ORAL

# Risk Analysis of Manganese In Clean Water In The Community of Supul Village, South Central Timor District

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## Abstract

**Background**. Manganese is an essential metal needed by the body to help the liver and brain performance. Excess Manganese can cause disease "*manganism*". Supul village was chosen because the location was close to the manganese mining area. **Purpose**. This study was to determine the risk of manganese in clean water in the community of Supul Village, South Central Timor Regency. **Method**. This research is a descriptive study, with a survey method. The research variables are the levels of manganese, manganese exposure and risk characteristics of manganese. The research samples were 9 clean water facilities and 84 people. Manganese levels are obtained through laboratory tests. Manganese exposure is obtained by calculating the intake of non-carcinogenic manganese risk agents. Risk characteristics are obtained with risk numbers (R). Data were analyzed using environmental health risk analysis. **Results**. The results of the study, the average level of manganese in clean water was 1.7741 mg / l. exposure Manganese in adults weighing 11 to 76 kg, at a minimum concentration of 0.032795 to 0.005178 mg / kg / day, at a maximum concentration of 2.131484 to 0.336550 mg / kg / day and at an average concentration of 0.283534 to 0.044768 mg / kg / day. Manganese exposure in children weighing 11 to 40 kg, at a minimum concentration of 0.017888 to 0.004919 mg / kg / day, at a maximum concentration of 1.162628 to 0.319723 mg / kg / day, at an average concentration of 0.154655 to 0.042530 mg / kg /day. The risk characteristics of manganese exposure in adults with a minimum concentration were declared safe, at a maximum concentration of 56 respondents it was not safe, at an average concentration of 1 respondent was not safe. The characteristics of the risk of manganese exposure in children at a minimum concentration are declared safe, at maximum concentrations it is declared insecure, at an average concentration there is one unsafe respondent. **Conclusion**. Characteristics of the risk of manganese exposure in adults with minimal concentration are declared safe. The characteristics of the risk of manganese exposure in children at maximum concentration are not safe. The community is advised to treat clean water before consumption.

**Keywords:** Risk analysis, Manganese

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## INTRODUCTION

Manganese (Mn) is a silvery gray metal which is the first element of group VIIB metal, valence 2, 4, and 7. Manganese essential metals needed by the body. The human body contains about 10 mg of Mn and is found in the liver, bones and kidneys. Mn can help the liver function in producing urea, *superoxide dismutase,* carboxylase pyruvate, and the enzyme glyoneogenesis and helps the brain's performance along with the enzyme glutamine synthetase. Excess Mn can cause poison. Manganese with 2 valences, especially in the form of permanganate, is a strong oxidizer that can disrupt themembrane *mucous*, causing esophageal disorders. The advantages of manganese cause *"manganism",* namely Parkinson's disease, bone disorders, osteoporosis, Perthe's disease, cardiovascular disorders, liver, reproductive and mental development, hypertension, hepatitis, *posthepatic cirrhosis*, hair discoloration, obesity, skin problems, cholesterol, *neurological symptoms* and cause epilepsy.

Regulation of the Minister of Health of the Republic of Indonesia No: 416 / MENKES / PER / IX / 1990 concerning Conditions and Supervision of Water Quality determines the level of manganese in clean water, which is 0.1 mg / l. Minister of Health Regulation No. 492 of 2010 concerning the requirements for drinking water quality stipulates manganese levels in drinking water 0.4 mg / l. If manganese is found in water consumed continuously it can cause health problems such as insomnia and liver damage.

Supul village is a village which is part of the area which is an area of manganese mining (exploration). In the mining process there are stages of manganese washing. Washing manganese produces waste water left over from the waste to surrounding clean water sources used by the community. It was found that people who use clean water from dug wells and springs have health complaints. Complaints are pain such as joint pain in the ankles and hands, itching of the skin, dizziness and digestive tract disorders. The background description in the previous paragraph shows that clean water used by the community can have health risks. The purpose of this study is to find out the risk of manganese in clean water in the community of Supul Village, Kuatnana District, South Central Timor Regency.

