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Coalmine dust concentration and rate of tuberculosis infection around Ib Valley Coalfield, Orissa, India

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Abstract: *The miners as well as the inhabitants vicinity to the mining areas are generally susceptible to the respiratory disorders due to constant exposure to the coalmine dust for a prolonged period. In this paper, the dust concentration and dust dose associated with the rate of tuberculosis around the major part of Ib Valley Coalfield (Belpahar and Brajarajnagar area) have been analysed. Several field trips around Ib Valley Coalfield have been conducted for consecutively three years (2005, 2006 and 2007) to evaluate the present status of the dust concentration and rate of tuberculosis infection. It was observed that the dust concentrations of different residential places as well as the places vicinity to the opencast mining projects have been increased in the subsequent years of investigation. As a result, the dust doses of various residential places have also increased in a parallel manner. The dust doses of various mining sites range from 25.51 to 37.08 mg, 34.76 to 41.03 mg and 37.8 to 44.49 mg during 2005, 2006 and 2007 respectively. Interestingly, in most of the mining sites the dust doses are more than the safe dust does (32 mg). An attempt has been made to correlate the dust concentration with tuberculosis infection in the area by making a questionnaire survey. Early symptoms of tuberculosis were reported in case of 121 out of 205, 129 out of 212 and 145 out of 220 inhabitants during 2005, 2006 and 2007 respectively. The study clearly revealed that the tuberculosis patients have been increased significantly in the successive years of investigation.*

Key words: *Dust, Tuberculosis, Ib Valley Coalfield, Coal mining*
PDF of full length paper is available online

Introduction

The rapid growth of mines with increasing out put has resulted in increased production of dust in and around mining areas. It has been estimated that about 10-100 g of dust below 5 μ size is generally produced per tonne of coal and 1% of this dust is perished by air (Chakrabarti and Ray, 2003). According to Dhar (1986), the dust generation is by and large 0.313 kg ton^{-1} of coal produced. The opencast coal production rate is 20 million tons yr^{-1} as in 1993-94 (Chakrabarti, 2000). Hence, the dust generation is at a rate of 869.4 kg hr^{-1} (20,865 kg day^{-1}).These estimations might have been increased several folds by now. Dust is generated during the quarrying operations in case of opencast mines. The huge amount of dust is also generated due to removal/dumping of overburdens, coal loading and unloading, coal transportation, blasting, drilling in coal mines, operation of coke ovens *etc.* Transportation of coal in dumpers especially from Lakhanpur, Lilari and Belpahar opencast coal projects to the nearby railway stations (Belpahar and Brajarajnagar) adversely affects the atmospheric environment of the said area. There is absolutely no doubt that the local inhabitants are exposed to the mine dust passively. One of the most infectious and contagious respiratory disease, tuberculosis spreads due to continuous exposure to the coal mine dust. Field surveys adopting questionnaire method have been carried out around the study area to detect the dust concentration and the rate of tuberculosis infection due to continuous inhalation of coal mine dust (Attfield and Hodous, 1992; Levinson and Jawetz, 2003).

Dust dose calculation is necessary to assess the impact of exposure of dust and other contaminants adhered to inhaled dust. Dust inhalation doses can be estimated and accordingly default air intake rate can be interpreted. A person's activity level, physical condition, gender and age are few factors that will influence the dust inhalation doses. The "dust dose" is a standard measure that relates a worker's total dust exposures to the permissible limit without adverse effect. It represents time weighted concentrations to which nearly all workers may be exposed over extended period of time without adverse effect (EPA, 1997; ATSDR, 2009; Chakrabarti, 2000). The safe dust dose per day is generally considered to be 32 mg (max) based on the findings that 250 g of dust deposition in lung causes severe trouble (Chakrabarti, 2000).

In the present study, estimation of the dust in the investigated area has been carried out and the number of suspected tuberculosis infected patients was detected for consecutive three years in a row (2005, 2006, 2007). The study depicts that both dust dose and number of tuberculosis patients have been increased significantly in the successive years of investigation.

