination of methods, including interviews,

questionnaire study, self observations, samplings, experimentation and informal and formal surveys. Frequencies, percentages, mean and standard deviation was calculated after feeding the data into suitable software (ezANOVA software) to derive the required relation between different parameters.

Figure-1
Mining activities in the Shatabdipuram mining area

Table-1
General description of the study area

Particulars	Details
Latitude	26°15'22" - 26°16'11"N
Longitude	78°11'14"- 78°11'54" E
Height above mean sea level	320-295 ft AMSL
Nearest City	Gwalior - 10-12 km
Nearest Airport	Gwalior airport - 1 km
Nearest residential area	DD Nagar- 0.5 km
Hills/Valley	Yes
Ecological Sensitive Zone	No national parks and sanctuary
Reserve Forest	No reserve forest present
Historical Place	A shrine
Annual Climatic Conditions	Max. Temperature – 49.6°C Min. Temperature – 4.0 °C Average Rainfall–1145 mm

Source: Pollution Control Board, Regional office, Gwalior, India

Air Sampling: In order to assess the effect of the mining activities on the ambient air quality, air sampling was carried out for two months, once after ten days, both in the mining area as well as in the local residential area. Handy air sampler MODEL PEM PGS1B was used for the sampling of gaseous pollutants like SOx and NOx and the suspended particulate matter (SPM). The air sampling was carried out for six hours by running the air sampler in the sampling area during the peak hours. A total of six air samplings were carried out both in the mining area as well as in the nearest residential area. After the sampling, the samples were brought into the laboratory for further chemical analysis. The oxides of sulphur (SOx) in the ambient air were assessed by USEPA or spectrophotometric method. The oxides of nitrogen (NOx) were assessed by the Jacob-hoshersier method and the SPM level was estimated by the filter paper method.

Water sampling: Mining activities has a drastic and profound effect on the water quality. The mining activities in the mining area have exposed the ground water which is being polluted by the pollutants released from the mining activities. In order to assess the effect of the mining activities on various parameters of the ground water quality, water sampling was carried out. Two sites were selected in the mining area where extensive pit mining has exposed the underground water. The sites, site 1 and site 2 designated as S1 and S2 respectively were selected in the mining area. A third sampling site was chosen, which is a tube well located about half an kilometer away from the mining area. The samples from this tube well were regarded as control (C). Collection and sample handling were conducted in accordance to standard methodology for the sampling and analysis of the analyzed parameters. Two water samplings were carried out at a gap of one month. The samples were collected and brought in the laboratory for rigorous water quality estimation. The chemicals used in the water quality analysis were of GR/AR grade. Standard methods of American Public Health Association (APHA 20th edition) were used for the analysis of water samples[7]. The sampling locations were chosen carefully so as to assess the effect of mining on the ground water quality. The description of the sampling sites is given in the table 2.

Table-2
Description of the water sampling sites

Sample code	Place of sample collection
SITE 1	Ground water exposed by intensive pit mining
SITE 2	Ground water exposed by intensive pit mining at second place
Control	Water sample collected from a tube well (boring) about half an Km away from the mining area

Noise level assessment: Noise pollution is one of the main nuisances created by the mining activities[8]. The noise pollution ranges from the noise by the vehicles, bulldozers and excavators to the noise from blasting using explosive material to get the rocks from the mines. Noise has serious implications for the workers working in the area in general and the residents dwelling in the nearest residential area in particular[9]. The noise level in the area was measured by using Noise Level Meter model SL 4010. The noise measurement was conducted in the working hours in the mining area at three sites (site 1, site 2 and site 3) which were heavily occupied by the mining machinery. Ten readings were recorded at each site with duration of five minutes between two consecutive readings. Average, maximum and minimum values were calculated and compared with the standards prescribed by the Central Pollution Control Board.

Health impact assessment: The mining activities have large scale ramifications for the health of not only the workers who are associated with this industry but also the local residents which are living in the close vicinity of the mining area[10, 11]. The health problems range from respiratory problems, digestive problems to psychological problems. In order to assess the health impacts of the mining activities, a questionnaire survey was conducted in the nearest residential area. Hundred respondents of different age groups and gender were randomly selected and questioned to know their response regarding the problems faced by them due to the mining activities going on in the area.

Results and Discussion

A total of 18 water samples were collected and subjected to analysis to assess the effect of mining activities on the water quality. The observed values of various water quality parameters were compared with the BIS (Bureau of Indian Standards) standards to assess the effect of the mining on the water quality. The values of the analyzed physico-chemical parameters of water are given in the table 3.