## METHODS

This research is a descriptive study, using a survey method. The variables of this study are the levels of manganese, manganese exposure and characteristics of manganese risk. The study population was 518 people and 21 dug wells and 3 springs. The research samples were 84 people and 9 clean water facilities were taken using *purposive sampling*. Manganese levels are obtained

by doing laboratory tests. Manganese exposure is carried out by calculating the intake / intake of non-carcinogenic manganese risk agents. Risk characteristics are obtained with risk numbers (R).

Data were analyzed using analysis of environmental health risks with the following formula:

**a. Manganese Exposure**

Intake non-carcinogenic to ingestion exposure pathway

$$I_{nk} = \frac{C \times R \times Fe \times Dt}{W_b \times t_{avg}}$$

*Ik* : Amount of risk agent concentration (mg) that enters the human body with a certain body weight (kg). Unit: (mg / kg x days)

*C* : Concentration of risk agents in clean water / drinking or on food. Unit: mg / l

*R* : The rate of consumption or the amount of volume of water or the amount of weight of food entering *every* hour. Unit: liter / day (water). Value for drinking water for settlements, namely adults: 2 liters / day and children: 1 liter / day

*f*E : Length or number of days of exposure each year (day/year). Exposure to settlements: 350 days / year

*D*t : Duration of exposure, year (*real time* or projection, 30 years forvalues *default* residential)

*W*b : Weight, kg

$t_{avg}$ : Average time period (*D*tx 365 days / year for non-carcinogens)

**b. Manganese**

Characteristics of risks in non-carcinogenic effects (RQ)

$$RQ = \frac{I}{RfD}$$

*RQ* : risk number

*RfD* : reference concentration for manganese (0.14mg / l / day)

*I* : Dust intake

The level of risk is expressed in numbers or decimal numbers without units.

The risk level is said to be SAFE when intake ⩽ *RfD* or expressed by *RQ* ⩽ 1.

The risk level is said to be UNSAFE when *intake* > *RfD* or expressed by *RQ* > 1.

## RESULTS

### 1. Manganese Levels

The measurement results of manganese levels in nine clean water facilities in Supul Village can be see table 1.

**Table 1. Manganese levels in clean water in Supul Village, Timor Tengah Selatan District**

| No | Sampling Points | (mg / l) |
|---|---|---|
| 1 | A1 | 0.5583 |
| 2 | A2 | 0.2052 |
| 3 | A3 | 0.2170 |
| 4 | A4 | 0.2525 |
| 5 | C1 | 0.4262 |
| 6 | C2 | 0.4538 |
| 7 | C3 | 13.3370 |
| 8 | D1 | 0.2802 |
| 9 | D2 | 0.2368 |
| | Average | 1.7741 |

The average level of manganese in clean water in the village of Supul is 1.7741 mg / l. There are 5 samples that are not in accordance with thecardManganeseon clean water as stipulated in Minister of Health Regulation 416 / MENKES / PER / IX / 1990 concerning clean water quality standards, namely 0.4 mg / l.

**2. Manganese Exposure**

Exposure is obtained by calculating non-carcinogenic intakes through ingestion. The value of body weight *(Wb)* is a value obtained from the results of direct weighing on respondents. The results of the weighing of adult respondents with the lowest body weight 12 kg and the highest body weight 76 kg. The respondent's body weight was the lowest 11 kg and the highest body weight was 40 kg. Exposure frequency value *(fE) was* used for exposure times in settlements of 350 days. While the duration of exposure *(Dt)* has been set at 30 years for settlement. The result of the calculation as follows:

**a. Exposure to manganese for adults**

Exposure to manganese (intake) manganese predicted received by adults weighing between 11 kg to 76 kg in Desa Supul is:

1) At the minimum concentration between 0.032795 to 0.005178 mg / kg / day
2) On maximum concentration between 2.131484 to 0.336550 mg / kg / day
3) At an average concentration between 0.283534 to 0.044768 mg / kg / day.

