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Environmental health assessment of stone crushers in and around Jhansi, U. P., India

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Abstract: *The mining and stone crushing activities have considerable effects on the environment quality and human health. The dust emissions contaminate the air and water. Investigations made on air and water quality in areas adjacent to stone crushers around Jhansi have been reported in this communication. Further, impact assessment of health effects in exposed human population has also been made. Results on water analysis show decline in DO and high values of total hardness, calcium, magnesium, chloride, total solids and total dissolved solids. Stone crushing and associated activities mainly contribute to particulate matter in the surrounding environment. The mean minimum and maximum values of SPM at crushing and residential sites were recorded of 1045.49µm/m^3, 1268.6µm/m^3 and 545.86 µm/m^3, 617.2 µm/m^3 respectively. Present investigations show that exposure to dust can cause serious respiratory (45.11%), skin (43.33%), hearing (21.53%), eye (17.8%), dyspnea (14.66%) like health problems. Present study reflects that regulatory measures are urgently needed to protect the environment against pollution caused by stone crusher.*

Key Words: Mining, Environmental contaminant, Health hazard, Environment impact.

Introduction

Mining is a major economic activity in many developing countries. Operations whether small or large magnitude affects the environment, spewing enormous quantities of dust and other pollutants. Mine and stone crushing industry in India has been growing rapidly due to increasing demand from the construction industry. Though reliable statistics are lacking for this industrial sector, it is estimated that there are more than 12000 stone crushers in India which provide direct employment to about 500,000 rural migrant and unskilled workers (Gotesfeld *et al.*, 2008). Stone crushing in India is basically a labour intensive small scale industry, where most of the operations are performed manually (Aslam *et al.*, 1992).Very little information is currently available regarding dust emissions from these units (Singh and Pal, 2010).

All major opencast mining and stone crushing operations release particulate emissions that not only deteriorate environmental quality but also cause serious health problems in man. The conversion of naturally occurring rock into crushed and broken stone products involve a series of distinct physical operations, including quarrying (like drilling, blasting, loading, hauling) and plant process operations (such as crushing, screening, conveying and transfer operations). They are significant sources of particulate emissions .Stone crushing and allied activities generally have a considerable impact on the air, water, land and biological resources as well as socio economic setting of local population. Mining activities always have negative impact on environmental quality (Eggert, 1994; Ripley *et al.*, 1996; Gabler and Schneider, 2000; Karbasi *et al.*, 2007). The magnitude and significance of environmental pollution caused by mining depends on the

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mineral being mined, the methods of mining and various other factors (Ghose, 2007). Weathering of mine waste piles can increase concentration of toxic elements down stream from the mine site as reduced phase in their host minerals oxidize (Lottermoser *et al.*, 1999; Baba and Gungar, 2002).

Exposure to heavy dust concentration from stone crushers may produce several diseases, chief among them being pneumoconiosis (Zenz *et al.*, 1994). Silicosis, caused by inhalation of dust containing silica, is an important form of this disease. Respiratory damage resulting from such exposures can range from reversible functional changes to reversible damage to the lungs and in some extreme exposures, causes lung cancer (Mathur and Chaudhary, 1996).

Mining is also a major activity causing water pollution (Allen and Allen, 1996; Choubey, 1991). Leaching of heavy metals is possible during rainy season to surface and ground water systems. The main reason of pollution of fresh water is acidic water and drainage from mines (Shu *et al.*, 2001). Mining operations with degradation of the land largely contribute to the erosion of soil a phenomenon that can be more in the surface mining activities (Sengupta, 1993).

Environment health assessment of stone crushers especially in Bundelkhand region has not been paid much attention by earlier workers. Since this is the predominant industrial activity of this region, occupational health problems associated with this industry need to be addressed (Singh *et al*., 2009). Present study has been undertaken to evaluate the health status of workers and working environmental conditions in and around stone crushing units of Jhansi district and to assess the water quality, air quality and health status under the operative influence of stone crushers at various study locations.

