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Health Risks and Community Perceptions due to the Impact of Fine Particles from Coal-Fired Power Plants

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Abstract: Coal-fired power plants produce various types of pollutants, some of them are produced by coal-fired power plants, namely sulfur dioxide, particulate matter, and nitrogen dioxide. Particulate matter in the air comprises heterogeneous solid combinations and suspended liquid mixtures and can be transported into the atmosphere over a long period and distances. Particulate matter is a key indicator of anthropogenic impact, which is very significant to the decline in human health. This study aims to use the Environmental Health Risk Analysis method and the interview method to establish public perceptions of health hazards related to the impact of fine particles (PM_{2.5}) from Coal Power Plants. The risk characteristics of carcinogenic and non-carcinogenic fine particles are still below the threshold in analyzing elemental risk. For the next 50 years, we determined the RQ value < 1 and the ECR value < 10⁻⁴. The locations of Sanetan, Trahan, Dadapan, Jerukwangi, Jinggotan and Jambu Timur had the highest RQ values sequentially. Sanetan, Trahan, Jinggotan, Jerukwangi, Jambu Timur, and Dadapan had the highest ECR values in a sequential order. Fine particles are perceived by 42-93% of respondents. However, the source of the dust is not thought to be from the power plant by 55-99% of respondents; 60-85.8% of respondents said their notion of fine dust was incorrect, while 18-78.6% of respondents did not know. Carcinogenic and non-carcinogenic risks in PM_{2.5} are still below the threshold, according to the analysis of metal elements in PM_{2.5}. The health dangers of fine particles are not well understood by some people in study locations.

Keywords: health risk assessment, community perceptions, fine particle, coal power plants, risk characteristics.

燃煤电厂细颗粒物的影响导致的健康风险和社区认知

摘要: 燃煤电厂产生的污染物种类繁多, 其中一些是燃煤电厂产生的, 即二氧化硫、颗粒物和二氧化氮。空气中的颗粒物包括异质的固体组合和悬浮的液体混合物, 可以长时期和远距离输送到大气中。颗粒物是人为影响的关键指标, 对人类健康的下降意义重大。本研究旨在使用环境健康风险分析法和访谈法建立公众对燃煤电厂细颗粒物(下午2.5)影响相关的健康危害的认知。致癌和非致癌微粒的风险特征仍低于元素风险分析的阈值。在接下来的50年中, 我们确定请求值<1和ECR值<10⁻⁴。萨内坦, 特拉汉, 达达潘、杰鲁万吉, 景戈滩和占布帖木儿的位置依次具有最高的请求值。萨内坦, 特拉汉, 景戈滩, 杰鲁万吉, 占布帖木儿和达达潘的ECR值依次最高。42-93%的受访者感知到细颗粒。然而, 55-99%的受访者认为粉尘的来源并非来自发电厂; 60-85.8%的受访者表示他们对微尘的概念不正确, 而18-78.6%的受访者不知道。根据对下午2.5中金属元素的分析, 下午2.5中的致癌和非致癌风险仍低于阈值。研究地点的一些人不太了解细颗粒对健康的危害。

关键词: 健康风险评估、社区认知、细颗粒物、燃煤电厂、风险特征。

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1. Introduction

Coal-fired power plants emit a variety of pollutants. They have other environmental consequences resulting from coal combustion. Over the last few decades, technological advancements have led to cleaner coal technology. It can improve the efficiency of coal-fired power plants (CFPPs), increasing the energy obtained from each tonne of coal while significantly reducing air emissions, particularly sulfur dioxide, particulate matter (PM), and nitrogen dioxide and lowering environmental impact [1]. Heterogeneous solid combinations and suspended liquid mixtures form particulate matter in the air. Their chemical compositions change over time. Particulate matter can be transported into the atmosphere over a long period, and distances are a key indicator of anthropogenic impact, which is very significant to the decline in human health. The smaller the particle size, the more harmful it could be. PM_{2.5} has a worse effect than PM₁₀ because fine particles easily penetrate the respiratory tract [2]. Community settlements are dust distribution areas, climatological factors affect the direction and extent of dust distribution, so the effect of dust particulates on human health is difficult to ascertain. The results of epidemiological studies in these cases vary widely [3]. Because coal-burning has shown that heavy metals bound to PM_{2.5} contribute to health concerns, research of metallic elements in fine particles (PM_{2.5}) was conducted in Taiyuan across four seasons [4].

The coal-fired power plants give the impression of high pollution and emissions, which usually causes residents to reject them. However, the research results were very different because the study involved people's perceptions of the place and their attitudes toward the environment, which could be affected. As a result, excellent power plant management is required so that respondents may appreciate the benefits of coal-fired power plants and support their continued operation [5]. Perception can be defined as an image in a person's mind of an object that is of concern to them, and it can also be used to analyze particular objects in society [6]. Community perceptions play an essential role in how people react to preventive activities and can be utilized to manage the consequences. The general public's perception might be either good or negative. Positive public perceptions of the environment will encourage the community's positive, environmentally friendly conduct, while negative public perceptions will

motivate the community's negative behavior toward the environment [7].

This study aims to look into the dangers and public perceptions associated with fine and coarse particles from coal-fired power plants.

2. Materials and Methods

The research method for environmental management recommendations combined a technological approach (Electrostatic Precipitator (ESP) and Electrostatic Precipitator (ESP) – Flue Gas Desulfurization (FGD)). The public perception of health risks regarding PM_{2.5} and PM_{2.5-10} was investigated using direct interviews from six research sites.

