Assessment of Coal Mine Road Dust Properties for Controlling Air Pollution

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***Abstract*— The paper describes analytical results of physico-chemical parameters and proximate analysis of coal dust collected from road surface of four opencast coal mines located in different coalfields of India. Value of pH, water holding capacity, ash percentage, moisture content, volatile matter, bulk density, specific gravity and fixed carbon was found to be in the range of 5.1–7.7, 21.17−31.71%, 45−76%, 0.5−3.0%, 12.6−20.0%, 1.15–1.70 g cm^{-3}, 1.73–2.30, and 10.2–45.3%, respectively. The study revealed that the coal dust abundantly available on road surface of opencast coal mines may be used as domestic fuel. Hence, collection and utilization of coal dust accumulated on mine road would not only reduce air pollution in mining regions but also help in enhancing economic benefit of coal mining industry by selling waste coal dust as domestic fuel.**

***Keywords*— Opencast mine, haul and transport roads; coal dust; physico-chemical properties; domestic fue**

I. INTRODUCTION

Coal is the most abundant fossil fuel resource present in India. Indeed there has been historical link between economical progress of India and use of coal for numerous basic requirements of the country, ranging from energy for domestic purpose to industrial application, like steel (8%) and cement (5%) industries, and electricity generation. Coal production in India grew by 7.8% from 457.08 Mt in 2007−08 to 492.95 Mt in 2008−09. The demand for coal in India is expected to increase rapidly in future dominated mainly by power sector. Majority of this coal is produced from opencast mines. The increasing trend of opencast mining along with adaptation of large scale mechanization leads to release of huge quantity of dust and gaseous pollutants which affect work zone air environment [1−5].

During coal production vehicular traffic on haul road in mechanized opencast mines has been identified as the most prolific source of fugitive coal dust and it contribute as much as 80% of total coal dust produced [6−8]. Around 50% of total dust is released during journey time on an unpaved haul road, while 25% is released during loading and unloading [9]. Sometimes, frequency of haul truck movements is deliberately reduced to overcome visibility problem arises due to emission of dust particles by heavy traffic movement [10]. Maximum concentration of coal particulates generally occurs during winter season and minimum in rainy season [11, 12]. Coal dust generation defiles the working sight and affects occupational health and biodiversity of the adjacent region. In fact, it causes several problems leading to environmental disturbances, threat to health and aesthetic destructions at a large scale [13]. Thus, dust emission is the foremost problem for opencast coal mines [14].

Coal dust is an undesired element but inevitable fact of life in most phases of coal production and it causes several occupational diseases [11, 15]. Its generation cannot be completely prevented. For effective control measures, dust has to be collected from road surface and converted into solid form, which may be used as domestic fuel considering its physico-chemical properties. Thus, main objective of the present study is to assess the feasibility of road dust of different Indian coalfields as domestic fuel [16].

II. STUDY SITES AND METHODS

A. Study sites

The coal dust samples were collected from four different opencast mines of India, namely (i) Tara mine of Bengal Emta in West Bengal state; (ii) Jamunia mine of Bharat Coking Coal Limited in Jharkhand state; (iii) Lakhanpur mine of Mahanadi Coalfields Limited in Orissa state; and (iv) Jhingurdah mine of Northern Coalfields Limited in Madhya Pradesh state. Location of the study sites are shown in Fig. 1. Brief descriptions of the four sites are given in Table I.

B. Climate

The climate of central and eastern India where the study sites are located is dry tropical and the year can be divided into cold winter season (November to February), very hot summer season (April to June) and wet rainy season (July to September). March and October are the transitional period between winter and summer, and rainy and winter seasons, respectively. The maximum amount of dust is found during winter season. In an annual cycle, mean daily minimum temperature ranges from 10–28 ºC, and mean daily maximum temperature varies from 26 to 45 ºC. The average annual rain fall is 1241 mm of which 1107 mm occurs between late June and September.

C. Geology

Formation of tertiary bed rock in general is medium to coarse grained sandstone with ferruginous band and carbonaceous shale. Average depth of soil surface layer is 80–110 cm. Soil is grey brown to very pale brown in colour and sandy loam to clay loam in texture with a sub-angular blocky structure. Low ferromanganese concentration and clay content are found in the subsoil. The overburden consists of alluvial loose sand, gravel, shale and sandstone.

