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Short Communication

Environmental Degradation due to Coal Mining in Baluchistan

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Abstract

Average emissions of methane (CH_4) and carbon monoxide (CO) from coal mining in Baluchistan, Pakistan, have been measured as 11.8 m^3/ton and 36 ppm, respectively, which exceeds the permissible limits of 1-10 m^3/ton and 30 ppm. The concentration of coal dust (carbon and quartz) have been measured as 4-5 mg/m^3 and 0.35 mg/m^3 against the threshold limits (recommended by NIOSH) of 2 mg/m^3 and 0.05-0.1 mg/m^3. The high concentrations of gases and coal dust in coal mining areas of Baluchistan is not only the source of a high death toll and health problems, but environmental issues have also been observed. Such health problems as headache; irritation of the throat, nose, and eyes; pneumoconiosis; tuberculosis; chronic obstructive bronchitis; heart problems; respiratory irritation; asthma; and even lung impairment and lung cancer are more pronounced in the coal workers of Baluchistan. Residual coal water and slurry are disposed off in an unconfined area that has become a source of soil, water, and health degradation.

Keywords: threshold limit values (TLVS), carbon capture and sequestration (CCS), National Institute of Occupational Safety and Health (NIOSH), maximum allowable concentration (MAC), occupational exposure limits (OEL), Mine and Mineral Department (MMD)

Introduction

The high death and disability rate of coal mine workers in Baluchistan can be attributed to the old "room and pillar" mining method [1], which is generally no longer practice around the world [2]. The frequent incidents of roof fall and suffocation due to over-emissions of methane are the main causes of increased death toll in Baluchistan coal mines [3]. Non-implementation of environmental standards are the main source of uncontrolled exposure of gases and effluents [4, 5]. Coal mine water, a major source of water pollution in the coal mines, is the carryover of the suspended solids in the drainage system of the mine water [6]. In some of the coal mines, acidic water has also been found in underground aquifers [7]. During mining operations potent greenhouse gases (methane and carbon) are released into the air [8] and result in global warming [9].

Methodology

The prospective study was conducted on coal mine workers of Baluchistan from May 2008 to April 2009. Two types of data were collected. Primary data was obtained through a topographic survey and questionnaire while secondary data about environmental degradation due to coal mining was collected from the Mine Mineral Department of Quetta, the Environmental Protection Agency of Quetta, hospitals, and medicals facilities in coal mine field areas, insurance companies, the Wildlife Department, and the Water, Agriculture, Forest, and Land departments. A total of three mine fields were selected

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Table 1. Emissions and presence of gases at all three selected sites of Baluchistan.

No.	Mine Location	Time-Weighted HRS	Average Emission of Methane m^3/ton		Concentration of		Method of Measurement
			During Mining	Post Mining	CO PPM/HR	Oxygen %age	
1.	Mach coal fields M1, M2, M3	8	11.2	5.43	37	13.5	Mine safety appliances Mining Detector Meotro NICs serial No 045 MEO 6101 Made in UK
2.	Sorange degori coal fields SD1, SD2, SD3	8	8.7	5.46	35	16.2	
3.	Chamalong coal fields C1, C2, C3	8	12.5	4.5	37	12.4	

Source: Field work

depending upon location, type of mining carried out, and type of coal extracted. For specific results the selected coal mine fields Mach, So-range-Degari, and Chamalong were further subdivided as M1, M2, and M3 at Mach coal field; SD1, SD2, and SD3; at So-range-Degari and C1, C2, and C3 at Chamalong coal field.

Results and Discussion

During research the exposure limits of gases measured in the coal mine fields of Baluchistan are given in Table 1.

Table 1 shows that the gas exposure limits are more than the permissible limits. Methane emissions from coal mining depend on mining methods, depth of coal mining, coal quality, and entrapped gas content in coal seams, but in any case the rate of emission of methane should range between 1-10 m^3/ton during mining [10], and a maximum of 3.5 m^3/ton in the case of post mining [11], but higher limits measured in both cases – especially after post mining – average concentrations of 6.5% [12]. The higher concentration of methane reacts with air ($CH_4+2O_2= CO_2+2HO$) and displaces the oxygen [13]. As highlighted in Table 1, the higher the concentration of methane, the lower the percentage of oxygen (min 18%) and thus it results in suffocation and ultimately sudden death [14].