Materials and Methods

The Ib Valley Coalfield is located in the South-Eastern part of NW-SE trending Mahanadi Master Basin belt between 21°30' and

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Table - 1: Dust concentration at various places in Jan, May and Sept in Ib Valley Coalfield during 2005, 2006 and 2007

Sampling locations	Dust concentrations ($mg\ m^{-3}$)											
	2005				2006				2007			
	Jan	May	Sept	Mean	Jan	May	Sept	Mean	Jan	May	Sept	Mean
Around Opencast coal projects												
Overburden removal of Lakhanpur Opencast project (SL_1)	7.3	7.4	7.1	7.266	7.4	7.5	7.3	7.4	7.7	7.8	7.6	7.7
Haul road near Lilari Opencast project (SL_2)	6.6	6.5	6.2	6.333	6.7	6.6	6.3	6.533	6.9	6.8	6.5	6.733
Haul road near Samaleswari Opencast project(SL_3)	6.4	6.3	6.2	6.3	6.6	6.5	6.2	6.433	6.5	6.7	6.4	6.533
Railway sliding region of Brajrajnagar (SL_4)	4.6	4.7	4.6	4.633	5.7	5.8	5.5	5.666	5.6	5.9	5.7	5.733
Just after blasting of Samaleswri Opencast project (SL_5)	NA	NA	NA	NA	13.8	14.6	15.4	14.6	15.7	16.5	14.7	15.633
Around residential areas												
In the village Bandhbahal near Lakhanpur Opencast project (SRL_1)	1.3	1.4	1.2	1.3	1.4	1.6	1.3	1.433	1.6	1.7	1.3	1.533
In the village Lajkura, adjacent to the Samaleswari and Lajkura Opencast project (SRL_2)	1.4	1.3	1.1	1.266	1.5	1.7	1.3	1.5	1.5	1.8	1.5	1.6
In the Khairikuni village near Lakhanpur Opencast project (SRL_3)	0.9	1.2	1.0	1.033	1.2	1.5	1.4	1.366	1.6	1.8	1.5	1.633
In the Darlipali village near Lilari Opencast project (SRL_4)	1.3	1.4	1.1	1.266	1.5	1.7	1.3	1.5	1.5	1.8	1.4	1.566
In the village Ganganagar near Railway sliding of Brajarajnagar (SRL_5)	1.5	1.7	1.3	1.5	1.7	1.8	1.5	1.666	1.8	2.0	1.6	1.8

NA : Not Assessed

Table - 2: Dust dose of various residential places around Ib Valley Coalfield during 2005, 2006 and 2007

Sl. no.	Monitoring locations	Safe dust dose (mg) (Chakrabarti, 2000)	Dust dose (mg) 2005			Dust dose (mg) 2006			Dust dose (mg) 2007		
			During rest	During work	Per day	During rest	During work	Per day	During rest	During work	Per day
1	In the village Bandhbahal near Lakhanpur Opencast project (SRL_1)	**32**	8.736	23.4	32.136	9.63	25.794	35.424	10.302	27.59	37.892
2	In the village Lajkura, adjacent to the Samaleswari and Lajkura Opencast project (SRL_2)		8.508	22.788	31.296	10.08	27.0	37.08	10.752	28.80	39.552
3	In the Khairikuni village near Lakhanpur Opencast project (SRL_3)		6.923	18.594	25.514	9.179	25.588	34.767	10.973	29.394	40.367
4	In the Darlipali village near Lilari Opencast project (SRL_4)		8.508	22.788	31.296	10.08	27.0	37.08	10.523	28.188	38.711
5	In the village Ganganagar near Railway sliding of Brajarajnagar (SRL_5)		10.08	27.0	37.08	11.155	29.88	41.035	12.096	32.40	44.496

22° 06' N latitudes and 83° 37' and 84° 10' E longitudes. The areas embrace the Himgir Sub-basin in the North and the Rampur Sub-basin in the South. The areas are covered by Gondwana rocks consisting mainly of Upper Kamthi, Lower Kamthi (Raniganj), Barakar, Kaharbari, Talchir formations. The investigated area of Ib Valley Coalfield comprises 5 opencast projects (*viz.*, Samaleswari, Lilari, Lakhanpur, Lajkura and Belpahar) around Belpahar and Brajarajnagar of Jharsuguda District, Orissa.

The following dust sampling locations are on either side of the haul roads and residential colonies adjacent to the opencast coal projects.

