Recent Research in Science and Technology 2010, 2(3): 50-57
ISSN: 2076-5061
www.recent-science.com

POLLUTION & ENVIRONMENTAL SCIENCES

ENVIRONMENTAL IMPACTS OF MINING ON BUNDELKHAND REGION OF UTTAR PRADESH, INDIA

Gayatri Singh and Amit Pal*
Institute of Environment & Development Studies, Bundelkhand University, Jhansi 284 128, India

Abstract
Surface mining creates more pollution in comparison to underground mining. This paper highlights the impact of mining on air, water and human health in and around the mining areas of Jhansi, Bundelkhand region, India. The possibility of leaching contaminants from the ore material kept in the open ground or from the wastages or degraded ore material produced during the mining processes may contaminate the groundwater in the study area. The mining activity comprising drilling, blasting, loading of waste, transport of overburden and crushing of ore is having considerable impacts on the air environment and well being of living organism. Mining either by opencast or by underground methods damages the water regime and thus causes a reduction in the overall availability of water in and around the mining areas. This study showed that the ground water and surface water was alkaline in nature. Mineral handling, mineral preparation and associated activities mainly contribute RSPM and SPM to the surrounding environment. The minimum and maximum value of RSPM and SPM was 173.1 μg m-3 to 212 μg m-3 and 462.4 μg m-3 to 521.3 μg m-3 respectively. High levels of suspended particulate matter increase respiratory diseases such as chronic bronchitis and asthma causing health hazards to the exposed population. Metals like Cd, Mn, Pb, Cu, Fe and Si concentrations were found to the above permissible limit at some places in different seasons and may cause health hazards in existing environment.

Key Words: blasting, chronic bronchitis, heavy metals, health hazards, overburden.

Introduction

All the operations can disturb environment of the area in various ways, such as removal of mass, change of landscape, displacement of human settlement, flora and fauna of the area, surface drainage, and change in air, water and soil quality. Air quality status in Indian environment is dominated by SPM causing great concern to environmental planners (Ravindra, 1991). Mining operations in general have adverse environmental impacts (Ghose, 1989). Underground mining impacts directly on the health of those working underground, but opencast mining creates wider air quality deterioration due to dust and gaseous pollutants in and around the mining complexes. The dust can also pollute nearby surface waters and stunt crop growth by shading and clogging the pores of the plants. The effects of dust clouds and deposition are both visible and tangible in communities around industrial activities or construction sites (Hall et al., 1993; Fuglsang, 2002). Dust not only deteriorates the environmental quality in and around mining areas but also creates the serious health hazards of living being.

The enormous consumption of water required by mining activities generally reduces the availability of water in and around mining areas. Mining and, particularly, the extraction of rock and minerals in open mining have always been considered aggressive activities with a high and negative impact on the environment. Mining is also a major activity causing water pollution (Allen et al.1996; Choubey, 1991; Galero et al. 1998; Ratha and Venkataraman, 1997). The clean mining will have nil to marginal impact. The pH of the water may go up to 8.0. The presence of heavy metals such as Mn, Ni, Fe, Cu, Si and Pb in high concentration in groundwater can cause an adverse effect on human health and making that water may not be potable. This excess metal amount must be attributed to an anthropogenic source associated to mining and cutting operations. Leaching of heavy metals is possible during the rainy season to the surface water bodies as well as to the groundwater systems. Health and safety risks associated with small and large-scale mining are complex, and dependent upon the mineral mined, depth of mining, and its scale. It is well documented that chronic and, in some cases, acute exposure to dust containing silica can cause serious health problems.

Materials and methods

Description of the study area

Jhansi is one of the important districts out of the five districts of Bundelkhand region of Uttar Pradesh.

* Corresponding author, *Email*: apu13@rediffmail.com

Bundelkhand region occupies almost 70,000km^2 of the central plains in India. The Bundelkhand rock massif covers about 26000 sq km of the total area of the southern Uttar Pradesh and north-eastern Madhya-Pradesh in central India and forms the northern fringes of the Peninsular Indian shield (Figure - 1). The district of Jhansi lies in southwest portion of Jhansi division of Uttar Pradesh state of India between $25^{0}30^{/}$ and $25^{0}57^{/}$ N latitude and $78^{0}40^{/}$ and$79^{0}25^{/}$ E longitudes. The present study area of the district according to survey of India is 5,024 km^2. Jhansi falls under a semi arid climate, with two main seasons: Monsoon and Dry. Mining is an essential activity that provides the raw material of society and Jhansi is one of the important granite mining centres in the region (Figure – 2). Due to lack of proper adequate preventive measures, granite mining has caused serious negative impacts on the environment and on human health in and around existing mining areas. In Jhansi granite mining is done mainly through the open cast mining by manual methods because of the following reasons; (1) it requires less mining investment (ii) mechanization is likely to prove inefficient (iii) availability of cheap labour, *etc*.

