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HEALTH RISKS OF SULFUR DIOXIDE ($S0_2$) TAXATION IN COMMUNITIES IN RESIDENTIAL SURROUNDING INDUSTRY PT. DIAN SWASTATIKA SENTOSA POWER IN KONAWE SELATAN DISTRICT

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Abstract

Background: Sulfur dioxide ($S0_2$)and fine particles are one of the emissions produced by coal-fired power plants which are harmful to breathing because they can damage the airways, causing irritation of the walls of the tubes and blocking the smooth passages in the lungs.
Methods: This research is an observational study with the study method of Environmental Health Risk Analysis. The location of this research is in the area of the PT. DSSP in Konawe Selatan District. The population is 2,723 people and the human sample is 337 respondents usingClustersampling. While environmental samples (air) were divided into 4 locations where air concentration measurements were carried out in the morning, afternoon and evening.
Results: The average sulfur dioxide intake of respondents at point 1 has a mean of 0.0101, at point 2 has a mean of 0.0084, at point 3 has a mean of 0.0105, and at point 4 has an average of 0.0101. Meanwhile, the respondent's risk level for sulfur dioxide RQ> 1 was 5 people.
Conclusion: Risk is influenced by body weight, rate of inhalation, time of exposure, frequency of exposure, duration of exposure. Risk management is carried out by reducing exposure time, planting trees that can absorb air pollution, maintaining endurance, implementing safe residential locations from the center of the factory which should be above 2.5 km.

Key words: *Environmental, Health, Sulfur dioxide, Exposure, Analysis*

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INTRODUCTION

Steam power plants are an industry that can change air quality by relying primarily on coal, diesel and sand. Coal is a solid hydrocarbon fuel derived from decomposing plants, both biochemically, chemically and physically, which are free from oxygen and last for a long time at certain pressures and temperatures(1).

Several industrial centers in Europe, North America and East Asia produce high levels of $S0_2$. In Western Europe, 90% of $S0_2$ produced is anthropogenic. Meanwhile, in the UK 2/3 $S0_2$ is produced by coal power plants, while in Germany 50% of $S0_2$ is produced by industry and 63% in Canada(2).

Sulfur dioxide comes from sulfur oxide gas (SOx). This gas is colorless, has an odor, and is more easily dissolved in water. Likewise O3, secondary pollutants such as sulfate particles originating from $S0_2$ gas, can be deposited far from the source(3).

Sulfur dioxide is formed when fossil fuels containing sulfur burn such as coal, crude oil, and ores containing copper, zinc, aluminum, lead and iron. Power plant activities whose fuel uses coal or diesel oil, exhaust gas from vehicles using diesel and industries whose fuel is coal or crude oil are one of the main sources of sulfur in urban areas(4).

Based on the Risk of Sulfur Dioxide ($S0_2$) Exposure in Communities Living Around PT. PLN (Persero) Sektor Tello in 2014 with the highest level of $S0_2$ was found at location IV with a concentration of 55,778 µg / Nm3. The results of the calculation of the amount of risk for the average community living around PT. PLN (Persero) The Tello Power Sector has an RQ> 1 so it has a high risk of being exposed to $S0_2$ and requires control. The impact of $S0_2$ on health is that it can harm the respiratory system and lung function and can also cause eye irritation. Inflammation of the respiratory tract can cause coughing, mucus secretions, chronic bronchitis and asthma can make people more susceptible to respiratory infections(4).

The results of air quality monitoring around the industrial area of South Konawe Regency in 2017 in April showed an average $S0_2$ value of 6.10 µg / Nm3 and in December it showed an average value of 6.12 µg / Nm3. In 2018, April showed an average $S0_2$ value of 9.29 µg / Nm3 and in December it showed an average value of 8.39 µg / Nm3. In 2019, April showed an average $S0_2$ value of 9.94 µg / Nm3 and in December it showed an average value of 8.45 µg / Nm3. The data shows that the $S0_2$ concentration has increased in the last 3 years.

PT Dian Swastatika Sentosa Power (DSSP) is a coal-fired power plant company. Where in technical terms, the emission or exhaust gas released by PT. DSSP is in the form of carbon dioxide, sulfur dioxide, and particulate matter. This gas can affect human respiration if inhaled for a very long time. One of them is the people who live in the area around the DSSP PLTU who can breathe CO2, $S0_2$, and PM2.5 every day because the location of the PLTU and community settlements is only ± 3 km from the industrial center. The distance of ± 3 km determined refers to the results of the study(5).

