Project Completion Report

for

The Project for Visualization of Impact of Chronic / Latent Chemical Hazard and Geo-Ecological Remediation

(KAbwe Mine Pollution Amelioration Initiative: KAMPAI)

by

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Abbreviations and Acronyms

6NDP:	Sixth National Development Plan
7NDP:	Seventh National Development Plan
AAS:	Atomic Absorption Spectrometry
As	Arsenic
Cd:	Cadmium
CEP:	Zambia Copperbelt Environment Project
Hg:	Mercury
HU:	Hokkaido University
JCC:	Joint Coordinating Committee
JICA:	Japan International Cooperation Agency
JSS:	Japan Space Systems
JST:	Japan Science and Technology Agency
KAMPAI:	KAbwe Mine Pollution Amelioration Initiative
KMC:	Kabwe Municipal Council
M/M:	Minutes of Meeting
MOE:	Ministry of Education
MOG:	Ministry of Green Economy and Environment
MOH:	Ministry of Health
MOHE:	Ministry of Higher Education
MOL:	Ministry of Lands and, Natural Resources and Environmental Protection
MOM:	Ministry of Mines and Mineral Development
MOTS	Ministry of Technology and Science
MOU:	Memorandum of Understanding
MOW:	Ministry of Water Development, Sanitation and Environmental Protection
MP-AES:	Microwave Plasma-Atomic Emission Spectroscopy
MT:	Mitsubishi Materials Techno Co.
Pb:	Lead
PDM:	Project Design Matrix
PO:	Plan of Operation
R/D:	Record of Discussion
SATREPS:	Science and Technology Research Partnership for Sustainable Development

SDGs:	Sustainable Development Goals
UNZA:	University of Zambia
UPS:	Uninterruptible Power Supply
WB:	World Bank
XRD:	X-ray Diffraction
ZEMA:	Zambia Environmental Management Agency
ZMERIP	Zambia Mining and Environmental Remediation and Improvement Project
ZMW:	Zambian Kwacha
Zn:	Zinc

Contents of the Project Completion Report

I. Basic Information of the Project

1. Country

Republic of Zambia

2. Title of the Project

The Project for Visualization of Impact of Chronic / Latent Chemical Hazard and Geo-Ecological Remediation

3. Duration of the Project (Planned and Actual)

Planned: 10th June 2016 to 9th June 2021

Actual: 10th June 2016 to 9th June 2022

4. Background (from R/D)

The increased occurrence of metal pollution in the environment has been associated with anthropogenic activities such as effluents and emissions from mines and smelters that often contain elevated concentrations of toxic metals including lead (Pb), cadmium (Cd), mercury (Hg) and arsenic (As). As such, widespread metal contamination has frequently been reported in regions with long histories of mining, especially in the vicinity of non-ferrous metal smelters where high concentrations of toxic metals contaminate water, soils and vegetation. Due to limited ecosystem-monitoring and health risk data in developing countries, metal contamination continues to pose a major health risk in humans and animals. In Kabwe Town, the capital of Zambia's Central Province, extensive Pb contamination of township soils resulting in alarming Pb poisoning in children in the vicinity of the Pb-Zn mine have been reported.

However, the actual status of environmental contamination is unknown in Zambia and many African countries. Given this background, there is urgent need to develop a database of environmental pollution in Zambia. It is also necessary to raise the level of environmental research and education as well as to develop social systems including assessment system for economic ecosystem and technologies for environmental remediation, in particular, geo-remediation and improvement of geo-ecosystem quality. "Visualizations" of negative impact on socio-ecosystem by pollutants are needed to accelerate the improvement of polluted environments and to attend to the "latent" health risk by the chemical

hazard. In addition, capacity building including “human capital” should also be strengthened for sustainable environmental management. The aim of this Project is to establish a model for the sustainable socio-ecosystem development in metal-polluted areas of African countries.

5. Overall Goal and Project Purpose (from R/D)

Overall Goal

The negative impact caused by Pb pollution in Kabwe mining area is reduced and novel protocol for metal pollution countermeasure established based on the research achievements is perceptible and utilized worldwide.

Objectively Verifiable Indicators

1. Established protocol based on research achievements is adopted into the governmental policy
2. Lead level in human blood is reduced and effectiveness of proposed countermeasure and/or protocol are verified
3. Monitoring for Pb contamination is continuously conducted
4. 10 papers regarding the Project are published in International academic journals

Project purpose

Novel and effective countermeasure and protocol are proposed.

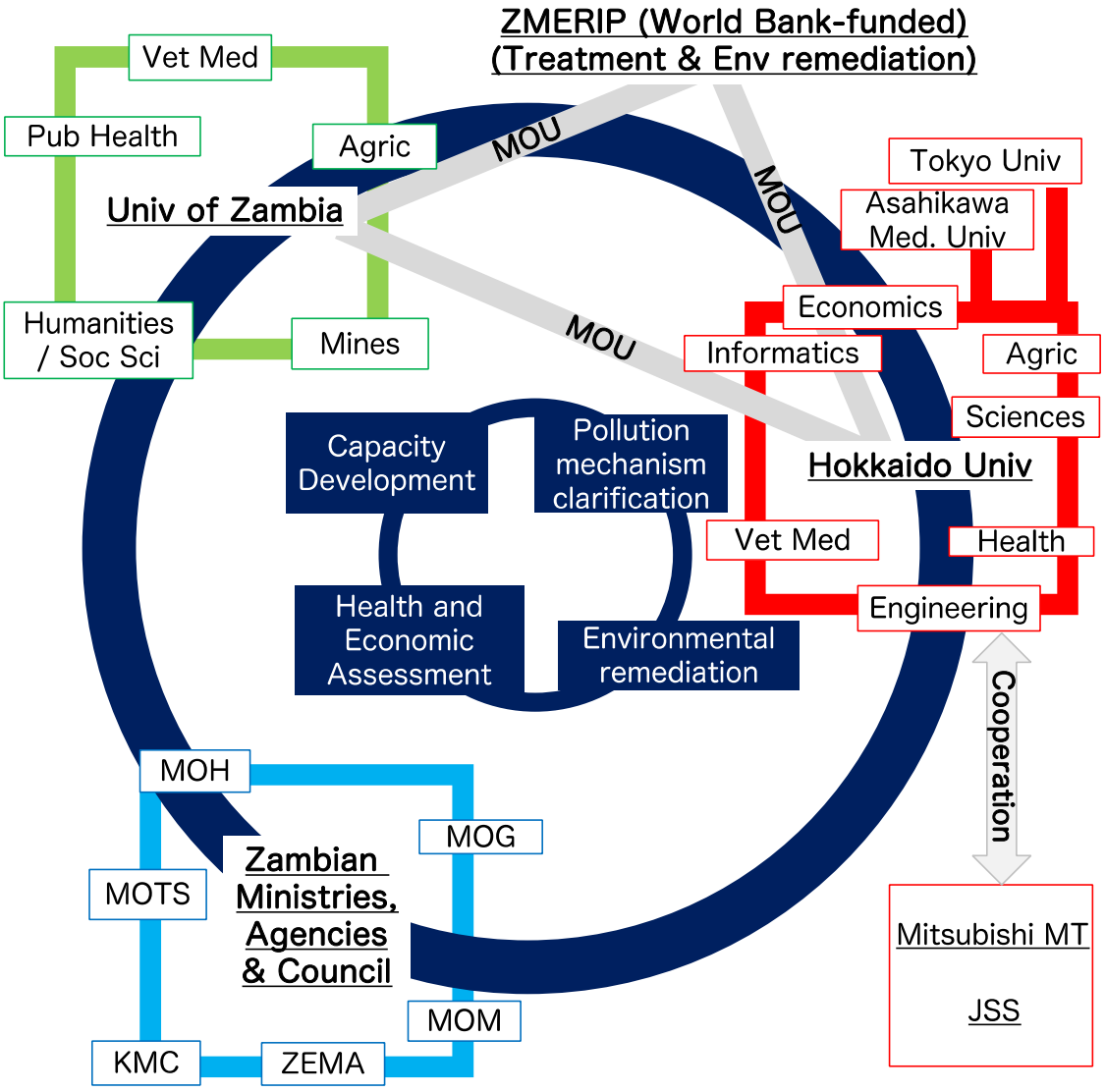
Objectively Verifiable Indicators

1. Lead pollution levels and contamination pathways and mechanisms in Kabwe area are evaluated
2. Health effects and impacts by Pb exposure are quantified
3. Economic impacts caused by Pb contamination are quantified
4. Appropriate remediation method for each contamination pathway is proposed
5. Monitoring system for Pb contamination is established

6. Implementing Agency

The project, called the KAbwe Mine Pollution Amelioration Initiative (KAMPAI) project, has been implemented by the University of Zambia (UNZA) and Hokkaido University (HU). The structure of all the implementing agencies is visualized as

below.


ZMERIP (World Bank-funded)
(Treatment & Env remediation)
Vet Med
Pub Health
Agric
Univ of Zambia
Humanities / Soc Sci
Mines
MOU
MOU
MOU
Tokyo Univ
Asahikawa Med. Univ
Economics
Informatics
Agric
Sciences
Hokkaido Univ
Vet Med
Health
Engineering
Capacity Development
Pollution mechanism clarification
Health and Economic Assessment
Environmental remediation
Cooperation
MOH
MOG
MOTS
Zambian Ministries, Agencies & Council
MOM
KMC
ZEMA
Mitsubishi MT
JSS

II. Results of the Project

1. Results of the Project

1-1 Input by the Japanese side

[Planned]

(1) Dispatch of Experts

Nineteen researchers including research director and managers from HU and other agencies planned to take part in the Project as short-term experts. It was agreed that the long-term project coordinators for administration would be assigned and dispatched to Zambia.

- Mayumi ISHIZUKA (Hokkaido University / Research Director)
- Yoshitaka UCHIDA (Hokkaido University / Research Manager)
- Shouta NAKAYAMA (Hokkaido University / Research Manager)
- Toshifumi IGARASHI (Hokkaido University / Research Manager)
- Other 15 members (Hokkaido University, Japan Space System, Mitsubishi Material Techno)

(2) Training

It was planned that the Japanese side receives the Zambian personnel connected with the Project for training in Japan. As shown in the Plan of Operation (PO), it was also agreed to conduct capacity development in Zambia throughout the project period and to accept Zambian students in the master's and doctoral courses at HU.

(3) Machinery and Equipment

It was agreed that the following equipment would be provided by the Japanese side. It was also agreed that the expenses for vehicles and fuels for project activities and boreholes for the activities in the Output 3 would be borne by the Japanese side.

- Instrument for metal analysis
- XRD
- Deep freezer
- Portable reflectance spectrometer
- Draft chamber

- Others

(4) Local Expenses

Although there is no agreement on the specific amount to be invested, the amount necessary for local activities should be invested throughout the project period.

[Actual]

A summary of the actual inputs is as follows.

- Total inputs amount: JPY213.9 million excluding local expense
- Dispatch of Experts from Japan: 3 project coordinators from JICA and 38 researchers including 1 long-term experts (Annex 1)
- Acceptance of trainees in Japan: 11 members (Annex 3)
- Machinery and equipment: JPY94,822,249 (Annex 4) (All the planed items were installed)
- Local expenses: ZMW5,986,534 (Annex 5)

(1) Dispatch of Experts

Thirty-eight (38) researchers, including the director and managers, and thirty-two (32) students traveled to Zambia regularly throughout the project period to conduct activities as summarized in Annex 1. The total number of days of travel for all dispatched personnel excluding the project coordinators is 5,922 days as of November 20, 2021. Dr. Ikabongo MUKUMBUTA, a Zambian researcher who received his PhD from HU, spent a total of approximately 1,600 days in Zambia as a short-term expert. Additionally, three project coordinators were assigned and dispatched to Zambia. The following four members were dispatched as long-term experts.

- Dr. Hokuto NAKATA - Expert (toxicology), Apr 2017 to Apr 2019
- Mr. Hisao ODAGIRI – Project coordinator, Aug 2016 to Aug 2018
- Ms. Michiko NYANGA – Project coordinator, May 2017 to June 2022
- Mr. Susumu MAKINO – Project coordinator, Aug 2018 to June 2022

(2) Training

Throughout the project period, various capacity development activities for field survey, laboratory experiments, and data analysis were promoted. Additionally, we have accepted Zambian students at HU's Master course and Ph.D. course in

Graduate School of Veterinary Medicine, Graduate School of Engineering, and Graduate School of Environmental Earth Sciences, and conducted capacity development in academic research and other areas (Annex 2). In particular, Dr. Andrew KATABA and Dr. Marthias SILWAMBA have returned to work as lecturers in the Faculty of Veterinary Medicine and the Faculty of Mines at the UNZA, respectively, after completing their Ph.D. While working to train the next generation of students and others at the University of Zambia, they are also making significant contributions as Zambian researchers in collaborative research with Japan.

Short-term training in Japan was conducted for 11 participants as described in Annex 3. The subjects covered included veterinary medicine, health, economics, agriculture, and engineering. The affiliations of the participants were diverse, including government agencies and various faculties of the UNZA. During their stay in Japan, they attended lectures and conducted experiments at various faculties of HU and in the field to develop their capacity. An intensive lecture on remote sensing, a technology that can be used for field research, was also conducted.

In addition to these, capacity development in Zambia was also carried out throughout the project implementation period. In particular, capacity development on laboratory experiment and data analysis was done in the monitoring lab at UNZA, and an intensive practical training for UNZA students and technical staff was conducted in August 2019.

(3) Machinery and Equipment

All of the planned equipment has been installed and is in proper working order. A monitoring laboratory has been established in the Faculty of Veterinary Medicine of the UNZA with these equipment as its core. As the overall activities such as field sampling and laboratory experiments have progressed well, two types of metal analysis equipment (AAS and MP-AES) and some freezers have been introduced, exceeding the initial plan.

A 40kVA generator and six UPSs with a total capacity of 39kVA were also installed to address power outages and surges, which are common problems when using commercial power in Zambia. To secure pure water (DW) and ultra-pure water (DDW) for experiments, we have also installed a facility that connects multiple devices. This has made it possible to continuously obtain pure and ultrapure water from the Zambian tap water, which contains impurities and high

concentrations of minerals. The list of equipment procured is given in Annex 4.

(4) Local Expenses

The total amount of the local expenses throughout the project period is ZMW5,986,534. The breakdown of the input is as summarized in Annex 5.

1-2 Input by the Zambian side

[Planned]

(1) Services of counterpart personnel and administrative personnel

It was agreed that the researchers, lecturers, and staff required to implement the Project would join the Project from the UNZA and relevant Ministries and Agencies.

(2) Provision of facilities for the Project implementation

It was agreed that spaces for the project office and laboratory would be provided from the UNZA for the implementation of the Project.

(3) Cost for office space and facilities

It was agreed that UNZA would bear the cost required for the maintenance of the given facilities (including cost for electricity, water etc.).

[Actual]

(1) Services of counterpart personnel and administrative personnel

A total of 114 members participated in the Project, including faculty members and students from various schools of UNZA and staff from relevant Ministries and Agencies. The list of participating members and their affiliations are summarized in Annex 6.

(2) Provision of facilities for the project implementation

From June 2016 until the end of the Project, the School of Veterinary Medicine, UNZA provided rooms for the project office and the KAMPAI monitoring lab; from September 2021, an additional room was provided for a second KAMPAI monitoring lab. For the pilot testing activity of Output 3, the space behind the School of Veterinary Medicine, UNZA was provided from August 2017; from October 2017, the School of Mines provided the space for the meteorological monitoring equipment. The School of Agricultural Sciences also provided the

space for the meteorological monitoring equipment since Sep 2018.
In Kabwe, the KMC provided office space for a satellite office from October 2017 and 4.6 ha of land for KAMPAI Green Park (agricultural experiment field) was provided in July 2017. The Central Provincial Veterinary Office provided one room for a satellite lab from July 2017. Further details are described in Annex 7.

(3) Cost for office space and facilities
As per the agreement, the UNZA paid for the necessary costs. In addition, the cost of maintenance of the office and KAMPAI Green Park provided by the KMC and the satellite laboratory provided by the Central Provincial Veterinary Office were borne by the KMC and the Veterinary Office, respectively. Details of the inputs and amounts are given in Annex 7.

1-3 Activities (Planned and Actual)
All activity plans were generally completed on schedule, although some activity plans were delayed due to various regulations and restrictions related to COVID-19. The details of planned and actual activities were summarized in Annex 8

2. Achievements of the Project
2-1 Outputs and indicators

Output 1: Lead contamination mechanisms and pathways from pollution source to soil surrounding the pollution source in Kabwe area are elucidated.

Objectively Verifiable Indicators	Achievement
1-1. Evaluation of research gap determined by the literature (report) review	Achievement degree: 100% A literature review was carried out to identify existing data in Kabwe. The extensive pollution has been observed in soils and foods. Also, Pb was found in wild plants (weeds). However, regarding the pollution sources, wind and water had been suggested but the detailed mechanisms were unknown. Also, the agricultural management related to the risks of Pb pollution was not well studied. The findings collected have been

	summarized in published scientific papers and other documents (Annex 9, paper No. 3, 18, 24, 34 etc. in Separate Volume 5).
1-2. Lead pollution source and Pb concentration in soil at Kabwe area are evaluated	Achievement degree: 100% Soil contamination levels were extensively evaluated. The results suggested that the soil surfaces are heavily contaminated, but the levels vary widely depending on the environmental factors such as plant cover and soil types (Annex 9, paper No. 3, 16 etc. in Separate Volume 5).
1-3. Contribution of each factor (water flow, air-dust and wind etc.) which affect Lead diffusion from pollution source to soil surrounding the pollution source in Kabwe area is evaluated	Achievement degree: 100% We modelled the impact of wind on the Pb dispersion in the targeted area. The results showed that Pb dispersion from the Kabwe mine was directly affected by wind directions and speeds in the dry season, although it was not appreciably affected in the rainy season. This indicates that Pb dispersion patterns depend on the season. In addition, the distribution of the amount of deposited Pb-bearing soils around the mine corresponded to the distribution of Pb contents in soils. These results suggest that Pb contamination in soils primarily results from dispersion of fine mine wastes. We published the data in a peer reviewed journal (Annex 9, paper No. 3, 16, 34 etc. in Separate Volume 5).
1-4. Research results are integrated in the GIS data base and the data base are opened in public	Achievement degree: 100% The website (https://taka-ohi.shinyapps.io/zambia_weather_password/) is publicly available so everyone can check the wind conditions as well as plant cover in the Kabwe area. These data are useful to future activities to cover the soils to prevent the dust (Pb containing)

	dispersion.

Output 2: Lead contamination mechanisms and pathways from soil surrounding the pollution source to human body in Kabwe area are elucidated, and human health risk and economic impact caused by Pb exposure (pollution) are quantitatively assessed.

Objectively Verifiable Indicators	Achievement
2-1-1. Evaluation of research gap determined by the literature (report) review	Achievement degree: 100% A literature review was carried out to identify existing data in Kabwe. Then, it was confirmed that knowledge on human lead exposure and health and socio-economic impacts were insufficient. The necessary studies and methods were refined through additional literature reviews. The findings collected have been summarized in published scientific papers and other documents (Annex 9, paper No. 1, 4, 12, 33 etc. in Separate Volume 5).
2-2-1. The research method to evaluate Pb contamination mechanisms from soil surrounding the pollution source to human body is determined	Achievement degree: 100% Potential sources of lead exposure were considered to be soil, dust, food, drinking water and breast milk. It was concluded that it would be appropriate to conduct a comprehensive search for exposure sources by collecting and analyzing these samples and comparing them with data from human blood and other sources (Annex 9, paper No. 1, 8, 13, 34 etc. in Separate Volume 5).
2-2-2. Lead contamination pathways from soil surrounding the pollution source to human body and mechanism are evaluated	Achievement degree: 100% A variety of environmental samples were collected over a wide area of Kabwe and analysed for lead concentrations and stable lead isotopes. The results show that soil and food are the main sources of lead exposure, while exposure through

	drinking water is limited. It was also shown that lead exposure through breast milk occurs in infants (Annex 9, paper No. 1, 8, 33, 34 etc. in Separate Volume 5).
2-3-1. Method of health risk assessment for chronic Pb exposure is determined	Achievement degree: 100% The findings from the literature collection and previous studies were used for the consideration. It was decided to analyze the indicators of liver, kidney and blood toxicity of lead, to assess the effects at the genetic level and to analyse the effects on neurodevelopment etc. By comparing these data with data on lead concentrations in blood and faeces, assessment of the effects on lead can be carried out (Annex 9, paper No. 13, 15, 19, 25, 31, 33, 35 etc. in Separate Volume 5).
2-3-2. Human health risks by Pb exposure (pollution) are assessed	Achievement degree: 100% It was found that lead levels were higher in residential areas closer to the mines, and that a large number of residents, particularly in the vicinity of the mines, were in need of urgent chelation treatment. Higher concentrations were found in children compared to adults. Comparisons of lead levels with various indicators also showed effects on haematopoietic function and at the genetic level. Children's exposure to lead was also shown to affect the quality of life of their mothers and to have an impact on neurodevelopment. It is very significant that the health effects of lead have been demonstrated for the first time, and not only in the assessment of contamination levels (Annex 9, paper No. 13, 15, 19, 25, 31, 33, 35 etc. in Separate Volume 5).
2-3-3. Novel therapy protocol based on the	Achievement degree: 100%

health risk assessment is proposed	The fieldwork for this Project involved the analysis of blood lead levels using the LeadCare device. The usefulness of the device for screening purposes was demonstrated by detailed laboratory experiments and data analysis. A Health Intervention protocol was developed, covering the whole process from blood collection to LeadCare analysis, as well as public education, basic information on lead and treatment with chelating drug. The prepared proposal was provided to the Ministry of Health, other relevant institutions and ZMERIP. In addition, several on-site trainings were provided to nurses and other health care workers in Kabwe (Separate Volume 2).
2-4-1. Negative impacts of health and environmental risks on the socioeconomic condition are quantitatively evaluated	Achievement degree: 100% Socio-economic data of a representative population of the entire Kabwe were collected and analyzed in relation to blood lead levels. The representative household survey data was used to estimate the distribution of lead exposure throughout Kabwe and to confirm the negative effect of blood lead levels on household economic conditions. In addition, it was simulated that the economic loss in terms of income loss of future generations due to reduced IQ and increased mortality caused by lead exposure would be enormous (Separate Volume 4).
2-4-2. Economic returns of the remediation are quantitatively assessed based on the Cost-Benefit Analysis	Achievement degree: 100% A cost-benefit analysis was conducted for several scenarios of engineering measures for dumping sites and residential areas. As the main economic benefits, we considered the effect of increased income for future generations due to increased IQ

	brought about by reduced lead exposure and the value of life due to reduced mortality. The results of the cost-benefit analysis for 50 years from 2025 showed that the engineering measures would bring economic benefits to Kabwe commensurate with the costs. In particular, the cost effectiveness of measures in the dumping sites was found to be high (Annex 11, Separate Volume 1).

Output 3: Effective and economical remediation and pollution source control technologies are developed and proposed.

Objectively Verifiable Indicators	Achievement
3-1-1. Evaluation of research gap determined by literature (report) review concerning remediation	Achievement degree: 100% The review and evaluation were done continuously. It was clarified that there is a need for efficient and realistic environmental restoration methods using locally available and inexpensive materials. A review of the literature necessary for the development of these methods was also conducted (Annex 9, Annex 11, Separate Volume 1, paper No. 6, 7, 10, 14, 17, 22, 23, 29, 37 etc. in Separate Volume 5).
3-2-1. The methods of pilot-scale remediation for pollution source control are determined and the determined pilot-scale remediation and monitoring are conducted	Achievement degree: 100% The methods were determined based on the findings from literature review and field survey. Potential pathways of lead from pollution source to surrounding areas were considered to be Pb-contained dust, ground water, and canal flood. These indicated that covering methods of pollution source combined with immobilization would be effective. Following these perspectives, pilot-scale tests, which aimed to evaluate immobilization method using half burnt dolomite and covering

	method, have been conducted and monitored in UNZA. Other methods including advanced methods, immobilization using phosphate, bio-cement methods, and removal and recovery of metals by leaching and cementation method, were also investigated on lab-scale. In addition, continuous weather monitoring was carried out to evaluate the effect of meteorological factors (Annex 9, Annex 11, Separate Volume 1, paper No. 6, 7, 10, 14, 17, 22, 23, 29, 37 etc. in Separate Volume 5).
3-2-2. The results of pilot-scale remediation are evaluated and the optimum remediation method is proposed	Achievement degree: 100% Evaluation of the pilot scale tests was done with the data of monitoring well, water quality of leachate and effluent waters, and soil sampled in vertical direction. Efficiency and effectiveness of other tested methods were also evaluated. These results were summarized and cost estimates were made for each method. A proposal summarizing the above results was prepared and presented to the relevant government agencies and to ZMERIP, of which KMC and the Ministry of Mines are the implementing agencies. In addition to written submissions, oral explanations and discussions were also conducted (Annex 9, Annex 11, Separate Volume 1, paper No. 6, 7, 10, 14, 17, 22, 23, 29, 37 etc. in Separate Volume 5).
3-3-1. The methods of pilot-scale remediation for surrounding soil are determined and pilot-scale remediation and monitoring are conducted	Achievement degree: 100% The methods were determined based on the findings from literature review and field survey. Pilot-scale tests was completed in UNZA. Water from the monitoring wells and leachate were sampled periodically, and at the end of the test, soil from the embankment was sampled vertically and

	used for laboratory experiments. Monitoring using weather station was also conducted throughout the test period to assess the impact of weather conditions (Annex 9, Annex 11, Separate Volume 1, paper No. 6, 7, 10, 14, 17, 22, 23, 29, 37 etc. in Separate Volume 5).
3-3-2. The results of pilot-scale remediation are evaluated and the optimum remediation method is proposed	Achievement degree: 100% The effectiveness and efficiency of the tested methods was evaluated from the experimental results obtained. It was shown that the methods using locally available and inexpensive materials can provide sufficient environmental restoration effects. Cost estimation for each method was also carried out. A proposal summarizing the above results was prepared and presented to the relevant government agencies and to ZMERIP, of which KMC and the Ministry of Mines are the implementing agencies (Annex 11, Separate Volume 1). In addition to written submissions, oral explanations and discussions were also conducted.

Output 4: Capacities for monitoring the Pb contamination are strengthened and Monitoring laboratory is operated.

Objectively Verifiable Indicators	Achievement
4-1. Monitoring laboratory to analyze heavy metal pollution is established in UNZA	Achievement degree: 100% A monitoring laboratory with two types of metal analyzers, draft cabinet and Microwave metal extraction equipment was established. The laboratory is also equipped with a power generator, UPS, and pure and ultrapure water production equipment to ensure stable experiments. We have also completed the capacity development of the use and

	maintenance of the devices and equipment.
4-2. The capacity to analyze monitoring results of researchers and officers in UNZA, Ministry of Health, Ministry of Land, Ministry of Mine and Kabwe municipal council is strengthened.	Achievement degree: 100% Capacity development on data analysis was carried out for various stakeholders. Capacity development on field collection activities was also carried out to strengthen the capacity of the research flow from sample collection to data analysis.
4-3. Number of seminars based on the training, ** times (for young researchers, woman / mother and farmers)	Achievement degree: 100% Seminars for young researchers were conducted continuously throughout the project period (Annex 12). Seminars were held in Kabwe for health personnel and representatives of various communities in Kabwe. Several focused seminars for health care providers working in clinics in contaminated areas were also conducted to educate mothers and children in the communities through them. Based on a request through the Central Province where Kabwe is located, awareness videos and teaching materials created based on the findings of this Project were provided to elementary school in Kabwe in 2020. Awareness raising activities were also conducted through public radio broadcasts over a period of three days. In order to further enlighten more Kabwe residents, radio programs were created and distributed through major local radio stations. Similarly, the

	prepared video materials on the project Youtube account and articles on the project Facebook page played important roles to distribute the appropriate knowledge to the local community. The created websites regarding awareness raising activity are as below. ➢ Project homepage: http://satreps-kampai.vetmed.hokudai.ac.jp/en/ ➢ Project Facebook page: https://www.facebook.com/kampai.zambia/ ➢ Project YouTube page: https://www.youtube.com/channel/UCzXjFyffgdJmL0nhsrkVrPg ➢ English press release from Hokkaido University ● https://www.global.hokudai.ac.jp/blog/lead-poisoning-could-reduce-gene-expression-in-humans/ ● https://www.global.hokudai.ac.jp/blog/the-lasting-effects-of-pollution-from-the-kabwe-mine/ ● https://www.global.hokudai.ac.jp/blog/cross-generational-consequences-of-lead-poisoning/ ● https://www.global.hokudai.ac.jp/blog/abnormal-dna-methylation-found-in-lead-exposed-dogs-genomic-study-shows/

KAMPAI Project Monitoring Laboratory No. 1
at the School of Veterinary Medicine, the UNZA

KAMPAI Project Monitoring Laboratory No. 2
at the School of Veterinary Medicine, the UNZA

2-2 Project Purpose and indicators

Project purpose: Novel and effective countermeasure and protocol are proposed.

Objectively Verifiable Indicators	Achievement
1. Lead pollution levels and contamination pathways and mechanisms in Kabwe area are evaluated	Environmental, animal and human lead contamination levels in the broader Kabwe area have been identified. Extremely high lead concentrations were detected in the vicinity of the mine, while concentrations exceeding the standard were also found in areas relatively far from the mine. By combining various methods such as lead level analysis by particle size, lead stable isotope ratio analysis, meteorological monitoring, and characterization of mine slag, the contamination mechanisms and pathways were clarified. For lead

	diffusion from the mine to the surrounding area, the effect of wind dispersal of lead-containing dust was significant. In the case of lead transmission from the environment to humans, the contribution of soil and food was found to be particularly large (Annex 9, Annex 11, Separate Volume 5).
2. Health effects and impacts by Pb exposure are quantified	The effects of lead exposure on hematopoiesis and liver function were clarified. Knowledge of gene methylation has been accumulated, and effects at the genetic level have also been observed. Neurodevelopmental delays in children and the effects of lead exposure in children on the quality of life of their mothers have also been elucidated (Annex 9, Annex 11, Separate Volume 3, Separate Volume 5).
3. Economic impacts caused by Pb contamination are quantified	Representative socio-economic data was collected for the entire Kabwe region. The impact of lead exposure on the household economy was identified. A simulated assessment of the loss of income for future generations caused by lower IQ and higher mortality due to lead exposure was also conducted (Annex 9, Annex 11, Separate Volume 4, Separate Volume 5).
4. Appropriate remediation method for each contamination pathway is proposed	Several environmental remediation methods were developed based on the findings from field studies, laboratory experiments, and pilot-scale experiments. These methods use locally available materials and are highly efficient and economical. The characteristics of each method were evaluated and the costs were estimated. A proposal summarizing the above results was submitted to the relevant ministries and agencies as well as to ZMERIP. Oral explanations and multiple discussions were held to brush up the recommendations (Annex 9, Annex 11, Separate Volume 1, Separate Volume 5).

5. Monitoring system for Pb contamination is established	A monitoring laboratory has been established at UNZA where metal analysis and various toxicity assessment experiments can be conducted. Capacity development for experimental operation, equipment maintenance and data analysis was continuously carried out throughout the project period. Capacity development for field sampling activities and research planning was also promoted. Monitoring of lead dispersal by meteorological instruments has also been made possible. As a result, an appropriate monitoring system for lead contamination has been well established (Annex 9, Annex 11, Separate Volume 3).

3. History of PDM Modification

None.

4. Others

4-1 Results of Environmental and Social Considerations (if applicable)

Not applicable.

4-2 Results of Considerations on Gender/Peace Building/Poverty Reduction (if applicable)

Not applicable.

III. Results of Joint Review

1. Results of Review based on DAC Evaluation Criteria

The Project was evaluated based on the five criteria according to the following five levels: HIGH, RELATIVELY HIGH, MODERATE, RELATIVELY LOW, and LOW.

1-1 Relevance

The relevance of the Project is assessed as “HIGH” from the following perspectives.

(1) Relevance with Zambia's development plan and development needs

Zambia has a mining history that spans over a century and continues to play a major role in the economic development of the country. The lead and zinc mines in Kabwe began operations in the early 20th century. Even after mine closure, formal and informal mine-related activities have continued and been a key industry. On the other hand, lead pollution has become a serious social problem due to inadequate environmental pollution control measures over the years. The Zambian government has indicated in the Mining Act, which was amended in 1995, that it will reduce not only the environmental damage caused by environmental operations, but also the health hazards to workers and the surrounding population. In 1997, the country also enacted the Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations, which clearly stipulate environmental management for mines. Environmentally friendly mining promotion is also mentioned in the Sixth National Development Plan (6NDP) (2013-2016). The importance of the mining industry is also emphasized in the Seventh National Development Plan (7NDP), and in order to maximize its benefits, the negative socioeconomic impacts of environmental pollution must be minimized. From 2017 to the present, the Zambian government is implementing a project (ZMERIP) with support from the World Bank that aims to solve the problem of metal pollution caused by mining activity. Therefore, the objectives, activities and achievements of this Project are highly relevance with the policies of the Zambian government.

(2) Relevance with social needs and consideration of beneficiaries

The mining industry, the backbone of Zambia's economy, directly or indirectly supports the livelihood of many people in the country. In Kabwe, many residents

still make a living by selling mining residues, etc. On the other hand, these activities pose a very high risk of lead exposure. The problem of lead contamination is a serious economic, social and health challenge in the Kabwe area. The less educated are often involved in these hazardous industries. In addition, there is insufficient knowledge and understanding of the reality and dangers of lead contamination and lead poisoning, as well as self-protection measures, resulting in harm, particularly in children, that could have been prevented. These problems are not only in Kabwe, but also in other mining areas in the country. The knowledge and results obtained in this Project can be horizontally expanded to other areas in the country. Therefore, this Project meets the needs of society and takes into consideration the beneficiaries, including the vulnerable.

(3) Relevance with other projects

Research surveys conducted in the past by Hokkaido University and the University of Zambia have revealed serious lead contamination in Kabwe. In addition, the World Bank-funded Zambia Copperbelt Environment Project (CEP") (2003-2011) also investigated contamination levels, but efforts to solve the problem were very limited. Similarly, the World Bank-funded ZMERIP (2017-present) touted efforts to provide treatment for lead poisoning and rehabilitation of canals etc., but the actual methodology was unclear and academic knowledge was lacking. While this Project consisted of components that were different from these other projects, it was expected to have extremely high synergy with them. In fact, a number of important results have been obtained based on the past findings and further developed, and in collaboration with the ZMERIP, a very high level of social implementation has been achieved. These important achievements were made possible by the MOUs signed between the Project and ZMERIP (in the areas of health and environmental remediation), which allowed for close collaboration.

(4) Relevance with Japan's policies

The "Strategic Task Force on Science and Technology Diplomacy" has identified environmental issues as an area where Japan's strengths in technology can contribute. In fact, Japan is one of the world's leading countries in terms of pollution experience, as exemplified by Minamata disease and *Itai-itai* disease, and has a wealth of knowledge. Japan's "Fifth Science and Technology Basic

Plan" includes addressing economic and social issues (Chapter 3) and strengthening the foundation for science and technology innovation (Chapter 4). Metals and rare-earth elements are essential for the science and technology that support today's advanced medical care and industry. This Project will contribute to solving the fundamental problems of global issues in a wide range of fields by implementing countermeasures against environmental pollution caused by the development of these metal resources. In addition, it clearly states the need for research on the evaluation of hazards and risks of environmental pollutants in air, water, and soil, as well as their management and countermeasures, in order to protect human health and preserve ecosystems. It also clearly states that Japan is responsible for international cooperation and contribution, including human resource development, to developing countries such as Africa. The "Japan-Africa Resource Development Promotion Initiative" includes support for the prevention of environmental pollution around mines, human resource development in the field, and the creation of laws and regulations. This Project is in line with these policies.

(5) Multidisciplinary approach

In the Project, a multidisciplinary approach from various fields was taken to address the environmental pollution issues caused by mining activity. Specifically, environmental remediation and pollution prevention through agricultural and engineering methods, health impact assessment through veterinary and health fields, and socioeconomic assessment in the economic domain. In global and social issues, various factors often intertwine in a complex manner. A cross-sectoral approach is essential to solve these issues, but the number of such cases is extremely limited. The uniqueness of this Project, in which the multidisciplinary approach was put into practice at an extremely high level, is worthy of special mention, and will provide significant suggestions for other projects.

1-2 Effectiveness

The effectiveness of the Project was assessed as “HIGH”, as the planned activities have been completed, and achievements beyond expectations have been produced through sufficient output.

(1) Strategic output structure and sufficient achievement

All of the Outputs 1~4 determined by the PDM were achieved at a high level. In addition, these four outputs interact with each other and have an important impact on overcoming lead contamination, which is the main issue of this Project. Elucidation of the lead contamination mechanism in Output 1, leads to effective prevention of the spread of contamination. Output 2, the assessment of health and socio-economic impacts, is a manifestation of the problems caused by lead contamination and is indispensable in taking steps to overcome the contamination. Output 3 deals with the development of environmental remediation methods, which is a more direct approach to overcoming pollution. Output 4 focuses on capacity development, since overcoming environmental pollution takes many years and requires continuous efforts. It is an effort that encompasses all the necessary approaches to overcome the lead pollution challenge, rather than from a single aspect.

(2) Achievement of project objectives and outcomes exceeding initial expectations

The five project objectives have already been enough achieved. In addition, it is noteworthy that the proposed health intervention is already in the process of implementation, with concrete benefits such as a decrease in blood lead levels among children living in contaminated areas. Due to the active approach to the relevant ministries and the ZMERIP, the developed environmental remediation methods have a good chance of becoming a reality. The achievements related to the establishment of a monitoring laboratory and capacity development to ensure continuous efforts in the future are also beyond the expectations.

1-3 Efficiency

The efficiency of the Project is rated as “HIGH” from the following reasons.

(1) Actual input according to the input plan and flexible adaptation to the situation

The costs have been invested as per the original input plan and all the expected outputs have been achieved. A long-term expert and continuous short-term experts were dispatched because it was considered necessary to station specialized personnel for a long period of time; however, by adjusting other input plans, the total input amount was as planned.

Due to the impact of COVID-19, the project implementation period was extended by one year to six years, and the Project responded to this by increasing the

budget to the minimum necessary (approximately 10 million yen). Although face-to-face exchanges and student dispatches became difficult during the COVID-19 disaster in FY2020 and beyond, we promoted the development of the next generation and mutual exchanges during this period through alternative measures such as online research debriefings, discussions, seminars, and so on. Since these online methods are expected to become more and more important in the after-corona era, we have taken the pandemic crisis as an opportunity to shift to future-type methods, and have optimized the online methods and promoted better understanding among the members. Meanwhile, the UNZA pilot test site was scheduled to be dismantled in June 2020, and samples taken from inside the embankment and analyzed in detail, but due to travel restrictions related to COVID-19 and the closure of UNZA, it was decided to postpone this until October 2021.

(2) Flexible plan changes in line with the plans of the World Bank-funded project for collaboration to maximize the achievements

It was found that the ZMERIP was planning to conduct environmental remediation activities in the polluted areas of Kabwe, which was considered to be an important scheme for social implementation of the findings from the Project initiative. For this reason, the implementation of pilot-scale tests and other activities were accelerated from the original plan to meet the ZMERIP timeline. This response enabled the Project to make timely recommendations in time for the ZMERIP examination of environmental remediation methods.

The Project was able to maximize its results by taking advantage of the characteristics of both the project, which mainly aims to develop and propose methods, and the ZMERIP, which focuses on examining and implementing effective methods.

1-4 Impact

The impact of the Project is considered as “HIGH”.

(1) Multidisciplinary approach to environmental issues

There are countless single-sector projects that target individual issues, such as improving environmental pollution, greening, changing industrial patterns, and improving health. This Project, while focusing on the issue of environmental pollution, integrated the efforts of all sectors involved at an extremely high level

to promote comprehensive change. Furthermore, by combining socio-economic evaluation, the Project demonstrated that improvements in the environment and human health are not just ethically motivated, but also contribute to social and economic benefits.
This balancing of social and economic benefits is a crucial point in the promotion of the SDGs, but achieving this balance in practice is not easy. It is commendable that a single project has been able to produce significant results with addressing all of these key points. The results of this Project will provide insights into the norms of social systems, and there is much to be learned about the structure and composition of the Project. In these respects, the indirect and long-term effects of the Project are also considered to be extremely high.

(2) Equal partnership with international organizations
Collaboration with international organizations and UN agencies is important to efficiently increase development effectiveness with limited inputs. Exchanging views through opportunities such as donor meetings or coordination to avoid duplication of aid scope is common. On the other hand, there are rare cases of collaboration in actual project operations to efficiently increase the development effectiveness of both sides. This Project worked very closely with the World Bank-funded ZMERIP project to maximize the development impact of both projects. This is a good example for other projects and donor agencies to follow.

1-5 Sustainability
While it is too early for a full-scale verification of sustainability, it is expected to be extremely sustainable.

During the implementation of this Project, a number of important results were obtained, including pollution monitoring, impact assessment, and the development and recommendation of solutions such as environmental remediation and treatment. The monitoring laboratory established at UNZA is self-sustainable in terms of equipment, protocols developed, and human resources with capacity development. The same can be said for field surveys, data analysis, and report writing.
The outputs of this Project have been under continuous discussion and review with the relevant ministries, and at the October 2021 meeting, the ministries recommended proposals to the Cabinet Office. Socio-economic estimates have

shown that the implementation of the environmental remediation approach proposed by this Project will have a positive impact on the socio-economy in the medium to long term. The Zambian government has received funding from the World Bank on two previous occasions to implement the CEP and ZMERIP, both of which are aimed at resolving environmental pollution from mining. From these perspectives, it can be fully expected that the recommendations of this Project will be realized in the future.

1-6 Summary

The review results of five criteria are summarized as below.

Item	Evaluation result	Remarks
Relevance	HIGH	It is in line with Zambia's development and social needs, and is fully considerate of the beneficiaries. The Project is highly compatible with Japan's policies, and its segregation from other similar projects is appropriate and synergistic.
Effectiveness	HIGH	The four main outputs are strategically structured. The Project has been recognized for exceeding the set project objectives, and there have been concrete improvements at the field level, such as the start of providing treatment to children with lead poisoning.
Efficiency	HIGH	Within the scope of the originally planned input amount, the Project has been flexible to work with World Bank-funded projects and to the impact of COVID-19, and has produced results beyond expectations.
Impact	HIGH	Combining multiple approaches, it has become an extremely important good practice as a solution to environmental pollution of industrial origin. It has also achieved effective collaboration with

		international organizations and a balance between social and economic values, and is expected to have a significant indirect and long-term impact.
Sustainability	HIGH	Although the evaluation should be conducted after the completion of the Project, the sustainability of the Project is considered to be high, as appropriate considerations and responses were observed from all perspectives, including policy and institutional aspects, organization and structure, and technology.

2. Key Factors Affecting Implementation and Outcomes

- Due to the active commitment of the local implementing agencies, especially the University of Zambia, the process of obtaining the necessary permits and approvals for the activities proceeded smoothly.
- The project ensured regular mutual communication with a wide range of stakeholders. In particular, the project dispatched the long-term expert to Kabwe, the target area, and carefully conducted close communication with local institutions such as the KMC and made preparations for field activities in advance. These efforts led to KMC providing the Project with 4.6 ha land and 24-hour security for the establishment of an agricultural experimental site, as well as a satellite office in KMC without any charge.
- Discussions with local organizations, consensus building, and field activities proceeded smoothly at a high level owing to the long-term dispatch of a two-person project coordinators and experts with different fields of expertise.
- From the early stages of the project period, the Project had been working to make the activities self-sustaining in Zambia, including the establishment of a monitoring laboratory and various capacity development.
- The MOUs was signed with ZMERIP in the areas of environmental remediation and health, and a collaborative system was established. By clarifying the scheme of technical guidance and knowledge provision by the Project and social implementation by ZMERIP, the project outcome and beneficiary effect were maximized.

3. Evaluation on the results of the Project Risk Management

- Since the sources of lead contamination were the slag on the mining company premises and the mining activities themselves, special consideration had to be given to the mining sector and operating companies, which are major industries in the nation and the region. Close communication with the mining companies was ensured from the project formulation stage and through the entire implementation period. The Project was able to gain their understanding by repeatedly explaining that the objective of the Project was not to abolish the mining industry, but to balance the socioeconomic benefits of the industry with solutions to environmental and health issues. Also, by communicating closely with a large number of agency officials, from the Permanent Secretary to the staff level, of various stakeholders including related ministries and agencies, the Project prevented the hollowing out of project activities due to personnel changes.
- The project focused on the care and explanation to the residents of Kabwe. Many residents were distrustful of the fact that lead contamination had been left untreated for many years in certain areas. In addition, the project's activities included taking blood samples from residents, and there was concern that handling blood, which is culturally customary, would be associated with witchcraft and other abhorrent practices. Taking these points into consideration, the Project tried to provide maximum explanations to the residents during our regular field activities, apart from workshops to give back the results.
- While promoting collaboration with the ZMERIP, maximum care was taken to ensure that the progress of this Project was not affected by external factors; namely, the progress of external project. The Project tried to be flexible in the project implementation plan and prepared to respond flexibly to external factors.
- From the early stage of the Project, the Project actively started the establishment of the monitoring laboratory, local capacity development activities, and short-term training in Japan to promote self-sustainability of various activities locally. In addition to looking ahead to after the completion of the project, the Project also endeavored to build a system that would allow activities to proceed locally without depending on the Japanese side in case of emergency during the project period.
- Efforts to make the Project self-driving ended up being the biggest

countermeasure to the COVID-19 disaster. Despite the fact that it was extremely difficult for the Japanese side to travel, the Project was able to develop activities in Zambia and avoid a complete shutdown of the Project. The introduction and active use of materials and equipment necessary for online meetings was also promoted before the COVID-19, and these also greatly helped to prevent stagnation in communication.

4. Lessons Learnt

- Appropriate consideration of various stakeholders and regular communication are essential for the smooth progress of a project. From this point of view, an appropriate deployment plan for long-term experts is important.
- Although the Project is positioned in the environmental sector, the Project have attempted to approach the issue from various perspectives, including health, veterinary, engineering, agriculture, and economics, and by integrating them at a high level, the Project have been able to achieve comprehensive solutions. This project, which is unique in terms of the breadth of fields involved, was a good practice that will be a great learning experience for future projects.
- By collaborating with similar projects of other donors, the output and overall benefit of both projects can be enhanced. In this Project, the Project signed an MOU with a World Bank funded project and actively collaborated with them.
- Capacity development in terms of human resource and infrastructure is important not only for sustainability after the completion of the project, but also for risk management. The capacity development that this Project tackled from the early stage had an extremely important effect on the COVID-19 disaster.

IV. For the Achievement of Overall Goals after the Project Completion

1. Prospects to achieve Overall Goal

Although a comprehensive evaluation should be done after the Project is completed, the results are still satisfactory at this point. This is noteworthy because it proves that the results of the Project have exceeded initial expectations. The details are as follows.

Overall Goal: To reduce the negative impact caused by lead (Pb) pollution in Kabwe mining area, Zambia, and to establish, based on the research achievements, a novel protocol for metal pollution countermeasure that is feasable and utilizable worldwide

Objectively Verifiable Indicators	Achievement
1. Established protocol based on research achievements is adopted into the governmental policy	The developed technologies and findings, including environmental remediation methods, have been discussed with the relevant Zambian ministries and KMC on multiple occasions. It is being considered that the content of these proposals will be reflected in the environmental remediation activities that ZMERIP, a World Bank-funded project, plans to implement. In discussions with the relevant ministries and agencies in October 2021, it was stated that they are ready to consider all measures to realize the recommendations. This indicator should be evaluated several years after the completion of the Project.
2. Lead level in human blood is reduced and effectiveness of proposed countermeasure and/or protocol are verified	The Project has already achieved more than expected. Based on the findings of this Project, a health intervention protocol was developed. Based on this protocol, the Zambian government launched a lead poisoning testing and treatment program in Kabwe under the World Bank-funded ZMERIP project. So far, more than 10,000 children living in contaminated areas have been tested.

	Children whose blood lead levels exceeded the reference level have been offered treatment programs using chelating agents. This has helped to reduce blood lead levels in children. Protocols and field activities have been reviewed on a regular basis.
3. Monitoring for Pb contamination is continuously conducted	Continuous monitoring was conducted throughout the project period. The establishment of the monitoring laboratory and the capacity development for field survey, laboratory experiments and data analysis have been completed. Thus, the pollution monitoring is expected to be continued even after the completion of the Project. This indicator should be evaluated several years after the completion of the Project.
4. 10 papers regarding the Project are published in International academic journals	The Project has already achieved much more than expected. Approximately 80 scientific papers have been accepted for publication in peer-reviewed international journals, in addition to Master and Ph.D thesis (Annex 8, 9). The topics of these papers include elucidation of pollution mechanisms, assessment of health and socioeconomic impacts, and development of environmental remediation methods (Annex 9, Separate Volume 5).

2. Plan of Operation and Implementation Structure of the Zambian side to achieve Overall Goal

With regard to item number 1, it will naturally take time to reflect it in concrete policies, but the discussions with the relevant ministries and agencies so far have shown an extremely positive attitude. We have received suggestions from several ministries and agencies not only for proposals to each ministry, but also for proposals to the Cabinet Office. Since the efforts and recommendations of this project span across multiple ministries and agencies, it is expected that the Cabinet Office will take the lead in cross-ministry efforts in the future.

Item number 2 has already been realized. Based on the recommendations of this Project and the manual prepared, the treatment activities of the population with ZMERIP as the implementing entity are being developed starting in 2020. The health intervention protocol that has been developed is also undergoing frequent validation. The Project has already achieved more than expected results for item number 4.
With regard to item 3, UNZA already has sufficient capaciy and there are no concerns about specific operations. Plans are in place to continue regular monitoring activities.

3. Recommendations for the Zambian side

Specific recommendations are shown in the attached documents (Annex 11, Separate Volumes), but continuous and persistent efforts are required to fully resolve the pollution issues. continuous monitoring surveys using the monitoring laboratory established at UNZA will be essential. The lead poisoning testing and treatment provision for Kabwe residents, which has already been realized, should be continued in Kabwe as a routine work.

4. Monitoring Plan from the end of the Project to Ex-post Evaluation

Not applicable.

(If the Project will be continuously monitored by JICA after the completion of the Project, mention the plan of post-monitoring here.)

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- Annex 1: List of Dispatch of Experts from Japan
- Annex 2. List of Zambian students in Master or Ph.D course of Hokkaido University
- Annex 3: List of Zambian Members who traveled to Japan for capacity development
- Annex 4: Procured and installed equipment for laboratory work and field activity
- Annex 5: Amount and breakdown of local expenses
- Annex 6: List of Project Members from Zambia
- Annex 7: Facilities and inputs provided by Zambian side
- Annex 8: PDM (version – Project Completion Report)
- Annex 9: List of Research Papers Published in International Journal
- Annex 10: List of Bachelor, Master and Ph.D thesis prepared under Project
- Annex 11: Policy Brief
- Annex 12: List of seminar and meeting
- Annex 13: R/D
- Annex 14: M/M
- Annex 15: Minutes of JCC (1st to 6th)
- Annex 16: Monitoring Sheet (No. 1 to No. 11)

(Remarks: Annex 13, 14, 15 and 16 are internal reference only.)