D. Sampling

Dust samples were collected from haul road (HR), transport road (TR) and road outside the mine, i.e. communication road (CR) of four mine sites. Three representative samples were collected at different locations of the above mentioned roads covering 1×1m length at each location. Dust samples were collected from mine sites and stored in polyethylene bags for analysis after removing larger particles [17].

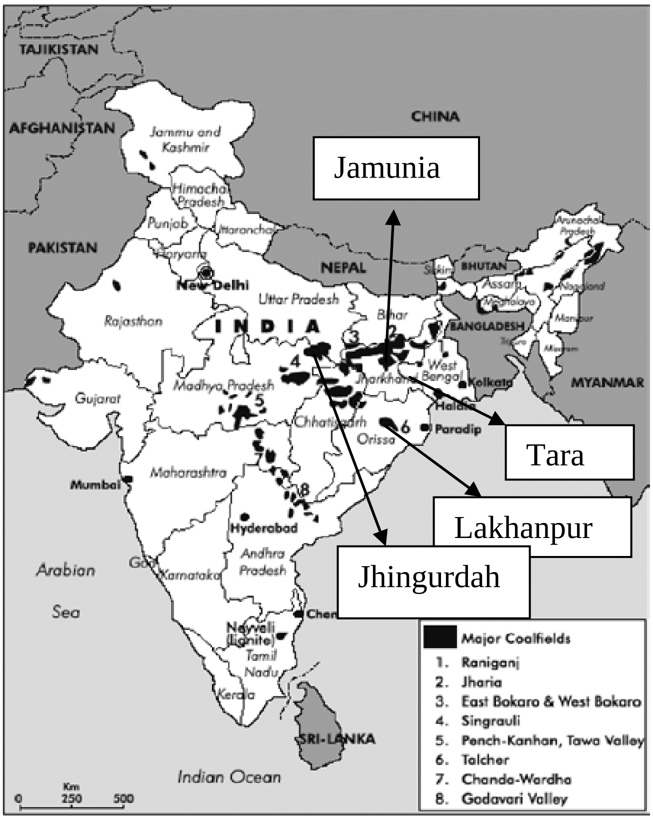


Fig. 1 Location of four study sites

TABLE I

DESCRIPTION OF THE STUDY SITES

Feature	Study Sites			
	Tara Mine	***Jamunia Mine***	***Lakhanpur Mine***	***Jhingurdah Mine***
Company	Bengal Emta	BCCL	MCL	NCL
Coalfield	Raniganj	Jharia	Ib Valley	Singrauli
District	Burdwan	Dhanbad	Jharsuguda	Sidhi
State	West Bengal	Jharkhand	Orissa	Madhya Pradesh
Mining method	Opencast	Opencast	Opencast	Opencast
Longitude	86° 43′ E	86°12′31″ E	83°50′38″ E	82° 27′ E
Latitude	23° 47′ N	23° 46′05″ N	21° 45′15″ N	24° 18′ N
Type of coal	Medium coking coal	Prime coking coal	Power grade coal	Power grade coal
Coal properties:				
- Carbon content	61%	65%	49%	53%
- Volatile matter	13%	11%	16%	15%
- Ash content	22%	20%	30%	27%
Annual coal production of the mine	4 Mt	4.75 Mt	15 Mt	3.86 Mt

Key: BCCL–Bharat Coking Coal Limited, MCL–Mahanadi Coalfields Limited, NCL–Northern Coalfields Limited.