According to the Ministry of Environment in 2013, $S0_2$ gas is a gas that is harmful to human health and also has an impact on the environment both locally and globally. The existence of research on the disease burden caused by the increase in $S0_2$ emissions in Southeast Asian countries has strengthened this point where burning with coal fuel can release $S0_2$ emissions so that it can form PM2.5 which can cause respiratory disease and heart disease(6).

An environmental impact analysis or AMDAL is a study that starts from planning, implementation to the final assessment when the activity or business is operating. The benefits of conducting this study are to assess the extent of the physical, chemical, biological, economic, social and cultural impacts caused by the activity or business. This has been regulated in Law of the Republic of Indonesia number 32 of 2009

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article 47 paragraph 2 concerning environmental protection and management, Decree of the Minister of Health number 876 of 2001 concerning technical guidelines for environmental health impact analysis, and Government Regulation number 27 of 1999 concerning analysis of environmental health impacts. environmental impact(7).

Therefore, an environmental health risk analysis method is needed to determine how much risk will be accepted by the community around the DSSP PLTU in Konawe Selatan Regency.

METHOD

This research is an observational study with the study method of Environmental Health Risk Analysis. . Risk identification is carried out by Hazard Identification, Exposure Analysis, and Dose Response Analysis to identify the risk from $S0_2$ exposure. The location of this research is in the area around the PT. DSSP in Konawe Selatan District. The population is 2,723 people and the human sample is 337 air respondents to residents who live around PT. DSSP in Konawe Selatan District. Use*Clustersampling*while environmental samples (air) were divided into 4 locations where air concentration measurements were carried out in the morning, afternoon and evening.

RESULTS

Table 1 shows the measurement results of Sulfur Dioxide ($S0_2$) at location 1 with coordinatesS 040 02'15.066 ", E 1220 40'02.200" of 26.4 µg / Nm3. At location 2 with coordinates S 040 02'20.239 ", E 122039'13.500" of 22.1 µg / Nm3.At location 3 with coordinates S 040 03'30.373 ", E 1220 38'52,297" amounting to 27.5 µg / Nm3. At location 4 with coordinates S 04004'08.426 ", E 1220 38'42.469" of 26.4 µg / Nm3.

Table 2 shows the duration of 12 hours of exposure was 90 people (26.71%), 53 people (15.73%) 13 hours of exposure, 67 people (19.88%) of 14 hours of exposure, 40 people (19.88%) of 15 hours of exposure (11.87%), 52 people of 16 hours of exposure (15.43%), 19 people of 18 hours of exposure (5.64%), 11 people of 20 hours of exposure (3.26%), and 11 hours of exposure 5 people (1.48%).

Table 3 explains the frequency of exposure per year with the category of 240 days is 166 people (49.26%), the annual exposure is for the category of 288 days as many as 155 people (45.99%), and the annual exposure is for the category of 365 days as many as 16 people (4 , 75%).

Table 4 explains the body weight of respondents 40-44 as many as 38 people (11.28%), body weight 45-49 as many as 48 people (14.24%), body weight 50-54 as many as 73 people (21.66%), body weight 55 -59 as many as 56 people (16.62%), body weight 65-69 as many as 100 people (29.67%) and body weight 75-79 as many as 22 people (6.53%).

Table 5 shows the results of the calculation of intake of exposure to sulfur dioxide ($S0_2$) in the community of Wawatu Village and Tanjung Tiram Village, North Moramo District for the duration of exposure of 30 years at point 1 minimum value of 0.0022, maximum 0.0131, at point 2 the minimum value is 0.0018, the maximum 0.0110, at point 3 the minimum value is 0.0023, the maximum 0.0137, and at point 4 the minimum value is 0.0022, the maximum 0.0131. Whereas for the duration of exposure to 70 years at point 1 the minimum value is 0.0051, the maximum0.0306, at point 2 the minimum value is 0.0043, the maximum 0.0025, at point 3 the minimum value is 0.0053, the maximum 0.0319, and at point 4 the minimum value is 0.0051, the maximum 0.0306.

Table 6 explains the level of risk is calculated based on the duration of current exposure and projected over the next 30 and 70 years. With the assumption that data related to intake, namely sulfur dioxide concentration and particulate matter, inhalation rate, frequency of exposure, body

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weight do not change until the next 30 and 70 years.

Table 7 shows that the CoV value of the variable concentration (C), time of exposure (tE), frequency of exposure (fE), and body weight (Wb) <30%, which means that the data is normally distributed so that the value used is the mean value.

