

Determination of Lead Accumulation in Livers and Feces of Kacang Goats Grazing Tsunami Affected Land

(Penentuan akumulasi timbal (Pb) dalam hati kambing kacang di daerah tsunami)

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ABSTRACT Tujuan dari penelitian ini adalah untuk mendeteksi akumulasi timbal pada hati dan feces kambing Kacang dan sekaligus mengukur kadar akumulasi timbal tersebut. Limabelas ekor kambing Kacang yang berasal dari rumah potong di daerah Tsunami dan limabelas ekor kambing Kacang yang berasal dari rumah potong di daerah Non-Tsunami. Diikuti dengan lima ekor kambing Kacang dari desa di daerah Tsunami dan lima ekor kambing Kacang dari desa di daerah Non-Tsunami. Ke-empatpuluh ekor kambing Kacang tersebut disembelih untuk diambil hati dan feces. Sebelum hati dan Feces tersebut akan dipreparasi untuk

analisis akumulasi dari Timbal, dilakukan pengamatan anatomi dari hati dan feces tersebut. Timbal berakumulasi dihati dan feces dari kambing Kacang, baik yang berasal dari daerah Tsunami dan dari daerah Non-Tsunami. Akumulasi Timbal didalam hati kambing Kacang lebih signifikan tinggi di daerah Non-Tsunami dibandingkan didalam hati kambing Kacang di daerah Tsunami. Sedangkan akumulasi Timbal didalam feces kambing Kacang lebih signifikan tinggi di daerah Tsunami dibandingkan didalam feces kambing Kacang di daerah Non-Tsunami.

Kata Kunci: kambing kacang, timbal, tsunami, non-tsunami.

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INTRODUCTION

After a large earthquake in the sea West of Sumatra which measured 9.1 on the Richter Scales on December 26th, 2004 a Tsunami in three waves with the highest as high as coconut trees flooded large parts of Nanggroe Aceh Darussalam Province. In the Province of Nanggroe Aceh Darussalam 97714 km² were flooded. The earthquake and Tsunami disaster caused the death of many people, much lost material and large areas were damaged.

The Tsunami flooded the area around Banda Aceh and Aceh Besar land was polluted with several heavy metals and other poisonous materials. Among these are cadmium, lead, cuprum, cobalt, ferrum, manganese, nickel, zinc, boron and arsenic (Tim Riset Walhi Daerah Istimewa Yogyakarta and Walhi Nanggroe Aceh Darussalam, 2006). The contamination of potentially harmful heavy metals and other dangerous material

creates a problem for the land use in Banda Aceh and Aceh Besar. The most dangerous of those heavy metals and non metals in the food chain are lead, cadmium and arsenic. The average contamination with lead, cadmium and arsenic measured in the soil and plant material in Banda Aceh and Aceh Besar is shown in Table 1.

This contamination may have a negative effect on livestock through their grazing and drinking on the Tsunami affected land. One of the most important livestock species in Banda Aceh and Aceh Besar is the Kacang goat. Acehnese people prefer to consume Kacang goat meat, liver and brain in their meals, and Kacang goat's feces is used as organic fertilizer for crops. However, Kacang goats kept in the Tsunami area can be contaminated by lead, cadmium and arsenic. The poisons may be accumulated in their livers or excreted with the feces. This may also may have a dangerous effect on the food chain and pose a threat to human health. Therefore, the Kacang goat was chosen as experimental livestock, Banda Aceh and Aceh Besar as

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sample areas and lead, cadmium and arsenic as research objects.

Table 1. Average contamination in mg kg⁻¹ with lead, cadmium and arsenic in soil and plant in Banda Aceh and Aceh Besar areas Tsunami affected land

Item	Lead	Cadmium	Arsenic
(mg kg ⁻¹)			
Soil	17.0	10.0	5.0
Plant	4.9	10.9	19.5

Source: Tim Riset Walhi Daerah Istimewa Yogyakarta and Walhi Nanggroe Aceh Darussalam

Objectives

The objective of the present study was to determine lead concentration accumulated in Kacang goat's liver and feces, thereby distinguishing between Tsunami-affected and non-affected areas.