Table-3
Effect of mining activities on the physico-chemical parameters of water from different sites

Different physicochemical parameters of water	Units	First sampling			Second sampling			BIS standards for drinking water
		Site 1	Site 2	Control	Site 1	Site 2	Control	
1.pH		7.21	7.26	7.51	6.98	7.15	7.05	6.5-8.5
2.Conductivity	µmhos/cm^2	842	874	222	914	972	254	600
3.Turbidity	NTU	15	18	8	17	22	9	5
4.TDS	mg/l	1.97	2.13	0.57	2.32	2.56	0.60	0.50
5.Total Alkalinity	mg/l	300	312	552	285	297	437	200
6.Free CO_2	mg/l	26.4	44.0	40.92	28.6	35.2	22	60
7.Total Hardness	mg/l	712	776	148	884	914	186	300
8hloride	mg/l	99.4	106.5	142	146	188	103	250
9. Fluoride	mg/l	1.5	**2.7**	1.3	1.5	**2.8**	1.2	1.5
10. DO	mg/l	4.1	3.2	5.2	3.8	4.8	6.9	5.0-6.0
11. BOD	mg/l	19	28	6	26	37	7	2-3
12. Oil and grease	mg/l	25.3	46	Nil	29.2	52.6	Nil	Nil
13.Nitrate	mg/l	52	67	27	53	66	27	45

Hydrogen ion concentration (pH): pH indicates the intensity of acidic or basic character at a given temperature. The pH of the water samples were found in the range of 7.21 – 7.51 in the first sampling and in the range of 6.98- 7.15 in the second sampling. All the sampling sites have pH in within the suitable and desirable range.

Electrical conductivity: Electrical conductivity is a measure of the ability of an aqueous solution to carry an electric current. It depends on the presence of ions, on their total concentration, mobility and temperature of measurement. Higher value of conductivity shows higher concentration of dissolved ions. Conductivity of water samples were found in the range of 872-874 µmhos/cm^2 in the first sampling and 914-972 µmhos/cm^2 in the second sampling. The conductivity of the water samples from the control site was 222 µmhos/cm^2 and 254 µmhos/cm^2 in the first and second sampling respectively. The conductivity of the water samples from the site 1 was 842 µmhos/cm^2 and 914 µmhos/cm^2 in the first and second sampling respectively. Similarly, the conductivity of the water samples from the site 2 was 874 µmhos/cm^2 and 972 µmhos/cm^2 in the first and second sampling respectively. Water samples from both the sites which are affected by the mining activities possess the electrical conductivity above the prescribed standards.

Turbidity: Turbidity, a key water quality test, is the cloudiness of the water which is an indication of the presence of suspended materials such as clay, silt, finely divided organic material, plankton, and other organic and inorganic materials. The turbidity of the water samples affected by the mining, was recorded in the range of 15 -18 NTU in the first sampling and 17-22 NTU in the second sampling, which is very much above the prescribed standards. The turbidity of the water samples from the control site was recorded as 8 NTU and 9 NTU in the first and second sampling respectively and these values are below the prescribed standards.

Total dissolved solids (TDS): The concentration of total dissolved solids in the water samples from the mining area was recorded in the range of 1.97-2.13 mg/l and 2.32-2.56 mg/l in the first and second sampling respectively. The values are more than the prescribed standards. However the TDS of the water samples from the control site was found nearly in compliance with the prescribed standards.

Total alkalinity: Total alkalinity of the water samples from the mining area was found in the range of 300-312 mg/l and 285-297 mg/l in the first and second sampling respectively. The total alkalinity of the water samples from the control site recorded as 552 and 437 mg/l in the first and second sampling respectively. The total alkalinity of the water samples from the mining area was found above the standard but below that of the water samples from the control site which shows the more acidic nature of the water samples affected from the mining area.

Free CO_2: Free CO_2 in the water samples from the mining area was observed in the range of 26.4 – 44.0 mg/l and 28.6 - 35.2 mg/l in the first and second sampling respectively. The free CO_2 in the samples from control site was recorded as 40.92 and 22 mg/l in the first and second sampling respectively. These findings clearly indicated that free CO_2 level in all the samples was below the prescribed standards.

Chloride: The chloride level in the water samples from the mining area was recorded in the range of 99.4 - 106.5 mg/l and 146 – 188 mg/l in the first and second sampling respectively. The chloride level in the water samples from the control site was 142 mg/l and 103 mg/l in the first and second sampling respectively. The chloride level of all the water samples including the water sample from the mining area as well as the water samples from the control area was found below the prescribed standards.