Table 1
Concentration of Sulfur Dioxide ($S0_2$) in Air in 2021

No.	Coordinate	Location	Yield (µg / Nm3)	TLV (µg / Nm3)	Method
1	S 040 02 '15.066 " E 1220 40'02.200 "	location 1	26.4	900	SNI 19-7119.7-2017
2	S 040 02 '20.239 " E 1220 39'13,500 "	location 2	22.1	900	SNI 19-7119.7-2017
3	S 040 03 '30,373 " E 1220 38'52,297 "	location 3	27.5	900	SNI 19-7119.7-2017
4	S 040 04 '08.426 " E 1220 38'42,469 "	Location 4	26.4	900	SNI 19-7119.7-2017

Source: Primary Data 2021

Table 2
Distribution of Length of Exposure Each Day, Year 2021

No.	Exposure (Hour / Day)	amount	Percentage (%)
1	12	90	26.71
2	13	53	15.73
3	14	67	19.88
4	15	40	11.87
5	16	52	15.43
6	18	19	5.64
7	20	11	3.26
8	24	5	1.48
Total		337	100

Source: Primary Data 2021

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Table 3
Distribution of Respondents Based on Frequency of Exposure in 2021

No.	Frequency of exposure (Days / Years)	amount	Percentage (%)
1	240	166	49.26
2	288	155	45.99
3	365	16	4.75
Total		337	100

Source: Primary Data 2021

Table 4
Distribution of Respondents Based on Body Weight in 2021

No.	Weight (Kg)	amount	Percentage (%)
1	40-44	38	11.28
2	45-49	48	14.24
3	50-54	73	21.66
4	55-59	56	16.62
5	60-64	0	0.00
6	65-69	100	29.67
7	70-74	0	0.00
8	75-79	22	6.53
Total		337	100

Source: Primary Data 2021

Table 5
***Intake* Concentration of Sulfur Dioxide ($S0_2$) in 2021**

	Intake (Ink) SO2 30 Years		Intake (Ink) PM2,5 30 Years		Intake (Ink) 70 Years SO2	
	Min	Max	Min	Max	Min	Max
Point 1	0.0022	0.0131	0.0001	0.0010	0.0051	0.0306
Point 2	0.0018	0.0110	0.0001	0.0010	0.0043	0.0256
Point 3	0.0023	0.0137	0.0002	0.0012	0.0053	0.0319
Point 4	0.0022	0.0131	0.0001	0.0010	0.0051	0.0306

Source: Primary Data 2021

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Table 6
***Risk Quetion* Concentration of Sulfur Dioxide ($S0_2$) in 2021**

	***Risk Quetion* (RQ) SO2 30 Years**		***Risk Quetion* (RQ) PM2,5 30 Years**		***Risk Quetion* (RQ) SO2 70 Years**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**
Point 1	0.0852	0.5056	0.0172	0.1025	0.1989	1,1798
Point 2	0.0713	0.4233	0.0183	0.1090	0.1665	0.9877
Point 3	0.0888	0.5267	0.0206	0.1225	0.2072	1,2290
Point 4	0.0852	0.5056	0.0176	0.1045	0.1989	1,1798

Source: Primary Data 2021

Table 7
Variable data to calculate population intake

SCORE	Pollutant concentration SO2	R	tE	Fe	Wb	Dt
Mean	0.0256	0.83	14	268	57	30 and 70
Median	0.0264		14	288	58	
standard deviation	0.0024		2.33	31.94	11.25	
Minimum	0.0221		12	240	40	
Maximum	0.0275		24	365	78	
Coevisiens of Varians	9.34		16.31	11.92	19.84	

Source: Primary Data 2021

DISCUSSION

Concentration of Sulfur Dicoside ($S0_2$)

Steam power plant (PLTU) is an industry that can change air quality with its main fuel depending on coal, diesel and sand.(1). The PLTU operation process will produce pollutants in the form of $S0_2$, NO_2, CO_2 and PM. The emergence of $S0_2$ gas comes from the content of sulfur compounds (S) in coal. The emitted $S0_2$ gas will spread to the ambient air, causing a decrease in ambient air quality(8).

The location chosen in making air measurements in this study is a location that is included in the area of waste gas contamination from PT. Dian Swastatika Sentosa Power, which is within a radius of 3000 meters from the emission source. The distribution of $S0_2$ concentration data was collected in 4 air sample points, each measuring 3 times using a spectophotometric instrument. Air quality measurement points

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that are evenly distributed at each location produce data that is normally distributed so that the mean value is used as the $S0_2$ concentration value. The mean value of $S0_2$ concentration is 0.0256 mg / m3 with a minimum value of 0.0221 mg / m3 and a maximum value of 0.0275 mg / m3. For the $S0_2$ concentration in ambient air in this study, both the minimum, maximum and concentration values, nothing that exceeds the quality standard stipulated by the Government Regulation of the Republic of Indonesia No. 41 years old 1999, which is 900 µg / Nm3 (0.9 mg / m3) for a measurement time of 1 hour.

