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Mercury pollution on district of Dimembe river system, North Sulawesi, Indonesia, due to traditional gold mining activities

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ABSTRACT. Mercury contamination caused by the amalgamation of gold in small scale gold mining is a environmental problem. Small-scale gold mining (SSGM) is common in mineral-endowed developing countries. It offers an important means of livehood and has served as a safety net in times of natural calamities or economic distress. In north Sulawesi Province alone, approximately 22,000 small-scale gold miners were active in 1998, and produced an estimated 10 tonnes of gold bullion. Activities of traditional / illegal gold mining (PETI) in Dimembe of district, which is located in Minahasa Regency, North Sulawesi Province. The major environmental concern associated with PETI in mercury pollution from processing of gold-bearing ore. In both the inorganic and organic forms, mercury is one of the most toxic substances to humans. One of the environmental pollution is water pollution on district of Dimembe river system that is probably caused by the use of mercury (Hg) in processing mine ore. This mercury is used in an iron rolling vessel, which is called tromol. Mercury concentration employed in this operation reaches 1 kg out of 30 kg ore. Sampling stage was conducted at Warat river, downstream Talawaan river, Merut river and Kadumut river on late April 2002 by BAPEDALDA team together with Health Laboratory staff. Material which were sampled was water.Sampling methods carried out were bottle sample immersed about 10 cm below the water surface. The analysis method used was mercury analyzer. The analysis result show that total concentration of mercury range from 1.69 to 25.54 ppb. This concentration is closed to Water Quality Standard IV Class that is 0.005 mg/L (Regulation Government No. 82/2001). The result of this research indicate that the district of Dimembe river system in the gold mining area have been contaminated by mercury.

1. INTRODUCTION

Small Scale Gold Mining (SSGM) is common in mineral endowed developing countries. It allows local communities to participate directly in the exploitation of their indigenous mineral resources. Small scale mining operations are labour intensive and engage large numbers of both men and women, over six million world wide by one estimate (Bugnosen 1998).

Many of these countries face enormous environmental and social problem, as a result or poor mining practices and lack of economic alternatives (sigit 1999). In North Sulawesi alone, approximately 22,000 small scale gold miners were active in 1998, and produced an estimated 10 tonnes of gold bullion (Polii 1998).

Mining activities in the District of Dimembe area began in 1998 when information leaked out regarding the findings of the 1997 exploration of PT. Tambang Tondano Nusajaya. There are many gold mining activities an Dimembe system rivers, North Sulawesi Province and almost all cases, especially for small scale firms are illegal. The district of Dimembe mining region encompases five villages : Wasian, Tatelu Rondor, Tatelu, Warukapas and Talawaan. Traditionally agriculture is the main livelihood, however since 1999 some people have also become involved in gold mining and processing. Today it is estimated that there are about 10,000 people within this area who are directly involved in small scale mining and processing activities. More of these people have come from other regions to seej their fortunes in the gold mines. Processing plant are located within villages, near dryland, rice fields, rice paddies, fish ponds and other agricultural lands.

The mining process is as follows ; the first step is to crush the ore which reduce (by about one half) the processing time in the mills. This is usually done by hand using a hammer and a large rock as a platform. A few prcess plants now use a home built crusher to replace manual labour. Approximately 30 to 40 kg of crushed run of mine ore, water, mercury (1 kg or more, depending on mill size) and balls (hard lava rocks) are loaded into the ball mill (a metal drum) and rotated for 3 to 4 hours to break down the ore to a find sand and release the gold and other precious metals.

Mercury is added and the mills rotated for another one half hour for amalgamation of the gold with mercury. The entire contents of the mill are then dumped into a large tub where through the process of panning, the (tailings) sand and water are separated from the amalgamated mercury. The mercury is separated from the amalgam by filtering, example; forcing the mercury through a fine woven cloth (parachute cloth is best) by twisting the cloth. The residu which remain in the cloth, the mercury / gold amalgam is roasted to vaporize the mercury, leaving glod bullion.

Mercury vapors in the processing may reach level a high as 960 ug/m^3 at the time of roating and take several hours to completely dissipate (Selinawati 1998). Finally, it will fall on accumulate on water river.

2. MATERIAL AND METHODS

2.1 Water Samples

Water samples were collected from five station in the district of Dimembe system rivers : Warat river, Talawaan river, Merut river dan Kadumut river on April 25, 2002. Water sampling points are presented in Figure 1.

