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Indoor Sulfur Dioxide (SO2) Pollutant in Wamena Papua Province, Indonesia

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Abstract- The use of biomass in Honai indoor (traditional house) in Wamena has been done for decades and became a habit honai dwellers. Because of the cold temperatures community burns Kasuari wood to warm their body. As a result , they continue to inhale sulfur dioxide (SO_2) and contaminated air in the room which can lead to various diseases. This study aims to analyze the level of indoor air contamination honai based on the SO_2 parameters, measuring the level of contamination and inhalation lung vital capacity of honai dwellers. Samples were collected from 30 Honai house before and after modification by measuring the concentration of SO_2 levels. Similarly, 30 respondents occupants of Honai house measured for their lung vital capacity and the level of their air inhalation. SO_2 samples were collected using midget impinger technique and concentration were measured using Pararosaniline - spectrophotometry. In addition, lung vital capacity was measured using spirometry while personal inhalation measured by the Personal inhalation tool. The results showed that, of the five villages average SO_2 concentration was between 0.650 ± 0.454 before modification and 0.057 ± 0.048 after modification. Statistical test results of t - test showed that the decrease in SO_2 concentrations indicated with p values of 0.000, or no effect modification in a decrease in the concentration of SO_2 honai. Of the 13 respondents to rate on a standard inhalation, there was 92.3 % which decreased vital capacity of the lungs and of the 17 respondents to the category of sub-standard level of inhalation , all respondents have a capacity of lung function were normal . The results of statistical tests using yate 's correction showed that the value of p = 0.000 which means that there is a relationship between the degree of inhalation with decreased lung function capacity.

Index Terms- Sulfur dioksida, modifikasi honai, polusi udara, tingkat inhalasi dan kapasitas vital paru.

I. Introduction

Indoor air pollution in developing counties is a major contributor to the global burden of illness and is becoming the second biggest environmental pollutant contributor to ill health in the world (WHO., 2002). The sources of air pollution mostly generated by the industry, forest fire, vehicles and the burning of biomass that are currently threatening the inhaled air quality in the entire world (McKenzie., James, Pinger., Robert, & Kotecki Jerome, 2002). At this era, most of people spent their time more in the indoor; the kind and varied range of indoor sources of emission and the increased magnitude of concentration of some pollutants indoors compared with the outdoors pollution (Harrison, 1997). In the last three decades, some evidence have been accumulating about the effect of health impacts of exposure to air chemical substances pollutants in childhood and of adult. Research from the United States, Poland, and Austria recorded significant relationships between decrements in lung function growth and chronic exposures to total suspended particulates (TSP), ozone, Sulfur Dioxide (SO_2) and nitrogen dioxide (NO_2) (Horak et al., 2002; Jedrychowski, Flak, & Mroz, 1999; Shwartz, 1989).

Some other examples were, the indoor air quality close to the industrial area is tightly associated to pollutant substances concentration rate, because the pollution from outdoor heavily influences air quality and, as the consequent of the inhabitants indoor health. Here, a pollution management system is necessary for human health protection especially from indoor pollution. Both manual or automatic air quality management systems have became a imperative research issue with strong implications for community's health. In this study we develop a chimney and modify the Honai ventilation based on neural networks for SO2 and NO_2 concentration control indoor of Honai traditional houses (Brunelli, Piazza, Pignato, Sorbello, & Vitabile, 2008). In addition, Air pollution from fossil fuel from vehicles combustion has been known to affect human health for region. More detailed insights developed in the 20th century, as a result of studies prompted by severe air pollution episodes such as those in the Meuse Valley, Belgium in 1930, and London, UK in 1952. The focus in the early studies was on local pollution produced by industry, power generation and home heating sources. (Brunekreef, 2010).

Some researches relate to the indoor air pollution have been done, although most of these studies were snapshots of a small number of locations, but Biersteker, de Graaf, & Nass, 1965 reported a larger study that measured indoor and outdoor chemical concentrations in 60 homes in Rotterdam, Netherlands. The study revealed that the mean concentrations of indoor smoke were about 80% of those outdoors, mean concentrations of indoor SO2 were about 20% of those outdoors. However, it was also found that a small number of homes had indoor concentrations much higher than those in outdoors, and the authors speculated on their contribution to elevated mortality during smog episodes. It is likely that higher concentrations would have been found in homes with open coal fires, as was common in the UK during the 1950s, than in this Dutch sample of homes primarily using gas for heating. The reasons for the much lower indoor concentrations of SO2 were considered by Spedding (Spedding, 1974), who summarized studies showing a large variation in the capacity of indoor materials to absorb SO2. He used measured deposition velocities and surface areas in a typical UK house to identify emulsion paint as the most important sink for SO2.

