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By Junaidi Junaidi

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Dust Distribution along Coal Transport Corridors in Tapin Regency, South Kalimantan

Junaidi[1], Soemarno[2], Arief Rachmansyah[3], Yudi Firmanul Arifin[4]
[1]Graduate Program on Environmental Science, Brawijaya University and Health Polytechnique Banjarmasin Indonesia
[2,3]Faculty of Engineering, Brawijaya University, Malang Indonesia
[4]Faculty of Forestry, Lambung Mangkurat University, Banjarmasin Indonesia

Abstract: *Transportation system is crucial issues in coal mining and the impact of coal mining transportation has been identified crucial in environmental and socials aspects. The aim of the research is to describe the distribution of dust fall along the roads which are used as transport corridors of coals. Research was set up at road in Tapin Regency, South Kalimantan. The levels of dust fall and its distribution was assessed in five observation transect in right and left sides of road. In each observation transect, there are five observation points which are set up at the distance of 1m, 10 m, 25m, 50m and 100 m from road. Research shows that the level of dust fall in the right sides of road was about 479.6 ton/km^2/month (1m distance from road), 176.7 ton/km^2/month (10m distance from road), 72.3 ton/km^2/month (25 m distance from road), 32.0 ton/km^2/month (50m distance from road) and 13.3 ton/km^2/month (100m distance from road). In the left site the level of dust fall was about 472.0 ton/km^2/month (1m distance from road), 131,9 ton/km^2/month (10m distance from road), 46.8 ton/km^2/month (100m distance from road), 22,9 ton/km^2/month (50m distance from road) and 11,4 ton/km^2/month (1m distance from road). The level of dust was decreasing in the far plot from road. The pattern of dust distribution was Y = 451,213 – 105.567 Ln(X) (in the right side), with R^2 = 0.713 and Y = 428,972 – 103.989 Ln(X) (in the left sides), with R^2 = 0.571.*

Keywords: *air pollution, coal mining, environmental hazard*

I. Introduction

South Kalimantan is one of the coal mining areas in Indonesia. The contribution of coal mining was significant both for provincial revenue and local economic development. The global and national demand of coal from South Kalimantan was increase yearly and it has been reported contributes to some serious consequences. The issues of the impact of coal mining was numerous, encompasses environmental, social, health, and economical aspects. Recently, new sites of exploitation, stockpiles and infrastructure for coal mining was increase and this phenomena becomes significant issues in recent sustainable development in south Kalimantan [1] [2].

One of the crucial aspects related to the coal mining is the impact of transportation to the human health. According to Indonesia Law number 4 2009 about coals and mineral mining activity, the transportation of mineral and coal should be use special road and corridor which area separated from public road. In south Kalimantan, however, limitation of the infrastructure becomes barrier for the implementation of Indonesia Law number 4 year 2009 [3]. As a result, some negotiation was released to accommodate two aspects, namely human health and industry. In south Kalimantan, there is regulation to permit the uses of public road but should be about 06.00 pm - 06.00 am.

Coal transportation is needed due to the long distance between exploration sites to the port. In Kalimantan, coals transfer from mining sites to part was done by dump truck with capacity 20 tones to 100 ton. The local company for coal mining often uses truck with capacity about 20 tomes, while big companies employ dump truck with 100 ton capacity. There are several transportation modes was used to deliver coal to the end of user, namely trains, waterborne, and truck.

The use of public road has been reported contributes to the traffic jam and accident. Since June, 1 2009, by the provincial regulation No. 3 year 2008 about regulation of road for public transportation and special road for mining transportation, there are changes of the transportation systems. The objectives of the provincial role are to protect human health and maintain infrastructure quality for public transportation. Following such regulation, company start to establish their own road to pick up coals. In some point however, the uses of public road was permitted due to some obstacles and limitation of infrastructure. The share of road usage was found in Tapin Regency. In km.94 of road, the road was used as public road and also used as corridors road for coal transportation. These roads connected mining location to coal stockpile station, and extended about more than 50 to the port.

The increase of coal mining activity significantly contributes to the high rate of coal transportation. Serious problems occur when number of dump truck increase. Previously, only two companies was recorded use the road, but recently there are about 25 coal company use roads. The volume of dump truck was recorded about 4,000 to 5,000 per days [4]. The significant impact of such activity is including impact to environment. These problems become complicated to the road connected to other road and pass the community settlements. For a long time, complaint about dust pollution has been reported by local community. Dust lead to the irritation and respiration problems among local dweller along roads [5].