List of Separate Volume

- Separate Volume 1: Technical Proposal on The Field Remediation in Kabwe to Reduce Environmental Risks due to Mining Activities
- Separate Volume 2: Health Intervention Manual on Lead Poisoning in Kabwe
- Separate Volume 3: Summary of Findings from Group 2
- Separate Volume 4: The Kabwe Household Socioeconomic Survey (KHSS) Report
- Separate Volume 5: Research Papers Published in International Journal

Annex 1: List of Dispatch of Experts from Japan

June 2022

Name	Director or Manager	Researcher or Student	From (yy/mm/dd)	To (yy/mm/dd)	Number of days
Mayumi Ishizuka	Research Director	Researcher	2016/07/11	2016/07/17	7
			2017/08/12	2017/08/18	7
			2017/10/14	2017/10/19	6
			2018/08/12	2018/08/18	7
			2018/09/15	2018/09/29	15
			2019/01/26	2019/02/01	7
			2019/08/11	2019/08/22	12
			2019/12/17	2019/12/25	9
			2021/10/02	2021/10/10	9
Shouta Nakayama	Research Manager for Output 2	Researcher	2016/06/09	2016/07/24	46
			2016/10/22	2016/11/07	17
			2017/02/04	2017/02/09	6
			2017/02/26	2017/03/06	9
			2017/05/28	2017/06/05	9
			2017/07/15	2017/09/18	66
			2018/06/09	2018/06/14	6
			2018/08/09	2018/08/19	11
			2019/01/26	2019/03/20	54
			2019/08/10	2019/08/26	17
			2019/10/26	2019/11/02	8
			2019/12/08	2019/12/26	19
			2021/10/02	2021/10/10	9
Masato Hiwatari		Researcher	2016/07/08	2016/07/17	10
			2016/10/22	2016/10/30	9
			2017/03/02	2017/03/12	11
			2017/07/14	2017/07/27	14
			2018/08/13	2018/08/26	14
			2018/08/11	2018/08/19	9
			2019/03/09	2019/03/17	9
			2019/08/17	2019/08/24	8
Toshifumi Igarashi	Research Manager for Output 3	Researcher	2016/07/12	2016/07/16	5
			2016/10/25	2016/10/31	7
			2017/07/12	2017/07/18	7
			2017/09/19	2017/09/24	6
			2017/10/09	2017/10/17	9
			2018/08/12	2018/08/21	10
			2018/10/06	2018/10/15	10
			2019/08/18	2019/08/25	8
			2019/10/27	2019/11/3	8
			2021/10/10	2021/10/17	8
Tsutomu Sato		Researcher	2016/07/12	2016/07/16	5
			2016/10/29	2016/11/07	10
			2017/07/01	2017/07/09	9
			2018/03/08	2018/03/20	13
			2018/08/28	2018/09/07	11
			2019/03/04	2019/03/14	11
Mayumi Ito	Research Manager for Output 3	Researcher	2016/10/25	2016/10/31	7
			2017/02/20	2017/03/05	14
			2017/07/01	2017/07/09	9
			2017/10/01	2017/10/14	14
			2018/02/18	2018/02/26	9
			2018/08/12	2018/08/21	10
			2019/03/08	2019/03/15	8
			2019/08/19	2019/08/25	7

			2021/10/01	2021/10/17	17
Yukihiro Takahashi		Researcher	2016/07/12	2016/07/15	4
Takeshi Saito		Researcher	2016/07/11	2016/07/17	7
Yoshitaka Uchida	Research Manager for Output 1	Researcher	2016/07/02	2016/07/18	17
			2017/01/13	2017/01/23	11
			2017/06/10	2017/06/18	9
			2017/08/16	2017/08/25	10
			2017/10/08	2017/10/15	8
			2018/01/13	2018/01/21	9
			2018/06/08	2018/06/18	11
			2019/01/11	2019/01/24	14
			2019/11/07	2019/11/13	7
Shunitz Tanaka		Researcher	2016/07/02	2016/07/11	10
Kazuhiro Toyoda		Researcher	2016/07/02	2016/07/11	10
			2017/05/01	2017/05/07	7
			2017/09/01	2017/09/10	10
			2019/04/29	2019/05/09	11
Yohannes Yared Beyene		Researcher	2016/06/09	2016/07/16	38
			2016/10/22	2016/11/07	17
			2017/02/26	2017/03/06	9
			2017/07/21	2017/09/07	49
			2018/08/12	2018/08/18	7
Daiju Narita		Researcher	2016/07/08	2016/07/17	10
			2016/10/22	2016/10/30	9
			2017/03/02	2017/03/11	10
			2017/07/14	2017/07/27	14
			2017/08/13	2017/08/28	16
			2018/08/11	2018/08/19	9
			2019/03/09	2019/03/16	8
			2019/08/17	2019/08/24	8
Wakako Fujita		Researcher	2017/02/26	2017/03/06	9
			2017/07/29	2017/08/06	9
John Yabe		Researcher	2016/10/22	2016/11/07	17
Hokuto Nakata		Researcher	2017/02/26	2017/03/06	9
			2017/04/26	2019/04/25	730
			2019/06/25	2019/09/04	72
			2019/09/17	2019/11/01	46
			2019/12/17	2020/03/21	96
			2020/07/27	2020/09/30	66
			2021/01/22	2021/02/26	36
			2021/05/27	2021/07/04	39
			2021/09/27	2021/11/28	63
Kazuyo Hirose		Researcher	2016/07/03	2016/07/18	16
			2017/10/21	2017/10/28	8
Tomomi Takeda		Researcher	2016/07/02	2016/07/17	16
			2017/10/21	2017/10/28	8
Shinsaku Nakamura		Researcher	2016/07/09	2016/07/17	9
			2017/02/18	2017/02/26	9
			2017/10/21	2017/10/29	9
			2019/08/18	2019/08/25	8
Yoshimitsu Negishi		Researcher	2016/07/02	2016/07/17	16
			2017/06/24	2017/07/09	16
Kazunori Nakashima		Researcher	2017/02/20	2017/03/04	13

Kazuhiro Nakashima		Researcher	2019/03/16	2019/03/28	13
Naoto Kiyanagi		Researcher	2016/07/10	2016/07/16	7
			2017/02/20	2017/03/04	13
			2017/10/01	2017/10/14	14
			2017/10/29	2017/11/03	6
			2018/02/18	2018/02/25	8
Kazuo Otomo		Researcher	2016/07/02	2016/07/17	16
			2016/10/29	2016/11/18	21
			2017/02/20	2017/03/04	13
			2017/06/24	2017/07/09	16
			2017/10/01	2017/10/20	20
			2017/10/29	2017/11/03	6
			2018/02/18	2018/02/25	8
			2018/08/12	2018/08/20	9
			2019/03/08	2019/03/15	8
Norio Ikeda		Researcher	2016/10/29	2016/11/18	21
			2017/02/20	2017/03/04	13
			2017/06/24	2017/07/09	16
			2017/10/09	2017/10/20	12
Takahiko Yoshida		Researcher	2017/02/26	2017/03/06	9
			2017/08/12	2017/08/24	13
Akane Chiba		Researcher	2017/06/10	2017/06/18	9
			2017/07/23	2017/08/25	34
			2018/01/13	2018/01/21	9
Harukazu Tohyama		Researcher	2017/07/15	2017/07/23	9
			2018/08/12	2018/08/18	7
Shokichi Sakata		Researcher	2017/10/01	2017/10/14	14
Ikabongo Mukumbuta		Researcher	2016/07/11	2016/07/24	14
			2017/11/01	2018/07/17	259
			2018/07/28	2019/07/15	353
			2019/08/03	2022/03/31	972
Takashi Fujimori		Researcher	2018/08/12	2018/08/18	7
Isabell von Rein		Researcher	2019/01/11	2019/01/24	14
Kanta Zaima		Researcher	2019/03/08	2019/03/15	8
			2019/08/18	2019/08/25	8
Pawit Tangviroon		Researcher	2019/03/08	2019/03/15	8
			2019/08/18	2019/08/25	8
			2019/10/28	2019/11/2	6
Takeshi Kawashima		Researcher	2017/09/20	2017/09/24	5
			2018/10/07	2018/10/13	7
Seiya Hasegawa		Researcher	2017/09/20	2017/09/24	5
Daichi Yamada		Student / Researcher	2016/10/22	2016/10/30	9
			2017/03/01	2017/03/12	12
			2017/07/12	2017/07/21	10
			2017/08/15	2017/09/15	32
			2018/08/12	2018/08/18	7
			2019/03/09	2019/03/16	8
			2019/08/17	2019/08/24	8
Haruya Toyomaki		Student / Researcher	2016/06/09	2016/07/24	46
			2016/10/22	2016/11/07	17
			2016/12/15	2017/05/11	148
			2017/07/18	2017/09/11	56
			2018/08/12	2018/08/18	7

Yui Yoshii		Student	2016/07/02	2016/07/18	17
			2018/08/11	2018/08/18	8
Toru Hamamoto		Student	2016/07/02	2016/07/18	17
			2017/06/11	2017/06/18	8
			2017/10/01	2018/10/10	375
			2019/01/11	2019/01/24	14
Moe Shimozuma		Student	2016/07/12	2016/07/16	5
Shouta Nakano		Student	2016/07/02	2016/07/11	10
Kenta Noto		Student	2016/10/25	2016/10/31	7
			2017/02/20	2017/02/28	9
Wilson Mwandira		Student	2017/02/20	2017/03/05	14
			2017/07/12	2017/07/18	7
			2018/08/27	2018/09/01	6
			2018/08/12	2018/08/27	16
			2019/03/16	2019/03/28	13
Shun Takakuwa		Student	2017/02/20	2017/03/05	14
			2017/07/12	2017/07/18	7
			2017/10/02	2017/10/13	12
Shojiro Yamasaki		Student	2017/02/26	2017/03/06	9
			2017/07/29	2017/08/14	17
Andrew Kataba		Student	2017/02/26	2017/03/06	9
			2017/07/15	2017/08/28	45
			2018/08/12	2018/08/18	7
			2019/08/10	2019/08/26	17
Rio Doya		Student / Researcher	2017/08/12	2017/09/18	38
			2018/08/12	2018/08/18	7
			2021/10/01	2021/10/27	27
Kazuto Iwadate		Student	2017/05/01	2017/05/11	11
Majorie Mbambara		Student	2017/05/01	2017/05/11	11
Jin Ohta		Student	2017/07/12	2017/07/18	7
			2017/10/09	2017/10/17	9
Natsumi Nagai		Student	2017/07/29	2017/08/14	17
Keigo Kimura		Student	2017/10/09	2017/10/17	9
			2018/02/18	2018/02/26	9
			2018/08/12	2018/08/21	10
			2018/10/06	2018/10/15	10
Tomoki Fukushima		Student	2017/02/18	2017/02/26	9
			2018/08/12	2018/08/21	10
			2018/10/06	2018/10/15	10
			2019/10/27	2019/11/3	8
Marthias Silwamba		Student	2018/02/18	2018/02/26	9
			2018/08/12	2018/08/27	16
			2018/10/06	2018/10/18	13
			2019/03/08	2019/03/19	12
			2019/10/27	2019/11/5	10
Tsubasa Hagino		Student	2018/08/12	2018/08/21	10
Yasuto Yoshida		Student	2019/01/11	2019/01/23	13
			2019/08/06	2019/08/26	21
Tsukino Ito		Student	2019/01/11	2019/01/23	13
Lawrence Kalaba		Student	2017/07/01	2017/07/16	16
			2018/03/01	2018/04/02	33
Hiroaki Kamegamori		Student	2017/07/01	2017/07/09	9
			2018/03/08	2018/03/20	13

			2018/08/28	2018/09/07	11
Daiki Shimazui		Student	2018/08/28	2018/09/07	11
			2019/03/04	2019/03/14	11
Cryton Phiri		Student	2019/03/04	2019/03/29	26
Kenta Nakajima		Student	2017/10/02	2017/10/13	12
Ryota Hashizume		Student	2019/10/27	2019/11/3	8
Takamitsu Ohigashi		Student	2019/11/07	2019/11/13	7
Kodai Motohira		Student	2019/08/10	2019/08/26	17
Musavi Yvonne Madegwa		Student	2019/11/07	2019/11/13	7
Walubita Mufalo		Student	2021/10/02	2021/10/31	30

Annex 2. List of Zambian students in Master or Ph.D course of Hokkaido University

June 2022

Name	Course	School	Year
Mbambara Majorie	Master	Graduate School of Environmental Earth Sciences	Apr 2017 - Mar 2019
Lawrence Kalaba	Master	Graduate School of Engineering	Apr 2017 - Mar 2019
Ikabongo Mukumbuta	Ph.D.	Graduate School of Agriculture	Oct 2014 - Sep 2017
Wilson Mwandira	Ph.D.	Graduate School of Engineering	Apr 2017 - Sep 2019
Marthias Silwamba	Ph.D.	Graduate School of Engineering	Apr 2018 - Mar 2021
Andrew Kataba	Ph.D.	Graduate School of Veterinary Medicine	Apr 2017 - Mar 2021
Walubita Mufalo	Ph.D.	Graduate School of Engineering	Oct 2019 -

Annex 3: List of Zambian Members who traveled to Japan for capacity development

June 2022

	Group	Name	Affiliation	Position	Travel Period
1	Group 1	Kabenuka Munthali	UNZA / Zambia Agriculture Research Institute, Ministry of Agriculture	Student, School of Agriculture	31 Oct 2017 to 1 Dec 2017
2	Group 1	Mukuka Mwansa	UNZA / Ministry of Agriculture	Student, School of Agriculture	31 Oct 2017 to 1 Dec 2017
3	Group 1	Charity Mundia	Zambia Environmental Management Agency	Senior Inspector	31 Oct 2017 to 15 Nov 2017
4	Group 2	Nosiku S. Munyinda	UNZA, School of Public Health	School of Publich Health	27 Oct 2017 to 26 Nov 2017
5	Group 2	Doreen Sakala	Ministry of Health	CEHO-OHS	27 Oct 2017 to 26 Nov 2017
6	Group 2	Chrispin Mphuka	UNZA, School of Humanty Science	Head of Department of Economics	27 Oct 2017 to 17 Nov 2017
7	Group 2	Bona M. Chitah	UNZA, School of Humanty Science	Lecturer, Department of Economics	27 Oct 2017 to 17 Nov 2017
8	Group 2	Peter Hangoma	UNZA, School of Public Health	Lecturer, School of Publich Health	27 Oct 2017 to 17 Nov 2017
9	Group 3	Imasiku A. Nyambe	UNZA, School of Mines	Director of Research and Graduate Studies, School of Mines	31 Oct 2017 to 15 Nov 2017
10	Group 3	Meki Chirwa	UNZA, School of Mines	Chief Scientist, School of Mines	31 Oct 2017 to 1 Dec 2017
11	Group 2	Golden Zyambo	UNZA, School of Veterinary Medicine	Chief Scientist, School of Veterinary Medicine	17 July 2018 to 28 Sep 2018

KAMPAI Project Handover Equipment List

(More than 50,000 yen value per unit)

Group 1) Scool of Agricultural Sciences, UNZA

(The exchange rate uses the JICA Monthly Transaction Rate)

#	Item	Currency	Unit price	Q'ty	Total	Total in J-yen	Procurement in	Date of introduction
1	Spectroradiometer (FieldSpec4)	JPY	10,000,000	1	10,000,000	10,000,000	Japan	Aug 2017
2	Weather station (POTEKA)	JPY	1,250,000	2	2,500,000	2,500,000	Japan	Aug 2017
3	Weather station (SESAME)	JPY	930,000	2	1,860,000	1,860,000	Japan	Aug 2017
4	CO2 analyzer	JPY	825,000	1	825,000	825,000	Japan	Feb 2017
5	Soil respiration analyzer	JPY	745,000	1	745,000	745,000	Japan	Feb 2017
6	EC meter	JPY	98,000	1	98,000	98,000	Japan	May 2017
7	ORP meter	JPY	65,000	1	65,000	65,000	Japan	May 2017
8	Desktop pH meter with accessories	JPY	66000	1	66,000	66,000	Japan	May 2017
9	Greenhouse(8mx12m)/ HAYGROVE PIONEER 4 SERIES POLY TUNNELS	ZMK	74,358	1	74,358	610,330	Zambia	Oct 2019
					Total	16,769,330		

Group 2) School of Veterinary Medicine, UNZA

#	Item	Currency	Unit price	Q'ty	Total	Total in J-yen	Procurement in	Date of introduction
1	TOYOTA Land Cruiser (BAE 5283)	USD	50,036	1	50,036	5,761,145	Zambia	Feb 2017
2	HP Color LaserJet Pro MFP M477fnw 4in1 -	ZMK	6,726	1	6,726	69,231	Zambia	Oct 2016
3	HP Personal Computer 15 Note Book	ZMK	6,586	1	6,586	75,429	Zambia	Dec 2016
4	HP Color LaserJet Pro MFP M477fdw 4in1 -	ZMK	22,668	1	22,668	273,921	Zambia	Sep 2017
5	40kVA Generator with shelter and fence	USD	15,866	1	15,866	1,767,429	Zambia	Sep 2018
6	Shelter and fence for 40kVA Generator	ZMK	13,650	1	13,650	149,850	Zambia	Sep 2018
7	10kVA UPS	ZMK	32,116	2	64,232	600,312	Zambia	Oct 2018
8	10kVA UPS	ZMK	82,320	1	82,320	403,533	Zambia	May 2021
9	3kVA UPS	ZMK	16,213	3	48,639	454,580	Zambia	Oct 2018
10	40 feet Container/warehouse for KAMPAI Monitoring Laboratory	ZMK	39,095	1	39,095	358,736	Zambia	Feb 2019
11	-20℃ deep freezer (vertical)	ZMK	6,919	1	6,919	86,813	Zambia	Jul 1917
12	-20℃ deep freezer (horizontal)	ZMK	9,995	1	9,995	48,906	Zambia	Jun 2021
13	-80℃ deep freezer	JPY	750,000	2	1,500,000	1,500,000	Japan	Oct 2018 Oct 2021
14	Microwave digestion system (Speed wave entry) with accessories	JPY	2,600,000	2	5,200,000	5,200,000	Japan	Oct 2018 Oct 2021
15	Microwave digestion system vessel	JPY	100,000	10	1,000,000	1,000,000	Japan	Feb 2020
16	Microwave digestion system turning table	JPY	110,000	1	110,000	110,000	Japan	Feb 2021
17	Atomic Absorption Spectrometry accessories	JPY	1,300,000	1	1,300,000	1,300,000	Japan	Dec 2018
18	Atomic Absorption Spectrometry with accessories	JPY	4,000,000	1	4,000,000	4,000,000	Japan	Dec 2018
19	Cooling water circulator (chiller)	JPY	200,000	2	400,000	400,000	Japan	Dec 2018 Oct 2021
20	Silent air compressor	JPY	260,000	1	260,000	260,000	Japan	Dec 2018
21	Draft chamber	JPY	1,700,000	1	1,700,000	1,700,000	Japan	Oct 2018
22	230V Centrifugal Fan Set CMP 514-4M/AL	JPY	160,000	1	160,000	160,000	Japan	Feb 2020
23	230V Centrifugal Fan Set CMP 616-4M/AL	JPY	180,000	1	180,000	180,000	Japan	Feb 2020
24	Speed Controller RM-01	JPY	80,000	2	160,000	160,000	Japan	Feb 2020
25	Mercury analyzer with accessories	JPY	5,000,000	1	5,000,000	5,000,000	Japan	Feb 2021
26	Air compressor	JPY	450,000	1	450,000	450,000	Japan	Feb 2021
27	Small program electric furnace	JPY	140,000	1	140,000	140,000	Japan	Feb 2021
28	Metal analyzer MP-AES Agilent 4210 with accessories	JPY	5,440,000	1	5,440,000	5,440,000	Japan	Oct 2021
29	Air/nitrogen gas generator	JPY	2,320,000	1	2,320,000	2,320,000	Japan	Oct 2021
30	Autosampler	JPY	1,400,000	1	1,400,000	1,400,000	Japan	Oct 2021
31	Sirocco fan and inverter	JPY	50,000	1	50,000	50,000	Japan	Oct 2021
32	Lab table small with wagon	JPY	130,000	2	260,000	260,000	Japan	Oct 2021
33	Lab table large	JPY	200,000	1	200,000	200,000	Japan	Dec 2018

34	Forced air flow oven and stand	JPY	160,000	2	320,000	320,000	Japan	Feb 2019
35	Down transformer	JPY	50,000	10	500,000	500,000	Japan	Oct 2018, Feb & Oct 2021
36	Lead care II Analyzer	USD	2,440	3	7,320	813,128	SOUTH AFRICA	Jun 2017
37	DW maker	JPY	620,000	1	620,000	620,000	Japan	Feb 2017
38	DDW (Milli-Q water) maker	JPY	390,000	1	390,000	390,000	Japan	Feb 2017
39	Water softening plant	JPY	130,000	1	130,000	130,000	Japan	July 2019
40	Autoclave quipment	JPY	530,000	1	530,000	530,000	Japan	Oct 2018
41	Thermal cycler	JPY	76,000	1	76,000	76,000	Japan	Feb 2018
42	Thermal cycler	JPY	350,000	1	350,000	350,000	Japan	July 2019
43	Realtime PCR with laptop computer and accessories	JPY	1,620,000	1	1,620,000	1,620,000	Japan	Oct 2018
44	DNA/RNA sequencer MinION	JPY	500,000	1	500,000	500,000	Japan	Feb 2018
45	Fluorometer	JPY	210,000	1	210,000	210,000	Japan	Feb 2018
46	Beads crusher and accessories	JPY	340,000	1	340,000	340,000	Japan	Dec 2018
47	Plate reader	JPY	500,000	1	500,000	500,000	Japan	July 2019
48	Spectrophotometer / fluorometer DS-11	JPY	1,230,000	1	1,230,000	1,230,000	Japan	Feb 2021
49	Vortex mixer	JPY	43,000	2	86,000	86,000	Japan	Feb 2021
50	Clean bench	JPY	150,000	1	150,000	150,000	Japan	Oct 2018
51	Blood biochemical analyzer	JPY	1,000,000	1	1,000,000	1,000,000	Japan	Oct 2018
52	Thermostat dry bath with accessories	JPY	70,000	1	70,000	70,000	Japan	Feb 2018
53	Desktop centrifuge A with accessories	JPY	150,000	4	600,000	600,000	Japan	May 2017
54	Desktop centrifuge B with accessories	JPY	670,000	1	670,000	670,000	Japan	Feb 2017
55	Refrigerated centrifuge with accessories	JPY	910,000	1	910,000	910,000	Japan	Dec 2018
56	Electronic balance	JPY	130,000	2	260,000	260,000	Japan	Feb 2018
57	Multi shaker with holder	JPY	300,000	1	300,000	300,000	Japan	Feb 2017
58	pH meter	JPY	70,000	1	70,000	70,000	Japan	July 2019
59	Multi function water quality meter	JPY	150,000	1	150,000	150,000	Japan	May 2017
60	Ultrasonic washing machine	JPY	136,000	1	136,000	136,000	Japan	Feb 2018
61	Low volume air sampler	JPY	800,000	1	800,000	800,000	Japan	Feb 2017
62	Agate motrar and pestle	JPY	82,000	1	82,000	82,000	Japan	May 2017
63	Hyperspectrum camera with accessories	JPY	4,670,000	1	4,670,000	4,670,000	Japan	Feb 2021
64	Cephalostat	JPY	154,000	1	154,000	154,000	Japan	Feb 2021
65	Gas cylinder stand	JPY	26,000	3	78,000	78,000	Japan	Feb 2021 Oct 2021
66	Dry shipper	JPY	630,000	1	630,000	630,000	Japan	Feb 2021
67	Ice crusher	JPY	90,000	1	90,000	90,000	Japan	Feb 2021
68	Vein viewer	JPY	80,000	3	240,000	240,000	Japan	Oct 2016
69	Dryice maker	JPY	150,000	1	150,000	150,000	Japan	May 2017
70	LED illuminators FAS-Digi	JPY	85,000	1	85,000	85,000	Japan	July 2019
71	Digital camera	JPY	78,000	1	78,000	78,000	Japan	July 2019
					Total	60,868,011		

Group 3) School of Mines, UNZA

#	Item	Currency	Unit price	Q'ty	Total	Total in J-yen	Procurement in	Date of introduction
1	Weather station	JPY	1,180,000	1	1,180,000	1,180,000	Japan	Feb 2017
2	Electronic fuenace	JPY	320,000	1	320,000	320,000	Japan	Oct 2018
3	Down transformer	JPY	59,000	1	59,000	59,000	Japan	Oct 2018
4	Portable XRD/XRF equipment and accessories	JPY	10,670,000	1	10,670,000	10,670,000	Japan	Feb 2017
5	Bore hole	USD	4,778	3	14,333	1,501,570	Zambia	Nov 2016
					Total	13,730,570		

Group 1 & 3) Kabwe Municipal Council

#	Item	Currency	Unit price	Q'ty	Total	Total in J-yen	Procurement in	Date of introduction
1	Wire fence and gate surrounding greening site	ZMK	6,205	1	6,205	69,273	Zambia	Jan 2018
2	Temporary shelter for security guard	ZMK	2,450	1	2,450	27,352	Zambia	Jan 2018
3	Bore hole / Green park	ZMK	39,000	1	39,000	430,755	Zambia	May 2018
4	Water pump with solar power generation system	ZMK	33,840	1	33,840	373,763	Zambia	May 2018
5	Steel fence surrounding water pump and solar power system	ZMK	31,235	1	31,235	344,991	Zambia	May 2018
6	Parmanent shelter for security guard	ZMK	44,291	1	44,291	486,674	Zambia	Jun 2018
7	Flush toilet with sanitary facilities	ZMK	19,915	1	19,915	219,961	Zambia	May 2018
8	Bore hole / EPL	USD	4,778	3	14,333	1,501,570	Zambia	Nov 2016
					Total	3,454,338		

Amount and breakdown of local expenses

Project cooperation period: 10 June 2016 ～ 9 June 2022 (6 years)

(Unit:Kwacha)

Items/JFY (JFY: Japanese Fiscal Year)		2016	2017	2018	2019	2020	2021	2022	Total
1	Miscellaneous	497,262	1,401,023	1,418,254	641,845	85,834	929,521	41,001	5,014,740
2	Travel Expenses (Air fare)	0	4,655	41,165	0	0	0	0	45,820
3	Travel Expenses (ex. Air fare)	0	0	0	97,085	2,300	21,240	290	120,915
4	Commission contract	0	516,800	0	142,859	0	129,600	15,800	805,059
Total		497,262	1,922,478	1,459,419	881,789	88,134	1,080,361	57,091	5,986,534

Annex 6: The list of Zambian member

June 2022

No	Name	Institute/Organization	position	Remarks	Project director, manager, and main contributor for project coordination and document preparation	Responsibility/ Group
1	Prof. Luke E Mumba	UNZA	Vice Chancellor	Project Director	○	1~3
2	Prof. Enala Tembo Mwase	UNZA	Deputy Vice Chancellor	Acting Project Director	○	1~3
3	Prof. King Nalubamba	UNZA	Dean of School of Veterinary Medicine	Dean	○	2
4	Dr. Kennedy Choongo	UNZA	Lecturer, Biomedical Department, School of Veterinary Medicine	Group 2 Exposure Assement team	○	2
5	Dr. John Yabe	UNZA	Lecturer, Head of Paraclinical Studies Department, School of Veterinary Medicine	Group 2 Exposure Assement team/ Group 2 Leader	○	2
6	Dr. Kaampwe Muzandu	UNZA	Lecturer, Former Head of Biomedical Department, School of Veterinary Medicine	Group 2 Exposure Assement team/ Group 1 Leader	○	2
7	Mr. Golden Zyambo	UNZA	Chief Scientist, School of Veterinary Medicine	Group 2 Exposure Assement team		2
8	Dr. Roy Mwenechanya	UNZA	Lecturer, Head of Biomedical Department, School of Veterinary Medicine	Group 2 Exposure Assement team	○	2
9	Dr. Stephens Kambani	UNZA	Lecturer, School of Mines	Head, Department of Mining Engineering		3
10	Prof. Imasiku A. Nyambe	UNZA	Professor, School of Mines	Group 3 Leader, Participant of short-term invitation program in 2017	○	1, 3
11	Dr. Kawawa Banda	UNZA	Lecturer, Hydrogeology, School of Mines	Group 1&3 member（Staying at Rep of South Africa until September 2018）	○	1, 3
12	Dr. Meki Chirwa	UNZA	Lecturer, Department of Geology, the School of Mines	Group 3 member, works with Kizuna members & Prof. Igarashi and Dr. Ito, Participant of short-term invitation program in 2017	○	1, 3
13	Dr. Chrispin Mphuka	UNZA	Head of Department of Economics, School of Humanities and Social Science	Group 2 Economic Assessment team Participant of short-term invitation program in 2017		2
14	Dr. Bona M. Chitah	UNZA	Lecturer, Department of Economics, , School of Humanities and Social Science	Group 2 Economic Assessment team Participant of short-term invitation program in 2017		2
15	Dr. Beatrice Matafwali	UNZA	Lecturer, School of Education	Group 2 IQ analysis team		2
16	Mr. Brighton Kateka	Ministry of Mines and Minerals Development	Chief Inspector, Safety Department	Participant of planning meeting prior to the beginning of project (from Ministry of Mines)		1, 3
17	Mr. Gideon Ndalama	Ministry of Mines and Minerals Development	Director of Mines Safety Department	Signer of Minutes (16 Oct 2015). ZMERIP Coordinator		1, 3
18	Mr. Absalon Sakala	Ministry of land, Natural Resources and Environment Protection-Environment and Natural Resources Management Department	Environmental Management Officer	Signer of Minutes (16 Oct 2015). Participant of planning meeting prior to the beginning of project (from Ministry of Lands). In Oct 2017, competent ministry changed due to reorganization.		1, 3
19	Dr. Chanda Kapata	Ministry of Health	Head of Research Department	Acting signer of Minutes (16th Oct 2015) due to the absence of Dr. Elizabeth Chizema. Currently, out of Country (-2017)		2
20	Ms. Doreen Sakala	Ministry of Health	CEHO-OHS	Group 2 Health team, key-person for the collaboration with MOH. Participant of short-term invitation program in 2017.		2

21	Mr. Binwell Mwansa	Ministry of Higher Education	Director, Human Resources Administration	Participant of planning meeting prior to the beginning of project		2
22	Dr. Elizabeth Chizema	Ministry of Health	Director	Visited Hokkido University in Dec 2016 and attended KAMPAI seminar		2
24	Mr. Spiriano Banda	Ministry of Higher Education	System analist	Participant of first JCC meeting (Kick Off symposium)		2
26	Ms. Esther Mulekwa Nkomo	Ministry of Lands	Senior Environmental Management Officer	competent ministry changed due to reorganization in Oct 2017.		1, 3
28	Joshua Chimusambo	Ministry of Mines and Minerals Development	Geologist	Participant of first JCC meeting (Kick Off symposium)		1, 3
29	Evaristo Kasunba	Ministry of Mines and Minerals Development	Senior Geologist	Participant of first JCC meeting (Kick Off symposium)		1, 3
30	Billy Chewe	Ministry of Mines and Minerals Development	Chief Mining Engineer	Participant of first JCC meeting (Kick Off symposium)		1, 3
31	George Milohao	Ministry of Mines and Minerals Development	Mining Engineer	Participant of first JCC meeting (Kick Off symposium)		1, 3
32	Mulowuwe Simukan	Ministry of Mines and Minerals Development	Mining Engineer	Participant of first JCC meeting (Kick Off symposium)		1, 3
33	Chaanza Chifwepa	Ministry of Mines and Minerals Development	Geologist	Participant of first JCC meeting (Kick Off symposium)		1, 3
34	Alphet Dokowe	Ministry of Mines and Minerals Development	Chief Geologist	Participant of first JCC meeting (Kick Off symposium)		1, 3
35	Mr. Paul Mukuka	Kabwe Municipla Council	Director of Public Health Department	ZMERIP Coordinator		1~3
36	Mr. Ronald Daka	Kabwe Municipal Council	Town Clerk	Minutes (2015.10.16) signer. Gave the site to the project for group 1 activity.		1~3
37	Dr. Mwamba Katema	Kabwe District Health Office	Medical Doctor	Acting of Dr. Mfune		2
38	Mr. John Ntapisha	Kabwe District Health Office	Chief Laboratory Technician	Staff under Dr. Mfune		2
39	Dr. Tembo Backsion	UNZA	Chemistry	Group 2 Exposure Assesment team		2
40	Dr. Peter Hangoma	UNZA	School of Publich Health	Group 2 Economic Assessment team Participant of short-term invitation program in 2017		2
41	Prof. Robert Serphell	UNZA	School of Education	Group 2 IQ analysis team (-Dec 2017)		2
42	Mr. Gabliel Walubita	UNZA	School of Education	Group 2 IQ analysis team (-Feb 2018)		2
43	Mr. Kalima Kalima	UNZA	School of Education	Group 2 IQ analysis team		2
44	Ms. Nosiku Sipilanyambe Munyinda	UNZA	School of Publich Health	Group 2 Neurodevelopment team. Participant of short-term invitation program in 2017		2
45	Dr. Nancy Zyongwe	UNZA/Capacity Strengthening Zambia Prevention CareTreatment II Bridge	Senior Advisorl	Group 2 Neurodevelopment team		2
46	Ms. Sandra Shanunga	UNZA	Psychosocial Consultant	Group 2 Neurodevelopment team		2
47	Dr. Charity Nalweya	ZEMA	Manager Natural Resources and Climate Change	Group 1, key-person for the collaboration with ZEMA. Participant of short-term invitation program in 2017		1, 3
48	Dr. Benson Chishala	UNZA	Dean, School of Agriculture	Group 1 Leader	○	1
49	Dr. Elijah Phiri	UNZA	School of Agriculture	Supervisor for Mr. Hamududu		1
50	Mr. Victor Shitumbanuma	UNZA	School of Agriculture	Former supervior for Mr. Kabenuka and Mr. Mukuka, Supervior for new students		1
51	Mr. Mukuka Mwansa	UNZA	School of Agriculture	Waiting for graduation (-Dec 2017) Participant of short-term invitation program in 2017		1
52	Mr. Kabenuka Munthali	UNZA	School of Agriculture	Waiting for graduation (-Dec 2017) Participant of short-term invitation program in 2017		1
53	Mr. Emmanuel Mulenga	ZEMA	Senior Inspector	Group 1		1
54	Aaron Soko	Ministry of Mines and Minerals Development	Head of Mine Safety Department	Participant of planning meeting at the beginning of project (July 2016)		1, 3
55	Patson Zulu	ZEMA	Acting Director General	Participant of planning meeting prior to the beginning of project (April 2016)		1, 3

56	David Kapindula	ZEMA	Manager Southern Region Office	Participant of meeting for application of pilot-scale study using contaminated soil (Feb 2017)		1, 3
57	Peter Malopa Mwanza	ZEMA	Inspector	Participant of planning meeting before the beginning of project (2015)		1, 3
58	Mr. Sydney Chikalipah	UNZA	Student	Waiting for graduation (-2017.12)		1, 3
59	Mr. Lubinda Nasilele	UNZA	Master course student, School of Mines	Waiting for graduation (-2017.12)		1, 3
60	Naphtallie Banda	Ministry of Energy and Water Development	District Water Development Officer	Participant of planning meeting at the beginning of project (July 2016)		1, 3
61	Succeed Mubanga	Ministry of Higher Education	Chief Planner	Participant of planning meeting prior to the beginning of project (from Ministry of Higher Education)		1~3
62	Norau Kacheha	Kabwe District Medical Office	Environmental Health, Kabwe District Health Officer	transferred to out of Kabwe（-2017）		2
63	Musamvie Wauki	Kabwe Municipla Council	Provincial Land Officer	transferred to out of Kabwe（-2017）		1~3
64	Mr. Sangwani Sichinga	Kabwe District Education Board	Planner	transferred to out of Kabwe（-2017）		1~3
65	Ms. Naomi Sakala	Kabwe Municipal Council	Director of Planning	Participant of first JCC meeting (Kick Off symposium)		1~3
66	Ms. Pamela Zulu	Kabwe Municipal Council	Department of Housing	transferred to out of Kabwe（-2017）		1~3
67	Dr. Tiza Mufune	Kabwe District Health Office	District Medical Officer	Ke-person for the collaboration with Kabwe District health office and ZMERIP. Principal Investigator of ZMERIP health component		2
68	Dr. Alan Liazambi	Central Provincial Fisheries and Livestock Office	Provincial Veterinay Officer	Key-person for the animal sampling in Kabwe		2
69	Dr. Alisheke Mutemwa	Central Provincial Fisheries and Livestock Office	Provincial Veterinary Coordinator	Key-person for the animal sampling in Kabwe. Gave a satellite laboratory to the project.		2
70	Mr. Chrispin Chitefwe	UNZA	Student, School of Agriculture	Group 1 (Dec. 2017) Changed research topics		1
71	Mr. Sydney Kulelwa	UNZA	Student, School of Agriculture	Group 1 (Dec 2017) Changed research topics		1
72	Dr. Lydia Chabala	UNZA	Head of Soil Science Department, School of Agriculture	Former Supervisor for Mr. Kabenuka Munthali and Mr. Mukuka Mwansa		1
73	Ms. Bridget Handiya	Kabwe District Health Office	Chief Nurse	Key-person for the collaboration with Kabwe District health office.		2
74	Mr. Friday Hannah Zimba	Kabwe Municipal Council	Director of Administration	Key-person for the local labor hire.		1~3
75	Ms. Angela Shibeene	Kabwe Municipal Council	Director of Housing	Participated of 2nd JCC. Key-person for the collaboration with KMC		1~3
76	Mr. Mike Glynn Moonga	Kabwe Municipal Council	Planning officer	Key-person for the collaboration with KMC especially for land use.		1~3
77	Mr. Sydney Mfune	UNZA	Student, School of Agriculture	Group 1 5th Year Student (Jan 2018-) working with Dr. Ikabongo		1
78	Mr. Byde Jobolola Hamududu	UNZA	Student, School of Agriculture	Group 1 5th Year Student (Jan 2018-) working with Dr. Ikabongo		1
79	Dr. Miyanda Moombe	UNZA	Lecturer, Soil Science, School of Agriculture	Supervisor for Sydney Mfune		1
80	Dr. Mirriam Phiri Chiwoya	UNZA	Lecturer, Soil Science, School of Agriculture	Former Supervisor for S. Mfune		1
81	Dr. Edward Chomba	Minstry of Water Sanitation Development and Environmental Protection	Permanent Secretary	became competent ministry due to reorganization in Oct 2017.		1, 3
82	Dr. Chizumba Shepande	UNZA	Lecturer, School of Agriculture, UNZA	Supervisor for Hamududu		1
83	Ms. Mweemba Sinkombo	UNZA	Student, IWRM centre, UNZA	Participant of field survey in Feb 2018		3
84	Mr. Taonga Chirwa	UNZA	Student, School of Mines	Work with Dr. Meki (sample analysis and data collecting)		3
85	Mr. Given Moonga	UNZA	Lecturer, School of Public Health	Group 2 Health team & ZMERIP		2

86	Ms. Lweendo Hachamba	UNZA	Intern, School of Public Health, Ridgeway campas UNZA	research assistant of neurodevelopment research in 2017		2
87	Ms. Grace Ndashe	UNZA	Student, School of Veterinary Medicine	Master course student of Biomedical department, School of Veterinary		2
88	Dr. Zikani Kaira	Kabwe District Education Board	Secretary	Joined the project in Nov 2017 due to his new assignment at Kabwe		2
89	Mr. Shalubala Goodson	UNZA	Student, School of Public Health	research assistant of neurodevelopment research in 2017		2
90	Mr. Major Simuvuka	UNZA	Student, School of Public Health	research assistant of neurodevelopment research in 2017		2
91	Mr. Saviour Mwila	UNZA	Student, School of Public Health	research assistant of neurodevelopment research in 2017		2
92	Ms. Mwiinga Dalphine	UNZA	Student, School of Public Health	research assistant of neurodevelopment research in 2017		2
93	Dr. Geoffrey Mainda	Central Provincial Fisheries and Livestock Office	District Veterinary Officer	Key-person for the animal sampling in Kabwe.		2
94	Mr. Samuel C. Maango	National Remote Sensing Centre	Acting Director	Participant of planning meeting prior to the beginning of project		1~3
95	Mr. Mutimba Kawisha	National Remote Sensing Centre	Intern	research assistant in 2017		1~3
96	Ms. Loziwe Chilufya	Minstry of Fisheries and Livestock	Senior Fisheries Research Officer, Departmen of Fisheries	Co-researcher of Dr. Muzandu		2
97	Tamara Kabali	UNZA	Lecturer, School of Humanities, Psychlogy Departmnt	Joined the project in May 2018		2
98	Kelsey Parker	UNZA	Researcher, Department of Soil Science, School of Agriculture	Joined the project in Sep 2018		1
99	Patricia Nalishebo Mwiola	UNZA	Masters student, Soil Science department, School of Agriculture	Joined the project in Nov 2018		1
100	Rhoda Kabaso	UNZA	undergraduate student, Soil Science department, School of Agriculture	Joined the project in Nov 2018		1
101	Choolwe Halwiindi	UNZA	undergraduate student, Soil Science department, School of Agriculture	Joined the project in Nov 2018, but changed the research topic		1
102	Zungukanji Nachilongo	UNZA	undergraduate student, Soil Science department, School of Agriculture	Joined the project in Feb 2019		1
103	Walubita Mufalo	UNZA	Research fellow, School of Mines	Joined the project in Feb 2019		3
104	Steve Lungu	UNZA	undergraduate student, Soil Science department, School of Agriculture	Joined the project in Feb 2019		1
105	Dr. Jones Yengwe	UNZA	Lecturer, Soil Science department, School of Agriculture	Supervisor of Zungukanji Nachilongo and Steve Lungu. Joined the project in Feb 2019		1
106	Tina Ndunguyonga	UNZA	undergraduate student, School of Mines	Joined the project in Mar 2019		3
107	George Nkonde	UNZA	undergraduate student, School of Mines	Joined the project in Mar 2019		3
108	Gilbert Simasiku	UNZA	undergraduate student, Soil Science department, School of Agriculture	Joined January 2020		1
109	Michael Mwenda	UNZA	undergraduate student, Soil Science department, School of Agriculture	Joined January 2020		1
110	Mabvuto Phiri	UNZA	MSc Student, Soil Science depart, School of Agriculture	Joined January 2020		1
111	Moses Mulenga	UNZA	MSc Student, Soil Science depart, School of Agriculture	Joined January 2020		1
112	Corette Nchimunya	UNZA	Intern, Department of Health Policy and Management, UNZA	Joined January 2020		2
113	Andrew Kataba	UNZA	Lecturer, Biomedical Department, School of Veterinary Medicine		○	2

114	Marthias Silwamba	UNZA	Lecturer, School of Mines		○	3
115	Simon Mwansa	ZEMA	Acting Director General	Joined 2021		1, 3

Note: Persons who are highlighted with gray were excused from the project.

Annex 7: Facilities and inputs provided by Zambian side

June 2022

No.	Item	Content	Venue	Amount (ZMW)	Japanese Financial Year	Remarks
1	Facility maintenance	Water, electricity	UNZA	5,000	2016	
2	Room	Toll	UNZA	10,000	2016	Laboratory, office, seminar room, meeting room etc.
3	Cleaning	Detergent	UNZA	600	2016	
4	Material	Office desk, chair, air conditioner	UNZA	20,000	2016	
5	Facility maintenance	Water, electricity	UNZA	7,200	2017	(600ZMW*12 months)
6	Room	Toll	UNZA	18,000	2017	(1,500ZMW*12 months)
7	Cleaning	Detergent	UNZA	960	2017	(80ZMW*12 months)
8	Land	Toll	UNZA	18,000	2017	at School of Veterinary Medicine and School of Mines. (3,000ZMW*6 months)
9	Facility maintenance	Electricity	Kabwe Municipal Council	600	2017	(100ZMW*6 months)
10	Room	Toll	Kabwe Municipal Council	6,000	2017	(1,000ZMW*6 months)
11	Cleaning	Detergent	Kabwe Municipal Council	300	2017	(50ZMW*6 months)
12	Material	Office desk, chair	Kabwe Municipal Council	4,000	2017	
13	Land	Toll	Kabwe Municipal Council	24,000	2017	Greening project site (3,000ZMW*8 months)
14	Facility maintenance	Water, electricity	Central Provincial Livestock and Fisheries office	1,800	2017	(200ZMW*9 months)
15	Room	Toll	Central Provincial Livestock and Fisheries office	3,600	2017	(400ZMW*9 months)
16	Cleaning	Detergent	Central Provincial Livestock and Fisheries office	450	2017	(50ZMW*9 months)
17	Facility maintenance	Water, electricity	UNZA	7,200	2018	(600ZMW*12 months)
18	Room	Toll	UNZA	18,000	2018	(1,500ZMW*12 months)
19	Cleaning	Detergent	UNZA	960	2018	(80ZMW*12 months)
20	Land	Toll	UNZA	36,000	2018	at School of Veterinary Medicine and School of Mines. (3,000ZMW*12 months)
21	Facility maintenance	Electricity	Kabwe Municipal Council	1,200	2018	(100ZMW*12 months)
22	Room	Toll	Kabwe Municipal Council	12,000	2018	(1,000ZMW*12 months)
23	Cleaning	Detergent	Kabwe Municipal Council	600	2018	(50ZMW*12 months)
24	Land	Toll	Kabwe Municipal Council	36,000	2018	(3,000ZMW*12 months)
25	Labor	Watchmen at greening site	Kabwe Municipal Council	16,800	2018	(1,400ZMW*12 months)
26	Facility maintenance	Water, electricity	Central Provincial Livestock and Fisheries office	2,400	2018	(200ZMW*12 months)
27	Room	Toll	Central Provincial Livestock and Fisheries office	4,800	2018	(400ZMW*12 months)
28	Cleaning	Detergent	Central Provincial Livestock and Fisheries office	600	2018	(50ZMW*12 months)
29	Facility maintenance	Water, electricity	UNZA	7,200	2019	(600ZMW*12 months)
30	Room	Toll	UNZA	18,000	2019	(1,500ZMW*12 months)
31	Cleaning	Detergent	UNZA	960	2019	(80ZMW*12 months)

32	Land	Toll	UNZA	36,000	2019	at School of Veterinary Medicine and School of Mines. (3,000ZMW*12 months)
33	Facility maintenance	Electricity	Kabwe Municipal Council	1,200	2019	(100ZMW*12 months)
34	Room	Toll	Kabwe Municipal Council	12,000	2019	(1,000ZMW*12 months)
35	Cleaning	Detergent	Kabwe Municipal Council	600	2019	(50ZMW*12 months)
36	Land	Toll	Kabwe Municipal Council	36,000	2019	(3,000ZMW*12 months)
37	Labor	Watchmen at greening site	Kabwe Municipal Council	16,800	2019	(1,400ZMW*12 months)
38	Facility maintenance	Water, electricity	Central Provincial Livestock and Fisheries office	600	2019	(200ZMW*3 months)
39	Room	Toll	Central Provincial Livestock and Fisheries office	1,200	2019	(400ZMW*3 months)
40	Cleaning	Detergent	Central Provincial Livestock and Fisheries office	150	2019	(50ZMW*3 months)
41	Facility maintenance	Water, electricity	UNZA	7,200	2020	(600ZMW*12 months)
42	Room	Toll	UNZA	18,000	2020	(1,500ZMW*12 months)
43	Cleaning	Detergent	UNZA	960	2020	(80ZMW*12 months)
44	Land	Toll	UNZA	36,000	2020	at School of Veterinary Medicine and School of Mines. (3,000ZMW*12 months)
45	Facility maintenance	Electricity	Kabwe Municipal Council	200	2020	(100ZMW*2 months)
46	Room	Toll	Kabwe Municipal Council	2,000	2020	(1,000ZMW*2 months)
47	Cleaning	Detergent	Kabwe Municipal Council	100	2020	(50ZMW*2 months)
48	Land	Toll	Kabwe Municipal Council	36,000	2020	(3,000ZMW*12 months)
49	Labor	Watchmen at greening site	Kabwe Municipal Council	16,800	2020	(1,400ZMW*12 months)
50	Facility maintenance	Water, electricity	UNZA	7,200	2021	(600ZMW*12 months)
51	Room	Toll	UNZA	20,000	2021	(1,500ZMW*12 months + 500ZMW*4 months)
52	Cleaning	Detergent	UNZA	960	2021	(80ZMW*12 months)
53	Land	Toll	UNZA	36,000	2021	at School of Veterinary Medicine and School of Mines (3,000ZMW*12 months)
54	Land	Toll	Kabwe Municipal Council	36,000	2021	(3,000ZMW*12 months)
55	Labor	Watchmen at greening site	Kabwe Municipal Council	16,800	2021	(1,400ZMW*12 months)

Annex 8: PDM (version – Project Completion Report)

Project Monitoring Sheet I （Revision of Project Design Matrix）

Project Title: The Project for Visualization of Impact of Chronic / Latent Chemical Hazard and Geo-Ecological Remediation

Version -

Project Completion Report

Implementing Agency: Hokkaido University, University of Zambia

Dated - June 2022

Target Group: University of Zambia, Ministry of Technology and Science, Ministry of Mines and Mineral Development, Ministry of Green Economy and Environment, Ministry of Health, and Zambia Environmental Management Agency, Kabwe Municipal Council

Period of Project:From May 2016 to May 2022

Project Site: Kabwe town

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal					
To reduce the negative impact caused by lead (Pb) pollution in Kabwe mining area, Zambia, and establish, based on the research achievements, a novel protocol for metal pollution countermeasure that is feasable and utilizable worldwide.	1. Established protocol based on research achievements is adopted into the governmental policy.	1. Policy papers		The developed technologies and findings, including environmental remediation methods, have been discussed with the relevant Zambian ministries and KMC on multiple occasions. It is being considered that the content of these proposals will be reflected in the environmental remediation activities that ZMERIP, a World Bank-funded project, plans to implement. In discussions with the relevant ministries and agencies in October 2021, it was stated that they are ready to consider all measures to realize the recommendations.	
	2. Lead level in human blood is reduced and effectiveness of proposed countermeasure and/or protocol are verified.	2. Project reports		Based on the findings of this project, a health intervention protocol was developed. Based on this protocol, the Zambian government launched a lead poisoning testing and treatment program in Kabwe under the World Bank-funded ZMERIP project. So far, more than 10,000 children living in contaminated areas have been tested. Children whose blood lead levels exceeded the reference level have been offered treatment programs using chelating agents. This has helped to reduce blood lead levels in children. Protocols and field activities have been reviewed on a regular basis.	
	3. Monitoring for Pb contamination is continuously conducted.	3. Project reports		Continuous monitoring was conducted throughout the project period. The establishment of the monitoring laboratory and the capacity development for field survey, laboratory experiments and data analysis have been completed. Thus, the pollution monitoring is expected to be continued even after the completion of the project.	
	4. 10 papers regarding the Project are published in International academic journals	4. International journals		Approximately 80 scientific papers have been accepted for publication in peer-reviewed international journals. The topics of these papers include elucidation of pollution mechanisms, assessment of health and socioeconomic impacts, and development of environmental remediation methods.	

Project Purpose					
Novel and effective countermeasure and protocol are proposed.	1. Lead pollution levels and contamination pathways and mechanisms in Kabwe area are evaluated.	1.Project reports		Environmental, animal and human lead contamination levels in the broader Kabwe area have been identified. Extremely high lead concentrations were detected in the vicinity of the mine, while concentrations exceeding the standard were also found in areas relatively far from the mine. By combining various methods such as lead level analysis by particle size, lead stable isotope ratio analysis, meteorological monitoring, and characterization of mine slag, the contamination mechanisms and pathways were clarified. For lead diffusion from the mine to the surrounding area, the effect of wind dispersal of lead-containing dust was significant. In the case of lead transmission from the environment to humans, the contribution of soil and food was found to be particularly large.	
	2. Health effects and impacts by Pb exposure are quantified.	2. Project reports		The effects of lead exposure on hematopoiesis and liver function were clarified. Knowledge of gene methylation has been accumulated, and effects at the genetic level have also been observed. Neurodevelopmental delays in children and the effects of lead exposure in children on the quality of life of their mothers have also been elucidated.	
	3. Economic impacts caused by Pb contamination are quantified.	3. Project reports		Representative socio-economic data was collected for the entire Kabwe region. The impact of lead exposure on the household economy was identified. A simulated assessment of the loss of income for future generations caused by lower IQ and higher mortality due to lead exposure was also conducted.	
	4. Appropriate remediation method for each contamination pathway is proposed.	4. Project reports		Several environmental remediation methods were developed based on the findings from field studies, laboratory experiments, and pilot-scale experiments. These methods use locally available materials and are highly efficient and economical. The characteristics of each method were evaluated and the costs were estimated. A proposal summarizing the above results was submitted to the relevant ministries and agencies as well as to ZMERIP. Oral explanations and multiple discussions were held to brush up the recommendations.	
	5. Monitoring system for Pb contamination is established.	5. Project reports		A monitoring laboratory has been established at UNZA where metal analysis and various toxicity assessment experiments can be conducted. Capacity development for experimental operation, equipment maintenance and data analysis was continuously carried out throughout the project period. Capacity development for field sampling activities and research planning was also promoted. Monitoring of lead dispersal by meteorological instruments has also been made possible. As a result, an appropriate monitoring system for lead contamination has been well established.	
Outputs					

Output 1: Lead contamination mechanisms and pathways from pollution source to soil surrounding the pollution source in Kabwe area are elucidated.	1-1. Evaluation of research gap determined by the literature (report) review.	1-1. Projects Reports		A literature review was carried out to identify existing data in Kabwe. The extensive pollution has been observed in soils and foods. Also, Pb was found in wild plants (weeds). However, regarding the pollution sources, wind and water had been suggested but the detailed mechanisms were unknown. Also, the agricultural management related to the risks of Pb pollution was not well studied. The findings collected have been summarized in published scientific papers and other documents.	
	1-2. Lead pollution source and Pb concentration in soil at Kabwe area are evaluated.	1-2. Reports on the data of Soil contamination in Kabwe, and evaluation by experts		Soil contamination levels were extensively evaluated. The results suggested that the soil surfaces are heavily contaminated, but the levels vary widely depending on the environmental factors such as plant cover and soil types.	
	1-3. Contribution of each factor (water flow, air-dust and wind etc.) which affect Lead diffusion from pollution source to soil surrounding the pollution source in Kabwe area is evaluated.	1-3. Reports on the contribution of each factor, and evaluation by experts		We modelled the impact of wind on the Pb dispersion in the targeted area. The results showed that Pb dispersion from the Kabwe mine was directly affected by wind directions and speeds in the dry season, although it was not appreciably affected in the rainy season. This indicates that Pb dispersion patterns depend on the season. In addition, the distribution of the amount of deposited Pb-bearing soils around the mine corresponded to the distribution of Pb contents in soils. These results suggest that Pb contamination in soils primarily results from dispersion of fine mine wastes. We published the data in a peer reviewed journal.	
	1-4. Research results are integrated in the GIS data base and the data base are opened in public.	1-4. GIS database		The website is publically available so everyone can check the wind conditions as well as plant cover in the Kabwe area. These data are useful to future activities to cover the soils to prevent the dust (Pb containing) dispersion.	
Output 2 : Lead contamination mechanisms and pathways from soil surrounding the pollution source to human body in Kabwe area are elucidated, and human health risk and economic impact caused by Pb exposure (pollution) are quantitatively assessed.	2-1. Evaluation of research gap 2-1-1. Evaluation of research gap determined by the literature (report) review.	2-1. Project reports		A literature review was carried out to identify existing data in Kabwe. Then, it was confirmed that knowledge on human lead exposure and health and socio-economic impacts were insufficient. The necessary studies and methods were refined through additional literature reviews. The findings collected have been summarized in published scientific papers and other documents.	
	2-2. Pb contamination mechanism to human body 2-2-1. The research method to evaluate Pb contamination mechanisms from soil surrounding the pollution source to human body is determined.	2-2. Reports on Pb contamination mechanism to human body, evaluation by experts		Potential sources of lead exposure were considered to be soil, dust, food, drinking water and breast milk. It was concluded that it would be appropriate to conduct a comprehensive search for exposure sources by collecting and analyzing these samples and comparing them with data from human blood and other sources.	