Materials and Methods

The research was conducted from August 2007 until November 2007 in Banda Aceh and Aceh Besar, Nanggroe Aceh Darussalam (NAD) province, Sumatra, Indonesia and from December 2007 until January 2008 in Bogor, West Java, Indonesia. The coastal and low areas of NAD province were affected by the Tsunami in 2004 whereas higher areas were unaffected. Two areas were selected for investigating heavy metal contamination in goats:

- Goats from Tsunami affected areas (Ts-Goats) originated from the villages Ulhelheu and Darussalam near Banda Aceh.
- Goats from areas not affected by the Tsunami (NTs-goats) originated from the villages Sibreh and Blangbintang in Aceh Besar district.

The villages in the Tsunami area were selected because in those two villages still a considerable number of goats were kept. A similar village structure with a slaughterhouse was sought in the Non-Tsunami area.

3.2 Selection of animals

A total of 40 Kacang goats were selected for sampling, 20 from the Tsunami affected area and 20 from the Non-Tsunami affected area. Goats were partly selected at the slaughterhouse and partly in the villages.

3.2.1 Selection at the slaughterhouses

The farmers generally bring their goats to the slaughterhouse in the evening. They start to slaughter the goats at 6:00 am the next morning. At the days the slaughterhouse in Banda Aceh was visited, 10 to 15 goats were brought to the slaughterhouse but only one to two per day from Ulhelheu village (Tsunami area) and Sibreh village (Non-Tsunami area). In the evening before slaughter, healthy male or female goats of Kacang breed of approximately two years of age were selected for the survey. After the goats were selected they were kept in a separate room overnight. The goats were fed grass in the evening at the slaughterhouse. After the selection of the goats, the farmers who brought the goats were interviewed. At the slaughterhouse, a total of 30 goats were selected, 15 being Ts-goats and 15 NTs-goats.

Interviews of farmers

A short formal interview was done with the owners of the goats. Interviews were done one day before slaughter of the goat in the slaughterhouse, whereas interviews were done on the day of slaughter of the goats in the village. Questions were asked about breed, sex, age and weight of the goats and the answers were compared to own observations. Further, questions were asked about feeding, especially feeding during the last three days and the place of grazing in Banda Aceh and Aceh Besar.

Sampling of livers and feces

After the goats were slaughtered, the liver was cut from the abdomen and kept in a tray. The rectum was cut off from the intestine and anus. Fresh feces were pressed out of the rectum in another tray.

Visual inspections

The anatomical condition of the liver and the visual appearance of the feces were examined immediately after slaughtering. The following parameters were recorded: fresh weight, color, consistency, condition, and for feces also smell. It was further recorded if visible parasites were present. Then the liver was put in a plastic bag, sealed and brought to the Histology Laboratory at the Veterinary Faculty, Syiah Kuala University, Banda Aceh, and kept in frozen at -20°C until chemical analysis. The feces samples were placed in a paper envelope and left in the sun for drying. After they were dry they were kept at room temperature until further analysis.

Preparation of liver and feces for lead, cadmium and arsenic analysis

The preparation of samples for lead analysis was done at the Microbiology Laboratory at the Veterinary Faculty, Syiah Kuala University, Banda Aceh. The liver samples were thawed, excised, rinsed with deionized water, blotted dry, and weighed. Then the samples were autoclaved at 120 °C for 1.5 hours. After that each sample was blended into a homogenous paste and placed into a paper envelope. The envelopes with the homogenous paste were dried in an oven at 70 °C for 24 hours and weighed again. The dry feces samples were weighed and also blended to a powder and weighed again. All powdered liver and feces samples were kept in paper envelopes (Peters, 2003). All the paper envelopes were kept at the Histology Laboratory at the Veterinary Faculty, Syiah Kuala University, Banda Aceh until further analysis in Bogor.

Lead analysis

The chemical analyses were conducted at the Soil Research Institute in Bogor, West Java. For the analyses of lead concentrations, the liver and feces samples were wet-ashed using a nitric acid and perchloric acid mixture.

A 1 g sub sample of the liver powder or ground feces was placed in a digestion tube, added 5 ml HNO₃ and 1 ml HClO₄ and then kept for 12 hours. After that, the mixture was heated at 100 °C for 1 hour 30 minutes. Then

the temperature was increased to 130 °C for 1 hour, and then further increased to 150 °C for 2 hours 30 minutes (until the yellow fume had disappeared). After this, the temperature was increased to 170 °C for at least 1 hour and then to 200 °C for 1 hour until about 1 ml of white fume was formed. The solution was left to cool down at room temperature after which it was diluted with 10 ml deionized water and then homogenized (Balai Penelitian Tanah, 2005).