2.1. Survey

People's opinions of health concerns due to the influence of fine particles in the distribution region were determined using a social survey utilizing interview techniques.

2.1.1. Sampling Method

The distribution region of tiny particles is first determined before sampling. After doing a dispersion study with AERMOD View, community settlements in the distribution region were chosen to determine the responders. With a total of 595 respondents, the purposive random sampling area approach was used to choose the sample (respondent). The Slovin method (sample proportion) was used to determine the number of respondents, with a margin of error is 0 %.[8]

Slovin Formula:
$$n = \frac{N}{1 + Ne^2}$$

where N is the number of people in the population, and e is the margin of error.

2.1.2. Tools and Material

Respondent identification, expected health profile owing to dust, perception of fine particles, and perceived danger of fine particles to health were used as interview instructions with interview material. Interview paper and stationery were used to create the materials.

2.2. Sampling Location

Location: the study took place in the Tanjung Jati coal-fired power plant in Jepara and the Rembang coal-fired power plant in Rembang, with three residential areas affected by dust particles resulting from the operational activity (Table 1 and Fig. 1).

Table 1 The concentration of particulate at Tanjung Jati B coal-fired power plant in Jepara and Rembang coal-fired power plant in Rembang

Tanjung Jati coal-fired power plant (P1)	Rembang coal-fired power plant (P2)
a) R1- Jambu Timur Village (Mlonggo district), Total Suspended Particulate: 0.5 µg/m ³ Fine dust (PM _{2.5}): 0.06 µg/m ³ Coarse dust (PM _{2.5-10}): 0.08 µg/m ³	a) R4- Dadapan Village (Sedan district), Total Suspended Particulate: 20 µg/m ³ Fine dust (PM _{2.5}): 3 µg/m ³ Coarse dust (PM _{2.5-10}): 4 µg/m ³
b) R2- Jerukwangi Village (Bangsri district), Total Suspended Particulate: 0.5 µg/m ³ Fine Dust (PM _{2.5}): 0.1 µg/m ³ Coarse Dust (PM _{2.5-10}): 0.08 µg/m ³	b) R5- Sanetan Village (Sluke district), Total Suspended Particulate: 2 µg/m ³ Fine dust (PM _{2.5}): 0.1 µg/m ³ Coarse dust (PM _{2.5-10}): 0.2 µg/m ³
c) R3- Jinggotan Village (Kembang district) Total Suspended Particulate: 1 µg/m ³ Fine dust (PM _{2.5}): 0.1 µg/m ³ Coarse dust (PM _{2.5-10}): 0.11 µg/m ³	c) R6- Trahan Village (Sluke district) Total Suspended Particulate: - Fine dust PM (PM _{2.5}): 0.1 µg/m ³ Coarse dust (PM _{2.5-10}): 2 µg/m ³



Fig. 1 Research Sites Tanjung Jati coal-fired power plant (P1) and Rembang coal-fired power plant (P2)

The AERMOD View model was used to establish the research location based on the overall distribution area of suspended particles from Tanjung Jati coal-fired power plant (P1) and Rembang coal-fired power plant (P2) in Central Java, Indonesia. Jambu Timur (R1), Jerukwangi (R2), Jinggotan (R3), the observation area around the Tanjung Jati B coal-fired power plant. Dadapan (R4), Sanetan (R5), and Trahan (R6), the observation area around the Rembang coal-fired power plant

2.3. Environmental Health Risk Assessment

Environmental Health Risk Assessment (EHRA) was used to calculate health risk following guidelines from the Indonesian Ministry of Health for Environmental Health Risk Assessment in 2012 [9]. Risks were calculated for Sb, Hg, Mg, Ba, V, Mo, Mn, Cu, Hg, Al, As, Pb, Cr, Co, Ni from fine particles.

2.3.1. Calculation of Intake Value

An intake value was calculated through inhalation from the resident. The following equation is used to calculate intake values [10] :

$$I = \frac{C \times R \times tE \times fE \times Dt}{Wb \times tavg}$$

where:

- I - intake (ingestion);
- C – concentration;
- R - rate of ingestion (m³/hour);
- tE - daily exposure time (hours/day);

- fE - frequency of exposure over the course of a year (days/year);
- Dt - real-time exposure length (30 years projection);
- Wb - weight (kg);
- T_{Avg} - average period, 30 years x 365 days/year (non-carcinogenic) or 70 years x 365 days/year (carcinogenic).

2.3.2. Calculation of Non-Carcinogenic Risk Values

The Risk Quotient (RQ) notation is used to calculate the level of risk of non-carcinogenic effects of heavy metal exposure [11]:

$$RQ = \frac{Inc}{RfC}$$

Table 2 Non-carcinogenic risk level

Notation	Information
Non-carcinogenic intake	The intake is determined using the non-carcinogenic intake exposure through the respiratory tract formula.
RfC (Reference for Concentration)	The literature contains the reference value of risk compounds in inhalation track exposure. www.epa.gov/iris was used in this research [12]

With the RQ from the calculation:

- 1) RQ > 1, implying that the concentration of risk agents affects health.
- 2) RQ ≤ 1, As a result, concentration is not yet in danger of producing health problems.