	2-2-2. Lead contamination pathways from soil surrounding the pollution source to human body and mechanism are evaluated.			A variety of environmental samples were collected over a wide area of Kabwe and analysed for lead concentrations and stable lead isotopes. The results show that soil and food are the main sources of lead exposure, while exposure through drinking water is limited. It was also shown that lead exposure through breast milk occurs in infants.	
	2-3. Human Health Risk 2-3-1.Method of health risk assessment for chronic Pb exposure is determined. 2-3-2. Human health risks by Pb exposure (pollution) are assessed. 2-3-3. Novel therapy protocol based on the health risk assessment is proposed.	2-3. Reports on human risk assessment and therapy protocol, and evaluation by experts, protocols		The findings from the literature collection and previous studies were used for the consideration. It was decided to analyse the indicators of liver, kidney and blood toxicity of lead, to assess the effects at the genetic level and to analyse the effects on neurodevelopment etc. By comparing these data with data on lead concentrations in blood and faeces, assessment of the effects on lead can be carried out. It was found that lead levels were higher in residential areas closer to the mines, and that a large number of residents, particularly in the vicinity of the mines, were in need of urgent chelation treatment. Higher concentrations were found in children compared to adults. Comparisons of lead levels with various indicators also showed effects on haematopoietic function and at the genetic level. Children's exposure to lead was also shown to affect the quality of life of their mothers and to have an impact on neurodevelopment. It is very significant that the health effects of lead have been demonstrated for the first time, and not only in the assessment of contamination levels. The fieldwork for this project involved the analysis of blood lead levels using the LeadCare device. The usefulness of the device for screening purposes was demonstrated by detailed laboratory experiments and data analysis. A Health Intervention protocol was developed, covering the whole process from blood collection to LeadCare analysis, as well as public education, basic information on lead and treatment with chelating drug. The prepared proposal was provided to the Ministry of Health, other relevant institutions and ZMERIP. In addition, several on-site trainings were provided to nurses and other health care workers in Kabwe.	
	2-4. Economic Impact Assessment 2-4-1. Negative impacts of health and environmental risks on the socioeconomic condition are quantitatively evaluated.	2-4. Reports on Cost-Benefit Analysis and data report		Socio-economic data of a representative population of the entire Kabwe were collected and analyzed in relation to blood lead levels. The representative household survey data was used to estimate the distribution of lead exposure throughout Kabwe and to confirm the negative effect of blood lead levels on household economic conditions. In addition, it was simulated that the economic loss in terms of income loss of future generations due to reduced IQ and increased mortality caused by lead exposure would be enormous.	

	2-4-2. Economic returns of the remediation are quantitatively assessed based on the Cost-Benefit Analysis.			A cost-benefit analysis was conducted for several scenarios of engineering measures for dumping sites and residential areas. As the main economic benefits, we considered the effect of increased income for future generations due to increased IQ brought about by reduced lead exposure and the value of life due to reduced mortality. The results of the cost-benefit analysis for 50 years from 2025 showed that the engineering measures would bring economic benefits to Kabwe commensurate with the costs. In particular, the cost effectiveness of measures in the dumping sites was found to be high.	
Output 3：Effective and economical remediation and pollution source control technologies are developed and proposed.	3-1. Evaluation of Research Gap 3-1-1. Evaluation of research gap determined by literature (report) review concerning remediation.	3-1. Project reports		The review and evaluation were done continuously. It was clarified that there is a need for efficient and realistic environmental restoration methods using locally available and inexpensive materials. A review of the literature necessary for the development of these methods was also conducted.	
	3-2. Study on Pollution Source Control 3-2-1. The methods of pilot-scale remediation for pollution source control are determined and the determined pilot-scale remediation and monitoring are conducted.	3-2. Reports on the optimum remediation method for pollurion control.		The methods were determined based on the findings from literature review and field survey. Potential pathways of lead from pollution source to surrounding areas were considered to be Pb-contained dust, ground water, and canal flood. These indicated that covering methods of pollution source combined with immobilization would be effective. Following these perspectives, pilot-scale tests, which aimed to evaluate immobilization method using half burnt dolomite and covering method, have been conducted and monitored in UNZA. Other methods including advanced methods, immobilization using phosphate, bio-cement methods, and removal and recovery of metals by leaching and cementation method, were also investigated on lab-scale. In addition, continuous weather monitoring was carried out to evaluate the effect of meteorological factors.	
	3-2-2. The results of pilot-scale remediation are evaluated and the optimum remediation method is proposed.			Evaluation of the pilot scale tests was done with the data of monitoring well, water quality of leachate and effluent waters, and soil sampled in vertical direction. Efficiency and effectiveness of other tested methods were also evaluated. These results were summarized and cost estimates were made for each method. A proposal summarizing the above results was prepared and presented to the relevant government agencies and to ZMERIP, of which KMC and the Ministry of Mines are the implementing agencies. In addition to written submissions, oral explanations and discussions were also conducted.	
	3-3. Study on Remediation for Surrounding Soil	3-3. Reports on the optimum			

	3-3-1. The methods of pilot-scale remediation for surrounding soil are determined and pilot-scale remediation and monitoring are conducted. 3-3-2.The results of pilot-scale remediation are evaluated and the optimum remediation method is proposed.	remediation method for surrounding soil		The methods were determined based on the findings from literature review and field survey. Pilot-scale tests was completed in UNZA. Water from the monitoring wells and leachate were sampled periodically, and at the end of the test, soil from the embankment was sampled vertically and used for laboratory experiments. Monitoring using weather station was also conducted throughout the test period to assess the impact of weather conditions. The effectiveness and efficiency of the tested methods was evaluated from the experimental results obtained. It was shown that the methods using locally available and inexpensive materials can provide sufficient environmental restoration effects. Cost estimation for each method was also carried out. A proposal summarizing the above results was prepared and presented to the relevant government agencies and to ZMERIP, of which KMC and the Ministry of Mines are the implementing agencies. In addition to written submissions, oral explanations and discussions were also conducted.	
Output 4 : Capacities for monitoring the Pb contamination are strengthened and Monitoring laboratory is established.	4-1. Monitoring laboratory to analyze heavy metal pollution is established in UNZA	4-1. Establishment of monitoring laboratory		A monitoring laboratory with two types of metal analyzers, draft cabinet and Microwave metal extraction equipment was established. The laboratory is also equipped with a power generator, UPS, and pure and ultrapure water production equipment to ensure stable experiments. We have also completed the capacity development of the use and maintenance of the devices and equipment.	
	4-2. The capacity to analyze monitoring results of researchers and officers in UNZA, Ministry of Health, Ministry of Land, Ministry of Mine and Kabwe municipal council is strengthened.	4-2. Project reports		Capacity development on data analysis was carried out for various stakeholders. Capacity development on field collection activities was also carried out to strengthen the capacity of the research flow from sample collection to data analysis.	
	4-3. Number of seminars based on the training, ** times (for young researchers, woman / mother and farmers).	4-3. Project reports		Seminars for young researchers were conducted continuously throughout the project period. Seminars were held in Kabwe for health personnel and representatives of various communities in Kabwe. Several focused seminars for health care providers working in clinics in contaminated areas were also conducted to educate mothers and children in the communities through them. Awareness raising activities were also conducted through public radio broadcasts over a period of three days.	

Plan				Achievement		
Activities	Inputs		Pre-Conditions	Activities	Inputs	
	Japanese Side	Zambia Side			Japanese Side	Zambia Side

1-1 Review of the previous study and determination of the research gap. 1-2 Evaluation of changes in land cover situation in Kabwe area from 1980s to date by using the available satellite data. 1-3 Establishment of methods for evaluation of soil characteristics and surveying of vegetation, using techniques such as GIS and/or spectrometry. Development of manuals for methods and implementation of capacity building in the methods. 1-4 Creation of maps usable on-site, particularly focusing on land usage, based on techniques such as field survey, digital elevation models (DEM), and aerial photo images. 1-5 Characterization of mine wastes; kinds and their spatial distribution. 1-6 Measurement of physical, chemical and mineralogical properties of mine wastes.	1. Dispatch of Japanese Experts Long-Term Experts a. Project coordinator Short-Term Experts a. Research Director / Toxicology b. Research manager for Output 1 / Agriculture c. Research manager for Output 2 / Toxicology d. Research manager for Output 3/ Engineering & Environmental Sciences e. Other experts shown in Annex III 2. Counterpart training in Japan Long-Term Training (Doctor course and Master course) a. Toxicology from UNZA Short-Term Training a. Remote sensing b. Toxicology and chemical analysis 3. Equipment/Facilities a. Instrument for metal analysis b. XRD c. Deep freezer d. Portable reflectance spectrometer e. Draft chamber f. Others 4.Expense a. Vehicles and fuels for project activities b. Ten boreholes with 10 to 15 m deep for Output 3 c. Other necessary expenses	1. Assignment of Counterpart Personnel a. University of Zambia b. Ministry of Technology and Science c. Ministry of Health d. Ministry of Green Economy and Environment e. Ministry of Mines and Mineral Development f. Kabwe Municipal Council g. Zambia Environmental Management Agency 2. Provision of facilities for the Project implementation a. Office space b. Office facilities - Electricity and tap water in the laboratory - Air conditioner in the laboratory 3. Expense Cost for office space / facilities (including cost for electricity, water, communication, etc.)		1-1 Review of the previous study and determination of the research gap. →A comprehensive literature review was carried out to examine the soil and plant contamination levels around Kabwe mine area. Also, we reviewed agricultural methods to reduce the risk of crop Pb contamination. The latest findings and trends were identified throughout the project implementation period. 1-2 Evaluation of changes in land cover situation in Kabwe area from 1980s to date by using the available satellite data. →Satellite image analyses were performed extensively using Landsat and Sentinel data. It was shown that the plant cover was markedly reduced in some area in early 2000s potentially due to the development of Kabwe city. The newly developed residential area is very close to the mine residue deposition area, thus the monitoring of people living in the area is needed. 1-3 Establishment of methods for evaluation of soil characteristics and surveying of vegetation, using techniques such as GIS and/or spectrometry. Development of manuals for methods and implementation of capacity building in the methods. →We have established several methods to reduce the Pb contamination in the area and the manuals explaining the methods were prepared and shared with the stakeholders. Several GIS trainings were performed on site and some stakeholders are utilizing the techniques to monitor the environment in Kabwe. 1-4 Creation of maps usable on-site, particularly focusing on land usage, based on techniques such as field survey, digital elevation models (DEM), and aerial photo images. →This has been almost completed and will be done soon as an online based map. The map includes plant cover as well as some risks associated with heavy winds. 1-5 Characterization of mine wastes; kinds and their spatial distribution. →This was completed by several borehole and excavation experiments. 1-6 Measurement of physical, chemical and mineralogical properties of mine wastes. → The property of mine wastes were measured from various aspects as planned.	1. Dispatch of Japanese Experts Long-Term Experts a. Project coordinator: Hisao Odagiri (Aug. 2016), Michiko Nyanga (May 2017), and Susumu Makino b. Researcher: Hokuto Nakata (Apr. 2017) Short-Term Experts a. Research Director / Toxicology b. Research manager for Output 1 / Agriculture c. Research manager for Output 2 / Toxicology d. Research manager for Output 3/ Engineering & Environmental Sciences e. Other experts shown in Annex III All the lists for a~e are shown in Annex IV. 2. Counterpart training in Japan Long-Term Training (Doctor course and Master course) a. Toxicology from UNZA: Andrew Kataba enrolled PhD course in Hokkaido University Vet School (Apr. 2017) Short-Term Training a. Agriculture from	1. Assignment of Counterpart Personnel a. University of Zambia b. Ministry of Technology and Science c. Ministry of Health d. Ministry of Green Economy and Environment e. Ministry of Mines and Mineral Development f. Kabwe Municipal Council g. Zambia Environmental Management Agency Member list is shown in Annex V. 2. Provision of facilities for the Project implementation a. Office space: Provided in UNZA Vet School from Jun. 2016 and in KMC from Oct. 2017. b. Office facilities - Electricity and tap water in the laboratory: Provided from Jun. 2016 - Air conditioner in the laboratory: Set up in Oct. 2016 c. Laboratory: Laboratory for Monitoring of metal levels is provided in UNZA Vet School

1-7 Surveying of geological, hydrogeological, mineralogical and geochemical conditions of the surrounding area of Mine in Kabwe. 1-8 Monitoring spatial distribution of mine waste dust. 1-9 Development of a database that integrates research results mentioned above and GIS data.				1-7 Surveying of geological, hydrogeological, mineralogical and geochemical conditions of the surrounding area of Mine in Kabwe. → Various conditions of the surrounding area of the Kabwe Mine was well studied. 1-8 Monitoring spatial distribution of mine waste dust. →We modelled this and found that the winds in dry season are important to explain the spatial distribution. 1-9 Development of a database that integrates research results mentioned above and GIS data. →This has been almost completed and will be done soon as an online based site.	Ministry of Aguriculture & UNZA: Kabenuka Munthali and Mukuka Mwansa (Nov 2017) b. Agriculture from ZEMA: Charity Nalweya (Nov 2017) c. Toxicology from UNZA: Nosiku Sipilanyambe Munyinda (Nov-Dec 2017) d. Toxicology from Ministry of Health: Doreen Sakala (Oct-Nov 2017) e. Economics from UNZA: Chrispin Mphuka, Bona M. Chitah and Peter Hangoma (Oct-Nov 2017) f. Engineering from UNZA: Imasiku A. Nyambe and Meki Chirwa (Nov 2017) g. Toxicology from UNZA: Golden Zyambo (Jul-Sep 2018) 3. Equipment/Facilities a. Instrument for metal analysis: Jan 2020 b. XRD: Feb 2017 c. Deep freezer: Dec 2018 d. Portable reflectance spectrometer: May 2017	from Jun. 2016 3. Expense Cost for office space / facilities (including cost for electricity, water, communication, etc.): Provided by UNZA
2-1 Reviewing the previous study and determination of the research gap. 2-2 Determination of the research method to evaluate Pb contamination mechanisms and pathways from surrounding soil to human body. 2-3 Conducting research on Pb contamination mechanisms and pathways from surrounding soil to human body. 2-4 Determination of the health risk assessment method. 2-5 Implementation of health risk assessment caused by Pb pollution.				2-1 Reviewing the previous study and determination of the research gap. →A comprehensive literature review was carried out to examine the mechanisms of lead transfer from the environment to humans and the methods used to assess the health and economic effects of lead exposure. The latest findings and trends were identified throughout the project implementation period. 2-2 Determination of the research method to evaluate Pb contamination mechanisms and pathways from surrounding soil to human body. →Based on the results of the literature review and the field survey to ascertain the local situation, the appropriate method was determined. 2-3 Conducting research on Pb contamination mechanisms and pathways from surrounding soil to human body. → The survey was carried out on an ongoing basis, using the methodology decided upon in the review. On the basis of the results and experience of the surveys already carried out, the detailed plan for the next survey was modified on a case-by-case basis. 2-4 Determination of the health risk assessment method. → Based on the results of the literature review, the methods considered most appropriate for Kabwe were reviewed and decided upon by both Zambian and Japanese members. 2-5 Implementation of health risk assessment caused by Pb pollution. → Using the determined methods, field sampling, data acquisition and laboratory experiments were carried out.		

2-6 Determination of the economic assessment method. 2-7 Evaluation of health and environmental risks quantitatively on socioeconomic condition. 2-8 Implentation of economic assessment caused by Pb pollution. 2-9 Development of a novel therapy protocol based on the health risk assessment.				2-6 Determination of the economic assessment method. → Based on the results of the literature review and the availability of data, an appropriate economic evaluation approach was determined. 2-7 Evaluation of health and environmental risks quantitatively on socioeconomic condition. → Socio-economic data representative of the entire Kabwe were collected and analyzed for risk to socio-economic status by conducting an econometric analysis coupled with data on blood lead levels. 2-8 Implentation of economic assessment caused by Pb pollution. → As for the economic costs of lead contamination, we attempted to elaborate on the economic costs of lead exposure, especially the effects of lost income for future generations due to reduced IQ and increased mortality, by combining our own data collected in Kabwe with estimates from existing studies. The results were applied to a cost-benefit analysis of remediation measures. 2-9 Development of a novel therapy protocol based on the health risk assessment. → The novel protocol was developed and shared with the stakeholders.	e. Draft chamber: Dec 2018 f. Others 4.Expense a. Vehicles and fuels for project activities: Project vehicle was set up in Feb. 2017 b. Ten boreholes with 10 to 15 m deep for Output 3: 5 boreholes in Kabwe mining site and 3 boreholes in UNZA c. Other necessary expenses	
3-1 Review of the previous study and determination of the research gap. 3-2 Selection of the sites of pilot-scale remediation for pollution control and conduction of background survey of the sites.				3-1 Review of the previous study and determination of the research gap. →A comprehensive literature review was carried out to o identify existing data in Kabwe. The latest findings were identified throughout the project implementation period. 3-2 Selection of the sites of pilot-scale remediation for pollution control and conduction of background survey of the sites. →Land within the UNZA was allocated for pilot-scale remediation tests with the permission from ZEMA.		

3-3 Preparation of pilot-scale remediation sites for pollution control; no countermeasure case, covering soil case, immobilization case, etc.			3-3 Preparation of pilot-scale remediation sites for pollution control; no countermeasure case, covering soil case, immobilization case, etc. → The pilot-scale test mounds in UNZA (covering soil cases using surrounding soil with/without plants, immobilization case using half burned dolomite, and no countermeasure case) have been prepared. As an immobilizer, half burned dolomite was selected and prepared using domestic dolomite and furnaces of NSIR in Zambia.		
3-4 Monitoring the diffusion of Pb and other heavy metals.			3-4 Monitoring the diffusion of Pb and other heavy metals. →Monitoring of the diffusion of Pb and other heavy metals from pilot-scale mounds were conducted by the data of monitoring well, water quality of leachate and effluent waters from test mounds.		
3-5 Evaluation of the results of pilot-scale remediation for pollution control and determination of feasable remediation methods.			3-5 Evaluation of the results of pilot-scale remediation for pollution control and determination of feasible remediation methods. →The final sampling of the pilot mounds (vertical direction) was done for the final evaluation. Other methods were evaluated and feasible remediation methods were selected by condition.		
3-6 Evaluation of the performance of the determined remediation methods.			3-6 Evaluation of the performance of the determined remediation methods. → The performance of the feasible remediation methods (a) immobilization using half burned dolomite and phosphate, (b)bio cement methods, and (c)removal/recovery of metals by leaching and cementation method were evaluated by the tests using LPR (leach plant residue of mine waste of Kabwe).		
3-7 Prediction of the performance of remediation methods in mine site.			3-7 Prediction of the performance of remediation methods in mine site. → The performance of remediation methods in mine site was predicted using the evaluation data obtained from the above tests.		
3-8 Proposal of appropriate countermeasures for pollution control.			3-8 Proposal of appropriate countermeasures for pollution control. →Several remediation approaches including advanced methods were proposed with cost estimation. This proposal was provided to the Ministry of Mines, ZEMA, other relevant institutions and ZMERIP. In addition, we had some meetings with stakeholders for further discussion.		
3-9 Evaluation of the results of pilot-scale remediation method for surrounding soil contamination.			3-9 Evaluation of the results of pilot-scale remediation method for surrounding soil contamination. →Evaluations of pilot scale tests (with immobilization) in UNZA have been carried out by the data of monitoring well, and water quality of leachate and effluent waters. Final soil sampling of the pilot test mound was done for the final evaluation.		

3-10 Prediction of the performance of remediation methods for surrounding soil contamination. 3-11 Proposal of appropriate countermeasures for surrounding soil contamination.				3-10 Prediction of the performance of remediation methods for surrounding soil contamination. →The performance of remediation methods for surrounding soil contamination was predicted using the evaluation data obtained from the above tests. 3-11 Proposal of appropriate countermeasures for surrounding soil contamination. → Some remediation options were summarized and proposed to the stakeholders as mentioned above.		
4-1 Preparation of manuals for the analytical equipment and strengthening the capacity of chemical analysis in the laboratory based on the manual. 4-2 Strengthening capacity in *in situ* monitoring through instructions by Japanese experts. 4-3 Strengthening capacity in data analysis through joint research and workshops. 4-4 Establishment of short training courses (1-12 months) and MS/PhD courses in Hokkaido 4-5 Holding community seminars and/or workshops for women, particularly mothers and pregnant women, and people who touch contaminated soil on daily basis, in order to provide accurate knowledge for prevention of Pb				4-1 Preparation of manuals for the analytical equipment and strengthening the capacity of chemical analysis in the laboratory based on the manual. →Manuals and SOPs for the equipment and laboratory work were prepared and used for the capacity development of laboratory experiments. 4-2 Strengthening capacity in *in situ* monitoring through instructions by Japanese experts. → The capacity for in situ monitoring was well developed through field work. 4-3 Strengthening capacity in data analysis through joint research and workshops. → Data analysis techniques were strengthened through joint work and guidances. 4-4 Establishment of short training courses (1-12 months) and MS/PhD courses in Hokkaido University. → The opportunity of Master and Ph.D. courses were provided to the Zambian students. 4-5 Holding community seminars and/or workshops for women, particularly mothers and pregnant women, and people who touch contaminated soil on daily basis, in order to provide accurate knowledge for prevention of Pb exposure. → The workshops were given to the community leaders and health personnels who can give a guidance to the community including mothers and pregnant women. In order to further enlighten more Kabwe residents, radio programs were created and distributed through major local radio stations.		

Annex 9: List of Research Papers Published in International Journal

Joint-research

Paper number	Japanese fiscal year	Authors, title, journal, year, page
1	2015	Nakata H*, Nakayama SMM*, Yabe J, Liazambi A, Mizukawa H, Darwish WS, Ikenaka Y, Ishizuka M (* Equal contribution). Reliability of stable Pb isotopes to identify Pb sources and verifying biological fractionation of Pb isotopes in goats and chickens. Environ Pollut. 208(Pt B):395-403 (2016)
2	2017	M'kandawire E, Choongo K, Yabe J, Mwase M, Saasa N, Nakayama SMM, Bortey-Sam N, Blindauer. Sediment Metal Contamination in the Kafue River of Zambia and Ecological Risk Assessment. Bulletin of Environmental Contamination and Toxicology. 98:172-177 (2017)
3	2017	Uchida Y, Banda K, Nyambe I, Hamamoto T, Yoshii Y, Munthali K, Mwansa M, Mukuka M, Mutale M, Yabe J, Toyomaki H, Yohannes YB, Nakayama SMM, Naruse N, Ishizuka M, Takahashi Y. Multidisciplinary field research in Kabwe, Zambia, towards better understanding of lead contamination of the city – A short report from a field survey. bioRxiv (2017)
4	2017	Yabe J, Nakayama S.M.M, Ikenaka Y, Yohannes YB, Bortey-Sam N, Kabalo AN, Ntapisha J, Mizukawa H, Umemura T, Ishizuka M, Lead and cadmium excretion in feces and urine of children from polluted townships near a lead-zinc mine in Kabwe, Zambia, Chemosphere. 202: 48-55 (2018)
5	2017	M'kandawire E, Choongo K, Yabe J, Mwase M, Saasa N, Nakayama SMM, Bortey-Sam N, Blindauer. Sediment Metal Contamination in the Kafue River of Zambia and Ecological Risk Assessment. Bulletin of Environmental Contamination and Toxicology. 98:172-177 (2017)
6	2017	Wilson Mwandira, Kazunori Nakashima, Satoru Kawasaki, Bioremediation of lead-contaminated mine waste by Pararhodobacter sp. based on the microbially induced calcium carbonate precipitation technique and its effects on strength of coarse and fine grained sand. Ecological Engineering 109: 57–64 (2017)
7	2018	Mwandira W, Nakashima K, Kawasaki S, Ito M, Sato T, Igarashi T, Banda K, Chirwa M, Nyambe I, Nakayama S, Ishizuka M. Efficacy of biocementation of lead mine waste from the Kabwe Mine site evaluated using Pararhodobacter sp.. Environmental Science and Pollution Research. 26(15), 15653-15664 (2019)
8	2019	Nakayama SMM*, Nakata H* (Equal contribution), Ikenaka Y, Yabe J, Oroszlanya B, Yohannes YB, Bortey-Sam N, Muzandu K, Choongo K, Kuritani T, Nakagawa M, Ishizuka M. One year exposure to Cd- and Pb-contaminated soil causes metal accumulation and alteration of global DNA methylation in rats. Environmental Pollution. 252:1267-1276 (2019)
9	2019	Hiwatari M, Yamada D, Hangoma P, Narita D, Mphuka C, Chitah B, Yabe J, Nakayama SMM, Nakata H, Choongo K, Ishizuka M. Assessing the population-wide exposure to lead pollution in Kabwe, Zambia : blood lead level estimation based on survey data. Faculty of Economics and Business, Hokkaido University, Discussion Paper, Series A 338: 1-28 (2019)
10	2019	Mwandira W, Nakashima K, Kawasaki S, Ito M, Sato T, Igarashi T, Banda K, Chirwa M, Nyambe I, Nakata H, Nakayama SMM, Ishizuka M., Solidification of sand by Pb(II)-tolerant bacteria for capping mine waste to control metallic dust: Case of the abandoned Kabwe Mine, Zambia. Chemosphere. 228: 17-25 (2019)
11	2019	Togao M, Nakayama SMM, Ikenaka Y, Mizukawa H, Makino Y, Kubota A, Matsukawa T, Yokoyama K, Hirata T, Ishizuka M. Bioimaging of Pb and STIM1 in mice liver, kidney and brain using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) and immunohistochemistry. Chemosphere. 238:124581 (2020)
12	2019	Yabe J, Nakayama SMM, Nakata H, Toyomaki H, Yohannes YB, Muzandu K, Kataba A, Zyambo G, Hiwatari M, Narita D, Yamada D, Hangoma P, Munyinda NS, Mufune T, Ikenaka Y, Choongo K, Ishizuka M. Current Trends of Blood Lead Levels, Distribution Patterns and Exposure Variations among Household Members in Kabwe, Zambia. Chemosphere 243: 125412 (2020)
13	2019	Toyomaki H, Yabe J, Nakayama SMM, Yohannes YB, Muzandu K, Liazambi A, Ikenaka Y, Kuritani T, Nakagawa M, Ishizuka M. Factors associated with lead (Pb) exposure on dogs around a Pb mining area, Kabwe, Zambia. Chemosphere. 247: 125884 (2020)
14	2020	Silwanba M, Ito M, Hiroyoshi N, Tabelin CB, Hashizume R, Fukushima T, Park I, Jeon S, Igarashi T, Sato T, Chirwa M, Banda K, Nyambe I, Nakata H, Nakayama S, Ishizuka M. Recovery of Lead and Zinc from Zinc Plant Leach Residues by Concurrent Dissolution-Cementation Using Zero-Valent Aluminum in Chloride Medium. Metals. 10(4): 531 (2020)
15	2020	Yohannes YB, Nakayama SMM, Yabe J, Nakata H, Toyomaki H, Kataba A, Muzandu K, Ikenaka Y, Choongo K, Ishizuka M. Blood Lead Levels and Aberrant DNA Methylation of the ALAD and p16 Gene Promoters in Children Exposed to Environmental-Lead. Environmental Research . 109759 (2020)
16	2020	Doya R, Nakayama SMM, Nakata H, Toyomaki H, Yabe J, Muzandu K, Yohannes Y, Kataba A, Zyambo G, Ogawa T, Uchida Y, Ikenaka Y, Ishizuka M. Land Use in Habitat Affects Metal Concentrations in Wild Lizards Around a Former Lead Mining Site. Environmental Science & Technology, 52(22), 14474-14481 (2020)
17	2020	Silwamba M, Ito M, Hiroyoshi N, Tabelin CB, Fukushima T, Park I, Jeon S, Igarashi T, Sato T, Nyambe I, Chirwa M, Banda K, Nakata H, Nakayama SMM, Ishizuka M. Detoxification of lead-bearing zinc plant leach residues from Kabwe, Zambia by coupled extraction-cementation method. Journal of Environmental Chemical Engineering. 104197 (2020)
18	2020	Yoshii Y, von Rein I, Munthali K, Mwansa M, Nakata H, Nakayama S, Ishizuka M, Uchida Y. Evaluation of phytoremediation effects of chicken manure, urea and lemongrass (Cymbopogon citratus) to remediate a lead contaminated soil in Kabwe, Zambia. South African Journal of Plant and Soil. 37(5), 351-360 (2020)

19	2020	Nakata H, Nakayama SMM, Yabe J, Muzandu K, Toyomaki H, Yohannes YB, Kataba A, Zyambo G, Ikenaka Y, Choongo K, Ishizuka M. Clinical biochemical parameters associated with the exposure to multiple environmental metals in residents from Kabwe, Zambia. Chemosphere.127788 (2020)
20	2020	Andrew Kataba, Tarryn L. Botha, Shouta M.M Nakayama, Yared B. Yohannes, Yoshinori Ikenaka, Victor Wepener, Mayumi Ishizuka. Acute exposure to environmentally relevant Pb levels induces oxidative stress and neurobehavioral alterations in larval zebrafish (Danio rerio). Aquatic Toxicology. 105607 (2020)
21	2020	Daichi Yamada, Masato Hiwatari, Peter Hangoma, Daiju Narita, Chrispin Mphuka, Bona Chitah, John Yabe, Shouta M.M. Nakayama, Hokuto Nakata, Kennedy Choongo, Mayumi Ishizuka. Assessing the population-wide exposure to lead pollution in Kabwe, Zambia: an econometric estimation based on survey data. Scientific Reports. 10: 15092 (2020)
22	2020	Pawit Tangviroon, Kenta Noto, Toshifumi Igarashi, Takeshi Kawashima, Mayumi Ito, Tsutomu Sato, Walubita Mufalo, Meki Chirwa, Imasiku Nyambe, Hokuto Nakata, Shouta Nakayama, Mayumi Ishizuka. Immobilization of lead and zinc leached from mining residual materials in Kabwe, Zambia: Possibility of chemical immobilization by dolomite, calcinated dolomite, and magnesium oxide. Minerals. 10(9): 763 (2020)
23	2020	Wilson Mwandira, Kazunori Nakashima, Satoru Kawasaki, Allison Arabelo, Kawawa Banda, Imasiku Nyambe, Meki Chirwa, Mayumi Ito, Tsutomu Sato, Toshifumi Igarashi, Hokuto Nakata, Shouta MM Nakayama, Mayumi Ishizuka. Biosorption of Pb (II) and Zn (II) from aqueous solution by Oceanobacillus profundus isolated from an abandoned mine. Scientific Reports. 10: 21189 (2020)
24	2020	Patricia N. Mwilola, Ikabongo Mukumbuta, Victor Shitumbanuma, Benson H. Chishala, Yoshitaka Uchida, Hokuto Nakata, Shouta MM Nakayama, Mayumi Ishizuka. Lead, Zinc and Cadmium Accumulation, and Associated Health Risks, in Maize Grown Near the Kabwe Mine in Zambia in Response to Organic and Inorganic Soil Amendments. Int. J. Environ. Res. Public Health. 17(23): 9038 (2020)
25	2020	Yared B. Yohannes, Shouta M.M. Nakayama, John Yabe, Haruya Toyomaki, Andrew Kataba, Hokuto Nakata, Kaampwe Muzandu, Yoshinori Ikenaka, Kennedy Choongo, Mayumi Ishizuka. Delta-aminolevulinic acid dehydratase (ALAD) and vitamin D receptor (VDR) genes polymorphisms in children residing in an abandoned lead-zinc mine area. Meta Gene. 27 (2021)
26	2020	Hokuto Nakata, Shouta M.M. Nakayama, Andrew Kataba, Yared Beyene Yohannes, Yoshinori Ikenaka, Mayumi Ishizuka. Evaluation of the ameliorative effect of Spirulina (Arthrospira platensis) supplementation on parameters relating to lead poisoning and obesity in C57BL/6J mice. Journal of Functional Foods. 77, 104344 (2021)
27	2020	Andrew Kataba, Shouta MM Nakayama, Hokuto Nakata, Haruya Toyomaki, Yared B Yohannes, John Yabe, Kaampwe Muzandu, Golden Zyambo, Ayano Kubota, Takehisa Matsukawa, Kazuhito Yokoyama, Yoshinori Ikenaka, Mayumi Ishizuka. An investigation of the wild rat crown incisor as an indicator of lead (Pb) exposure using inductively couple plasma mass spectrometry (ICP-MS) and laser ablation-ICP-MS. International Journal of Environmental Research and Public health. 18(2):767 (2021)
28	2020	Nakata H, Nakayama SMM, Yabe J, Muzandu K, Toyomaki H, Yohannes YB, Kataba A, Zyambo G, Ikenaka Y, Choongo K, Ishizuka M. Assessment of LeadCare® II analysis for testing of a wide range of blood lead levels in comparison with ICP–MS analysis. Chemosphere. 129832 (2021)
29	2020	Wilson Mwandira, Kazunori Nakashima, Yuki Togo, Tsutomu Sato, SatoruKawasaki, Cellulose-metallothionein biosorbent for removal of Pb(II) and Zn(II) from polluted water, Chemosphere, 246, 125733 (2020)
30	2020	Yuki Togo, Kazunori Nakashima, Wilson Mwandira, and Satoru Kawasaki, A Novel Metal Adsorbent Composed of a Hexa-histidine Tag and a Carbohydrate-binding Module on Cellulose, Analytical Sciences, 36(4), 459-464 (2020)
31	2021	Hokuto Nakata, Harukazu Tohyama, Wakako Fujita, Shouta M.M. Nakayama, Mayumi Ishizuka, John Yabe, Nosiku S. Munyinda, Doreen Sakala, Kennedy Choongo, Shojiro Yamasaki, Natsumi Nagai, Takahiko Yoshida, Takeshi Saito. The impact of elevated blood lead levels in children on maternal health-related quality of life. Chemosphere. 130490 (2021)
32	2021	Jumpei Yamazaki, Haruya Toyomaki, Shouta M.M. Nakayama, John Yabe, Kaampwe Muzandu, Jaroslav Jelinek, Shoko Yokoyama, Yoshinori Ikenaka, Mitsuyoshi Takiguchi, Mayumi Ishizuka. Genome-wide DNA methylation analysis of dogs with high lead exposure living near a lead mining area in Kabwe, Zambia. Environmental Pollution. 117229 (2021)
33	2021	Toyomaki H, Yabe J, Nakayama SMM, Yohannes YB, Muzandu K, Mufune T, Nakata H, Ikenaka Y, Kuritani T, Nakagawa M, Choongo K, Ishizuka M. Lead concentrations and isotope ratios in blood, breastmilk and feces: Contribution of both lactation and soil/dust exposure to infants in a lead mining area, Kabwe, Zambia. Environmental Pollution 286: 117476 (2021)
34	2021	Shinsaku Nakamura, Toshifumi Igarashi, Yoshitaka Uchida, Mayumi Ito, Kazuyo Hirose, Tsutomu Sato, Walubita Mufalo, Meki Chirwa, Imasiku Nyambe, Hokuto Nakata, Shouta Nakayama, Mayumi Ishizuka. Evaluation of Dispersion of Lead-Bearing Mine Wastes in Kabwe District, Zambia. Minerals. 11(8) :901 (2021)
35	2021	Yared Beyene Yohannes (Equal contribution), Shouta M. M. Nakayama (Equal contribution, Co-corresponding), John Yabe, Haruya Toyomaki, Andrew Kataba, Hokuto Nakata, Kaampwe Muzandu, Yoshinori Ikenaka, Kennedy Choongo, Mayumi Ishizuka (Co-corresponding). Glutathione S-transferase gene polymorphisms in association with susceptibility to lead toxicity in lead- and cadmium-exposed children near an abandoned lead-zinc mining area in Kabwe, Zambia. Environ Sci Pollut Res. (2021)
36	2021	Andrew KATABA, Shouta M.M. NAKAYAMA (Co-corresponding), Yared Beyene YOHANNES, Haruya TOYOMAKI, Hokuto NAKATA, Yoshinori IKENAKA, Mayumi ISHIZUKA (Co-corresponding). Effects of zinc on tissue uptake and toxicity of lead in Sprague Dawley rat. JVMS (2021)

37	2021	Walubita Mufalo, Pawit Tangviroon, Toshifumi Igarashi, Mayumi Ito, Tsutomu Sato, Meki Chirwa, Imasiku Nyambe, Hokuto Nakata, Shouta Nakayama, Mayumi Ishizuka. Solid-phase partitioning and leaching behavior of Pb and Zn from playground soils in Kabwe, Zambia. Toxics. 9(10) :248 (2021)
38	2021	Andrew Kataba, Tarryn L. Botha, Shouta M.M Nakayama, Yared B. Yohannes, Yoshinori Ikenaka, Victor Wepener, Mayumi Ishizuka. Environmentally relevant lead (Pb) water concentration induce toxicity in zebrafish (Danio rerio) larvae. Comparative Biochemistry and Physiology, Part C (2021, in press)

Others

	Japanese fiscal year	Authors, title, journal, year, page
39	2016	Mahmoud AFA, Ikenaka Y, Yohannes YB, Darwish WS, Eldaly EA, Morshdy AE, Nakayama SMM, Mizukawa H, Ishizuka M. Distribution and health risk assessment of organochlorine pesticides (OCP) residue in edible cattle tissues from northeastern part of Egypt: High accumulation level of OCP in tongue. Chemosphere 144:1365-71 (2016)
40	2016	Gerber R, Smit NJ, Van Vuren JH, Nakayama SMM, Yohannes YB, Ikenaka Y, Ishizuka M, Wepener V. Bioaccumulation and human health risk assessment of DDT and other organochlorine pesticides in an apex aquatic predator from a premier conservation area. Sci. Total. Environ. 550: 522-533 (2016)
41	2016	Bortey-Sam N*, Nakayama SMM*, Ikenaka Y, Akoto O, Baidoo E, Mizukawa H, Ishizuka M (* Equal contribution). Heavy metals and metalloid accumulation in livers and kidneys of wild rats around gold-mining communities in Tarkwa, Ghana. Journal of Environmental Chemistry and Ecotoxicology, 8(7), pp.58-68 (2016)
42	2016	Bortey-Sam N, Ikenaka Y, Akoto O, Nakayama SMM, Marfo J, Saengtienchai A, Mizukawa H, Ishizuka, M. Excretion of polycyclic aromatic hydrocarbon metabolites (OH-PAHs) in cattle urine in Ghana. Environmental Pollution. 218: 331-337 (2016)
43	2016	Yohannes YB, Ikenaka Y, Nakayama SMM, Mizukawa H, Ishizuka M. DDTs and other organochlorine pesticides in tissues of four bird species from the Rift Valley region, Ethiopia. Sci. Total. Environ. 574: 1389-1395 (2017)
44	2016	Yohannes YB, Ikenaka Y, Nakayama SMM, Mizukawa H, Ishizuka M. Trace Element Contamination in Tissues of Four Bird Species from the Rift Valley Region, Ethiopia. BECT. 98:172-177 (2017)
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78	2021	Ryouta Torimoto, Chihiro Ishii, Hiroshi Sato, Keisuke Saito, Yukiko Watanabe, Kohei Ogasawara, Ayano Kubota, Takehisa Matsukawa, Kazuhito Yokoyama, Atsushi Kobayashi, Takashi Kimura, Shouta M. M. Nakayama, Yoshinori Ikenaka, Mayumi Ishizuka. Analysis of lead distribution in avian organs by LA-ICP-MS: study of experimentally lead-exposed ducks and kites. Environmental Pollution. 117086 (2021)

Annex 10: List of Bachelor, Master and Ph.D thesis prepared under Project

June 2022

Name	Degree	Year	Thesis title
Yui Yoshii	Bachelor	March 2018	The effects of lemongrass and chicken manure on a lead-contaminated soil
Yuto Maeda	Bachelor	March 2018	Changes in soil respiration and bacterial community structures in a lead-contaminated soil
Miyuki Oka	Bachelor	March 2018	Evaluation of the effect of a Pb-contained slag on a soil nitrogen cycle using 15N labelling approach
Yusuke Kamegamori	Bachelor	March 2018	ザンビア共和国カブウェ地区廃石場における鉛のAssisted natural remediation
Tomoki Fukushima	Bachelor	March 2018	ザンビア・カブウェ鉱山廃滓からの有価金属の回収
Natsumi Nagai	Bachelor	March 2018	鉛の母乳移行に関する文献検討
Rio Doya	Bachelor	December 2018	Effect of habitat type and location on metal concentrations in wild lizards living around a lead-zinc mine in Kabwe, Republic of Zambia
Kosuke Aoki	Bachelor	March 2020	Adsorption behavior of metal-binding protein on amorphous cellulose
Tomoki Shigemasa	Bachelor	March 2021	重金属イオンに応答して固化するバイオベースゲルの開発
Jin Ohta	Master	March 2018	Study on heavy metal contamination in soil, groundwater, and dust around Kabwe, Zambia
Kenta Noto	Master	March 2018	Immobilization of Heavy Metals Contained in Mine Wastes of Kabwe, Zambia by Adsorbents
Ming Jin	Master	March 2018	Chemical characterization and removal effect by some chemical cleaners on heavy metals in lead-contaminated field soils in Kabwe, Zambia
Chooi Wen	Master	September 2018	Spatial distribution of heavy metals around the abandoned mine in Kabwe, Zambia
Keigo Kimura	Master	February 2018	Diffusion of heavy metals from mine wastes and its countermeasures in Kabwe, Zambia
Yusuke Kamegamori	Master	February 2020	Insolubilization of heavy metals by phosphorus fertilizers at a dump site in Kabwe, Zambia
Tomoki Fukushima	Master	February 2020	Recovery of lead and zinc from zinc leaching residue by carrier-in-pulp method using Al powder
Tohki Li	Master	February 2021	Heavy metal distribution in particle-size fractions of soils around the abandoned Kabwe mine, Zambia
Yuki Togo	Master	February 2021	Fabrication of novel metal ion adsorbing materials composed of protein and cellulose
Ryota Hashizume	Master	February 2021	Removal and Recovery of Lead and Zinc from Zinc plant leach residues in Kabwe Mine , Zambia by Coupled Extraction Cementation Method using Aluminum Powder
Wilson Mwandira	Ph.D.	July 2019	Development of bioremediation methods for soil and water contaminated with heavy metals in Kabwe mine
Haruya Toyomaki	Ph.D.	June 2020	Field studies on Pb poisoning in animals and humans to contribute to the settlement of Pb pollution in a mining area, Kabwe, Zambia
Marthias Silwamba	Ph.D.	March 2021	Development of the detoxification method for zinc plant leach residues by removing heavy metals using coupled extraction-cementation (CEC) process
Andrew Kataba	Ph.D.	March 2021	Studies on toxicological effects of lead in animals for evaluation of worldwide environmental lead pollution
Hokuto Nakata	Ph.D.	June 2021	Assessment of toxicological effects regarding lead exposure and investigation of testing and treatment methods

POLICY BRIEF

for KAMPAI & DRINK projects

Executive summary

Lead contamination in residential areas originating from the lead-zinc mines in Kabwe is serious and residents are exposed to high levels of lead. In order to solve this problem

- Measures to prevent the spread of lead from tailings dams to residential areas
- Environmental remediation of residential areas already contaminated with lead
- Prevention of exposure to lead through food and other sources
- Screening of the population for lead poisoning and provision of health intervention

are important. We have addressed these issues and have developed engineering and agricultural environmental remediation approach applicable to mining and residential areas. Additionally, we have estimated the cost of implementing these approaches. We have also estimated the expected reduction in lead exposure of the population and quantified the long-term socio-economic benefits. Health intervention protocol was also compiled. On the basis of these results, we make the following recommendations to the Zambian government.

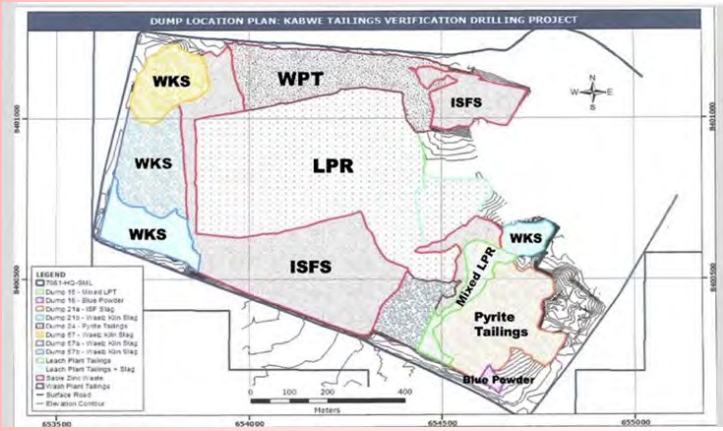
Introduction

The University of Zambia and Hokkaido University, JAPAN, have worked together under the SATREPS project (KAMPAI, 2016-2022) and the aXis project (DRINK, 2020-2022) to address the lead contamination challenge in Kabwe. Here, we provide recommendations for environmental remediation methods that may be effective in Kabwe. The characteristics and costs of each approach are also summarized. We also estimate the extent to which the reduction in environmental lead levels through remediation practices will reduce lead exposure in children, who are particularly vulnerable to lead. The socio-economic benefits of the improvements are also estimated. In addition, we have compiled guidelines on lead poisoning testing and treatment protocols for residents living in contaminated areas.

Tailing impoundments (old tailing dam in the mine area)

The mine wastes in Kabwe are the source of the continued lead (Pb) and zinc (Zn) pollution for the surrounding residential areas. These mine wastes cover an approximate area of around 970,000 m^2. They were generated by different metallurgical processes and dumped discriminately as Leach Plant Residues (LPR), Imperial Smelting Furnace Slag (ISFS) and Weal Kiln Slag (WKS) etc.

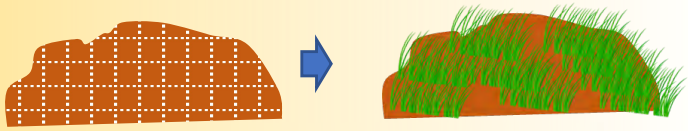
The LPR is the largest in quantity and covers the largest area. It pauses a great environmental threat to the surrounding residential areas as it is composed of very fine particles that are easily dispersed by wind easily. The mine waste that covers the second-largest area when combined is the ISFS and WKS. The particle sizes of these wastes are coarse in the range of millimeters to centimeters size. This entails that they cannot easily be transported by wind. It is important to note that ISF is currently being exploited by small-scale miners. The sampled water from the shallow well in residual areas showed that the concentration of Pb was below the drinking water Pb level standards.



Engineering approach – mine waste dumping site

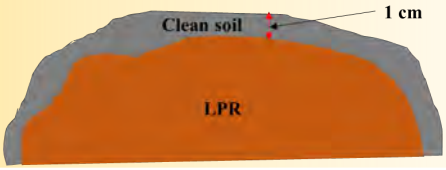
A. Revegetate sheet method

- Cover the LPR with a sheet containing grass seeds to prevent the transportation of very fine particles containing Pb and Zn by wind erosion



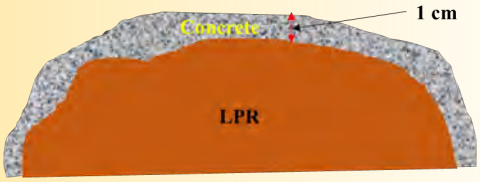
B. 1 cm clean soil capping

- Cover the LPR with a thin layer of clean soil of around 1 cm to prevent the erosion and transportation of fine particle to residential area



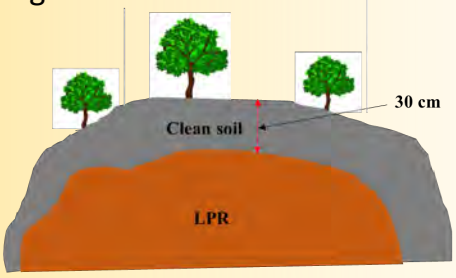
C. 1 cm cement mortar capping

- Cover the LPR with cement mortar of thickness around 1 cm to prevent erosion and transportation, as well as leachability of Pb and Zn



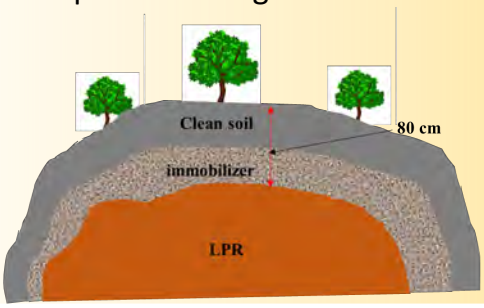
D. 30 cm clean soil capping + revegetation

- Cover the LPR with around 30 cm thick (required for deep root growth) of clean soil and revegetate the covered area with shrubby tree



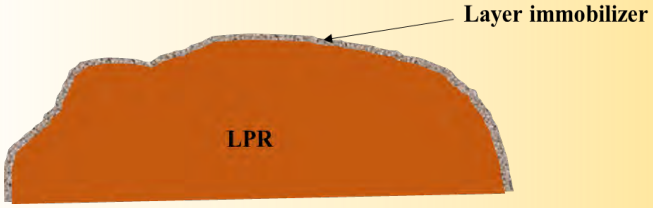
E. Mixing immobilizer or phosphate fertilizer + 30 cm clean soil capping

- Add immobilization layer with either half-burned dolomite or phosphate fertilizer to option D to avoid growth failure of the tree, with an option of revegetation



F. Scattering of phosphate fertilizer

- Convert $PbSO_4$ (major mineral controlling the leachability from LPR) to more geochemically stable minerals by addition of phosphate fertilizer mixed with half burnt dolomite



Advanced processing options

G. Bio-cementation

H. Detoxification method by removing heavy metals using coupled extraction-cementation (CEC) process

I. Immobilization of heavy metals using ubiquitously distributed dolomite around Zambia

Method comparison

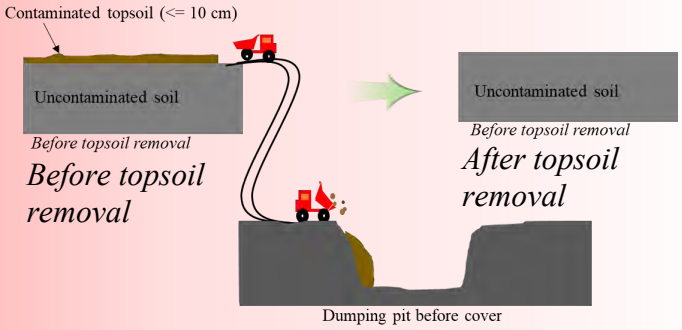
	Initial cost (USD)	Frequency of maintenance	Efficiency to prevent dispersion of very fine particles	Efficiency of penetration of rain water
A	10.1 M	High	Low	Very low
B	32.6 M	High	Low	Very low
C	34.1 M	Middle	Middle	Middle
D	48.1 M	Low	High	High
E1	176.0 M	Very low	Very high	Very high
E2	354.3 M	Very low	Very high	Very high
F	-	Very high	Very low	Very low

Engineering approach – contaminated residential area

1. Options for an area with 30 cm or less topsoil contamination

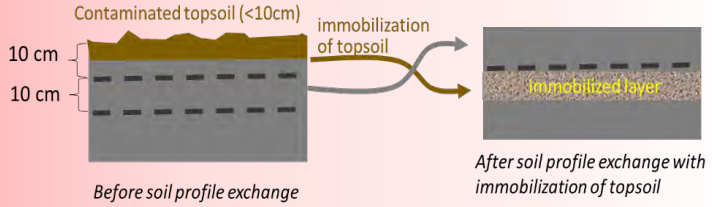
A. Removal of topsoil

- The removed contaminated topsoil should be dumped in the constructed dump and covered



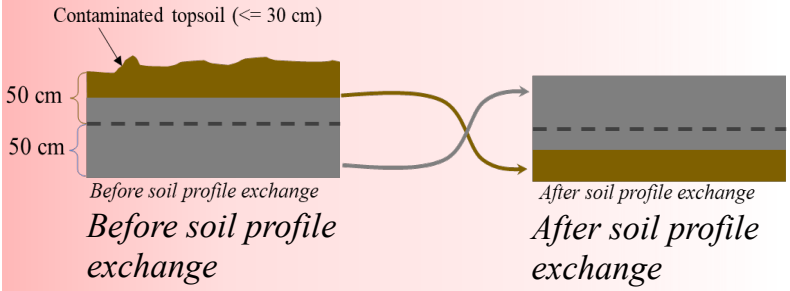
B. Soil profile exchange with immobilization of topsoil

- The contaminated topsoil is immobilized by mixing with half-burnt dolomite or phosphate fertilizer, then putted beneath the bottom soil. No need for dumping site.



C. Soil profile exchange

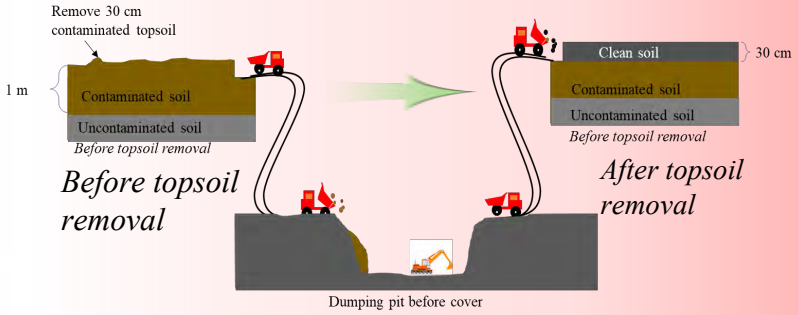
- 50 cm of topsoil (including 20 cm uncontaminated) is exchanged with 50 cm bottom clean soil. No need for dumping site



2. Options for an area with deep contamination

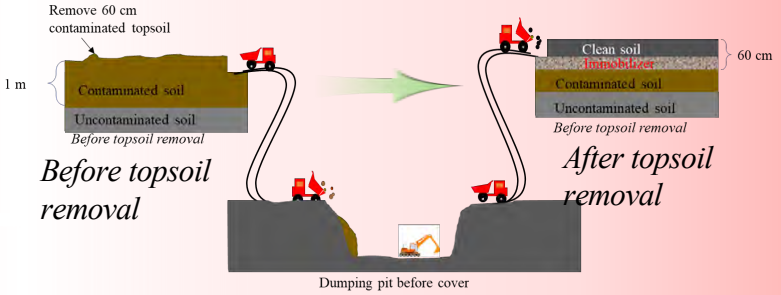
D. Removal of topsoil and replacing it with clean soil

- Contaminated 30 cm topsoil is removed and buried from the pit where clean soil is excavated from, then replaced with clean soil



E. Remove topsoil and replace it with clean soil and immobilizer

- Similar with option D, but adding immobilizer in between clean soil and contaminated soil



Cost comparison

	Cost (USD/ m2)
A	4.7
B1	36.6
B2	73.4
C	25
D	15
E1	118
E2	229

Effects of dispersion of mine wastes on soil contamination

- dispersion simulation of dumped mine wastes by considering wind direction and speed -

The dispersion simulation of dumped mine indicated that aerial dispersion of mine wastes causes contamination of soil in residential area, meaning that the mine dump site is the source of heavy metals. If residential areas are remediated, say by covering the topsoil with clean soil, leaving the source of Pb contaminated particles the problem of Pb contamination on residential areas would resurface in few months and years' time.