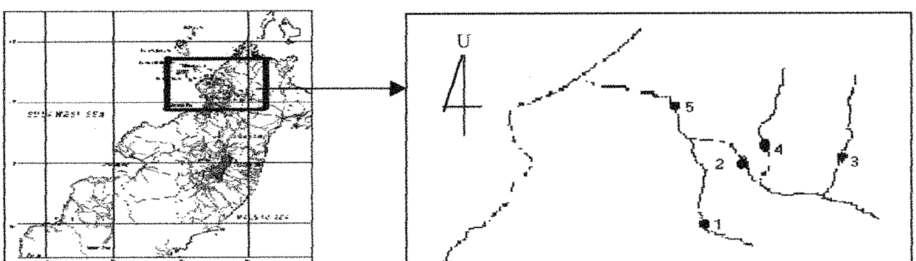

Figure 1. Water Sampling Points

Water samples were collected the main stream of each sampling site. A 250 cc bottle sample is immersed about 10 cm below the water surface, then it cap is opened for one to two minutes to allow the water overflow to ensure the elimination of air bubbles. In the bottle add drop by drop HNO_3 to pH < 2 for acidified. Water sample were place in icebox and covered with ice during the transportation to the laboratory. Sample were kept in a cooling room at < 4 °C and analyzed immediately. Field data sheet can be shown in Table 1.

Tabel 1. Field Data Sheet of Surface Water Sample

Sampling site / Para Meters	No.1 Warat river	No.2 Talawaan river (upstream)	No.3 Merut river	No.4 Kadumut river	No.5 Talawaan river (downstream)
Suhu Udara (^0C)	29.8	27.4	26.9	26.9	28
Suhu Air (^0C)	27.4	27.1	27.2	27.6	29.9
PH	7.58	6.5	6.5	6.4	5.55
Turbidity (mg/L)	83	137	132	150	114
TDS (mg/L)	63.3	67.2	66.5	47.2	63.3
DO (mg/L)	4.4	7.4	6.5	0.6	5.3

2.2 Sample Treatment and Analytical Determination

The total concentration of mercury (total mercury) was measured using the method proposes by Method Sandard National Indonesia (SNI) 06-2462-1991.
Water sample 100 mL was poured to a 250 mL labu Erlenmeyer. Added 5 mL H_2SO_4 and 2.5 mL HNO_3, then added 15 mL of 5 % potassium permanganate solution. Sample solutin allowed to stand for 15 minutes. 8 mL of potassium peroxodisulfate (5%) was added and labu Erlenmeyer was heated for 2 hours at 95 ^0C using water bath. Sample was allowed to stand until room temperature and hydroxylamine hydrochloride was added until purple color disappeared. Sample was water to make a final volume of 100 mL. Concentration of mercury from sample solution was determined with AAS (Aotomatic Hg Analyzer).

3. RESULT AND DISCUSSION.

Total mercury concentration measured in water of the district Dimembe rivers system varied from 1.69 to 25.54 ppb. The maximum values were measured in the Talawaan river up stream (Tatelu Villages) with concentration 25.54 ppb. Total mercury concentration in water are indicated figure 2.

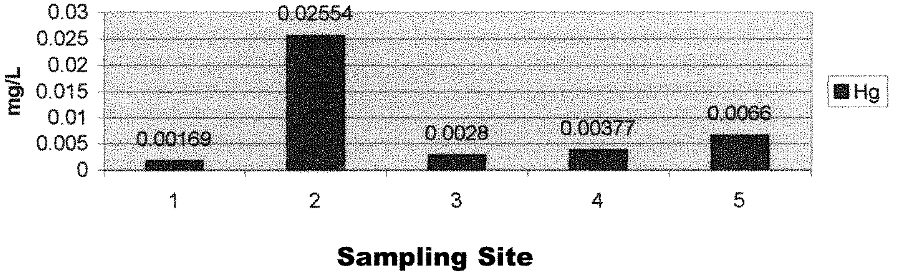

Figure 2. Result of total mercury analysis in water.

Sampling point no. 2 (Talawaan river upstream at Tatelu village) indicated the value of 25.54 ppb is contact beetwen Kadumut river and Merut river and then declined at the one sampling location (Talawaan river downstream at Talawaan village) to 6.60 ppb.

The highest concentration of mercury on this water to indicated will be strong contribution SSGM activities to mercury poluttion in water and because run of mine ore attached with clay, which in process amalgamation mercury attached in particles clay, so that to suspended in waters. Mercury is rapidly attached to suspended soil particles and organic matter where it can be rapidly converted into an organic form and bioacumulated. Mercury concentration in water is thus a strong indicator of aquatic contamination.

Result of total mercury analysis in water to do compare with Indonesian Government Regulation No. 82/2001 to show that concentration of mercury in area study is fill to use as besides water drinking (0.005 ppm), except to location no. 2 (0.2554 ppm) dan location no. 5 (0.0066 ppm) had more standard Indonesia Government Regulation.

4. CONCLUSIONS

From the data presented in this report, the following conclusions may be drawn and subjected to further consideration.

1. The district of Dimembe river system in the gold mining area have been contaminated by mercury.
2. Total mercury concentration in distric Dimembe rivers system, North Sulawesi Province, Indonesia were not so severe campared to Tapajos, Amazon, Brazil (Akagi H et al 1995) and Minamata Disese in Minamata (Sumio A 1970) ad Niigata (Niigata Prefectural Reseach Laboratory For Health and Environment 1995) in Japan.

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