

Global Leadership Training Programme in Africa 2016

Activity Report of Field Research

**The impact of lead (Pb) pollution on animal and human health in a lead polluted area,
Kabwe, Zambia**

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I. Summary

1. English Summary

The objectives of my field trip to Kabwe, Zambia were (i) to assess lead levels in blood and breast milk in lactating mothers and blood in their infants from the lead polluted townships, (ii) to determine the lead concentration dynamics in blood and breast milk during the lactation period, and (iii) to assess blood lead levels in dogs and monitor their behavior using GPS.

For human blood sampling, three sites around the mine (Chowa, Kasanda and Makululu), and two sites far from the mine (Bwacha and Katondo) were selected. Blood, and milk samples were collected from mothers during the lactating period. Blood and fecal samples were also collected from their babies at clinics located in the selected communities. Interviews of mothers were conducted before collecting blood samples. In total, 426 mothers' and 417 infants' samples were collected in 5 clinics.

Dog sampling was conducted in Kasanda. The behavioral patterns of the sampled dogs were monitored for about a week using GPS devices attached to collars. Blood samples were collected before attaching the collar and after a week. Information about the dogs was obtained from the owners through questionnaires. Soil and water samples from lands adjacent to dog houses were collected during this sampling. In total, 53 male and 48 female dogs were examined.

All collected samples will be transported to Japan. Lead concentrations in the above-mentioned matrices will be analyzed using Inducted Coupled Plasma Mass Spectrometry. In addition, biochemistry test will be conducted using plasma samples of mothers. The questionnaires will be summarized in electronic form data and statistical analysis will be done using statistical software R. GPS data will be summarized with QGIS. Analysis of the present study has been still in the process.

From the first report by Blacksmith Institute (2007), lead pollution in Kabwe is still a big concern. However, the situation has not been revealed clearly. Results from this study will be helpful to understand lead pollution in Kabwe. The further studies are necessary to determine the lead exposure route of human and animals, and the situation of lead exposure in the entire area of Kabwe. In addition, local people are hoped to be informed of lead pollution, in order to raise their awareness of the risk of it.

2. Japanese summary

当研究の目的はザンビアの鉛汚染が深刻な問題となっている鉛鉱床地域 Kabwe で、(i)母子の血中及び母乳中の鉛濃度の測定、(ii)授乳を介した乳幼児への鉛曝露の解明、(iii)GPS を用いた犬の行動のモニタリングと、その行動が鉛曝露に及ぼす影響の解明である。

ヒトサンプリングは鉱床周辺の3つの地域 (Chowa、Kasanda、Makululu) と鉱床から離れた2つの地域 (Bwacha、Katondo) で行った。クリニックを訪れた母親から血液と血漿、母乳、子供から血液と糞便を採取した。また、母親には質問票調査が行われた。

イヌサンプリングは Kasanda 地域のみで行った。GPS 装置が付いた首輪をイヌに装着し、一週間程度その行動をモニタリングした。首輪の装着時と脱着時に血液を採取し、脱着時のみ血漿も採取した。また、サンプリング中に飼い主への質問票調査と、イヌの家周辺の土壌と飲み水の採取も行った。

ヒトサンプリングでは5つのクリニックから計426人の母親と417人の乳幼児から試料が提供された。イヌサンプリングでは53頭のオスイヌと48頭のメスイヌの行動をモニタリングし、試料を採取した。採取されたこれらのサンプルは日本に送付予定である。誘導結合プラズマ質量分析計を用いて、ヒト血液、母乳、糞便、イヌ血液、土壌、水の鉛濃度を測定予定である。また、母親とイヌの血漿は生化学分析を行う予定である。質問票はデータ化し、鉛濃度と併せて統計解析する予定である。イヌの GPS データは QGIS を用いて、解析を行う予定である。

Kabwe の鉛汚染に関する最初の報告から10年経過したが、未だに Kabwe の鉛汚染問題は深刻である。その汚染状況に関しても、Kabwe 全体で明らかになっていない。当研究結果は Kabwe の鉛汚染問題解決に寄与できると考えている。ヒト及び動物の鉛汚染源の解明や鉛汚染状況を明らかにするために、引き続き調査を行っていく必要がある。また、鉛汚染の被害を軽減するために調査と併せて、地域住民への鉛汚染に関する教育と警鐘が喫緊の課題である。

II. Research Activity

1. Introduction

Lead (Pb) is one of the metals used early in the history of humankind and still valuable in manufacturing nowadays. Pb toxicity has been known from the Ancient Roman era and caused neurological symptoms and death in the worst case. In developing countries, Pb mining, smelting and battery recycling are among the most important sources of Pb exposure.