One of the reasons for sudden death due to over emissions of methane in Baluchistan coal workers is the weak cardiac sensitizers in humans [15], following inhalation exposure to high concentration (greater than 5%isobutene and greater than 10% for propane) cardiac sensitizers cause the sudden onset of irregular heart beat and sudden death [16]. In some cases due to high concentration and oxygen deprivation damage to some or all organs [17] (including the nervous system and the brain) has also been observed in Baluchistan coal workers.

Exposure to carbon has caused acute damage to lung functions because of the high level of car boxy hemoglobin [18]. During medical examinations headaches, dizziness, drowsiness, unconsciousness, nausea, vomiting, and shortness of breath were found to be common in Baluchistan coal workers. Problems of aging and illness due to carbon-induced neurobehavioral effects have been observed, because, under normal circumstances, the brain can increase blood flow to tissue, and oxygen extraction to

Table 2. Summary of field results of coal dust exposure at select sites.

No.	Mine ID	Location of Reading	Average Dust Concentration mg/m^3	Threshold Limit Value mg/m^3	Difference mg/m^3
1.	Mach (Abe-gum) M1, M2, M3	At the mine face	5.26	2	+3.26
2.	Mach (Abe-gum) M1, M2, M3	At the loading place	4.25	1-2	+2.25
3.	Mach (Abe-gum) M1, M2, M3	At Ventilation / Exhaust	3.47	2	+1.47
4.	Sorange degari SD1, SD2, SD3	At the face of the mine	3.54	2	+1.54
5.	Sorange degori SD1, SD2, SD3	At the loading point	3.05	1-2	+1.05
6.	Sorange degori SD1, SD2, SD3	At Ventilation / Exhaust	2.75	2	+0.75
7.	Chamalong C1, C2, C3	At the face of mine	5.2	2	+2.2
8.	Chamalong C1, C2, C3	At loading place	4.35	1-2	+2.35
9.	Chamalong C1, C2, C3	At Ventilation / Exhaust	4.05	2	+2.05

Source: Field work

Table 3. Summary of the field results of quartz exposure at select sites.

No.	Mine ID	Location of Reading	Average Dust Concentration mg/m^3	Threshold Limit Value mg/m^3	Difference mg/m^3
1.	Mach (Abe-gum) M1, M2, M3	At the face of mine	0.67	0.1	0.57
2.	Mach (Abe-gum) M1, M2, M3	At the loading place	0.55	0.05-0.1	0.45
3.	Mach (Abe-gum) M1, M2, M3	At Ventilation / Exhaust	0.44	0.1	0.34
4.	Sorange degori SD1, SD2, SD3	At the face of the mine	0.45	0.1	0.35
5.	Soange degori SD1, SD2, SD3	At the loading point	0.39	0.05-0.1	0.29
6.	Sorange degori SD1, SD2, SD3	At Ventilation / Exhaust	0.35	0.1	0.25
7.	Chamalong C1, C2, C3	At the face of mine	0.67	0.1	0.57
8.	Chamalong C1, C2, C3	At loading point	0.58	0.05-0.1	0.45
9.	Chamalong C1, C2, C3	At Ventilation / Exhaust	0.52	0.1	0.42

Source: Field work

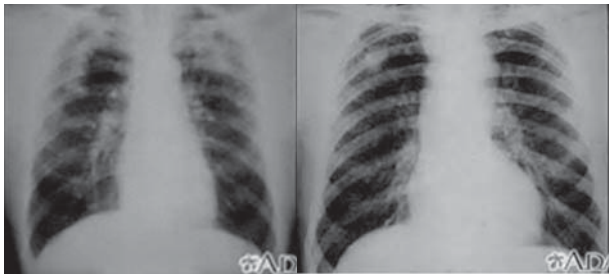

Fig. 1. Pictures of damaged lungs of coal workers of so-range Degari taken during medical examination at CMH Quetta.

compensate for the hypoxia caused by exposure to carbon [19]. Tissues of highly active oxygen metabolism, such as heart, brain, liver, kidney, and muscle, may be particularly sensitive to carbon poisoning [20].