Sampling of SPM and RSPM

Air quality survey was carried twice a month covering the post monsoon (October) and winter (January) seasons for four weeks in each seasons. Ambient air quality samples were collected each day for 24h in three 8h shifts, corresponding to day time(6-14h) evening (14-22h) and night time (22-6h).For the collection of samples of suspended particulate matters (SPM), glass fibre filter paper was used in a high volume sampler (HVS). Air samples were drawn at the flow rate of 1.0-1.5m^3 min^{-1}, which allows the SPM to deposit on the filter paper. Particulate with size range 0.1-100 μm diameter collected .Respirable dust sampler was used for the collection of respirable particulate matters (RSPM).The cut point diameter of RDS was less than 10 μm. Both HVS and RDS were manufactured by m/s Envirotech Ltd., New Delhi.

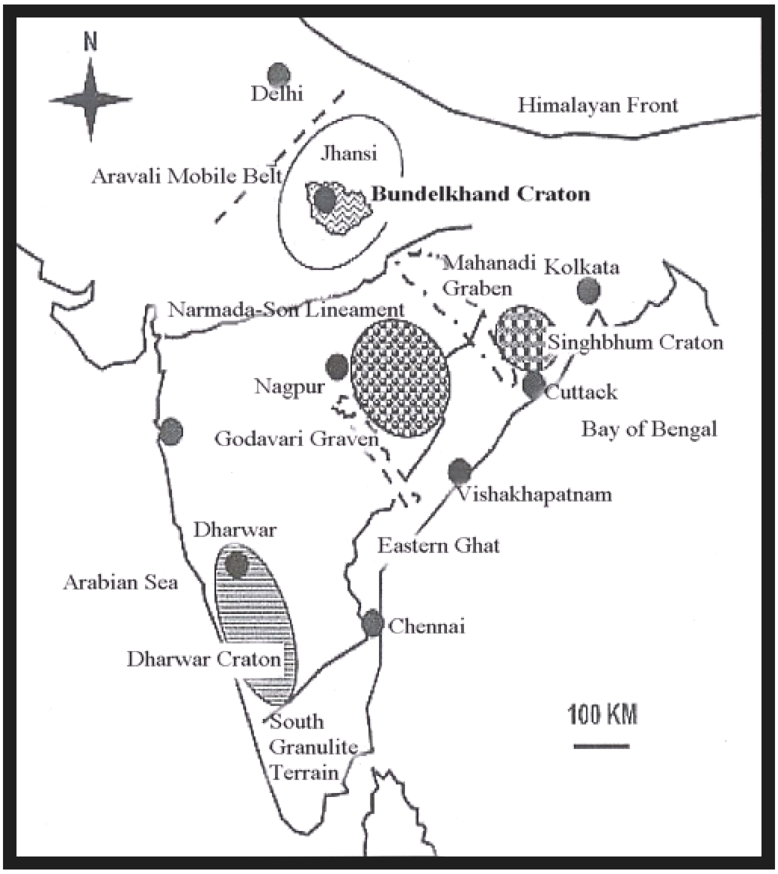


Figure 1 : Location map of Bundelkhand region and their geological tectonic setup

Information pertaining to the health effects of granite mining on the mine workers and the local residents in the nearby villages were survey with the help of a structured Questionnaire. The information collected include, respiratory, eye, hearing loss, skin, accident and others. Various informal interviews with miners, mining officials, government officials, and local community members (around the source of air pollution) were conducted during the study period. An attempt has been made to correlate the health effects of the mine worker and the local residents with the ambient air quality existing in the area. A total of 150 mine workers, were selected randomly within the age group of 35-60 year. All the workers had been working in the mining area for not less than 8 years at the time of survey. Out of 102 respondents 40 were female workers. In granite mining, the involvement of female workers is very less and is mainly restricted in the granite crushing and allied activities. Information pertaining to the study was also collected from different Governmental and Non Governmental sources.