After the wet-ashing lead concentrations in mg kg⁻¹ (ppm) in the pure solution were determined by Atomic Absorption Spectrometer (AAS) against standards of 1 ppm Pb (Titrisol) (Balai Penelitian Tanah, 2005).

Data processing and analysis

Lead, cadmium and arsenic concentration in liver and feces were analyzed statistically using SAS and CSTAT. The results were expressed as mean and standard deviation. The statistic model used was General Linear Model (ANOVA) for test of significant differences between the two treatments (influences of the x variables).

Results

Goat husbandry in the study area

Among the selected goats there were 75% female and 25% male for both Tsunami and Non Tsunami areas. The average weight was 20.4±3.72 kg for Kacang goats in Tsunami areas and 20.9±3.25 kg for Kacang goats in Non Tsunami areas. There were 80% black, 10% brown and 10% white goats.

The interviewed farmers informed that the two major feeding systems used in Kacang goat husbandry in Banda Aceh and Aceh Besar are the cut and carry and the grazing systems. Drinking sources are wells and surface water. Basic grass in the lowland area was *Paspalum vaginatum* which was supplemented with *Leucaena leucocephala* and *Glyricidia sepium*.

Visual assessments of liver and feces

Liver

The general condition of the livers appeared normal with the color dark reddish-brown and an elastic consistency.

Feces

The general condition of the feces samples was normal with dark green color and a solid consistency.

Lead concentrations in livers

Lead concentrations in the goat's livers from Non-Tsunami areas and Tsunami areas are shown in Table 2. Lead concentrations in the goats' livers from Non-Tsunami areas were significantly higher than in samples from Tsunami areas.

Table 2. Elements in liver (mg kg⁻¹ fresh matter) according to survey place

Element	NTs - Goats	Ts - goats
Lead	0.16 ^a ± 0.07	0.07 ^b ± 0.05

Different superscripts (a, b) in a row denote a significant difference at P<0.05.

The livers of goats fed on *Gliricida sepium* & *Paspalum vaginatum* contained significantly higher lead concentrations than livers from goats fed on *Leucaena leucocephala* & *Paspalum vaginatum* or on *Leucaena leucocephala*, *Gliricida sepium* & *Paspalum vaginatum* (Table 3).

Table 3. Elements in liver (mg kg⁻¹ fresh matter) according to feed

Element	L.l & P.v*	G.s & P.v*	L.l, G.s & P.v*	n.f.*
Lead	0.15 ^a ± 0.11	0.17 ^a ± 0.05	0.09 ^b ± 0.08	0.09 ^b ± 0.05

*: L.l.: *Leucaena leucocephala*, P.v.: *Paspalum vaginatum*, G.s.: *Glyricidia sepium*, n.f.: not fixed;

Different superscripts (a, b) in a row denote a significant difference at P<0.05.

Lead concentrations in feces

Lead concentration in the goats' feces in Tsunami areas was significantly higher than in Non-Tsunami areas (Table 4).

Table 4. Elements in feces (mg kg⁻¹ fresh matter) according to survey place

Element	NTs - Goats	Ts - goats
Lead	0.36 ^b ± 0.36	1.05 ^a ± 0.53

Different superscripts (a, b) in a row denote a significant difference at P<0.05.

There were no significant differences in lead (Table 5).

Table 5. Elements in feces (mg kg⁻¹ fresh matter) according to feed

Element	L.l & P.v*	G.s & P.v*	L.l, G.s & P.v*	n.f*
Lead	0.96 ± 0.91	0.57 ± 0.61	0.72 ± 0.37	0.67 ± 0.51

*: L.l.: *Leucaena leucocephala*, P.v.: *Paspalum vaginatum*, G.s.: *Glyricidia sepium*, n.f.: not fixed;

Correlation of concentrations in liver and feces

Table 6 shows the correlation of lead concentrations in livers with those in feces. The correlation is not high. In other words, there is no correlation between concentrations of lead in livers with those in feces.

Table 6. Regression coefficient from the linear regression between element concentrations in livers and in feces

Element	r ²
Lead	0.09

Correlation value (r² > 0.3) indicates a tendency for correlation; correlation value (r² > 0.5) indicates a tighter or tight correlation .