Materials and Methods

Site/Location: Bundelkhand region is known for its rich deposits of granite, diasporas, sand, etc. Jhansi is one of the important districts out of the seven districts of Bundelkhand region of Utter Pradesh (Fig. 1). The district Jhansi lies in South West 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 area of Jhansi according to survey of India is 5,024 km^2 and there are about 350 stone crushers. Jhansi falls under a semi arid climate with two main seasons' monsoon and dry. Jhansi is one of the important granite mining centers in the region and mining is done mainly through the open cast mining methods because of the two main reasons (I) it requires less mining investment (II) availability of cheap labour.

Sampling: Water samples were collected from three sampling stations. Samples of surface and ground water were collected in the early hours of the day (7 to 11am) during summer season from March-May 2010. For estimation of dissolved oxygen water samples were filled at the site in BOD bottles and chemical analysis was carried out in laboratory within 24 hours. Some of the physico-chemical tests viz: pH, conductivity, total solids, TDS, free CO_2, alkalinity, chlorides, total hardness, calcium and magnesium hardness, BOD and COD were performed (APHA, 2005).

Air quality survey was carried out twice a month. Ambient air quality sampling was carried out in three 8 hour shift for 24 hours. For the collection of suspended particulate matter (SPM) glass fiber filter paper was used in a high volume sampler (HVS Environ tech ltd., New Delhi). Air samples were drown at the flow rate of 1.0– 1.5 m^3/mn which allows the SPM (0.1 – 100 µm) deposit on the filter paper. The information pertaining to health effects caused by stone crushers on workers and the local