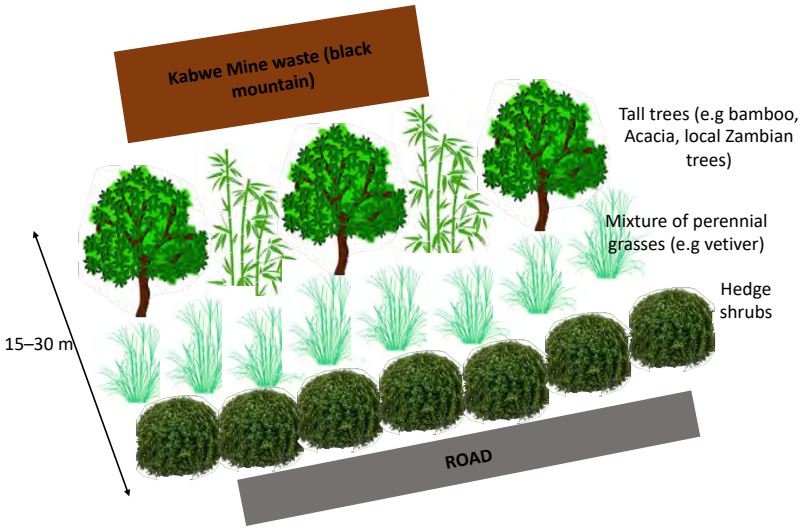
Agricultural approach

Greenbelt

Certain plants have the ability to grow and thrive even in highly polluted soils. These plants can act either as hyper-accumulators, which take up large amounts of heavy metals from the soils, or stabilizers, which keep the heavy metals locked up in their root system. Additionally, vegetation cover reduces dust and sediment movement through air and water further minimizing the spread of the heavy metals.

We propose to establish a greenbelt around the entire mine area including mine waste damp (black mountain). The greenbelt will be made from selected fast-growing tree species, perennial grasses. A nursery will be established at the KAMPAI project's greenpark located on the southern side of the black mountain to provide the needed plant resources.

The greenbelt will be 15-30 m in diameter but with flexible size in areas where space will be limited due to existing structures. The total length of the greenbelt is estimated at 5.5 km. The estimated total budget for this work is USD82,950.



Tips

- The plants to be used for greenbelt are
  - trees (bamboo, acacia, local trees), 5-10m spacing
  - perennial grasses (vetiver grass), 1 m spacing
  - hedge shrubs, 2-5 m spacing
- Apply soil amendments (manure, biochar, lime)
- A minimum of one year of close monitoring and management is required
- Start planting at the beginning of rainy season
- Dust emission shall be monitored regularly, from inception to establishment stage of the greenbelt

Greening around the yard

In contaminated residential areas, we propose greening with lawn grass, such as local Kampinga grass, to minimize exposure to dust. This can be achieved at very minimal cost. Hedges around the yards could add further protection from dust.

Minimizing health risks from food grown in back-yard gardens with contaminated soil

The consumption of foods that grow up in polluted site can be a health risk as lead is taken up into the plant from the soil. To help reduce the lead level in the crops, we propose the following measures as part of the "good practice".

A. Application of soil amendments to immobilize lead in the soil

Apply soil amendments (e.g. compost, animals manure, biochar, and phosphate fertilizers) before planting, and mix in the topsoil. This results in reduction of lead level in the edible plant parts and improve of the crop growth.

B. Thorough washing of vegetables before cooking

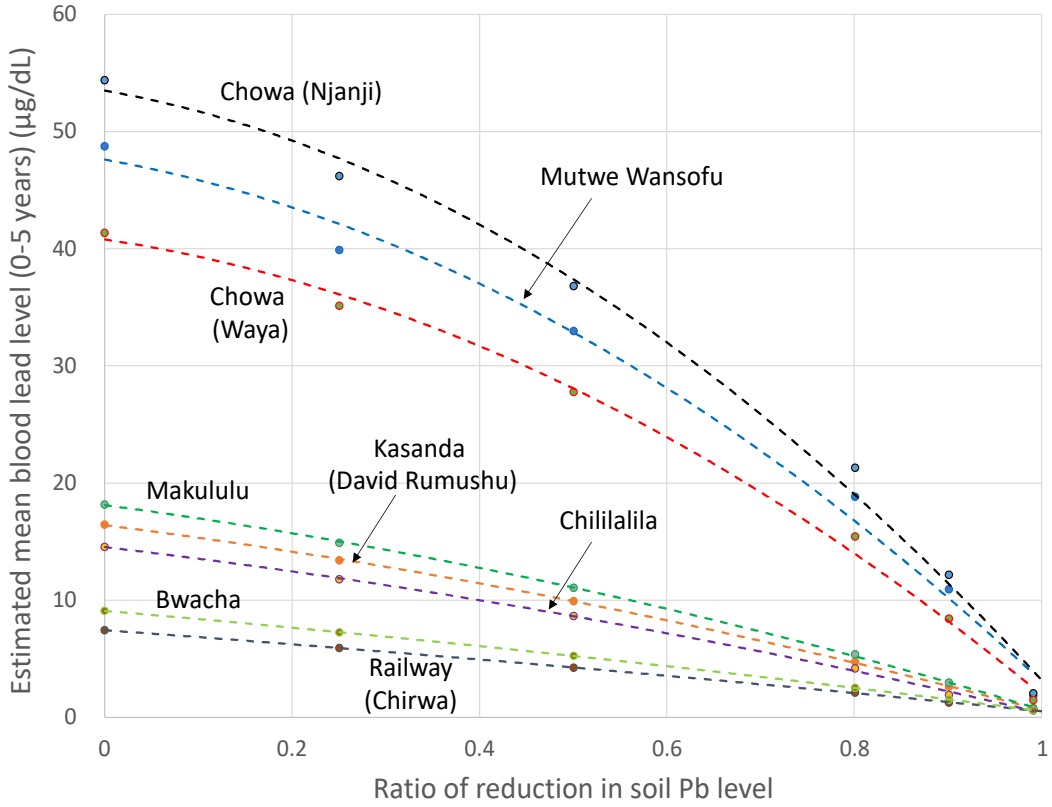
Lead containing dust particles accumulate on the vegetables whilst in the field. Thorough washing of vegetables before cooking has been shown to significantly reduce the concentration in cooked food. This is a simple, and yet very effective practice that also promotes general hygiene.

Estimation of the effect of lowering blood lead levels

Lead is known to enter the human body through oral or respiratory exposure from various environmental media. The environmental remediation measures reduce the amount of lead entering the human body and the lead present in the body is gradually eliminated from the body, thus reducing the concentration of lead in the body.

The Integrated Exposure Uptake Biokinetic (IEUBK) model was used to estimate blood lead levels (BLLs) of children in Kabwe. The model allows the estimation of the BLL by using the lead level data in environmental samples described above. The extent to which BLL is reduced by reducing soil lead concentrations through environmental remediation practices was verified in various areas of Kabwe.

The results show that the average BLL for the whole Kabwe is below the reference level of 5 µg/dL due to a 99% reduction in soil lead concentrations and a same reduction in lead concentrations in house dust, airborne dust and foodstuffs.



Cost-benefit analysis

We investigated the costs and benefits of remediation options. The costs account for the initial investment and maintenance. The improvement in IQ and labour productivity and the decrease in lead-related mortality are considered as the benefits. The results show that the benefits exceed the costs, and the dumping site remediation is particularly effective.

50-year costs and benefits of remediation options

Remediation scenario	Total costs	Total benefit
Entire dumping site only	367	747
Entire dumping site + residential (small scale)	667	943
Entire dumping site + residential (large scale)	801	1,124
LPR only	95	693
LPR + residential (small scale)	395	823
LPR + residential (small scale)	529	936

*LPR = Leach Plant Residues *All terms are in million ZMW

BLL testing and chelation therapy protocol

The reduction of lead levels in the environment through environmental remediation and the prevention of future exposure is crucial. On the other hand, health interventions for the population already exposed to lead are equally important. For this reason, a manual on health intervention for local health workers has been developed in collaboration with the ZMERIP. This includes on-site BLL measurement methods, patient follow up and guidelines for chelator treatment.

The ZMERIP has already started health interventions based on the manual developed, but this activity needs to be continued on a regular basis, mainly by the Ministry of Health.

Annex 12: List of seminar and meeting

June 2022

Japanese Fiscal Year	Date	Name	Venue	Number of participants
2015	2015/6/5	Meeting No. 1	Vet, HU	13
2015	2015/6/16	Meeting No. 2	Vet, HU	3
2015	2015/7/1	Meeting No. 3	JSS	3
2015	2015/7/2	Meeting No. 4	JSS	3
2015	2015/7/8	Meeting No. 5	Vet, HU	16
2015	2015/7/23	Meeting No. 6	JICA HQ	6
2015	2015/7/28	Meeting No. 7	Vet, HU	4
2015	2015/8/3	Meeting No. 8	Vet, HU	4
2015	2015/8/7	Meeting No. 9	Vet, HU	16
2015	2015/8/17	Meeting No. 10	JICA Zambia	8
2015	2015/8/17	Meeting No. 11	Ministry of HEALTH, Public Health Section, Research Section	8
2015	2015/8/17	Meeting No. 12	School of Veterinary Medicine, UNZA	5
2015	2015/8/17	Meeting No. 13	National Remote Sensing Center (NRSC)	5
2015	2015/8/18	Meeting No. 14	ZEMA	8
2015	2015/8/19	Meeting No. 15	Ministry of Lands	7
2015	2015/8/19	Meeting No. 16	Ministry of Education, Science, Vocational Training and Early Education	6
2015	2015/8/20	Meeting No. 17	Ministry of Mines	5
2015	2015/9/1	Meeting No. 18	Web Meeting	5
2015	2015/9/4	Meeting No. 19	Earth Science, HU	4
2015	2015/9/7	Meeting No. 20	Web Meeting	3
2015	2015/9/9	Meeting No. 21	Web Meeting	4
2015	2015/9/10	Meeting No. 22	JST	4
2015	2015/9/10	Meeting No. 23	Web Meeting	6
2015	2015/9/10	Meeting No. 24	JSS	3
2015	2015/9/14	Meeting No. 25	World Bank Office, Lusaka	11
2015	2015/9/14	Meeting No. 26	Ministry of Health	9
2015	2015/9/15	Meeting No. 27	Ministry of Mines	6
2015	2015/9/15	Meeting No. 28	World Bank, Kabwe Ministry of Council, Blachsmith Institute	30
2015	2015/9/15	Meeting No. 29	UNZA Acting VC	5
2015	2015/10/1	Meeting No. 30	Agriculture, HU	16
2015	2015/10/5	Meeting No. 31	Web Meeting	11
2015	2015/10/7	Meeting No. 32	JICA Zambia	2
2015	2015/10/8	Meeting No. 33	KMC	11
2015	2015/10/9	Meeting No. 34	National Remote Sensing Center (NRSC)	3
2015	2015/10/9	Meeting No. 35	Mine Safety Department in Kitwe	4
2015	2015/10/11	Meeting No. 36	Vet, HU	6
2015	2015/10/12	Meeting No. 37	JICA Zambia	6
2015	2015/10/12	Meeting No. 38	UNZA	7
2015	2015/10/12	Meeting No. 39	UNZA	8
2015	2015/10/12	Meeting No. 40	Ministry of Higher Education	8
2015	2015/10/12	Meeting No. 41	Meeting with WB	10
2015	2015/10/13	Meeting No. 42	Lusaka	20
2015	2015/10/14	Meeting No. 43	KMC	10
2015	2015/10/14	Meeting No. 44	KMC	20

2015	2015/10/15	Meeting No. 45	KMC	10
2015	2015/10/15	Meeting No. 46	Embassy of Japan	10
2015	2015/10/16	Meeting No. 47	UNZA	20
2015	2015/10/16	Meeting No. 48	JICA Zambia	10
2015	2015/10/14	Meeting No. 49	HU	2
2015	2015/10/22	Meeting No. 50	HU	4
2015	2015/10/30	Meeting No. 51	Web Meeting	9
2015	2015/11/4	Meeting No. 52	Vet, HU	10
2015	2015/11/9	Meeting No. 53	Engin, HU	4
2015	2015/11/19	Meeting No. 54	JSS	3
2015	2015/11/20	Meeting No. 55	Engin, HU	10
2015	2016/1/13	Meeting No. 56	School of Education, UNZA	3
2015	2016/1/14	Meeting No. 57	JICA Zambia	4
2015	2016/1/14	Meeting No. 58	School of Education, UNZA	4
2015	2016/1/15	Meeting No. 59	KMC	3
2015	2016/1/18	Meeting No. 60	School of Mines, UNZA	3
2015	2016/2/15	Meeting No. 61	Vice Chancellor's Office, UNZA	2
2015	2016/2/15	Meeting No. 62	School of Agriculture, UNZA	3
2015	2016/2/22	Meeting No. 63	JICA Zambia	8
2015	2016/2/22	Meeting No. 64	UNZA	8
2015	2016/2/22	Meeting No. 65	UNZA	11
2015	2016/2/22	Meeting No. 66	UNZA	7
2015	2016/2/24	Meeting No. 67	WB office	13
2015	2016/2/24	Meeting No. 68	UNZA	25
2015	2016/2/25	Meeting No. 69	Ministry oh Health	8
2015	2016/2/25	Meeting No. 70	Ministry of Mines	8
2015	2016/2/25	Meeting No. 71	JICA Zambia	8
2015	2016/2/24	Meeting No. 72	School of Engin, HU	5
2015	2016/2/25	Meeting No. 73	CZC	5
2015	2016/3/14	Meeting No. 74	Web Meeting	18
2016	2016/4/19	Meeting No. 75	JICA Zambia	8
2016	2016/4/19	Meeting No. 76	ZEMA	8
2016	2016/4/19	Meeting No. 77	MOL/JICA	8
2016	2016/4/20	Meeting No. 78	UNZA	9
2016	2016/4/21	Meeting No. 79	JICA	8
2016	2016/4/21	Meeting No. 80	JICA	8
2016	2016/4/21	Meeting No. 81	World Bank Office	10
2016	2016/4/22	Meeting No. 82	UNZA	8
2016	2016/4/22	Meeting No. 83	UNZA	10
2016	2016/4/22	Meeting No. 84	National Remote Sensing Center (NRSC)	10
2016	2016/5/10	Meeting No. 85	Web Meeting	24
2016	2016/5/12	Meeting No. 86	Agriculture, HU	8
2016	2016/6/9	Meeting No. 87	Agriculture, HU	3
2016	2016/6/13	Meeting No. 88	Web Meeting	26
2016	2016/6/10 - 7/22	Meeting No. 89	Lusaka, Kabwe	6
2016	2016/7/3 - 7/15	Meeting No. 90	Lusaka, Kabwe	22
2016	2016/7/11	Meeting No. 91	Agriculture, UNZA	5
2016	2016/7/11 - 7/13	Meeting No. 92	School of Mine, UNZA	8

2016	2016/7/13	Meeting No. 93	Vet, UNZA	8
2016	2016/7/14	Meeting No. 94	CRESTA Golfview Hotel, Lusaka	66
2016	2016/7/14	Meeting No. 95	Geological Survey Department, Ministry of Mines	6
2016	2016/7/14	Meeting No. 96	Ministry of Finance	5
2016	2016/7/14	Meeting No. 97	Embassy of Japan	7
2016	2016/7/14	Meeting No. 98	HU	10
2016	2016/7/15	Meeting No. 99	Vet, UNZA	14
2016	2016/7/15	Meeting No. 100	KMC	7
2016	2016/8/10	Meeting No. 101	Vet, HU	23
2016	2016/9/12	Meeting No. 102	Econ, HU	9
2016	2016/10/12	Meeting No. 103	Web Meeting	36
2016	2016/10/24	Meeting No. 104	Melsim Lodge, Lusaka	9
2016	2016/10/25	Meeting No. 105	Vet, UNZA	14
2016	2016/10/26	Meeting No. 106	KMC	11
2016	2016/10/26	Meeting No. 107	Mines, UNZA	5
2016	2016/10/28	Meeting No. 108	Medical, UNZA	8
2016	2016/11/1	Meeting No. 109	Kabwe	5
2016	2016/11/4	Meeting No. 110	Econ, HU	4
2016	2016/11/18	Meeting No. 111	Web Meeting	13
2016	2016/11/30	Meeting No. 112	JICA HQ	6
2016	2016/12/1	Meeting No. 113	Web Meeting	6
2016	2016/12/6	Meeting No. 114	Vet	11
2016	2016/12/12	Meeting No. 115	Engin, HU	10
2016	2016/12/15	Meeting No. 116	Vet, HU	5
2016	2016/12/20	Meeting No. 117	Vet, HU	6
2016	2016/12/20	Meeting No. 118	Web Meeting	21
2016	2016/12/27	Meeting No. 119	Kabwe District Medical Office	2
2016	2016/12/28	Meeting No. 120	KMC	2
2016	2016/12/28	Meeting No. 121	Kabwe District Veterinary Office	2
2016	2017/1/4	Meeting No. 122	Asahikawa Med Univ	4
2016	2017/1/6	Meeting No. 123	Vet, HU	3
2016	2017/1/10	Meeting No. 124	Vet, HU	4
2016	2017/1/10	Meeting No. 125	Engin, HU	10
2016	2017/1/11	Meeting No. 126	Agriculture, HU	2
2016	2017/1/13	Meeting No. 127	Web Meeting	8
2016	2017/1/17	Meeting No. 128	Kabwe District Medical Office	2
2016	2017/1/19	Meeting No. 129	Vet, HU	6
2016	2017/1/19	Meeting No. 130	Web Meeting	40
2016	2017/1/19 - 1/20	Meeting No. 131	Kusiro	7
2016	2017/1/23	Meeting No. 132 (Annual Report Meeting)	JST HQ	30
2016	2017/2/1	Meeting No. 133	Engin, HU	10
2016	2017/2/1	Meeting No. 134	Web Meeting	3
2016	2017/2/6	Meeting No. 135	UNZA	2
2016	2017/2/7	Meeting No. 136	UNZA	3
2016	2017/2/16	Meeting No. 137	Web Meeting	4
2016	2017/2/21	Meeting No. 138	UNZA	10
2016	2017/2/22	Meeting No. 139	Mines, UNZA	15

2016	2017/2/22	Meeting No. 140	World Bank Office in Lusaka	8
2016	2017/2/23 - 2/25	Meeting No. 141	Kabwe	10
2016	2017/2/27	Meeting No. 142	Vet, HU	6
2016	2017/2/28	Meeting No. 143	Vet, HU	6
2016	2017/2/28	Meeting No. 144	ZEMA	11
2016	2017/2/28	Meeting No. 145	Mines, UNZA	7
2016	2017/3/1	Meeting No. 146	Vet, UNZA	9
2016	2017/3/1	Meeting No. 147	Web Meeting	36
2016	2017/3/2	Meeting No. 148	UNZA	8
2016	2017/3/3	Meeting No. 149	UNZA	9
2016	2017/3/2	Meeting No. 150	KMC	17
2016	2017/3/3	Meeting No. 151	District Educational Board Office	14
2016	2017/3/4	Meeting No. 152	Medical, UNZA	13
2016	2017/3/5	Meeting No. 153	Econ, HU	5
2016	2017/3/6	Meeting No. 154	Econ, HU	4
2016	2017/3/8	Meeting No. 155	KMC	4
2016	2017/3/10	Meeting No. 156	Web Meeting	7
2016	2017/3/10	Meeting No. 157	Econ, HU	5
2016	2017/3/17	Meeting No. 158	Vet, HU	5
2016	2017/3/23	Meeting No. 159	Web Meeting	7
2016	2017/3/28	Meeting No. 160	Web Meeting	5
2017	2017/4/3	Meeting No. 161	Vet, HU	4
2017	2017/4/5	Meeting No. 162	Web Meeting	8
2017	2017/4/6	Meeting No. 163	Agriculture, HU	2
2017	2017/4/6	Meeting No. 164	Vet, HU	5
2017	2017/4/7	Meeting No. 165	Vet, HU	4
2017	2017/4/7	Meeting No. 166	Vet, HU	38
2017	2017/4/24	Meeting No. 167	Web Meeting	7
2017	2017/5/3	Meeting No. 168	Ministry of Mines	4
2017	2017/5/3	Meeting No. 169	Ministry of Mines	3
2017	2017/5/3	Meeting No. 170	ZEMA	5
2017	2017/5/4	Meeting No. 171	Ministry of Health	3
2017	2017/5/5	Meeting No. 172	KMC	3
2017	2017/5/5	Meeting No. 173	Kabwe District Health Office	3
2017	2017/5/5	Meeting No. 174	Kabwe Veterinary Office	3
2017	2017/5/18	Meeting No. 175	Kabwe Veterinary Office	3
2017	2017/5/18	Meeting No. 176	Kabwe Mine Hospital	2
2017	2017/5/22	Meeting No. 177	Web Meeting	7
2017	2017/5/23-24	Meeting No. 178	Kabwe	50
2017	2017/6/6	Meeting No. 179	Kabwe Veterinary Office	3
2017	2017/6/7	Meeting No. 180	Kabwe Municipal Council	3
2017	2017/6/8-9	Meeting No. 181	Kabwe	20
2017	2017/6/12	Meeting No. 182	Web Meeting	12
2017	2017/6/13	Meeting No. 183	KMC	9
2017	2017/6/15	Meeting No. 184	KMC	7
2017	2017/6/19	Meeting No. 185	UNZA	4
2017	2017/6/20	Meeting No. 186	World Bank Office in Lusaka	11
2017	2017/6/20	Meeting No. 187	World Bank Office in Lusaka	12
2017	2017/6/21	Meeting No. 188	Web Meeting	30
2017	2017/6/22	Meeting No. 189	Web Meeting	11

2017	2017/6/30	Meeting No. 190	Web Meeting	13
2017	2017/7/6	Meeting No. 191	Web Meeting	11
2017	2017/7/11	Meeting No. 192	Web Meeting	5
2017	2017/7/11-7/14	Meeting No. 193	Kabwe	16
2017	2017/7/12	Meeting No. 194	Web Meeting	5
2017	2017/7/17	Meeting No. 195	UTH Ridgeway Campus, UNZA	17
2017	2017/7/17	Meeting No. 196	Kabwe District Health Office	19
2017	2017/7/18	Meeting No. 197	Kabwe District Health Office	21
2017	2017/7/19	Meeting No. 198	KMC	6
2017	2017/7/20	Meeting No. 199	Kabwe District Health Office	22
2017	2017/7/24	Meeting No. 200	Kasanda Clinic	24
2017	2017/8/14	Meeting No. 201	JICA Zambia	5
2017	2017/8/14	Meeting No. 202	UNZA	6
2017	2017/8/15	Meeting No. 203	KMC	5
2017	2017/8/16	Meeting No. 204	Kabwe District Medical Office	7
2017	2017/8/16	Meeting No. 205	Kabwe Veterinary Office	6
2017	2017/8/16	Meeting No. 206	KMC	4
2017	2017/8/18	Meeting No. 207	ZMERIP Office in Lusaka	3
2017	2017/8/21	Meeting No. 208	KMC	4
2017	2017/8/26	Meeting No. 209	KMC	6
2017	2017/8/30	Meeting No. 210	KMC	6
2017	2017/8/31	Meeting No. 211	Web Meeting	7
2017	2017/9/8	Meeting No. 212	Web Meeting	6
2017	2017/9/14	Meeting No. 213	KMC	5
2017	2017/9/18	Meeting No. 214	KMC	3
2017	2017/9/26	Meeting No. 215	Ministry of Health	5
2017	2017/9/27	Meeting No. 216	ZEMA	4
2017	2017/9/27	Meeting No. 217	Ministry of Mines	5
2017	2017/9/27	Meeting No. 218	Ministry of Lands	4
2017	2017/10/3	Meeting No. 219	WARMA	2
2017	2017/10/5～10/8	Meeting No. 220	Kabwe	10
2017	2017/10/11	Meeting No. 221	Ministry of Higher Education	6
2017	2017/10/12	Meeting No. 222	Web Meeting	40
2017	2017/10/16	Meeting No. 223	InterContinental Lusaka	30
2017	2017/10/16	Meeting No. 224	JICA Zambia	10
2017	2017/10/17	Meeting No. 225	KMC	12
2017	2017/10/25	Meeting No. 226	Ministry of Health	4
2017	2017/10/25	Meeting No. 227	Ministry of Lands	3
2017	2017/11/6	Meeting No. 228 (1st KAMPAI International Symposium)	Engin, HU	74（10）
2017	2017/11/7	Meeting No. 229 (1st KAMPAI International Symposium)	Engin, HU	50（10）
2017	2017/11/9	Meeting No. 230	Vet, HU	6
2017	2017/11/9	Meeting No. 231	Vet, HU	6
2017	2017/11/10	Meeting No. 232	Vet, HU	11
2017	2017/11/27	Meeting No. 233	Vet, HU	6
2017	2017/11/29	Meeting No. 234	Vet, UNZA	4

2017	2017/11/29	Meeting No. 235	KMC	10
2017	2017/11/30	Meeting No. 236	KMC	5
2017	2017/12/6	Meeting No. 237	Web Meeting	6
2017	2018/1/8	Meeting No. 238	KMC	3
2017	2018/1/9	Meeting No. 239	Kabwe District Health Office	2
2017	2018/1/11	Meeting No. 240	Web Meeting	32
2017	2018/1/15	Meeting No. 241	KMC	9
2017	2018/1/16	Meeting No. 242	KMC	3
2017	2018/1/17	Meeting No. 243	UNZA	4
2017	2018/1/23	Meeting No. 244	Ministry of Health	3
2017	2018/1/23	Meeting No. 245	Ministry of Mines	3
2017	2018/1/23	Meeting No. 246	Ministry of Higher Education	3
2017	2018/1/24	Meeting No. 247	WB ZMERIP Office	2
2017	2018/1/25	Meeting No. 248	Web Meeting	39
2017	2018/2/1	Meeting No. 249	Web Meeting	7
2017	2018/2/1	Meeting No. 250	Web Meeting	7
2017	2018/2/2	Meeting No. 251	MOWDSEP	11
2017	2018/2/9	Meeting No. 252	Econ, UNZA	8
2017	2018/2/19	Meeting No. 253	HU	6
2017	2018/2/20	Meeting No. 254	KMC	6
2017	2018/2/20	Meeting No. 255	KMC	12
2017	2018/2/22	Meeting No. 256	KMC	4
2017	2018/2/23	Meeting No. 257	InterContinental Lusaka	21
2017	2018/2/26	Meeting No. 258	Kabwe Veterinary Office	4
2017	2018/2/28	Meeting No. 259	KMC	43
2017	2018/3/7	Meeting No. 260	Vet, HU	8
2017	2018/3/14	Meeting No. 261	Vet, HU	5
2017	2018/3/26	Meeting No. 262	Web Meeting	15
2017	2018/3/29	Meeting No. 263	Web Meeting	9
2018	2018/4/10	Meeting No. 264	Web Meeting	30
2018	2018/4/19	Meeting No. 265	Web Meeting	6
2018	2018/4/24	Meeting No. 266	Web Meeting	30
2018	2018/5/13	Scieintific Seminar	Sapporo Maruyama Zoo	60
2018	2018/5/15	Meeting No. 267	Web Meeting	5
2018	2018/5/18	Meeting No. 268	Web Meeting	10
2018	2018/5/29	Science Café Event	Sanseido book shop	50
2018	2019/6/5	Meeting No. 269	JICA Zambia	6
2018	2018/6/12	Meeting No. 270	Vet UNZA	4
2018	2018/6/15	Meeting No. 271	Web Meeting	12
2018	2018/6/20	Meeting No. 272	Web Meeting	7
2018	2018/6/22	Meeting No. 273	Web Meeting	6
2018	2018/7/4	Meeting No. 274	Ministry of Higher Education	5
2018	2018/7/10	Meeting No. 275	Ministry of Higher Education	5
2018	2018/7/11	Meeting No. 276	UNZA	6
2018	2018/7/23	Meeting No. 277	KMC	3
2018	2018/7/24	Lecture	Agric, UNZA	30
2018	2018/7/25	Meeting No. 278	Ministry of Mines	4
2018	2018/7/31	Meeting No. 279	Vet UNZA	25
2018	2018/8/3	Meeting No. 280	MOWDSEP	6
2018	2018/8/6	Mid-term evaluation meeting	JST HQ	30

2018	2018/8/13	Meeting No. 281	Ministry of Higher Education	4
2018	2018/8/14	Mid-term evaluation meeting (KAMPAI Internatilnal Symposium)	InterContinental Lusaka	250
2018	2018/8/15	Meeting No. 282	KMC	30
2018	2018/8/24	Inspection by JICA president	Vet UNZA	20
2018	2018/8_27	Meeting No. 283	Ministry of Mines	8
2018	2018/9/4	Meeting No. 284	Ministry of Higher Education	7
2018	2018/9/26	Meeting No. 285	Vet, HU	20
2018	2018/10/2	Meeting No. 286	JICA Zambia	6
2018	2018/10/12	Meeting No. 287	Web Meeting	40
2018	2018/10/19	Meeting No. 288	KMC	4
2018	2018/11/9	Meeting No. 289	JICA Zambia	6
2018	2018/11/13	Meeting No. 290	Web Meeting	20
2018	2018/11/19	Meeting No. 291	Web Meeting	5
2018	2018/12/5	Meeting No. 292	KMC	3
2018	2018/12/7	Meeting No. 293	JICA Zambia	6
2018	2018/12/12	Meeting No. 294	JICA Zambia	10
2018	2018/12/17	Meeting No. 295	Web Meeting	35
2018	2019/1/7	Meeting No. 296	Web Meeting	8
2018	2019/1/10	Meeting No. 297	Engin, HU	6
2018	2019/1/11	Meeting No. 298	Vet, HU	11
2018	2019/1/18	Meeting No. 299	Web Meeting	7
2018	2019/1/23	Meeting No. 300	Vet, HU	7
2018	2019/2/4	Meeting No. 301	Web Meeting	5
2018	2019/2/7	Workshop	Tanzania	150
2018	2019/2/8	Inspection by HU director	UNZA	6
2018	2019/2/8	UNZA inter-departmental meeting	UNZA	20
2018	2019/2/12	Meeting No. 302	Web Meeting	10
2018	2019/3/5	Meeting No. 303	Web Meeting	6
2018	2019/3/10	Meeting No. 304	Mines, UNZA	14
2018	2019/3/15	Meeting No. 305	Web Meeting	17
2018	2019/3/20	Chemical Hazard Symposium	Vet, HU	60
2018	2019/3/29	JST mid-term evaluation	JST HQ	30
2019	2019/4/9	Meeting No. 306	JICA Zambia	5
2019	2019/4/11	Monitoring lab launch meeting	UNZA	20
2019	2019/4/17	Meeting No. 307	KMC	4
2019	2019/4/18	Meeting No. 308	UNZA	4
2019	2019/4/24	Meeting No. 309	UNZA	5
2019	2019/5/22	Meeting No. 310	HU	4
2019	2019/5/31	Meeting No. 311	JICA HQ	3
2019	2019/6/6	Meeting No. 312	Web Meeting	7
2019	2019/6/17	Meeting No. 313	HU	6
2019	2019/7/4	Meeting No. 314	UNZA	7
2019	2019/7/8	Meeting No. 315	UNZA	8

2019	2019/7/9	Meeting No. 316	UNZA	6
2019	2019/7/12	Meeting No. 317	Kabwe Veterinary Office	4
2019	2019/7/17	Meeting No. 318	Web Meeting	5
2019	2019/7/24	Meeting No. 319	Web Meeting	8
2019	2019/7/24	Meeting No. 320	UNZA	5
2019	2019/7/29	Meeting No. 321	UNZA	15
2019	2019/7/30	Meeting No. 322	Web Meeting	30
2019	2019/7/31	Meeting No. 323	UNZA	10
2019	2019/8/1	Lecture	UNZA	15
2019	2019/8/8	Meeting No. 324	UNZA	9
2019	2019/8/12	Meeting No. 325	Ministry of Mines	4
2019	2019/8/13	Meeting No. 326	Ministry of Higher Education	5
2019	2019/8/14	Monitoring lab launch meeting	UNZA	40
2019	2019/8/19-23	Lecture	UNZA	20
2019	2019/8/21	Lecture	Web Meeting	80
2019	2019/8/29	Meeting No. 327	UNZA	9
2019	2019/8/29	Symposium & Booth exhibition at TICAD7	Yokohama	400
2019	2019/9/10	Meeting No. 328	Web Meeting	9
2019	2019/10/2	Meeting No. 329	JICA Zambia	5
2019	2019/10/8	Meeting No. 330	HU	5
2019	2019/10/9	Meeting No. 331	KMC	5
2019	2019/10/11	Meeting No. 332	UNZA	6
2019	2019/10/17	Meeting No. 333	UNZA	4
2019	2019/10/28	Meeting No. 334	UNZA	5
2019	2019/11/13	Meeting No. 335	Web Meeting	7
2019	2019/11/14	Meeting No. 336	Web Meeting	7
2019	2019/11/22	Lecture	Iiyama High School	80
2019	2019/11/22	Lecture	Nagano High School	40
2019	2019/12/5	Lecture	Kojiya elementary school	100
2019	2019/12/9	Invited-presentation	JST HQ	36
2019	2019/12/9	Lecture	HU	20
2019	2019/12/19	Meeting No. 327	Embassy of Japan	5
2019	2019/12/20	Meeting No. 328	Web Meeting	8
2019	2019/12/23	Meeting No. 329	JICA HQ	8
2019	2019/12/24	Meeting No. 330	Web Meeting	5
2019	2020/1/15	Meeting No. 331	UNZA	6
2019	2020/2/24	Meeting No. 332	Web Meeting	6
2019	2020/1/30	Meeting No. 333	Web Meeting	30
2019	2020/1/31	Meeting No. 334	Web Meeting	7
2019	2020/2/17	Lecture	UNZA	20
2019	2020/2/24-28	Lecture	UNZA	4
2019	2020/3/4	Meeting No. 335	Ministry of Mines	6
2019	2020/3/11	Meeting No. 336	Web Meeting	8
2019	2020/3/16	Meeting No. 337	Web Meeting	5
2019	2020/4/7	Meeting No. 338	HU	8
2020	2020/4/15	Meeting No. 339	HU	6
2020	2020/5/8	Meeting No. 340	Web Meeting	6
2020	2020/5/22	Lecture	Web Meeting	120
2020	2020/6/2	Meeting No. 341	Web Meeting	5

2020	2020/6/15	Meeting No. 342	Web Meeting	4
2020	2020/6/23	Meeting No. 343	Web Meeting	6
2020	2020/7/6	Meeting No. 344	HU	6
2020	2020/7/6	Meeting No. 345	Web Meeting	8
2020	2020/7/10	Meeting No. 346	Web Meeting	10
2020	2020/7/27	Meeting No. 347	Web Meeting	11
2020	2020/7/30	Meeting No. 348	Web Meeting	3
2020	2020/8/12	Meeting No. 349	KMC	4
2020	2020/8/13	Meeting No. 350	Web Meeting	5
2020	2020/8/17	Meeting No. 351	UNZA	3
2020	2020/8/18	Meeting No. 352	KMC	3
2020	2020/8/25	Meeting No. 353	ZMERIP office	5
2020	2020/8/26	Meeting No. 354	KMC	3
2020	2020/8/31	Meeting No. 355	Embassy of Japan	4
2020	2020/9/1	Meeting No. 356	Web Meeting	6
2020	2020/9/3	Meeting No. 357	KMC	4
2020	2020/9/9	Meeting No. 358	UNZA	4
2020	2020/9/10	Meeting No. 359	Embassy of Japan	4
2020	2020/9/15	Task force meeting	UNZA	8
2020	2020/9/16	Meeting No. 360	Kabwe Veterinary Office	5
2020	2020/9/22	Meeting No. 361	UNZA	3
2020	2020/9/23	Meeting No. 362	JICA Zambia	4
2020	2020/10/16	Meeting No. 363	Web Meeting	5
2020	2020/11/6	Meeting No. 364	HU	4
2020	2020/11/12	Meeting No. 365	Web Meeting	8
2020	2020/11/16	Meeting No. 366	Web Meeting	4
2020	2020/11/17	Meeting No. 367	北大	10
2020	2020/11/30	Meeting No. 368	Web Meeting	8
2020	2020/12/1	Meeting No. 369	Web Meeting	30
2020	2020/12/8	Lecture	Web Meeting	40
2020	2020/12/9	Meeting No. 370	HU	4
2020	2021/1/14	Meeting No. 371	HU	4
2020	2021/1/21	Meeting No. 372	HU	4
2020	2021/2/8	Meeting No. 373	Web Meeting	5
2020	2021/2/11	Meeting No. 374	UNZA	5
2020	2021/2/18	Meeting No. 375	KMC	5
2020	2021/2/24	Task force meeting	Web Meeting	8
2020	2021/3/18	Meeting No. 376	北大	15
2020	2021/3/24	Progress meeting	Web Meeting	91
2021	2021/4/7	Meeting No. 377	Web Meeting	5
2021	2021/4/7	Meeting No. 378	Web Meeting	6
2021	2021/4/13	Meeting No. 379	Web Meeting	7
2021	2021/4/19	Meeting No. 380	HU	3
2021	2021/5/11	Research Seminar	HU	67
2021	2021/6/1	Meeting No. 381	Web Meeting	40
2021	2021/6/2	Meeting No. 382	KMC	4
2021	2021/6/10	Meeting No. 383	Vet UNZA	5
2021	2021/6/10	Research Seminar	Web Meeting	100
2021	2021/6/23	Meeting No. 384	Vet UNZA	4
2021	2021/7/28	Meeting No. 385	Engin, HU	4
2021	2021/8/5	Meeting No. 386	Vet, HU	6
2021	2021/8/24	Meeting No. 387	Web Meeting	6

2021	2021/8/25	Meeting No. 388	Web Meeting	4
2021	2021/8/27	Meeting No. 389	Web Meeting	30
2021	2021/8/31	Meeting No. 390	Web Meeting	10
2021	2021/9/8	Lecture	Web Meeting	120
2021	2021/9/17	Lecture	Web Meeting	300
2021	2021/9/28	Meeting No. 391	Web Meeting	6
2021	2021/10/1	Meeting No. 392	Kabwe Veterinary Office	6
2021	2021/10/4	Meeting No. 393	Vet UNZA	5
2021	2021/10/4	Meeting No. 394	Embassy of Japan	9
2021	2021/10/4	Meeting No. 395	JICA Zambia	8
2021	2021/10/4	Meeting No. 396	Web Meeting	10
2021	2021/10/5	Meeting No. 397	Ministry of Mines	15
2021	2021/10/5	Meeting No. 398	ZEMA	12
2021	2021/10/6	Meeting No. 399	Ministry of Mines	12
2021	2021/10/7	Meeting No. 400	KMC	40
2021	2021/10/26	Meeting No. 401	Ministry of Green Economy	10
2021	2021/11/2	Meeting No. 402	Web Meeting	8
2021	2021/11/12	Meeting No. 403	Web Meeting	6
2021	2021/11/16	Meeting No. 404	Vet UNZA	8
2021	2021/11/19	Meeting No. 405	Web Meeting	8

TECHNICAL PROPOSAL

ON

THE FIELD REMEDIATION IN KABWE TO REDUCE ENVIRONMENTAL RISKS DUE TO MINING ACTIVITIES

FOR

The Government of Republic of Zambia

BY

KAbwe Mine Pollution Amelioration Initiative (KAMPAI) PROJECT

AND

Demonstration and Risk-based Implementation of
New lead remediation approach in Kabwe (DRINK) PROJECT

LUSAKA

November 2021

TECHNICAL SUBMISSION PROPOSAL

The Government of Republic of Zambia

Dear Sir/Madam,

REF: SUBMISSION OF PROPOSAL

Reference is made to the above captioned subject matter.

This serves to submit a proposal on suggestions on THE FIELD REMEDIATION IN KABWE TO REDUCE ENVIRONMENTAL RISKS DUE TO MINING ACTIVITIES to the Government of Republic of Zambia following the agreement that was made at the beginning of the project. We are hereby submitting our technical proposal.

This contains approximation costs of implementing each option proposed for remediation, estimation of the reduction in human exposure that can be expected from remediation practices, and cost-benefit analysis. Our proposals are binding upon us and subject to the modifications.

We understand you are not bound to accept any proposal you receive.

Yours sincerely,

The team from KAMPAI and DRINK projects

13 November 2021

TABLE OF CONTENTS

1.0 INTRODUCTION

The University of Zambia and Hokkaido University, JAPAN, have worked together under the SATREPS project with the name of "Visualization of Impact of Chronic/Latent Chemical Hazard and Geo-Ecological Remediation in Zambia" (KAbwe Mine Pollution Amelioration Initiative (KAMPAI), 2016-2022) which is funded by Japan International Cooperation Agency (JICA) and Japan Science and Technology Agency (JST), and the aXis project with the name of "Implementation and Effectiveness Verification of Risk-based Control Approaches for Lead Contaminated Environment and Lead Poisoning in Zambian Mining District" (Demonstration of Risk-based Implementation of New lead remediation approach in Kabwe (DRINK), 2020-2022) which is funded by JST, to address the lead (Pb) contamination challenge in Kabwe. Here, we provide recommendations for environmental remediation methods and lead exposure prevention methods that would be effective in the old tailing dam area and residential areas impacted by mine wastes in Kabwe. The characteristics and costs of each approach are also summarized. We also estimate the extent to which the reduction in environmental lead levels through remediation practices will reduce lead exposure in children, who are particularly vulnerable to lead. The socio-economic benefits of the improvements are also estimated.

2.0 OVERVIEW OF THE PROJECTS

In Kabwe town, the capital of Zambia's Central Province, extensive Pb contamination of township soils resulting in alarming Pb poisoning in population in the vicinity of the Pb-Zn mine have been reported. However, the actual status of environmental contamination was still unclear at the beginning of the project. The mechanism of Pb diffusion from mine site to residential area and exact route of human exposure were also unknown. Visualizations of negative impact of contamination on human health and economy were needed to accelerate the improvement of polluted improvements and to attend to the latent risk by the pollution. Additionally, establishment of a model for the sustainable socio-ecosystem development in metal-polluted areas was desired. In view of these needs, we have been working to contribute to the solution of pollution problems in Kabwe. As a result, we have been able to achieve important results in elucidating the pollution situation and the mechanisms of pollution spread, and in developing locally applicable environmental remediation methods.

3.0 SCOPE OF SERVICES – ENGINEERING APPROACH

3.1. Main objective

This proposal seeks to provide options devised to reduce the risks related to toxic heavy metals spread in the air, surface soil, groundwater, and surface water due to past mining activities in Kabwe, Zambia. The proposed remediation options for hotspots should be considered case by case.

3.1.1 Tailing impoundments (old tailing dam in the mine area)

The mine wastes in Kabwe are the source of the continued Pb and zinc (Zn) pollution for the surrounding residential areas. These mine wastes cover an approximate area of around 970,000 m^2. They were generated by different metallurgical processes and dumped discriminately as Leach Plant Residues (LPR), Imperial Smelting Furnace Slag (ISFS), Weal Kiln Slag (WKS), Wash Plant Tailing (WPT), and Pyrite Tailings (PT) piles as shown in Fig. 1.

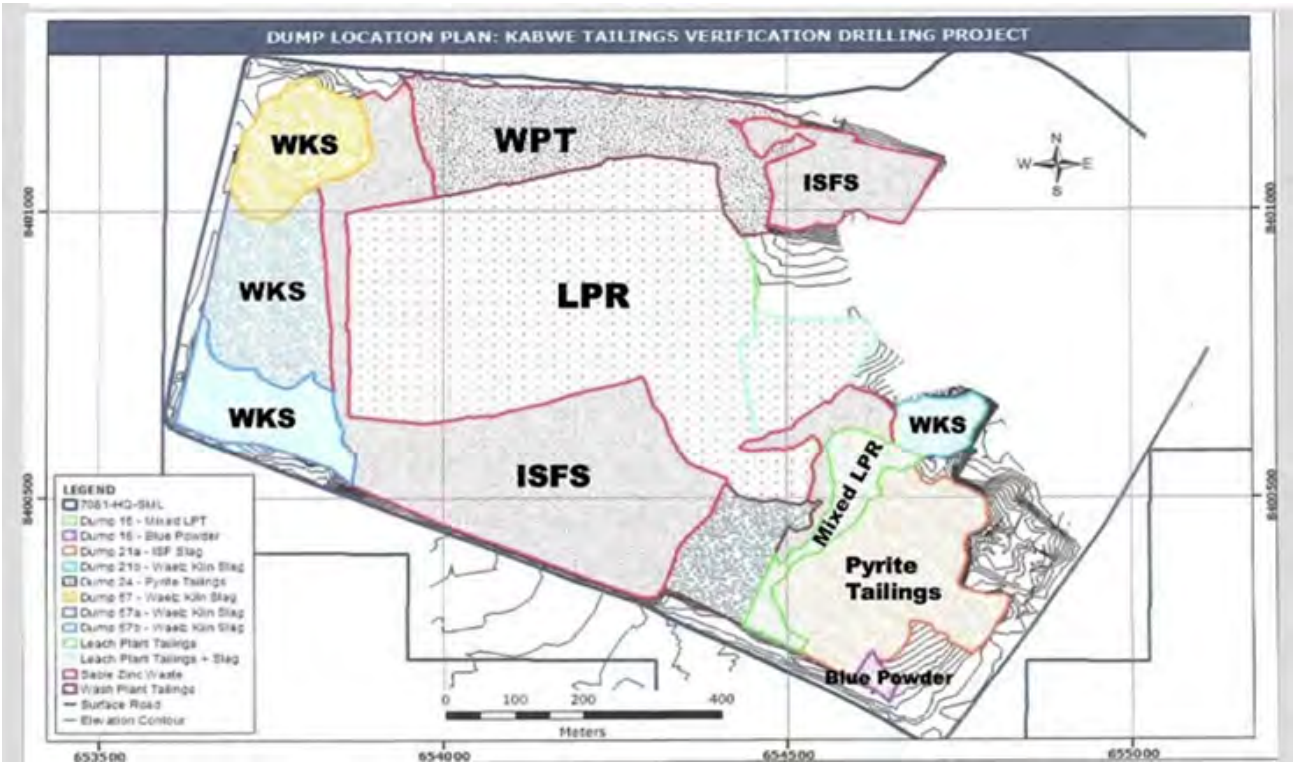


Figure 1. Types of the mine wastes dumped in old Pb-Zn Kabwe mine site

The LPR is the largest in quantity and covers the largest area. It pauses a great environmental threat to the surrounding residential areas as it is composed of very fine particles ($D_{50} \approx 10$ μm) that are easily transported/dispersed by wind easily. Furthermore, the toxicity characteristic leaching

procedure of LPR shows that as much as 12.95 mg/L Pb (against the 5 mg/L USEPA threshold) and 473.5 mg/L Zn can leach out. The major minerals of Pb and Zn that control the leachability of these metals from LPR were identified to be $PbSO_4$, ZnO, and $ZnSO_4/2H_2O$. The mine waste that covers the second-largest area when combined is the ISFS and WKS. The particle sizes of these wastes are coarse in the range of millimeters to centimeters size. This entails that they cannot easily be carried/transported by wind from the mine site to the residential areas. Additionally, these wastes contain Pb and Zn in relatively stable mineral forms such as glass (Si-Pb-Zn), corkite ($PbFe_3(PO_4)(SO_4)(OH)_5$), and spinel ($(Zn.Fe)(Fe,Al)_2O_4$). It is important to note that ISF is currently being exploited by small-scale miners.

The sampled water from the shallow well in residual areas showed that the concentration of Pb was low and below the drinking water Pb concentration standards/recommendation. However, when suspension matters from the wells were analyzed, it was found that they contain high amount of Pb. The isotopic measurement results suggest that the high lead content in the suspended matters from the well is derived from dust soils on the ground but not through the leachability of permeable layers. (K Toyoda, International Chemical hazard symposium in Hokkaido Univ., Sapporo, Japan/ March 20, 2019).

3.1.2. Remediation options recommended for Kabwe mine waste dumpsite area

Based on the above description we propose the following to contain or prevent the transportation of the Pb and Zn from the mine wastes, particularly the plant leach residues as follows. To estimate the costs of remediation options, unless specified otherwise, the costs of machineries, materials and fuels are based on the Japanese prices, assuming that their prices follow the international prices, whereas the labor costs account for the wage rate in Zambia when possible.

a. Revegetate sheet method

This method is commonly used for a greenery project of roadside steep slope in Japan. The LPR can be covered with a sheet containing grass seeds that are suited for growing on the LPR to prevent the transportation of very fine particles containing Pb and Zn components by wind erosion from the mine wastes (Fig. 2).

Assuming the mine waste area of 970,000 m^2, this option for the approximated area will cost around 10.1 million USD. The data of the material cost of revegetate sheets included the cost

to install them and, thus, all cost components are based on the standard prices in Japan. As described above, fine particles from LPR are easily transported by wind from waste dump to residential area. This suggested remediation method can be applied only to an area that covers LPR which is smaller than the entire mine wastes area. This implies that the cost of implementation could be scaled down.

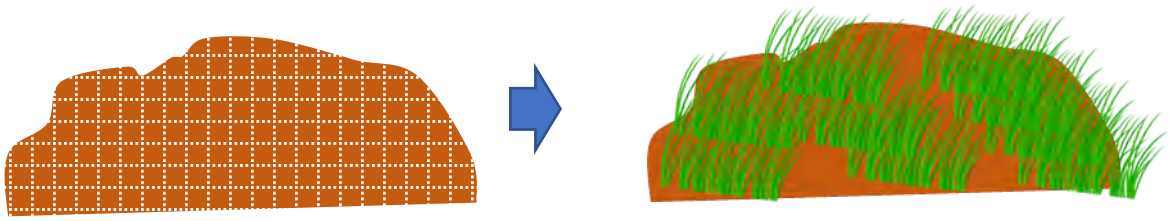


Figure 2. Schematic diagram of revegetate sheet method.

Although the initial cost of implementing this remediation option is low, frequent monitoring and maintenance are required especially when removal of vegetation occurs.

b. 1 cm clean soil capping

The dumping site can be covered with a thin layer of clean soil of around 1 cm as shown in Fig. 3. This can prevent the erosion and transportation of contaminated fine particle from the mine wastes to residential areas. Assuming the mine waste area of 970,000 m^2, volume of clean soil required is around 9,700 m^3. Thus, this method of remediation for the approximated area and required volume of clean soil will cost around 32.6 million USD. The cost includes soil excavating, soil dressing and transportation to the mine dumpsite (including workers' wages, standard price in Japan). Like the previous option, this method can be applied only to the area of LPR, and the cost of implementation could be scaled down.

Although the initial cost of implementing this remediation option is low, the required frequency of maintenance is high because the thin layer can be easily eroded by wind and rainwater.

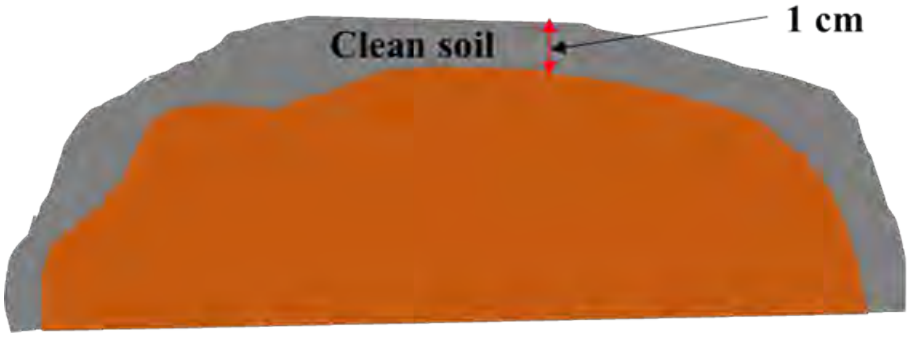


Figure 3. Schematic diagram of 1 cm clean soil capping

c. 1 cm cement mortar capping

Unlike the previous case where clean soil is proposed, this option suggests the use of cement mortar of thickness around 1 cm to cover the mining site (Fig. 4). Assuming 970,000 m^2 of area and 9,700 m^3 of volume as above, the cost of implementing this remediation option is approximated to be around 34.1 million USD. The cost includes the material costs of cement mortar and metal laths and the labour costs, all in the standard prices in Japan.

Although the initial cost of this option is almost the same as that of clean soil, monitoring and maintenance for this option could be less frequent. Besides, covering the LPR wastes with cement mortar would likely minimize the leachability of Pb and Zn because the proposed 1 cm layer would limit the seepage of rainwater during the rainy season. Another advantage of using cement mortar is to utilize its initial pH which is about 12. At this pH, Pb and Zn are immobilized via precipitation as oxyhydroxide.

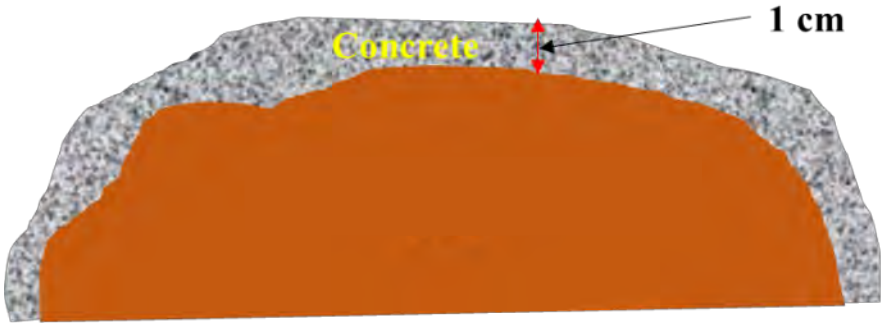


Figure 4. Schematic diagram of 1 cm clean soil capping

d. 30 cm clean soil capping and revegetation of the covered area

The fourth is covering these wastes with around 30 cm thick of clean soil and revegetate the covered area with shrubby trees (Fig. 5) since 30cm is required for deep root growth (standard thickness in Japan). The clean soil cover and trees/grasses will prevent the dispersion of the contaminated LPR to residential areas. The latter will also prevent clean soil erosion and at the same time take up heavy metals (i.e., phytoremediation). Assuming the same mine waste area of 970,000 m^2, the volume of clean soil required for 30 cm is around 17,250 m^3. The cost of soil capping, planting trees and labour (the wage rate in Zambia from now on) will be around 48.1 million USD.