Discussions

Kacang goats in the study area

According to the interview in my study area, commonly Kacang goat husbandry is a grazing system in Banda Aceh and Aceh Besar. The farmers practice the cut and carry system if they have to go somewhere for a long time. Water sources for Kacang goats are wells and surface water. The farmers offer water from wells to Kacang goats they live far from natural source water. If farms are located close to natural water resources, Kacang goats find water for drinking by themselves. The common forage for Kacang goats is *Paspalum vaginatum* (field grass = rumput lapang). *Leucaena leucocephala* and *Gliricidia sepium* serve as forage supplement only. Farmers were giving both of these plants for three or four days in a week.

In my study region Kacang goats' livers were anatomical normal although Kacang goats have been contaminated with lead. The observation results are affected by the survey place and forage for lead. These values are lower than references from Radostits *et al.* (1994) according to whom the tolerance of lead concentration is > 4.5 mg kg⁻¹.

Lead concentration in Non-Tsunami and Tsunami areas

The data presented in Table 1 indicate that the average concentrations of lead in liver samples of Kacang goats were high in Non-Tsunami rural areas. On the other hand, Table 13 shows that the average concentrations of lead in feces samples of Kacang goats are high in Tsunami rural areas. In Non-Tsunami and Tsunami rural areas the results of lead concentration of the livers of goats were compared with the threshold values (Radostits *et al.* 1994). According to this reference, the lead concentration in livers was very small in the present study. In the study region, Kacang goats were not affected by lead poisoning. However, this contamination of the liver can pose a threat to human health because one of the famous foods is the liver of Kacang goats, which is consumed as a meal by the Acehnese people every day. According to WHO database (2006), the maximum lead concentration in food is 0.1 mg kg^{-1} . With regard to this limit, the lead concentration in liver was very high in the study areas. So, goat liver consumption might be very dangerous to human health in the study area. Lead concentrations in Kacang goats feces in the present study were compared to international lead concentrations in soils. Based on Tim Riset Walhi Daerah Istimewa Yogyakarta and Walhi Nanggroe Aceh Darussalam (2006), the maximum tolerable lead concentration in soil is 100 mg kg^{-1} . With regard to this limit, the lead concentration in feces was lower in the study areas. Beside this, in soil the lead concentration is a hazard for agricultural land. In Banda Aceh and Aceh Besar, Kacang goats' feces are commonly used as organic fertilizer. The lead contamination will thus be maintained through regular recycling of dung to agriculture areas. It has been documented by Rahmawati (2008) that by the addition of manure rice straw reached lead concentrations of 14.88 mg kg^{-1} in Tsunami rural areas and water spinach reached lead concentrations of 0.022 mg kg^{-1} in Tsunami rural areas.

The current data show that the lead concentrations in Kacang goat livers in Non-Tsunami rural areas were higher compared to

those around 0.08 mg kg^{-1} detected in the Egyptian rural areas (Abou-Arab, 2001). In addition, Abou-Arab (2001) annotated that in rural areas Pb concentrations were found in livers of cattle and buffalo because of heavy metal pollution from the environment. Conversely to lead concentration in liver, lead concentration in feces of Kacang goats from Tsunami areas is higher than lead concentrations in the liver of Kacang goats in Non-Tsunami areas. These results could be confirmed. It is clearly showed that Non-Tsunami rural areas and Tsunami rural areas have contamination with lead. Most lead contamination of the Kacang goats is probably due to the soil and forage consuming by grazing, drinking and by inhalation in Non-Tsunami and Tsunami contamination rural areas. The contamination of lead to the forage, water source and environment were largely due to the automotive exhaust fumes, erosive weathering of Pb-base paints from the outer walls of buildings or houses, old batteries, paint tins, garages, metal workshop and dispersal of sewage sludge and waste. The lead contamination was largely due to forage and water by soil distribution. The atmospheric deposition is probably due to the toxic air. The toxic air could be poisoning the leaves of forage and respiration air of goats. Another important factor in Non-Tsunami rural areas is that clay soils have a much greater capacity to bind Pb than sandy soils, and Aceh Besar has clay soils. Moreover, Aceh Besar is located in a mountain area where lead pollution might be from volcanoes or forest fires. Although Banda Aceh as Tsunami rural area is located in a coast area and has sandy soils, lead contamination to the forage, water source and environment is distributed through sewage sludge dispersal from Tsunami mud and waste dispersal. Likewise, it has been reported by Tim Riset Walhi Daerah Istimewa Yogyakarta and Walhi Nanggroe Aceh Darussalam (2006) that Banda Aceh's soil got lead contamination around 17 mg kg^{-1} due to the Tsunami. Moreover, Yulvizar (2008) documented Banda Aceh's well water got a lead contamination around 0.15 mg kg^{-1} due to the Tsunami, too.