Sampling locations -

Around Opencast coal projects (SL):

1 Overburden removal site of Lakhanpur Opencast project (SL_1)
2 Haul road near Lilari Opencast project (SL_2)
3 Haul road near Samaleswari Opencast project (SL_3)
4 Railway sliding region of Brajrajnagar (SL_4)
5 Just after blasting of Samaleswri Opencast project, only during 2006 and 2007 (SL_5)

Around residential areas (SRL):

1 Village Bandhbahal near Lakhanpur Opencast project (SRL_1)
2 Village Lajkura adjacent to the Samaleswari and Lajkura Opencast project (SRL_2)
3 Khairikuni village near Lakhanpur Opencast project (SRL_3)
4 Darlipali village near Lilari Opencast project (SRL_4)
5 Village Ganganagar near Railway sliding of Brajarajnagar (SRL_5)

Estimation of dust concentration: For the measure of mass of the dust, Respirable Dust Sampler of Envirotech make is employed by sampling dust laden air at a rate of 2.5 lt min^{-1}. Monitoring has been done 10 days in each month of January (winter), May (pre-monsoon), September (monsoon) and 8 hr in a day, on different dates at aforesaid sampling locations of the study area for consecutively three years (2005, 2006 and 2007). The average dust concentration at and around opencast coal-projects and residential areas and dust dose particularly of residential places in the respective months have been calculated and tabulated (Chakrabarti, 2000).

Dust Dose = C x T x 60 x V x R x 10^{-3}
Where, C = Dust concentration of air in mg m^{-3}.

T = Time spent in dust laden atmosphere in hr (working time: 10 hours and rest time: 14 hr).

V =Total volume in liters, it is generally taken as 500 cc (0.5 l) during rest and 1000 cc (1.0 l) during active work. This is the volume of inspired air in lungs during rest and working condition.

R = Number of respiration per minute (16 times in rest and 25 times in work).

Detection of tuberculosis suspects: To delineate the effect of dust on health of local community around the study area, a reprehensive sample of public (205 inhabitants in 2005, 212 in 2006 and 220 in 2007) were interviewed using a questionnaire. Questions in the questionnaire were drafted in such an intricate fashion so as to detect the public's degree of tolerance and awareness to tuberculosis. This preliminary survey adopting questionnaire method enabled us to detect early symptoms of tuberculosis among the local inhabitants.

Results and Discussion

Dust concentration: The estimated dust concentrations in various sampling locations are presented in the Table 1. The estimated dust concentrations at and around the opencast projects are more than the residential areas. The mean values of dust concentrations range from 7.266 (SL_1) to 4.633 mg m^{-3} (SL_5), 5.666 (SL_1) to 14.6 mg m^{-3} (SL_5) and 5.733 (SL_4) to 15.663 mg m^{-3} (SL_5) at and around the opencast projects during 2005, 2006 and 2007 respectively. Its values in the residential places range from 1.003 (SRL_3) to 1.5 mg m^{-3} (SRL_5), 1.366 (SRL_3) to 1.666 mg m^{-3} (SRL_5) and 1.533 (SRL_1) to 1.633 mg m^{-3} (SRL_5) during 2005, 2006 and 2007 respectively. The data explicitly depict that the dust concentrations have been increased in the successive years from 2005 to 2007. From the said analysis, it has been observed that the dust concentrations in various residential places around the study area during pre-monsoon (May) are comparatively higher than that of monsoon (September). It is because; the suspended dust particles are suppressed in rainy days. Only during the monsoon period the air is free of suspended particulate matters. However, its value gradually increases after rainy season due to increase of mining activities and coal transportations on the haul road. Blasting releases severe dusts than other operations (Table 1). It indicates that the gradual increase in the mining activities in the Ib Valley Coalfield influx more dust to the air and the air become dustier.

Presence of some fine invisible coal dust in the air may enter into lungs during inspiration. It causes disastrous effects and various health hazards among the local inhabitants. The size of dust affecting lungs ranges from 2 to 20 μ. However, dust particles having 2-3 μ size cause more serious problems. Damage of epithelial tissue of lungs is caused by the dust of about 1 μ size (Attfield and Hodous, 1992; Attfield and Seixas, 1995; Henneberger and Attfield, 1996). As the size of the dust decreases, a greater percentage of it is deposited in lungs. The dust that enters into lung is finally deposited and causes lesions.