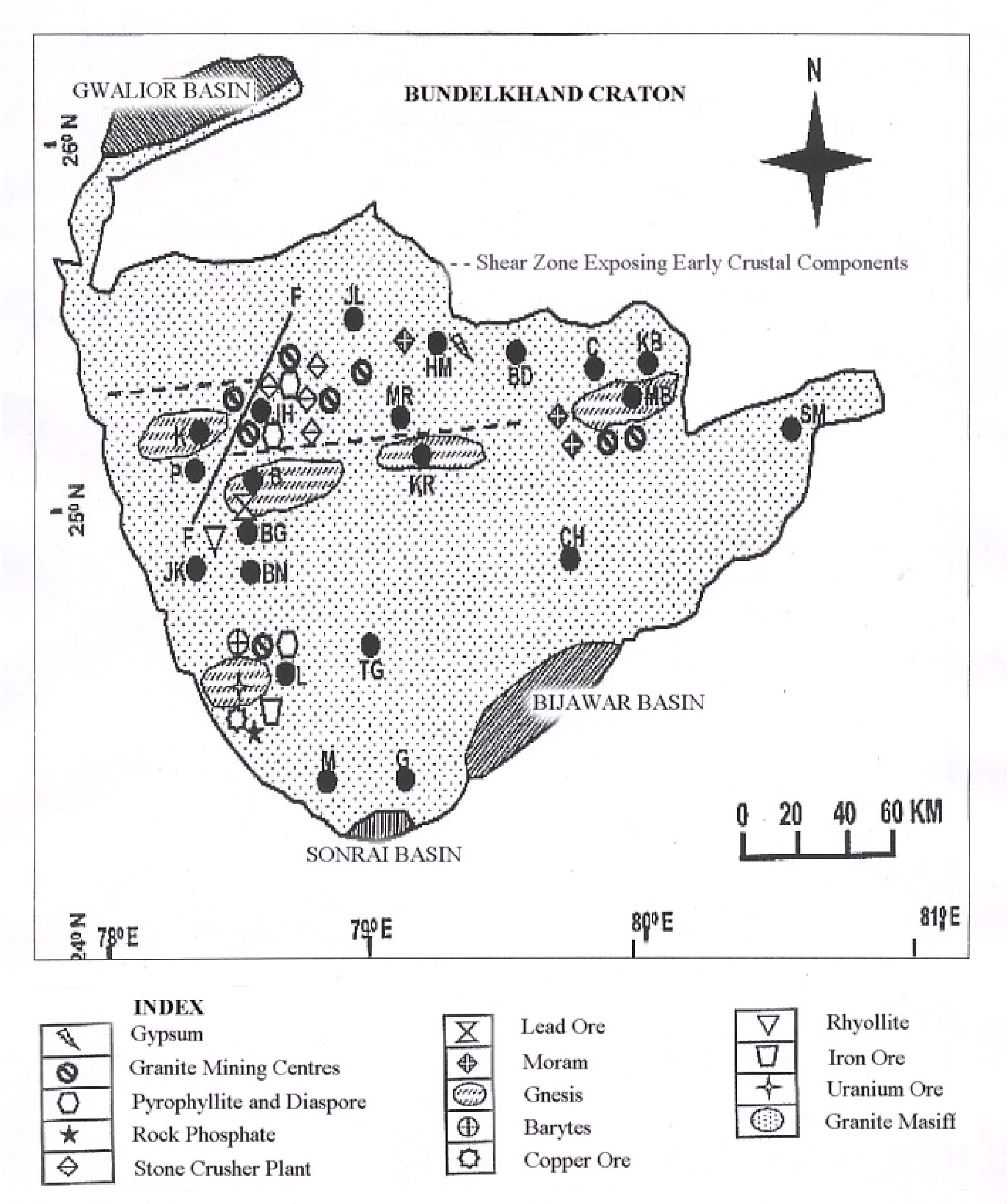


Figure 2: Map showing the mineral and granite deposits in Bundelkhand

Sampling of water

The water samples were collected from the hand pump and tap water in and around Gora machiya mining areas. After filtration and preservation with acidification with HNO_3 the water samples were stored in plastic bottles of polyethylene (250 mL), and finally analyzed in order to determine the following heavy metals contents: Cd, Pb, Mn, Fe, Si and Cu. Electrical conductivity (EC) and pH values were measured in the field using a portable conductivity and pH meter.

