Risks Assessment due to the Exposure of Copper and Nitrogen Dioxide in the Goldsmith in Malimongan Makassar

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Abstract: Manufacture of gold jewelry is one of the manufacturing processes involving several dangerous chemicals. These chemicals are used for melting, refining, welding, electroplating, and polishing the gold metal. This research aimed to determine the health risk as the resulted of the exposure to copper and nitrogen dioxide of the goldsmiths in Malimongan village Sub wajo, Makassar city. The research used observational design with the environmental health risk assessment approach. The 30 environmental samples and 30 human samples were chosen using the simple random sampling. The data were analyzed using the Environmental Health Risk Analysis and processed using Microsoft Excel and IBM SPSS version 21. The research results of indoor concentrations copper from measurement point all represent bellow 1 mg/m$^3$. The highest concentration is 0,07390 mg/m$^3$ and the lowest  is 0,0015 mg/m$^3$, the mean concentration of Copper  is 0,0268 mg/m$^3$. As for NO$_2$ measurement point also is concentrations below 3 ppm, the highest concentration is 0,020 ppm and the lowest is 0,010 ppm, the mean concentration of nitrogen dioxide  is 0,0154 ppm. The non carcinogenic risk to copper of the goldsmiths showed that the average is 3,927. From the 30 people indicated 23 goldsmiths (76,7%) at risk had RQ $\geq$ 1 and 7 goldsmiths (23,3%)  had risk RQ $\leq$ 1, the health risk NO$_2$ average is 0,05947. In conclusion, from all of respondent 30 people (100%) had RQ $\leq$ 1. Goldsmiths has shown risks of exposure copper but not nitrogen dioxide.

1. Introduction
Inhaling copper oxide or fine copper dust is associated with metal fume fever such as burning sensations, redness of the throat, coughing, sneezing, shortness of breath, nausea, and fever. This effect occurs usually within a few hours after exposure and lasts for 24-48 hours [1], [2]. In addition to copper, chemicals used from the process of making gold jewelry are also sourced exposure to harmful gases. HNO$_3$ decomposition releases nitrogen dioxide (NO$_2$) and nitric oxide (NO). In practice, HNO$_3$ is usually found in association with NO$_2$ which appears to be more dangerous [3]. NOX (NO$_2$ and NO gas mixture) is brownish red and poisonous gas. When inhaled through the respiratory tract and absorbed through the skin, causing various skin diseases and respiratory problems. Based on in vitro studies, the environmental concentration of HNO$_2$ is formed in the respiratory system dominated by hydrogen abstraction, with subsequent conversion of HNO$_2$ in physiological pH, to H$^+$ and NO$_2$[4]. Research of [5], goldsmiths experienced musculoskeletal complaints (91.37%), respiratory complaints (43.1%), eye irritation (77.58%), skin irritation (13.79%), headache during work (72.41%) and none of the goldsmiths use a mask of the nose.
Indoor air pollution, especially home is very dangerous to human health, because in general people spend more time to do activities in the house so that the house becomes very important as a micro environment related to the risk of air pollution. A total of 400 to 500 million people, especially in developing countries, are facing the problem of indoor air pollution [6]. The United State Environmental Protection Agency (US.EPA) study, on humans exposed to pollution indicates that the degree of pollution in space can be two to five times higher [7], [8].

The route from exposure to metal fumes, steam and dust is mostly through inhalation. Exposure tends to accumulate chronically from a goldsmith exposed every day at work. Furthermore, in conditions of continued exposure, not all metals entering the body will be removed. Instead, such exposure will accumulate in body tissues such as hair, bones and can cause toxicological effects of heavy metals and diseases [9]. A single case report of a female patient accidentally inhaled copper metal dust, suffered respiratory failure several hours later, and acute respiratory distress syndrome after three days of hemolytic anemia, liver failure, renal failure and evidence of acute tubular injury. Samples from bronchoalveolar lavage showed positive copper macrophages [10]. According to [11] work hazards reported on gold jewelry workers caused by exposure to chemicals during jewelry making. Twenty men who worked as goldsmiths 10 years ago with a period of exposure to chemical fumes > 5 hours / day were tested for lung spirometry function parameters ie FVC was 63.95 ± 9.77% in cases and 76.95 ± 8.1 control. The pulmonary spirometry function parameters were found to be significantly lower in goldsmith workers. Based on these facts, it supports the authors to conduct research on the analysis of exposure risk of copper (Cu) and nitrogen dioxide (NO\(_2\)) to Gold Craftsmen in Malimongan Urban Village, Wajo Sub-district, Makassar City.