**b. Manganese exposure in children**

estimated to be received by manganese is between 11 kg and 40 kg in Supul village through clean water as follows:

1) At a minimum concentration of 0.017888 to 0.004919 mg / kg / day,
2) at the maximum concentration is between 1.162628 to 0.319723 mg / kg / day.
3) At an average concentration between 0.154655 to 0.042530 mg / kg / day.

**3. Manganese Risk Characteristics**

Risk characteristics were obtained by calculating thevalue *RQ* for ingestion in adults and children in Supul village. The reference concentration (*RfD*) of manganese is 0.14 mg / $m^3$/ day. RQ (risk characteristics) is declared safe if it is less than one and is not safe if it is equal to or more than 1.

a. Characteristics of risk of manganese in adults

Details of risk characteristics in adults are as follows:

1) At minimum concentration (0.2052 mg / l / day stated safe.

2) At the maximum concentration (13 337 mg / l / day) there were 56 respondents are not safe.
3) On average concentration (1,774 mg / l / day) there is one respondent to the characteristics of the risk of unsafe weight 12 kg.

b. children

characteristics the risk of manganese in children weighing 11 kg to 40 kg as follows:

1) At the minimum concentration (0.2052 mg / l / day) declared safe
2) Exposure to the maximum concentration (13 337 mg / l / day) declared unsafe.
3) Exposure to average concentration (1,774 mg / l / day) there is one respondent with the characteristics of being unsafe with 11 kg body weight

**DISCUSSION**

Measurement of manganese concentration in Supul Village on average 1.7741 mg / lintake Manganese in adults with a body weight between 11 kg and 76 kg, at a minimum concentration of 0.032795 to 0.005178 mg / kg / day, at a maximum concentration of 2.131484 to 0.336550 mg / kg / day and at an average concentration of 0.283534 to 0.044768 mg / kg / day. Manganese intake in children with a body weight between 11 kg and 40 kg, at a minimum concentration of 0.017888 to 0.004919 mg / kg / day, at a maximum concentration between 1.162628 to 0.319723 mg / kg / day and at an average concentration of 0.154655 up to 0.042530 mg / kg / day. The characteristics of the risk of manganese exposure in adults weighing 12 kg to 76 kg at a minimum concentration (0.2052 mg / l / day) were declared safe, at maximum concentration (13,337 mg / l / day) there were 56 respondents not safe, at concentration on average (1,774 mg / l / day) there is 1 respondent with unsafe risk characteristics (weight 12 kg). The characteristics of the risk of manganese exposure in children with a body weight of 11 kg to 40 kg at a minimum concentration (0.2052 mg / l / day) were declared safe, at maximum concentration (13,337 mg / l / day) stated to be unsafe and at concentration on average (1,774 mg / l / day) there is one respondent with unsafe characteristics (weight 11 kg.

Manganese can be found in almost every geological layer and all water bodies such as other substances in drinking water such as Ca, Mg, Fe, Manganese elements mostly also come from their contact with soil and rock formation. According to Setiyono (2014) the content of Mn in soil in the manganese mining area contributes to increasing levels of manganese in dug well water in addition to the distance of Mn washing waste disposal adjacent to the dug wells. Regulation of the Minister of Health of the Republic of Indonesia No. 416 / MENKES / SK / IX / 90 concerning Requirements for Clean

Water quality states that the maximum manganese concentration is 0.5 mg / l. Based on this Minister of Health Regulation, then of the nine clean water facilities, there are 7 facilities whose manganese concentration is still below the maximum permissible level, while the 2 facilities of the manganese concentration exceed the permissible levels with the highest concentration reaching 13,337 mg / l.