The $S0_2$ concentration value in this study was lower than the results of the research conducted by (4)around PT. PLN (Persero) Tello Sector with an average $S0_2$ value of 0.0445925 mg / m3. Other research conducted in settlements around the PT. Pusri Palembang $S0_2$concentration is 0.246 mg / m3(7). The same is the case with research conducted by(9) Around the Semen Tonasa factory in Bungoro District, the average $S0_2$ concentration in the morning and evening is 0.283 mg / m3 and 0.216 mg / m3.

The big difference in concentration between this study and other studies is influenced by humidity, temperature and wind speed at the time of sampling the ambient air at that location.

The concentration of $S0_2$ in the settlements around PT. This DSSP may from time to time increase beyond the average $S0_2$concentration measured at the time of this research. This condition could have happened if PT. DSSP increases the production power of the factory from production activities in its normal state. In addition, the $S0_2$ concentration can increase if the power plant chimney, fuel heater and boiler operate simultaneously without stopping. This is strengthened when PT. The DSSP does not maintain the physical condition of the waste gas filter in power plant chimney towers, boilers and fuel heaters where the waste gas is discharged into the ambient air. Other than that, $S0_2$ concentrations in residential areas can increase if the company does not maintain the preservation of protective forests around the factory area where the protective forest functions as a noise damper due to the production activities of the protective forest factory as well as a medium to reduce air pollutants such as $S0_2$. Maintain forest conditions in this case according to article 38 of the Republic of Indonesia Government Regulation no. 142 of 2015 is one of the environmental management and monitoring that must be carried out by the company and is supported by the Regulation of the Minister of Industry no. 35/2010 wherein an industrial area is required to have a minimum of 10% green open space as a form of the company's efforts in realizing the environmental carrying capacity of industrial activities that PT. DSSP run.

Weight

Individual body weight is an important anthropometric variable that greatly affects the actual dose of a risk agent received by an individual because the greater the individual's body weight, the smaller the internal dose received. Body weight has implications for the standard numerical value or quality standard as a form of risk control(10).

The mean value of body weight was 57 kg which was obtained from direct weighing of each respondent. These results were obtained after testing for normality which resulted in normally distributed data so that the mean value was used as a measure.Some studies suggest that being overweight can reduce a person's lifespan. Even an overweight person who doesn't smoke means a healthier life(11). However, in contrast to the intake of air pollutants,the large value of risk is inversely proportional to the value of body weight, so the greater the value of the respondent's body weight the smaller the value of the risk of the respondent. According to research(12) which results in respondents with body weight above the

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average have a greater risk than respondents who have body weight below the average value.

Exposure Time

The time or length of exposure also affects the intake value. The results showed that the data obtained in the field were normally distributed so that the reference was the mean value. The mean value of daily exposure time was 14 hours / day which was obtained from direct interviews with respondents.

Based on the results of interviews when collecting data other than work, other things that cause respondents to leave the settlement are daily activities such as taking children to school and to the market. Therefore, most of the time spent by respondents who live in the vicinity of the PT. DSSP is used for activities within the research area itself. The exposure time of 24 hours / day is the maximum time of exposure in hours / day, so that if exposed in the maximum time, the greater the chance that the respondent has a greater risk of being unsafe, such as research(13)which indicates that the longer a person is exposed to ammonia the greater the acceptable health risk. This also applies to all other air pollutants including $S0_2$.

Frequency of Exposure

The frequency of exposure is the number of days of $S0_2$ exposure received by the respondent in one year minus the length of time the respondent leaves the research location in units of days. The mean frequency of exposure was 268 days / year. This is because most of the respondents in this study did not leave the research location for 1 full day and also many respondents were original people from the research location so that during religious holidays or long holidays the respondents did not leave the research location for 1 full day because their extended family was also live in an area close to the research location.

The frequency of exposure received by respondents in this study is quite high because 365 days / year is the maximum exposure received by humans in units of time of day / year, so if the exposure received by the respondent is a maximum exposure it can also increase the risk of health problems for the respondent because the respondent continuously exposed to air containing $S0_2$.