The initial cost of this option is relatively high because a huge quantity of clean soil is needed to be excavated and transported to the mine site. It is important to pay attention to the selection of types of trees because growth failure and stunted growth may be experienced.

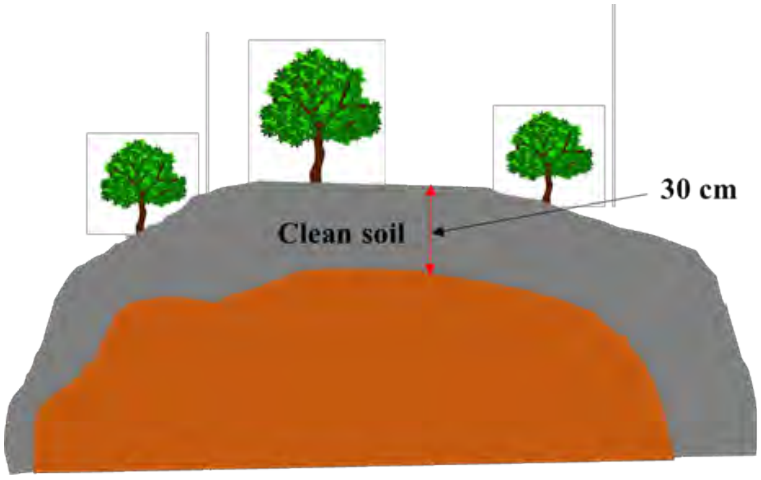


Figure 5. Schematic diagram of 30 cm clean soil capping and revegetation

e. Mixing immobilizer (half-burnt dolomite (10 wight %) or phosphate fertilizer (5 weight %)) with 50 cm of the mining waste, capping with 30 cm clean soil, and revegetation

If shrubby trees/ or grasses growth failure is recorded for option (e) above, then immobilization layer with either half-burnt dolomite or phosphate fertilizer should be considered to be placed beneath the clean soil (Fig. 6). Again, assuming the same area to be covered with clean soil and immobilization layer (phosphate fertilizer or half burnt dolomite) the final cost will depend

on the immobilizer chosen. The approximate total cost using phosphate fertilizer is around 354.3 million USD (phosphoric fertilizer: 67 ZMW/kg at Zambia price). The approximate total cost using half burnt dolomite is around 176.0 million USD (half-burnt dolomite: 1.33 USD/kg at the standard price in Japan). However, dolomite is available in Kabwe area as the very mined and processed Pb-Zn was hosted by dolomitic rock, indicating that the price of half-burnt dolomite may become lower than indicated.

These immobilization methods (phosphate fertilizer and half burnt dolomite) were investigated in our research projects. (Research paper: T Pawit et. all, minerals, 10, 763, 2020, Master thesis March 2020: H. Kamegamori, Hokkaido University).

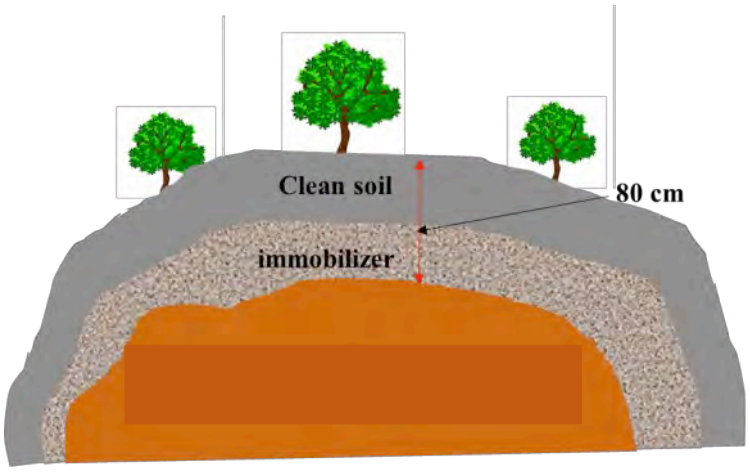


Figure 6. Schematic diagram of immobilization, 30 cm clean soil capping and revegetation

f. Scattering of phosphate fertilizer on top of LPR

The dissolution of Pb and Zn from the LPR is controlled by $PbSO_4$ and $ZnSO_4.2H_2O$ minerals as stated in the brief description of the Kabwe Mine Wastes above. To immobilize Pb in LPR there is a need to convert $PbSO_4$ to more geochemically stable minerals such as pyromorphite $(Pb,Ca)_5(PO_4)_3Cl$) by addition of phosphate fertilizer. Since phosphate fertilizer lowers the pH and affects the mobility of Zn and Cd, there is a need to mix phosphoric fertilizer with half burned dolomite as shown in Fig. 7. Without planting trees/grasses, dust will still be transported by wind from LPR to residential areas but the bioavailability of Pb and Zn will be

limited. To lower the frequency of maintenance, trees/grasses may be considered to be planted on top because phosphate fertilizer would provide needed macronutrients to plants.

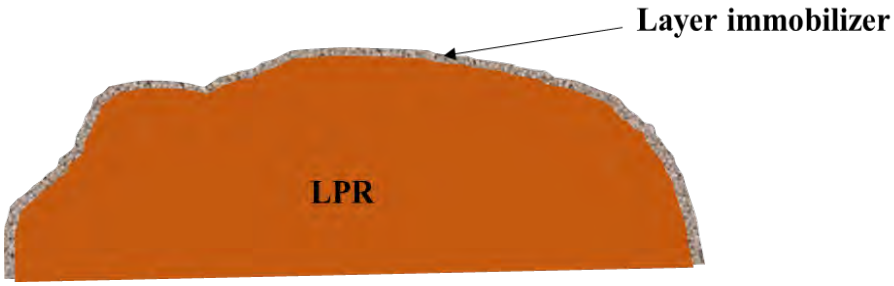


Figure 7. Schematic diagram of covering the LPR phosphoric fertilizer and half burned dolomite

The initial cost of this remediation option is lowest (phosphate fertilizer: 67 ZMW/kg in Zambia price, half burned dolomite: 1.33 USD/kg in the standard price in Japan).

Comparison of each option

Initial cost: cheap f < a < b ≒ c < d << e expensive

Frequency of maintenance: very often f < a < b < c < d < e not so often

Efficiency to prevent transportation/dispersion of very fine particles by wind to residential areas: Small effect f < a < b < c < d < e highly prevented

Efficiency of penetration of rain water: easily penetrate f, a, b << c << d <e

Immobilization treatment method: f, e

*As described above, Pb and Zn components contained in the LPR show high leachability rather than other mine wastes indicating that prevention of rain water penetration is also effective to prevent and limit ground water pollution.

Prevention of transportation/dispersion of very fine particles by wind to residential areas before the remediation of residential areas is important to avoid re-contamination of the residential area. Even if the initial cost is relatively high, however, the frequency of monitoring and maintenance is many times lower. Consequently, the long-term cost is relatively cheap.

Advanced processing options

Following methods were developed based on experimental research using LPR in our project.

g. Bio-cementation

One of the eco-friendly techniques to prevent metallic dust from becoming airborne in-situ is the immobilization of these wastes by microbially induced calcium carbonate precipitation (MICP) using ure-olytic bacteria. MICP involves the hydrolysis of urea into ammonium and carbonate by urease catalysis, which results in CaCO3 formation in the presence of Ca2þ ions. The proposed use of MICP to cap mine wastes is expected to eliminate both dust generation and water infiltration, restoring the contaminated site.

The initial cost of this remediation option is around 23.4 USD/m^2 (5cm thickness)

This method was investigated in our research project and applicability of using bacteria in Zambia was also confirmed. (Research paper: M Wilson et. all, Chemosphere, 228, 17-25, 2019, Environmental Science and Pollution Research, 26, 15653-15664, 2019, Ecological Engineering 109, 57-64, 2017, Dr. Thesis Sep. 2019: M Wilson, Hokkaido University)

h. Detoxification method by removing heavy metals using coupled extraction-cementation (CEC) process

The environmental and resource concerns of the PLR can be addressed by removing/or recovering heavy/or valuable metals. An innovative method, a coupled extraction-cementation (CEC) process that combines two stages (i.e., extraction and recovery of extracted valuable/heavy metals thereby minimizing the operation stages and amounts of lixiviant) was developed to detoxify high-Pb and Zn PLRs in our project.

Kabwe mine have facilities for hydrometallurgical treatments, thus initial cost may be reduced using these facilities.

This method was investigated in our research projects. (Research paper: M Silwamba, 10, 531, 2020, Journal of Environmental Chemical Engineering 8 (2020) 104197, Dr. Thesis March. 2021: M Silwamba, Hokkaido University)

i. Immobilization of heavy metals using ubiquitously distributed dolomite around Zambia

The base rock around Kabwe consists of dolomite. The half-burnt dolomite is known to be effective in immobilizing or adsorbing heavy metals. When the original dolomite is calcinated at around 700 to 800 degree Celsius, carbonated magnesium is changed to magnesium oxide. The half-burnt dolomite was found to be adsorb or immobilize significant amount of lead and zinc I our project. This method was investigated in our research projects (Research paper: P. Tangviroon et al., minerals, 10, 763, 2020).

3.1.3. Remediation option recommended for contaminated residential areas

Kabwe residential areas in the windward from the mine wastes have been polluted by Pb and Zn. The wastes, particularly the LPR, have been transported by wind and accumulated on the topsoil of residential areas. Another means by which these wastes have been transported to residential areas is by residents who use these wastes for landfilling and construction. To achieve proper remediation of residential areas there is a need to characterize the soil contamination by depth. From the characterization and profiling of the extent and depth of topsoil of contamination, the following options may be considered for remediation.

1. **Options for an area with 30 cm or less topsoil contamination**
   a. **Removal of topsoil for an area with 10 cm or less topsoil contamination**

      This method is one of the methods used in Japan and described in Soil Contamination Countermeasures Act, Japan. It was used for the crisis at the Fukushima nuclear power plant after the Great East Japan Earthquake to remove topsoil contaminated with radioactive cesium. Therefore, in an area where the topsoil is contaminated up to 10 cm depth, then removal of the contaminated topsoil should be considered (Fig. 8). The removed contaminated topsoil should be dumped in a newly constructed dump and covered. There is a need to monitor the groundwater from where this contaminated soil will be dumped.

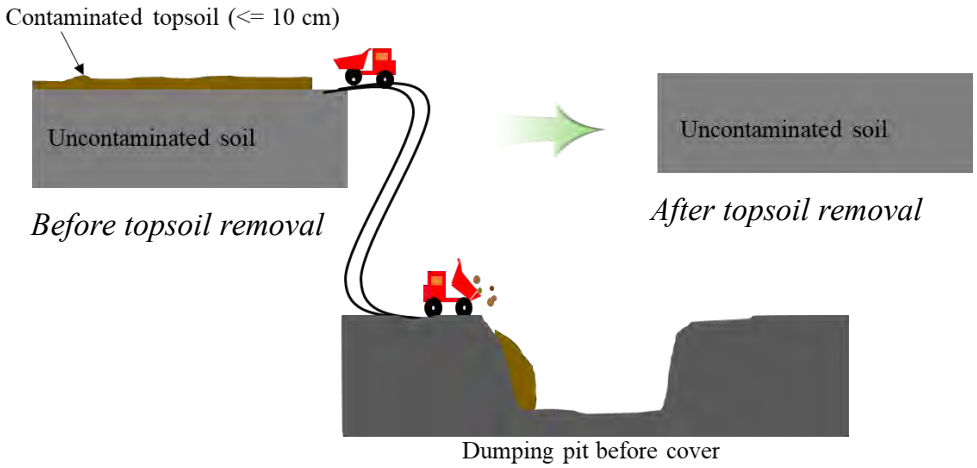


Figure *8*. Schematic diagram of showing contaminated topsoil removal and damping in designed pit

The costs of this option include the cost of excavation and transportation of contaminated soil as well as the cost to set up a new dumping site. The approximate cost is around 4.7 USD per m^2.

b. Soil profile exchange for an area with 10 cm or less topsoil contamination with immobilization of topsoil

Another option for the area where the topsoil is contaminated up to 10 cm depth is to exchange the top 10 cm of soil with 10 cm bottom soil (uncontaminated) as shown in Fig. 9. The contaminated topsoil of 10cm depth is removed and then immobilized by mixing with half-burned dolomite (10 wight %) or phosphate fertilizer (5 weight %) and putted beneath the uncontaminated soil of 10cm. An advantage of this option is that special constructed dumping site of contaminated soil which needs monitoring as described in option (a) is not required. Furthermore, immobilized layer can prevent groundwater pollution.

The cost of soil profile exchange (10cm) with the addition of the immobilizer is approximated to be around 36.6 USD per m^2 (half burned dolomite 1.33 USD/kg: standard price in Japan) and 73.4 USD per m^2 (phosphate fertilizer: 67 ZMW/kg at Zambia price). Dolomite is basement rock in Kabwe area indicating that the price of half burned dolomite may become low. Unlike the soil removal (option a), a new dumping site is not needed.

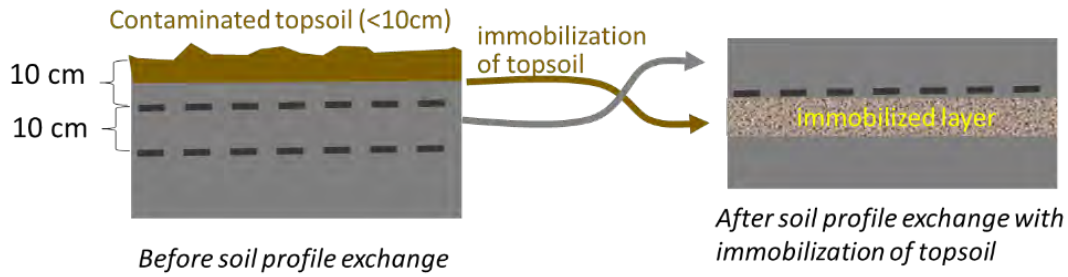


Figure 9. Schematic diagram soil profile exchange where the bottom 10 cm soil is exchanged with 10 cm topsoil after immobilization of contaminated topsoil.

c. Soil profile exchange for an area with around 30 cm topsoil contamination

This method is used by Japanese farmers as soil improvement method and this is one of the methods recommended under the Soil Contamination Countermeasures Act, Japan.

Soil profile exchange is recommended for the area(s) where contamination is around 30 cm. About 50 cm of topsoil (30 cm contaminated plus 20 cm uncontaminated) should be exchanged with 50 cm bottom soil (uncontaminated) as shown in Fig. 10. Like option b, a new dumping site for contaminated soil is not required. The cost of soil profile exchange for 50 cm is approximated to be around 25 USD per m^2.

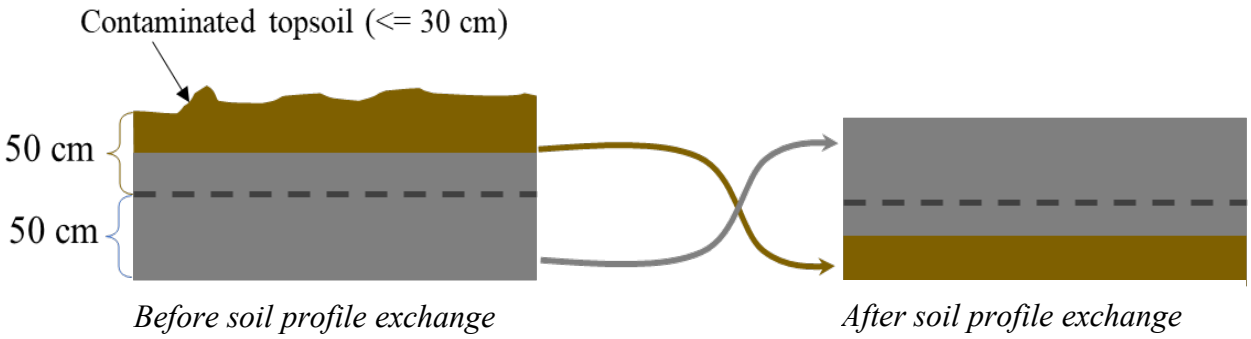


Figure 10. Schematic diagram soil profile exchange where the bottom 50 cm soil is exchanged with 50 cm topsoil.

2. Options for an area with deep contamination

d. Removal of topsoil and replacing it with clean soil for an area with around 30 cm to 1 m topsoil contamination.

Contaminated 30 cm topsoil can be removed and replaced with clean soil. The contaminated soil can be buried from the pit where clean soil is excavated from as shown in Fig. 11. There

is a need to monitor the groundwater from the pit where contaminated soil is buried. In a case where contamination is about 1 m there is a need to monitor groundwater from residential areas where soil profile has been disturbed by this option as only to 30 cm is recommended for removal while leaving 70 cm contaminated soil. The approximate cost of excavating and transporting of soil and setting up of a new dumping site is around 15.0 USD per m^2.

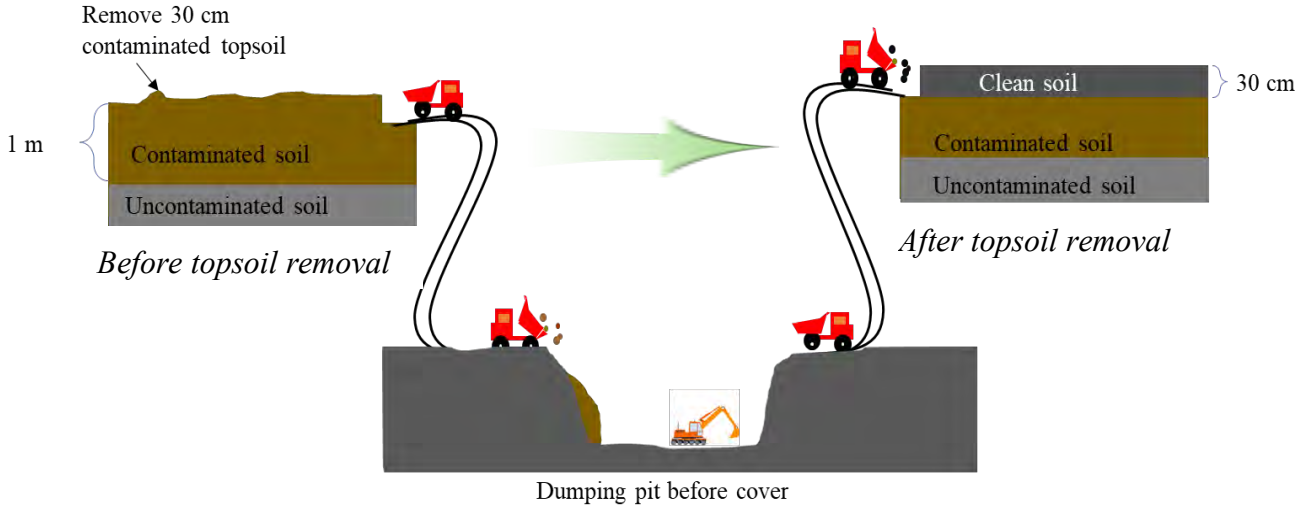


Figure 11. Schematic diagram showing removal of 30 cm contaminated topsoil regardless of the depth of contamination and replacing the topsoil with clean soil.

e. Remove topsoil and replace it with clean soil and immobilizer: for an area with around 30 cm to 1 m topsoil contamination.

This remediation suggestion, in addition to the option (d), adds immobilizer in between clean soil and contaminated soil (Fig. 12). As discussed above, the immobilizer may be half burned dolomite or phosphoric fertilizer. Similarly, there is a need to monitor the groundwater from the pit where contaminated soil buried and residential area where this option is applied as the addition of immobilizer may have an adverse effect on the mobility of heavy metals.

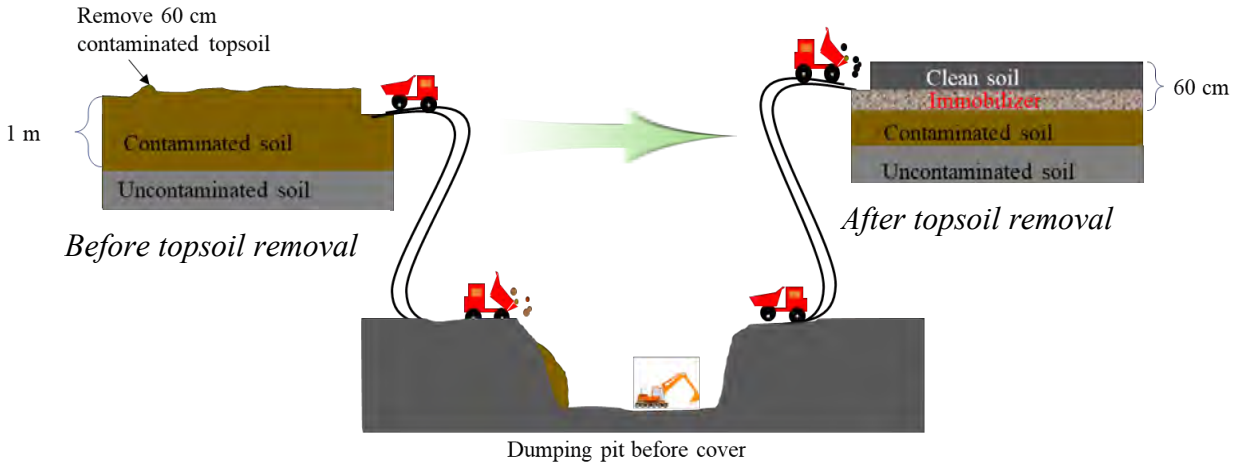


Figure12. Schematic diagram of showing removal of 60 cm contaminated topsoil and replacing it with immobilizer and clean soil on top

The cost of this option is approximated to be around 118 USD per m^2 (half burned dolomite: standard price in Japan) and 229 USD per m^2 (phosphate fertilizer: 67 ZMW/kg at Zambia price), including the cost to set up a new dumping site. Dolomite is basement rock in Kabwe area indicating that the price of half burned dolomite may become low.

3.1.4. Effects of dispersion of mine wastes on soil contamination - dispersion simulation of dumped mine wastes by considering wind direction and wind speed-

The soil contamination by Pb is evaluated by dispersion simulation of dumped mine wastes by considering wind direction and wind speed. According to the simulation, mine wastes are dispersed downwind, and accumulate on ground surface. The accumulated amounts of contaminated particles on the ground surface from the mine wastes correlated with the Pb content, which means that aerial dispersion of mine wastes causes soil contamination. Thus, the mine dump site is the source of heavy metals pollution hence should be covered to reduce the emission of contaminated particles. If residential areas are remediated, say by covering the topsoil with clean soil, leaving the source of Pb contaminated particles the problem of Pb contamination on residential areas would resurface in few months and years' time.

This dispersion simulation was investigated in our research projects. (Research paper: S Nakamura, Minerals, 11, 901, 2021)

4.0 SCOPE OF SERVICES – AGRICULTURAL APPROACH

4.1 Background and theory

It is known that certain plants have the ability to grow and thrive even in highly polluted soils such as those in parts of the Kabwe. Therefore, such plants can be used to remediate polluted soils. These plants can act either as hyper-accumulators, which take up large amounts of heavy metals from the soils, or stabilizers, which keep the heavy metals locked up in their root system and thereby minimizing the bioavailability and mobility of the heavy metals in the environment. Additionally, vegetation cover reduces dust and sediment movement through air and water further minimizing the spread of the heavy metals. This in turn reduces the health risks related to the presence of these heavy metals in the environment.

4.2 Main objective

To establish a "green-belt" of various plant species around the Kabwe mine area (including waste damp (black mountain) for phytoremediation and suppression of dust emitted to prevent it from going to residential areas. Through this work, we also propose to provide soil testing and related advisory services as and when needed.

4.3 Site and design

We propose to establish a greenbelt around the entire mine area including mine waste damp (black mountain) as shown in Fig. 13. The greenbelt will be made from selected fast-growing tree species (such as bamboo and indigenous trees already growing in the surrounding areas), perennial grasses such as vetiver grass and hedge shrubs (to be sourced locally within residential areas in Kabwe where possible). A nursery will be established at the KAMPAI project's greenpark located on the southern side of the black mountain to provide the needed plant resources for the greenbelt as well as to serve as demo-site for the local community. Additionally, the nursery shall be used to supply plants to local people that would like to plant trees around their homes or anywhere within the affected areas in Kabwe.

Figure 12. Proposed coverage of the greenbelt.

The greenbelt will be 15-30 m in diameter (Fig. 13) but with flexible size in areas where space will be limited due to existing structures. On the western side for example, where there already exist some tall trees like Eucalyptus and Toona ciliata (Cedrella), we propose to focus more on planting perennial grasses and hedge shrubs to cover up the spaces between the trees at the bottom. The total length of the greenbelt is estimated at 5.5 km (Fig. 13).

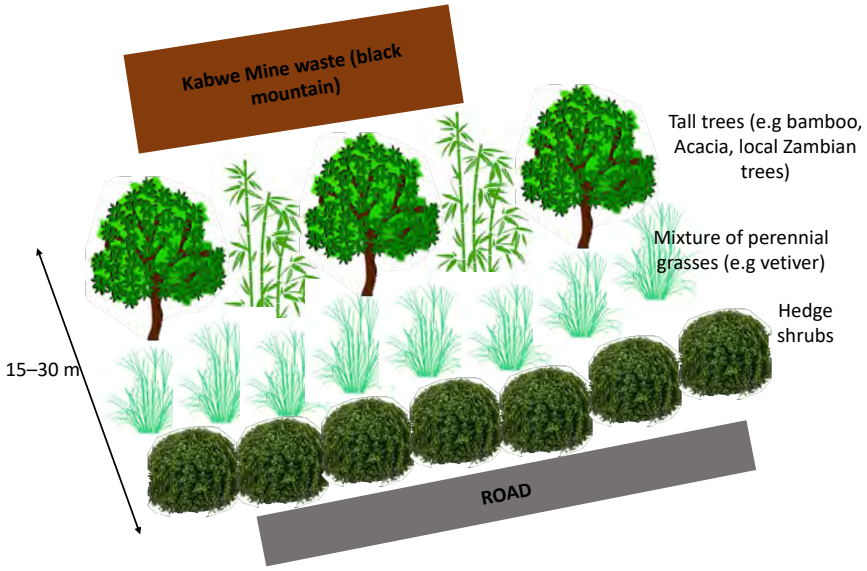


Figure 13. Proposed design of the greenbelt.

Among the plants to be used for greenbelt are trees (such as bamboo, acacia, local Zambian trees etc), perennial grasses (mainly vetiver grass, with inclusion of locally grown native species like colgon grass) and hedge shrubs. The grasses will be planted at a spacing of 1 m, the trees at 5-10 m spacing, and the shrubs at 2-5 m spacing. To ensure a good establishment of the proposed plant species, soil amendments such as manure, biochar and lime will be applied. It is envisaged, from the KAMPAI team's experience, that a minimum of one year of close monitoring and management is required and up to 2-3 years for good establishment of the grasses and shrubs. The trees are expected to establish within 1-2 years but the full potential/benefits will take longer. To increase chances of success, we propose to start the planting at the beginning of the rainy season.

To provide tangible data on the effectives of the greenbelt, we propose to install dust sensors in selected areas of the mine area. Dust emission shall be monitored regularly, from inception to establishment stage of the greenbelt, to provide data on the expected reduction in dust emission to the environment. The dust sensors could also be used as alert or warning system.

4.4. Proposed budget

The summary budget of this work is as shown in table below.

NO.	Description	Cost (USD)	
1	Plant materials, soil amendments and sensors	64,100	
2	Labour (digging, planting etc)	9,350	
3	Transport and tools	3,500	
4	Communication and mobilization	1,000	
	Total cost estimate (to establishment)		**77,950**
5	Maintenance (watering in dry season, weeding for 1-2 years)	**5,000**	
	Grand total		**82,950**

Note: Cost based on estimated for size shown in Figure 12.

4.5 Greening around the yard to minimise exposure to dust

Section 4.4 about talks about greening around the mine area to prevent further spread of soil and dust particles. However, a number of townships are already polluted with high lead concentrations in soils within the residential areas. In these areas we propose greening with lawn grass, such as local Kampinga grass. Having the land covered around the yard will minimize exposure to dust to local residents, especially children that play in dust conditions. Results at the KAMPAI green park in Kabwe shows that greening with lawn grass can be achieved at very minimal cost and most residents can afford as it is possible to get the lawn grass at little or no cost. Hedges around the yards could add further protection from dust.

Figure 14. Greening around storehouse at KAMPAI green park

4.6. Minimizing health risks from food grown in back-yard gardens with contaminated soils.

Growing of edible vegetables and crops in backyard gardens within some of the polluted areas in Kabwe is widespread. The consumption of such foods can be a health risk as Pb is taken up into the plant from the soil. To help reduce the concentration of lead in the crops, we propose the following measures as part of the "good practice"

i. Application of soil amendments to immobilize lead in the soil

   Apply soil amendments such as compost, animals manure, biochar (fine charcoal material), and phosphate containing fertilizers before planting. These amendments should be applied and mixed/incorporated in the topsoil (0-15cm depth). The amendments react with the lead to make it less mobile and therefore reduces its movement from the soil into the plant, and ultimately this reduces the concentration in the edible plant parts. These amendments have the added advantage of improving the growth of the crops by providing nutrients to the plants.

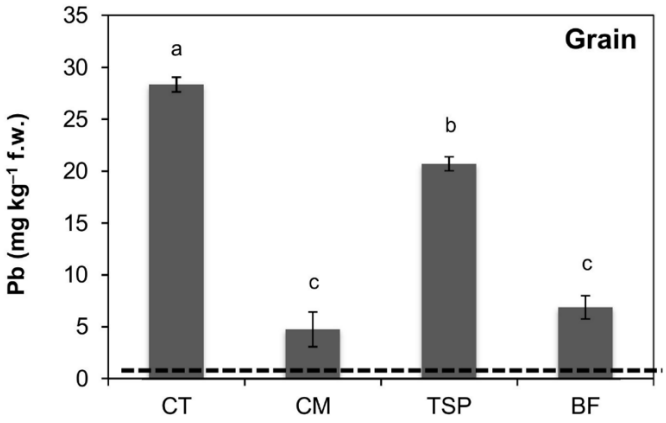


Figure 15. Results from the KAMPAI research showing the reduction in concentration of lead in maize grain after application of chicken manure (CM), triple super-phospate (TSP) and blended-fertilizer (BF; a mixture of D-compound fertilizer and chicken manure). Lead in maize grain reduced by 83%, 76% and 27% after applying chicken manure, blended-fertilizer and triple super-phospate, respectively. More details can be found here https://www.mdpi.com/1660-4601/17/23/9038.

ii. Thorough washing of vegetables before cooking

Dust particles accumulate on the vegetables whilst in the field. Dust particles are among the major ways through which lead enters the human body through direct inhalation, but also consumption of food not thoroughly washed. Thorough washing of vegetables before cooking has been shown to significantly reduce the concentration in cooked food. Residents should therefore be sensitized on the need to thoroughly wash foods before cooking. This is a simple, and yet very effective practice that also promotes general hygiene.

5.0 ESTIMATION OF THE EFFECT OF LOWERING BLOOD LEAD LEVEL

5.1 Background and theory

Lead is known to enter the human body through oral or respiratory exposure from various media in the environment (soil, atmospheric dust, indoor dust, food, water, etc.). The above-mentioned environmental remediation measures reduce the amount of lead entering the human body and the lead present in the body is gradually eliminated from the body, thus reducing the concentration of lead in the body. In medicine and health field, blood lead levels (BLLs) are commonly used as an indicator of lead accumulation in the body, and this section examines the extent to which environmental remediation measures reduce blood lead levels.

The Integrated Exposure Uptake Biokinetic (IEUBK) model is generally used to estimate BLLs of children environmentally exposed to lead. The model allows the estimation of the BLL by using the lead concentration data in various environmental samples described above. When soil lead concentrations are reduced by environmental remediation, it is expected that lead concentrations in atmospheric dust, house dust and foodstuffs will be similarly reduced. By comparing the BLL estimated from the lead concentrations in these environmental samples at the present time, when no remediation measures have been taken, with the BLL estimated from the reduced lead concentrations in environmental samples that are expected to result from the implementation of remediation measures, it is possible to verify the effect of environmental remediation on the reduction of the BLL.

5.2 Main objective

The IEUBK model is used to estimate the extent to which the reduction in environmental lead concentrations expected from environmental remediation practices will result in a reduction in human blood lead concentrations. The IEUBK was developed to estimate blood lead concentrations in children and the health and future economic effects of lead are particularly severe in children. Therefore, changes in blood lead levels in children are estimated here.

5.3 Target area

In addition to Chowa (Njanji, Waya), Mutwe Wansofu, Makululu, Kasanda (David Rumushu) and Chililalila with high pollution levels, Bwacha and Railway (Chirwa) were targeted (Fig. 16). Soil, house dust, drinking water and representative vegetables (rape) from these areas were collected in

September 2020 and analysed for lead levels. Lead concentrations in meat (poultry) and BLLs of mothers were based on data from samples obtained before 2017 in this project. Lead concentrations in atmospheric dust were taken from previous literature.

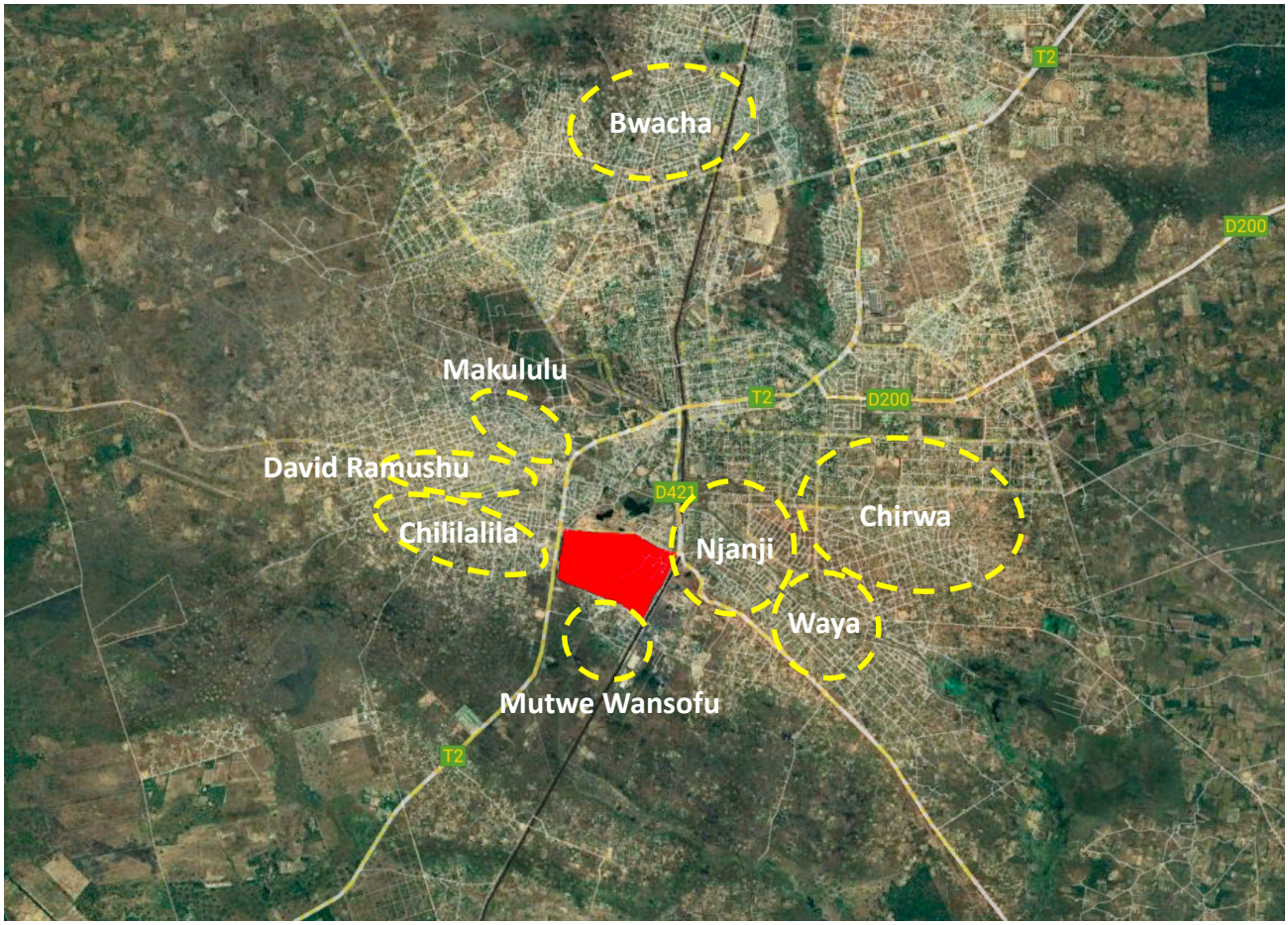


Figure 16. Map of Kabwe town showing target areas (yellow circle) and old tailing dam (red).

5.4 Estimated reduction in BLL

It was estimated as shown in Fig. 17. In the absence of environmental remediation (leftmost side of the figure, with a ratio of 0), extremely high mean BLLs in excess of 40 µg/dL were estimated for Chowa and Mutwe Wansofu. This is comparable to the actual BLLs measured in children in these areas during this project. The CDC's reference level for BLL is 5 µg/dL, and the mean BLL was above this level in all areas. If environmental remediation measures reduce lead concentrations in soil and house dust, atmospheric dust and food by 90%, the average BLL will be about 10 µg/dL in Chowa and Mutwe Wansofu and below the reference level in the rest of the Kabwe areas. Similarly, a 99% reduction in the concentration of lead in soil etc. would result in a BLL below 5 µg/dL in all areas.

The BLLs for drinking water and mothers are assumed to remain constant because it is difficult to predict the rate of reduction in lead concentrations due to environmental remediation practices. The rate of decrease in child BLLs may be underestimated to some extent, since in practice some decrease is expected.

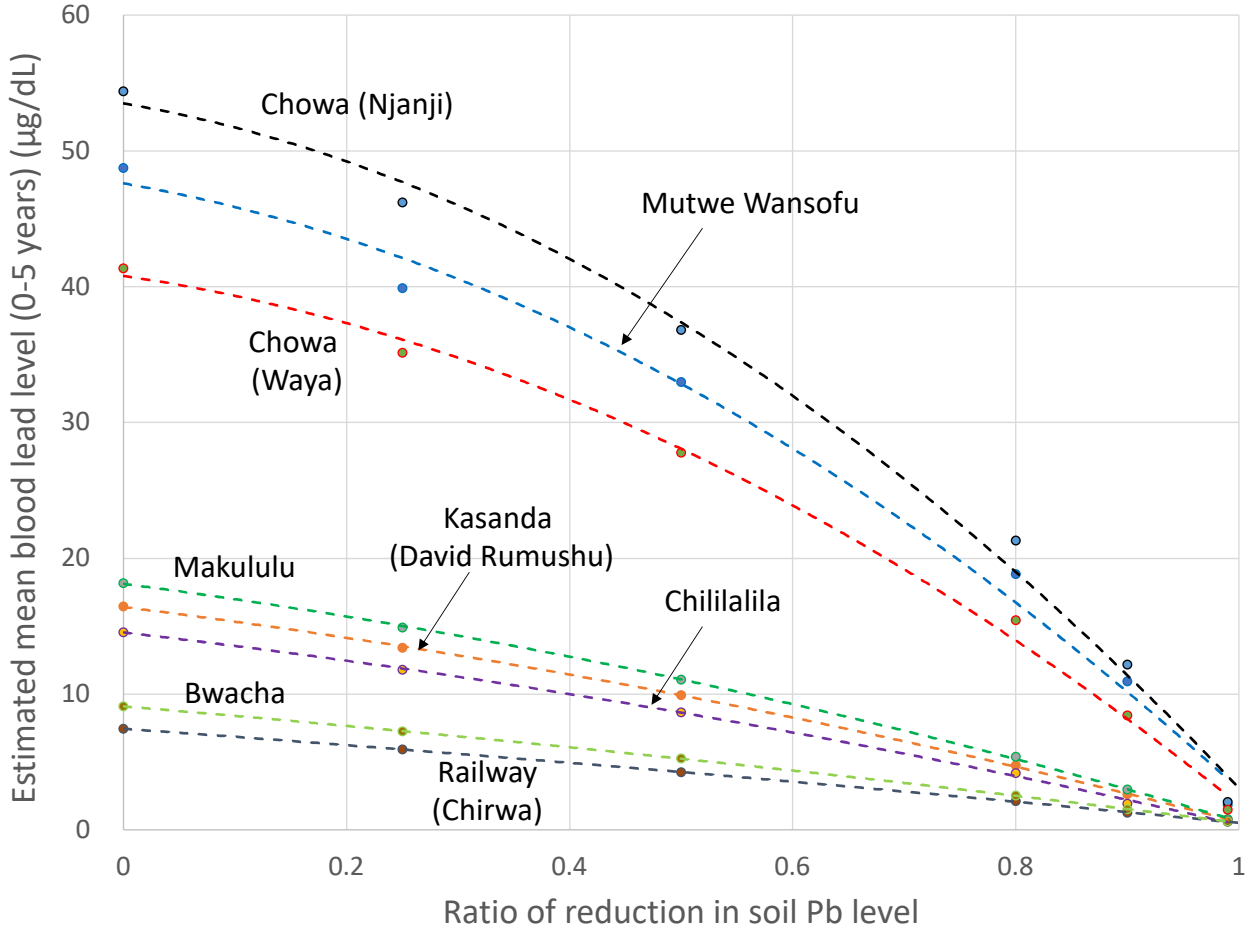


Figure 17. Estimated mean blood lead levels of children in Kabwe areas on the rate of reduction of soil lead concentrations.

6.0 ECONOMIC EVALUATION OF REMEDIATION

6.1. Main objective

We conducted a cost–benefit analysis of potential remediation options to investigate the economic desirability of these options. The basic idea is that a remediation option that provides greater benefits than costs are publicly supportable.

We accounted for two types of benefits: 1) the improvement in IQ and labour productivity from the reduction of early-childhood exposure to lead and 2) the decrease in the lead-related mortality. Since these benefits can arise in the long term, we accounted the benefits arising in 50 years between 2025 and 2074, hypothetically assuming that a remediation begins in 2025.

6.2. Cost–benefit analysis framework

6.2.1. Remediation scenarios and costs

We considered two types of remediation: one for the mine waste dumping site and the other for residential areas. As for the dumping site, we considered the 1cm cement cap (option c in Section 3.1.2), which is in an intermediate level in terms of both the cost and efficiency in preventing lead transportation compared to the other options. As for the residential areas, the 30 cm soil replacement (option d in Section 3.1.3) will be employed for deeply contaminated areas and the 10 cm topsoil removal (option a in Section 3.1.3) for not deeply contaminated areas. Combining these methods, we mainly considered the following three remediation scenarios:

- Scenario Aa: Conduct only the dumping site remediation.
- Scenario Ab: The dumping site remediation + the residential-area remediation in a small scale.
- Scenario Ac: The dumping site remediation + the residential-area remediation in a large scale.

The dumping site remediation gradually lowers the soil lead level in all areas of Kabwe. Considering the uncertainty of the speed of the soil lead pollution decrease, we assume the following two cases. In the fast-track case, the soil lead level halves in five years. In the slow-track case, the soil lead level halves in ten years. In both cases, we assume that the soil lead level reaches a plateau at 5% of the current level. Based on the calculation in Section 3.1.2, we set the initial cost of this remediation option at 366 ZMW/m^2. Maintenance is needed for 3% of areas every five years, and the maintenance cost is 4.6 ZMW/m^2. Additionally, we consider capping of the LPR instead of the entire dumping site (referred to by scenarios Ba, which does not include residential-area remediation, and by Bb and Bc, which include a small scale and large scale residential-area remediation, respectively). The LPR is the

main source of lead pollution and the capping of only the LPR would reduce the majority of lead transported to residential areas. Nevertheless, it would not perfectly prevent lead transportation and we assume that the soil lead level does not drop below 20% of the current level.

The residential-area remediation lowers the soil lead level immediately. We assume that 80% of the surface soil can be removed or replaced, and, thus, the average soil lead level drops to 20% of the current level. The soil lead level further decreases gradually owing to the dumping site remediation. We set the initial cost at 49 ZMW/m^2 for 10 cm soil removal and 156 ZMW/m^2 for 30 cm soil replacement, including the costs to set up a new dumping site for the removed soil. Maintenance is not needed for the residential areas, as long as lead transportation from the dumping site is prevented, but it is needed for the new dumping site. We assume that the 10% of the areas need maintenance

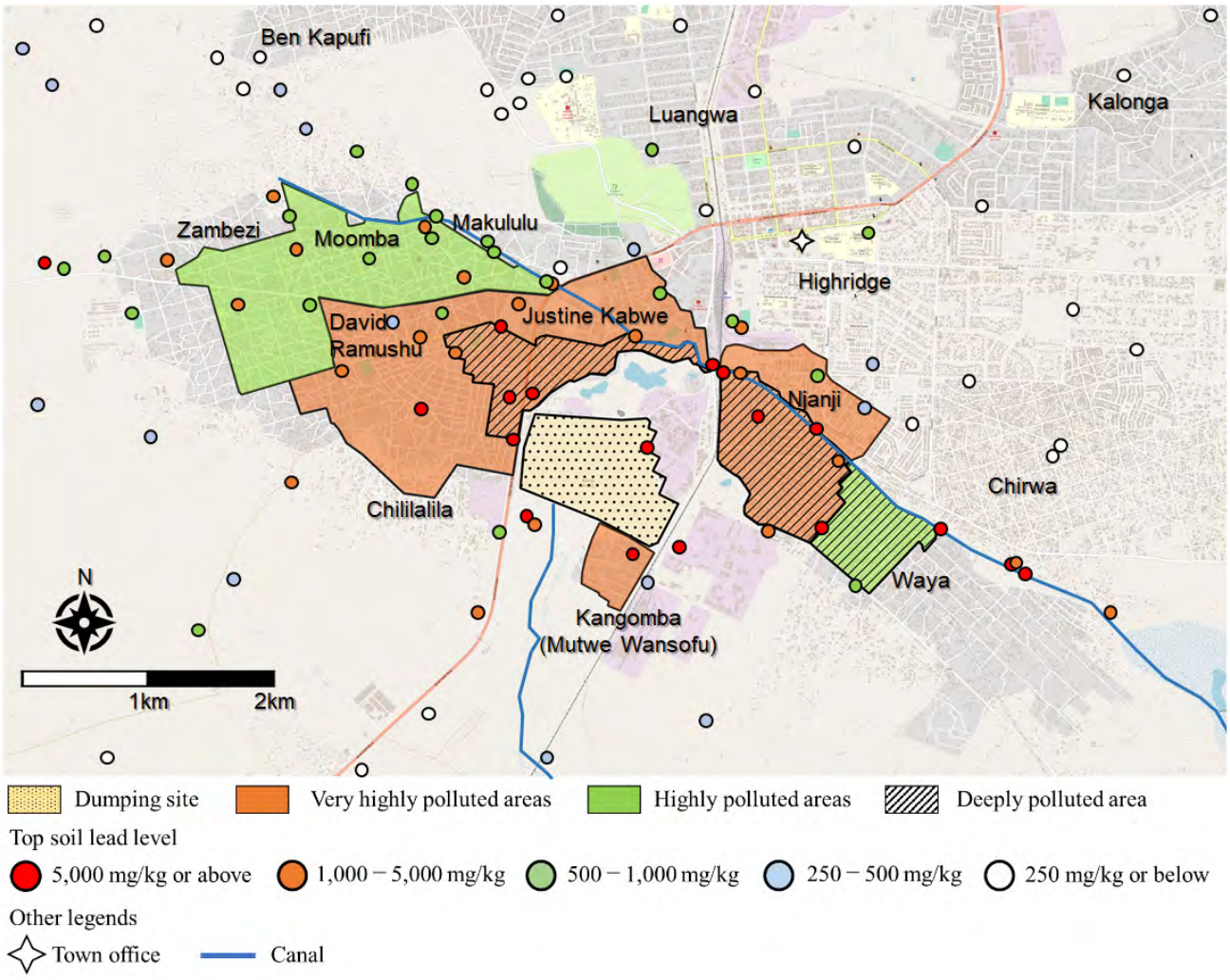


Figure 6.1. Areas where remediation options are applied.

Note: The soil pollution levels are based on the data of our own and Kříbek et al. (2019).

every five years, and the maintenance cost is 0.4 ZMW/m^2 for 10 cm soil removal and 1.2 ZMW/m^2 for 30 cm soil replacement (4 ZMW/m^3).

Figure 6.1 shows the areas in which these remediation options are applied. Scenario B covers the residential areas coloured in yellow, where the soil lead level mostly exceeds 1,000 mg/kg. Scenario C additionally covers the green areas, where the soil lead level exceeds 500 mg/kg. These areas are determined based on the soil pollution data of our own and Kříbek et al. (2019, Journal of Geochemical Exploration 197, 159–173). Deeply contaminated areas are the shaded areas.

6.2.2. Impacts of remediations on BLL

Based on our own estimation of the current BLLs of the residents (Yamada et al. 2020, Scientific Reports 10, 15092) and the IEUBK results in Section 5.4, we estimated the expected BLLs under each remediation scenario. Generally, the relationship between the soil lead level and BLL is non-linear. Based on an underlying calculation of the IEUBK results, we obtained the elasticity of the BLL with respect to the soil lead level (a percentage change in the BLL associated with a percentage change in the soil lead level). Based on the elasticity, we estimated the improvement in the BLL following the improvement in the soil pollution level. We assume that the BLLs of those to be born in 2025 or after drops following these trajectories. In other words, the BLLs of those having been born prior to 2025 is unchanged, since, for those having already chronically exposed to lead, the excretion of lead takes a long period, and the adverse effects of lead are often irreversible.

6.2.3 Benefits from decreased BLL

The benefit from the improved IQ level and labour productivity can be expressed by the product of the improvement in BLL, the impact of BLL on IQ, the percentage impact of IQ on labour productivity, and the base income level. Based on Lanphear et al. (2005, Environmental Health Perspectives 113, 894–899), we assume that a unit decrease in BLL increases the IQ by 0.513 points, 0.19 points, and 0.11 points when BLL is less than 10 μg/dL, 10–20 μg/dL, and greater than 20 μg/dL, respectively. The effect of an additional IQ point on income has been examined for the US cases (Salkever 1995, Environmental Research 70, 1–6; Heckman et al. 2006, Journal of Labour Economics 24, 411–482), but incomes generally are more elastic with human capital in developing countries. Weighting by the human capital premium, we assume that an additional IQ point increases the income by 2.10% for male and 3.19% for female. We projected the income levels in future periods, assuming 3% growth

per annum (equal to the per capita GDP growth of Zambia in 2000–2019) as the benchmark. For sensitivity analysis, we also considered 2% and 4% of the growth rate.

To account for the benefit from the decreased mortality, we first obtained the equation between the mortality rate and BLL, based on the mortality causes data of the Global Burden of Disease Study (2020, Seattle: Institute for Health Metrics and Evaluation) and the existing studies on the impact of lead poisoning on each cause. The expected number of the saved lives is, thus, equal to the population times the difference between the mortality rate under current and improved BLLs. Then, we estimate the monetised value of the decreased mortality (or saved lives), employing the Value of Statistical Life (VSL).

The VSL is a comprehensive measure of the value of life. It includes both the value of a productive life and that in non-productive ages, such as the childhood and post-retirement lives, as opposed to the lifetime income, another common measure to monetise the value of life, that accounts only the value of productive lives. Although the VSL in developing countries has not been fully estimated, we adjusted the VSL in developed countries to that in Zambia based on the per capita GDP, following the recommendation of the World Bank and Institute for Health Metrics and Evaluation (2016, The cost of air pollution: strengthening the economic case for action. Washington DC: World Bank).

6.2.4. Other notes for the framework

An estimation of total benefits requires a population projection for future periods. We project the future population of Kabwe based on the 2010 Census data, the projection of the national population by the World Population Prospects 2019 of the UN, the national–urban difference in the fertility and mortality pattern in Zambia, and the lead-related mortality risks.

In the calculation of monetary terms, we discount their values based on the 6.5% annual discount rate. This transforms future monetary values into the current equivalent. The price level is fixed constant at that in 2017 so that the influence of nominal inflation is excluded. In addition, we use the average exchange rate in 2015–2019 when expressing the monetary terms in USD.

6.3. Results: evaluation of remediation options

Table 6.1 summarises the results of cost–benefit analysis. For each remediation scenario, the estimated benefits vary by parametric settings (half-life of soil lead level, economic growth rate, and the population projection). The total benefits in Table 6.1, thus, refer to the average of these values.

- Scenario Aa has a higher benefit–cost ratio compared to scenarios Ab and Ac. Whereas the 50-year total cost is 367 million ZMW (35 million USD), the mean 50-year benefit is 747 million ZMW (72 million USD). The benefits amount to 971 million ZMW (93 million USD) if the soil lead level drops rapidly. Even if the soil lead level drops slowly, the benefits (523 million ZMW, 50 million USD) still exceed the costs.
- In Scenarios Ab and Ac, the mean benefit still exceeds the costs. However, comparing scenarios Aa versus Ab, the benefits do not increase more than the costs. This implies that, since the soil lead level in the highly contaminated areas will eventually decrease owing to the dumping site remediation, the additional benefit of the residential area remediation to immediately lower the soil lead level is not greater than the cost of remediation. Nevertheless, the residential area remediation could be supported if higher values are placed on saving the acute cases of lead pollution.
- The benefit–cost ratio improves if the dumpsite remediation focuses only on the LPR areas, suggesting the cost–efficiency of this remediation option. However, even after reducing the soil

Table 6.1. Summary of cost–benefit analysis results.

Remediation scenario		Total costs	Total benefits
Aa	Entire dumping site	367 mil. ZMW [35 mil. USD]	747 mil. ZMW [72 mil. USD]
Ab	Entire dumping site + very highly polluted residential areas	667 mil. ZMW [64 mil. USD]	943 mil. ZMW [91 mil. USD]
Ac	Entire dumping site + very highly and highly polluted residential areas	801 mil. ZMW [77 mil. USD]	1,124 mil. ZMW [108 mil. USD]
Ba	LPR	95 mil. ZMW [9 mil. USD]	693 mil. ZMW [67 mil. USD]
Bb	LPR + very highly polluted residential areas	395 mil. ZMW [38 mil. USD]	823 mil. ZMW [79 mil. USD]
Bc	LPR + very highly and highly polluted residential areas	529 mil. ZMW [51 mil. USD]	936 mil. ZMW [90 mil. USD]

Notes: The values are converted into USD based on the official exchange rate in 2019.

lead level to 20% of the current level, the BLL of children residing adjacent to the dumping site still exceed 10 μg/dL.