Pb concentration in the whole blood is the main biomarker used to monitor exposure and has been widely used in epidemiological studies. Recently, the reference level of Blood Lead Levels (BLLs) was revised to 5 µg/dL following findings in Canfield's study¹ which demonstrates that BLLs below 10 µg /dL were inversely associated with children's IQ scores. Children, especially infants are vulnerable to Pb compared with adults. They should be protected from Pb exposure for their health and future.

Breastfeeding is nutritionally important for infants. However, it is known that Pb can diffuse into breast milk from maternal blood. As such, a positive correlation has been reported between maternal BLLs and Pb concentrations in breast milk.^{2,3} Therefore, breastfeeding from mothers exposed to Pb is considered as one of the sources of Pb exposure to infants. The Centers for Disease Control and Prevention, USA (CDC) does not encourage breastfeeding in lactating mothers with high blood or milk lead concentrations. Chelation therapy is a treatment of choice for lead poisoning. However, chelation therapy to mothers during the lactation period is not recommended by the CDC as it may lead to increased exposure of suckling infants to metals in milk. Safety of chelation therapy during the lactation period is not clear due to a lack of information.

Kabwe, the capital of the Zambian Central Province, is one of "The World's Worst Polluted Places" recognized by the Blacksmith Institute.⁴ The lead-zinc mining in Kabwe was operational for over 90 years without pollution-related laws regulating emissions from the mine. The mine has left the city with hazardous concentrations of Pb in biota, soil and water. Our research group has investigated heavy metal pollution in Kabwe since 2007 and found high Pb accumulation in different environmental and biota samples.^{5,6,7} In addition, this group found high BLLs in children aged under 7 near the mine and all samples were higher than the level of concern: 5 µg/dL.⁸ However, BLLs in mothers in Kabwe have not been reported up to today. To understand Pb exposure on infants, BLLs in mothers are needed to be measured.

The general objective of this fieldwork was to assess the situation of Pb poisoning in Kabwe, Zambia. This fieldwork was designed in particular: (i) to assess Pb levels in blood and milk in lactating mothers and blood Pb in their infants from the affected communities, and (ii) to determine the Pb concentration dynamics in blood and breast milk during the lactation period.

Prior to this project, I was involved in a field survey in Kabwe to assess BLLs in dogs. This allowed me to reveal lead exposure in dogs around the mine. There were some differences in BLLs in dogs within the same community. It is considered that the levels of their exposure to Pb are associated with their unique behavioral patterns. A similar outcome is reported by a relevant study in domestic cats, which took place in a community through GPS monitoring.⁹ While collecting blood samples from mothers and infants, this fieldwork attempted (iii) to determine the effects of dogs' behaviors on their Pb exposure by using GPS.

2. Study Area

This fieldwork was conducted in Kabwe, Zambia.

(1) Human blood sampling

Three sites around the mine (Chowa, Kasanda and Makululu) and two sites far from the mine (Bwacha and Katondo) were selected. Three sites around the mine was examined in the previous research⁸ and high BLLs in children were found. The situation of Pb exposure on human in Kabwe has not been revealed clearly. Thus, the two new sites were included in this fieldwork.