Manganese is an essential micronutrient for all living things. Manganese plays an important role as part of the natural antioxidant enzyme superoxide dimustase, which functions to destroy free radicals. Manganese also functions in thyroid metabolism and blood sugar control (Freeland, 1987). The amount of manganese needed by the body is 3.5 - 7 mg / day for adults, is an adequate and safe daily dietary intake (Freeland-Graves, 1987). But based on a diet study in adults, WHO recommends adequate daily dietary intake of 2-3 mg / day, and doses of 8 - 9 mg / day are still safe enough to consume (WHO, 1981). There are several effects of manganese deficiencies, although very rare cases of manganese deficiency have been reported. Symptoms of manganese deficiency are temporary skin redness (Anonimous, 2010), weight loss, skin irritation, hair discoloration, and slow hair growth (Sela, 2010). In addition, people who lack manganese are also reported to be more at risk of developing diabetes, osteoporosis, rheumatism, and high cholesterol (Anonimous, 2009).

There are several effects of excess manganese on health. The advantages of manganese cause symptoms that involve disorders of the nervous system such as insomnia, weakness in the legs and facial muscles so that facial expressions become frozen and the face looks like a mask. If the exposure continues, then the speech slows down and is monotonous, running in broken directions. The symptoms that arise are similar to symptoms in Parkinson's sufferers (Slamet, 2009). Manganese also causes iron levels in the body to decrease, causing the risk of anemia, skin, heart, liver, blood vessel and brain damage. In addition, excessive manganese can prevent the absorption of copper by the body (Sela, 2010). concentrations Mngreater than 0.5 mg / l can cause a strange taste in the drink and leave the brown color in the clothes that are washed, cause liver damage and have a direct impact on the respiratory tract and brain. The symptoms of manganese poisoning are hallucinations, forgetfulness and nerve damage. When long-term manganese people become impotent, a syndrome caused by manganese has symptoms such as schizophrenia, ignorance, muscle weakness, headaches and insomnia. Disorders health which can arise due to manganese toxicity that has been studied are as follows:

a. Bleich et al. (1999) published a case report on the neurological effects that occur in adult men who ingest about 1.8 mg / kg-day of Potassium permanganate (0.62 mg Mn) for 4 weeks with a *follow-up*period of 14 years. Most of the symptoms noted are muscle stiffness, muscle pain, *hypersomnia*, increased libido, sweating, *fatigue*, and anxiety.
b. Manganese intoxication occurs in 62-year-old men who receive total parenteral nutrition containing 2.2 mg daily for 23 months (Ejima et al., 1992). This concentration is comparable to a dose of 0.023 mg Mn / kg-day for an adult weighing 70 kg. Manganese concentration from the results of the patient's blood tests increases. Patients show signs of dysarthria, mild stiffness, hypokinesia with a 'mask face', fractured*gait*, and severe postural reflex reflex reflexes, and the diagnosis of this disorder is Parkinson's. Assuming an average absorption of 5% through oral exposure, a dose of 2.2 mg Mn / day intravenously will be equivalent to *intake* oralof 40 mg Mn / day (US EPA, 1993).
c. Health problems reported by Kawamura et al. (1941) are *lethargy,* increased muscle tone, tremors, and mental disorders caused by ingestion of manganese that contaminates well water. The source of contamination is *leachate* from around 400 dry battery cells buried near drinking water wells. Of the 50 people examined, 15 people had symptoms. A total of 5 cases were categorized as severe cases, 2 moderate cases, and 8 mild cases. Most of the severe cases occur in those who are older. Young people are not very affected, and symptoms of intoxication are not found in children (ages 1 to 6 years). There were 3 deaths, one of which was a result of suicide. From the results of the autopsy, the manganese concentration in the brain of one of the deceased patients was found to be 2 to 3 times higher than the concentration measured in the other 2 autopsy controls. Striking macroscopic and microscopic changes are seen in brain tissue, especially in the globus pallidus region.