When car boxy-hemoglobin levels are higher than 50% convulsion and cardio pulmonary arrest has been observed, complications have been observed frequently in carbon poisoning such as immediate death, myocardial impairment, hypotension, arrhythmias, and pulmonary edema [21]. Perhaps the most insidious effect of carbon poisoning observed is the delayed development of neuron psychiatric impairment and neurobehavioral consequences [22]. The impact on the central nervous system, causing hallucinations and a heightened emotional state, has also been observed. It is unfortunate that no stakeholder is aware of these issues. This has given rise to different health problems, including respiratory, lung tissue impairment, and pneumoconiosis; impact on brain, kidneys, and other organs; itching and irritation problems; tuberculosis; and asthmatic problems are most common due to overexposure of coal dust in Baluchistan.

Some pictures of damaged lungs of coal workers shown in Fig. 1 were taken during x-rays at CMH Quetta. During medical examinations some coal workers were diagnosed with T.B.

Table 4. Yearly health analyses of coal workers of Baluchistan.

No.	Types of Occupational Illnesses	Number of patients / year				
		2005	2006	2007	2008	2009
1.	T.B	204	289	319	307	379
2.	Post-T.B	348	372	412	407	389
3.	Bronchitis	396	422	453	392	512
4.	Asthmatic problems	423	447	492	398	307
5.	Skin and other infection	729	597	612	707	779
6.	Hypertension	837	714	745	810	823
7.	Lung C.A	149	112	132	79	93
8.	Death in hospital due to injury	119	139	122	98	109

Source: Data collected from different hospitals in Quetta

Table 5. Concentrations of suspended solids in coal mine waste of Baluchistan.

No.	Mine Location	Type of effluents	Measured qty in mg/L except PH	WHO standards in mg/L, except/pH	Measuring apparatus
1.	Mach coal field	PH	4.9	6.9	PH meter's/no 558272,HM 25r, TKK_TOA Japan
		Turbidity	0.59	0.5	Turbidity meter's/no F412R-05NB Nippon Dashiki Japan
		BOD	220	250	Hatch BOD Track's/no 26197-01/0104103 U.S.A
		COD	370	400	Hatch COD Reactors, s/no 021200010120 p/ n45600-02 love land colo U.S.A
		TSS	425	400	Vacuum Pump filter system for TSS
		TDS	3720	3500	Ion sense meter hatch TDS- EC Salinity meter
2.	Sorange coal field	Taste	Objectionable	–	–
		Odor			
		Hardness	515	500	Titration Method, NO 460130
		PH	5.0	6.9	PH meter
		Turbidity	0.57	0.5	Turbidity meter
		BOD	215	250	Hatch BOD Track
		COD	350	400	Hatch COD Reactors
		TSS	430	400	Vacuum Pump filter system for TSS
		TDS	3600	3500	Ion sense meter hatch TDS- EC Salinity meter
		Taste	Objectionable	–	–
		Odor			
		Hardness	530 mg/L	500 mg/L	Titration Method
3.	Chamalong coal field	PH	4.9	6.9	PH meter
		Turbidity	0.52	0.5	Turbidity meter
		BOD	225	250	Hatch BOD Track
		COD	360	400	Hatch COD Reactors
		TSS	435	400	Vacuum Pump filter system for TSS
		TDS	3650	3500	Ion sense meter hatch TDS- EC Salinity meter
		Taste	Objectionable	–	–
		Odor			
		Hardness	520	500 mg/L	Titration Method

Source: Field work and WHO-2007; BOD - Bio-available oxygen demand, COD - Chemical oxygen demand, TSS - Total suspended solid, TDS - Total dissolved solid.

Exposure to Coal Dust

The tabulated values received as a result from analysis in an EPA laboratory have exceeded the recommended threshold exposure limits (Tables 2 and 3). The most obvious reason for higher concentrations of coal dust in Baluchistan coal fields is the lack of monitoring by the EPA and the Mine and Mineral Department (MMD), and non-adherence to precautionary measures by coal workers. This gives rise to numerous health and environmental problems. The inhalation of these particles through airways and throats goes into lungs and causes damage to various organs of the body, including irritation in eyes, throat, and nose; lung infection and impairment; shortness of breath; and wheezing, asthma, coughing, and chest pain.