Results of Risk Level Analysis of Sulfur Dioxide ($S0_2$)

Sulfur Dioxide ($S0_2$) Risk Level

This ARKL study examines the Risk Quetient (RQ) according to the concentration of risk agents at 4 sampling points in the settlements around PT. DSSP is carried out on at-risk populations who live around the PLTU area. Respondents were drawn based on the sampling area, namely people living within a radius of 3,000 meters from the emission center.

The magnitude of the risk level is obtained from the comparison between the intake / intake and the reference dose value issued by the IRIS EPA, with the relationship that the greater the intake value compared to the reference dose value (RfC), the greater the health risk. The reference dose value (RfC) for $S0_2$ is 0.026 mg / kg / day ((14).

From the results of the calculation of the amount of risk for the duration of the next 30 years it is known that at this time (realtime) there are no respondents who have RQ≥1 because the value of the amount of risk obtained is only 0.1461 mg / kg / day for SO2. the risk magnitude value is 0.3423 mg / kg / day for $S0_2$.

However, from the results of the calculation of the level of risk (RQ) concentration$S0_2$In the community of Wawatu Village and TanjungTiram Village, the RQ> 1 was obtained as many as 5 respondents. An RQ value> 1 indicates that they are underweight so that the amount of intake that enters their body is greater or in other words someone who is underweight

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will have a higher risk of exposure to sulfur dioxide. Apart from the weight factor, other factors that make the respondent have an RQ> 1 are the time of exposure and the frequency of exposure. Where the respondents on average live 24 hours per day in 7 days a week so that the risk of exposure will be even greater.

For example, one respondent who has a body weight of 40 kg, sulfur dioxide concentration of 0.0256 mg / m3, who lives for 24 hours / day, 365 days / year with an RfC SO2 value of 0.026 mg / kg / day, $S0_2$ exposure is RQ.1.1423 mg / kg / day. This means that the residential areas around the PT. DSSP with a $S0_2$ concentration of 0.0256 mg / m3 is not safe (non-carcinogenic) for people with an inhalation rate of 0.83 / hour for 365 days / year who lives for 24 hours / day and weighs 40 kg in the next 70 years .

Risk management

a) Risk Management Strategy

The risk management strategy is carried out by establishing safe concentration limits and determining the duration of safe exposure. The safe concentration calculation uses the RfC $S0_2$ value of 0.026 mg / kg / day. Then the calculation of the safe concentration is as follows:

Non-carcinogenic safe concentration

$$C_{nk(aman)} = \frac{0{,}026 \; x \; 40 \; x \; 10950}{0{,}83 \; x \; 24 \; x \; 365 \; x \; 70}$$

$$= 0.0223 \text{ mg / m3}$$

So that the truly safe concentration value is below 0.0223 mg / m3 (<0.0223 mg / m3) = 0.0222 mg / m3.

Determination of the duration of safe exposure

$$Dt_{nk(aman)} = \frac{0{,}026 \; x \; 40 \; x \; 10950}{0{,}0256 \; x \; 0{,}83 \; x \; 24 \; x \; 365}$$

$$= 61.18 = 61 \text{ years.}$$

So the duration of stay in a safe community is 61 years.

b) Risk Management Method

Controlling pollutants in the air can also be carried out by reforesting and developing green open spaces or planting trees in industrial areas and community settlements. Trees can naturally absorb pollutants in the air and are more effective on broadleaf trees(5). In addition, every one hectare of green open space can produce 0.6 tons of oxygen per day. This can reduce the concentrated concentration of dissolved pollutants in the air(5). Government regulations also need to be tightened to implement residential locations in safe areas of the center of the factory. Based on this study, a safe residential location from the center of the factory should be above 2.5 km. However, for other types of industry further studies are needed. This is in accordance with the Regulation of the Minister of Industry No. 35/2010 concerning Technical Guidelines for Industrial Estates that the distance for settlements is at least 2 km from the industrial center.

CONCLUSION

The average sulfur dioxide intake of respondents at point 1 has a mean of 0.0101, at point 2 has a mean of 0.0084, at point 3 has a mean of 0.0105, and at point 4 has an average of 0.0101. Risk is influenced by body weight, rate of inhalation, time of exposure, frequency of exposure, duration of exposure. Risk management is carried out by reducing exposure time, planting trees that can absorb air pollution, maintaining endurance, implementing safe residential locations from the center of the factory which should be above 2.5 km. It is necessary to measure $S0_2$concentrations routinely in community settlements around PT. Dian Swastatika Sentosa Power so that the air quality of people exposed to $S0_2$ can be monitored.

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