E. Analysis

Laboratory studies were conducted by using standard methods (Table II) to determine the physico-chemical properties (Table III) of dust samples. Dust pH was measured by Orion Ion Analyzer, using glass electrode (1:5, dust: water) [18]. Moisture content (MC) was determined by oven dry method using Indian standard [19], where pre-weighed dried samples were oven dried at 105º C till the constant weight was obtained. Determination of volatile matter was carried out by placing a weighed sample in a covered crucible and heated at 900 ± 10ºC for 7 minutes in a muffle furnace. The sample was cooled and weighed. Loss of weight represents volatile matter. Ash content was determined by using Indian standard [19]; weighed quantity of dust sample was placed in an uncovered crucible and heated in muffle furnace at 815 ± 10ºC. The residue was weighed which is incombustible ash. Fixed carbon was determined directly by deducting the sum total of moisture, volatile matter and ash percentage from 100 [19]. Specific gravity was determined by using density bottle method [20]. Water holding capacity (WHC) and bulk density (BD) was determined using perforated circular boxes [21]. Dust was packed into perforated box lined with a filter paper by adding small quantity of dust at a time. Container was repeatedly tapped after each addition. When the box was full it was weighted and placed in a Petri plate containing water, permitting the dust to get saturated. The amount of water retained by dust was determined by oven drying and treated as its WHC. BD was estimated as the weight of oven dried dust per unit volume.

Table II

STANDARD PROCEDURE FOLLOWED FOR DUST ANALYSIS

Variables	Procedure	References
pH	Glass Electrode	AWWA (1992) [18]
Ash Content	IS Method	IS: 1350–Part 1 (1970)[19]
Moisture Content	IS Method	IS: 1350–Part 1 (1970)[19]
Volatile Matter Content	IS Method	IS: 1350–Part 1 (1970)[19]
Fixed Carbon	IS Method	IS: 1350–Part 1 (1970)[19]
Water Holding Capacity	Keens Cup Method	Piper (1944)[21]
Bulk Density	Keens Cup Method	Piper (1944)[21]
Specific Gravity	Density Bottle Method	IS: 2720–Part 3 (1980)[20]
Particle Size Distribution	Sieve Analysis	Jumikis (1995)[17]

Particles size distribution of dust samples was analyzed by using sieves of different mesh size [17] as well as micron photosize analyzer manufactured by Seisin Enterprise, Japan (Model SKN 1000). In sieve analysis 4 mm, 2 mm, 425 µ and 75 µ sieves were used for sieving. Dust samples were categorized into coarse particles (>4 mm–2 mm), medium size particles (<2 mm–425 µ), fine particles (<425 µ–75 µ), and silt and clay particles (<75 µ). Dust particles of smaller fractions (up to 100 µ) were further categorized with the help of micron photosize analyzer. These were further divided into four groups, i.e. particle size of ≤2.5 µ, >2.5 to ≤10 µ, >10 to ≤100 µ and >100 µ.

Quantity of dust (kg m─1) available on road surface was calculated based on average quantity (kg) of dust collected from three locations covering 1×1m length of particular road in each sampling site. Subsequently, measured dust quantity (kg m─1) was converted to conventional unit (t km─1).

III. Results and Discussion

The results for various physico-chemical properties of coal dust samples collected from four opencast coal mine sites are given in Table III. The mean and standard error (±) values are summarized for the selected parameters.

A. The pH Values

Dust samples of all the four mining sites were found to be acidic in nature (5.1–6.8) except those of haul road of Tara (7.7) and Lakhanpur (7.3) mines (Table III). These were slightly basic.

A little variation was observed in pH value of dust samples of Tara mine with respect to other three mines. Dust samples of Tara mine were having comparatively higher pH values. This may be due to deposition of adjacent soil particles during wind erosion. The normal soil of adjacent area is basic in nature.

B. Particle Size Distribution

Sieve analysis revealed that among all the four mines the maximum percentage (38.26) of coarse particles (<4 to 2 mm size) was obtained in haul road dust samples, while the minimum percentage (11.27) was found in communication road of Jamunia mine (Fig. 2). Coarse particles in road dust samples of Lakhanpur, Tara and Jhingurdah mines ranged from 14.08–21.18, 21.41–23.49 and 12.88–19.02%, respectively. Dust particles of medium size (<2 mm to 425 µm) varied from 19.22–21.83, 23.16–28.97, 22.32–25.53 and 20.32–21.51% for Jamunia, Lakhanpur, Tara and Jhingurdah mines, respectively. Fine particles (<425 to 75 µm diameter) varied from 26.41–46.29, 40.40–43.64, 41.26–45.32 and 41.37–42.14% in dust samples from Jamunia, Tara, Jhingurdah and Lakhanpur mines, respectively. Among all the four mines, the maximum (23.99%) silt and clay content (particle size less than 75 µm diameter) was found in transport road dust samples of Jamunia mine, while the minimum (10.55%) was measured in haul road dust samples of Tara mine. In general, silt and clay content was higher in transport road followed by communication and haul roads, except for Jhingurdah mine where it was higher (20.46%) in communication road than transport (20.16%) and haul (18.21%) roads.