Impact of dust to the human health has been widely reported. Survey confirms that dust has negative impact to respiration systems and significantly related to the epidemiology. In India, survey confirm that the operational of coal mining contributes significantly to the increase of Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM), SO_2 and NO_2 beyond the quality levels. It is found that the increase of SPM for industrial area, settlements and sensitive zones (i.e. hospital) was about 500 $\mu gr/m^3$, 200 $\mu gr/m^3$ and 100 $\mu gr/m^3$ [6]. Increase of coal production in west Virginia has significant correlation with the poor health status of the community, indicated by lung disease, cardiopulmonary, cardiovascular, diabetes and problems of kidneys functions. The incident of COPD (*chronic obstructive pneumonic disease*), *black lung disease* and hypertency was also reported increase [7]. In Scotland, COPD was increase in mining area in Douglasdale about 60% within four years, while in control area (Prestwick) less than 10%. Increase of incident also found in (44%), hyperthyroid (80%), cancer (250%) [8].

The environmental management related to the coal mining was important. The data and information such as dust concentration and distribution along coal transport corridors was important for decision maker to construct the proper strategy. The aim of the research is to measure the dust fall along road corridors which are important for the environmental management.

II. Methodology

Study sites

Field survey was done in Tapin Regency, South Kalimantan (Fig.1). Geographically, Tapin Regency was located at 2°32’43” to 3º00’43” longitude and 114°46’13” to 115º30’33” latitude. Tapin has huge deposits of coal. The transportation coal was uses corridors about 56 kilometers. This road connected point sites of exploration to the port. In this research, survey was done from road sin Km. 32 to km 56. In this road, there are community settlement from 5 sub-district and encompasses 8 villages (Table 1).

Table 1. The community settlement in study area

Sub district	Village
Binuang	Pulau Pinang Utara
Tapin Selatan	Tatakan, Suato Tatakan, Rumintin and Lawahan
Salam Babaris	Pantai Cabe
Bungur	Kalumpang
Lokpaikat	Bitahan Baru

Methods

The collection dust fall was done using dust fall collector, (SNI 13-4703-1998) (Fig.2). The collection was done at observed point in five locations. In each location three are about 10 dust fall collectors was set up, 5 in left sides and 5 in right sides. The distance of each sample sites was about 1 m , 10 m, 25 m, 50 m and 100 m from roads. In each point of collection, the dust level was observed in the day 1st, 5th, 10th, 20th, and 30th. Dust fall is the dust particle with size > 10 µm that fall due to the gravitation mechanism.

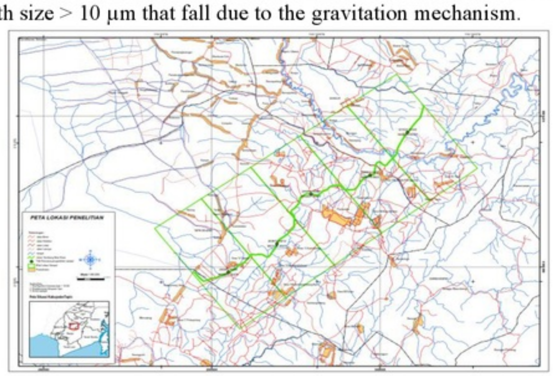

Fig.1. map of study sites and observation plot (green line)

Fig. 2. Dust fall collector which was set up at point observation.

Data analysis

Field data was analyzed descriptively and the dust fall levels were compared to the dust levels of mining following Indonesia governmental role no 41 year 1999 about air pollution. In order to describe the mathematical models of dust and its relationship to the air quality standard, three mathematical models namely linear, quadratic and logarithmic models was assessed.

III. Result And Discussion

The importance of South Kalimantan as coal supplier can be traced back from its geological history. Recent survey confirm that South Kalimantan is the centre of coal deposits in Indonesia [9]. Among 13 regency in Kalimantan, only four regency namely Banjarmasin, Banjarbaru, Barito Kuala dan Hulu Sungai Utara has less coal deposits. The other regency such Tabalong, Hulu Sungai Tengah, Hulu Sungai selatan, Tapin, Kota Baru, Banjar, Tanah Laut and Kota Baru are the sites with huge coal deposits (Fig.3)

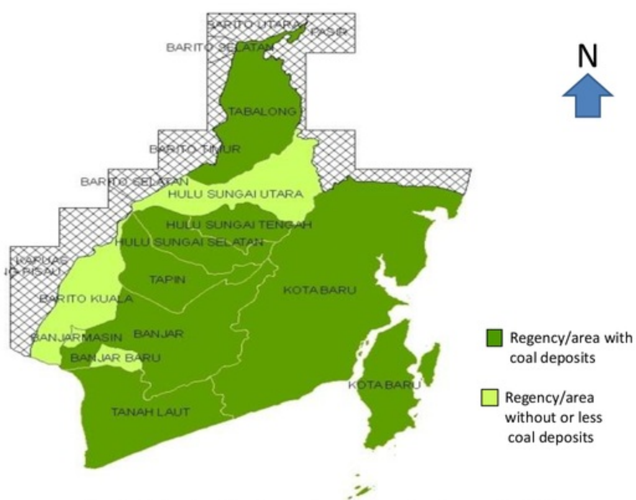

Fig. 3. The distribution of coal deposits in south Kalimantan

Dust fall level along corridors

The level of dust fall from all of the observed point in 1m, 10m, 25m and 50m from the edge, both in left and right sides, was beyond air quality standard that area stated in Indonesian Law Number 41 year 1999 about air pollution. There are however, two point of observation at 100m point observations has low level of dust fall (Table 1 and Table 2).

