# Sulfur Dioxide (SO2) and Nitrogen Dioxide (NO2) Indoor Honai Pollution in Wamena, Papua Province, Indonesia

**A.L. Rantetampang[1*], Alimin Maidin[2], Muhammad Furqaan Naiem[3] and Anwar Daud[4]**

[1]Postgraduate Program, Medical Faculty, Public Health Study Program, Hasanuddin University, Makassar, South Sulawesi, Indonesia, 90245
[2]Faculty of Public Health, Hasanuddin University, Makassar Indonesia
[3]Occupational Health Department, Faculty of Public Health, Hasanuddin University, Makassar, Indonesia
[4]Environmental Health Department, Faculty of Public Health Hasanuddin University, Indonesia

*Author to whom the correspondence should be addressed: alrant17@yahoo.co.id

***Abstract-*** *The use of biomass indoor Honai (traditional house) in Wamena have been conducted for several decades and become a traditional habit of Honai occupants. Since air temperature at night in Wamena Regency is cold the inhabitans burn the Kasuari woods to warm their body. As a result, they continuously inhale the Sulfur Dioxide ($SO_2$) and Nitrogen Dioxide ($NO_2$) and some contaminated air in Honai room daily which may lead to varies illnesses. This study aimed to investigate the $SO_2$ and $NO_2$ contaminated Honai indoor air, record the air contaminated inhalation rate and lung vital capacity among the honai occupants at five villages in Wamena regency. Samples were collected from 15 Honai before and after the honai modification by recording the $SO_2$ and $NO_2$ levels. Likewise, 30 inhabitants of Honai occupants were measured for their lung vital capacity as well as the personal $SO_2$ and $NO_2$ inhalation rate. Sample of $SO_2$ and $NO_2$ were collected used midget impinger technique and concentration measured by using the pararosaniline-spectrofotometri. In addition, lung vital capacity was measured use a spirometric whereas personal inhalation was measured by personal inhalation tool. Results implied that, of those five villages showed the mean of $NO_2$ values before honai modification were $4.011 \pm 1.138$ μg/Nm$^3$ and after the modification were $0.350 \pm 0.201$ μg/Nm$^3$, respectively. Based on the statistical t -test showed that the decrease in $NO_2$ concentrations was shown with p values of 0.000, or in other words no influence homes honai modification to the decrease of $NO_2$ concentration. Likewise, $SO_2$ concentrations were between $0.650 \pm 0.454$ before modification and $0.057 \pm 0.048$ after modification indicated over the standard. 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.*

***Index Terms*** *- Sulfur Dioxide, Nitrogen Dioxide, Honai modification, Indoor Air Pollution, Inhalation Rate and Lung Capacity.*

## 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 [1]. 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 [2]. 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 [3]. 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, and nitrogen dioxide ($NO_2$) [4-6].

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 Idoor of Honai traditional houses [7]. 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

ISSN 2250-3153

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. [8].

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 et al [9] 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 [10], 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 [11, 12]. 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 $SO_2$ and $NO_2$ by using a personal sampler inhalation. The ambient indoor *Honai* air samples were taken for SO2 and NO2 as the object samples for the *honai* house communities. All sample 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*. Ina ddition, 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 [13]. 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

ISSN 2250-3153

consideration issued by Medical Faculty of Hasanuddin University number UH13070282. The measurement of those sample 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 $SO_2$ and $NO_2$ samples were done by using impinger method and measurement techniques using pararosaniline-spectrofotometri accordance with the Indonesian National Standard (SNI 19-7119.7-2005) [14]. Principle of this method is based on the absorption of $SO_2$ and $NO_2$ 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 $SO_2$ and $NO_2$ in the air sample has been taken. The measurement method is based on Schiff reaction that can measure the concentration of $SO_2$ and $NO_2$ 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*

Lung capacity measurement was conducted both for $NO_2$ and $SO_2$ parameters. All data recorded at the same time. 30 respondent were participated in this study, the results are shown on **Table 1** and T**able 2** as follow:

**Table 1**. Distribution of respondent lung capacity by category of Inhalation Rate for $NO_2$ in Five Villages, Kurulu District, Wamena 2013

| $NO_2$ | Lung Capacity | | | | Total | | Statistical value |
|---|---|---|---|---|---|---|---|
| | Decrease of function | | Normal | | | | |
| | n | % | n | % | n | % | |
| > standard | 0 | 0 | 0 | 0 | 0 | 0 | P =0,000 |
| < standard | 12 | 40 | 18 | 60 | 30 | 100 | |
| Total | 12 | 40 | 18 | 60 | 30 | 100 | |