2. Method

This type of research is an observational analytic study with the design of Environmental Health Risk Analysis (ARKL) due to exposure to copper (Cu) and nitrogen dioxide (NO\(_2\)). The object population in this study was air in the home of gold craftsmen. The total number of houses of gold craftsmen in Malimongan Urban Village Wajo Sub-district Makassar City as many as 44 houses, while the population of subjects in this study are gold craftsmen. Sampling was done by simple random side, so that air samples obtained 30 samples and human samples of 30 respondents.

Air sampling is taken directly in the workshop of gold craftsmen with the help of the Center for Occupational Safety and Health Makassar (B2K3 Makassar). Measurements were made 1 time for 60 minutes. Primary data of indoor airborne concentration was obtained by measuring the concentration of copper (Cu) and nitrogen dioxide (NO\(_2\)) and then examined in the laboratory. Risk analysis data in the form of respondent intake was obtained by using questionnaire and weighing weight of respondents by using weight measuring tool. Secondary data is obtained from books, literature, research results, agency data, and reading related to the theme in this study.

3. Results and Discussion

The results of this study illustrate the concentration level of copper (Cu) and nitrogen dioxide (NO\(_2\)) in the air in the workspace of gold craftsmen in Malimongan sub-district, Wajo sub-district, Makassar city, and the level of health risk of daily exposure both real time and lifetime in gold craftsmen as respondents in the study.

Table 1 Average Distribution of Measurement Results Cu and NO\(_2\) Concentrations In Gold Craftsmen in Malimongan Urban Village Wajo Sub-district Makassar City.

| Locations  | (Cu) concentration | (NO\(_2\)) concentration |
|------------|--------------------|--------------------------|
|            | mg/m\(^3\)        | ppm                      | mg/m\(^3\) |
| House 1    | 0.0227             | 0.017                    | 0.0319     |
| House 2    | 0.0317             | 0.014                    | 0.0263     |
| House 3    | 0.0703             | 0.010                    | 0.0188     |
| House 4    | 0.0257             | 0.016                    | 0.0300     |
| House 5    | 0.0376             | 0.012                    | 0.0225     |
| House 6    | 0.0559             | 0.010                    | 0.0188     |
| House 7    | 0.0436             | 0.017                    | 0.0319     |
| House 8    | 0.0739             | 0.015                    | 0.0282     |
| House 9    | 0.0317             | 0.014                    | 0.0263     |
The maximum allowed limit of Cu is 1 mg/m$^3$; The maximum allowed limit of NO$\textsubscript{2}$ is 3 ppm.

The average concentration of Cu and NO$\textsubscript{2}$ at all points of the house is still below the NAV. The highest concentration for copper (Cu) parameters is 0.07390 mg/m$^3$ (home 8) and lowest 0.00001 mg/m$^3$ (home 16). While for nitrogen dioxide (NO$\textsubscript{2}$) the highest concentration is 0.0200 ppm (house 13) and the lowest concentration is 0.0100 ppm (house 3 and house 6).

Table 2. Distribution of Risk Quotient (RQ) Copper (Cu) and Nitrogen Dioxide (NO$\textsubscript{2}$) In Gold Craftsmen in Malimongan Urban Village Wajo Sub-district Makassar City 2016