In general coarse particles were maximal in haul road. It may be due to fall of overloaded transport coal on road surface from dumpers during plying of dumpers and jerking. The falling of coal gradually decreases towards transport and communication roads. These strewn materials are being crushed during frequent movements of heavy earth moving machinery. As a result, minimum coarse particles were found in communication road. Fine particles (<425 to 75 µm diameter) were higher in all haul road, transport road and communication road which ranged from 39–45%, except haul road (26%) dust sample of Jamunia mine (Fig. 2). Generally, lower values of silt and clay content were found in all the dust samples.

As per micron photosize analyzer, very fine dust particles (<1 µ diameter) varied from 2–22, 6–19, 5–17 and 7–19% for Tara, Jamunia, Lakhanpur and Jhingurdah mines, respectively (Fig. 3). Respirable dust particles (<1–10 µm diameter) was found to be 32, 39 and 31% in haul road, transport road and communication road of Tara mine, respectively. For Jamunia, Lakhanpur and Jhingurdah mines, it was found to be 28, 32 and 26%, respectively. Suspended dust particles (<10–100 µm) ranged between 22 and 38% among all the mines. Dust particles of size greater than 100 µm varied from 18–37% for all the four mines.

All PM10 particles are considered respirable; those less than 2.5 µm in diameter are likely to penetrate further into lung and generally considered to cause a greater risk to health [22–28]. Presence of 0.3 to 0.5 µm coal dust particles in human lungs is harmful. As per the analytical results, haul road and transport road showed higher percentage of dust particles of size 1–10 µm in all the mines which ranged from 28–39%, except transport road of Lakhanpur (24%) and Jhingurdah (23%) mines (Fig. 3). As a result, miners and peoples in the vicinity of these coal mines may suffer from respiratory diseases. It is reported that 10% people of Asansol and 6% people of Raniganj blocks (where Tara mine is located) are affected by respiratory disease, and a few villagers of Ratibati, Narsamuda, Siarsol, Mangalpur and Baradhema are also affected by this disease (http://www.gisdevelopment.net). Dust particles of size 1–10 µm was higher in Lakhanpur (27%) and Jhingurdah (26%) mines, thus miners working in these mines and surrounding peoples may be affected from respiratory diseases.

C. Water Holding Capacity

Water holding capacity of dust sample from Jhingurdah mine was found to be maximum (29.64–31.71%), while dust samples of Lakhanpur mine showed minimum (21.17–22.45%) among all the four mines (Table III). Further, it was found to be 21.64% in communication road, 24.77% in haul road, and 27.60% in transport road of Tara mine, and it was 23.86, 22.80 and 26.5%, respectively in Jamunia mine.

Water holding capacity of transport road samples from all the four coal mines showed maximum ability to retain water, because silt and clay contents were higher in transport road samples than haul road. Silt and clay particles have greater water retention capacity than coarse coal dust. Dust samples from Jhingurdah mine showed the highest water retention capacity among all the sites. Dust having higher water holding capacity requires more water to make it paste. For dust collection and utilization point of view, greater amount of water (around 30–35% of total dust quantity) is required for converting road dust into paste form and subsequently making it coal briquettes.

D. Ash Content

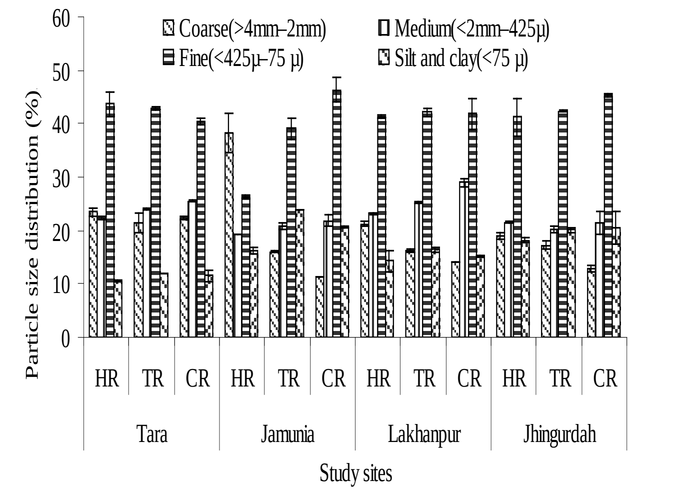
Ash content in dust samples was found to be maximal (54–76%) for Tara mine and minimal (39–53%) for Jamunia mine among all the four mines (Fig. 4). In case of Lakhanpur and Jhingurdah mines it ranged from 48─64 and 45─60%, respectively.