2.3.3. Calculation of Carcinogenic Risk Value

The level of carcinogenic risk is stated in Excess Cancer Risk (ECR). To obtain an ECR value, multiplication is performed between carcinogenic intake values, and Cancer Slope Factor (CSF) expressed in the following equation:

$$ECR = I_c \times CSF$$

Table 3 Information of carcinogenic risk calculation

Notation	Information
Carcinogenic intake	The intake is calculated using the formula carcinogenic exposure through the inhalation tract.
SF (Slope Factor)	The reference value of risk agents in exposure to inhalation track is contained in the literature. In this study, www.epa.gov/iris was used [13]

With the ECR from the calculation:

1) The $ECR \leq 10^{-4}$, the concentration of the risk agent is not yet a carcinogenic risk.

2) The $ECR > 10^{-4}$, the concentration of risk agents creates a carcinogenic risk.

3. Results and Discussion

The Aermod View model is used to simulate the distribution of Total Suspended Particulate in the form of wind direction and speed data with hourly readings for one year, with the years to be modeled being 2016 and 2017. Windrose analysis is used to visualize the wind speed and direction data [14]. According to the results of the Windrose recapitulation, the dominating wind direction in 2017 was southeast with a speed of 5.7–8.8 m/s. While in 2016, the dominant wind direction was east–southeast with a speed of 5.7–8.8 m/s. The following data on wind direction and speed comes from the Meteorological Station, BMKG-Ahmad Yani Semarang’s measurement results can be seen in Fig. 2. The distribution pattern of fine dust that is projected to be exposed to the public will be determined by using the results of the AERMOD View to establish the distribution area. The necessary measurement parameters can be seen in table 4.

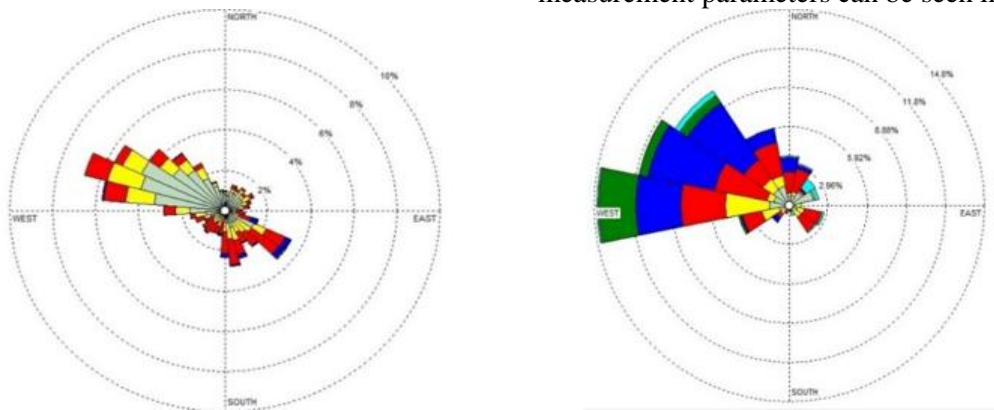


Fig. 2 Windrose of 2016 and 2017

Table 4 Parameters required for AERMOD modeling

Parameter	Jejara		Rembang		Unit
	Unit	Value	Unit	Value	
Exhaust gas temperature	Unit 1	64.9	Unit 20	163.53	°C
	Unit 2	66.6	Unit 10	151.23	°C
	Unit 3	55.4			°C
	Unit 4	48.15			°C
Chimney diameter The inside part	Unit 1	7.5	Unit 20	4.8	m
	Unit 2	7.5	Unit 10	4.8	m
	Unit 3	7.5			m
	Unit 4	7.5			m
Exhaust gas speed	Unit 1	17.27	Unit 20	28.767	m/s
	Unit 2	18.07	Unit 10	29.553	m/s
	Unit 3	24.27			m/s
	Unit 4	16.05			m/s
Cross-sectional area	Unit 1	4.415.625	Unit 20	180.864	m ²
	Unit 2	4.415.625	Unit 10	180.864	m ²
	Unit 3	4.415.625			m ²
	Unit 4	4.415.625			m ²
Emissions load/emission rate					
PM10	Unit 1	5.017.766	Unit 20	4.786.682	g/s
	Unit 2	5.521.492	Unit 10	8.872.822	g/s
	Unit 3	4.790.375			g/s
	Unit 4	5.605.879			g/s
PM2,5	Unit 1	2.714.779	Unit 20	2.299.688	g/s
	Unit 2	3.119.802	Unit 10	3.303.256	g/s

Continuation of Table 4					
Coarse	Unit 3	2.218.361			g/s
	Unit 4	2.849.005			g/s
	Unit 1	3.584.119	Unit 20	260.666	g/s
	Unit 2	3.917.706	Unit 10	1.605.126	g/s
	Unit 3	389.017			g/s
	Unit 4	4.287.682			g/s

The AERMOD (The American Meteorology Society Environmental Protection Agency Regulatory Model), considered ideal, was used to simulate fine and coarse particle dispersion from operational emissions at the Tanjung Jati B coal-fired power plant and the Central Java I Rembang coal-fired power plant [15]. PM_{2.5} is known to cause serious health problems compared to other air pollutants, so this study used an air dispersion modeling system AERMOD to simulate PM_{2.5} concentrations from Tema Oil Refining (TOR) and assess the risk of non-cancer and death in the exposed population [16]. The AERMOD View model map for the distribution of Total Suspended Particulate (TSP), PM_{2.5}, and PM_{2.5-10} is overlaid with the coordinates of the location of the environmental monitoring plan and the environmental management plan for dust impacts to assess the accuracy of the location monitoring analysis of environmental impacts.