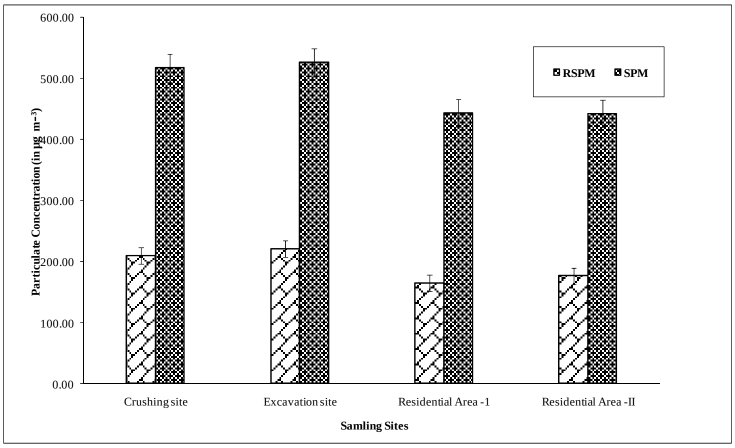
Results and discussion

The concentration of the RSPM recorded in the study areas ranged between 173.1 to 212.3 μg m^{-3} (Table 1). The values of RSPM in both the residential areas exceeded the National Ambient Air Quality Standards prescribed for residential areas by the Central Pollution Control Board (CPCB). Residential area –I (RA-I), has slightly lower values of RSPM (173.1 μg m^{-3}) compared to the Residential area –II (RA-II), that has mean RSPM value of 183.8 μg m^{-3}. Both the residential areas under study are located close to granite crushing sites and have crushing machines within a radius of half a kilometre. In RA-I, the nearest crushing site was enclosed by a thick cover of tree and vegetative plantation where as the nearest crushing site in case of RA-II was devoid of any vegetative enclosure, this probably might have attributed to the slightly higher RSPM in RA-II. It was also found that the stone crushing site was more polluted with RSPM compared to the excavation sites (Figures 3-5). The average values of RSPM recorded in the Granite crushing site and the granite excavation site was 209.89 and 203.78 μg m^{-3}, respectively. Both these values exceeded the National Ambient Air Quality Standards (NAAQS) prescribed (150 μg m^{-3}) for industrial areas by the Central Pollution Control Board (CPCB), New Delhi.

Table 1 : Concentration of RSPM and SPM in and around Gora Macchiya Mining site

Sampling sites	RSPM (μg m^{-3})		SPM (μg m^{-3})	
	Average	Range	Average	Range
Granite crushing site	212.3 ± 0.718	(193 – 236)	518.0 ± 0.487	(498 – 538)
Excavation site	205.2 ± 1.041	(162 – 245)	521.3 ± 0.703	(489 – 547)
Residential Area – I	173.1 ± 0.776	(158– 202)	462.4 ± 1.262	(404 – 505)
Residential Area – II	183.8 ± 0.929	(159 – 214)	467.0± 0.776	(421 –500)

Figure 3: Showing the concentration of RSPM and SPM in different locations during the month of October



During the same period of sampling, corresponding concentration of the SPM recorded in the sampling stations ranged between 462.4 and 521.3 μg m^{-3}. The RA-II was found more polluted (467.00 μg m^{-3}) with SPM compared to the RA-I (462.4 μg m^{-3}). The values of SPM in both the residential areas exceeded the NAAQS (200 μg m^{-3}) prescribed for residential areas by the CPCB. Out of the two major working sites the excavation sites (521.3 μg m^{-3}) was more polluted with SPM compared to the Stone crushing sites (518.0 μg m^{-3}). The SPM pollution in the excavation site was within the values prescribed by the NAAQS prescribed (500 μg m^{-3}) for industrial areas, but the pollution level in the crushing site exceeded the prescribe limits given by the CPCB. All major opencast mining activities produce dust and granite mining is not an exception. Most major mining activities contribute directly or indirectly air pollution (Kumar *et al.*, 1994; CMRI, 1998). Sources of air pollution in mining areas generally include drilling, blasting, overburden loading and unloading, road transports and losses from exposed overburden dumps (CMRI, 1998). Drilling and blasting in the granite excavation sites, loading, transport, crushing in granite crushing sites and overburden dumps are the main sources of particulate pollution in and around the mining sites in Jhansi.