The overall implication of the cost–benefit analysis is that the remediation options considered in this analysis are expected to provide greater benefits than costs. The dumpsite remediation provides the largest benefits as it affects the entire Kabwe areas, although the soil lead level does not drop immediately. The residential area remediation provides a lesser extent of benefits, but these benefits could be of importance for the residents needing immediate interventions.

HEALTH INTERVENTION MANUAL ON LEAD POISONING IN KABWE

COMPILED BY

KAbwe Mine Pollution Amelioration Initiative (KAMPAI) project

BASED ON THE DOCUMENTS PREPARED BY

Zambia Mining and Environmental Remediation and Improvement Project (ZMERIP)

CONTENTS

1. BACKGROUND AND INTRODUCTION

1.1. Introduction

The mining sector has been a major contributor to Zambia's economic growth from inception. Copper production has been the backbone of the country's economy and historically, the performance of the Zambian economy has closely followed the fortunes of copper mining. In addition to copper mining on the Copperbelt Province of Zambia, Kabwe City, the capital of the Central Province has had a long history of lead (Pb) and zinc (Zn) mining. The mine that also produced cadmium (Cd) as a by-product operated from 1902 to 1994 with addressing negative environmental impacts in the city. This has led to a lot of negative impacts on the environment including soil contamination (Tembo et al., 2006; Nakayama et al., 2011). Therefore, communities residing within and around the mining areas have been exposed to a variety of pollutants that affect their health and livelihood especially children (Yabe et al., 2015; Mbewe et al., 2015). These affected mining communities have continued to struggle with adverse mining related environmental and public health impacts, poor access to basic social infrastructure services and poverty to greater extent. Lead contamination is particular concern for young children as it affects cognitive development and can cause health problems, including death in some cases (Needleman et al., 1990).

In 2001, The Government of the Republic of Zambia (GRZ) obtained the support of the World Bank for the Copperbelt Environment Project (CEP), to address the environmental liabilities and obligations retained by Zambia Consolidated Copper Mines - Investments Holdings (ZCCM-IH) following the privatization of Zambia's state mining interests in 2000. In Kabwe, which was the main focus of the CEP's activity the project implemented a comprehensive set of complementary activities aimed both at treating children with elevated blood lead levels (BLLs) as well as preventing recontamination by reducing lead exposure in children's living, learning and play environments and through behavior modification. A lot of good work was done under CEP but the residual environmental health problems in Kabwe still persist due to widespread lead contamination.

In 2015, the Government of the Republic of Zambia requested the World Bank to support Zambia in addressing various historical environmental and social issues arising from mining and other developmental activities to further continue where the CEP ended. The

World Bank-funded Zambia Mining Environmental Remediation and Improvement Project (ZMERIP) aims to strengthen the capacity of national and state level institutions, improved enforcement for pollution prevention and address the environmental health impacts associated with poor mining practices. The development objective of the ZMERIP is to reduce environmental health risks and lead exposure to the local population associated with the mining sector in critically polluted areas in Kabwe and Copperbelt provinces through improved capacity of the key institutions at national, regional and local levels.

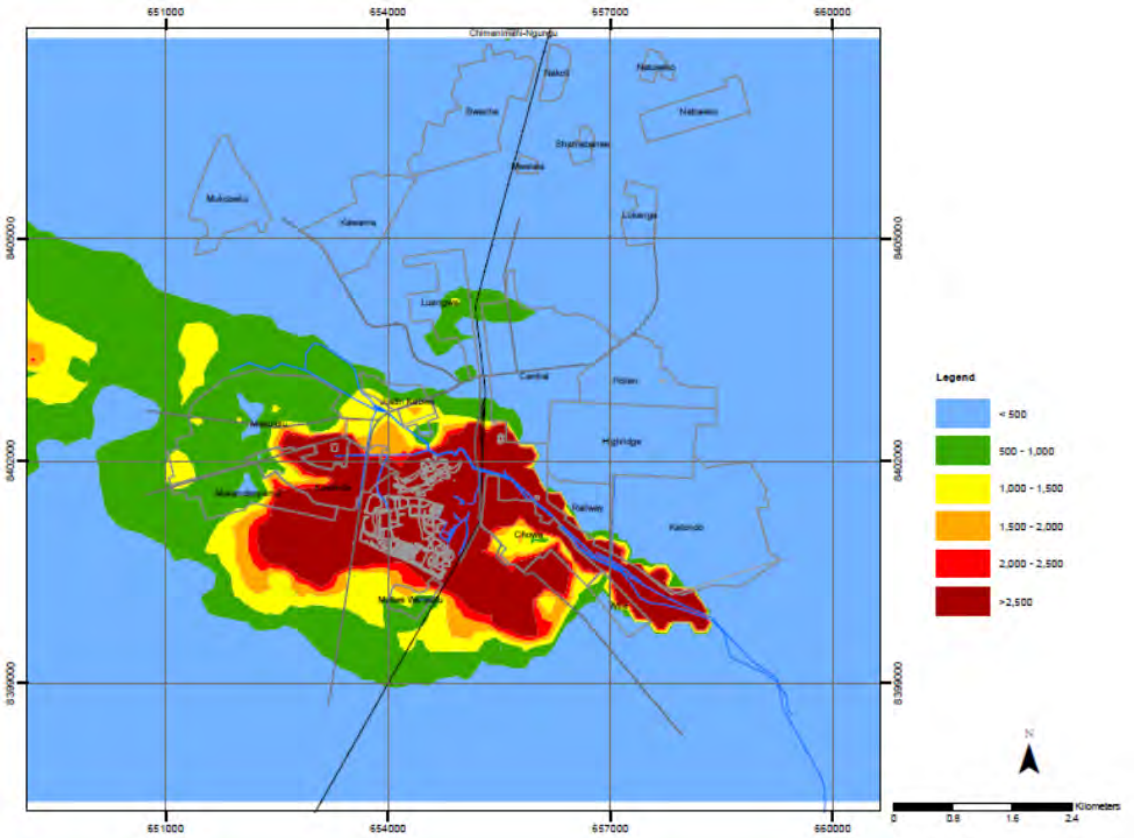


Figure 1. Distribution of lead contamination in soil in Kabwe Town.

1.2. Education

Education as a viable intervention for the maintenance of health and the prevention of disease has received increasing attention in the last decade. In the United States one factor which has brought education to the fore is the recognition that both individual and collective behavior contribute to the high rate of chronic disease. Behaviors such as

overeating, smoking or lack of exercise, all of which have been determined to be major risk factors for cardiovascular disease and cancer, are ameanable to educational interventions. In public health and medical care, the goal of most of the educational programs is some kind of behavioral change. We look to the elimination of a behavior, such as smoking, or the modification of a behavior, such as dietary practices, or the addition of a new behavior, such as, physical activity. Many programs with a behavioral change goal, assume that the giving of information about the behavior and its relation to an illness is all that is needed.

Since education has an excellent potential for the maintenance of health and the prevention of disease and since all health personnel are educators, it is important that there be a common understanding of their educational role versus the role of the health education specialist. It is equally important that all public health and medical care personnel have a grasp of basic learning principles and the application of these principles to their specific setting.

1.3. Health Education

Health education as applied to health and disease issues is defined as "A process with intellectual, psychological, and social dimensions relating to activities which increase the abilities of people to make informed decisions affecting their personal, family, and community well being. This process, based on scientific principles facilitates learning and behavioral change in both health personnel and consumers, including children and youth," (Joint Committee, 1973).

1.4. Learning and Social Change

There is sometimes confusion about the difference between "learning" and "social change". That is understandable since the experts have difficulty defining either term precisely. The fact is these concepts are two sides of the same coin. Learning Kidd10 (1977:24, 15, 16) suggests that although "we cannot pin down anything as dynamic as learning . . . we can observe it, note its course and its character... Learning... is not simply a matter of accretion — of adding something. The learning involves a change in behavior: it may make us respond differently... These responses may be primarily intellectual

changes — the acquiring of new ideas or some reorganization of presently held ideas. The changes may be in attitude where we hope that people will come to a different appreciation and more positive feelings about a subject, or they may be changes in skill where we expect the learner to become more efficient in performing certain acts. Much of learning is related to shifts in the tasks or roles that a person performs." Other educators agree with Kidd's description (Darkenwald and Merriam5 1982:8; Knowles11 1970:50-52). From this definition, the reader will recognize that "learning" occurs within the individual; whereas education is often defined as teaching the learner or the process of helping the learner, learn. However, some definitions of education include both teaching and learning.

1.5. Social Change

Zaltman and Duncan27 (1977:6, 9) state that "perhaps the most difficult conceptual issue in studying social chance is to adequately define social change. There is a wide array of theories focusing on the process of social change, leaving the definition implicit in the theory." Further, persons or groups change their behavior "when they define the situation as being different and now requiring different behavior." Rogers20 (1983) describes social change as "the process by which alterations occur in the structure and function of a social system. The structure of a social system is provided by the various individual and group statuses which compose it. The functioning element within this structure of status is a role or the actual behavior of the individual in a given status." Although both processes, learning and social change require individual change, they differ significantly in their central focus: learning tends to focus on change as it relates to the individual; social change tends to focus on change as it occurs in groups or social systems or society. There are, however, social change theories about individual change (Weber26, 1958). Both perspectives recognize that individual learning can result in societal change, and that societal change does require that a certain number of individuals have learned. The similarity between these two concepts is clear. It is also obvious that, in regard to health education activities, in the community setting it is often more appropriate to use social change principles rather than learning principles, whereas in a school or medical care setting, learning principles are apt to be more useful than social change principles.

1.6. Educational Role of Health Professionals

Public health and medical care professionals will identify with these definitions. For example, with regard to the definition of health education, the nutritionist, environmentalist, physician, nurse, physical therapist, do "increase the abilities of people to make informed decisions affecting their personal, family and community well being." Education is clearly integral to the role of all health professionals. In fact the providers of public health and medical care are usually the first line educators of the patient, the consumer, the community. Role theory holds that the occupation of a position in a social system is a role that carries with it expectations from those who interact with it (Merton14 , 1957). Thus, patients and consumer have expectations of doctors, nurses, dietitians, environmentalists, physical therapists, and other providers of public health and medical care. One of these expectations is that the provider will help them learn to cope with their illness or their community health problem. The provider fulfills this expectation either positively or negatively in every encounter with a patient, or community by what is said and done and by what is unsaid and not done. There is no way a provider can avoid this expectation.

1.7. What Is lead?

One of the common minerals known to man, lead is a highly toxic metal found in the Earth's crust. Because of its abundance and low cost to produce, it has been widely used in a variety of products. Metallic lead occurs rarely in a natural format, it is usually found in ore with copper, zinc and silver.

Lead is a soft, ductile, dense and highly malleable metal with a dull bluish-gray colour. Once melted into a liquid it has a shiny chrome-silver lustre. It is a poor conductor of electricity and is corrosion resistant thus used extensively in the construction and building industry.

1.8. The uses of lead

Lead is one of the oldest known and used metals, the Romans used it in solder and to make pipes and traces of its use can be found way back to ancient Egypt and Babylonia. One of leads' most important uses is as a shield against radiation during x-rays. Lead is

also used in

- Glazing bars for stained glass
- Machine tools
- Customisation of tennis rackets
- Batteries
- Cars
- Paint
- Organ pipes
- Ceramic products
- Some toys
- Scuba diving weight belts
- Containers storing radioactive materials

According to the website called Info Please, the single most important commercial use of lead is in the manufacture of lead-acid storage batteries. It is used in alloys, and for covering cables and lining laboratory sinks, tanks and chambers for the manufacture of sulphuric acid. It was used in the foundations of the Pan Am Building built over Grand Central station in New York because of its excellent vibration-dampening characteristics

1.9. Production of lead

Lead compounds are found in abundance throughout the world. The chief producers of lead are Australia, China, America, Canada and Russia. Other countries that produce lead are Peru, Mexico, Sweden, Morocco, South Africa and North Korea.

Even though lead is plentiful, environmental analysts have predicted that it will run out within the next 18 – 42 years. Its uses have dropped over the years due to lead poisoning scares and more legislation has been in place to restrict its usage in certain products. However, it does have its benefits as a shield against radiation. With emerging technologic advancements in radioactive warfare, lead is not going to be phased out anytime soon.

1.10. Toxicity of lead

Lead poisoning can cause a variety of symptoms and signs which vary depending on the individual and the duration of lead exposure. Symptoms are nonspecific and may be subtle, and someone with elevated lead levels may have no symptoms. Symptoms usually develop over weeks to months as lead builds up in the body during a chronic exposure, but acute symptoms from brief, intense exposures also occur. Symptoms from exposure to organic lead, which is probably more toxic than inorganic lead due to its lipid solubility, occur rapidly. Poisoning by organic lead compounds has symptoms predominantly in the central nervous system, such as insomnia, delirium, cognitive deficits, tremor, hallucinations, and convulsions.

Symptoms may be different in adults and children; the main symptoms in adults are headache, abdominal pain, memory loss, kidney failure, male reproductive problems, and weakness, pain, or tingling in the extremities.

Early symptoms of lead poisoning in adults are commonly nonspecific and include depression, loss of appetite, intermittent abdominal pain, nausea, diarrhea, constipation, and muscle pain. Other early signs in adults include malaise, fatigue, decreased libido, and problems with sleep. An unusual taste in the mouth and personality changes are also early signs.

In adults, symptoms can occur at levels above 40 μg/d, but are more likely to occur only above 50–60 μg/dL. Symptoms begin to appear in children generally at around 60 μg/dL. However, the lead levels at which symptoms appear vary widely depending on unknown characteristics of each individual. At blood lead levels between 25 and 60 μg/dL, neuropsychiatric effects such as delayed reaction times, irritability, and difficulty concentrating, as well as slowed motor nerve conduction and headache can occur. Anemia may appear at blood lead levels higher than 50 μg/dL. In adults, abdominal colic, involving paroxysms of pain, may appear at blood lead levels greater than 80 μg/dL Signs that occur in adults at blood lead levels exceeding 100 μg/dL include wrist drop and foot drop, and signs of encephalopathy (a condition characterized by brain swelling), such as those that accompany increased pressure within the skull, delirium, coma, seizures, and headache. In children, signs of encephalopathy such as bizarre behavior, discoordination, and apathy occur at lead levels exceeding 70 μg/dL. For both adults and children, it is rare to be asymptomatic if blood lead levels exceed 100 μg/dL.

1.11. Effects on children

A woman who has elevated blood lead levels during pregnancy is at greater risk of a prematurely birth or with a low birth weight. Children are more at risk for lead poisoning because their smaller bodies are in a continuous state of growth and development. Lead is absorbed at a faster rate compared to adults, which causes more physical harm than to older people. Furthermore, children, especially as they are learning to crawl and walk, are constantly on the floor and therefore more prone to ingesting and inhaling dust that is contaminated with lead.

The classic signs and symptoms in children are loss of appetite, abdominal pain, vomiting, weight loss, constipation, anemia, kidney failure, irritability, lethargy, learning disabilities, and behavioral problems. Slow development of normal childhood behaviors, such as talking and use of words, and permanent intellectual disability are both commonly seen. Although less common, it is possible for fingernails to develop leukonychia striata if exposed to abnormally high lead concentrations.

1.12. Exposure routes

Lead is a common environmental pollutant. Causes of environmental contamination include industrial use of lead, such as is found in facilities that process lead-acid batteries or produce lead wire or pipes, and metal recycling and foundries. Storage batteries and ammunition are made with the largest amounts of lead consumed in the economy each year, in the US as of 2013. Children living near facilities that process lead, such as lead smelters, have been found to have unusually high blood lead levels. In August 2009, parents rioted in China after lead poisoning was found in nearly 2000 children living near zinc and manganese smelters. Lead exposure can occur from contact with lead in air, household dust, soil, water, and commercial products. Leaded gasoline has also been linked to increases in lead pollution. Some research has suggested a link between leaded gasoline and crime rates. Man-made lead pollution has been elevated in the air for the past 2000 years. Lead pollution in the air is entirely due to human activity (mining and smelting).

1.13. Prevention

In most cases, lead poisoning is preventable by avoiding exposure to lead. Prevention strategies can be divided into individual (measures taken by a family), preventive medicine (identifying and intervening with high-risk individuals), and public health (reducing risk on a population level).

Recommended steps by individuals to reduce the blood lead levels of children include increasing their frequency of hand washing and their intake of calcium and iron, discouraging them from putting their hands to their mouths, vacuuming frequently, and eliminating the presence of lead-containing objects such as blinds and jewellery in the house. In houses with lead pipes or plumbing solder, these can be replaced. Less permanent but cheaper methods include running water in the morning to flush out the most contaminated water or adjusting the water's chemistry to prevent corrosion of pipes. Lead testing kits are commercially available for detecting the presence of lead in the household. As hot water is more likely than cold water to contain higher amounts of lead, use only cold water from the tap for drinking, cooking, and for making baby formula. Since most of the lead in household water usually comes from plumbing in the house and not from the local water supply, using cold water can avoid lead exposure. Measures such as dust control and household education do not appear to be effective in changing children's blood levels.

Screening is an important method in preventive medicine strategies. Screening programs exist to test the blood of children at high risk for lead exposure, such as those who live near lead-related industries.

Prevention measures also exist on national and municipal levels. Recommendations by health professionals for lowering childhood exposures include banning the use of lead where it is not essential and strengthening regulations that limit the amount of lead in soil, water, air, household dust, and products. Regulations exist to limit the amount of lead in paint; for example, a 1978 law in the US restricted the lead in paint for residences, furniture, and toys to 0.06% or less. In October 2008, the US Environmental Protection Agency reduced the allowable lead level by a factor of ten to 0.15 micrograms per cubic meter of air, giving states five years to comply with the standards. The European Union's Restriction of Hazardous Substances Directive limits amounts of lead and other toxic substances in electronics and electrical equipment. In some places, remediation programs

exist to reduce the presence of lead when it is found to be high, for example in drinking water. As a more radical solution, entire towns located near former lead mines have been "closed" by the government, and the population resettled elsewhere, as was the case with Picher, Oklahoma in 2009. Removing lead from airplane fuel would also be useful.

2. COMMUNITY MOBILIZATION

2.1. Introduction

All intervention activities will be carried out at Kasanda, Makululu, Chowa and Katondo Health Facilities. It is expected that the targeted children will be brought to the health centers by their parents/guardians on agreed dates. Community Health Volunteers (CHV) or Neighbor Health Volunteers (NHV) will be recruited to achieve that purpose.

Recruitment of the CHV will be carried out at the local health centers with the involvement of the nurse-in-in charge, the Environmental Health Practitioner (EHP) and District Health Director.

2.2. Selection Criteria

- Resident of the community and well known by the residents
- Literate - to be able to read the training materials and disseminate information correctly
- Committed to his/her duties
- Good inter-personal skills

2.3. Requirements and scope of activities

- Should attend the training program designed by the TWG
- Should attend community sensitization meetings organized by the TWG
- Should have an understanding of the project information sheet and concert procedure
- Disseminate information and sensitize the community about the project background and intervention activities to be undertaken (emphasis should be put on the household heads for consent as they are decision makers)
- Regularly update the community client referral form (data capture form)
- Record addresses of the participating children (homes) and tracer information e.g. prominent landmarks
- Make follow-ups to ensure compliance for medication and nutritional supplementation

- Monthly meetings at the health to report progress and challenges with the in-charge and the EHP [the Health Center to submit the record of discussions to the Project Implementation Unit]
- Attend quarterly meetings with the PIU

2.4. Reporting

The CHV will work operate under the supervision of the EHP and will report to the same.

3. TESTING

3.1. General Information

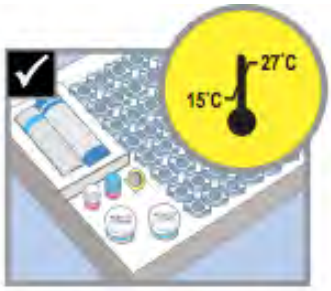
- Blood Lead Levels (BLLs) is generally considered as the indicator of Pb contamination in humans.
- In the current health intervention activities, BLLs will be measured using LeadCare Plus® analyzer (Magellan Diagnostics, USA), which is an on-the-spot analyzer. The analyzer that can analyse BLLs accurately and is easy to operate. LeadCare Plus® is widely used in the U.S.A for Pb screening programs.
- The limitation of Lead Care Plus® is that the maximum level that the analyzer can detect in blood is 65 µg/dL (1.9 µg/dl to 65 µg/dl). Therefore, in addition to training on how to operate the analyzer, the staff need training on dilution protocol so that samples with high levels can be diluted to determine the exact levels of Pb in samples > 65 µg/dL.

3.2. Principle and procedures

(Following pictures was gotten from LeadCare® user's guide)

Wear protective gloves, safety glasses and lab coats.

Dispose of materials in appropriate biohazard containers.

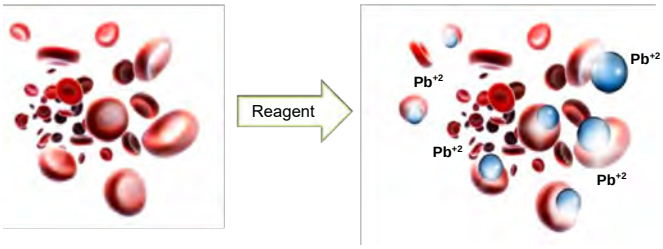


Allow analyzer, test kit and samples to reach room temperature before testing.

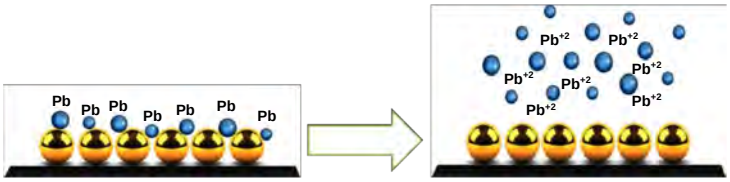
How the LeadCare II System Works

The LeadCare II System uses an electrochemical technique called Anodic Stripping Voltammetry (ASV) to determine the amount of lead in a blood sample. The diagram below illustrates the methodology.

1 Blood is mixed with LeadCare Treatment Reagent and the red blood cells (RBC) are lysed, which releases the lead that is bound to the RBC wall.

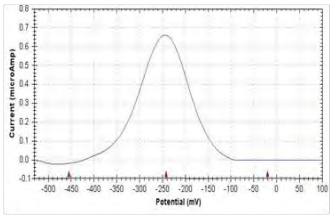


2 A negative potential is applied to the sensor to accumulate lead atoms on the test electrode. The potential is rapidly reversed releasing the lead ions.



Reduction step **Oxidation (stripping) step**

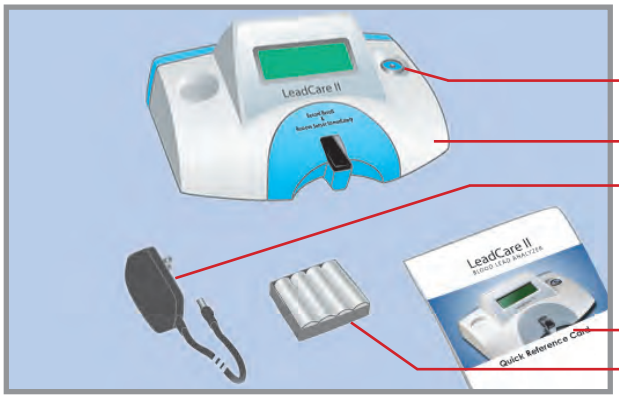
3 The current produced is directly proportional to the amount of lead in the sample. The area underneath the curve is used to calculate a quantitative blood lead result.



Analysis

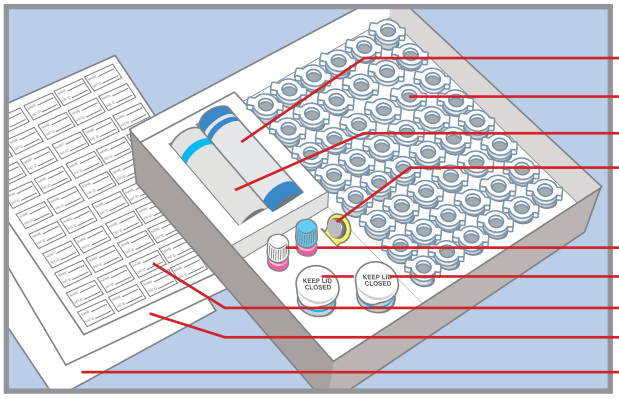
Result:
11.3 µg/dL

Required Materials



Analyzer Kit Contents

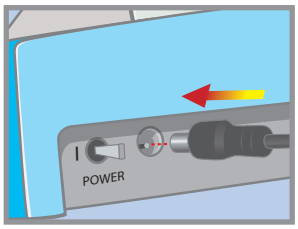
- Calibration Button Reader
- LeadCare II Blood Lead Analyzer
- AC Adapter and Plug Set
- LeadCare II Flash Drive containing User's Guide & Instructional Videos (not pictured)
- Quick Reference Guide
- AA Batteries



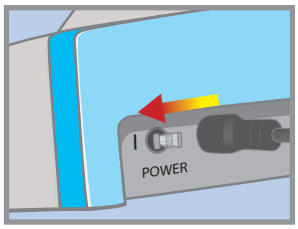
Test Kit Contents

- Droppers
- Treatment Reagent Tubes
- Capillary Tubes and Plungers
- Calibration Button
- Control Solutions
- Blood Lead Sensors
- Labels
- Package Insert
- LeadCare II Worksheet & Assay Control Sheet

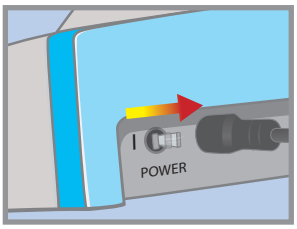
Power on the Analyzer



Connect the analyzer to an outlet using the AC power cord or install batteries as shown below.

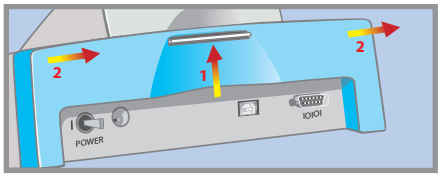


To turn ON the analyzer, move the switch to the left.

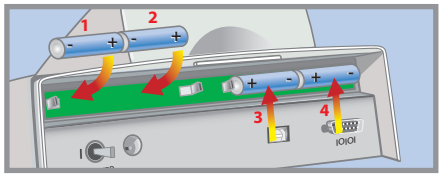


To turn the analyzer OFF, move the switch to the right.

Battery Installation (Optional)



Push white tab up and pull blue cover off.

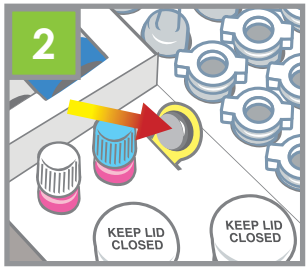


Insert batteries as shown and replace cover.

Analyzer Calibration and Quality Control

Perform this calibration procedure each time you open a new test kit.

The first time you turn on the analyzer, you will see the PLEASE CALIBRATE message.

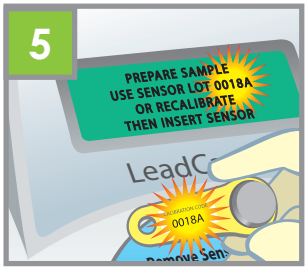


Remove the calibration button from the test kit.

Hold the calibration button to the button reader until you hear a beep.

NOTE: Button must touch both the center contact and metal side of button reader.

Test two levels of quality control on each new kit lot. Refer to the 'Quality Control' section for further instructions on when to run controls.



Make sure the number on the button matches the display.

The analyzer is ready when the PREPARE SAMPLE message appears.

Quality Control

LeadCare II Blood Lead controls are intended to monitor the accuracy and precision of your blood lead testing using the LeadCare II Blood Lead Testing System.

How Often to Test with Controls

Test two levels of quality control:[1]

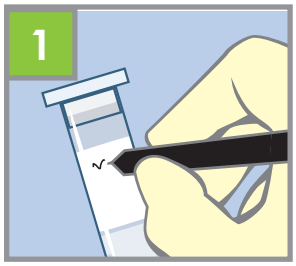
- on each new lot, or on each new shipment of materials
- with each new operator
- monthly, as a check on continued storage condition
- when problems (storage, operator, instrument, or other) are suspected or identified
- if required by your laboratory's standard QC procedure

Results obtained on control samples that are within the expected ranges means that your LeadCare II System is operating properly. Refer to the LeadCare II User's Guide for additional important information on quality control.

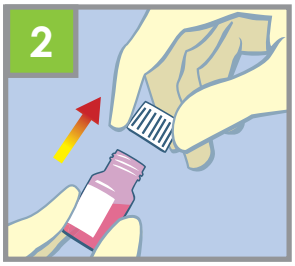
[1]Benson, Carol 2008, 'Recommendations for Clinical Laboratory Improvement Amendments of 1988 (CLIA) Waiver Applications for Manufacturers of in Vitro Diagnostic Devices', Guidance for Industry and FDA Staff:, p. 34, viewed 26 January 2009, <www.fda.gov/cdrh/oivd/guidance/1171.pdf>.

Using the Controls (See Prepare the Sample for Additional Information)

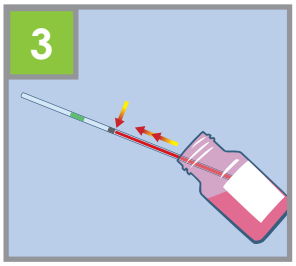
Treat the controls as you would a patient blood sample. Refer to the LeadCare II User's Guide for detailed instructions on how to perform blood lead testing.



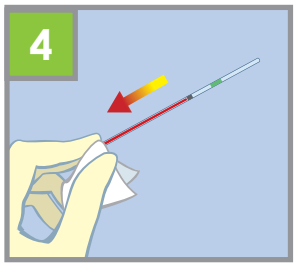
Label a fresh treatment reagent tube "**Level 1 Control**".



After thorough mixing, remove the cap from the Level 1 control vial and place it top down on a clean surface.

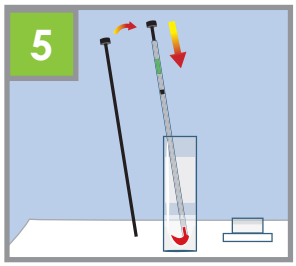


Holding the capillary tube almost horizontally with the green band on top, fill the tube to the 50 µL black line. Replace the cap on the control vial.

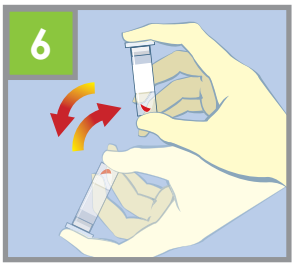


Wipe the outside of the capillary tube to remove any excess control.

Inspect the capillary tube to confirm that it is properly filled (see step 5 on page 7).



Place the capillary tube into the treatment reagent tube. Insert a plunger into the top of the capillary tube and push down, ensuring the entire volume of control is dispensed into the treatment reagent.



Replace the tube cap. Invert the tube 8 to 10 times to mix the sample completely. Control material in treatment reagent tube will appear red.

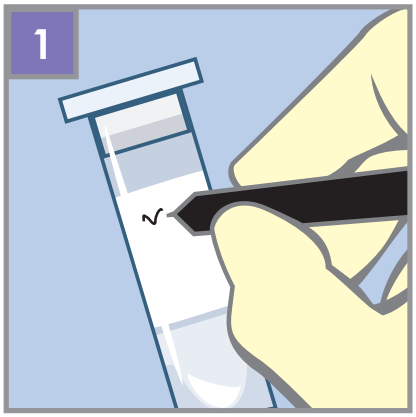
Analyze the control sample according to the instructions provided in the ***Analyze the Sample*** section. Repeat this process for the Level 2 control.

Lead Control Test Results: Expected Results

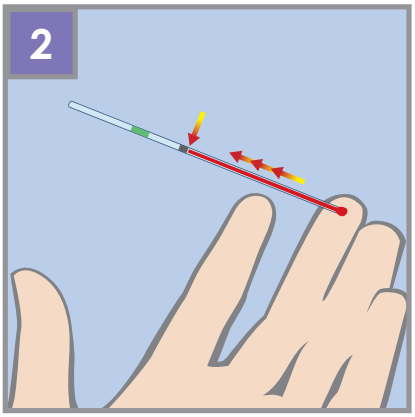
Control target values and acceptable ranges are provided on the control vial label. The blood lead result you obtain for a control should be within the acceptable range. If the results are not within the listed range, refer to the Troubleshooting section of the User's Guide. If, after following the instructions, the controls are still out of range, call Product Support.

CAUTION: Do NOT proceed to patient samples unless both Level 1 and Level 2 control results are within the acceptable ranges.

Prepare the Sample

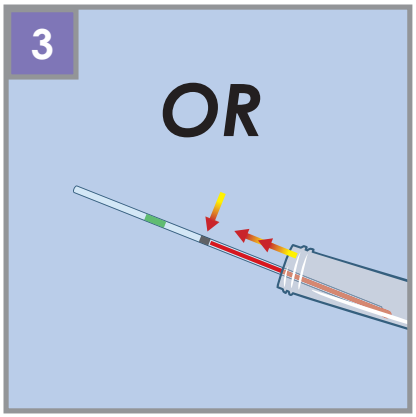


Label the tube with the patient ID using the labels provided.



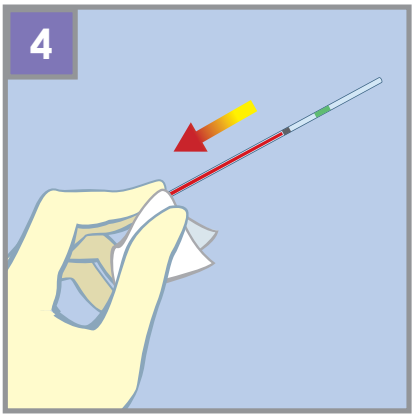
Holding the capillary tube almost horizontally with the green band on top, fill the capillary to the 50 µL black line.

Note: The CDC's Steps for Collecting Fingerstick Blood Samples for Lead Testing is provided in Appendix C of the User's Guide (see LeadCare II Flash Drive).



If using blood from a tube, make sure the blood is well mixed by inverting the tube 8 to 10 times before sampling.

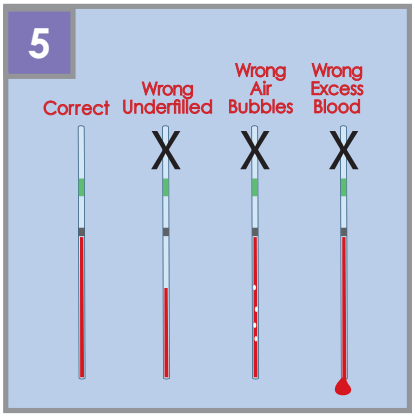
Hold the capillary tube almost horizontally with the green band on top, fill the tube to the 50 µL black line.



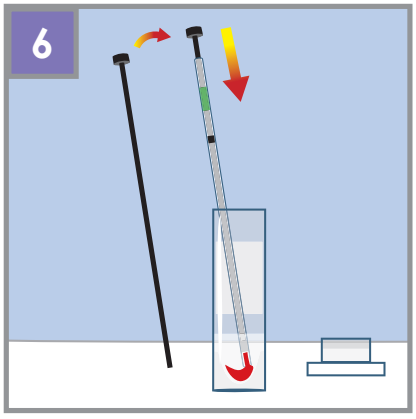
Remove excess blood from the outside of the tube with a clean wipe or gauze.

Use caution not to drain the blood from the end of the capillary tube.

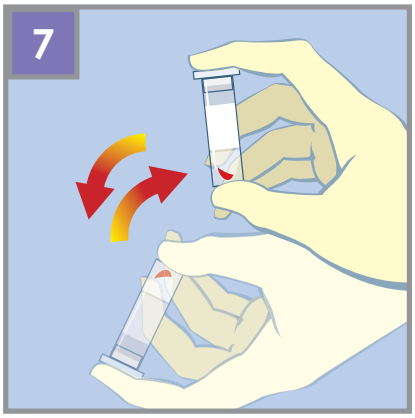
Note: Client should wash their hand properly or the finger where blood is collected from should be wiped with cotton before testing to minimize the contamination from environment like dust.



Inspect the capillary tube for proper filling. Make sure there are no gaps, air bubbles, or any excess blood on the outside of the capillary.

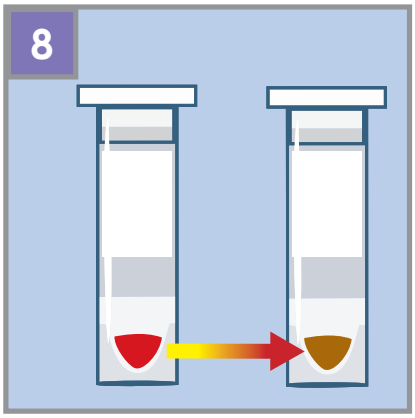


Place the capillary tube into the treatment reagent tube. Insert a plunger into the top of the capillary tube and push down, ensuring the entire volume of sample is dispensed into the treatment reagent.



Replace the tube cap. Invert the tube 8 to 10 times to mix the sample completely.

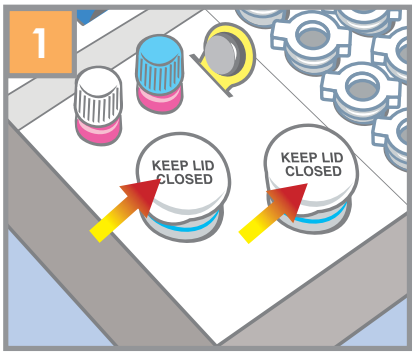
NOTE: The mixture of blood and treatment reagent is stable for up to 48 hours at room temperature and up to 7 days refrigerated. If refrigerated, bring to room temperature prior to analysis.



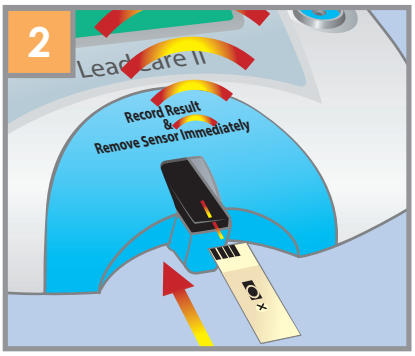
The sample is ready when the mixture turns brown. Samples may be stored up to one week if refrigerated.

CAUTION: Any visual impairment, such as color blindness may affect the operator's ability to detect the sample color change. Operators with vision deficiencies should invert the tube 8 to 10 times to ensure that the sample is properly mixed.

Analyze the Sample

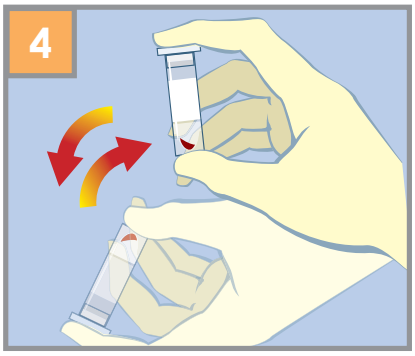


Remove a sensor from the sensor container. Close the container.

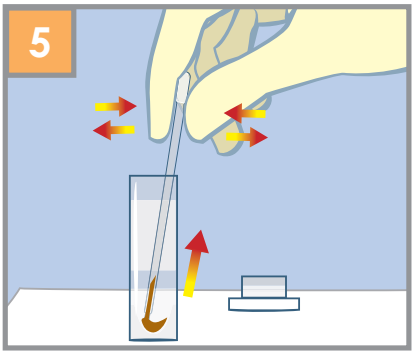


Insert the sensor (with black bars facing up) under the sensor guides on the sensor deck. Insert completely into the analyzer until you hear a beep.

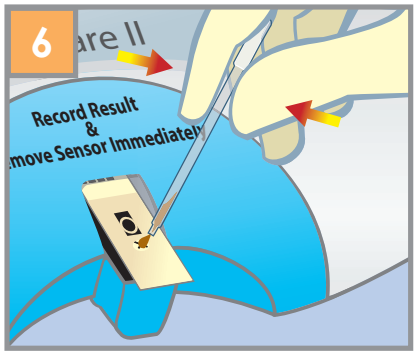
Make sure the sensor lot number matches the display.



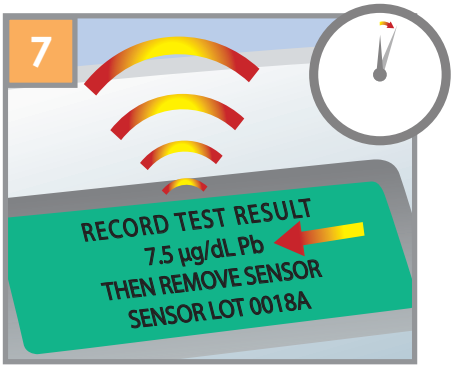
Make sure the sample is thoroughly mixed. Allow samples that were stored refrigerated to reach room temperature before use.



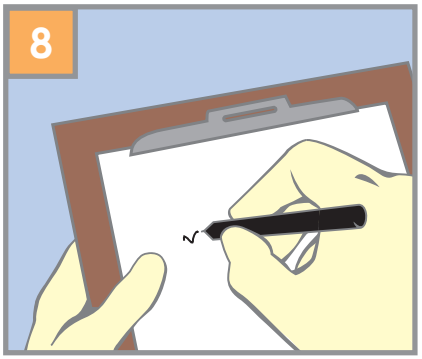
Remove the cap from the treatment reagent tube. Squeeze the walls of the dropper and insert into the sample. Release the pressure to draw some sample into the dropper.



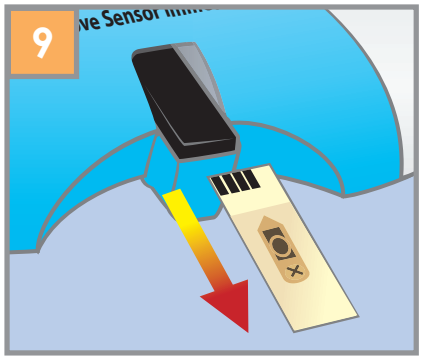
Touch the dropper tip to the **X** on the sensor and squeeze the walls to dispense the sample. The analyzer will "beep" and begin the 3 minute countdown.



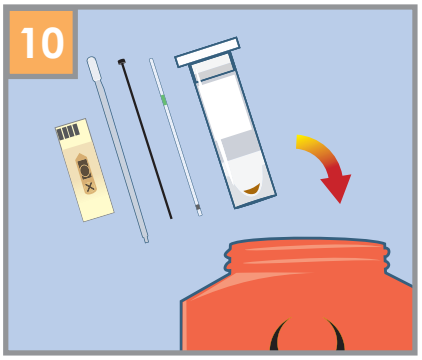
Wait 3 minutes until the test is done. The analyzer will beep and display the lead result in µg/dL Pb.



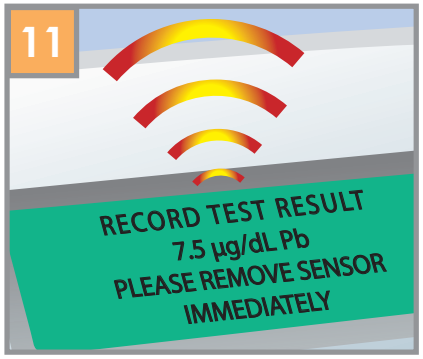
Record the test results on the LeadCare II worksheet provided.



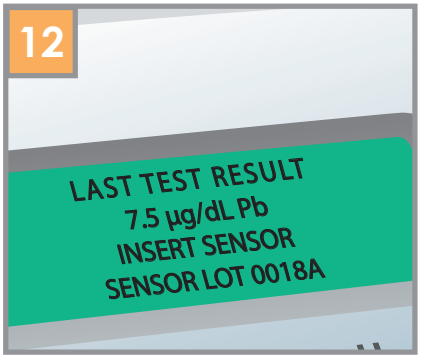
Remove the used sensor immediately after recording the test result.



Discard materials in appropriate containers.



A beep will sound if you do not remove the sensor after the result is displayed. Once the sensor is removed, the beep will stop.



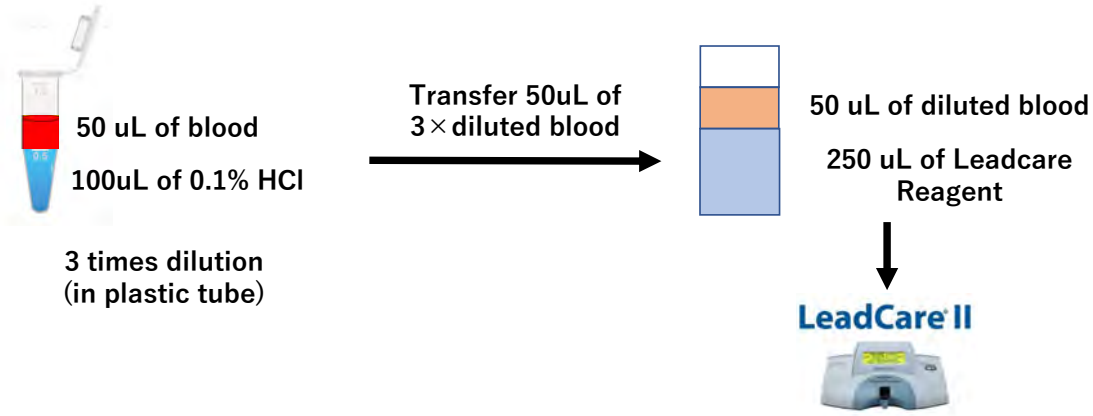
The analyzer is ready for the next sample.

3.3. Interpreting patient test results

- The analyzer's display window shows the result. The result is in microgram of lead per deciliter (µg/dL) of whole blood. No calculation is needed. Results are displayed to one decimal place. The reportable range of the test is 1.9 to 65 µg/dL.
- "Low" in the display window indicates a BLL less than 1.9 µg/dL.
- "High" in the display window indicates a BLL greater than 65 µg/dL. Dilution of blood will be needed if reading is than 65 µg/dL.

3.4. Dilution protocol of blood in case of "High"

- Prepare plastic tube and 0.1 % HCl (hydrochloric acid) for dilution
- Add 50 µL of collected blood into 100 µL of 0.1% HCl (3 times dilution)
- Take 50 µL of diluted blood to Reagent Tube (contains 250 µL of 0.1% of HCl)
- Analyze using LeadCare Plus® in the same way as for undiluted blood.



3.5. Maintaining the analyzer

- Remove used sensors from the analyzer as soon as a result is recorded.
- Clean the analyzer with a damp cloth and warm, soapy water. Do not immerse in water.
- Disinfect with dilute (10%) bleach solution.
- Do not leave any soap film on the analyzer.
- Do not allow liquid of any kind on to the sensors connector.
- Do not get the metal pins in the sensor connector wet.
- Do not wash the inside of the calibration button reader.

4. CLINICAL ASSESSMENT

4.1. Introduction

Lead is a naturally occurring toxic metal found in the Earth's crust. Its widespread use has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world. Important sources of environmental contamination include mining, smelting, manufacturing and recycling activities, and, in some countries, the continued use of leaded paint, leaded gasoline, and leaded aviation fuel. More than three quarters of global lead consumption is for the manufacture of lead-acid batteries for motor vehicles. Lead is, however, also used in many other products, for example pigments, paints, solder, stained glass, lead crystal glassware, ammunition, ceramic glazes, jewellery, toys and in some cosmetics and traditional medicines. Drinking water delivered through lead pipes or pipes joined with lead solder may contain lead.

Young children are particularly vulnerable to the toxic effects of lead and can suffer profound and permanent adverse health effects, particularly affecting the development of the brain and nervous system. Lead also causes long-term harm in adults. This may include increased risk of high blood pressure and kidney damage. Exposure of pregnant women to high levels of lead can cause miscarriage, stillbirth, premature birth and low birth weight, as well as minor malformations.

4.2. Sources and routes of exposure

People can become exposed to lead through occupational and environmental sources. This mainly results from: inhalation of lead particles generated by burning materials containing lead, for example, during smelting, recycling, stripping leaded paint, and using leaded gasoline or leaded aviation fuel; and ingestion of lead-contaminated dust, water (from leaded pipes), and food (from lead-glazed or lead-soldered containers). The use of some traditional cosmetics and medicines can also result in lead exposure.

Young children are particularly vulnerable because they absorb 4–5 times as much ingested lead as adults from a given source. Moreover, children's innate curiosity and their age-appropriate hand-to-mouth behaviour result in their mouthing and swallowing lead-containing or lead-coated objects, such as contaminated soil or dust and flakes from

decaying lead-containing paint. This route of exposure is magnified in children with pica (persistent and compulsive cravings to eat non-food items), who may, for example pick away at, and eat, leaded paint from walls, door frames and furniture.

Once lead enters the body, it is distributed to organs such as the brain, kidneys, liver and bones. The body stores lead in the teeth and bones where it accumulates over time. Lead stored in bone may be remobilized into the blood during pregnancy, thus exposing the fetus. Undernourished children are more susceptible to lead because their bodies absorb more lead if other nutrients, such as calcium, are lacking. Children at highest risk are the very young (including the developing fetus) and the impoverished.

4.3. History

The clinical presentation varies widely, depending upon the age at exposure, the amount of exposure, and the duration of exposure. Organic lead, because of its higher lipid solubility, causes greater toxicity and affects the neurological system predominantly. Younger patients tend to be affected more than older children and adults, because lead is absorbed from the gastrointestinal (GI) tract of children more effectively than from that of adults.

4.4. Neurological Toxicity

The neurological system is most vulnerable to lead toxicity. Children are more likely to develop central nervous system toxicity while the peripheral nervous system is more often affected in adults.

The manifestations in children include temperamental lability, irritability, behavioral changes, hyperactivity or decreased activity, loss of developmental milestones and language delay. Lower IQ and ADHD like symptoms may be present. Severe toxicity can cause delirium, convulsions and encephalopathy. Depression and anxiety are more common in patients. Lead causes demyelination of the peripheral nervous system and the abnormalities mostly affect the extensor motor nerves and may result in hand and foot drop.

4.5. Hematological Toxicity

Anemia may develop with lead poisoning due to impaired synthesis of haeme, hemolysis of red cells and shortened red cell survival. Anemia is usually mild and is more commonly seen in adults.

4.6. Gastrointestinal Toxicity

Patients may develop lead colic, nausea, vomiting and anorexia. Occasionally, some patients with acute poisoning can develop severe diarrhea and dehydration.

4.7. Renal Toxicity

Acute nephropathy manifests with tubular defects, which may include phosphaturia, glucosuria and amino aciduria. This combination of tubular defects is referred to as Fanconi's syndrome. Chronic lead nephropathy is frequently associated with hypertension and gout. Adverse renal effects have been reported at mean blood lead levels of less than 5 mcg/dL. Cumulative lead dose has also been associated with worse renal function.

4.8. Cardiovascular Toxicity

Lead exposure has been associated with the development of hypertension. The development of hypertension may be secondary to oxidative stress or an association with chronic nephropathy.

4.9. Reproductive Effects

In men, lead causes a reduction in libido, abnormal spermatogenesis, chromosomal damage and infertility. Women experience an increase in the incidence of stillbirth, miscarriage, pregnancy induced hypertension and prematurity.

4.10. Children

No pathognomonic symptoms exist. When symptoms do occur, they are typically

nonspecific. Consider lead poisoning whenever a small child presents with peculiar symptoms that do not match any particular disease entity. Common nonspecific symptoms include the following:

- Temperamental lability, irritability, behavioral changes
- Hyperactivity or decreased activity
- Loss of developmental milestones, language delay

More significant exposure to lead may cause symptoms in children that are more likely to lead to a medical evaluation. They are as follows:

- Abdominal pain, loss of appetite, vomiting, constipation
- Headache, ataxia, somnolence
- Lethargy, seizures, stupor, coma

The presence of fever does not rule out the diagnosis, which still must be given full consideration.

Inquiries should be made regarding possible sources of lead exposure. For example, query families about the condition of the home, the presence of peeling or cracking paint and plaster, the occupations or hobbies of the family members, and the presence of industry in the immediate vicinity.

Investigate the patient's past medical history, including developmental milestones or delays, hygiene, pica, and previous exposure to lead. Evidence suggests that delayed weaning is associated with excessive pica and lead poisoning. It is commonly found that lead-poisoned children are bottle-fed for protracted periods. Inquire about the patient's siblings (eg, ages, developmental history, school performance, and BLLs if known).

4.11. Adults

In adults, similar symptoms may develop, although cognitive changes may be discerned more easily, especially since exposures are more typically acute. In addition, adults with chronic exposure may develop other symptoms, such as the following:

- Weakness of extensor muscles (eg, foot drop, wrist drop)
- Delirium, hallucinations

Adults with lead poisoning frequently have sleep disorders. They may be hypersomnolent or have difficulty falling asleep at the appropriate time.

A meticulous environmental history is necessary in patients with suspected lead exposure.

Depending on whether it is tailored to children or adults, it should include the following information:

Inquire about present and recent residences, including the location, age, and condition of the building; any history of renovations, inspections, or deleading programs.

In adults, obtaining a careful occupational and hobby history is important. More than 900 occupations have been associated with cases of lead poisoning. Always ask patients not just the name of their job but also the duties the job entails. This may uncover an obvious cause of exposure.

4.12. Physical Examination

Subtle changes in cognitive performance are not identified easily on physical examination. Careful mental status examination may detect changes in more severe cases, while formal neuropsychological testing may be needed to detect changes in other cases.

A child with lead toxicity is frequently iron deficient and pale because of anemia. The child may be either hyperactive or lethargic.

Impaired fine-motor coordination or subtle visual-spatial impairment may be seen. In adults, chronic distal motor neuropathy (e.g. foot drop or wrist drop) may be seen with decreased reflexes and weakness of extensor muscles; sensory function is relatively spared.

It is important to evaluate the patient for papilledema, cranial nerve abnormalities, and signs of increased intracranial pressure (ICP). Cranial nerve involvement, particularly involvement of the optic nerve, is not uncommon. Chronic lead exposure has been shown to cause optic neuritis and blindness.