It was surprising that the Pb concentration in Kacang goats' livers in Non-Tsunami rural areas was significantly higher than in Tsunami rural areas. Conversely, Pb concentrations in Kacang goats' feces in Tsunami rural areas were significantly higher than in Non-Tsunami rural areas. The different lead concentrations in Kacang goats liver and feces between Non-Tsunami and Tsunami rural areas are probably results from different sources of diet, water and air pollution. The fodder, water and air of Kacang goats in Tsunami rural areas are more exposed to lead pollution from the environment than those in Non-Tsunami rural areas. In Non-Tsunami rural areas Kacang goats were longer exposed to lead pollution from the environment than in Tsunami rural areas. This is related to the metabolism of lead in Kacang goats. Lead is commonly regarded as a cumulative poison in tissue (Underwood *et al*, 2001). Lead needs more time for accumulation in liver. Then, irrespective of the chemical form of the ingested lead, only a small proportion is absorbed because of the formation of insoluble lead complexes in the alimentary tract, which are excreted in the feces. Lead concentration in Kacang goats' feces in Tsunami rural areas indicated a higher lead pollution than of the goats in Non-Tsunami rural areas, since feces are the immediate digestion results (last 24-28 hours) of Kacang goats.

Table 2 shows that the livers of Kacang goats feeding on *Gliricidia sepium* and *Paspalum vaginatum* contained significantly higher lead concentrations. Kloeke (1974) reports that lead levels of 20 to 30 mg kg⁻¹ are common in roadside plants. *Gliricidia sepium* is commonly growing along roadsides. The lead contamination of *Gliricidia sepium* is due to external pollution where the stomata of leaves are clogged with lead dust or salts (Brewer, 1966). *Paspalum vaginatum* is growing everywhere; therefore it is easily contaminated with lead.

Correlation between concentration of elements in liver and in feces

The present results documented that lead concentrations in feces were higher than lead concentrations in livers. This indicates that the Tsunami has caused a contamination of the agriculture land with lead, particularly at Ulhelheu and Darussalam, which are located in Banda Aceh city and belong to the areas most badly affected by Tsunami. While feces are the immediate results of ingestion of lead accumulation in the liver needs more time.

According to the analysis of the correlation between lead accumulation in livers and in feces, there is no correlation between livers and feces for lead accumulation. Feces can thus not be used as an indicator pointing to a risk of lead accumulation in livers.

Conclusions

The present study has confirmed that both Tsunami- and Non-Tsunami areas were contaminated with lead. Lead was accumulating much more in Banda Aceh (Tsunami affected land) than lead in Aceh Besar (Non-Tsunami affected land). The Kacang goats have ingested lead by grazing and air pollution, cadmium by grazing and arsenic by grazing and drinking on Tsunami- and Non-Tsunami affected land. The liver is one of the organs in Kacang goats where an accumulation of lead was measured. The liver content gives a long time-term indication for lead accumulation in Kacang goat. Also in the feces of the goats was an accumulation of lead measured. The content in the feces gives immediate results indication for lead uptake.

The level of lead measured in the present study is higher than the maximum concentration for lead in food according to guidelines and other recommendations related to the quality and safety of feeds and foods: Codex General Standard for Contaminants and Toxins in food (Codex Stan 193-1995) (WHO database, 2006). This indicates that the liver from the Kacang goats which counts to the preferred foods and is consumed as a meal by Acehnese people every day, can pose a threat to human health. The Kacang goat faeces

which are used as dung for crops in Banda Aceh city and Aceh Besar district may also contain lead. According to Tim Riset Walhi Daerah Istimewa Yogyakarta and Walhi Nanggroe Aceh Darussalam (2006) documented from International Standard for soil, the level of lead are not higher than the tolerance level. But, this may cause hazard by the recycling in agricultural land in Banda Aceh city and Aceh Besar district.

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