

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

(Penentuan akumulasi cadmium (Cd) dalam hati kambing kacang di daerah tsunami)

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ABSTRACT Tujuan dari penelitian ini adalah untuk mendeteksi akumulasi cadmium pada hati dan feces kambing Kacang dan sekaligus mengukur kadar akumulasi cadmium 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 cadmium, dilakukan pengamatan anatomi dari hati dan feces tersebut. Cadmium berakumulasi dihati dan feces dari kambing Kacang, baik yang berasal dari daerah Tsunami dan dari daerah Non-Tsunami. Akumulasi cadmium didalam hati kambing Kacang signifikan lebih tinggi di daerah Non-Tsunami dibandingkan didalam hati kambing Kacang di daerah Tsunami. Pada feces kambing Kacang akumulasi cadmium juga signifikan lebih tinggi di daerah Non-Tsunami dibandingkan didalam feces kambing Kacang di daerah Tsunami.

Kata Kunci: kambing kacang, cadmium, 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 sample areas and lead, cadmium and arsenic as research objects.

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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 (2006)

Objectives

The objective of the present study was to determine cadmium 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:

- a) Goats from Tsunami affected areas (Ts-Goats) originated from the villages Ulhelheu and Darussalam near Banda Aceh.
- b) 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 cadmium 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.

3.6 Cadmium analysis

The chemical analyses were conducted at the Soil Research Institute in Bogor, West Java. For the analyses of cadmium 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

Cadmium concentration in liver and feces were analyzed statistically using SAS and CYSTAT. 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

Cadmium concentrations in the goat's livers from Non-Tsunami areas and Tsunami areas are shown in Table 2. Cadmium

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
Cadmium	0.16 ^a ± 0.10	0.08 ^b ± 0.07

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

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

Element	L.I & P.v*	G.s & P.v*	L.I, G.s & P.v*	n.f.*
Cadmium	0.20 ± 0.11	0.14 ± 0.10	0.10 ± 0.08	0.10 ± 0.09

*: L.I.: *Leucaena leucocephala*, P.v.: *Paspalum vaginatum*, G.s.: *Glyricidiy sepium*, n.f: not fixed; Different superscripts (a, b) in a row denote a significant difference at P<0.05.

There were no significant differences between four different diets in the cadmium concentrations in the livers (Table 3).

Cadmium concentrations in feces

The statistical analysis showed that the concentration of cadmium in the feces was not different between goats from the Tsunami areas and Non-Tsunami areas (Table 4).

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

Element	NTs - Goats	Ts - goats
Cadmium	0.19 ± 0.16	0.15 ± 0.07

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

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

Element	L.I & P.v*	G.s & P.v*	L.I, G.s & P.v*	n.f.*
Cadmium	0.18 ± 0.17	0.17 ± 0.21	0.17 ± 0.08	0.16 ± 0.08

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

There were no significant differences in cadmium concentration in the feces between goats fed on different diets (Table 5)

Correlation of concentrations in liver and feces

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

concentrations of cadmium 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
Cadmium	0.04

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 which the tolerance of lead concentration is > 4.5 mg kg⁻¹.

Cadmium concentration in Non-Tsunami and Tsunami areas

Data in Table 2 indicate that the highest concentration of Cd in Non-Tsunami rural areas was detected in Kacang goats' livers. Cadmium concentration in Non-Tsunami rural areas were compared with the recommended threshold values for liver of goats (Radostits *et al.*, 1994). With regard to this limit, the cadmium concentration in liver was very low in this study. Kacang goats in the study region were not at risk through Cd poisoning. A popular food from Kacang goats

is the liver, which is consumed as a meal by the Acehese people every day. The contamination of the liver can pose a threat to human health. According to the WHO database (2006), the maximum Cd concentration in food is 0.1 mg kg^{-1} . With look upon to this limit, the Cd concentration in liver was very high in the study areas.