Figure 4 : Showing the concentration of RSPM and SPM in different locations during the month of November

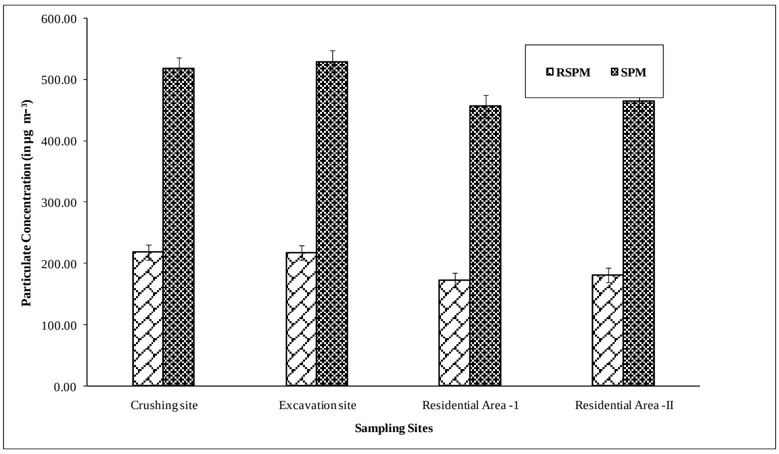


Figure – 5: Showing the concentration of RSPM and SPM in different locations during the month of December

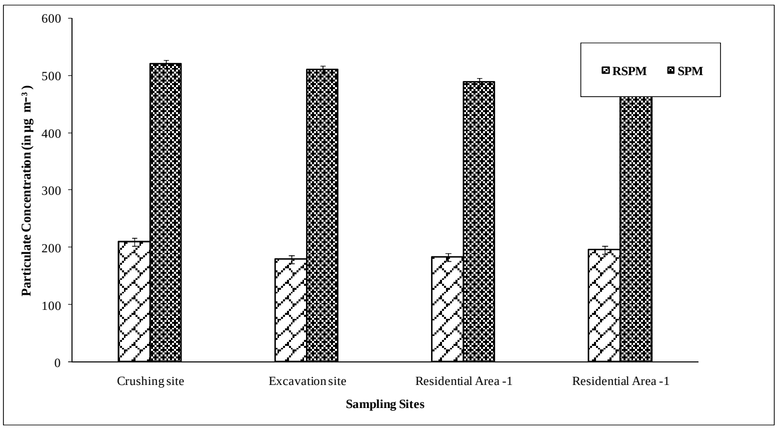


Figure 6: Showing the Health impact of human being in and around Goramachiya Mining area.

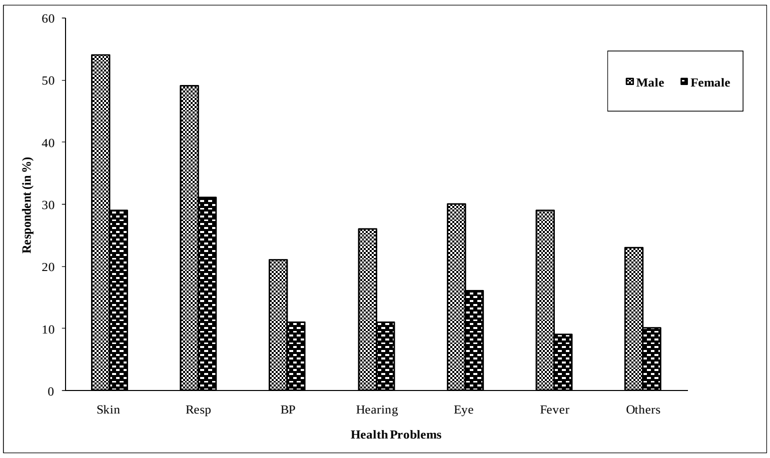


Table 2: Physico-Chemical Properties of Ground water and Surface water in and around mining areas of Goramachiya village (values are in mgL^{-1} except pH and EC)