In this study area, the common forms of cooking energy in use in Wamena are fuel wood, kerosene, limited liquefied petroleum gas (LPG) and very limited electricity. Here in this study site of Wamena District, water boiling and cooking experiments using the common household energy sources from biomass where Casuari wood that available in the area and surround are available in large quantity. The experimental data obtained, the energy price data, cooking energy intensity and the frequency biomass were used for cooking as well as the major diseases suffered by community who occupy *Honai* the traditional house. The effect on air quality arising from consumption of these biomass energy types was computed using emission factors (EPA., 1995; WHO., 1992). No initial data relate use of biomass, the frequency of the cooking and the duration of wood burning during the cold in the evening. This study cover of five village in Kurulu District and similar studies have not been reported elsewhere, however, relate to the current trends regarding the penetration of air conditioners in homes, this suggests that domestic air pollution may be an issue of concern for the foreseeable future.

II. MATERIAL AND METHODS

2.1 Study Area

This study was commenced in five villages, namely; Punakul Village, Wenabubaga Village, Musalfak Village, Kilugaba Villages and Mulimah Village in Kurulu District, Wamena Province, Papua-Indonesia. District Kurulu was selected to be sampling areas on the basis that this region is a zone has many traditional housing (Honai) and they use wood for cooking and for warming the indoor air temperature daily. In addition the majority of illnesses suffered by residents of this area were found of *asthma, pneumonia* and *tuberculosis*.

2.2 Sample Design

Data were collected both for subject and objects samples of population, then we measure lung vital capacity for those *Honai* occupants by using a *spirometer* and proceeds with inhalation rate measurements for SO_2 by using a personal sampler inhalation. The ambient indoor *Honai* air samples were taken for SO_2 as the object samples for the *honai* house communities. All samples were recorded at 16:00 to 17:00, 17:00 to 18:00 or 18:00 to 19:00 in the evening. Each sample was collected for 60 minutes at every house. Numbers of sampling points were 15 *Honai* houses done before and after the chimney installation. We do the installation of chimney (close technology) with a diameter of 30 cm that is placed along the 2.5 m above the furnace roof and wall edges out of *Honai*. The aim of this chimney installation was to flow out the smoke in *Honai*. In addition, these object sampling sites were divided into 5 regions based on availability of *Honai* or *Honai* density at those five selected villages. We also taking into account the willingness of residents to involve during this research as the explained in the ethical consideration. Likewise, we took into account the distance between *Honai* sample points where about 300 to 500 m each *Honai* were selected that subsequently obtained through a Global Positioning System coordinates (Carlson & Clay, 2011). Moreover, the number of respondents or subject samples in this study was 30 respondents. They were split evenly by the large number of traditional houses Honai in each village, in this study we got 6 respondents every village who voluntarily wanted to involve during this study.

2.3 Consideration of Ethical Clearance

All respondent living in the five villages area who were requested as the respondent signed an informed consent letter prior to inclusion in the study commencement. The collection of samples of Inhalation rate and lung vital capacity were done base on the ethical clearance consideration issued by Medical Faculty of Hasanuddin University number UH13070282. The measurement of those samples were base on the voluntary case of people. Confidentiality of initial information and freedom to withdraw from the study anytime was stipulated and without any force from the third parties. Those found to have health concerns such as disease symptoms or any illness will be informed individually or provided with the appropriate management and informed secretly, as necessary. All questions and complaints were also adopted and answered directly by authors if required.

2.4 Samples Analysis

The collection of SO_2 samples were done by using impinger method and measurement techniques using pararosaniline-spectrofotometri accordance with the Indonesian National Standard (SNI 19-7119.7-2005) (SNI., 2005). Principle of this method is based on the absorption of SO_2 gas from the air on absorbent solution of potassium tetra kloromerkurat (TCM). In this case the complex formed diklorosulfito merkurat air oxidation resistant. Furthermore the complex is then reacted with formaldehyde to form pararosanilin and sulfonic acid methyl pararosanilin colored. The color intensity is measured with a spectrophotometer that occurs directly associated with the amount of SO_2 in the air sample has been taken. The measurement method is based on Schiff reaction that can measure the concentration of SO_2 in the range of 25-1000 μg/m3 in the air sample flow rate, while for the smaller than 25 μg/m3 could be measured by the volume of air that a larger sample. All the sequences were done in accordance by laboratory staffs in Accredited Chemical Laboratory of Makassar Indonesia

III. RESULTS AND DISCUSSION

3.1. Lung capacity base on NO_2 parameter

Table 1. Distribution of lung vital capacity of respondents by category inhalation rate of SO_2 in Five Villages Kurulu District, Wamena 2013

SO_2	Lung Vital Capacity				Total		Statistical value
	Decrease of function		Decrease of function				
	n	%	N	%	n	%	
> standard	12	92.3	1	7.7	13	100	P =0,000
< standard	0	0	17	100	17	100	
Total	12	40	18	60	30	100	

Lung vital capacity was measured by using spirometer to 30 respondent who stay in the area of concern and occupy the traditional house of Honai.