**Table 1** described that the rate of 30 respondents with inhalation under the allowed standard, there were 40% of respondent have decreased lung vital capacity. Based on the table also shows that all respondents have inhalation rate for $NO_2$ in the category parameters under the allowed standard, so it does not qualify for the test conducted chi-square statistic. Although some stations were still under the set regulation of pollutant, the continual inhalation of contaminated indoor air will lead to varied illness that might be suffered by the Honai occupants. Relevant study results by Haddad [15] showed that residents who exposed with indoor air pollutant for more than 5 years will be potentially suffering from varies diseases. The study showed that 29 % respondents had been diagnosed with at least one type of respiratory disorders and 24% for adult acute [15].

### *3.2 Lung capacity base on $SO_2$ parameter*

**Table 2.** 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 | |

**Table 2** 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.

### *3.3 $NO_2$ and $SO_2$, air temperature, and humidity, before and after the installation of closed model chimney*

**Table 3.** Distribution concentrations $NO_2$ and $SO_2$, 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 |
| $NO_2$ concentrations (µg/Nm$^3$) | Before modification | 4.011 ± 1.138 | 2.481 | 6.557 | 13.400 | 0.000 |
| | After modification | 0.350 ± 0.201 | 0.118 | 0.728 | | |
| $SO_2$ 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 ($^o$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 | | |

Table 3 revealed the average concentration of $NO_2$ prior to the modification of home *honai* was 4.011 µg/Nm$^3$ with a standard deviation of ± 1,138 µg/Nm$^3$. The concentration was higher when compared to the average concentration of $NO_2$ after the home modification 0.350 µg/Nm$^3$ with standard deviation 0.201 µg/Nm$^3$. Based on the statistical t -test showed that the decrease in $NO_2$ concentrations was shown with p values of 0.000, or in other words no influence homes *honai* modification to the decrease of $NO_2$ concentration. Relevant study revealed that the mean indoor concentrations of $NO_2$ in the expolis study ranged from 13 mg m$^{-3}$ to 43 mg m$^{-3}$ in different cities [17]. Typical daily mean indoor air concentrations in homes with gas cooking vary between 25 and 200 mg m$^{-3}$ [18, 19].

For $SO_2$ concentration, the average concentration of $SO_2$ prior to any modification of home *honai* 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.

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 installation 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 [20] 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 $^o$C with ± 2,606 $^o$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 $^o$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.

## 2. CONCLUSION

Based on the results of the study, it can be concluded that the indoor air concentration of $SO_2$, and $NO_2$ 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. $NO_2$ concentrations at several homes Honai still under NAB, but the majority have been exceeded. Furthermore, the value of lung capacity and inhalation rate for both $SO_2$ and $NO_2$ parameters showed decreased lung capacity and some of respondents have experienced pneumonia and lung vital capacity were not normal.

## ACKNOWLEDGEMENT

Authors highly appreciate, would like to thank the Head of Kurulu District and Head Wamena Regency who have given a permission of research commencement and a very kind cooperation during the field study in Wamena Regency. Hence, we thank to the Head of Health Department and Head of Hospital of Wamena Regency and all staffs for their great assistance and effort in sampling process period. We grateful thanks to laboratory members of chemical laboratory, Indonesia for their very good work for sample analysis in accordance to the quality assurance and quality control.

