

ABSTRACT

Background: Small scale gold-mining (SSGM) in Krueng Sabee, Aceh Jaya, Aceh Province, has damaged the surrounding environment and population health. The mercury used by gold amalgamation has an adverse effect on the atmosphere, river water and biota, and people residing in the vicinity. Acute and chronic mercury intoxication symptoms resembling Minamata disease were present. Unprotected gold miners were especially affected by the amalgamation process.

Objective: To investigate the extend of mercury contamination in environment and human by SSGM activity in the Krueng Sabee Subdistrict, Aceh Jaya District, Aceh Province.

Methods: A cross sectional survey was conducted in four villages of the Krueng Sabee Subdistrict during August 2013-April 2014. Seventy two respondents, aged 15–65, were randomly selected from a total population of 1531 of the four villages: 17 of Curek, 26 of Paya Seumantok, 17 of Panggong, and 12 of Panton Makmur. A structured questionnaire was used to interview the respondents regarding work, residence, length of stay in Krueng Sabee, type of work in the gold mining process, length of contact with the amalgamation procedure and symptoms. Mercury concentrations were determined by means of: (a) the Cold Vapor AAS for river water, well water, tap water, fish, mussels and shrimp samples; and, (b) the Coupled Plasma Mass Spectrometry for respondent head hair samples. Data were analyzed by using analisis of variance (anova), independent sample t-test, and one sample t-test. A prediction model was constructed through multiple linear regression analysis. ArchGIS version 10.2. was used to process spatial data.

Results: Laboratory test results revealed the following mercury concentrations: 0.057 µg/L in river water and 0.237 µg/L in well water. No mercury was detected in tap water. The highest mercury concentration in biota was in fish (*Puntius latristriga* – 172.299 ± 10.626 µg/g), followed by mussel (*Polymesoda caroliniana* – 160.032 ± 0.522 µg/g) and shrimps (*Penaeus monodon* – 116.975 ± 4.807 µg/g). The average village mercury concentrations in respondent head hair samples were: in Curek 11.23 ± 4,02 µg/g, in Panggong 35.12 ± 13,38 µg/g, in Panton Makmur 42.05 ± 10,03 µg/g, and in Paya Seumantok 48.32 ± 22,29 µg/g. SSGM activity risk factors that were correlated with respondent's head hair mercury concentrations were location of residence, river bathing, inhaling amalgam combustion gas, and using protective work wear (respiratory protective equipment, gloves and apparel). Acute and chronic health symptoms related to mercury intoxication were detected in respondents. The most frequent acute and chronic symptoms were headache, muscle cramps, fatigue, cough and aphthous ulcers. Based on the prediction model, constructed by means of a multiple linear regression analysis, 45,8% of the head hair mercury concentration can be predicted by the risk factors: type of work, village location, length of stay, role in the mining process, and length of contact with amalgamation combustion. Geospatial analysis identified cluster of high mercury concentration

Conclusion: Mercury concentrations of river, well, and tap water did not exceed the government 1 ppb threshold level (Regulation No 82/2001), of biota exceeded 0,5 ppm threshold level set by the MoH Food & Drug Administration 1989, and of

head hair exceeded the WHO stipulated 10 $\mu\text{g/g}$ threshold level. The major risk factors of head hair mercury concentration were personal characteristic of respondents and gold miners, risk factors generated from respondents and gold miners. A predictive model was constructed to measure head hair mercury concentration in the respondents. Pathways of mercury exposure in human influenced by multivariate factors. The geospatial analysis could be used as an analysis of the distribution of mercury in community as the result of SSGM activity.

Keywords: mercury contamination, mercury intoxication, small-scale gold mining, gold miners, risk factors

ABSTRAK

Latar Belakang: Kegiatan penambangan emas skala kecil (PESK) yang dilakukan di Krueng Sabee, Aceh Jaya, Provinsi Aceh telah merusak tatanan lingkungan dan kesehatan masyarakat disekitarnya. Proses pengolahan emas secara amalgamasi menggunakan merkuri menyebabkan efek buruk terhadap udara, air dan biota sungai, dan masyarakat yang tinggal di sekitarnya. Keluhan gangguan toksisitas akut dan toksisitas kronik merkuri didapati menyerupai kejadian penyakit Minamata. Pekerja yang tidak menggunakan alat pelindung diri akan mendapatkan dampak buruk bagi kesehatan mereka dari kegiatan amalgamasi ini.