It was observed that ash content was moderate in all the haul road dust samples except Tara mine where a distinct variation was observed, which showed 76% ash, while transport and communication roads dust samples contained 54 and 64% ash, respectively (Fig. 4). In general, it is quite obvious that amount of coal particles is more in haul road which is confined near the mine working, and as distance from mine working increases, road dust mixes more with soil particles which increases ash percentage. Ash content of haul road dust samples of all the mines was slightly more than that of in-situ coal of the respective mine except haul road of Tara mine. In case of Tara mine it was very high even though in-situ coal of Raniganj Coalfields, where the mine is located, contains low ash. This may be due to presence of new haul road in Tara mine containing large amount of soil, silt and clay, which decrease the amount of coal dust on the road. Ash content of all the coal dust samples (45–76%) was greater (Table III) than that of in-situ coal of Jharia (20–25%), Raniganj (15–36%), Ib Valley (15–40%) and Singrauli (22–35%) coalfields [29], where the study sites are located. Ash content of coal used in different Indian power generated plants varies from 26–47% (Table IV). Thus, it may be concluded that haul road dust of all the four mines, except Tara mine and transport road dust of Jamunia mine, may be used for domestic fuel purpose.

TABLE III

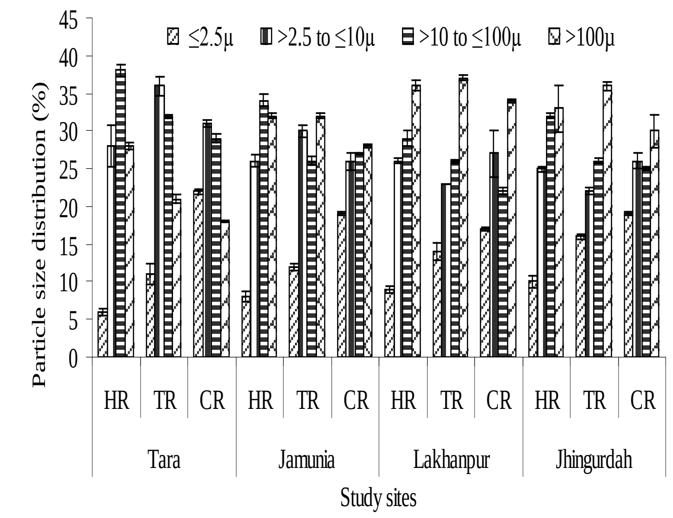
VALUE OF DIFFERENT PARAMETERS OF COAL DUST (MEAN ±S.E.)