Table 6. Coal waste produced per ton of coal from Baluchistan coal fields.

No.	Mining technique	Parameter	Year of production	Coal produced in million tons	Coal waste in ton /1000 ton of coal produce	
					Permissible limits	Measured limits
1.	Underground	Liquid effluents	2004-2005	1.89	1.1	1.7
			2005-2006	2.02	1.1	1.8
			2006-2007	1.92	1.1	1.74
			2007-2008	2.3	1.1	2.09
			2008-2009	1.98	1.1	1.8
2.		Coal waste	2004-2005	1.98	3	4.2
			2005-2006	2.02	3	5.9
			2006-2007	1.92	3	4.3
			2007-2008	2.3	3	6.3
			2008-2009	1.98	3	5.2
3.		Coal Dust	2004-2005	1.98	0.01	0.041
			2005-2006	2.02	0.01	0.087
			2006-2007	1.92	0.01	0.043
			2007-2008	2.3	0.01	0.091
			2008-2009	1.98	0.01	0.045

Source: EPA and MMD Quetta

The summary of health problems of coal mine workers reported from different hospitals for five years is given below in Table 4.

Impacts of Coal Waste

Mining produces coal waste (coal slurry) as a waste product that spreads into unconfined places on Baluchistan coal fields. It contaminates nearby sources of drinking water and also becomes the source of waterborne diseases. The matter was investigated by taking a water sample and testing it in a laboratory, the results in comparison of WHO prescribed limits have been tabulated in Tables 5 and 6.

The comparison shows that the concentration limits of TSS and TDS in Baluchistan coal fields are higher than those prescribed by the World Health Organization. The higher concentration of these effluents makes the water heavier and unsuitable until it is purified and the lower PH value shows that the water is acidic. The less BOD and COD demand shows that either the microorganisms are less in numbers or mostly dead due to the presence of higher concentrations of TDS and TSS. Moreover, the non-availability of a facility to purify water is the reason for no health impacts in coal workers of Baluchistan. The quantity of coal waste produced is more than the requisite limits as prescribed by WHO, which speaks to the substandard mining techniques in Baluchistan. This element contributes to the deterioration of the health of coal workers, environmental degradation (air, water, and soil degradation), and significant impact on the economy of the province. The results so obtained can be represented graphically in comparison with WHO figures (Fig. 2).

Noise Impact due to Coal Mining

Noise in coal mining [8] can cause impaired hearing, deafness, etc. Mining operation like drilling, collection, transportation, and handling of coal, sizing, and segregation units are major sources of noise pollution/degradation in underground coal mining of Baluchistan.

Land/Soil Degradation

The coal waste produced is disposed of in an open area instead of a confined place that becomes a source of land degradation. The coal Slurry and other wastes in the shape of liquid or solid spread out in surrounding areas as shown in Fig. 3, and renders the land unfit for other purposes like vegetation or agriculture [23].

During coal mining in Baluchistan about 20-25% of coal is removed as waste and it disposed of as a loose dumping landfill, which causes soil degradation. Many times large forest areas have been transferred for coal mining purposed. The clearing of trees, plants, and topsoil from mining areas have destroyed forests and natural wildlife habitats. It has also promoted soil erosion

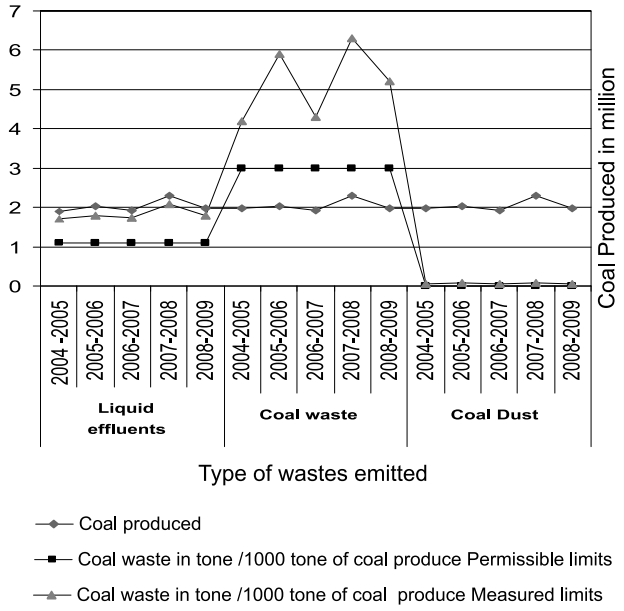

Fig. 2. Comparison of different types of waste emitted due to coal mining in last five years.