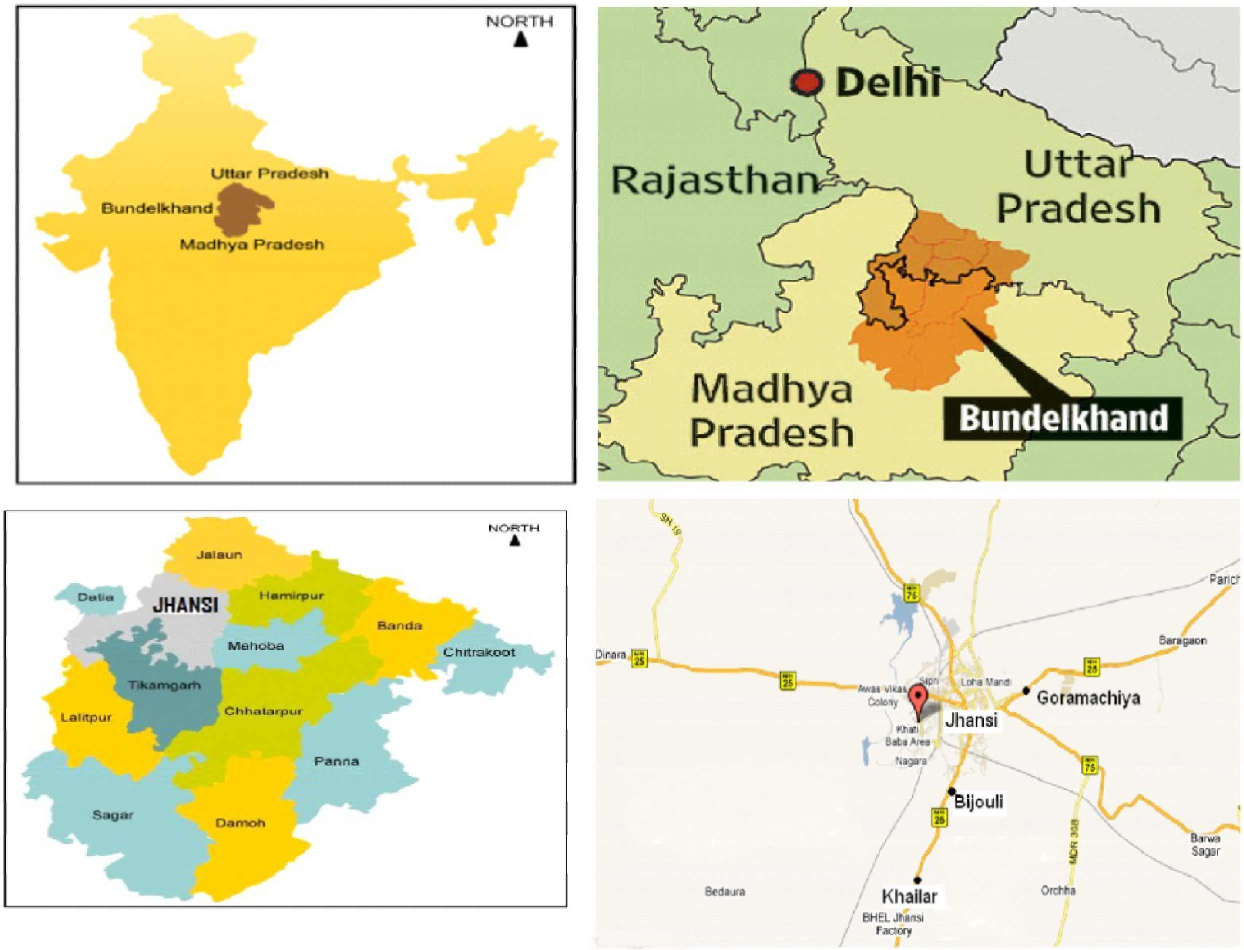

Fig. 1: Location of study sites.

residents in the nearby villages was collected with the help of a questionnaire.

A total of 300 people in the age group of 20-45 years were randomly selected for health survey. The information was collected regarding the respiratory, eye, skin, hearing loss, blood pressure, fatigue, and other symptoms. The involvement of women workers is less and mainly restricted to crushing activities.

Results and Discussion

Water quality assessment*:* The mean values of various physico–chemical parameters of surface and ground water at three study sites are given in Table-1.

Temperature is one of the most important factors and no other single factor has so many direct and indirect influences. A close relationship between air and surface water temperature has been reported in present study. Water temperature depends on air temperature besides climate and topography. There was a significant variation in mean water temperature at three selected sites. Differences in air temperature contribute to difference in water temperature. In general the mean pH values of all the locations lie more or less within the permissible limits of WHO (1984). Variation in pH was relatively small (6.2-8.2). pH is directly dependent on the amount of CO_2 present (Juday and Burdge, 1980) and indirectly proportional to photosynthetic activity (Pandit *et*

Table 1. Water quality at three mining sites of Jhansi.

	Goramachiya		Bijouli		Khailar	
Parameters	SW	GW	SW	GW	SW	GW
Air Temp (^{0}C)	27.67 ±3.48	ND	25.5 ±2.64	ND	32.33 ±4.05	ND
Water temp (^{0}C)	20.16 ±2.77	ND	19.33 ±4.48	ND	24.5 ±3.40	ND
pH	7.6 ±0.115	7.0 ±0.260	7.6 ±0.176	7.02 ±0.252	7.66 ±0.233	7.2 ±0.426
EC (µs/cm)	670 ±65.31	826.7 ±21.40	600 ±59.87	772.6 ±45.62	706.6 ±61.02	900 ±24.58
Total solids (mg/l)	2511.3 ±196.6	1307 ±140.33	2284.3 ±132.94	1127.6 ±67.63	2726.7 ±153.80	1342±56.46
TDS (mg/l)	1884.3 ±81.4	868 ±35.15	1704 ±45.62	756.6 ±60.40	1912.6 ±114.67	949.3 ±150.49
Free carbon dioxide (mg/l)	4.73 ±0.66	2.53 ±0.352	4.13 ±0.786	2.56 ±0.554	4.93 ±0.592	2.53 ±0.59
Total alkalinity mg/l	133 ±7.234	166.7 ±8.51	134 ±13.31	169.3 ±18.8	156 ±14.42	189.3 ±17.37
Chlorides (mg/l)	15.4 ±1.065	11.2 ±0.529	13.9 ±1.143	9.56 ±1.134	17.03 ±1.039	11.8 ±0.611
Total hardness (mg/l)	381.3 ±25.54	264 ±60.10	337.3 ±23.91	405.3 ±11.09	377.66 ±9.02	432.7±11.79
Calcium hardness (mg/l)	194 ±12.41	202.7 ±29.76	222 ±4.978	212 ±12.22	334.7 ±44.68	252.7 ±24.47
Dissolved oxygen (mg/l)	3.2 ±0.133	2.4 ±0.202	2.48 ±0.796	1.48 ±0.213	2.47 ±0.362	1.76 ±0.20
BOD(mg/l)	2.58 ±0.169	1.40 ±0.128	3.22 ±0.185	1.9 ±0.306	3.22 ±0.549	1.83 ±0.219
COD (mg/l)	5.88 ±0.670	4.6 ±0.422	7.22 ±0.323	4.8 ±0.190	8.95 ±0.286	6.78 ±0.181

Results are expressed as mean ± SE.
SW= Surface water, GW= Ground water

al., 2001). However, the values reveal the slight alkaline nature of surface water (SW) and ground water (GW).