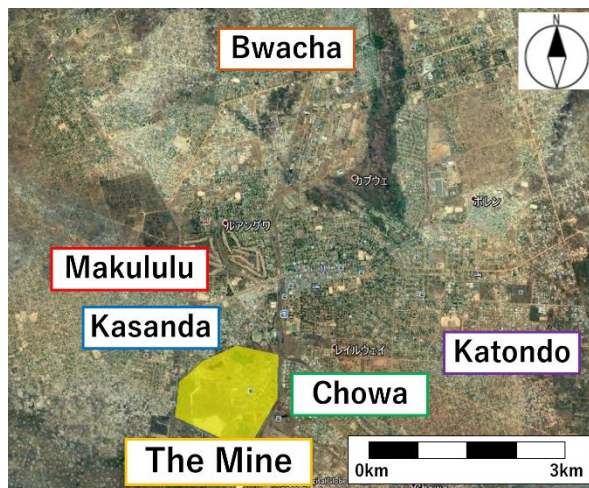


Fig 1. A map of Kabwe

(2) Dog sampling

This sampling was conducted in Kasanda, which is one of the nearest communities to the mine. My previous study in the same area demonstrated Pb exposure on dogs.

3. Methodology

(1) Human blood sampling

Prior to this sampling, ethical clearance and approval were obtained from the University of Zambia Biomedical Research Ethics Committee (UNZABREC) and the National Health Research Authority under the Ministry of Health.

The details of sampling were explained to clinic staff and community health workers. Community health workers informed people in the communities of the sampling a week before. Sampling activities at each clinic were conducted for 5 days from Monday to Friday.

During the course of the study, willing participants who visit the health centers in Kabwe for various reasons were recruited for this study after informed consent. Blood and milk samples from lactating mothers and blood samples from infants were collected by nurses or laboratory technicians at the clinics. Mothers were interviewed before blood sampling. This questionnaire was mainly in terms of social demographic factors, including age, sex, and so on. After collecting blood samples, they were given stool containers whereby their infants' fecal samples could be sent back to the clinics during the sampling period.

BLLs were analyzed by portable blood lead analyzers: LeadCare II at health clinics. The range of detection is 3.3 – 65 $\mu\text{g}/\text{dL}$. The samples above 65 $\mu\text{g}/\text{dL}$ were measured using the dilution method.⁹ Mothers' blood samples were centrifuged and plasma was collected.



Fig 2. Preparing of sampling at clinics

(2) Dog blood sampling

In Kasanda, I carried out door-to-door visits to collect information about domestic dogs. First, male dogs were examined. GPS devices were set to log every 1 minute 30 seconds, packed in plastic tube and attached to dog collars. Blood samples were collected before attaching the collar. After a week, blood samples were collected again before removing the GPS devices. The dog owners were asked to answer questionnaires about their dogs. Soil and water samples from dog houses were collected during the sampling period. Female dogs were sampled in the same way.

BLLs before and after putting the collar were analyzed by LeadCare II. The collected blood samples were centrifuged and plasma was collected.



Fig 3. GPS devices and a dog collar

4. Research Findings

(1) Human blood sampling

In total, 426 mothers' and 417 infants' samples were collected in 5 clinics (Table1).

The sampling was conducted at Katondo clinic for the first time. Compared to the three study areas around the mine, people in Katondo devoted less attention to lead pollution due to the lack of knowledge. Some mothers refused to participate in this sampling. Pb exposure on mothers and infants in Katondo were found from LeadCare II results.

Table 1. Summary of number of samples

Area	Mothers	Infants
Overall	426	417
Chowa	59	51
Kasanda	85	82
Makululu	104	105
Bwacha	84	85
Katondo	94	94



Fig 4. Human blood sampling

(2) Dog blood sampling

In total, 53 male and 48 female dogs were sampled. Two GPS devices were lost from male and female dogs. Blood samples were not collected from one male and one female dog.

During sampling, we needed some assistance from the owners to restrain the dogs. Only the adult men were capable of restraining dogs; adult women and children failed to do. When adult men were not available, we could not collect blood from dogs. Dogs in Kasanda were not commonly chained. Sometimes, it took time to catch dogs for this survey.



Fig 5. Dog blood sampling

The collected samples will be transported to Japan. Lead concentrations in human blood, milk, fecal, dog blood, soil and water samples will be analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). In addition, biochemical tests will be conducted using plasma samples of mothers and dogs. The answered questionnaires will be summarized in electronic form data and statistical analysis will be done using statistical software R. The GPS data of behavioral patterns of the dogs will be summarized with QGIS.