4.13. Differential Diagnosis

- Acute Anemia
- Chronic Anemia
- Confusional States and Acute Memory Disorders
- Depression and Suicide
- Diabetic Neuropathy
- Epileptic and Epileptiform Encephalopathies

- Gout and Pseudogout
- Radial Mononeuropathy

4.14. Diagnostic Tests

The most commonly used biological marker is the concentration of lead in blood. The concentrations of lead in plasma are so low that they have hitherto been extremely difficult to measure. The free erythrocyte protoporphyrin or zinc protoporphyrin levels reflect impaired haeme synthesis. These may therefore be increased in children with increased lead levels, but they can also be increased in iron deficiency or hemolytic anemia. As this test is not sensitive enough to identify blood levels between 10 and 25 μg/dl, it is no longer recommended as a screening test. If either blood lead or free erythrocyte protoporphyrin is elevated, then other tests for lead effects on the kidneys (urea nitrogen, creatinine, and urinalysis) and blood (complete blood count with smear) should be performed.

Radiological examination of the abdomen in children may reveal radiopaque densities or radiographic evidence of paint chip ingestion. At the ends of long bones, the radiological finding is the appearance of dense transverse bands, “lead lines”, across the metaphysis of long bones and along the margins of flat bones, such as the iliac crest. The width of the lead line varies, depending upon the amount of lead involved and the length of time of exposure. Therefore, radiological examination is not a sensitive method for diagnosing acute lead poisoning

Nerve conduction velocity testing should be considered when there are persistent symptoms or clinical findings suggestive of the presence of peripheral neuropathy. Neurobehavioral testing is indicated in cases where there is persistent impairment of cognitive function and blood lead levels are usually above 80 μg/dl. This testing can demonstrate changes

5. PHARMACOVIGILANCE AND DRUG SAFETY MONITORING

5.1. Terms and Definitions

- Pharmacovigilance (PV) also called drug safety
  - Pharmakon-------in greek----drug
  - Vigilare ----------in latin------to keep watch

- *Pharmacovigilance* is the science and activities relating to the detection, assessment, understanding and prevention of adverse effects (WHO collaborating centre for international /drug monitoring*)*.

- A*dverse drug event (ADE)* means, any untoward medical occurrence that may present during treatment with a medicine but which does not necessarily have a causal relationship with this treatment". The basic point in this case is the coincidence in time without any suspicion of a causal relationship.

- A*dverse drug reaction (ADR)* means „a response to a medicine which is noxious (harmful) and unintended, and which occurs at doses normally used in man". It is of important that it concerns the response of a patient, in which individual factors may play an important role, and that the phenomenon is noxious (an unexpected therapeutic response, for example, may be a side effect but not an adverse reaction).

- *Counterfeit medicinal products* means a medicinal product which is deliberately and fraudulently mislabeled with respect to identity and / or source. Counterfeit can apply to both branded and generic products and may include products with correct ingredients with the wrong ingredients with an insufficient quantity of active ingredient or with fake packaging.

- D*rug* or *medicine* means a pharmaceutical product, used in or on the human or animal body for the prevention, diagnosis or treatment of a disease, or for the modification of physiological function".

- S*ide effect* is any unintended effect of a pharmaceutical product occurring at doses normally used by a patient which is related to the pharmacological properties of the drug. Essential elements in this definition are the pharmacological nature of the effect, that the phenomenon is unintended, and that there is no deliberate overdose.

- *Serious adverse* event is any event that is:
  A) fatal
  B) life-threatening
  C) permanently/significantly disabling
  D) Requires or prolongs hospitalisation
  E) Causes a congenital anomaly
  F) Requires intervention to prevent permanent impairment or damage

- *Unexpected adverse reaction* is an adverse reaction, the nature or severity of which is not consistent with domestic labelling or market authorisation, or expected from characteristics of the drug.

- *Signal:* Reported information on possible causal relationship between an adverse event and a drug, the relationship being unknown or incompletely documented previously. Usually more than one single report is required to generate a signal depending upon the seriousness of the event and quality of information.

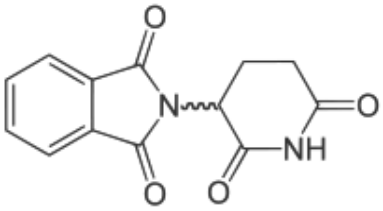
5.2. Learning from History

Thalidomide: History and Manifestations

It is a tranquilizer and a notorious human teratogen introduced in 1956 by Chemie Grunethal and marketed under different trade names, e.g. Contergan, Distaval, and Kevadon. It was used as a sedative or hypnotic and to ameliorate nausea and vomiting in pregnancy. It can cause fetal phocomelia and amelia if taken during pregnancy. Causal association was established in 1960-1961. Today it is used for leprosy treatment and as an immunosuppressant drug.

Thalidomide structure

Thalidomide was synthesized in West Germany in 1953 by Chemie Grünenthal.



Proposed mechanism of thalidomide toxicity:

- Interference with folic acid or glutamic acid metabolism
- Depurination of DNA through intercalation between base pairs and acylation of polyamines.

2-(2,6-dioxo-3-piperidyl)isoindole-1,3-dione

Dr. Frances Kelsey

A reviewer for the United States Food and Drug Administration (FDA)

She refused to authorize thalidomide for market because she had concerns about the drug's safety. A number of reports showed that it caused peripheral neuritis, especially, after prolonged use of 18 months or more.

Lessons learnt from the thalidomide tragedy

- More stringent preclinical testing protocols are needed.
- Such protocols could have prevented the thalidomide tragedy and the like.
- Chemically-induced cases without characteristic appearance could escape attention, unless preclinical toxicity data are available to lend support.

5.3. Diagnosis and Management of Adverse Drug Reactions

How are ADRs discovered?

- Most common adverse reactions are detected in premarketing clinical trials (reported in prescribing information)
- However, most clinical trials are of short duration, and patient numbers in trials are low compared to population
    - Latent ADRs often missed
    - 3000 patients at risk needed to detect with an incidence rate of 1/1000 with 95% certainty

- Most trials also exclude the very young and old, pregnant women, patients with multiple diseases, and any potentially interacting medications
- Additional ADRs are discovered once a drug enters the marketplace

Types of Drug Reactions: Immunologic

Type	***Example***
Immunologic	
Type I reaction (IgE-mediated)	Anaphylaxis from β-lactam antibiotic
Type II reaction (cytotoxic)	Hemolytic anemia from penicillin
Type III reaction (immune complex)	Serum sickness from ani-thymocyte globulin
Type IV reaction (delayed, cell-mediated)	Contact dermatitis from topical antihistamine
Specific T-cell activation	Morbiliform rash from sulfonamides
Fas/Fas ligand-induced apoptosis	Stevens-Johnson syndrome
	Toxic epidermal necrolysis
Other	Drug-induced lupus-like syndrome
	Anticonvulsant hypersensitivity syndrome

Types of Drug Reactions: Non Immunologic

Type	***Example***
Non-immunologic	
Predictable	
Pharmacologic side effect	Dry mouth from antihistamines
Secondary Pharmacologic side effect	Thrush while antibiotics
Drug toxicity	Hepatotoxicity from methotrexate
Drug-drug interactiions	Seizure from theophylline while taking erythromycin
Drug overdose	Seizure from excessive lidocaine (Xylocaine)
Unpredictable	

Pseudoallergic	Anaphylactoid reaction after radiocontrast media

Body Systems Commonly Involved

- Central Nervous System
- Hematologic
- Cardiovascular
- Renal/Genitourinary
- Sensory
    - Neuropathy
    - Auditory
- Dermatologic
    - especially visible lesions or eruptions
- Gastrointestinal
- Metabolic

Risk Factors for Adverse Drug Reactions

- Simultaneous use of several different drugs
    - Drug-drug interactions
- Very young, or very old in age
- Pregnancy
- Breast Feeding
- Hereditary Factors
- Disease states which may affect drug absorption, metabolism, and/or elimination

Methodologies in Pharmacovigilance

1. Passive surveillance
    a) Spontaneous reporting
    b) Case reports
    c) Case series
2. Stimulated reporting
3. Active surveillance

4. Comparative observational studies
    a) Cross sectional studies
    b) Case control study
    c) Cohort study

5.4. Reporting of Adverse Events

a) How to Recognize ADRs

Since ADRs may act through the same physiological and pathological pathways as different diseases, they are difficult and sometimes impossible to distinguish. However, the following step-wise approach may be helpful in assessing possible drug-related ADRs:

i. ensure that the medicine ordered is the medicine received and actually taken by the patient, at the dose prescribed;
ii. verify that the onset of the suspected ADR was after the drug was taken, not before and discuss carefully the observation(s) made by the patient;
iii. determine the interval between the commencement of the drug treatment and the onset of the event;
iv. evaluate the suspected ADR after discontinuing the drug(s) or reducing the dose and monitor the patient‟s status;
v. analyse the alternative causes, other than the drug that could on their own have caused the reaction;
vi. use relevant up-to-date literature and personal experience as a health worker on drugs and the ADRs of the drugs and verify if there are previous conclusive reports on such reactions. The NPVU is a very important source for purposes of obtaining information on ADRs. The manufacturer of a drug can also be consulted; and
vii. report any suspected ADRs to the person nominated for ADRs reporting in the hospital or district or directly to the NPVU.

b) What should be reported?

i. Report all suspected reactions, including minor ones, in the case of “new ” drugs.
ii. Report all serious or unexpected or unusual ADEs, in the case of established or

well known drugs.

iii. Report if an increased frequency of a given reaction is observed.

iv. Report all suspected ADRs associated with drug-drug, drug-food or drug-food supplements interactions

v. Report ADRs in special case or conditions such as drug abuse, and drug use in pregnancy and during lactation.

vi. Report when suspected ADRs are associated with drug withdrawals.

vii. Report ADRs attributed to an overdose or medication error.

viii. Report when there is a non-response or when suspected pharmaceutical defects are observed.

ix. Report all drug-related problems for example, problems associated with the quality of a product quality problems, suspected counterfeit products or treatment failure.

x. Report all adverse events following the ingestion of herbal or traditional medicines.

xi. Report even if you are not certain whether the product caused the adverse reaction or adverse event and whether or not you have all the details.

c) How and where to report ADEs?

Where to report

- Direct to NPVU (National Pharmacovigilance Unit, ZAMRA)
- Through DHMT, Health facility or health professions (doctors, pharmacists, etc)

How to report

- Using the ADE report form, which could be forwarded to nearest health center.
- By telephone or fax or e-mail. All verbal (including telephone) should be transcribed immediately onto ADE report form.

The ADE report form

The main features on the ADE report form are:

- Date of reporting
- Patient characteristics: initials, sex, ID, NRC, date of birth, weight (in kilograms), height (in centimeters), pregnancy status and HIV status

- Description of the problem
- Outcome
- Products given to the patient in the past 28 days (including drugs, vaccines and herbal treatments)
- Reporter‟s details (Name, designation, contact address and telephone number). The reporter's details are considered confidential and are to be used only for data verification, completion of case report and case follow-up

5.5. DMSA and its toxicity

Description

CHEMET (succimer) is an orally active, heavy metal chelating agent. The chemical name for succimer is *meso* 2, 3-dimercaptosuccinic acid (DMSA).

Adverse Drug Reactions

Clinical experience with CHEMET has been limited. Consequently, the full spectrum and incidence of adverse reactions including the possibility of hypersensitivity or idiosyncratic reactions have not been determined. The most common events attributable to succimer, i.e., gastrointestinal symptoms or increases in serum transaminases, have been observed in about 10% of patients (see PRECAUTIONS). Rashes, some necessitating discontinuation of therapy, have been reported in about 4% of patients. If rash occurs, other causes (e.g. measles) should be considered before ascribing the reaction to succimer.

INCIDENCE OF ADVERSE EVENTS IN DOMESTIC STUDIES REGARDLESS OF ATTRIBUTION OR SUCCIMER DOSAGE

	Pediatric Patients (191)		Adults (134)	
	%	(n)	%	(n)
Digestive:	12.0	23	20.9	28
Nausea, vomiting, diarrhea, appetite loss, hemorrhoidal symptoms, loose stools, metallic taste in mouth.				
Body as a Whole:	5.2	10	15.7	21
Back pain, abdominal cramps, stomach pains, head pain, rib pain, chills, flank pain, fever, flu-like symptoms, heavy head/tired, head cold, headache, moniliasis.				
Metabolic:	4.2	8	10.4	14
Elevated SGPT, SGOT, alkaline phosphatase, elevated serum cholesterol.				
Nervous:	1.0	2	12.7	17
Drowsiness, dizziness, sensorimotor neuropathy, sleepiness, paresthesia.				
Skin and Appendages:	2.6	5	11.2	15
Papular rash, herpetic rash, rash, mucocutaneous eruptions, pruritus.				
Special Senses:	1.0	2	3.7	5
Cloudy film in eye, ears plugged, otitis media, eyes watery.				
Respiratory	3.7	7	0.7	1
Throat sore, rhinorrhea, nasal congestion, cough.				
Urogenital:	0.0	-	3.7	5
Decreased urination, voiding difficulty, proteinuria increased.				
Cardiovascular:	0.0	-	1.8	2
Arrhythmia				
Heme/Lymphatic:	0.5*	1	1.5*	2
Mild to moderate neutropenia, increased platelet count, intermittent eosinophilia.				
Musculoskeletal:	0.0	-	3.0	4
Kneecap pain, leg pains.				

*Does not include neutropenia - see WARNINGS.

5.6. Compliance / adherence

WHO definition of adherence:

'the extent to which a person's behaviour – taking medication, following a diet and/or executing lifestyle changes – corresponds with agreed recommendations from a healthcare provider'

NONADHERENCE

This simply means failure of a patient to follow medical instructions and advice

EXAMPLES:

- Patient does not take his or her medicine at all
- Improper dosages are taken
- The medicine is taken along with unprescribed drugs (including traditional medicine). This can lead to adverse interactions.
- Not following advice on nutrition e.g. during pregnancy and lactation

FACTORS AFFECTING NONADHERENCE

- Personality of the patient e.g. some patients like to "rebel against authority", denial of disease
- Poor quality of doctor-patient interaction
- Cognitive factors e.g. forgetting, unclear instructions, too complex medications, careless
- Uncomfortable side effects
- Drugs are too expensive (patient tries to "stretch" the medicine by skipping a dose)
- Patient frustration with being dependent on drug
- "Testing" by the patient
- Food taboos and beliefs – sickness, pregnancy, lactation, menstruation

STEPS TO IMPROVE ADHERENCE

- Give clear and simple instructions
- Better doctor-patient communication and interaction (emphasise, repeat, be specific, etc.)

- Simplify the regimen if possible
- Prescribe cheaper generic drugs in place of expensive, branded drugs
- Inform patient about possible side effects
- Change the medication if severe side effects
- Explain about taking antibiotics properly
- Get family members to monitor adherence
- Doctor can also monitor adherence
- Deal with food taboos and beliefs

5.7. Outstanding issues

- Zinc interaction with DMSA – monitor Zn levels after treatment; Zn supplementation
- During follow up, mothers can be asked on any Adverse events occured

6. FOLLOW UP VISITS FOR CHILDREN WITH HIGH BLOOD LEAD LEVELS

6.1. Introduction

Systematic follow up is critical in attaining desired results when managing patients with high BLLs. Follow up visits will enable health care providers to monitor the progress of treatment including adherence to medication, identify and manage side effects and evaluate the general health status of the patient. They will also provide an opportunity for caregivers to seek clarification on various concerns and enable health providers reinforce health education messages. The schedule of follow up visits will depend on the classification of the Blood Lead Levels (BLLs) in the children.

6.2. Classification

Class I (BLLs< 10µg/dl)

- Questionnaire
- Clinical assessment
    - ✓ Age, weight, height/Length,
    - ✓ Detailed history and physical examination (urinalysis)
- Nutrition assessment and counseling
- **Children with other conditions requiring attention should be managed according to standard practice at the facility**
- **Pay attention to immunization schedules (for children under five)**
- Health Education to reduce and prevent exposure
- Annual Review (checkup)

Class II (BLLs>10 -19µg/dl)

- Questionnaire
- Clinical assessment
    - ✓ Age, weight, height/Length
    - ✓ Detailed history and physical examination (urinalysis)
- Nutrition assessment and counseling
- **Children with other conditions requiring attention should be managed**

according to standard practice at the facility

- **Pay attention to immunization schedules (for children under five)**
- Health Education to reduce and prevent exposure
- Recommend for Remediation
- Annual review (checkup)

Class III (20-44 µg/dl)

- Questionnaire
- Clinical assessment
    - ✓ Age, weight, height/length
    - ✓ detailed history and physical examination (urinalysis)
- Nutrition supplementation and counseling
- Health Education to reduce and prevent exposure
- **Children with other conditions requiring attention should be managed according to standard practice at the facility**
- **Pay attention to immunization schedules (for children under five)**
- Remediation
- Review after 3 months (Clinical evaluation, Nutrition assessment and follow up of BLLs)
- Annual review (checkup)

Class IV (45-64 µg/dl)

- Questionnaire
- Clinical assessment
    - ✓ Age, weight, height/length
    - ✓ Detailed history and physical examination (urinalysis)
    - ✓ Lab investigations (FBC, U/E, creatinine, LFTs/Enzymes)
- Neurological assessment (To be determined)
- Medical treatment with DMSA
- Nutrition supplementation and counseling
- **Children with other conditions requiring attention should be managed according to standard practice at the facility**
- **Pay attention to immunization schedules (for children under five)**

- Remediation
- Adherence counseling
- Health education to reduce and prevent exposure
- Review after 14 days

After 14 days,

- Clinical assessment
- Continue nutrition supplements (if BLL>20 µg/dl) and counseling
- Recommence treatment cycle (according to level) if BLL>45 µg/dl
- Adherence counseling
- **Children with other conditions requiring attention should be managed according to standard practice at the facility**
- **Pay attention to immunization schedules (for children under five)**
- Health education to reduce and prevent exposure
- Review after 3 months for clinical assessment and follow up BLLs

Class V (65-119 µg/dl)

- Questionnaire
- Clinical assessment
    - ✓ Age, weight, height/length
    - ✓ Detailed history and physical examination (urinalysis)
    - ✓ Lab investigations (FBC, U/E, creatinine, LFTs/enzymes)
- Neurological assessment (To be determined)
- **Patients with overt clinical signs will require immediate hospital admission (Need to decide on referral criteria)**
- **Children with other conditions requiring attention should be managed according to standard practice at the facility**
- **Pay attention to immunization schedules (for children under five)**
- Medical treatment with DMSA
- Nutrition supplementation and counseling
- Adherence counseling
- Health education to reduce and prevent exposure
- Remediation
- Review after 14 days

After 14 days,

- Clinical assessment
- Continue nutrition supplements if BLL>20 µg/dl)
- Recommence treatment cycle (according to level) if BLL>45 µg/dl
- **Children with other conditions requiring attention should be managed according to standard practice at the facility**
- **Pay attention to immunization schedules (for children under five)**
- Adherence counseling
- Health education to reduce and prevent exposure
- Environmental assessment and domestic interventions
- Review after 3 months for clinical assessment and follow up of BLLs

Class V (>120 µg/dl)

- Questionnaire
- Clinical assessment
    - ✓ Age, weight, height/Length
    - ✓ detailed history and physical examination (urinalysis)
    - ✓ Lab investigations (FBC, U/E, creatinine, LFTs/enzymes)
- Neurological assessment (To be determined)
- **Patients with overt clinical signs will require immediate hospital admission**
- **Children with other conditions requiring attention should be managed according to standard practice at the facility**
- **Pay attention to immunization schedules (for children under five)**
- Medical treatment with DMSA
- Nutrition supplementation and counseling
- Adherence counseling
- Health education to reduce and prevent exposure
- Remediation
- Review after 7 days

After 7 days,

- Clinical assessment
- Continue nutrition supplements if BLL>20 µg/dl)
- Recommence treatment cycle (according to level) if BLL>45 µg/dl

- Adherence counseling
- Health education to reduce and prevent exposure
- Environmental assessment and domestic interventions
- Review after 3 months for clinical assessment and follow up of BLLs

6.3. Outstanding issues

- Update the review schedules
- Re-align document and classes
- Develop referral criteria for severe lead intoxication
- Capacity build in at least one lab, and Pharmacy including budget for perishables
- Link between the HF treatment and remediation activities
- Develop protocols for environmental assessment
- Neurological assessment- need to develop tools and train staff.
- Hearing testing – need to engage stakeholder to train staff.
- Drug interactions (e.g. vaccines etc)
- GPS for client location and household mapping

7. DRUG MANAGEMENT

7.1. Treatment of lead poisoning

Dimercaptosuccinic Acid (DMSA) or Succimer is an orally administered drug that is commonly used for the treatment of blood lead. DMSA is a lead chelating agent; it forms water soluble chelates and, consequently, increases the urinary excretion of lead from the body. Figure1 shows DMSA binding to lead ions to form complex structures which are easily excreted from the body removing them from intracellular or extracellular spaces.

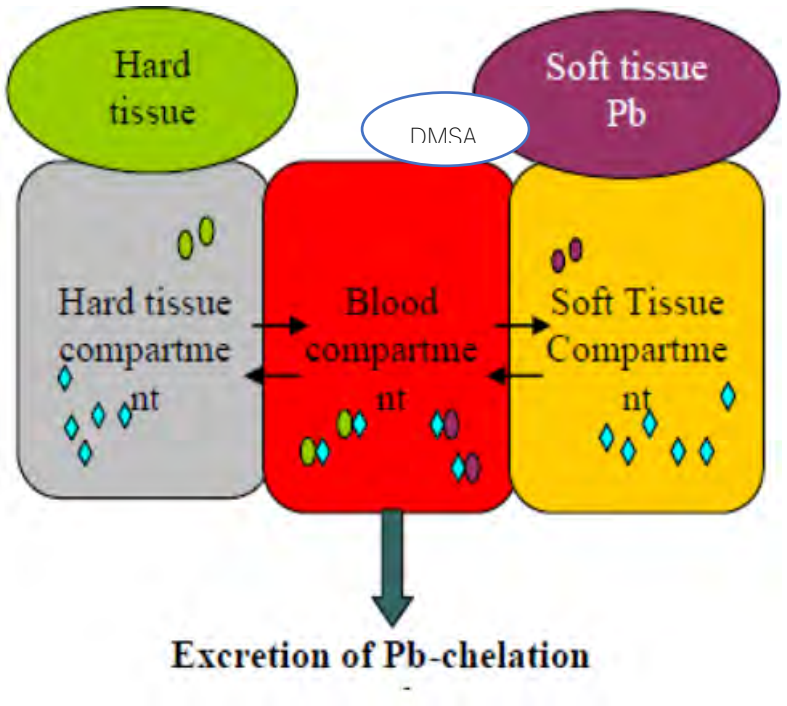


Figure 2. Chelating agents bind to toxic metal ions to form complex structures which are easily excreted from the body.

Each DMSA opaque white capsule for oral administration, contains beads coated with 100 mg of succimer. Inactive ingredients in medicated beads are: povidone, sodium starch glycolate, starch and sucrose. Inactive ingredients in capsule are: gelatin, iron oxide, titanium dioxide and other ingredients.

7.2. Effect of DMSA on Essential Minerals

Studies have shown that DMSA has no significant effect on the urinary elimination of iron, calcium or magnesium except Zinc. Zinc excretion has been shown to be doubled during treatment with DMSA. The effect of DMSA on the excretion of essential minerals is small compared to that of calcium disodium versenate (CaNa2EDTA), which can induce more than aten-fold increase in urinary excretion of zinc and doubling of copper and iron excretion. This is why DMSA is prefereved over CaNa2EDTA.

7.3. Indications and Usage of DMSA

DMSA is indicated for the treatment of lead poisoning in pediatric patients with blood lead levels above 45 mcg/dL. DMSA is not indicated for prophylaxis of lead poisoning in a lead-containing environment; the use of DMSA should always be accompanied by identification and removal of the source of the lead exposure.

7.4. Contraindications

DMSA should not be administered to patients with a history of allergy to the drug.

7.5. Warnings

Keep out of reach of pediatric patients. DMSA is not a substitute for effective abatement of lead exposure. Mild to moderate neutropenia has been observed in some patients receiving DMSA. While a causal relationship to DMSA has not been definitely established, neutropenia has been reported with other drugs in the same chemical class. A complete blood count with white blood cell differential and direct platelet counts should be obtained prior to and weekly during treatment with DMSA. Therapy should either be withheld or discontinued if the absolute neutrophil count (ANC) is below 1200/mcL and the patient followed closely to document recovery of the ANC to above 1500/mcL or to the patient’s baseline neutrophil count. Patients treated with DMSA should be instructed to promptly report any signs of infection.

7.6. Precautions

The extent of clinical experience with DMSA is limited. Therefore, patients should be carefully observed during treatment.

General: Elevated blood lead levels and associated symptoms may return rapidly after discontinuation of DMSA because of redistribution of lead from bone stores to soft tissues and blood. After therapy, patients should be monitored for rebound of blood lead levels, by measuring blood lead levels at least once weekly until stable. However, the severity of lead intoxication (as measured by the initial blood lead level and the rate and degree of rebound of blood lead) should be used as a guide for more frequent blood lead monitoring. All patients undergoing treatment should be adequately hydrated. Caution should be exercised in using DMSA therapy in patients with compromised renal function. Limited data suggests that DMSA is dialyzable, but that the lead chelates are not. Transient mild elevations of serum transaminases have been observed in 6-10% of patients during the course of DMSA therapy. Serum transaminases should be monitored before the start of therapy and at least weekly during therapy. Patients with a history of liver disease should be monitored closely. No data are available regarding the metabolism of DMSA in patients with liver disease. Clinical experience with repeated courses is limited. The safety of uninterrupted dosing longer than three weeks has not been established and it is not recommended. The possibility of allergic or other mucocutaneous reactions to the drug must be borne in mind on readministration (as well as during initial courses). Patients requiring repeated courses of DMSA should be monitored during each treatment course. One patient experienced recurrent mucocutaneous vesicular eruptions of increasing severity affecting the oral mucosa, the external urethral meatus and the perianal area on the third, fourth and fifth courses of the drug. The reaction resolved between courses and upon discontinuation of therapy.

Information for Patients: Patients should be instructed to maintain adequate fluid intake. If rash occurs, patients should consult their physician or pharmacist. Patients should be instructed to promptly report any indication of infection, which may be a sign of neutropenia (see WARNINGS and ADVERSE REACTIONS). In young pediatric patients unable to swallow capsules, the contents of the capsule can be administered in a small amount of food (see DOSAGE AND ADMINISTRATION).

Drug Interaction: DMSA is not known to interact with other drugs including iron

supplements; interactions have not been systematically studied. Concomitant administration of DMSA with other chelation therapy, such as CaNa2EDTA is not recommended.

Carcinogenesis, Mutagenesis and Impairment of Fertility: DMSA has not been tested for carcinogenic potential in long-term animal studies. DMSA up to a dose of 510 mg/kg/day in males and 100 mg/kg/day in females did not show any adverse effect on fertility and reproductive performance. It was not mutagenic in the bacterial assay and in the mammalian cell forward gene mutation assay.

Pregnancy: *Teratogenic Effects - Pregnancy Category C*. DMSA has been shown to be teratogenic and fetotoxic in pregnant mice when given subcutaneously in a dose range of 410 to 1640 mg/kg/day during the period of organogenesis. In a developmental study in rats, DMSA produced maternal toxicity and deaths at the dose of 720 mg/kg/day or more during organogenesis.

The dose of 510 mg/kg/day was the highest tolerable dose in pregnant rats. Impaired development of reflexes was noted in pups of 720 mg/kg/day group dam. There are no adequate and well controlled studies in pregnant women. DMSA should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus.

Nursing Mothers: It is not known whether this drug is excreted in human milk. Because many drugs and heavy metals are excreted in human milk, nursing mothers requiring DMSA therapy should be discouraged from nursing their infants.

Pediatric Use: Refer to the INDICATIONS and DOSAGE AND ADMINISTRATION sections. Safety and efficacy in pediatric patients less than 12 months of age have not been established.

7.7. Adverse Reactions

Clinical experience with DMSA has been limited. Consequently, the full spectrum and incidence of adverse reactions including the possibility of hypersensitivity or idiosyncratic reactions have not been determined. The most common events attributable to DMSA, i.e., gastrointestinal symptoms or increases in serum transaminases, have been observed in about 10% of patients (see PRECAUTIONS). Rashes, some necessitating discontinuation of therapy, have been reported in about 4% of patients. If rash occurs, other causes (e.g. measles) should be considered before ascribing the reaction to DMSA.

Rechallenge with DMSA may be considered if lead levels are high enough to warrant retreatment. One allergic mucocutaneous reaction has been reported on repeated administration of the drug (see PRECAUTIONS). Mild to moderate neutropenia has been observed in some patients receiving DMSA (see WARNINGS). Table I presents adverse events reported with the administration of DMSA for the treatment of lead and other heavy metal intoxication.

Table 1. Incidence of Adverse Events in Domestic Studies Regardless of Attribution or DMSA Dosage

	Pediatric Patients (191)		**Adults (134)**	
	%	(n)	%	(n)
Digestive:	12.0	23	20.9	28
Nausea, vomiting, diarrhea, appetite loss, hemorrhoidal symptoms, loose stools, metallic taste in mouth.				
Body as a Whole:	5.2	10	15.7	21
Back pain, abdominal cramps, stomach pains, head pain, rib pain, chills, flank pain, fever, flu-like symptoms, heavy head/tired, head cold, headache, moniliasis.				
Metabolic:	4.2	8	10.4	14
Elevated SGPT, SGOT, alkaline phosphatase, elevated serum cholesterol.				
Nervous:	1.0	2	12.7	17
Drowsiness, dizziness, sensorimotor neuropathy, sleepiness, paresthesia				
Skin and Appendages:	2.6	5	11.2	15
Papular rash, herpetic rash, rash, mucocutaneous eruptions, pruritus.				
Special Senses:	1.0	2	3.7	5
Cloudy film in eye, ears plugged, otitis media, eyes watery.				
Respiratory:	3.7	7	0.7	1
Throat sore, rhinorrhea, nasal congestion, cough.				
Urogenital:	0.0	-	3.7	5
Decreased urination, voiding difficulty, proteinuria increased.				
Cardiovascular:	0.0	-	1.8	2

Arrhythmia				
Heme/Lymphatic:	0.5*	1	1.5*	2
Mild to moderate neutropenia, increased platelet count, intermittent eosinophilia.				
Musculoskeletal:	0.0	-	3.0	4
Kneecap pain, leg pains.				

*Does not include neutropenia - seeWARNINGS.

7.8. Overdosage

Doses of 2300 mg/kg in the rat and 2400 mg/kg in the mouse produced ataxia, convulsions, labored respiration and frequently death. No case of overdosage has been reported in humans. Limited data indicate that DMSA is dialyzable. In case of acute overdosage, induction of vomiting or gastric lavage followed by administration of an activated charcoal slurry and appropriate supportive therapy are recommended.

7.9. Dosage and Administration of DMSA

It may be difficult to get a child to swallow a capsule of DMSA. It is therefore recommended that the total daily dose be combined in a favourite beverage (do not put in milk products or grapefruit juice). Ideally, DMSA should be given every 4 hours as it has a 4 hour half-life inside the body. Practically, however, it is not always feasible to get yourself and your child up throughout the night to do this. If you choose to follow the 5 days on 14 days off schedule, getting up in the night may be workable as you only have to do it for 5 days. The side effects of orally administered DMSA in children include **diarrhea**, **nausea**, **vomiting**, appetite loss and **rashes.** ZMERIP study will take a phased approach, with the first phase focusing on children aged 0-5 years of age being the most vulnerable group.

Start dosage at 10 mg/kg every 8 hours for five days. Initiation of therapy at higher doses is not recommended. Reduce frequency of administration to 10 mg/kg every 12 hours (two-thirds of initial daily dosage) for an additional two weeks of therapy. A course of treatment lasts 19 days. Repeated courses may be necessary if indicated by weekly monitoring of blood lead concentration. A minimum of two weeks between courses is recommended unless blood lead levels indicate the need for more prompt treatment.

Table 2: DMSA Pediatric Dosing Chart

BLL	**Kg**	**Dose (mg)***	**Number of Capsules***
18-35	8-15	100	1
36-55	16-23	200	2
56-75	24-34	300	3
76-100	35-44	400	4
> 100	> 45	500	5

*To be administered every 8 hours for 5 days, followed by dosing every 12 hours for 14 days.

In young pediatric patients who cannot swallow capsules, DMSA can be administered by separating the capsule and sprinkling the medicated beads on a small amount of soft food or putting them in a spoon and following with fruit drink.

Identification of the source of lead in the pediatric patient's environment and its abatement are critical to a successful therapy outcome. Chelation therapy is not a substitute for preventing further exposure to lead and should not be used to permit continued exposure to lead.

7.10. Blood lead level (BLL) assessment

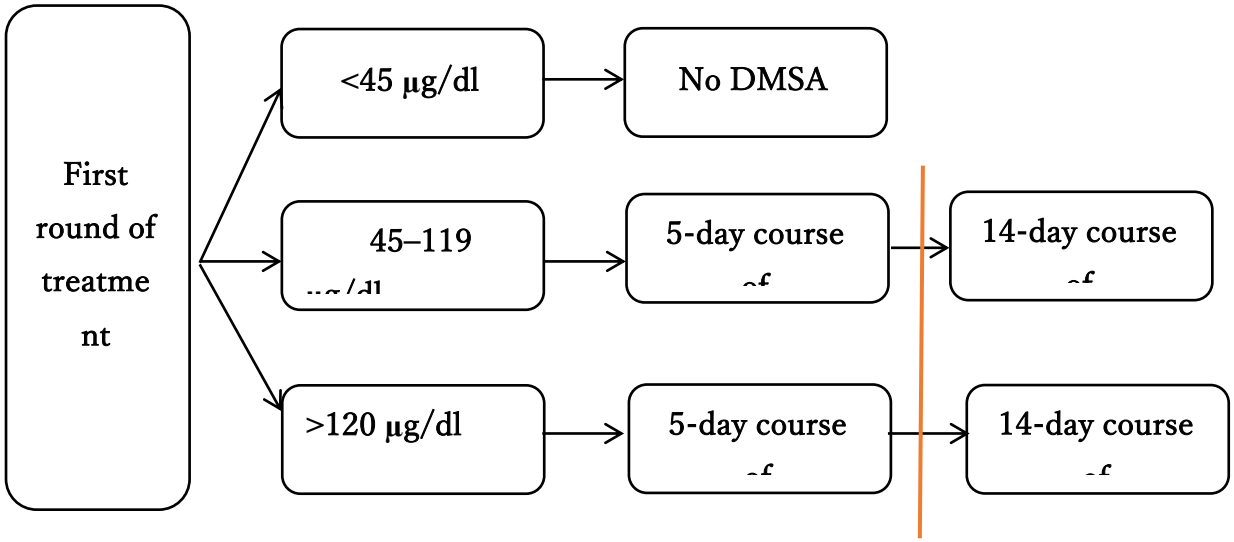
Categories of BLL for action (US CDC guidelines)

Level (µg/dL)	**Action**
<9	1. Repeat BLLwithin 3 months 2. Evaluate sources 3. Education: cleaning, hands and mouth
10–44	- Repeat BLL within 1-4 weeks - As above + referral to dept of health
45-59	- Confirmatory test within 48 hrs - As above + CHELATION therapy

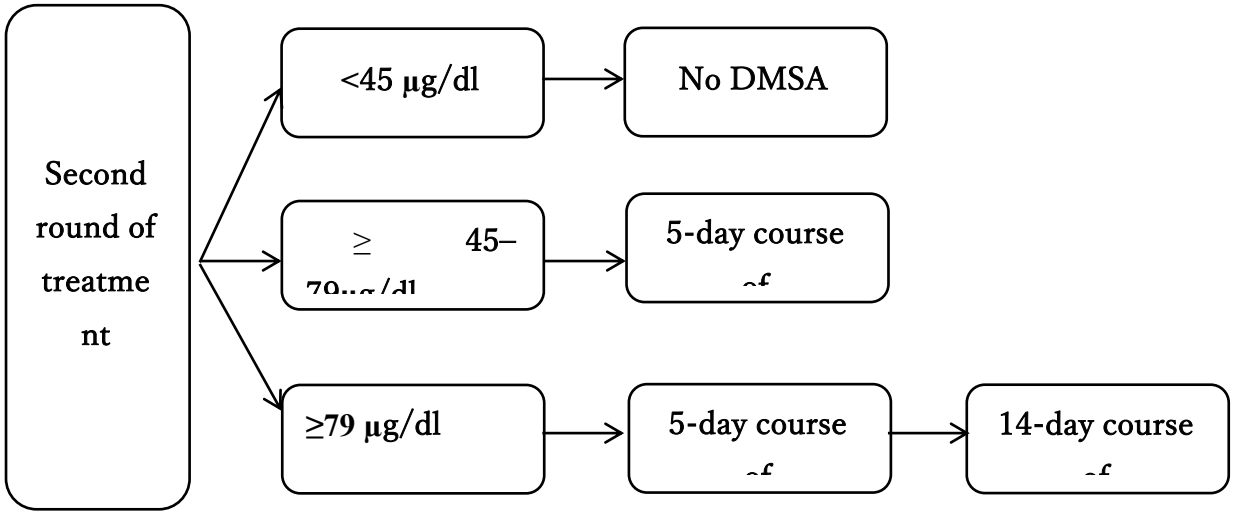
60-69	- Confirmatory test within 24 hrs
	- As above
>70	Immediate Hospitalization
	- As above

7.11. Treatment Protocols

Current lead poisoning medical treatment protocol for *first round* of treatment with DMSA



Current lead poisoning medical treatment protocol for *second* round of treatment with DMSA



7.12. Dosage and Administration of DMSA

It may be difficult to get a child to swallow a capsule of DMSA. It is therefore recommended that the total daily dose be combined in a favourite beverage (do not put in milk products or grapefruit juice). Ideally, DMSA should be given every 4 hours as it has a 4 hour half-life inside the body. Practically, however, it is not always feasible to get yourself and your child up throughout the night to do this. If you choose to follow the 5 days on 14 days off schedule, getting up in the night may be workable as you only have to do it for 5 days. The side effects of orally administered DMSA in children include **diarrhea**, **nausea**, **vomiting**, appetite loss and **rashes.** ZMERIP study will take a phased approach, with the first phase focusing on children aged 0-5 years of age being the most vulnerable group.

Start dosage at 10 mg/kg every 8 hours for five days. Initiation of therapy at higher doses is not recommended. Reduce frequency of administration to 10 mg/kg every 12 hours (two-thirds of initial daily dosage) for an additional two weeks of therapy. A course of treatment lasts 19 days. Repeated courses may be necessary if indicated by weekly monitoring of blood lead concentration. A minimum of two weeks between courses is recommended unless blood lead levels indicate the need for more prompt treatment.

Table 1: DMSA Pediatric Dosing Chart

BLL	**Kg**	**Dose (mg)***	**Number of Capsules***
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56-75	24-34	300	3
76-100	35-44	400	4
> 100	> 45	500	5

*To be administered every 8 hours for 5 days, followed by dosing every 12 hours for 14 days.

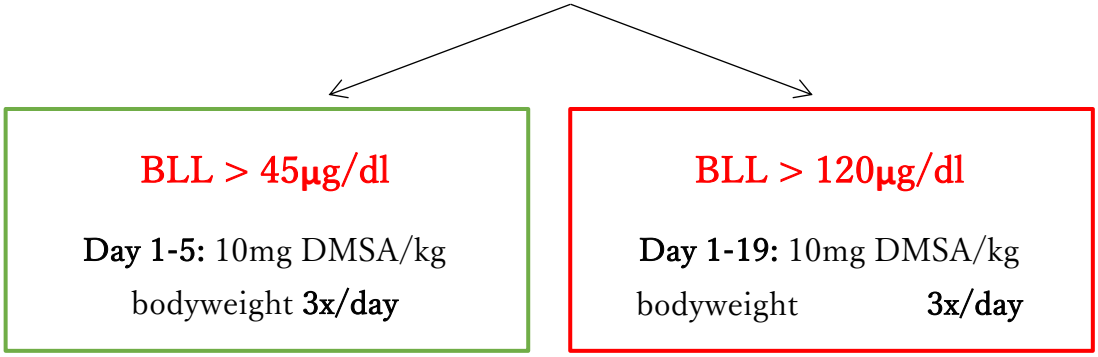
In young pediatric patients who cannot swallow capsules, DMSA can be administered by separating the capsule and sprinkling the medicated beads on a small amount of soft food

or putting them in a spoon and following with fruit drink.

Summary

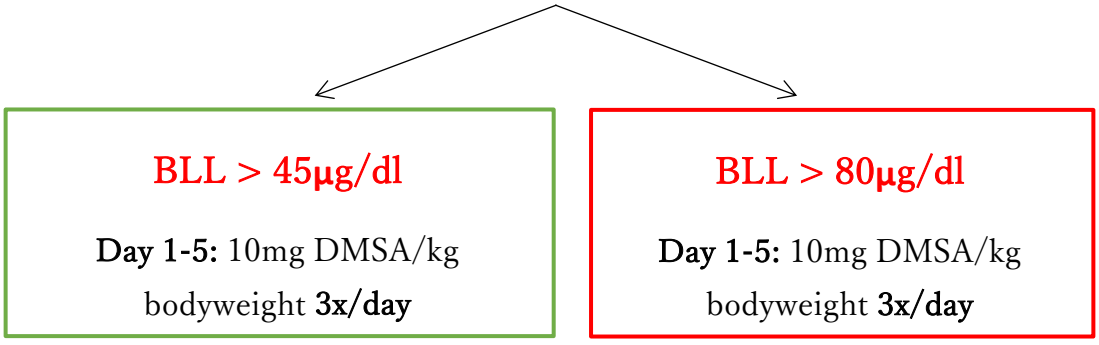
The blood lead level (BLL) of all participating children will be tested with the LeadCare II machine

First treatment



Second and if needed subsequent treatments

Children with an end-course BLL > 45µg/dl need to be treated again. Next course is to start immediately, if end-course BLL > 120 µg/dl, otherwise a minimum of two weeks between courses is recommended



If the case of child with an encephalopathy (unconsciousness, seizures) oral DMSA or intravenous CaNa2EDTA to be used.

Note: 10 mg/kg/dose are to be approximated and need to be **rounded to 100 mg or 200 mg per dose** depending on weight.

7.13. Drug Accountability and Logistics Management

Storage and Dispensing DMSA

Kabwe Municipal Council procured DMSA and is stored at the District Health office (DHO) pharmacy. The Health Facilities should obtain DMSA from DHO. Pharmacies at DHO and Health Facilities must have air conditioners which are pre-set at a required temperature to ensure the drug (DMSA) is kept at temperatures not exceeding 25 ^{o}C and well protected from light. The temperature should be monitored daily. An inventory of DMSA received, stored and dispensed should be maintained in the Health facilities.

Standard Operating Procedure for Dispensing DMSA

1. Dispensing of DMSA must be done under supervision of a pharmacist.
2. DMSA should only be dispensed on a well completed written prescription stating name of medicine, dosage, frequency and duration.
3. Education and counseling should be provided to parents of the child before after dispensing of DMSA

Drug Accountability

The primary intervention in ZMERIP study is DMSA (2,3 Dimercaptosuccinic Acid or Succimer). DMSA is an orally **chelating agent** that is commonly used for the treatment of blood lead concentrations above 45 mcg/dL. DMSA purchased shall be stored and distributed to dedicated pharmacy rooms in all study sites, and all stocks shall be logged at every stage. The following forms namely; (1) DMSA Requisition Form A , (2) Returned DMSA form B and ZMERIP DMSA Stock Control Card shall be filled-in for DMSA stock accountability.

8. DATA MANAGEMENT

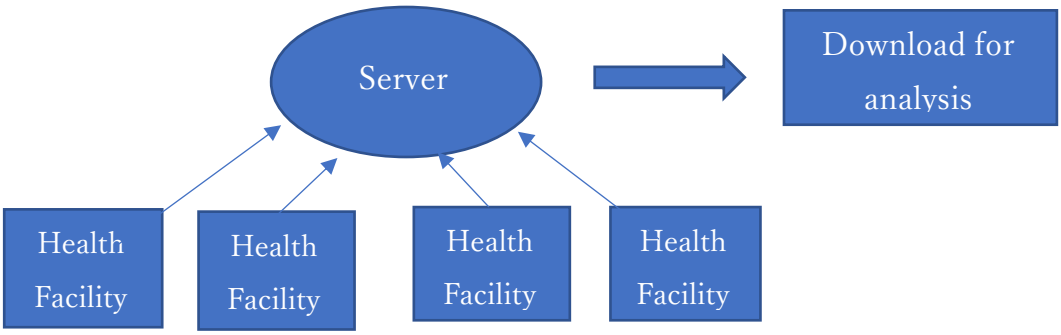
8.1. Introduction

Health interventions including testing and treatment will be supported through 4 health centres in hotspot areas - Chowa, Makululu, Kasanda, Katondo - and in the 2 hospitals.

Data Collection Approach

- We estimate 6 facilities from which the data will be collected
- Data will be electronically collected and stored on a central server with restricted access.
- A survey questionnaire will be put on the tablet which will be filled in before the child is screened.
- Electronic collection of data will allow for easy assessment of the progress of the project, outcomes and any adverse events.
- The server will be accessed by project coordinator, Principle Investigators, Data manager and Project Health manager.

Data management sequence



Data collection tools

- Electronic data collection using tablets
- Information collected will include
- Basic information of the child receiving treatment
- Blood Lead Levels
- Decision for treatment
- Any specified drug reactions reported at review.

- Any adverse drug events reported at review.
- The data will be entered on a tablet using Census and Survey Processing System (**CSPro**) software
- The tablets will be synchronised after every case, or at least at the end of each working day.

Data collection procedure

- Open a new case for each child
- Assign a four-digit code number for each child
- Complete the patient form
- Save the file on the tablet
- If connected to the internet, synchronise the tablet, otherwise synchronise at the end of the day

Data Cleaning

- Data managers will constantly check the data for anomalies as it is transmitted.
- Any anomalies observed are immediately communicated to the relevant staff to effect changes or clarify anomalies
- This will ensure that at any time, a complete and clean and high-quality dataset is available and ready for analysis.
- Data managers will conduct data quality monitoring daily by accessing the server

Data Analysis

- The cleaned data will be exported to STATA 15 for analysis.
- Basic descriptive analysis
    - Number of children that have received treatment, totals and by gender
    - Age of the children receiving treatment
    - BLL averages, classes (Appropriate statistics)
    - Variations in treatment being given
    - Recommended remediations

Data presented stratified by

- Facility where assessment is given

- Residence of children

8.2. Background

The Samsung tablet, chargers are being provided to you to collect data for the Zambia Environment Remediation and Improvement Project (Kabwe Health Intervention). Handle this equipment with care while they are in your possession and ensure they are returned in good working order at the end of data collection.

8.3. Purpose

The main purpose of the tablets is for data collection and uploading data

Dos

i. Ensure your tablet is functioning and you know how to operate it **BEFORE** commencement of the project. If you have questions, ask data manager for support
ii. Ensure that your tablet is fully charged **BEFORE** commencement of duty.
iii. At the end of each day, switch off the tablet to preserve battery power and data bundles.
iv. **Only** use the tablet for collecting and sending data
v. **Only** use the CSPRO application on the tablet.
vi. Ensure that you select the **CORRECT RESPONSE** when entering responses in the tablet.
vii. Always **'SAVE AS COMPLETE'** at the end of every complete interview.
viii. After each interview, go to the '**SEND COMPLETED DATA**' tab and send all completed data. In the event that there's no network coverage, send the completed forms at the end of each day once you have returned to an area with network coverage.
ix. In the event that you have any problem with the tablet, report the problem to your data manager **IMMEDIATELY!**

8.4. Procedures

i. Do not use the tablets for personal use.

ii. Do not use applications other than CSPro. Do not surf the web.
iii. Do not delete anything before checking with the data manager.
iv. Do not give the tablet to anyone apart from the data manager.
v. Do not switch off the tablet during an interview as you may lose the data you collected so far during the interview.
vi. Do not use the 'HOME' button or 'Back' button while you are entering data.
vii. Do not let sand, liquid or debris get come into contact with the tablet.

9. ETHICS PROCEDURES

9.1. Purpose of the manual

To establish a standard procedure for the ethical conduct of the Zambia Mining Environment Remediation and Improvement Project (ZMERIP) to assure the protection of the rights, welfare and safety of human participants, while obtaining high quality data from the study.

9.2. Policy

The Principal Investigator (or designee) will ensure that all staff involved with the ZMERIP study, including the investigators, community volunteers, nurses, nutritionists, laboratory, pharmacy and environmental health personnel, are well-trained in the procedures for conducting the research in accordance with local and international ethical standards.

9.3. Principles of Research Ethics

Universally, conducting research on human participants entails sticking to ethical principles enshrined in the Declaration of Helsinki and the Belmont Report. At the core of these ethical principles is the imperative to do the following:

a) do good (known as beneficence) and do no harm (known as non-malfeasance).
b) respect participants (called autonomy)
c) be fair to participants (called justice)

In practice, these ethical principles mean that as a researcher, you need to:

a) obtain informed consent from potential research participants;
b) minimise the risk of harm to participants;
c) protect their anonymity and confidentiality;
d) avoid using deceptive practices; and
e) give participants the right to withdraw from your research.

Members of the study team should ensure that their conduct not only aims to do good (i.e., beneficence), but also avoid doing any harm (i.e., non-malfeasance). This is important not only for ethical reasons, but also practical ones, since a failure to meet

such basic principles may result in penalties under the Health Research Act, Act no. 2 of 2013, Laws of Zambia.

9.4. Obtaining informed consent

Participants taking part in any research study need to understand that (a) they are taking part in research and (b) what the research requires of them. This is called INFORMED CONSENT. The information to be provided differs according to the study, but usually includes information on the purpose of the research, the methods being used, the possible outcomes of the research, as well as associated demands, discomforts, drug side effects, inconveniences and risks that the participants may face. Researchers should make a full disclosure of the benefits and risks of participation in the study so that participants make an independent and informed decision to take part in the research.

Informed consent is also premised on the idea that the participants should be volunteers, taking part without having been coerced or deceived. It is therefore imperative that those obtaining consent should respect the rights, welfare and wellbeing of participants, and obtain the permission of participants before any study related procedures can take place.

9.5. Responsibilities

Principal Investigator:

The Principal Investigator will assure that all necessary source documentation is available to demonstrate that the site and designated personnel have adequate qualifications and resources, including number of qualified staff and facilities, to safely and properly conduct study. The Principal Investigator will demonstrate via source documentation and regulatory files that the conduct of the study is accordance with the protocol, the law and Good Clinical Practice.

Nurses:

The nursing staff will be responsible for obtaining consent from participants. They will ensure that there is adequate space to assure privacy of the participants. They will take steps to ensure confidentiality of the study information obtained from participants. They will also ensure that the study procedures will be adequately explained, and that the consent is obtained in an ethical manner, free from coercion, intimidation or threats.

The steps for obtaining consent will be as follows:

1. Welcome the parent/guardian and make them sit down
2. Ensure that there is privacy in the place where the consent will take place
3. Provide the information sheet to the parent/guardian (in a language they understand best) and give them time to read and understand the contents. Ensure that the parents have understood the study procedures, that participation is completely voluntary, that the parents are free to withdraw form the study at any time without suffering any consequences.
4. Request the participant to ask questions and clarify them.
5. Have the parent/guardian to sign the consent form when they are ready to do so. In case they are not ready immediately, allow them to go home and think about it.
6. After the patient has signed, the nurse will sign the consent form on behalf of the principal investigator
7. If the patient is illiterate, explain the study in a language they understand (using the translated information sheets). After explaining the study purpose, procedures, drug side effects, patient responsibilities, and answering questions, the have the patient sign the consent form.
8. An impartial witness to verify that the consent form has been read to the parent/guardian will need to sign the consent form.
9. After the patient and witness have signed, sign the consent form on behalf of the PI

Environmental Health Personnel

The environmental health personnel will be responsible for community mobilization, public education and overall community sensitization. They will ensure that the mobilization of the community is done in a manner free from mis-information or coercion. They will work with community volunteers and other existing community structures to ensure community buy-in.

Pharmacy personnel:

The research pharmacist and team will have an ethical responsibility to ensure adequate drug storage, inspection and drug accountability via signed and dated relevant inventory forms, dispensation logs, and temperature logs. The Study pharmacist will supply necessary documentation and demonstrate adequate instruction to study participants on

dosing, handling, storing of the drugs.

Laboratory Personnel

Laboratory personnel will be responsible to testing and recording of study results. Keeping the results of participants in a confidential manner is of primary importance. The laboratory personnel also have an ethical responsibility for keeping adequate records and accountability for clinical supplies.

Community Volunteers

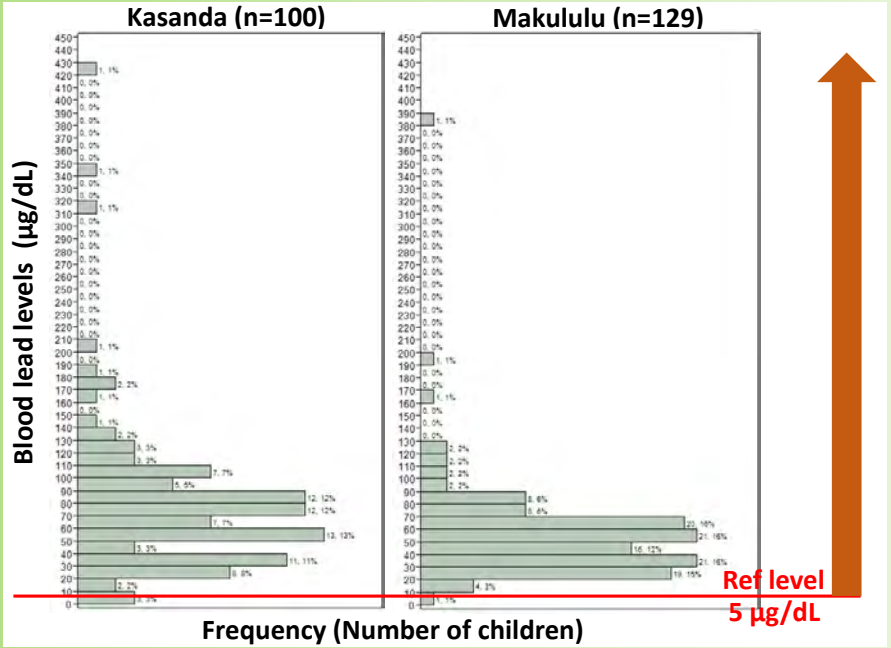
The community volunteers will work with environmental health officers to recruit patients from the community. A basic information pack consisting of the information sheet, posters and any other information will be used during the process of recruiting the patients. Care will be taken to provide accurate information to the participants that does not deceive, mislead or otherwise pressure them to participate in the study.