| Locations | (Cu) concentration | (NO$\textsubscript{2}$) concentration |
|-----------|-------------------|------------------------------------|
|           | mg/m$^3$          | ppm                                | mg/m$^3$ |
| House 10  | 0.0136            | 0.016                              | 0.0300   |
| House 11  | 0.0438            | 0.018                              | 0.0338   |
| House 12  | 0.0257            | 0.019                              | 0.0357   |
| House 13  | 0.0317            | 0.020                              | 0.0376   |
| House 14  | 0.0016            | 0.014                              | 0.0263   |
| House 15  | 0.0136            | 0.011                              | 0.0207   |
| House 16  | 0.0015            | 0.012                              | 0.0225   |
| House 17  | 0.0136            | 0.017                              | 0.0319   |
| House 18  | 0.0317            | 0.015                              | 0.0282   |
| House 19  | 0.0618            | 0.019                              | 0.0357   |
| House 20  | 0.0438            | 0.017                              | 0.0319   |
| House 21  | 0.0314            | 0.014                              | 0.0263   |
| House 22  | 0.0144            | 0.018                              | 0.0338   |
| House 23  | 0.0017            | 0.015                              | 0.0282   |
| House 24  | 0.0276            | 0.014                              | 0.0263   |
| House 25  | 0.0215            | 0.019                              | 0.0357   |
| House 26  | 0.0016            | 0.017                              | 0.0319   |
| House 27  | 0.0126            | 0.013                              | 0.0244   |
| House 28  | 0.0161            | 0.018                              | 0.0338   |
| House 29  | 0.0015            | 0.015                              | 0.0282   |
| House 30  | 0.0019            | 0.017                              | 0.0319   |

Mean: 0.0268600, SD: 0.0204410, Min-Max: 0.00150, 0.07390

Mean: 0.015433, SD: 0.002715, Min-Max: 0.0100, 0.0200

The average concentration of Cu and NO$\textsubscript{2}$ at all points of the house is still below the NAV. The highest concentration for copper (Cu) parameters is 0.07390 mg/m$^3$ (home 8) and lowest 0.00001 mg/m$^3$ (home 16). While for nitrogen dioxide (NO$\textsubscript{2}$) the highest concentration is 0.0200 ppm (house 13) and the lowest concentration is 0.0100 ppm (house 3 and house 6).

Table 2. Distribution of Risk Quotient (RQ) Copper (Cu) and Nitrogen Dioxide (NO$\textsubscript{2}$) In Gold Craftsmen in Malimongan Urban Village Wajo Sub-district Makassar City 2016

| RQ (Cu) Non Carcinogenic | RQ (No$\textsubscript{2}$) Non Carcinogenic | Total |
|--------------------------|-------------------------------------------|-------|
| RQ ≤1                    | RQ >1                                      |       |
| 7                        | 23                                        | 30    |
| 23.3%                    | 76.7%                                     | 100%  |

| RQ (Cu) Non Carcinogenic | RQ (No$\textsubscript{2}$) Non Carcinogenic | Total |
|--------------------------|-------------------------------------------|-------|
| RQ ≤1                    | RQ ≥1                                      |       |
| 30                       | 0                                         | 30    |
| 100%                     | 0%                                        | 100%  |

| RQ (Cu) Non Carcinogenic | RQ (No$\textsubscript{2}$) Non Carcinogenic | Total |
|--------------------------|-------------------------------------------|-------|
| RQ ≤1                    | RQ ≥1                                      |       |
| 30                       | 0                                         | 30    |
| 100%                     | 0%                                        | 100%  |

| RQ (Cu) Non Carcinogenic | RQ (No$\textsubscript{2}$) Non Carcinogenic | Total |
|--------------------------|-------------------------------------------|-------|
| RQ ≤1                    | RQ ≥1                                      |       |
| 30                       | 0                                         | 30    |
| 100%                     | 0%                                        | 100%  |
Air pollutants will move from low-pressure areas and the process of removal is highly dependent on the direction of wind velocity [12]. The temperature of the air plays a significant role in the comfort of working because the human body generates the heat used for basal and muscular metabolism. But of all the energy that the body produces only 20% is used and the rest will be discharged into the environment, where the average temperature of the room is 28.67 °C. The relatively low air humidity (<40%) can result in dryness of membrane mucous membranes, while high humidity (> 70%) can increase the growth of microorganisms.

Risk Level RQ (Risk Quotient) Gold Craftsmen due to exposure to Cu and NO2 Table 2 shows the risk of exposure to Cu and NO2. Real time Cu exposure risk level from 30 respondents, there are 7 respondents were at risk (23.3%) RQ \( \geq 1 \), while 23 respondents (76.7%) were not at risk because RQ value \( \leq 1 \).