The monitoring locations that are recommended for monitoring and environmental management at P1 -

Tanjungjati B Jepara Coal-fired Power Plant, Unit 1, 2, 3, 4 are R1 (Jambu Timur village), R2 (Jerukwangi village), R3 (Jinggotan village). TSP concentrations were sequentially 0.5 g/m³, 0.5 g/m³, 1 g/m³, PM_{2.5} with a concentration value of 0.06 g/m³. Based on the AERMOD View model, conditions at the P2 - Central Java I Rembang CFPP location show that the monitoring location for the implementation of dust impact management for TSP does not enter the distribution area, whereas the distribution of the impact of PM_{2.5} and PM_{2.5-10} is at location R6 with a value of 0.1 g/m³, indicating that the monitoring location is close to the generator. Because climatological variables modify the receptors of incoming emissions in ambient air, distance affects little dust distribution. Because of the influence of the dominating wind direction, the dust distribution from the Rembang coal-fired power plant operation is expected to be further scattered.

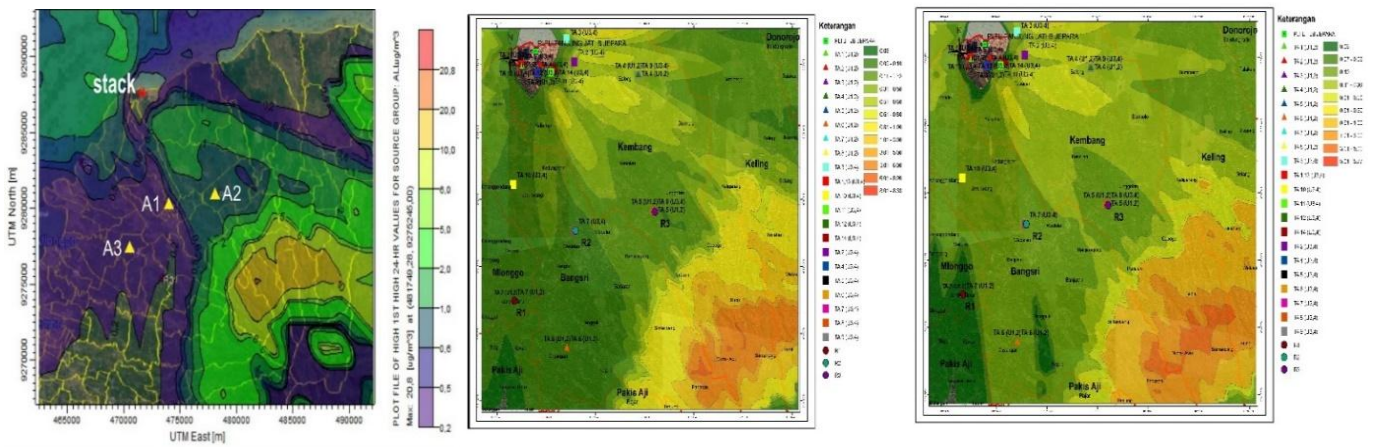


Fig. 3 Evaluation of location accuracy monitoring of environmental impacts based on the overlay distribution model of TSP, PM_{2.5}, PM_{2.5-10} AERMOD at the Tanjung Jati B Power Plant

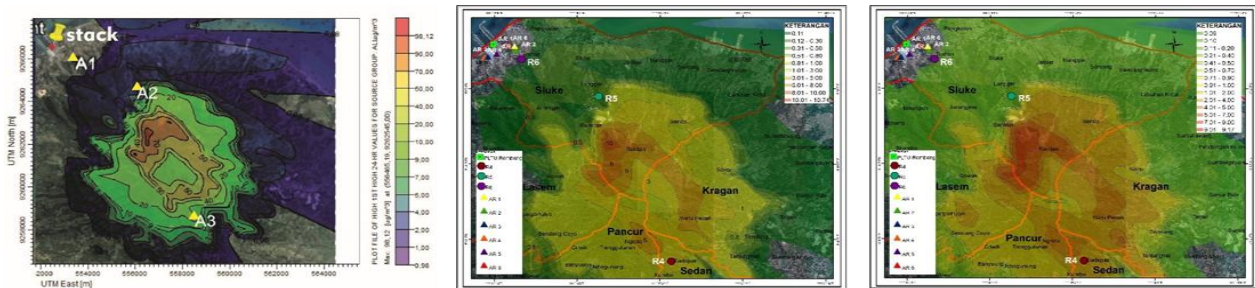


Fig. 4 Evaluation of location accuracy monitoring of environmental impacts based on the overlay distribution model of TSP, PM_{2.5}, PM_{2.5-10} AERMOD at the Rembang Power Plant

Fine and coarse dust dispersion can be localized in the neighborhood surrounding the coal-fired power plant with a precise risk analysis that examines the precision of monitoring and environmental management location.

It is important to do a risk analysis on public health in dust distribution areas originating from the coal-fired power plant Tanjung Jati B Jepara Units 1,2,3,4, and coal-fired power plant Rembang. According to several studies, particulate pollution has been linked to various health and environmental problems. Particulate matter (PM), in particular fine particulate matter (i.e., PM, aerodynamic diameter 2.5 μm), harms human health [17]. Assessment of human health risk (RA) is the most appropriate tool for expressing the potential impact activities can have in the affected area. Coal-fired power plants are a significant source of air pollution, which can harm people's health [18].