Table 1. Dust fall level in right sides of roads

No	Distance from road edge (m)	Average of dust fall (ton/km^2/month) in days of observation				
		1st	5th	10th	20th	30th
1	1	768.92	453.54	418.04	389.96	367.76
2	10	237.70	189.64	203.72	108.02	144.40

3	25	92.76	64.24	76.68	64.50	63.3
4	50	42.5	28.92	31.64	26.10	30.90
5	100	19.00	12.42	14.42	7.50	13.68

Table 2 Dust fall level in left sides of roads

No	Distance from road edge (m)	Average of dust fall (ton/km^2/month) in days of observation				
		1st	5th	10th	20th	30th
1	1	724.50	418.8	462.34	328.90	425.20
2	10	200.40	97.62	153.84	83.42	124.26
3	25	71.62	37.86	46.86	33.30	44.36
4	50	27.44	19.54	27.02	19.14	21.52
5	100	14.82	10.90	11.54	11.04	8.72

The high level of dust has correlation with the dump truck movements along corridors, temperature and air humidity. Vehicle movement frequency is the sources of dust and become the important factor for dust dispersal [10]. Based on the Table 3, it is clear that the road was crowded and the distribution of vehicle moving was quite similar during 24 hours, including car 107 unit, truck with 8 tones capacity 31 unit, truck with 20 tones capacity 3,338 unit. Dust dispersion caused by transportation system come from several factors as described below.

(1) Traffic density. Number of truck with 20 ton capacity was about 3.338 unit/days or 139 unit per hour.
(2) Coal spills along road corridors. Over capacity of dump truck to pick up coal lead to the coal spills. These spill easily become dust.
(3) The vehicle speed was recorded about >40 km/hour. Dump truck without coal more fast, calculated about 60 km/hour. These lead to the increase of wind velocity which are able to destroy solid material become dust.

Fig. 4 impact of transportation system in producing dust

Another factor of dust production area related to the air environments, such as temperature and humidly. These factor contributes to the dust development. The road conditions also contributes to the dust dispersal. Poor road with exposed soils and gravels contributes to the abundance of dust [11]. In order to minimize the impact of dust, watering in some point of road was done by villager. During the study, it was recorded that watering was done about 16 and 24 times, but the times of watering was not done regularly (Table 3).

Table 3 The temperature, air humidity and watering frequency of roads.

Hours	First observation			Second observation		
	Temperature (ºC)	Air humidity (%)	Watering (times)	Temperature (ºC)	Air humidity (%)	Watering (times)
12.00	34.1	65.0	-	34.0	73.3	-
13.00	40.9	53.5	1	33.9	68.7	2
14.00	36.9	61.0	3	34.9	65.8	3
15.00	30.4	76.8	1	32.2	79.5	3
16.00	28.8	77.5	1	30.2	79.1	2
17.00	27.2	81.4	-	27.5	83.1	1
18.00	26.4	82.2	-	27.1	83.2	-
19.00	26.1	83.2	-	26.6	84.2	1
20.00	25.3	85.4	2	25.4	87.2	2
21.00	25.1	88.1	2	24.8	90.6	1
22.00	25.0	87.9	-	25.1	90.8	1
23.00	25.0	86.3	-	24.8	90.9	-
00.00	24.4	88.8	-	23.7	93.3	-
01.00	24.2	89.6	-	24.6	90.8	-
02.00	24.0	90.5	-	24.5	91.6	1
03.00	24.9	87.3	-	24.7	91.1	-

04.00	23.9	88.4	-	24.9	90.3	-
05.00	23.5	89.8	-	25.1	89.0	-
06.00	23.6	88.4	-	23.6	92.7	-
07.00	24.2	88.7	-	26.5	89.3	-
08.00	26.4	85.8	-	27.5	87.4	1
09.00	28.6	82.1	2	29.6	82.8	2
10.00	29.1	79.9	2	31.8	77.0	2
11.00	30.9	73.9	2	37.5	65.9	2

In the longest distance of observed point in 100 m from road, the levels of dust were above air quality standard which area stated in Indonesian Government regulation [12]. Considering the statistical data analysis, the selected and tested models is the models with higher R^2 value.