Table 1 implied showed that of the 13 respondents with inhalation rate above allowed standard, there were 92.3% who had a reduction in lung vital capacity. Of those 17 respondents the rate inhalation category under allowed standard, all of them have normal lung capacity function. Results of statistical tests using yate's correction showed that the value of p = 0.000, which means that there is a relationship between inhalation rate with decreased lung function capacity.

In line with study conducted by Fernandez [16] who compared the use of biomass in home for cooking and those homes cook without biomass. The results indicated that the concentration levels of SO_2 and NO_2 were much higher at home with biomass in cooking or 9.8 times compared with that home that cook without biomass. Likewise, the potential diseases associated with respiratory disturbance among patients illustrated that residents with biomass will be faster and more likely to suffer higher than those without biomass.

3.2 SO_2, air temperature, and humidity, before and after the installation of closed model chimne

We measured the concentrations of SO_2, air temperature, and humidity, before and after the installation of closed model chimney indoor of the honai.

Table 2 revealed the average concentration of SO_2 prior to the modification of *honai* was 0.650 µg/Nm^3 with a standard deviation of ± 0.454 µg/Nm^3. The concentration was higher when compared to the average concentration of SO_2 after the home / honai modification 0.057 µg/Nm^3 with a standard deviation of 0.048 µg/Nm^3. Based on the statistical t -test showed that a decrease in the concentration of SO_2 is shown with p values of 0.000, or no influence *Honai* modification to decrease the SO_2 concentration.

Table 2. Distribution concentrations SO_2, air temperature, and humidity, before and after the installation of closed model chimney, in Five Villages, Kurulu District, Wamena 2013

Variable		Mean ± SD	Minimum	Maximum	Statistical test	
					t-test	P
SO_2 concentrations (µg/Nm^3)	Before modification	0.650 ± 0.454	0.086	1.247	5.249	0.000
	After modification	0.057 ± 0.048	0.007	0.150		
Temperature Udara (°C)	Before modification	26.487 ± 2.606	21.700	29.200	2.182	0.047
	After modification	25.813 ± 2.515	21.700	29.700		
Humidity (%)	Before modification	70.827 ± 2.377	67.900	74.800	-2.378	0.032
	After modification	71.420 ± 2.462	67.900	74.800		

The wide range of building design leads to large variations in infiltration rate and hence indoor and personal exposure. Compare to *Honai* building that has a closed model design it may lead to a hazard of indoor air pollutant. Concentration of SO_2 indoor of *Honai* might be reduced by the proper instllation of chimney that may flow out the contaminated air. Although new houses do not necessarily mean air tight houses, but it need the installation of chimney to flow out the pollutant. Study relate the indoor pollution relate to the house design conducted by Sherman and Matson (Sherman & Matson, 2002) implied that the main reasons for tighter construction are to reduce energy costs and maintain thermal comfort which is more efficient.

For the air temperature, the average temperature before the honai modification was from 26.487 °C with ± 2,606 °C for its standard deviation. This concentration was lower when compared to the average air temperature after a honai modification which leveled to 25.813 °C with a standard deviation of 2,515 °C. Based on the test statistic t -test showed that an increase in air temperature indicated by a p value of 0.047, or in other words no influence honai modifications to the increase of air temperature. This increase is relatively small at an average of only 0.674 °C.

Likewise, the average humidity of the air before the honai modification was 70.827 % with a standard deviation of ± 2.377 %. This concentration was lower when compared to the average air humidity after the honai modification which amounted to 71.420 % with a standard deviation of ± 2,462 %. Based on the statistical t -test showed that there was an increase in air humidity indicated by the p value of 0.032, or we can say that no influence of honai modifications to the increase of air humidity. This increase is relatively small at an average of only 0.593.

IV. Conclusion

It can be concluded that indoor air concentration of SO_2, in the *Honai* house mostly exceeded the standard. Measurement of lung capacity in 30 respondents who stayed in *Honai* for more than 10 years as well as inhalation rate measurements were found that all concentrations of SO_2 in the honai has exceeded the threshold value both set by Nasional and International standards. Furthermore, the value of lung capacity and inhalation rate for SO_2 parameters showed decreased lung capacity and some of respondents have experienced pneumonia and lung vital capacity were not normal.

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