Fluoride: The value of fluoride in the water samples taken from the mining area was found in the range of 1.5-2.7 mg/l and 1.5 – 2.8 mg/l in the first and second water sampling respectively. These values are very high above the permissible limits. However the fluoride level in the water samples from the control area was found below the standards. The highest fluoride was observed in the water samples from site 2 (S2) which was 2.7 mg/l in the first sampling and 2.8 mg/l in the second sampling. A fluoride concentration of approximately 1.0 mg/l in drinking water effectively reduces dental caries without harmful effects on the health. Fluoride may occur naturally in water or it may be added in controlled amounts. Sometimes fluorosis may occur when the fluoride level exceeds the recommended limits[12].

Dissolved oxygen (DO): Dissolved oxygen is an important water quality parameter indicating the quality of water. The values of DO were observed in the range of 3.2-4.1 and 3.8 – 4.8 mg/l in the first and second water sampling which is below the desirable standards. The DO level in the water samples from the control area was recorded as 5.2 and 6.9 mg/l in the first and second sampling respectively. These values are in compliance with the desirable standard.

Biochemical Oxygen Demand: Biochemical oxygen demand is a valuable water quality parameter. BOD is a measure of the dissolved oxygen needed by aerobic biological organisms in water to break down the organic matter present in a water sample at certain temperature over a specific time period[13]. It is an index of organic matter susceptible to oxidation having biological origin i.e. dead plant and animal wastes[14]. The value of BOD in the mining affected water samples ranges from 19-28 mg/l and 26-37 mg/l in the first and second sampling respectively. The BOD content in the water samples from the control site was found 6 and 7 mg/l in the first and second sampling respectively. The BOD values recorded at both the sites, site 1 and site 2 were very high representing high organic pollution of these sites due to mining activities.

Oil and grease: Oil and grease present in the water samples represent the contamination caused by the petrol, diesel and other hydrocarbon fractions spilled from the machinery and washed down by rain. The oil and grease content in the water samples from the mining area was recorded in the range of 25.3-46 mg/l and 29.2-52.6 mg/l in the first and second sampling respectively. Oil and grease was totally absent in the water samples from the control site. Oil and grease represents an extreme water pollution as it can pollute the whole water table and can significantly make the water unfit for drinking purposes.

Nitrate: The value of nitrate in the water samples from the mining area ranges from 52 – 67 mg/l and 53 – 66 mg/l in the first and second sampling respectively. The nitrate content in the water samples from the control site was recorded as 27 mg/l in both the samplings. The nitrate level in the water samples from the mining area was above the prescribed standards. The level of nitrate in the water is very dangerous as it can cause a dreadful disease- methaemoglobinaemia, also known as blue-baby syndrome, which mostly affects the children under three months of age[15].

Effect on air quality: The mining activities have a marked and profound effect on the air quality both in the mining area as well as in the nearest residential area. The effect of the mining activities on the ambient air quality is shown in the table 4.

Table-4
Effect of the mining activities on the ambient air quality in the mining as well as in the residential area

Sampling No.	Unit	Concentration of various air pollutants in the mining area			Concentration of various air pollutants in the residential area		
		SOx	NOx	SPM	SOx	NOx	SPM
1	**µg/m^3**	166.6	175.5	601.6	112.5	125.7	314.5
2	**µg/m^3**	183.7	201.3	693.8	127.3	141.1	361.9
3	**µg/m^3**	214.4	232.0	753.6	102.4	131.5	311.7
Average		188.2	202.9	683	114.06	132.7	329.3
CPCB Ambient air quality standards		**120**	**120**	**500**	**80**	**80**	**250**

The results clearly indicated that mining activities have a profound effect on the ambient air quality. The air quality parameters like SOx, NOx and suspended particulate matter was observed above the standards both in the mining area as well as in the residential area. The values of the SOx observed in all the samplings were observed in the range of 166.6 – 214 $\mu g/m^3$ in the mining area and in the range of 102.4 – 127.3 $\mu g/m^3$ in the residential area. Similarly the values of NOx observed in all the samplings was observed in the range of 175.5 – 232.0 $\mu g/m^3$ in the mining area and in the range of 125.7 – 141.1 $\mu g/m^3$ in the residential area. The concentration of the suspended particulate matter ranges from 601.6 – 753.6 $\mu g/m^3$ in the mining area and in the range of 311.7 – 361.9 $\mu g/m^3$ in the residential area. The parameters observed were above the prescribed standards by Central Pollution Control Board both in the mining as well as in the residential area. Similar results were also recorded by various researchers for Indian coal mining areas[16, 17]. The impairment of ambient air quality in the residential area is more serious as significant number of population is living in this area. The ambient air quality was seriously affected by the mining activities not only in the mining area but also in the nearest residential area. These pollutants can be a health hazard, exacerbating various respiratory disorders not only the workers but also with the common masses living in the nearest residential area[18].