Mines	Parameters								
	Sample	pH	WHC (%)	Ash (%)	MC (%)	VM (%)	BD (g cm^{-3})	SG	FC (%)
Tara	HR	7.7	24.77±3.05	76±2.51	0.5±0.02	13.3±0.03	1.54±0.04	2.18±0.06	10.2±0.52
	TR	6.4	27.60±0.28	54±1.56	0.7±0.03	13.4±0.06	1.44±0.04	2.08±0.02	31.9±1.49
	CR	6.4	21.64±0.64	64±3.02	0.8±0.09	12.6±0.07	1.48±0.04	1.92±0.08	22.6±2.94
	Coal[1]			15–36		25–43			61–90
Jamunia	HR	6.8	22.80±0.63	39±2.75	1.3±0.04	14.4±0.53	1.42±0.02	1.91±0.15	45.3±0.44
	TR	6.2	26.55±0.47	47±1.12	0.7±0.03	13.4±0.38	1.39±.0.02	1.73±0.23	38.9±1.36
	CR	5.7	23.86±0.55	53±1.29	0.6±0.02	13.3±0.92	1.55±0.06	2.15±0.23	33.1±0.29
	Coal[2]			20–25		26–40			65–87
Lakhanpur	HR	7.3	21.31±0.02	48±1.03	3.0±0.11	13.6±0.14	1.70±0.07	2.30±0.01	35.4±1.13
	TR	5.8	21.17±0.78	59±1.53	2.4±0.35	14.5±0.23	1.50±0.02	2.11±0.05	24.1±1.19
	CR	5.3	22.45±0.56	64±1.59	1.4±0.09	14.4±0.36	1.47±0.01	1.87±0.03	20.2±1.90
	Coal[3]			15–40		35–45			49–82
Jhingurdah	HR	5.6	29.64±0.31	45±1.96	2.2±0.17	19.9±0.39	1.29±0.02	1.95±0.01	32.9±1.16
	TR	5.3	31.71±1.07	55±2.61	1.4±0.31	20.0±0.64	1.21±0.01	2.02±0.04	23.6±1.36
	CR	5.1	30.91±0.79	60±2.34	0.5±0.07	18.9±0.74	1.15±0.01	1.89±0.09	20.6±1.06
	Coal[4]			22–35		40–42			46–78



HR – Haul road, TR – Transport road, CR – Communication road

Fig. 2 Particle size distribution of different dust samples analysed by sieve analysis



HR – Haul road, TR – Transport road, CR – Communication road

Fig. 3 Particle size distribution of different dust samples analysed by micron photosize analyzer

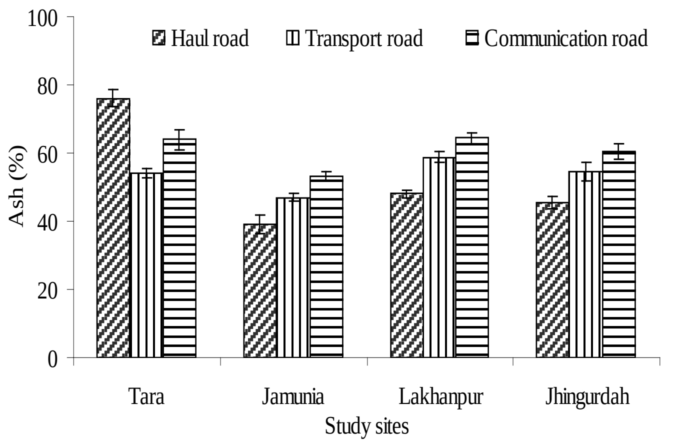


Fig. 4 Ash content in different dust samples

TABLE IV

TYPICAL COAL CHARACTERISTICS IN SELECTED INDIAN POWER PLANTS

Location of coal	**State**	**Ash Content (%)**	**Moisture Content (%)**	**Carbon (%)**
Simhadri	Andhra Pradesh	46.0	15.0	29.0
Sipat	Chhattisgarh	45.0	15.0	30.7
Singrauli	Uttar Pradesh	26.3	12.0	50.2
Chandrapur	Maharashtra	47.0	5.1	37.7
Dahanu	Maharashtra	38.5	5.9	42.4
Neyveli lignite	Tamilnadu	7.0	47.0	26.1
Kutch lignite	Gujarat	15.0	36.0	28.3

E. Moisture Content

In the present study, moisture content was highest in dust samples of Lakhanpur mine (1.4–3.0%) followed by Jhingurdah, Jamunia and Tara mines having moisture content in the range of 2.2–0.5, 1.3–0.6 and 0.5–0.8%, respectively (Table III).

Moisture content varied from mine to mine. Lakhanpur mine showed the highest amount of moisture content (3%) in haul road dust and the lowest (0.5%) was found in Tara mine. This may be due to variation in water spraying intervals on haul roads of both the mines. In general, it was observed during the study period that moisture content was higher in haul roads followed by transport and communication roads, except for Tara mine where it was reverse. Moisture content of Tara mine haul, transport and communication roads were 0.5, 0.7 and 0.8%, respectively (Table III), due to less frequent water sprinkling on the mine site.