Conductivity an excellent indirect measure of dissolved salts in surface and ground water. The electric conductivity was found to fluctuate between 600 µS/cm to 706.6 µS/cm and 772.6 µS/cm to 900 µS/cm in surface and ground water. The higher conductivity may be due to the contamination from sewage, inorganic inputs and soluble ionic salts from the catchment. The emissions contain metallic constituents which may increase conductivity. Total solids in water are caused by clay, silt, organic matter and other microscopic organisms (Kishor *et al.*, 2005). An increasing trend of total solids was recorded during the present study. The minimum and maximum mean values of TS in surface and ground water were recorded 2511.3 mg/l, 2726.7 mg/l and 1127.6 mg/l 1342 mg/l respectively. Mining and stone crushing activities release dust particles of various sizes into immediate atmosphere, which fall on the ground and may be the cause of increase in TS and TDS.

The free CO_2 respective of sites increased with the outset of spring. The CO_2 content of water depends upon the water temperature, rate of respiration, decomposition of organic matter and geographical features of the terrain surrounding the water body (Sakhre and Joshi, 2002). The lowest and highest mean values of CO_2 content in SW and GW recorded were 4.13 mg/l, 4.93 mg/l and 2.53 mg/l, 2.97 mg/l respectively. The high value of free CO_2 is indicative of high degree of pollution (Cole, 1979). During the present investigation an inverse relationship between CO_2 and DO was observed.

Alkalinity of water is attributed by CO_2 content. The highest and lowest mean values of total alkalinity of water recorded were of 133 mg/l, and 156 mg/l for (SW) while 166.7 mg/l and 189.3 mg/l for GW respectively. Bicarbonates are mainly responsible for imparting alkalinity. Generally, the chlorides in water are due to the presence of salts of sodium, calcium and potassium. Chloride concentration varied from 13.9 mg/l to 17.03 mg/l in surface water and 9.56 mg/l to 11.8 mg/l in ground water. The present study, respective of sites depicted a narrow range of fluctuations with increasing trend from March to May. Large content of chlorides is an indicator of organic pollution (Venkatasubramani and Meenamibal, 2007).

In the present survey, hardness ranged from 337.5 mg/l to 381.3 mg/l in surface water and 364 mg/l to 432.7 mg/l in ground water. The total hardness was maximum which might be associated to carbonate and bicarbonates of calcium and magnesium salts from anthropogenic interferences. Calcium and magnesium showed a similar trend to that of total hardness. Calcium was recorded to be higher than magnesium Increase in concentration Ca^{++} and Mg^{++} could be related to human interferences and mining activities. Magnesium remains generally lower than the calcium (Venkatasubramani and Meenaimbal, 2007). Magnesium is essential for chlorophyll and act as a limiting factor for the growth of phytoplankton's (Dagaonkar and Saksena, 2000).

The present investigation revealed that the DO content ranging from 2.47 mg/l to 3.2 mg/l in surface water and 1.48 mg/l to 2.4 mg/l in ground water denoting the inverse relationship with temperature as well as CO_2 (Saxena *et al.*, 1966). The effluent may contain high organic pollutants which might have invaded the surface and ground water which decreases the DO content as a result of microbial activities and high rate of oxygen consumption. This is because organic wastes act as medium for microbial multiplication (Sharma and Pandey, 1998). DO values were found below the permissible limits of WHO (6 ppm). Low DO indicates the biodegradation of organic matter. In summer reason dissolved oxygen was decreased due to increased temperature of water (Naz and Turkmen, 2005). Low level of DO points towards the nutrient enrichment and low quality of water (Sheikh *et al.*, 2010).