5. Discussion & Conclusion

In this study, infants below 1 years old were mainly surveyed. The child-rearing practices I observed through the fieldwork implies that BLLs in children above 1 years old might be higher than younger infants. In most cases, infants are treated very well and held by mothers most of time. They do not have many opportunities to be in contact with contaminated soils. By contrast, children around 1 years old start crawling and trying to stand up and walk. It means that opportunities to come into contact with soil increase from around 1 years old. To examine the difference of Pb exposure, regular monitoring of BLLs in infants is needed to be explored.

The GPS data of behavioral patterns of dogs is valuable for illustrating the route of infection like rabies as well as of Pb exposure. I saw many dogs were roaming about communities during the sampling period. It suggested that those dogs might be exposed to Pb not only around their houses but also in other places.

From the first report by Blacksmith Institute,⁹ Pb pollution in Kabwe is still a big concern. Its situation has not been understood clearly, however. My pilot study shows that, while local people in the communities around the mine have become aware of Pb pollution, those in areas far from the mine pay less attention to the risk of it. Actually the fieldwork in Katondo indicated Pb exposure to mothers and their infants.

I hope the outcomes of the analysis of the collected samples will be helpful to understand Pb pollution in Kabwe. The further studies are necessary to determine Pb exposure routes in both human and animal

cases, and clarify the situation of lead exposure in the entire area of Kabwe. In addition, local people are hoped to be informed of lead pollution and become aware of the risk of it.

III. Reflection to the GLTP in Africa

My research topic is lead pollution in Kabwe, Zambia. Then, it was necessary for my research to understand the situation in Kabwe and their culture also. It was a great opportunity for me to join this GLTP in Africa and stay for a long time in Kabwe.

During this GLTP, I was staying in Kabwe only by myself. I needed to prepare and organize my sampling by myself. Of course, my supervisors from the University of Zambia, Dr John Yabe and Dr Kaampwe Muzandu, visited Kabwe sometimes and helped me, and we also communicated using phone and e-mail frequently. The laboratory of Toxicology, Hokkaido University, the University of Zambia, Kabwe District Health Offices and Veterinary Offices have built a good working relationship already through previous research collaborations, so the relationship helped me a lot to work in Kabwe. Without the relationship, I think I could not manage my sampling well.

In Zambia, there is an Under 5 program that mothers take their children below 5 years old for monitoring children growth and free vaccination at least once a month. I did not know about this program, so I needed to understand what clinics were doing in the program before making my sampling plan. Human blood sampling was conducted in 5 clinics, and nurses and lab technician participated from each clinic. Before the sampling, I told them about my research and how to collect samples at each clinic. The beginning of sampling is always difficult, so the first sampling days at each clinic were tough and challenging. Fortunately, clinic staffs in all clinics were really kind and engaged in my sampling nicely.

There were some differences of culture between Japan and Zambia concerning dog keepings. Dogs are considered as pets in Japan. Thus, they are kept in house or chained outside and treated well. On the other hand, dogs are generally kept as guards in Zambia. They are not treated as pets, because friendly dogs are not suitable as guards. The biggest difference is that dogs are not chained and they are roaming in the community in Zambia. The differences made some difficulties during my sampling as some dogs were so vicious and the owners could not manage those dogs, so we failed to collect blood.

Staying in Kabwe for 5 months, it was really great opportunity for me to learn and understand many things about both of my research and life. In future, I would like to engage in solving environmental pollution in developing countries. My experiences through this GLTP can contribute not only to my PhD research, but also to my future career.

The period of Master or PhD course is limited, so three months are very important for those students and their research. However, staying for a few months in developing countries, doing research and learn new cultures within Master or PhD course are valuable experiences to those students for their research and future career also. It is difficult to express everything here, but I broadly and deeply learned a lot of things in this GLTP, even not regarding my research. I recommend other students to join in GLTP, and go and study in Africa.



Fig 6. My activities

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