F. Volatile Matter

Volatile matter content value was greater in dust samples of Jhingurdah mine (18.9–20.0%), whereas it was lower in Tara mine which ranged from 12.6–13.4% (Fig. 5). In case of dust samples of Lakhanpur and Jamunia mines volatile matter was found to be 13.6–14.4 and 13.3–14.4%, respectively for all the mine roads.

In general, volatile matter in coal dust sample was less in all the sites compared to the in-situ coal of the respective site. It was found to be 12.6–13.4, 13.3–14.4, and 13.6–14.5%, respectively for Tara, Jamunia and Lakhanpur mines, whereas volatile matter of in-situ coal of respective coalfields [29] is 25–43, 26–40 and 35–45% (Table III). Dust samples of Jhingurdah mine showed higher percentage (18.9–20.0) of volatile matter than the dust samples of other three mines. This may be due to presence of higher volatile matter (40–42%) in in-situ coal of the coalfield (Fig. 5). Volatile matter was not significantly different among sites and sub-sites. Higher volatile matter is indicative of higher ash content in coal dust.

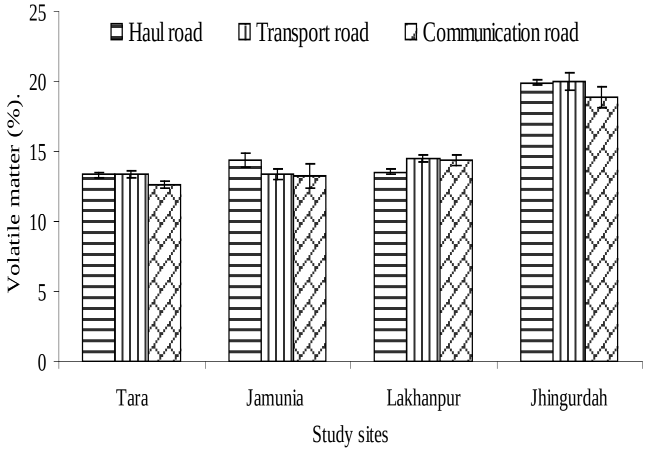


Fig. 5 Volatile matter content of different dust samples

Bulk density was higher in haul road dust of all the mines except Jamunia mine, in which it was higher in communication road dust samples. Percentage of bulk density was the highest in haul road dust samples of Lakhanpur mine and the lowest in communication road of Jhingurdah mine. As bulk density is inversely proportional to water retention capacity, more water is required to suppress dust of such mines which contain dust of higher bulk density. Higher bulk density indicates lower calorific value of coal dust and lower efficacy as domestic fuel.

G. Specific Gravity

Among all the four sites, the maximum specific gravity was observed in dust samples of haul road (2.30), transport road (2.11) and communication road (1.87) of Lakhanpur mine (Table III). It was 1.95, 2.02 and 1.89 for respective roads of Jhingurdah mine. Specific gravity of dust samples of Tara and Jamunia mines ranged from 1.92–2.08 and 1.73–2.15, respectively. The minimum specific gravity (1.73) was found in transport road of Jamunia mine.

In general, specific gravity of all the coal dust samples from Tara and Lakhanpur mines was maximal in haul road followed by transport and communication roads. In case of Jamunia and Jhingurdah mines this pattern of variation was not same. Specific gravity was higher in communication road of Jamunia mine and transport road of Jhingurdah mine. Higher specific gravity shows coarse particles in coal dust and lower efficacy as domestic fuel.

H. Fixed Carbon

Fixed carbon content of dust samples from haul road, transport road and communication road of Jamunia mine was maximum (33.1–45.3%) followed by Lakhanpur (20.2–35.4%) and Jhingurdah (20.6–32.9%) mines (Fig. 6). The minimum value (10.2−31.9%) was observed for all the roads of Tara mine.

Dust samples from communication road of all the three mines (Jamunia, Lakhanpur and Jhingurdah) showed lower values of fixed carbon than those of transport and haul roads except Tara mine (Fig. 6). For Tara mine it was observed to be the lowest in haul road because of presence of high ash content in these samples. Fixed carbon of coal for respective coalfields [29] of Tara, Jamunia, Lakhanpur and Jhingurdah mines varied to a greater extent with the values ranging from 61–90%, 65–87%, 49–82% and 46–78%, respectively as compared to the road dust of same mines (Table III). The maximum fixed carbon was measured in communication road due to accumulation of coal dust on paved road, where chances of mixing with impurities are less. Higher the percentage of fixed carbon more is its efficiency as fuel. Thus, all the haul road coal dusts except those of Tara mine may be used as domestic fuel.