According to the results of the interviews, the average age of respondents in each village ranged from 30 to 45 years. The majority of respondents worked as farmers, fishermen, and private employees. Respondents for health risk assessments were chosen from those exposed to at least 2 hours each day. Although ARI (4.1-8.2%), shortness of breath (2-13%), and skin irritation (1-24.5%) were reported by a small percentage of respondents, the majority of them did not feel ill (69-87%). According to respondents (65-96.8%), the CFPPs had little effect. Burning (62.2-93%), throwing it in the river (2-23.5%), dumping it on the vacant ground (7-11.2%), dumping it (2-23, 5%), and processing it into fertilizer are the methods used by respondents for waste management (1-3%). Because of its proximity, most respondents (52.1-80.6%) chose public health centers as a treatment option (10-73.5%). The answer did not match the data acquired at primary health care, where respiratory disorders were assumed to be caused by dust and were listed in the top 10 ailments in each primary health care for the last four years. Respiratory diseases, such as influenza, acute nasopharyngitis, acute pharyngitis, asthma, allergic, atopic skin diseases, and dermatitis, were among the top 10 diseases, according to data from the Kembang, Bangsri, and Mlonggo Health Centers in 2015-2018, Sluke Health Centers in 2015 and 2016, and Sedan Health Centers in 2017.

This information should be supplemented with a risk assessment of fine dust in the neighborhood of the power plant. Fine particles ($\text{PM}_{2.5}$) and coarse particles ($\text{PM}_{2.5-10}$) should be the focus of the health risk assessment since they have the potential to create health problems because they can be inhaled directly by the community surrounding the power plant site because it is extremely harmful and can infiltrate deep into the cardiovascular and respiratory systems of humans [19]

A risk assessment is a method of determining the health consequences of exposure to dangerous chemicals and conditions based on facts. RQ and ECR calculations are used in this study to measure environmental health risks at each research location. The results of the analysis of all refined PM elements can be seen in the supplementary material. At location P1, several elements, including Hg 0.0008 g/Nm^3 , Be 0.0007 g/Nm^3 , Mn 0.002 g/Nm^3 , Co 0.0001 g/Nm^3 , Se 0.0004 g/Nm^3 , were found to be below the detection limit value, and at location P2, Se and Be elements were found to be below the detection limit value. Environmental health risk analysis results for each element in $\text{PM}_{2.5}$ and $\text{PM}_{2.5-10}$ from Tanjung Jati B Jepara coal-fired Power Plant and Rembang coal-fired Power Plant. Because $\text{PM}_{2.5}$ can directly enter the lungs, the impact of $\text{PM}_{2.5}$ on health was calculated. It can induce respiratory problems by penetrating deep into the cardiovascular system. Risk analysis is a method of determining the health impacts of hazardous substances or conditions on individuals or communities based on facts. [20]. The nature of non-carcinogenic and carcinogenic metals is distinguished in environmental health risk assessments due to the impact of metal components in $\text{PM}_{2.5}$ and $\text{PM}_{2.5-10}$ [21]. If humans are exposed to a given amount and period, tiny particle toxicity can constitute a health risk. Effect Non-carcinogenic (systemic effect) and carcinogenic effects are two types of health effects that might occur. The degree of fine particulate toxicity risk is described as non-risk carcinogenic, Risk Quotient (RQ), and carcinogenic risk, excess cancer risk (ECR). If the RQ number is greater than one or the ECR value is greater than 10⁻⁴, it is considered dangerous or undesirable [22].

The highest element value for $\text{PM}_{2.5}$ is Ba with a value of 3.26×10^{-2} , while the highest element value for $\text{PM}_{2.5-10}$ is Ba with a value of 3.57×10^{-3} , according to the results of the risk analysis of non-carcinogenic elements at P1. The highest element value of $\text{PM}_{2.5}$ was Cu with a value of 4.94×10^{-1} , while the highest element value of $\text{PM}_{2.5-10}$ was Cu with a value of 3.22×10^{-1} at P2. The highest value for $\text{PM}_{2.5}$ in the risk analysis of carcinogenic elements at P1 was element Ni with a value of 9.72×10^{-10} , while the highest value for $\text{PM}_{2.5-10}$ was element Cr with a value of 8.91×10^{-11} . The highest value of $\text{PM}_{2.5}$ was Cd with a value of 6.57×10^{-9} , while the highest value of coarse dust was Cd with a value of 6.35×10^{-8} at P2. Overall, the health hazards associated with $\text{PM}_{2.5}$ and $\text{PM}_{2.5-10}$ concentrations of risk agents, both carcinogenic ($\text{ECR} < 10^{-4}$) and non-carcinogenic ($\text{RQ} < 1$), have not yet influenced health. Complete environmental health risk analysis results for each element in $\text{PM}_{2.5}$ and $\text{PM}_{2.5-10}$ from Tanjung Jati B Jepara Coal-fired Power Plant and Central Java I Rembang Coal-fired Power Plant can be seen in the supplementary material.

RQ and ECR calculations evaluate heavy metal exposure to fine particles resulting from power plant operation [23]. Metal exposure due to fine particles originated from Tanjung Jati B Jepar CFPPs units 1, 2, 3, 4, and Rembang CFPPs units 10 and 20. It was still in the boundary category safe because the RQ value was < 1 , and the ECR value was $< 10^{-4}$ to 50 years in the future, according to the RQ and ECR calculations used in the research at each location. The highest RQ values are found at R5, R6, R4, R2, R3,

and R1 in sequence. The highest ECR values are found at R5, R6, R3, R2, R1, and R4 in sequence. Fig. 5 depicts the results of the RQ calculation of the non-carcinogenic risk owing to metals in $PM_{2.5}$ that are inhaled by persons in the dust dispersion region regularly. Fig. 6 shows the results of the ECR calculation of the carcinogenic risk due to metals in fine particles $PM_{2.5}$ that are always inhaled by the community in the dust dispersion area.