Biochemical oxygen demand (BOD) is the amount of oxygen utilized by microorganisms in stabilizing the organic matter. BOD in the present study was recorded in range of 2.58 mg/l to 3.22 mg/l in surface water and 1.40 mg/l to 1.9 mg/l is ground water. The level of BOD increased in summer reason. A similar observations also been reported by Deveraju *et al.*, (2005). The aerobic microbes flourish and bring about biological decomposition which consumes oxygen; it is not practically feasible to determine this ultimate oxygen demand (Garg *et al.*, 2006).

Chemical oxygen demand is the oxygen required by the organic substances in water to oxidize them by strong chemical oxidant. In general COD values were more than BOD values for most of the water samples. Thus, COD is reliable parameter for judging the extent of pollution in water (Amirkolaie, 2008). The COD of water increases with increasing concentration of organic matter (Boyd, 1981). In the present investigation, COD ranged from 5.88 mg/l to 8.95 mg/l in surface water and 4.6 mg/l to 6.78 mg/l in ground water with higher values in summer.

Air quality assessment: The concentration of SPM recorded in the study sites ranged between 1045.49 to 1268.6 μg/m^3 at crushing site and 545.86 to 617.2 μg/m^3 at residential area. The highest concentration of SPM was recorded at site – III (Khailar) as compared to other sites. At residential areas the SPM concentration at all the sampling locations exceeded the standards recommended by CPCB (1988), New Delhi (200 μg/m^3) and also SPM at crushing sites was higher than that of the permissible limit prescribed by NAAQS (Table- 2). All major open cast mining crushing activities produce dust and granite mining is not an exception, most major mining and allied activities contribute directly or indirectly to air pollution (Singh *et al.*, 2009). The sources of air pollution in mining areas include blasting, loading transport, crushing, unloading, losses from exposed overburden dumps (CMRI, 1998).

The blasting, loading, transportation, unloading, crushing at granite crushing sites and overburden dumps are the main sources of particulate pollution in and around mining sites in Jhansi which, leads to various problems like respiratory, skin, silicosis, asthma, coughing headache, hearing loss, tuberculosis and others. The mining activities have increased air and water pollution manifold causing health hazards to the mine workers and surrounding areas.

Table 2. Results on SPM (μg/m^3) at crushing and residential area at three locations.

Sampling site	Crushing station	Residential area
Goramachiya	1045.49 ±187.11	545.85 ±47.442
Bijouli	1079.53 ±206.19	586.35 ±48.579
Khailar	1268.6 ±209.79	617.2 ±86.686

Results are expressed as mean ± SE (n=3)

The concentrations of SPM at crushing and residential areas are given in Table 2. Stone crushing creates enormous quantity of dust of various sizes which passes into air and disperse significant amount of suspended particulate matter (SPM) and gaseous pollutants into the atmosphere. The polluted air not only affects the workers but also the nearby population, agricultural crops and livestock. During the study SPM was major source of emission from stone crushing in Jhansi. It cause respiratory disorders in human and animals due to inhalation of fine dust particles, lowers agricultural yield as the dust covers the leaf surface of plants and poor visibility near crushers. Stone crushing was known to affect both surface and ground water regime. The dewatering of mine water spent for dust suppression and leacheate run off from waste dumps. The leachete water can be extremely toxic containing heavy metals and may pollute ground water.

Occupational health assessment: Stone crushing causes severe air pollution problems in active mining and crushing sites, workers are persistently exposed to large concentrations of dust, gaseous pollutants, high level of noise and accidents which constantly pose a severe threat to workers life and communities in close proximity to operations. The data on various health effects obtained from the current survey among the stone crushing workers and the