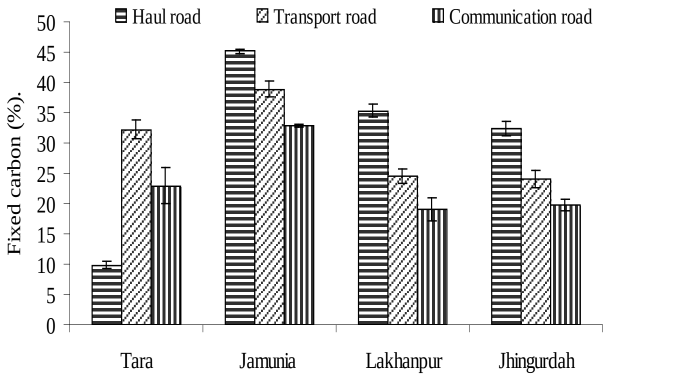


Fig. 6 Fixed carbon in different dust samples

J. Dust Quantity

Quantity of dust in Lakhanpur mine was found to be 78.4, 51.7 and 42.6 t km^{-1}, and for Jhingurdah mine it was 116.0, 98.2 and 50.3 t km^{-1} on haul, transport and communication roads, respectively (Fig. 7). It was measured to be 96.2, 64.5 and 38.7 t km^{-1} for Jamunia mine, and 124.5, 48.0 and 45.3 t km^{-1} for Tara mine, respectively.

Dust quantity was maximum on haul road (78–124.5 t km^{-1}) of all the four mines followed by transport (48–98.2 t km^{-1}) and communication (38.7–50.3 t km^{-1}) roads (Fig. 7). This may be due to presence of heavier particles and coal lumps on haul roads. As the distance from coal extraction point increases, presence of heavier particles on road surface decreases due to crushing by frequent movement of heavy vehicles. Fine particles were more on transport road of all mining areas, and the maximum dust dispersion was observed from transport road followed by haul and communication roads. Quantity of dust was more in Tara and Jhingurdah mines in comparison to the other two mines due to presence of unpaved road in these mines.

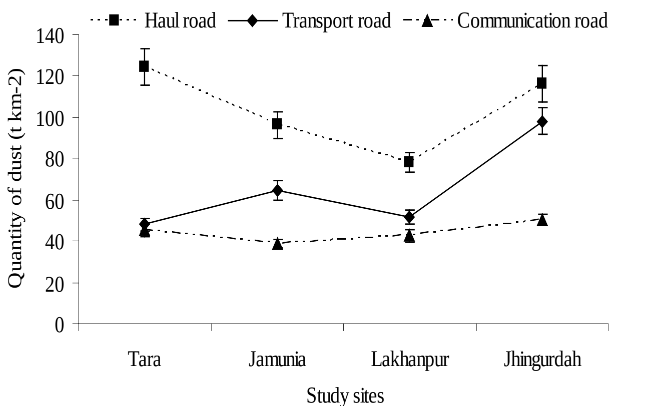


Fig. 7 Quantity of dust in various roads of four mines

IV. CONCLUSIONS

Coal mining plays an important role in economic development of many countries as well as fulfilling industrial demands. In transportation of coal through haul and transport roads in opencast mining areas generate around 80% of total dust emission which causes environmental problems and threats to health, biodiversity and aesthetic beauty at a large scale. Various available techniques are implemented in field to minimize and control dust in mining areas. However, these techniques are not very effective to remove dust completely from road surface. The analytical results of physico-chemical parameters and proximate analysis of road dust samples collected from four coalfields of India revealed that coal dust from mining roads can be used as domestic fuel. So for effective control, dust of opencast mining areas has to be collected from road surface and converted into solid form for using as a domestic fuel. Thus, findings of the study would greatly help in understanding the properties of coal dust abundantly available on road surface of opencast coal mining areas and consequently help in converting this undesirable problem into an economic benefit as well as reducing air pollution.

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