## REFERENCES

1. WHO., *The World Health Report 2002 - Reducing risks, promoting healthy life. Geneva, Switzerland: World Health Organisation*. 2002.
2. McKenzie., et al., *(An Introduction to Community Health). Fourth edition, Translated by Atik Utami, Nova S. Indah Hippy, and Iin Nurlinawati. 2007. Jakarta: Book Medical Publishers*. 2002.
3. Harrison, P.T., *Health impacts of indoor air pollution. Chem Indust 1997; 17: 677–681*. 1997.
4. Jedrychowski, W., E. Flak, and E. Mroz, *The adverse effect of low levels of ambient air pollutants on lung function growth in preadolescent children, Environ Health Perspect.1999;107:669–674*. 1999.
5. Shwartz, J., *Lung Function and Chronic Exposure to Air pollution: a crosssectional analysis of NHANES II. Environ Res. 1989;50:309–321*. 1989.
6. Horak, F., et al., *Particulate matter and lung function growth in children: a 3-yr follow-up in Austrian schoolchildren. Eur Respir J.19:838–845*. 2002.
7. Brunelli, U., et al., *Three hours ahead prevision of SO2 pollutant concentration using an Elman neural based forecaster*. Building and Environment, 2008. **43**(3): p. 304-314.
8. Brunekreef, B., *Air Pollution and Human Health: From Local to Global Issues.* Procedia - Social and Behavioral Sciences, 2010. **2**(5): p. 6661-6669.
9. Biersteker, K., H. de Graaf, and C.A.G. Nass, *Indoor air pollution in Rotterdam homes. International Journal of Air and Water Pollution 9, 343–350*. 1965.
10. Spedding, D.J., *Air Pollution. Clarendon Press, Oxford*. 1974.
11. WHO., *World Health Organisation. Indoor air pollution from biomass fuel. Geneva*. 1992.
12. EPA., *Compilation of air pollutant emission factors, vol. I: stationary point and area sources, fifth ed. Research Triangle Park NC, USA: United States Environmental Protection Agency, Office of Air Quality Planning and Standards*. 1995.
13. Carlson, C.G. and D.E. Clay, *C.G. Carlson and D.E. Clay. 2011 The Earth Model—Calculating Field Size and Distances between Points using GPS Coordinates. The Site-Specific Management Guidelines series.The Potash & Phosphate Institute (PPI), (Online), http://www.ipni.net/ppiweb/ppibase. 2011.pdf diakses 4 April 2013)*. 2011.
14. SNI., *Udara Ambien – Bagian 7: Cara Uji Kadar Sulfur Dioksida (SO2) Dengan Metoda Pararosanilin Menggunakan Spektrofotometri. Badan Standardisasi Nasional. [Online] ICS 13.040.20. http://staff.undip.ac.id/.../SNI-19-7119.7-2005 [diakses 17 September 2013]*. 2005.
15. Barakat-Haddad, C., S.J. Elliott, and D. Pengelly, *Health Impacts of Air Pollution: A Life Course Approach for Examining Predictors of Respiratory Health in Adulthood. Annals of*

*Epidemiology, 22(4), 239-249. doi: http://dx.doi.org/10.1016/j.annepidem.2012.02.010*. 2012.

16. Fernández, C.L., et al., *Indoor Air Contaminants and Their Impact on Respiratory Pathologies. Archivos de Bronconeumología (English Edition), 49(1), 22-27. doi: http://dx.doi.org/10.1016/j.arbr.2012.11.004*. 2013.
17. Kousa, A., et al., *Personal exposures to NO2 in the Expolis study: relation to residential indoor, outdoor and workplace concentrations in Basel, Helsinki and Prague. Atmospheric Environment 35, 3405–3412*. 2001.
18. WHO., *Air Quality Guidelines – Global Update 2005. WHO Regional Office for Europe, ISBN 92 890 2192 6*. 2006.
19. VITA., *Testing efficiency of wood burning cook stoves, provisional international standards. Volunteers in technical assistance, Arlington, Virginia, USA, 1982*. 1982.
20. Sherman, M.H. and M.E. Matson, *Air Tightness of New U.S. Houses: A Preliminary Report. Lawrence Berkeley National Laboratory. Report No. LBNL-48671. 2002*. 2002.

## Authors

**First Author** – A.L. Rantetampang, PhD Program of Public Health, Faculty of Public Health, Cenderawasih University, Papua, Indonesia; email address. Alrant17@yahoo.co.id

**Second Author** – Alimin Maidin. Professor of Public Health, Faculty of Public Health Hasanuddin University, Makassar Indonesia

**Third Author** – *Muhammad Furqaan Naiem*, PhD of Occupational Health , Occupational Health Department, Faculty of Public Health, Hasanuddin University, Makassar Indonesia
**Fourth Author** – Anwar Daud, PhD of Environmental Health, Department of Environmental Health, Faculty of Public Health, Hasanuddin University, Indonesia. email address. Daudanwar50 @yahoo.com

**Correspondence Author** ; A.L. Rantetampang
Email Address: *alrant17@yahoo.co.id*