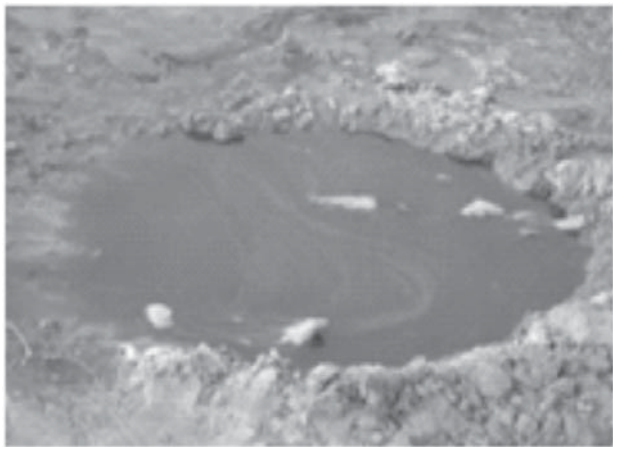

Fig. 3. Land degradation due to coal waste water and acid mine drainage in a Baluchistan coal field.

Fig. 4. Unhygienic conditions of coal.

and flooding, and stirred up dust pollution that leads to respiratory problems in coal workers and even nearby communities.

Biodiversity

During research it was revealed by coal workers, mine owners, and even the local population that a variety of wild animals including bear, jackal, fox, deer, and even lions used to be found in the area, but illegal hunting, coal mining, and other activities have decreased their populations. Migrating birds that used to come to Baluchistan are very rare due to coal mining activities.

Impact on Communities

Baluchistan is a deserted place where cities, towns, and villages are far apart. Coal mining activity is normally carried out quite far away from living communities, but in some places people are living near mined areas. Moreover, the families of coal workers are very close to the mined areas so that the coal workers and their families are the most victimized due to acid mine drainage, AMD, and water impurities. The poor and unhygienic living conditions of coal workers of Baluchistan, and unsafe water and food has made the life of coal workers quite miserable and is leaving a negative impact on environment (Fig. 4).

Negative Change to the Environment

Tops are removed from mountains to expose thick coal seams underneath, and the removed soil and rock are deposited in nearby valleys, hollows, and depressions, resulting in blocked and sometimes contaminated waterways. The remediation is often delayed for decades; one of the legacies of coal mining is the low coal content waste forming slag heaps. Where the coal has significant sulfur content, such coal heaps generate highly acidic, metal-laden drainage when exposed to rainfall. These liquors can cause severe environmental damage to waterways.

Climate Change

The consequences of activities attributed directly and indirectly to humans, like coal mining, have resulted in the alteration in the composition of the atmosphere and the global climate in general, thereby causing climate change [24]. Over emissions of methane and carbon monoxide – both of which are greenhouse gases from the coal fields of Baluchistan – may not be significant, but contributing to climate change.

Conclusion

Although much research is being conducted across coal-mining countries in order to improve coal extraction techniques and to overcome the emission rates of methane and carbon, thus reducing death and injury rates and environmental degradation. Efforts have also been instituted to overcome and reduce the toxicity of coal effluents on the health of the coal workers, but in Pakistan (especially Baluchistan) no such measures have been taken by the government and mine owners. A study was designed to ascertain whether coal mining in Baluchistan is carried out as per international standards. Special emphasis was paid to evaluating environmental degradation in Baluchistan. The analysis of samples in the EPA Laboratory and pathological test results have revealed that the overexposure of coal dust, over emission of methane, carbon and other coal effluents are not only the source of increased death tolls, but have severe health implications and are contributing factors toward environmental degradation and climate change.

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