An study was epedemiological identified to look for links between high exposure to manganese by oral and the incidence of neurotoxicity in children. Neurological side effects characterized by decreased learning ability in schools have been reported in children aged 11-13 years who are exposed to excessive manganese concentrations through ingestion of contaminated drinking water and consuming foods made from wheat plants watered with dirty water (Zhang et al., 1995). In risk analysis, weight will affect the value of the risk and theoretically the more a person's weight, the less likely it is to risk health problems. From the data it can be seen that the results of the study in

accordance with the large mathematical calculations of RQ will be inversely proportional to body weight, meaning that the smaller a person's weight, the greater the risk (RQ) of the individual. Because of theunsafe risk ofmanganese exposure, risk management is necessary. Risk management can be done by determining safe concentration and determining the amount of safe intake.

levels Manganese (Mn)in the environment increase with increasing human and industrial activity, Manganese sourced from human activities can enter the water, soil, air and environment. According to the research of Nisaul Makhmudah and Suprihanto Notodarmojo using a two-level slow sand filtering method for decreasing Manganese levels in river water flow in the Cikapundung area. Manganese content in raw water before processing, ranges from 0.14 - 1.6 mg / l. After processing using slow sand filters, the level of manganese in water has decreased, which ranges between 0.012-0.228 mg / l. The efficiency of manganese removal by the reactor ranged from 89.3%. Manganese in water can be found in the form of Mn2 + (bivalent manganese) and Mn4 + (quadrivalent manganese). Manganese with high valence is difficult to dissolve in water, while the two-valent manganese has the properties of being easily soluble in water and unstable when meeting oxygen (easily oxidized). So it is recommended for people to do simple water treatment using one method, namely slow sand filters, especially water in springs in Hamlet C and wells that are related to color, taste, smell and levels of Manganese. The concentration of manganese can be reduced by processing clean water before use. Results Research from Eko Hartini in 2012 In theirrigation well in the Central Kalimantan Kumai Hilir Village, showing use *the cascade aerator* gives better results in reducing the level of Mn dug water with an average of 0.02 mg / l, in accordance with the quality standard with an effectiveness of 98.74%. *Bubble aerator* can reduce the level of Mn of dug well water with an average of 0.43 mg / l, and the effectiveness of 76.47%.

**CONCLUSIONS AND SUGGESTION**

The average level of manganese in clean water in Supul Village is 1.7741 mg / l. Manganese exposure in adults weighs between 11 kg and 76 kg, at a minimum concentration of 0.032795 to 0.005178 mg / kg / day, at a maximum concentration of 2.131484 to 0.336550 mg / kg / day and at an average concentration of 0.283534 to 0.044768 mg / kg / day. Manganese exposure in children weighing between 11 kg and 40 kg, at a minimum concentration of 0.017888 to 0.004919 mg / kg / day, at maximum concentrations between 1.162628 to 0.319723 mg / kg / day and at an average concentration of 0.154655 up to 0.042530 mg / kg / day. The risk characteristics of manganese exposure in

adults with a minimum concentration (0.2052 mg / l / day) with a body weight of 12 kg to 76 kg were declared safe. Manganese risk characteristics at maximum concentration (13,337 mg / l / day) there were 56 unsafe respondents weighing between 11 kg and 54 kg. At an average concentration (1,774 mg / l / day) there is 1 respondent with risk characteristics that are unsafe with a weight of 12 kg. The risk characteristics of manganese exposure in children with a body weight of 11 kg to 40 kg at a minimum concentration (0.2052 mg / l / day) were declared safe, exposure to maximum concentration (13,337 mg / l / day) was declared unsafe. Manganese risk characteristics at an average concentration (1,774 mg / l / day) there was one respondent with a characteristic of being unsafe with a weight of 11 kg.

For people not to consume clean water that comes from facilities that contain more levels of manganese than the standard, namely C3 clean water facilities in village C, Supul village. If you continue to consume, it is recommended that the water is first processed to reduce the levels of manganese, one of which is by using a slow sand filter. For the government of Supul Village to be able to provide information about water conditions and impacts on the community so that there is an awareness of using clean water that meets health requirements.

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