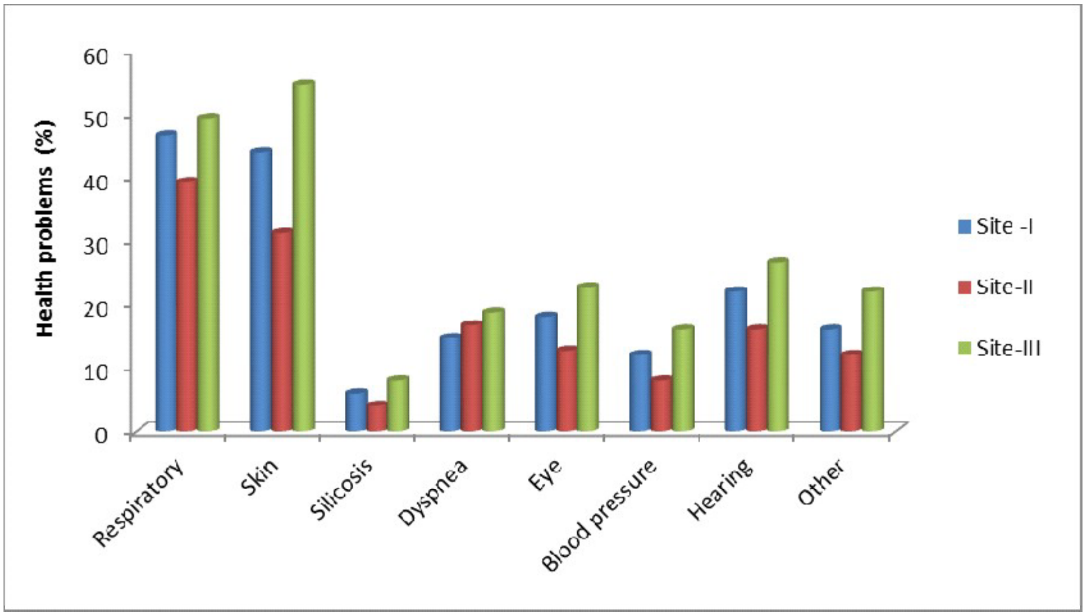

Fig. 2. Human health problems at crushing and residential areas.

population inhabiting in and around mining sites is exhibited by Fig. 2.

The activities such as digging, blasting, unloading, crushing, loading release dust particles of variable sizes into immediate atmosphere. The workers are encountered with substantial exposure to dust and noise which may lead to manifestation of various occupational diseases in long term. Most of this dust is made up of silica and workers are facing serious health problems. The most prevalent occupational diseases among the mine and stone crusher workers in Bundelkhand are: respiratory, hearing, eye, skin, fever, silicosis, dyspnea, blood pressure problems and accidents (Singh and Pal, 2010). The dust released during mining and crushing activities not only affect humans but also plant and animals.

The over all observations showed that the dust exposure cause serious health problem which accounts respiratory (45.11%), skin (43.33%), hearing loss (21.53%), eye (17.8%), dyspnea (14.66%) followed by high blood pressure, silicosis, accidents etc. The respiratory problems observed in present study were coughing, shortness of breath, chest pain, silicosis, asthma, bronchitis etc.

It is well documented that chronic and in some cases, acute exposure to dust containing silica can cause serious health problems (IARC, 1997). The constant and heavy exposure to this silica dust may result in death. Silica dust also tends to increase the risk to individuals of developing lung cancer, tuberculosis, auto immune diseases etc. Skin problems include dryness and roughness of skin. There are many respiratory diseases that have been documented in literature as being related to work either as a direct casual agent or as being aggravated by work exposures (Hendrick *et al.*, 2002). Background noise and vibration is an unavoidable by product of mining and crushing activities often inducing considerable stress on the work force. The problems related to noise ranged from sleeping disorders, depression, and high blood pressure and hearing loss both temporary and permanent. Fever and mild illness are common occurrence among the workers. Investigations have revealed that the workers were not aware about the proper safety and control measures. Most working women usually left there children near working place hence they also get exposed to dust. Children are more sensitive to the dust. The pollution level was high at Khailar (site – III) as it was clear from the more health problems followed by Goramachiya (site–I) and Bijouli (site–II). Based on present study, it may be concluded that the ambient environmental conditions at stone crushers in Jhansi are not safe. The dust generated from the stone crushing contains a significant amount of fine inhalable particles. The workers engaged in the stone crushers encounter substantial exposure to dust and noise which may lead to the manifestation of various occupational diseases.

There is immediate need to formulate a comprehensive, occupational and environ - ment health management strategy for stone crushers. Remedial and control measures can improve the environmental conditions at the stone crushers to a considerable extent.

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