S.No.	Pre-Monsoon GW Average	Pre-Monsoon SW Average	Monsoon GW Average	Monsoon SW Average	Post Monsoon GW Average	Post Monsoon SW Average
DO	1.72 ± 0.044	2.85 ± 0.133	1.79 ± 0.020	1.96 ± 0.048	1.97 ± 0.041	3.03 ± 0.144
BOD	1.49±0.0326	2.63±0.0808	1.62±0.039	1.76±0.0534	1.81±0.0486	2.90±0.1217
pH	7.02 ± 0.039	7.2 ± 0.048	7.10 ± 0.03	7.1 ± 0.0260	7.21 ± 0.024	7.3 ± 0.0484
EC	931.6 ±0.248	377.9 ±0.057	636.7 ± 0.043	325.0 ±0.046	454.2± 0.071	538.9 ±0.045
Alkalinity	91.9 ± 0.074	56.8 ± 0.104	75.9 ± 0.145	56.8 ± 0.161	85.7 ± 0.060	70.4 ± 0.970
Ca^{++}	254.3 ± 0.054	121.0 ±0.084	126.14±0.038	109.3 ±0.099	194.3 ±0.040	101.5 ± .056
Mg^{++}	112.2 ± 0.064	124.8 ±0.153	153.4 ± 0.065	50.6 ± 0.107	249.3 ±0.080	113.4 ±0.831
TDS	342.3 ± 0.049	239.6 ±0.035	517.7 ± 0.035	203.9 ±0.046	514.6 ±0.031	515.3 ±0.029

The variation of SPM and RSPM in the four sampling stations for the month of October to December is depicted separately in Figures 3.5. In general the SPM load in all the sampling stations was larger than the RSPM concentration and this is as per expectation.

In general, the mean pH values of all the location lie more or less within the permissible limits of WHO (6.4–8.2). The variations in pH are relatively small. However, the values reveal the slight alkaline nature of the ground water (GW) and surface water (SW). The condition of dissolved oxygen (DO) is slightly complicated since in contrast to other pollutants, the quality of water is enhanced if it contains more oxygen. An ideal DO value of 5.0 mg/l is the standard for drinking water (Bhanja and Patra, 2000). In natural waters, DO values vary according to the physicochemical and biological activities. The DO values of all the three profiles are below the permissible limits of WHO (6 ppm). This indicates that the effluent of mining containing high organic pollutants have invaded the ground water which decreases the dissolved oxygen content as a result of microbial activities. This is because organic wastes (carbohydrates, proteins, etc.) act as a medium for microbial multiplication (Sharma and Pande, 1998). The characteristics of the groundwater or surface water are presented in Tables 2 and 3.

These tables clearly shows that the water qualities are not within the permissible limit, Fe concentration is more in the groundwater as well as surface water samples in during Post Monsoon and Monsoon and in the Pre monsoon period due to the top lateritic soil cover which itself is of ferruginous in nature.

Table- 3: Concentration of Heavy metals (mgL-1) in Ground water and Surface water in and around mining areas of Goramachiya village

S.No.	Pre-Monsoon GW Average	Pre-Monsoon SW Average	Monsoon GW Average	Monsoon SW Average	Post-Monsoon GW Average	Post-Monsoon SW Average
Cd	0.085±0.231	0.054 ±0.209	0.036 ± 0.0011	0.030 ± 0.0125	0.049 ±0.0193	0.048 ±0.001
Cu	0.02 ± 0.008	ND	0.061 ± 0.0014	0.049 ± 0.0009	0.040 ± 0.001	0.050 ±0.001
Fe	0.14 ± 0.017	0.144 ± 0.011	0.133 ± 0.0007	0.132 ± 0.0009	0.14 ± 0.0007	0.13 ± 0.001
Mn	0.12 ± 0.001	0.150 ± 0.108	0.103 ± 0.205	0.177 ± 0.029	0.048 ± 0.001	0.06 ± 0.001
Pb	0.193 ± 0.05	0.132 ± 0.1319	0.145 ± 0.1216	0.129 ± 0.042	0.129 ± 0.001	0.13 ± 0.001
Si	0. 518 ±0.012	0.486 ± 0.011	0.556 ± 0.012	0.696 ± 0.111	0.640 ± 0.006	0.726 ± 0.004

The desirable limit of Fe is 0.3 mg/l and maximum permissible limit is 1.0 mg/l as per Indian standards. If water content more than these limit gives brackish color and bitter or metallic taste, therefore may not be use for drinking purposes. Concentrations of Cu in GW and SW samples varies from 0.029 to 0.088 mg/l and 0.039 to 0.062 in all the three seasons indicates that samples have more than permissible limit of Cu (<0.05 mg/l). High concentration of Cu in water causes digestive disturbance, liver and kidney damage and the source is industrial or mining waste. Similarly, the Cd contents also varies 0.027 to 0.064 mg/l and 0.013 to 0.059 mg/l in GW and SW in all the three seasons which have been found more than permissible limit of Cd (0.01 mg/l), in potable water

(WHO, 1984), beyond this the water become toxic. Concentration of Mn in GW as well as SW in all the three seasons are also more than permissible limit. Pb and Si concentrations are also found very high in GW and SW. The health effects of these metals are neurotoxic and three human system are most affected: blood forming system, nervous system (which include irreversible brain damage) and renal system.