The present data is similar to the Cd concentration reported for the Egyptian rural areas, which is around 0.09 mg kg^{-1} . The Cd concentrations in fertilizers and public waste may contribute to the Cd levels of goat liver in Egypt (Abou-Arab, 2001), but our values were lower than those of the Egyptian study. Cadmium contamination to the Kacang goats is possibly due to the soil and forage which were consumed by grazing in Non-Tsunami rural areas as well as in Tsunami rural areas. Probably the highest contamination by cadmium to the Kacang goats is through soil ingestion. Cadmium uptake by plants is generally poor and cadmium is strongly retained in topsoil. Occurring of cadmium contamination to the Kacang goats is mostly through soil ingestion. The evidence of cadmium contamination to the forage, water and environment has contributed from superphosphate fertilizers residual, metal workshop, garages and dispersal of sewage sludge and waste.

The cadmium concentration in Kacang goats' liver from Non-Tsunami rural areas was significantly higher than from Tsunami rural areas. These results were confirmed which showed that the Non-Tsunami and Tsunami rural areas have contain cadmium pollution. The difference probably results of cadmium concentration from different sources of Kacang goats forage are exposed. It is assumed that the Non-Tsunami areas have been more contaminated by cadmium pollution than the Tsunami areas. Recent research by Yulvizar (2008) revealed that farmers in Aceh Besar area are commonly using more superphosphate fertilizer in their agriculture farmland. Moreover, there are many garages and metal workshop around samples collecting location in Aceh Besar.

Correlation between concentration of elements in liver and in feces

The present results documented that cadmium concentrations in feces were higher than lead, cadmium concentrations in livers. This indicates that the Tsunami has caused a contamination of the agriculture land with cadmium 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 cadmium accumulation in the liver needs more time.

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

The impact of Tsunami - discussion of the hypothesis

The results of the study are verifying the hypothesis. There is cadmium contamination in Banda Aceh due to the Tsunami disaster. Moreover, in the study site, it was surprising that there is cadmium accumulation in the Non-Tsunami area Aceh Besar. Mostly, cadmium was accumulating in Aceh Besar. However, Kacang goats in both areas were contaminated with cadmium in their livers and feces. Kacang goats' liver in Tsunami and Non-Tsunami rural areas was hazardous for human consumption since cadmium concentrations were higher than the tolerance levels which are given by WHO database (2006). Furthermore, the practice of using feces as dung in Tsunami and Non-Tsunami rural areas is hazardous for agriculture land; the dung can contribute to cadmium contamination, which will be continued through regular recycling.

Conclusions

The present study has confirmed that both Tsunami- and Non-Tsunami areas were contaminated with cadmium. Cadmium was accumulating much more in Aceh Besar (Non-Tsunami affected land) than cadmium in Banda Aceh (Tsunami affected land). The Kacang

goats have ingested cadmium by grazing on Tsunami- and Non-Tsunami affected land. The liver is one of the organs in Kacang goats where an accumulation of cadmium was measured. The liver content gives a long time-term indication for cadmium accumulation in Kacang goat. Also in the feces of the goats was an accumulation of cadmium measured. The content in the feces gives immediate results indication for cadmium uptake.

It has been observed that the agricultural land in Banda Aceh city and Aceh Besar district is contaminated with cadmium. Banda Aceh city was not only contaminated by the Tsunami disaster and but also by other sources of pollution. Aceh Besar district have been contaminated by other sources of pollution. Due to that the agricultural land was contaminate by cadmium, the fodder, pasture land and sources of water were contaminated with cadmium. Particularly *Leucaena leucocephala*, *Gliricidia sepium* and *Paspalum vaginatum* were contaminated with heavy metal and semi-metal, as well as the sources of water.

The level of cadmium and measured in the present study is higher than the maximum concentration for lead, cadmium and arsenic 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 cadmium. According to Tim Riset Walhi Daerah Istimewa Yogyakarta and Walhi Nanggroe Aceh Darussalam (2006) documented from International Standard for soil, the level of cadmium 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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