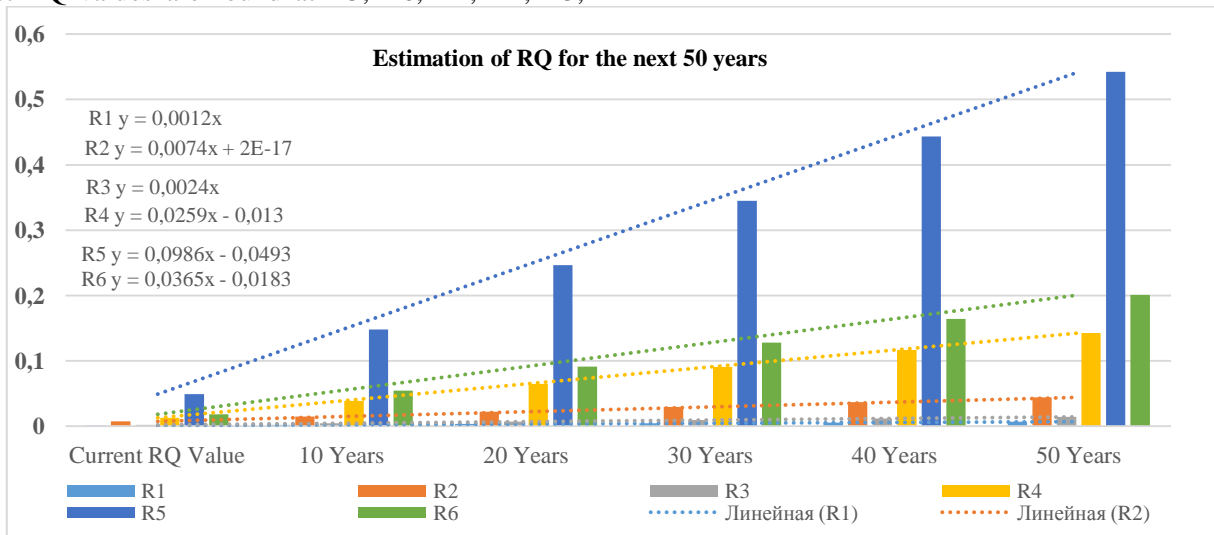


Fig. 5 Estimated RQ for the next 50 years

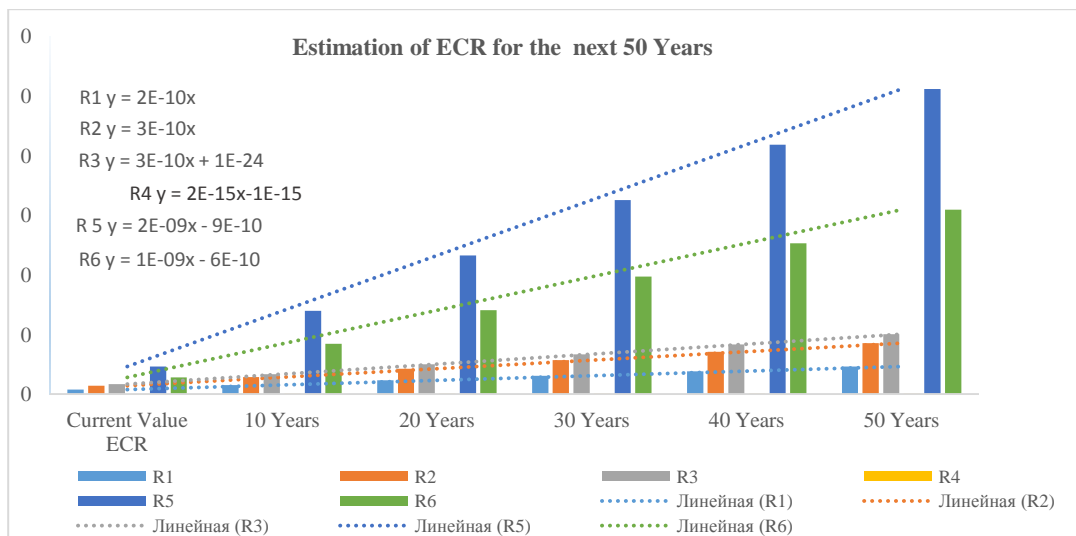


Fig. 61 Estimation of ECR for 50 years to come

Although these components are normally found in extremely low/safe concentrations in most coals, continuous emissions from coal combustion can considerably increase their concentration in the environment [24]. It may be observed in the growing RQ and ECR calculations. Calculating and mapping inhalation cancer risks (R) and hazard quotients (HQ) for each pollutant and each target organ affected by the inhalation pathway is critical in risk analysis, same as selecting inhalation risk unit (UR) and reference concentration values (RfC) [25]. The air quality and

potential health risks posed by emissions from coal-fired power plants were calculated as part of this study.

3.1. Community Perception

Perception is a set of beliefs held by individuals and their thoughts, feelings, and personal experiences, which significantly impact how they assess specific items [26]. As a result, perception significantly impacts the daily experiences of respondents who lived in the research area before the coal-fired power plant was operational [27]. The purpose of this study was to see how the community felt about the presence of fine dust

(PM_{2.5}) and to examine the health risks associated with the operation of the Tanjung Jati and Rembang coal-fired power plants. [5]. According to the findings of interviews conducted in six villages at P1 and P2, the community perceives fine dust (42-93 %) and coarse dust (72-78.6%). People believe the source of dust is not from the CFPP because their settlement is located

far from the CFPP. The dust that most people are familiar with is dust that can be seen and observed. At P1, 60-65% of respondents said yes, and at P2, 71.5-85.8% said yes. The interview results on the community's perception of fine particles are shown in Fig. 7.