The data on various health effects obtained from the current survey for the mine workers and the population inhabiting in and around the granite mining site is illustrated in Figure - 6. Health problems related to skin and respiratory disorder are widely prevalent in the area. Maximum of the respondents complain problems related to skin and respiratory diseases.

A total of 101 respondents have skin problems which comprises of 64 men and 37 women. The common skin problems are dryness of skin, roughness of skin, minor skin infection, etc. Out of the 78 respondents interviewed, 51 men and 27 women have respiratory problems. There are many respiratory diseases that have been documented in the literature as being related to work, either as a direct causal agent or as being aggravated by work exposures (Hendrick, *et al.,* 2002). Some of the respiratory problems encountered in the present survey were silicosis, pneumoconiosis, occupational asthma, chronic obstructive pulmonary disease (including emphysema and/or chronic bronchitis), toxic pneumonitis and hypersensitivity pneumonitis. Crystalline silica is a common but variable component of granite. It is well documented that chronic and, in some cases, acute exposure to dust containing silica can cause serious health problems (IARC, 1997). It has its own brand of pneumoconiosis in the form of silicosis which affects those in constant and heavy contact with this type of dust; within a few years of prolonged inhalation it can result in death. Silica dust also tends to increase the risk to individuals of developing lung cancer, tuberculosis, auto-immune diseases and arthritis.

The digging, blasting and drilling of granite mine generated dust particles of various sizes into the immediate atmosphere. Most of this dust is usually made up of silica (occurring as silicon dioxide SiO_2). Among all the contaminants of the atmosphere in the granite mining areas, dust is probably the most abundant and ubiquitous. Investigations revealed that several workers were not aware of the proper safety procedures. Background noise and vibration is an unavoidable by-product of mining activity often inducing considerable stress on the workforce. The problems related to noise in the granite mining sites at GoraMachiya ranged from sleeping disorder, depression, hearing loss both temporary and permanent. Hearing disorders are mainly complained by the workers involved in the blasting sites. About 26 % and 11 % respectively of the male and female either working or residing around the mining site have hearing disorder. Health problems related to blood pressure changes was common among the workers involved in the granite blasting. However female workers (11 %) do complain problems related to blood pressure, but the exact causes could not be figure out. Problems related to eye disorder and eye infection are a major problem encountered among the mine workers. Around 35 % of the male and 21 % of the female workers have eye problems. Fever and mild illness are common occurrence in both the men (45 %) and women (29%) workers. To sum up, achieving good health and living in a healthy environment are justifiable rights of any person, and should be in the centre of any major governmental policies (Sen, 2001).

Conclusion

This overview of the interactions between surface mining and the environment leads to some fundamental general conclusions. It demonstrates that the industry's environmental problems are interconnected and that they have an international character. The same is true of their remedies. The solutions for environmental problems related to surface mining involve both the mining company and wider community in action at all levels from personal to international/governmental. However, the most important changes seem to be framed in personal/management attitudes and local practices. Environmental problems related to mining, particularly the health aspect is a course of concern taking in consideration the safety of the mine workers and the population residing in the vicinity of mining sites. In Jhansi and in the Bundelkhand region of Uttar Pradesh, India granite mining is one of the main economic activities that engaged many peoples both man and women. Knowing the health status of the workers is essential to devise a framework to improve the health of the workers. The results of the present study shown that the mine workers are prone to diseases such as skin problem, respiratory, eye problem, hearing disorder, fever, etc. At all the locations under study RSPM concentrations exceeded the permissible limits specified by CPCB. The pollution control measures used by the mining authorities are inadequate, and urgent action is required to remediate the pollution problem. High level of Cu, Cd, Fe, Mn, Si and Pb in groundwater indicated the unsuitability of most of these water samples for potable purposes. There is a need for choosing strong environmental health indicators that can be used to address the health issues. Gaining insights into questions of economic development, environmental degradation, and health are critical to building sustained, and effective interventions to bolster health and quality of life, while improving economic livelihood. The surface mining industry in Jhansi is struggling to come to terms with a new world of environmental awareness enforced by increasingly strict regulation and enhanced public accountability.