Tujuan: Meneliti tingkat kontaminasi merkuri di lingkungan dan di masyarakat dari kegiatan penambangan emas skala kecil di wilayah Kecamatan Krueng Sabee Kabupaten Aceh Jaya, Provinsi Aceh

Metode: Rancangan *cross sectional survey* di empat desa kecamatan Krueng Sabee pada bulan Agustus 2013-April 2014. Sebanyak 72 responden, umur 15-65 tahun, dipilih secara acak dari total 1531 penduduk di empat desa: 17 dari Curek, 26 dari Paya Seumantok, 17 dari Panggong, dan 12 dari Panton Makmur. Kuesioner terstruktur digunakan saat wawancara dengan responden terkait kerja, lokasi tinggal, lama tinggal di Krueng Sabee, status pekerjaan dalam proses penambangan emas, lama paparan dengan kegiatan pengolahan emas, dan gangguan keluhan kesehatan. Kadar merkuri diukur dengan: (a) *Cold Vapor AAS* untuk jenis sampel air sungai, air sumur, air PDAM, ikan, kerang dan udang; dan, (b) *Coupled Plasma Mass Spectrometry* untuk jenis sampel rambut kepala responden. Data dianalisis menggunakan analisis varian (anava), *t-test* sampel bebas, *t-test* satu sampel. Model prediksi dihasilkan dengan analisis regresi linier berganda. Data spasial diolah menggunakan ArchGIS versi 10.2.

Hasil: Hasil penelitian laboratorium menunjukkan kadar merkuri: 0,057 µg/L pada air sungai dan 0,237 µg/L pada air sumur. Merkuri tidak terdeteksi pada air PDAM. Kadar merkuri tertinggi pada biota adalah di ikan (*Puntius latristriga* - 172,299 ± 10,626 µg/g), diikuti kerang (*Polymesoda caroliniana* - 160,032 ± 0,522 µg/g), dan udang (*Penaeus monodon* - 116,975 ± 4,807 µg/g). Rerata kadar merkuri rambut kepala responden adalah: di Curek 11,23 ± 4,02 µg/g, di Panggong 35,12 ± 13,38 µg/g, di Panton Makmur 42,05 ± 10,03 µg/g, dan di Paya Seumantok 48,32 ± 22,29 µg/g. Faktor-faktor risiko aktivitas PESK yang menunjukkan ada hubungan dengan kadar merkuri pada rambut kepala responden adalah lokasi tempat tinggal, kebiasaan mandi di sungai, kegiatan menghirup asap pembakaran amalgam, dan pemakaian alat pelindung kerja (alat pelindung pernafasan, tangan dan pakaian pelindung). Keluhan gangguan kesehatan akut dan kronik akibat toksisitas merkuri telah terdeteksi pada responden. Keluhan gangguan kesehatan akut dan kronik yang paling sering dikeluhkan adalah nyeri kepala, kram otot, mudah lelah, batuk, dan sariawan. Berdasarkan model prediksi dari analisis regresi linier berganda, 45,8% kadar merkuri pada rambut kepala dapat diprediksikan dari faktor-faktor risiko: status bekerja di Krueng Sabee, lokasi desa, lama tinggal, status pekerja tambang, dan lama penggunaan pembakar amalgam. Analisis geospasial menunjukkan terjadi pengelompokan kadar merkuri yang sudah tinggi.

Kesimpulan: Kadar merkuri pada air sungai, sumur, dan air PDAM tidak melebihi nilai ambang batas 1 ppb (Peraturan Pemerintah No 82 /2001), pada biota sudah melebihi nilai ambang batas 0,5 ppm dari Direktorat Jenderal Pengawasan Obat dan

Makanan Departemen Kesehatan RI tahun 1989, dan pada rambut kepala sudah melebihi kadar $10 \mu\text{g/g}$ yang ditetapkan *World Health Organization* (WHO). Faktor-faktor risiko yang memengaruhi kadar merkuri pada responden adalah faktor risiko dari karakteristik responden dan pekerja tambang, faktor-faktor risiko dari masyarakat dan pekerja tambang. Didapatkan model prediksi untuk memperkirakan faktor-faktor risiko yang memengaruhi kadar merkuri di rambut kepala responden di wilayah Krueng Sabee. Jalur masuk merkuri ke manusia dipengaruhi banyak faktor dari sumber paparan. Analisis geospasial dapat dipakai untuk analisis sebaran merkuri di masyarakat akibat aktivitas PESK.

Kata kunci: kontaminasi merkuri, keracunan merkuri, penambangan emas skala kecil, pekerja tambang, faktor risiko