Dust dose of different investigated residential places and tuberculosis contamination: The dust doses of different residential places are evaluated following the formula given in materials and methods and presented in the Table 2. The data depict that the dust dose of various residential places is accelerated with the increasing dust concentration. It is observed that the dust doses during 2005 in various monitoring location ranges from 25.51 to 37.08 mg. Dust doses in SRL_1, SRL_5 are found to be more than the safe dust dose during this period. Its values have been increased in all the places during 2006 and 2007 successively. During these periods, the dust doses have been exceeding the safe dust dose (32 mg) (Chakrabarti, 2000). The value of dust dose attains maximum (44.496 mg) in SRL_5 during 2007. An attempt has been made to correlate these data with tuberculosis contamination.

Tuberculosis is a bacterial disease caused due to infection of a bacillus (rods) called *Mycobacterium tuberculosis*. Suspected tuberculosis patients were detected in the investigated area adopting questionnaire method for consecutively three years (2005, 2006, 2007) to infer the possible effect of mine dust towards this disease. The numbers of suspected persons detected are 121, 129 and 145 during 2005, 2006 and 2007 respectively.

From the said investigation, it is concluded that the rate of infection of tuberculosis gradually increases. During 2005, the suspected case detected was 59.02% out of total interviewed cases. However, its number increases to 60.85 and 65.91% in the subsequent years of 2006 and 2007 respectively. It is interesting to note that the most of the inhabitants of the investigated Ib Valley area are illiterate tribal having poor economic background and least health consciousness. Moreover, they are not made aware of different health problems.

It is evident that the silicosis is a common health hazard in most of the coalfields. Moreover, silicosis has some deleterious effects upon the immune system. Impairment of the immune system may give rise to the reduction in the ability of macrophages to inhibit the growth of tubercle bacilli. Nontuberculosis mycobacterial infection (involving intercellular bacterial parasites) may occur, but long-continued exposure to silica has been linked to increased rates of infection with pulmonary tuberculosis. The casual relation between silicosis and tuberculosis has been demonstrated in the occupational health studies carried out by several workers (Derbyshire, 2007; Saiyad, 1999). Silicosis may be an important factor in the higher prevalence of tuberculosis in some desert and mining areas. Some rheumatic diseases as well as chronic kidney diseases also show higher than average incidence in individuals exposed to silica in coal mines. Such increased susceptibility of patients to several mycobacterial diseases is due to impaired function of macrophages in silicotic lungs (Goudie and Middleton, 2001; Mathur and Choudhary, 1997; Xu *et al.,* 1993).

Tuberculosis seems a likely disease to be found in the present study area, because droplet transmission of pulmonary tuberculosis is favoured by higher humidity and overcrowding of this locality. It has been established that the infection of male is considerable more than the female. The males are cumulatively more exposed to the mine dust as they work and stay outside for longer period. However, the tuberculosis disease is contagious and contaminated due to coughing and sneezing of infected persons. The data represent that the infection rate of female in the subsequent years comparatively higher than the previous years. They come across with their infected male members within a single habitat for a long time. As a result infection rate between female gradually increases.

The present study reveals that the dust is an obligatory factor for the tuberculosis infection. The dust dose of various residential places is accelerated with increasing dust concentration. Dust dose, a weighted measure of dust in mg is inspired due to exposure in a dusty environment. The assessed values of dust in various residential places were increased in the subsequent years of investigation due to increase of mining operations in and around the investigated area. The dust doses of these places are more than the safe dust dose. It indicates that the dust laden environment of the study area is the source of respiratory disorder, 'tuberculosis'.

The increased dust concentration in the coal mining area can be reduced by giving some special attention during the mining operations. All long life haul and service roads should be black topped and well maintained. All haul roads are to be regularly sprayed with water. As far as possible, haul roads are to be replaced by railways and conveyors. Wetting of the surfaces of the overburden dumps are to be regularly practised. Broken pieces of coal are to be wetted prior to their loading to the dumpers. In addition, some of the pollution tolerant species (*Acacia arabica, Ailanthus excels, Albizzia lebbak, Butea monosperma etc.)* should be grown in and around the mining premises.

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