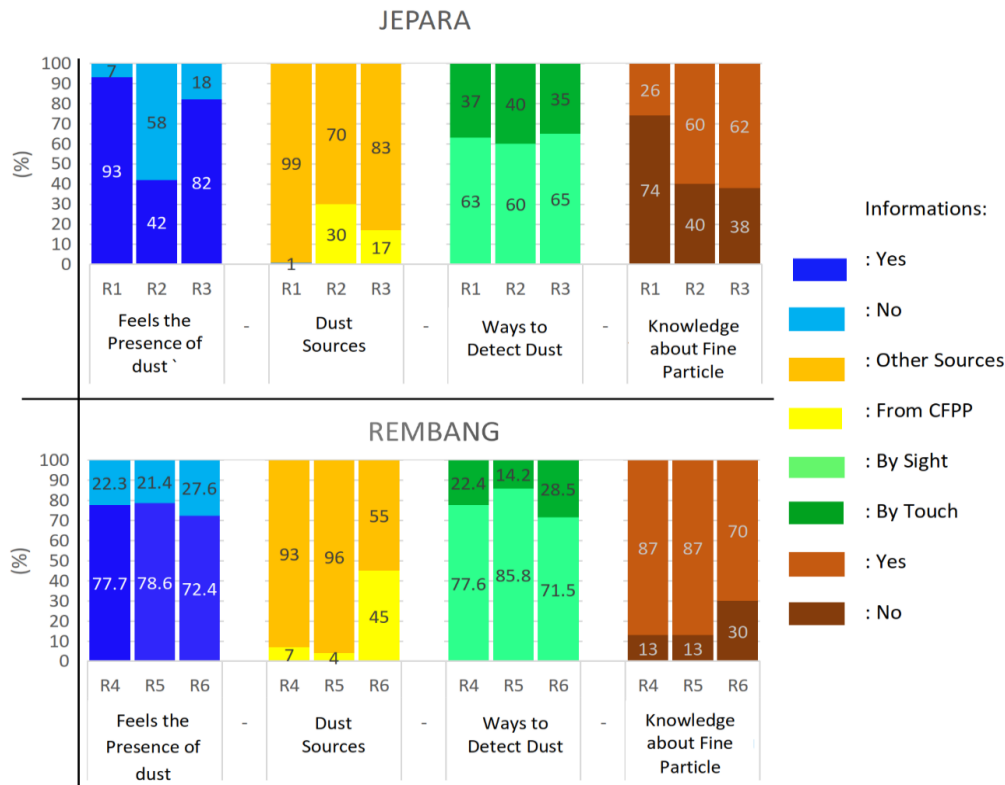


Fig. 7 Community perception of fine particles

Fig. 8 shows the results of a community survey on the health dangers posed by fine particles. In the previous year (2018), the majority of respondents stated that they were suffering from illness due to the highest dust in respondents R1 (Jambu Timur village), with 37% believing that the source of dust is the coal-fired power plant Tanjung Jati B Jepara. However, respondents in other regions were lower. R1 is the furthest away from the coal-fired power plant than other research locations, at 10.3 kilometers.

Particulate matter that may be transported for a long time and over a large distance into the atmosphere is a fundamental indicator of anthropogenic pollution, linked to a reduction in human health. The smaller the

dust particle size, the easier it will be carried by the wind, exposing the R1 region to more dust - PM_{2.5}. The smaller the particle, the more harmful it is; PM_{2.5} is more harmful than PM₁₀ because it is very easy to infiltrate the respiratory tract in fine particles [28]. With the majority of respondents working (55%) and having a good education, such as high school (40%), the perception of fine particle health concerns is very high, at 82%. Risk perceptions that must be understood should be linked to knowledge of hazard prevention, evaluation, risk management, and safety procedures. Risk evaluation knowledge aids in the analysis and evaluation of risk communication (Fig. 8).