In this study use the indicator intake (Exposure Assessment). The respondent working hours are 7 to 10 hours with an average of 8.73 hours. The duration of exposure to the respondent is directly related to the number of sources of Cu and NO\(_2\) pollutants, although the daily inhalation is still below the threshold based on measured concentration values, but if the pollutants ingested daily during the work affect the amount of intake from the exposure itself. Research conducted by[13], most goldsmith workers work 7 to 8 hours per day (48%), 8-9 hours per day helps to earn a high income and even work at night. Sometimes if a festive event or social ceremony then the demand for gold jewelry is high, workers work for 12-14 hours a day. Level of exposure risk Cu life time for 30 years there are 6 respondents (20.0%) are not risky or RQ < 1, whereas 24 respondents (80.0%) were at risk RQ > 1. The risk of nitrogen dioxide exposure (NO\(_2\)) real time and non carcinogenic life time of 30 respondents (100%) was categorized as not risky because RQ value was < 1.

Cumulative Risk Level (RQcum) of gold craftsmen due to exposure to Cu and NO\(_2\)

Figure 1 is the result of an analysis of the cumulative risk between two types of pollutants. Real time cumulative Risk Quotient of 30 respondents had 7 people (23.3%) at risk RQ cum > 1 and 23 people (76.7%) were not at risk RQcum value < 1.

![Comparison of real time cumulative RQ and life time 30 years](image)

As for the cumulative Risk Quotient life time 30 years there are 6 people \( \geq 20.0\%)\) are not at risk and 24 people (80.0%) risk because RQcum. The time, frequency, duration of exposure is very influential on the size of the intake obtained. These factors have the same unit that is the time at which the concentration will accumulate in the body of the respondent depending on how long the time obtained. The greater the value of time, frequency, and duration of exposure then the intake will be greater.
Research[14], on the goldsmith a change in respiratory index depends on the duration of exposure to hazardous smoke and gas. Exposure tends to increase as a breathing barrier. The study found that a total of 56 goldsmiths were estimated to be FEF values of 25-75% lower than 70% of predictions, 12 people suspected of suffering from respiratory disturbances in the workplace. The lung function of the goldsmith significantly (p <0.01) decreased from the control group. Intergroup comparisons also showed decreased lung function associated with exposure time. The results showed that the average inhalation rate of respondents was 0.728 m³ / hour. The lowest inhalation rate is 0.6875 m³ / hr and the highest value is 0.766 m³ / hr. The inhalation rate calculation in this study is based on the default value of EPA standard 2011 based on gender and age. The greater the measured body weight, the higher the rate of inhalation of respondents. The average body weight of respondents was 64.57 Kg, with the lowest range between 50 Kg to 90 Kg. The weight variable affects the intake of harmful substances received by individuals, the longer a person is exposed to hazardous substances, the likelihood of health risks to be received is also greater. The greater the weight, the more likely the risk will be less (inversely proportional).

Similar to the research conducted by [15], the greater the weight in the concept of risk analysis, the risk received by respondents due to the source of pollutants will be smaller. This is because a person with a larger body weight has more nutrients than a smaller person and therefore has less risk. However, judging from the condition and there are several other factors that can affect the risk characteristics of a person. The health risks posed by the metal, then assess the potential health risks associated with inhaling the fine particles released during cooking using charcoal. The total HQ of 4.09 is four times greater than the acceptable limit of 1.0 [16], [17], [18]. The study of [19], investigation of indoor dust containing metals as a major pathway in the exposure of children. Heavy metal concentrates found on the floor, fan and windows of 0.17-6.14 μg / g / g for Cd, 34-454.86 μg / g for Pb and 12.63-185.82 Cu. Maximum levels of Cd, Pb and Cu are either comparable or lower than those reported elsewhere. According to Hazard Quotient (HQ) calculations in the case of non-cancer effects, primary school children do not pose a health hazard.

The real time copper (Cu) risk level (R) of 30 respondents is 7 people (23.3%) is not at risk or is within the safe limits for the respondent while the risk is 23 people (76.7%). Time up to 30 years life time respondents are not at risk there are 6 people (20%) and there are 24 people (80.0%) risk. This shows that up to 30 years of exposure has health risks. While non-carcinogenic nitrogen dioxide (NO2) exposure in real time from 30 respondents (100%) was not at risk and NO2 exposure to 30 years was also not risky. From these results it can be concluded that all respondents have not shown any non-carcinogenic health risks, so the health risks need not be controlled but need to be maintained so that the numerical value of RQ does not exceed 1.

4. Conclusion
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