References

Allen, S.K, Allen, J.M., Lucas, S. (1996). Concentration of contaminants in surface water samples collected in west-central Indiana impacted by acid mine drainage. *Environ. Geol*. 27, 34–37

Bhanja, K., Mohanta, A., Patra, K.U. (2000). Studies on the water quality index of river Sanamachhakandana at Keonjhar Garh, Orissa, India. *Poll. Res.* 19(3), 377–385.

Choubey, V.D. (1991). Hydrological and environmental impact of coal mining, Jharia coalfield, India. *Environ. Geol*. 17, 185–194.

CMRI (1998). Determination of emission factor for various opencast mining activities, *ReportGAP/9/EMG/MOEF/97*, Central Mining and Fuel Research Institute, Dhanbad, India.

Fuglsang, K. (2002). An automatic sampler for measurement of dust deposition rates around fugitive sources. *Journal of Air and Waste Management Association.* 52, 789–795.

Galero, D.M., Pesci, H.E., Depetris, P.J. (1998). Effects of quarry mining and of other environmental impacts in the mountainous Chicam-Toctina drainage basin (Cordoba, Argentina). *Environ. Geol*. 34, 159–166.

Ghose, M. K. (1989). Pollution due to air borne dust particles in coal mining, its monitoring and abatement measures. *Minetech*. 10(1), 91–95.

Ghose, M. K. (2007). Generation and quantification of hazardous dusts from coal mining in the Indian context. *Environmental Monitoring and Assessment*, 130, 35–45.

Hall, D. J., Upton, S. L., Marsland, G.W. (1993). Improvements in dust gauge design. in: Couling, S. (Ed.), *Measurements of Airborne Pollutants*. Butterworth-Heinemann, London.

Harrison, R. M. (1986). Analysis of particulate pollutants. in: Harrison,R.M., Perry, R. (Ed.), *Handbook of Air Pollution Analysis*. Chapman & Hall, London.

Hendrick., D.J., Burge. P.S., Beckett, W. S., Churg, A. (2002). Occupational disorders of the lung. *Recognition, management, and prevention*. WB Saunders,

International Agency for Research on Cancer (1997). IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Silica, Some Silicates, Coal Dust and Para-aramid Fibrils. World Health Organization (WHO) Ed, Lyon 68.

Kolusberg, H. J., Severenes, R. L. (1979). Development of a fugitive assessment sampling train for particulate and organic emissions. *Report No. EPA-600/7–79–181*. Research Triangle Park, NC: USEPA.

Kumar, C.S.S., Kumar, P., Deshpande, V. P., Badrinath, S. D. (1994). Fugitive dust emission estimation and validation of air quality model in bauxite mines, In Khuntia, G.S.,(Ed.), *Proceeding of International conference on Environmental Issues in Minerals and Energy Industry*, IME Publications, New Delhi, India, pp. 77- 81.

Ratha, D.S., Venkataraman, G. (1997). Application of statistical methods to study seasonal variation in the mine contaminants in soil and groundwater of Goa, India. *Environ. Geol.* 29, 253–262.

Ravindra, P. (1991). Studies on suspended particulate matter in an Industrial area*. Indian J. Env. Protection.* 11(5), 358-359.

Sen, Amartya. (2001). Why Health Equity. Keynote Address to the Third International Conference on "*The Economics of Health: Within and Beyond Health Care*," York, July 23, 2001.

Sharma, S. D., Pande, K. S. (1998). Pollution studies on Ramganga river at Moradabad – Physicochemical characteristics and toxic metals. *Poll. Res*. 17(2), 201–209.

Singh, G., Pal, A., Khoiyanbam, R.S. (2009). Impact of mining on human health in and around Jhansi. Bundelkhand region of Uttar Pradesh, India. *J. Ecophysiol. Occup. Hlth*. 9, 47-54.

Vallack, H. W., Shillito, D. E. (1998). Suggested guidelines for deposited ambient dust. *Atmospheric Environment,* 32 (16), 2737–2744.

WHO (1984). Guidelines for drinking water quality, World Health Organization, Washington DC, 333-335.