Noise level: The ambient air quality standards for noise level (which has been described as an air pollutant under section 20 of the amended Air Pollution Act of 1987) in the industrial region prescribed by Central Pollution Control Board are 65 dB (A)[19]. The noise level recorded at all the three sites in the mining area recorded a noise level which exceeded the prescribed standard level. All the three sites recorded an extremely high level of noise in the working hours. The highest as well as the lowest noise level was recorded at site 2 which was 108.7 and 89.5 dB (A) respectively. The noise level recorded at site 1 was in the range of 94.3 – 106.5 dB (A). The noise level recorded at site 2 was in the range of 89.5 – 108.7 dB (A). The noise level recorded at site 3 was in the range of 95.1 – 106.7 dB (A) (table 5). The workers working in the area are exposed to this high level noise and hence have to face the hazards associated with noise pollution. Not only the workers, the persons living in the nearest residential area also got seriously affected by the noise produced from the mining activities.

Health impacts: Mining activities has a large scale health effects. The subjective response was collected from 100 respondents randomly selected from the persons living in the residential area. The results of the questionnaire interviews revealed that a significant number of the respondents were affected by the air pollution generated from the mining area. The findings revealed that 38% of the respondents reported the problem of suffocation, 73% reported eye irritation, 67% reported sore throat, 65% reported cough, 37% reported chest pain and 21% of the respondents complained of sneezing. As far as the problems by the noise are concerned, 74% of the respondents felt annoyed, 43% reported problem of headache, 73% reported irritation, 18% reported mental disturbance and 23% of the respondents reported sleeplessness. As far as the problems created by the blasting in the mining area is concerned, 100% of respondents reported that the blasting causes shaking of the houses and other buildings and cause disturbance among the inhabitants. The health effects caused by the mining activities and the pollutants created from it are given in table 6.

Table-5
Noise level recorded at different sites in the mining area

Sites	I	II	III	IV	V	VI	VII	VIII	IX	X	Average ± S.D.
Site 1	**106.5**	95.5	103.2	94.5	97.2	101.4	99.8	96.4	101.7	**94.3**	99.05± 4.11
Site 2	100.8	100	99.9	**108.7**	94.5	93.6	98	**89.5**	97.6	96.6	97.92±5.12
Site 3	100.2	99.7	105.2	103.1	98.4	99.3	**106.7**	**95.1**	98.2	102.3	100.82±3.50

Table-6
Subjective response of various respondents in percentage

Questions	Percentage
(1). Problems created by air pollution	Suffocation 38%, eye irritation 73%, sore throat 67%, cough 65%, chest pain 37%, sneezing 21%
(2). Problems created by noise pollution	Annoyance 74%, headache 43%, irritation 73%, mental disturbance 18%, sleeplessness 23%
(3). Shaking of houses by blasting	Yes 100%

Conclusion

Extraction and processing of mineral resources plays a pivotal role in the national economy of many developed and developing countries of the world. However, various environmental problems caused by mineral exploitation such as abandoned mines, biodiversity damage, use of hazardous chemicals with potential health risk to mine workers and neighborhood communities deserved timely attention and intervention. The present study conducted at the mining industry of Shatabdipuram revealed that the various mining operations have a drastic and a strong negative effect on the local environmental quality. The concentration of various pollutants present in water and air is above the prescribed standards. Noise level created by various operations is also above the prescribed standards, which has made the mining industry noisy. The combined effects of above environmental problems have resulted into health problems with high prevalence of diseases such as respiratory tract infections and health problems related with noise pollution in the local area. The need of the hour is to implement strong legislative measures to curb various negative environmental effects caused by the mining activities in the area. Adoption of sustainable technology and environmental friendly procedures can substantially alleviate the negative consequences of the mining operations. Of course, the impacts of mining are many, not inevitable, but rather, possible to mitigate with appropriate regulation and enforcement, imposing accountability for local environmental and health quality, so that this robber industry can turn out to be a sustainable one.

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