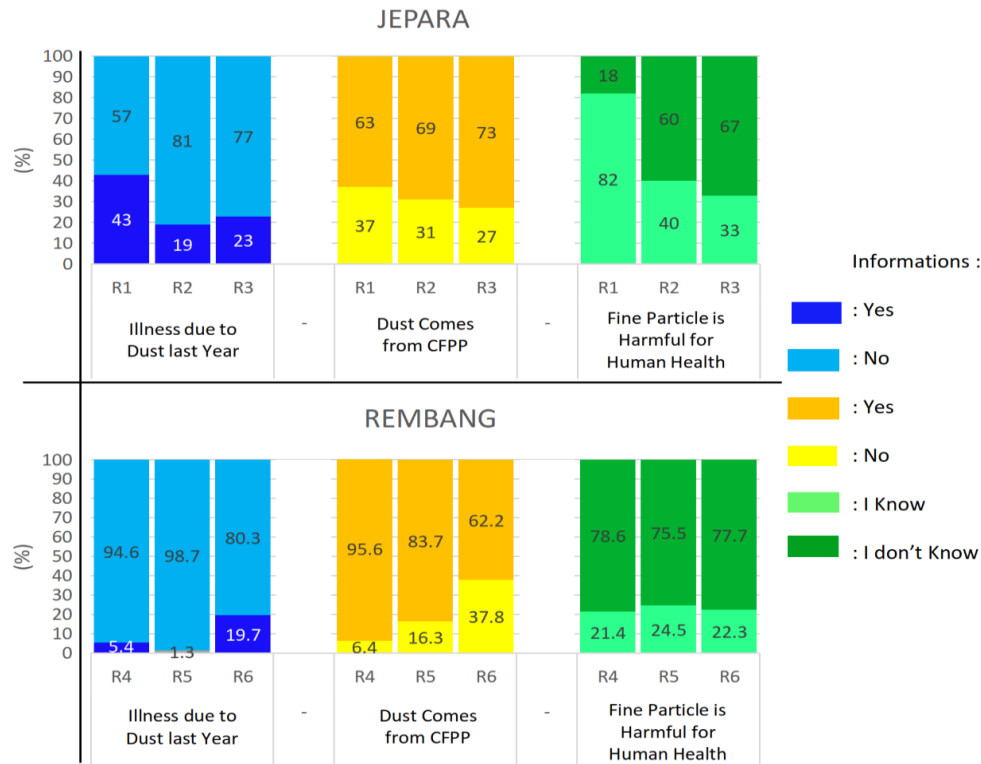


Fig. 8 Community perception of fine particles risk

The effects of dust on people's behavior have been mixed. The response to maintaining the best health was 13.3% at location R6 (Trahan village). The response with the category of being aware of the impact of fine dust was 84% at R3, but with the perception of 83% of respondents that fine dust is not from the coal-fired power plant activities, so the people in the area have no desire to wear masks (0%). In contrast, 31% of respondents perceived fine dust from coal-fired power plant activities, and 40% perceived fine dust posing a health risk at location R2 (Jerukwangi village). At the same time, 44% stated that they were aware of fine dust, indicating that efforts to prevent it were quite high, and 47% had a desire to wear a mask. The reaction is observed from the impacts of disruption and is then continued by examining the cause-and-effect relationship of the activity's effect.

The individual's response to preventive action is influenced by perception. The community should take preventive measures against the impact of fine dust from the operation of the Tanjung Jati B coal-fired power plant and the Central Java I Rembang coal-fired power plant, such as wearing masks to protect their

health through important adaptation steps that consider perception and behavior change [29].

The presence of heavy metals in $PM_{2.5}$ can be harmful to human health. Even though heavy metals make up a minor portion of $PM_{2.5}$, they are non-degradable when linked to particles and can bioaccumulate through the food chain, contributing to toxicity. Individual and regional-level features were strongly associated with perceptions of pollution levels, while pollution-related health problems were significantly connected to individual and regional-level variables. Public awareness campaigns should be combined with education about how the public can protect themselves. They should be specifically targeted at vulnerable populations (e.g., the elderly and people with respiratory problems) and socioeconomically vulnerable areas (e.g., areas with more racial segregation and poverty) that are exposed to more pollution [30]. The community's reaction to the threat of fine dust is shown in Fig. 9.

The impact felt as a result of fine dust exposure will help prevent the effects. The public's reaction to the health risks posed by fine particles is determined by how these risks are perceived and assessed.

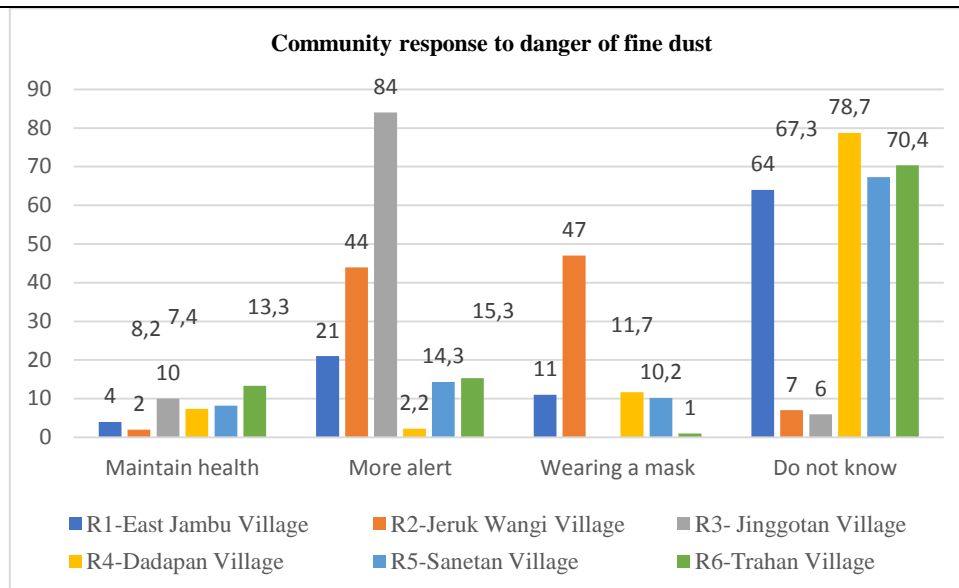


Fig. 9 Community response to the danger of PM₂

4. Conclusion

Risk analysis results of the metal element in PM_{2.5} show that the risk characterization results for carcinogenic and non-carcinogenic are still below the threshold value. Thus, it is still safe for people living in the area for the next 50 years. Because they stated that their community was far from the power plant, most residents felt the presence of fine particles but assumed that the source of the dust was not from the power plant. The interview revealed that most people had no idea what fine particles are. People also do not appreciate the health concerns posed by fine particles since, according to the majority, they do not know and assume that power plants should not be blamed for diseases caused by dust.

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