Distribution models of dust falls in right sides of sides

Statistically, all of the dust distribution models in Table 4 were significant, and logarithmic models is the better models to estimate dust fall variable due to the highest R^2 value, as modeled Y = 451,213 – 105,567 Ln (X). The R^2 = 0.713 means that the observed level of dust fall in coals mining roads about 71.3% was caused by distance variable. From this models, it is estimated that dust fall in left road was about 451,213 ton/km^2/month. This amount similar with the field observation. According to logarithmic models, the critical distance point of dust pollution to pollution in the right sides was about 65.3m.

Table 4. Dust fall level distribution in right sides of road

No	Models	R^2	Probability	Mathematical equations
1	Linear	0.378	0,000	$Y = 283.394 - 3.457 (X)$
2	Quadratic	0.616	0,000	$Y = 402.06 - 13.758 (X) + 0.1 (X^2)$
3	Logarithmic	0.713	0,000	$Y = 451.213 - 105.567 \text{ Ln } (X)$

Notes: Y= dust level (μg/m³) and X = Distance (meter)

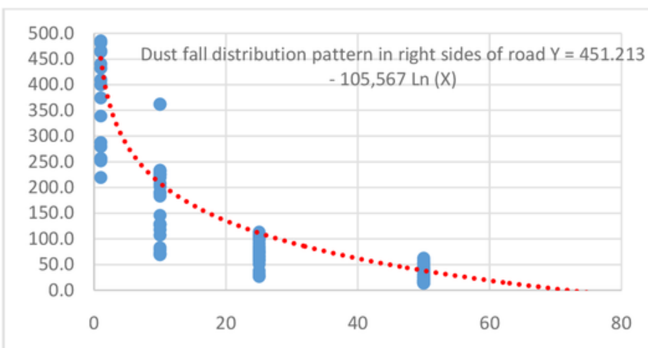

Fig. 5 Dust distribution in right sides of road

Distribution models of dust falls in left sides of sides

Statistically, all of the dust distribution models was significant, and the logarithmic models can be said as a better models to predict dust fall level variable due to its highest R^2 value, Y = 428,972 – 103,989 Ln (X). The value of R^2 = 0,571, means that observed *dust fall* distribution about 57.1% was determined by distance variable. From this model, it is predicted that dust fall was about 428,972 ton/km^2/month. This amount similar with the field observation. According to logarithmic models, the critical distance point of dust pollution to pollution in the left sides was about 56.2m.

Table 5. Models of dust distribution in left sides of road

No	Models	R^2 value	Probability	Mathematical equations
1	Linear	0.269	0.000	$Y = 256.345 - 3.208 (X)$
2	Quadratic	0.475	0,000	$Y = 377.794 - 13.752 (X) + 0.102 (X^2)$
3	Logarithmic	0.571	0.000	$Y = 428.972 - 103.989 \text{ Ln } (X)$

Notes: Y= dust level (μg/m³) and X = Distance (meter)

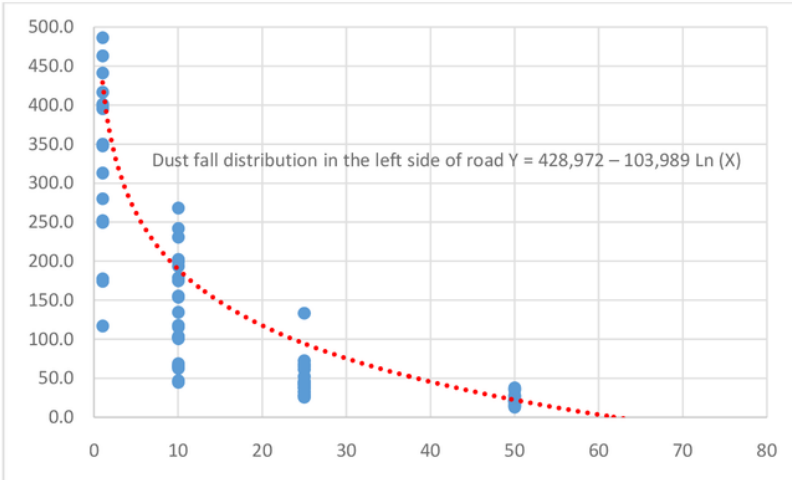

Fig. 6 Dust distribution in left sides of road

IV. Conclusions

The average levels of dust fall as an impact of coal transportation was about 768.92 ton/km^2/month in right sides of road and 724.50 ton/km^2/month in the left sides of road. Compared to the dust levels in Indonesian Law no. 41 year 1999 about air pollution, the level of dust was beyond the air quality standard (10 ton/km^2/month). The pattern of dust distribution in coal transport corridors was Y = 451.213 – 105.567 Ln (X) for the right sides of road and Y = 428.972 – 103.989 Ln (X) for the left sides of road. Distance about 65,3 is the critical point for dust quality level in right side f road, while it the left site the critical distance from dust fall beyond air quality levels was about 56,2 meter.

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