Summary of findings

from GROUP 2

for KAMPAI & DRINK projects

Human survey in Kabwe before the projects



Quite high blood Pb levels in children

- Almost all the children (≤ 7 y/o) living in townships around the mine recorded their BLL > 5 µg/dL (CDC's ref level)
- 65% of the tested children > 45 µg/dL (immediate chelation therapy is needed)
- BLLs of Younger children (0-3 y/o) > BLLs of elder children (4-7 y/o)

[Yabe et al., Chemosphere, 2015]

Sample	n	Mean	GM	Median	Minimum	Maximum	IQR
Cd-F (mg/kg)							
Chowa	8	0.18	0.15	0.16	0.07	0.43	0.23–0.09
Kasanda	88	0.54	0.31	0.28	0.04	4.49	0.57–0.15
Makululu	94	0.26	0.18	0.17	0.04	1.58	0.29–0.10
Cd-U_{SG} (µg/L)							
Chowa	8	0.43	0.19	0.13	0.06	1.67	0.93–0.09
Kasanda	88	1.47	0.46	0.38	0.02	18.1	0.79–0.19
Makululu	94	0.71	0.35	0.30	0.03	7.66	0.61–0.17
Cd-B (µg/L)							
Chowa	8	0.69	0.66	0.67	0.46	1.06	0.80–0.51
Kasanda	88	1.10	0.84	0.72	0.24	7.70	1.31–0.40
Makululu	94	0.52	0.44	0.49	0.08	1.56	0.68–0.32

Sample	n	Mean	GM	Median	Minimum	Maximum	IQR
Pb-F (mg/kg)							
Chowa	8	11.6	9.32	10.3	3.03	92.7	19.9–5.17
Kasanda	88	90.6	35.3	31.9	3.45	1259	71.2–15.4
Makululu	94	67.8	20.3	15.0	2.27	2252	53.3–7.99
Pb-U_{SG} (µg/L)							
Chowa	8	13.4	12.1	13.5	4.62	19.9	17.8–8.88
Kasanda	88	207	67.8	59.6	1.84	2914	117.8–31.2
Makululu	94	81.3	35.1	29.7	2.57	1113	56.4–18.6

Elevated Pb and Cd in urine and fecal

- Extremely high levels of Pb and Cd in fecal and urine of children living near the mine
- Higher metal levels in younger children (0-3 y/o) than elder children (4-7 y/o)
- Positive correlation for Pb and Cd among blood, urine and fecal

[Yabe et al., Chemosphere, 2018]

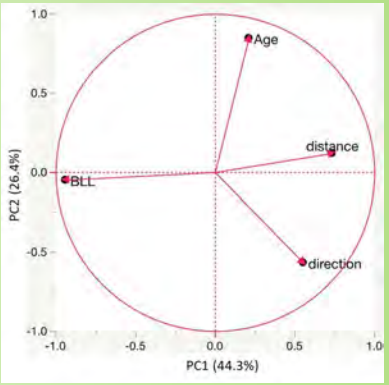
*Pb-F = Pb in fecal, Pb-U = Pb in urine, Cd-F = Cd in fecal, Cd-U = Cd in urine, Cd-B = Cd in blood

Human survey in Kabwe under the projects

Effect of distance and direction from the mine

- 1190 household members including parents & children were tested
- 23% of the tested children exceeded BLL of 45 µg/dL
- Lead level differences were attributed to distance and direction from the mine, with younger children at highest risk

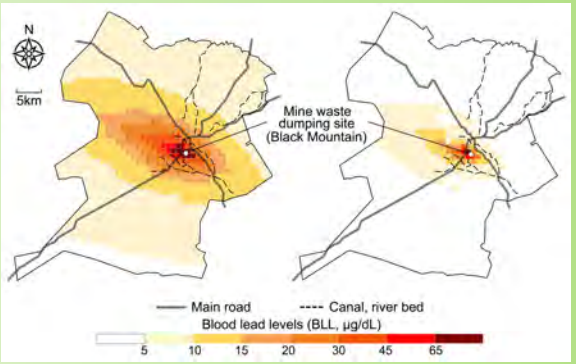
[Yabe et al., Chemosphere, 2020]



Estimation of mean BLL in entire Kabwe

- BLLs of individuals representing the population were econometrically estimated
- The estimated population mean BLL was 11.9 µg/dL
- Geographical distribution of estimated BLL (right figure)

[Yamada et al., Scientific Reports, 2020]



Pb exposure sources in infants

- High breastmilk Pb (mean 5.3 µg/L) above WHO acceptable level (2-5 µg/L)
- Pb exposure in infants through breastfeeding and soil ingestion could potentially exceed daily Pb intake

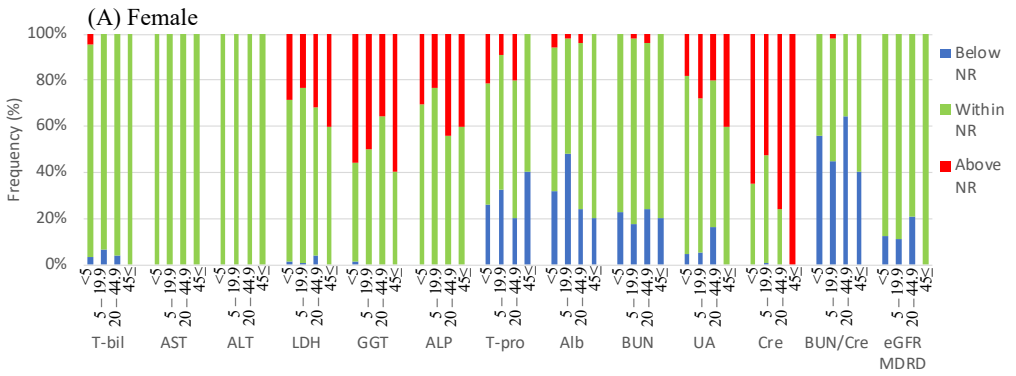
[Toyomaki et al., Environmental Pollution, 2021]

Evaluation of accuracy of LeadCare test

- LeadCare analysis is a good screening method at lower BLLs around 5 µg/dL although careful consideration is needed at higher BLL

[Nakata et al., Chemosphere, 2021]

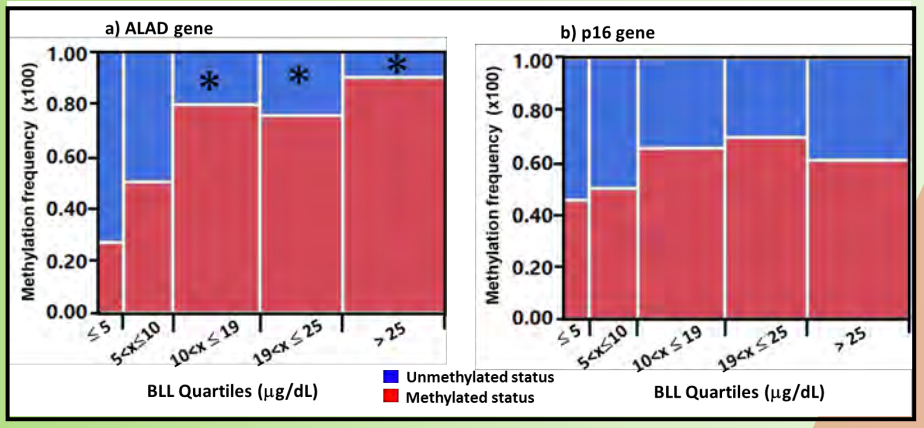
Assessment of health effects in human



Clinical effects by metal exposure

- Blood metals and biochemical parameters
- Negative correlation b/w Pb level and indicator of hematological toxicity
- Negative association b/w Cd level and kidney function indicator

[Nakata et al., Chemosphere, 2021]



Effects at the genetic level

- Pb exposure increases aberrations in methylation of genes
- Association of gene polymorphic variants with BLL in children
- Polymorphisms of specific genes are associated with susceptibility to Pb toxicity

[Yohannes et al., Environ Res, 2020; Meta Gene, 2021; Env Sci Pol Res, 2021]

Effect on maternal QoL

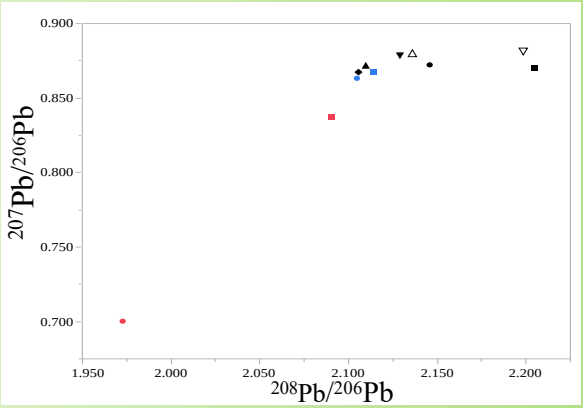
- Elevated BLLs in children negatively affect mental health and social role functioning scores of their mothers regardless of mother's BLL *[Nakata et al., Chemosphere, 2021]*

Other studies with animal samples

Source of Pb contamination in animals & vegetables

- Pb isotope analysis suggested that Pb-contained particles from mine site would be a major source of Pb contamination in animals (goats, chickens and dogs) and vegetables

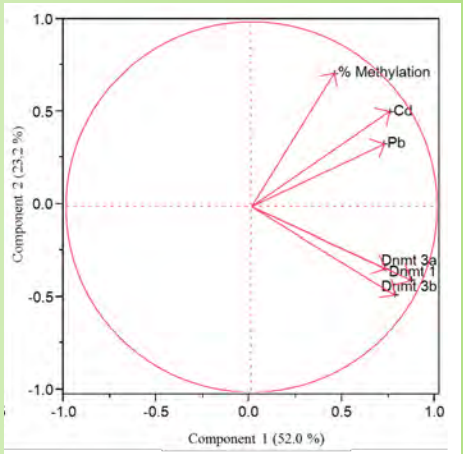
[Nakata et al., Env Pol, 2016; Toyomaki et al., Chemosphere, 2020]



Pb exposure via inhalation of contaminated soil particle

- Kabwe soil causes tissue metal accumulation and epigenetic alterations, such as elevation of global DNA methylation in rats
- Respiratory exposure would make up a significant proportion of metal absorption into the body

[Nakayama et al., Environmental Pollution, 2019]



Environmental monitoring using wild rat

- Pb level in crown incisor of rat teeth would be a possible indicator of Pb exposure

[Kataba et al., IJERPH, 2021]

Genome-wide DNA methylation analysis of Kabwe dogs

- Aberrant hypermethylation is prevalent in dogs exposed to Pb

[Yamazaki et al., Env Pol, 2021]

SATREPS:
Science and Technology Research Partnership for Sustainable Development
by JST & JICA

SATREPS
Science and Technology Research Partnership for Sustainable Development Program

JICA

JST

北海道大学
HOKKAIDO UNIVERSITY

The Kabwe Household Socioeconomic Survey (KHSS) 2017

Economics Team of KAMPAI Project

2017

The Kabwe Household Socioeconomic Survey (KHSS) Report

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The Kabwe Household Socioeconomic Survey (KHSS) Report

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The fieldwork of the KHSS 2017 was an activity contracted by the KAMPAI Project to the joint project team of the University of Zambia and the Central Statistical Office (CSO). The Economics Team of the KAMPAI Project appreciates the effort and input of three statisticians from CSO, Frank Kakungu, Owen Siyoto and Taonga Zulu, and thanks CSO for sharing the fieldwork training manual used in the previous surveys, which was modified and used in the fieldwork training for the KHSS 2017. The Economics Team also extends its gratitude to two coordinators from the KAMPAI Project, Hisao Odagiri and Michiko Nyanga, for their effort in finalising the outsourcing contract and their assistance in the fieldwork preparation. The fieldwork preparation was conducted in cooperation with the medical sub-group members of the KAMPAI Project: Mayumi Ishizuka, Yared Beyene, Andrew Kataba, Kaampwe Muzandu, Shouta Nakayama, Hokuto Nakata, Haruya Toyomaki, John Yabe and Golden Zyambo. The Economics Team appreciates their work. The efforts of the following 21 enumerators, including two from CSO Kabwe, were vital for completing the fieldwork: Ntalasha Aggrey, Masiku Banda, Saidi Banda, Yvone Chama, Jackson Chansa, Paul Chavula, Bornface Chuulu, Michael Kambwela, Norman Limwanya, Collins Mapunga, Kashoba Mukwilima, Brian Munamunungu, Gabriel Mphuka, Paul Mwauluka, Tamika Nakawala, Peter Njalaikadza, Joseph Njobvu, Kahilu Samuyachi, Matilda Sibongile, Nchimunya Sichimbwe, and Gabriel Yali.

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Table of Contents

The questionnaire of the KHSS 2017 attached at the end of the report.

Abbreviations

BLL: Blood lead level
CSO: Central Statistical Office of Zambia
JICA: Japan International Cooperation Agency
JST: Japan Science and Technology Agency
LCMS: Living Condition Monitoring Survey
K: Kwacha
KAMPAI: Kabwe Mine Pollution Amelioration Initiative
KHSS: Kabwe Household Socioeconomic Survey
SAR: School attendance ratio
SEA: Standard Enumeration Areas

Executive Summary

The Kabwe Household Socioeconomic Survey (KHSS) 2017 is a household survey conducted from August to September in 2017 in Kabwe district, Zambia. The objectives of the survey were to assess the socioeconomic and living conditions of residents of the district and to provide information that could be used to examine the socioeconomic causes and consequences of lead exposure in Kabwe. The KHSS 2017 is a component of the "Kabwe Mine Pollution Amelioration Initiative (KAMPAI)," formally referred to as the "Project for Visualization of Impact of Chronic/Latent Chemical Hazard and Geo-Ecological Remediation in Zambia," which is an interdisciplinary research project carried out by Hokkaido University, Japan, the University of Zambia, and other partners and funded by the Japan International Cooperation Agency (JICA) and the Japan Science and Technology Agency (JST). The KHSS is an interview survey with a similar (i.e., comparable) design to that of the Zambia Living Conditions Monitoring Survey (LCMS), and collects data on 895 households (4,900 individuals) in Kabwe district, randomly chosen as a representative sample of the district.

The total population of Kabwe district is estimated at 270,389, an increase of 33.6 % from the 2010 national census figure, 202,360. The survey data shows that the population of Kabwe district is concentrated among young individuals aged 25 years or below, which closely mirrors the national picture during 2015. The 5-9 year age group accounted for the largest population share (15%) among all age groups.

The KHSS collected data on residents' educational status and schooling conditions. The number of students in any grade is estimated to be 92,699, 34.3% of the total population. The proportion of students is higher than the national average of 30.4%. Despite being largely urban, the school attendance ratio (SAR) in Kabwe is almost the same as the Zambian average, although the SAR for male children in senior secondary and tertiary school ages is slightly higher than the Zambian average. On average, households in Kabwe pay 1,365.6 Kwacha (henceforth abbreviated as K) per year (i.e., K113.8 per month) for each student in the family, and school fees constitute 87.4% of this amount.

The KHSS also collected data on health status, types of illnesses and medical costs. Regarding health status, 19.1% of the population in Kabwe reported being ill or injured in the two weeks preceding the survey. This amount is higher than the national average of 14.2% and the urban average of 9.1% in 2015 identified by the LCMS. In line with the national data, women are more likely to be ill or injured (20.3%) than men (17.8%).

A number of questions regarding the economic activities of household members, such as their jobs, wages and labour time were also included. The proportions of the economically active population and those in paid employment in Kabwe district are estimated to be 57.7% and 39.6% respectively. These proportions are similar to the urban averages across all of Zambia (58.6% and 40.0%). Trade (20.2%), agriculture (19.8%), and construction (10.2%) constitute the top three sectors of employed persons. Regarding working status, Kabwe district exhibits intermediate characteristics of total and urban Zambia. Among those who have jobs in Kabwe, including unpaid ones, the proportion of those who actually worked in the last seven days was 77.1%, and their average working hours were 44.4 hours.

The KHSS also gathered data on agricultural activities relating to the 2016–2017 farming season. The percentage of households engaged in agricultural activities in Kabwe (41.7%) is lower than the national average (58.7%) but higher than the average for the urban areas in the whole of Zambia (17.9%), as collected by the LCMS 2015. About half of all agricultural households are engaged in hybrid maize production, which is the same as the national average recorded by the LCMS 2015. The survey also finds that the average farm size in the Kabwe district is 33.4 acres (13.2 hectares), and the average size of a home garden is 2.6 acres.

The survey asked about monthly wage income and income from non-agricultural business in the last month. The average total monthly household income is K3,492.7, translating to K764.9 per capita. Compared to national averages as captured by the LCMS 2015, these figures are similar to those of urban areas of Zambia. As for ownership of household assets and durables, the items owned by more than 80% of households are beds, mattresses, cellular phones, and braziers (*mbaula*). Ownership rates are lower for electronic durables, such as televisions, electric stoves and refrigerators. Proportions of ownership of these items are close to the urban average in the LCMS 2015 data.

As the most commonly used measure for assessing living standards or poverty of households in developing countries, household expenditure plays a vital role for household welfare. The average monthly household total expenditure is estimated at K3,532 in the Kabwe district, translating to K773 per capita. These values are considerably higher than the averages at the national level, as estimated by the LCMS 2015. It is suggested that the residents of Kabwe enjoy relatively higher living standard in Zambia, despite substantial differences in average household expenditure across areas (wards) within Kabwe, with the richest wards having over K5,000 of average expenditure while the poorest have less than K2,000. The share of food expenditure to the total expenditure in Kabwe accounts for 36%, which is not different from the urban average of Zambia (35%).

The KHSS 2017 also surveyed the housing conditions of people in Kabwe district, namely, the type of housing unit, the tenancy status, the main source of drinking water, and the electricity connection. The findings show that the most common type of housing unit in Kabwe is a detached house (53.9%), that most households in Kabwe occupied their own housing units (64.4%) or rented them from private individuals (25.7%). The survey also found that the proportion of households with a safe/improved water source in Kabwe (88.9%) reflects the average for that of urban areas in Zambia (89.1%).

The KHSS 2017 is a joint survey with the health assessment sub-group of the KAMPAI project. The health assessment sub-group invited individuals—up to two children and their parents from each household—for blood sampling and measured the blood lead level (BLL) using the testing kit LeadCare II. The mean BLL of all sampled individuals (827 individuals—fewer than those covered by the socioeconomic interview study owing to separate survey procedures) is 20.9 μg/dL, twice the frequently used reference level of 10 μg/dL, above which health risks become a concern. The mean BLL is the highest among children aged 5-9 years (29.1 μg/dL), and the lowest among adults aged 20-49 years (13.9 μg/dL). The mean BLL is higher for males than for females, suggesting that men tend to have more occasions of lead exposure.

Chapter 1
Survey Background and Sample Design

1.1. Introduction

Zambia is a land-locked Sub-Saharan African country sharing boundaries with Malawi and Mozambique to the east; Zimbabwe, Botswana and Namibia to the south; Angola to the west, and the Democratic Republic of Congo and Tanzania to the north. According to the Human Development Report (UNDP 2016), Zambia is a middle-human-developed country, and its Human Development Index ranks 139th in the world and 8th amongst Sub-Saharan African countries. However, the country's economy depends on primary commodities. Copper and Cobalt exports are the main source of foreign currency revenue. 58.2 per cent of the population lives in rural areas and are dependent on agriculture for their livelihood (CSO 2016). Inequality is an important issue for the country with its GINI coefficient reaching 55.6, fifth- highest amongst Sub-Saharan African countries after South Africa, Namibia, Botswana, and Central African Republic in 2010-2015 (UNDP 2016).

Kabwe is the administrative capital of the Central Province, one of ten provinces of Zambia. Despite being a medium-sized municipality (the population was slightly above 200,000 according to 2010 Census), the socioeconomic conditions and living standards in Kabwe demonstrate great diversity; ranging from relatively wealthy areas on the eastern side of the centre to the relatively poor Makululu Compound—one of the largest compounds in Africa—on the western side, and from the commercial areas in the centre to the farming areas in the outskirts. Kabwe was also once one of the main mining sites in Zambia producing lead and zinc. The closure of the mine in 1994 made the city less dependent on mining. However, lead pollution and human exposure to lead remain critical problems. Lead-containing mining wastes are left abandoned in the dumping site located at the centre of Kabwe, which is the main source of lead pollution.

Lead poisoning leads to various health and human developmental problems, such as neuronal, circulatory and reproductive disorders, lack of concentration, fatigue and loss of IQ (Meyer et al. 2008). These problems may further lead to poverty and other socioeconomic problems by limiting their labour activities, productivity, and physical and human capital accumulation (Zivin and Neidell 2013). At the same time, poverty and other socioeconomic problems can be the risk factors of lead exposure (Sargent et al. 1995). In a deprived circumstance that lacks a mean of education, adequate shelter from lead-containing dust, and access to less-contaminated food and water, one may be subject to a relatively high risk of lead exposure and poisoning. The direct health problems of lead poisoning may create a

vicious cycle of the abovementioned interlocking problems that could put the economy into a poverty trap and undermine the development potential of Kabwe and Zambia.

The Kabwe Household Socioeconomic Survey (KHSS) 2017 is a household survey aiming to illustrate the socioeconomic and living conditions of residents of the Kabwe district and to provide information that could be used to examine the socioeconomic causes and consequences of lead exposure in further research. The KHSS 2017 forms a component of the "Kabwe Mine Pollution Amelioration Initiative (KAMPAI)," formally referred to as the "Project for Visualization of Impact of Chronic/Latent Chemical Hazard and Geo-Ecological Remediation in Zambia," and is conducted in collaboration with the health assessment sub-group of the KAMPAI project.

In this report, from Chapter 2 onwards, we present an overview of the KHSS 2017 and data of key indicators to characterise the socioeconomic and living conditions of residents in Kabwe. The remainder of this chapter provides basic information on the KAMPAI project and the framework designs and fieldwork results of the KHSS 2017.

1.2. Overview of the KAMPAI Project

The "Kabwe Mine Pollution Amelioration Initiative (KAMPAI)," formally referred to as the "Project for Visualization of Impact of Chronic/Latent Chemical Hazard and Geo-Ecological Remediation in Zambia," has begun to tackle those multi-dimensional issues of lead pollution and human exposure to lead. The KAMPAI project is an interdisciplinary research project that involves a wide range of researchers from different academic fields. The project aims to examine multifaceted issues related to lead pollution and exposure in Kabwe, including the geographical, biomedical and socioeconomic causes and consequences of lead exposure and the potential remediation strategies. The project is financed by the Japan International Cooperation Agency (JICA) and the Japan Science and Technology Agency (JST). It also shares information with a project of the World Bank, "Zambia – Mining and Environmental Remediation and Improvement Project."

1.3. Objectives of KHSS 2017

The aim of the KHSS 2017 was to collect detailed information on the socioeconomic conditions of individuals and households in Kabwe district that would allow us to:

1. Assess the socioeconomic conditions of the whole Kabwe district;
2. Examine the socioeconomic causes and consequences of lead exposure.

The questionnaire design of the KHSS 2017 largely followed that of the Living Conditions Monitoring Surveys (LCMSs), the nationwide surveys conducted by Central Statistical Office (CSO) of Zambia every 2-5 years since 1996. Although we modified the structure of the questionnaire and added various questions, the KHSS 2017 provides data that allows us to measure the socioeconomic conditions of individuals and households in Kabwe district in a way that is comparable to the results of the

LCMSs. The structure of the questionnaire is as follows:

- Section 1. Household roster
- Section 2. Biological relationships of household members
- Section 3. Health
- Section 4. Education
- Section 5. Economic activities and income at the individual levels
- Section 6. Agriculture
- Section 7. Other income
- Section 8. Household assets
- Section 9. Household amenities and housing conditions
- Section 10. Household expenditure
- Section 11. Child health and nutrition
- Section 12. Deaths in household

To accomplish its second objective, the KHSS 2017 was designed to be complementary with the parallel surveys conducted by the health assessment team of the KAMPAI project. The health assessment team measured the blood lead levels (BLLs)—a frequently used biomarker for lead exposure and poisoning—to investigate health status of individuals from the biomedical aspect and conducted questionnaire surveys on behavioural aspects of lead exposure, the quality of life, etc. The surveys of the health assessment sub-group were conducted separately from the KHSS 2017. However, the sample was designed so that the data of each research component can be used in the other analyses. This enables us to examine the socioeconomic causes and consequences of lead exposure although this report only describes the BLLs of the sample individuals and leaves detailed analysis of these issues to further research.

1.4. Sample Design and Coverage

The KHSS 2017 was designed to select 1,000 households from the whole Kabwe district, including both its centre and outskirts, so that the sample represents the population of the entire Kabwe district. It is also desirable that the sample is drawn from areas diverse in the levels of lead contamination.

The KHSS 2017 employed two-stage random sampling to find the sample households using the sampling frame of CSO. The sample frame divides the whole Kabwe district into 384 Standard Enumeration Areas (SEAs). In the first stage, 40 SEAs are randomly selected. The second stage randomly selected 25 households from each SEA. To ensure the representativeness of the sample, sampling weights were calculated (for details on sampling weights, see Chapter 1.6). One limitation is that we could not conduct a survey in areas near military basements. Thus, households in these areas were excluded in the second stage of the random sampling. Apart from this issue, our strategy provides a reasonable sample representative of the whole Kabwe district.

1.4.1. Selecting SEAs

Table 1.1 shows the coverage of the chosen SEAs at the ward level. A ward is the smallest administrative unit and Kabwe district is divided into 27 wards. As a natural consequence of random selection of SEAs, the chosen SEAs do not cover all 27 wards, especially wards comprising a relatively small number of SEAs. However, this would not be a serious problem for making the sample

representative of the whole Kabwe district. Figure 1.1 shows the maps of the whole Kabwe district and its centre, where the chosen SEAs are coloured in green. They are widely distributed across the whole Kabwe district, including its centre and outskirts. Also, the chosen SEAs cover diverse areas in terms of lead pollution. Areas far from the centre are thought to be least contaminated since the slag dumping site is located close to the centre. The level of lead pollution is also thought to vary within the centre (Tembo, Sichilongo and Cernak 2006): The Western side, containing wards such as Makululu, Moomba and David Ramushu, is considered to be the most severely contaminated whereas the Eastern side, such as Waya, Chirwa and Highridge, to be less.

1.4.2. Selecting Households

In each SEA chosen in the previous step, the KHSS 2017 randomly located 25 households plus a few replacement households. To do this, we conducted a household listing in July/ August 2017 in collaboration with the health assessment sub-group of the KAMPAI project.

A standard method for the listing and household selection, which was also followed by the LCMSs, is to visit all households in each selected SEA, make a list of households, and select 25 households randomly. However, this method turned out to be difficult for most SEAs in the KHSS 2017 due to the logistical, financial and time constraints. The household lists obtained in this way were used only for a few SEAs.

Table 1.1: Coverage of the Chosen SEAs

Ward name	Total SEAs	Chosen SEAs
Ben Kapufi	12	0
Bwacha	16	2
Chililalila	14	1
Chimanimani	7	0
Chinyanja	8	1
Chirwa	51	6
David Ramushu	17	5
Highridge	16	1
Justine Kabwe	10	0
Kalonga	19	2
Kangomba	11	2
Kaputula	19	3
Kawama	21	0
Luangwa	27	0
Luansase	6	0
Makululu	7	2
Moomba	21	6
Mpima	11	1
Munga	6	0
Munyama	7	2
Muwowo	8	0
Muwowo East	12	3
Nakoli	14	0
Ngungu	11	0
Njanji	8	0
Waya	10	1
Zambezi	15	2

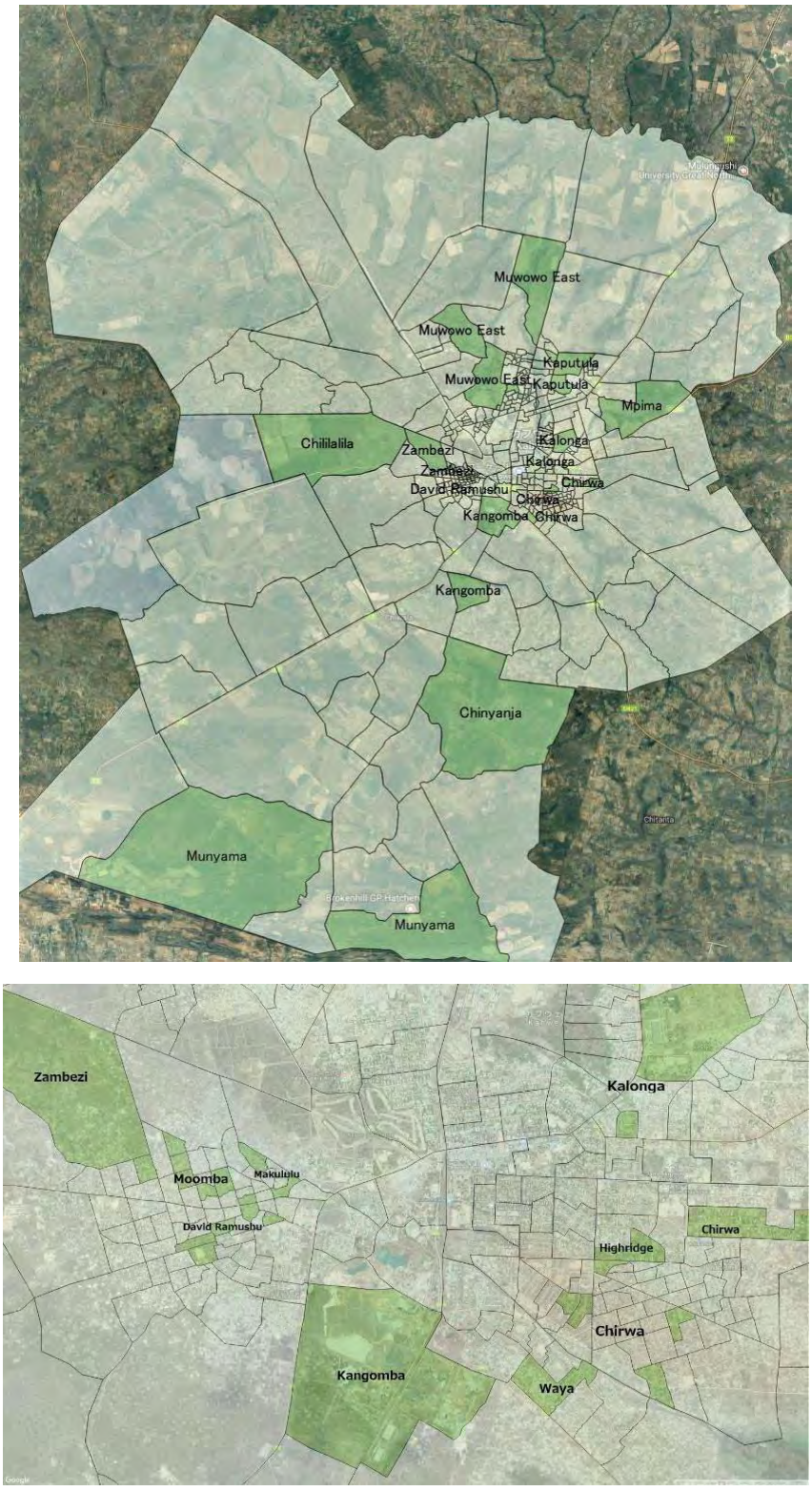

Figure 1.1: The map of Kabwe (chosen SEAs in deep green)

Instead, we sampled households in the following alternative way utilising the satellite maps of Google Earth, in cooperation with the health assessment sub-group of the KAMPAI project. We first counted the number of residential buildings or structures recognisable on the satellite maps (let us call them *houses*). Then, we listed the houses in a random order using the random numbers. Ideally, if houses and households have one-to-one correspondences, then we can obtain the set of randomly selected sample households by selecting the 25 houses in the top of the list. However, the list of houses could include empty houses, detached rooms or non-residential buildings (we made effort to avoid counting these buildings, but it may not perfectly eliminate these cases). Therefore, we visited the houses in the list in a descending order to make the list of sample households. If a house was inhabited by a household, then we included it in the list of sample households.[1] In cases where multiple households share the same building, we chose one of them randomly. In cases where some houses seemed inhabited but no individual was present, we asked neighbours whether the houses were inhabited. We continued visiting houses until at least 25 households were listed as sample households. In SEAs where we could list more than 25 households, we reserved households in the 26th or higher orders as replacement households.

It turned out that our house counts from the satellite maps were relatively accurate. In most cases, the visited houses were inhabited by single households and used as the main residential buildings. This allowed us to use the house counts to calculate the sampling weights, the details of which are explained in Chapter 1.6.

1.5. The Main Survey

1.5.1 General Description of Interviews

The fieldwork for the main survey of the KHSS 2017 was conducted during three weeks from late August to early September 2017, in the form of Computer Assisted Personal Interviewing (CAPI) using the application Survey Solutions (version 5.22.20, the latest version at the time of the survey), developed by the World Bank. The fieldwork involved five supervisors/trainers and 21 enumerators, including three Economics Team members from the University of Zambia and four CSO personnel.

Interviews were conducted mostly at the houses of the sampled households, each lasting two to three hours on average. In cases where the knowledgeable persons were absent, the enumerators stopped interviewing and revisited these households when the knowledgeable persons were available.

Although the questionnaire is prepared in English, interviews were also conducted in local languages, such as Bemba, Nyanja and Tonga. Enumerators were required to speak at least two local languages as well as English and to be able to translate the questionnaire

[1] The details of the definition of a household is provided in Appendix of this chapter.

into these languages. The ability to conduct interviews in local languages was also examined in the pre-survey training session.

1.5.2. The Response Rate and the Final Sample Size

The main survey visited 1,015 households (996 originally sampled households and 19 replacement households). The number of originally sampled households is four households fewer than 1,000 because it turned out when conducting the main survey that four groups of individuals listed as independent households in the sampling procedure were members of other households according to our definition.

Table 1.2: The Description of the Samples for Each Ward

Ward	Chosen SEAs	The number of households						Response rate
		Original sample	Replacement used	Total visited households	Not available	Refusal	Final sample	
Bwacha	2	50	2	**52**	4	1	**47**	90.4%
Chililalila	1	25	0	**25**	0	0	**25**	100.0%
Chinyanja	1	25	0	**25**	0	4	**21**	84.0%
Chirwa	6	149	0	**149**	17	7	**117**	78.5%
David Ramushu	5	125	2	**127**	12	0	**115**	90.6%
Highridge	1	24	0	**24**	3	0	**21**	87.5%
Kalonga	2	50	8	**58**	7	2	**44**	75.9%
Kangomba	2	50	0	**50**	2	1	**47**	94.0%
Kaputula	3	75	1	**76**	3	0	**72**	94.7%
Makululu	2	50	0	**50**	5	1	**44**	88.0%
Moomba	6	150	0	**150**	19	0	**131**	87.3%
Mpima	1	23	0	**23**	2	0	**21**	91.3%
Munyama	2	50	1	**51**	1	0	**50**	98.0%
Muwowo East	3	75	4	**79**	6	2	**71**	89.9%
Waya	1	25	1	**26**	4	0	**22**	84.6%
Zambezi	2	50	0	**50**	3	0	**47**	94.0%
Total	40	996	19	**1,015**	102	18	**895**	88.2%

"Not available" includes the cases where the households turned out to be shifted and where we could not have any contact.

Among the visited households, the overall response rate was 88.2% and we could not conduct interviews with 11.8% of households (i.e. 120 households). For 17.5% of the 120 failed cases, we learnt, by asking neighbours or making phone calls, that the sample households had shifted during the period between the listing and the main survey. These cases include single student households who were listed in the listing procedure but were absent at the time of the survey because of summer vacations. For 67.5% of the failed cases, we could not make any contact even after repeated attempts to revisit them, perhaps because either the households had shifted or were temporarily absent. The explicit refusal of interviews was rare, constituting 15% of the failed cases and 1.8% of the total cases.

The final sample size in the main survey is 895 households (4,900 individuals). Table 1.2 summarises the sample sizes, the breakdown of the failed cases, and the response rate for each ward, excluding wards from which no SEA was chosen.

1.5.3. The Final Sample for the Surveys by the Health Assessment Team

The sample of the KHSS 2017 was designed to be shared with the parallel surveys by the health assessment team of the KAMPAI project, which, as earlier mentioned, conducted blood sampling and questionnaire surveys on aspects such as lead exposure and avoidance behaviours and the qualities of lives. These data could be merged with the KHSS 2017 data at the individual and household levels. This subsection briefly describes their survey procedure.

The surveys of the health assessment team were conducted over six weeks from July to August in 2017. Unlike the KHSS 2017, where the enumerators visited sample households, the health assessment team invited sample individuals to communal clinics and conducted blood sampling and the other surveys there due to hygiene and ethical reasons. Eleven clinics were chosen as the venues for their surveys.

For each household, up to four persons—two parents and two children—were invited to the nearest one of the chosen clinics. In SEAs with no nearby clinic, the health assessment team provided means of transportation. The dates of blood sampling and interviews were pre-assigned since it was not feasible to allocate the health assessment team members to all 11 clinics at once. Instead, the members formed four groups, visited the clinics sequentially, and requested the sample individuals to attend the clinics while they were staying there. The assigned dates had one-week windows so that invited individuals could attend when they were available during the week.

Regarding the final sample of the health assessment team, there are two points to be noted. First, in addition to the sample shared with the KHSS 2017, the health assessment team invited additional households to partake in their surveys. However, the information on these samples cannot be merged with the KHSS 2017 data as no information is available for these samples in the KHSS 2017 data.

Second, and unfortunately, the attendance rate at the clinics was quite low. Some individuals might not have been able to find time to visit

the clinics despite one-week windows. Some explicitly refused to visit the clinics because the idea of blood sampling was not religiously or ethically acceptable for them. Among the final sample of the KHSS 2017, blood sampling was conducted for 827 out of 4,900 individuals (16.9%), or 372 out of 895 households (41.6%).

1.6. Sample Weights

To find estimates representative of the population of the whole Kabwe district, the use of sampling weights is essential. Since the sample size per SEA is fixed, mostly at 20-25 households, but each SEA differs in its population size, differences in representation of the samples need to be corrected by sampling weights. The weights also correct the differences in the response rates across the SEAs.

Since we did not adopt stratified sampling, the weights of the sample are equal to the inverse of the product of the two selection probabilities employed at each stage of selection. The sample weight for a household in the *i* th SEA, W_i, is calculated as follows:

$$W_i = \frac{1}{P_{1i}P_{2i}}$$

where:
P_{1i}: the probability of selecting the *i* th SEA in the first-stage selection, and
P_{2i}: the probability of selecting a household in the *i* th SEA in the second-stage selection.

In our sampling design, P_{1i} is equal to 40/384 for any *i*, since we conducted random selections of 40 SEAs from 384 SEAs that cover the entire Kabwe district at the first stage. P_{2i} is calculated by dividing the final sample size in the *i* th SEA by the total number of households in the *i* th SEA. In SEAs where the standard method of listing was feasible, the total number of households is available. In the other SEAs, we could reasonably use the number of houses counted from the satellite maps as the estimated number of households since it roughly matches the actual number of households.

Because this report aims to describe the information representative of the whole residents in the Kabwe district, we use the sampling weights for most of the calculation. Whenever we present a figure calculated without using the sampling weights, we clearly state so.

Appendix: Definition of a Household

The KHSS 2017 uses the same concept and definition of a household member as the LCMSs. A household member is defined so that it includes an individual who was temporarily absent at the time of the survey, but excludes an individual who usually lives in other places but happened to stay in the household.

A more precise definition of a household member is as follows: A household member is basically defined as one who (i) has continuously lived with the household for at least six months, (ii) lives together with other household members in one house or closely related premises and takes his/her meals from

the same kitchen, and (iii) regards the person who is regarded as head by other household members as head. He/she may or may not be related to the other household members by blood or marriage. A house helper or labourer (maid, nanny or house servant) is also a household member as long as he/she meets the criteria above. Conversely, there are situations where people eat together and even sleep under one roof, but have different persons whom they regard as head. These persons are considered as belonging to separate households. The exceptional cases where persons not meeting the criteria are regarded as household members are newly married couples, newly born babies, those who are away for temporary basis and those attending boarding schools, colleges and universities within Zambia.

Chapter 2
Demographic Characteristics

2.1. Introduction

The KHSS 2017 collected information on the representative sample of the population of the whole Kabwe district. Over seven years after the census, the demography in Kabwe has seemingly changed. New houses were built in suburban areas. New households may have moved in from outside of the Kabwe district while some households may have split into several new households as children became adults.

Under such circumstances, the demographic characteristics would be interesting for their own sake. They are also important in understanding the living conditions of the people because they would affect the socioeconomic behaviour of individuals and households, and *vice versa*. In addition, the demographic characteristics would also be important factors regarding lead exposure.

2.2. Population Size and Distribution

Table 2.1 shows the population distribution by sex and age group. The population weights are used so that the distribution reflects that of the whole Kabwe district. The first four columns of the table refer to the population distribution of Kabwe as found in the KHSS 2017 while the last two columns are the national population distribution according to the LCMS 2015. The population is concentrated among those below the age of 25 years, which closely mirrors the national picture during 2015. The age group with the largest population is 5-9 years, accounting for 15.5% of the total population of Kabwe in 2017. This percentage compares well with the national population distribution in 2015 where that age group accounted for 18.8%. There is no marked difference in the population distribution within a particular sex. Finally, the total population of Kabwe district is estimated at 270,389 based on the KHSS data, an increase of 33.6% from the 2010 national census figure of 202,360.

2.3. Migration and Lengths of Residence in Kabwe

Migration has implications on population changes and has a close relationship with living conditions. It would also be related to the duration of individuals' exposed to lead, which is one of the main focuses of the KAMPAI project.

The term migration in the KHSS 2017 refers to any change in residence, including relocation within a township, a district, a province or a nation and international immigration. Considering the objective of the whole project, the KHSS 2017 modified and added various questions about migration to the questionnaire in the LCMS 2015.

Table 2.1: Population Estimates and Percentage Distribution by Age Group and Sex

Age group	Population estimates for Kabwe (from the KHSS 2017)				Population estimates for Zambia (from the LCMS 2015)	
	Population distribution			Estimated population	Population distribution	Estimated population
	Male	Female	Both sexes			
Total	100.0	100.0	100.0	270,389	100.0	15,473,905
0-4	15.2	12.1	13.6	36,893	9.9	1,536,048
5-9	17.0	14.0	15.5	41,888	18.8	2,902,927
10-14	11.8	13.2	12.5	33,800	14.2	2,201,329
15-19	13.0	12.3	12.6	34,180	12.6	1,951,215
20-24	8.6	10.7	9.7	26,140	9.6	1,483,666
25-29	6.8	8.3	7.5	20,407	7.5	1,163,404
30-34	5.4	7.5	6.5	17,457	6.2	960,741
35-39	5.6	5.7	5.7	15,357	5.6	868,372
40-44	4.9	3.5	4.2	11,270	4.2	647,030
45-49	3.3	3.5	3.4	9,221	3.0	466,454
50-54	2.6	2.9	2.7	7,391	2.3	362,640
55-59	1.8	1.7	1.7	4,725	1.9	287,784
60-64	1.7	1.4	1.6	4,229	1.3	198,116
65+	2.4	3.1	2.7	7,433	2.9	444,177

Sample weights used.

A notable change from the LCMS 2015 is that migration here is not restricted to the events of residential changes within one year. The LCMS 2015 asked each household member whether he/she had changed his/her residence within one year prior to the survey. Meanwhile, the KHSS 2017 asked whether he/she had ever changed his/her residence.

Table 2.2 shows the percentage distribution of persons by area of the previous residence. Of the total population of Kabwe, 71.8% had ever moved in their life. However, the previous residence of 52.5% of the population was located within the Kabwe district. Immigrants from outside of the Kabwe district, including other districts in Central Province, other provinces, or foreign countries, accounted for 19.2% of the population.

Table 2.2: Proportions of Individuals by Type of Migration (Past Residence); %

	Has never moved	Different dwelling/ same township	Different township	Different district/ the same province	Different province	Different country	Don't know/ refusal	Total
Total Kabwe	28.2	33.4	19.1	3.2	15.7	0.3	0.1	100.0
Bwacha	30.3	20.9	17.9	3.5	27.0	0.0	0.3	100.0
Chililalila	28.1	21.5	26.4	4.1	13.2	6.6	0.0	100.0
Chinyanja	24.0	23.0	27.0	12.0	14.0	0.0	0.0	100.0
Chirwa	28.3	26.0	22.6	5.4	16.9	0.7	0.1	100.0
David Ramushu	35.4	28.3	16.1	5.2	15.1	0.0	0.0	100.0
Highridge	36.4	23.4	15.0	2.8	21.5	0.0	0.9	100.0
Kalonga	22.2	35.7	15.5	1.1	25.4	0.0	0.0	100.0
Kangomba	38.5	21.4	24.6	3.5	12.3	0.0	0.0	100.0
Kaputula	30.6	38.8	15.0	2.1	13.2	0.2	0.0	100.0
Makululu	25.5	26.0	24.5	2.5	21.5	0.0	0.0	100.0
Moomba	39.4	31.4	12.2	4.1	12.9	0.0	0.0	100.0
Mpima	27.0	25.2	14.4	0.9	32.4	0.0	0.0	100.0
Munyama	33.7	25.0	15.4	5.1	19.8	1.0	0.0	100.0
Muwowo East	19.6	38.0	25.3	3.1	14.0	0.0	0.0	100.0
Waya	26.2	50.8	6.9	1.5	13.8	0.8	0.0	100.0
Zambezi	19.7	48.5	25.8	1.5	4.6	0.0	0.0	100.0

Sample weights used.

The survey also asked about the number of years each individual had stayed continuously in the Kabwe district. Figure 2.1 shows the lengths of stay in the Kabwe district expressed in years. The chart shows that 23.8% had lived in Kabwe for less than 5 years and 20.4% for 5-9 years, including young children and those who had recently moved in to the Kabwe district. However, more than 55% of individuals had lived in Kabwe for more than a decade.

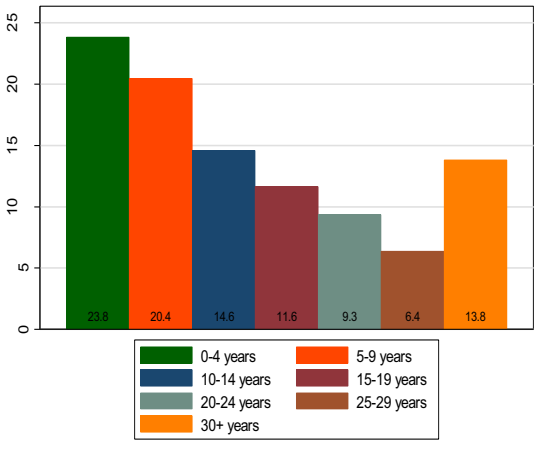

Figure 2.1: Distribution of the Length of Stay in Kabwe District

The reasons for migration are diverse. Table 2.3 shows the distribution of reasons for migrating. The most frequently reported reason is the transfer of the household head (36.7%). Schooling is a quite common reason for young children, accounting for 8.9% of the cases. Among those aged 15 years or above, 'decided to resettle' and 'acquired new/ different accommodation' are commonly observed. Marriage and 'new household' are also common among adults.

Considering the possibility that some people may migrate to avoid environmental pollution, the KHSS 2017 added this answer as an option. However, only 0.1% of the population chose this as the main reason for migration. Either people do not care about pollution or are not fully informed of pollution or its danger, or those who care about pollution do not live in polluted areas in the first place and do not need to migrate to avoid environmental pollution.

Table 2.3: Reasons of Migration (Proportions Among Those Who Have Ever Migrated)

	Total			Aged 0-14 years			Aged 15 years or older		
	Both sex	Male	Fem	Both sex	Male	Fem	Both sex	Male	Fem
For school	5.8	5.6	6.0	8.9	5.6	10.4	4.9	5.6	4.2
Back from school/studies	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1
To seek work/ business	2.0	3.0	1.1	0.0	0.0	0.0	2.9	4.5	1.6
To start work/ business	2.2	3.1	1.3	0.0	0.0	0.1	3.1	4.7	1.7
Transfer of head of household	36.7	35.0	38.2	57.3	63.7	50.1	27.8	20.1	33.7
Previous household could not afford to keep him/her	2.8	2.9	2.7	4.0	3.3	4.7	2.3	2.7	2.0
Death of parent/guardian	3.7	3.2	4.1	3.7	2.1	5.5	3.7	3.8	3.5
Got married	5.6	1.6	9.5	0.0	0.0	0.0	8.1	2.4	13.1
New household	8.8	9.6	8.0	8.4	8.9	7.9	8.9	9.9	8.0
Retirement	0.5	0.7	0.4	0.0	0.0	0.0	0.8	1.0	0.5
Retrenchment	0.2	0.2	0.1	0.0	0.0	0.0	0.2	0.3	0.2
Decided to resettle	12.9	15.6	10.4	5.6	6.2	5.0	16.1	20.2	12.5
Acquired own/different accommodation	11.6	13.3	9.9	2.8	3.2	2.4	15.3	18.3	12.7
Found new agricultural land	0.3	0.5	0.2	0.0	0.0	0.0	0.5	0.7	0.3
Environmental pollution	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.2	0.2
Other	6.6	5.5	7.6	10.2	6.8	13.9	5.0	4.8	5.2
Don't know	0.2	0.1	0.4	0.1	0.1	0.0	0.3	0.1	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Sample weights used

2.4. Death

The KHSS 2017 collected information on the deaths of household members during the period 12 months prior to the survey. Information collected included sex, age and the main cause of death of the deceased.

Unlike the other sections of Chapter 2, throughout this section, we do not intend to provide a generalised, representative picture of deaths in Kabwe mainly because the number of reported deaths is small—58 persons deceased within 12 months. Instead, we focus on describing the details of the reported deaths. This figure itself is not disproportionately low. We do not use the sampling weights, either.

The crude death rate per thousand persons is of 11.7%, slightly lower than the rate in urban Zambia in the LCMS 2015. Among 55 deceased persons whose ages at the time they deceased are reported, 22.2% were 0-4 years old, 9.3% were 5-14 years old, and 68.5% were 15 years old or above.

The most frequent causes of deaths were 'Other including natural deaths' and 'hypertension.' Deaths owing to malaria ('Fever/malaria' and 'Cerebral malaria') are reported, but their proportion is smaller than the national average in the LCMS 2015. Non-health-related deaths (suicide, murderer and accident) are also reported.

Table 2.4: The Crude Death Rate (CDR) Per Thousand Persons, and the Breakdowns of Deaths

	CDR, %	
Kabwe	11.7	
Total Zambia*	15.8	
Urban Zambia*	12.5	
Rural Zambia*	18.1	
Distribution of the ages at the time the persons deceased (*N*= 55), %		
0-4 years	5 – 14 years	15 years or older
22.2	9.3	68.5
Causes of deaths	**Cases (proportion)**	
Fever/malaria	4	(6.9%)
Cerebral malaria	2	(3.4%)
Cough/cold/chest infection	5	(8.6%)
Tuberculosis	1	(1.7%)
Pneumonia chest pain	3	(5.2%)
Diarrhoea without blood	2	(3.4%)
Vomiting	2	(3.4%)
Liver infection / side pain	1	(1.7%)
Lack of blood / aneamia	1	(1.7%)
Suicide	1	(1.7%)
Murdered	2	(3.4%)
Accident	1	(1.7%)
Hypertension	6	(10.3%)
Diabetes / sugar disease	1	(1.7%)
Headache	2	(3.4%)
Cancer	1	(1.7%)
Still birth	2	(3.4%)
Other (incl. Natural death)	15	(25.9%)
Don't know / Refusal	6	(10.3%)

Sample weights not used. * Data from the LCMS 2015.

Chapter 3
Education

3.1. Introduction

Education is an important determinant of people's living conditions because it may affect a household's welfare through employment and health. Information collected during the survey includes questions seeking to establish whether an individual was attending school at the time of the survey. If attending school, the individual was asked about the grades they were attending and absenteeism at school, based on how often one missed school in the last term. Information about education expenditure made in the last 12 months (2nd term, 1st term, and 3rd term in the previous school year) was also collected.

The survey also asked for the highest grade of education an individual had attained. Data collected on education is based on the current formal education system. For those educated under the different education standards and forms in the past (Zambia has made three major changes to its education system in 1956, 1966 and 1980), their information on the highest educational attainment is converted to the current equivalent.

The current education system of Zambia comprises pre-primary/nursery school, lower and upper primary school, junior and senior secondary school, and tertiary school. The official ages for these education levels, which are the ages of students who start schooling at the standard age and do not skip or repeat any grade, are as follows:

- Pre-primary/nursery level corresponds to persons aged 5-6 years
- Lower primary grades 1-4 correspond to persons aged 7-10 years
- Upper primary grades 5-7 correspond to persons aged 11-13 years
- Junior secondary grades 8-9 correspond to persons aged 14-15 years
- Senior secondary grades 10-12 correspond to persons aged 16-18 years
- Tertiary education level corresponds to persons aged 19-22 years

Note that the age information of the KHSS 2017 does not allow us to construct a complete set of children whose ages correspond to the official school ages. To see this, let us take children aged 10 years as an example. Based on their age, we treat them as children in the official lower primary school age group. However, children aged 10 years at the time of the survey include children who became 10 years old in the 2017 school year (and were thus in the lower primary school ages) and those who would have their birthday after the survey and become 11 years old by the end of the 2017 school year (and were indeed in the upper primary school ages). This occurs because the survey took place in August/ September, between the 2nd and 3rd terms, and

the ages were asked as of the time of the survey. Considering the timing of the survey, roughly two-thirds of the children aged 10 years would fall into the former case and one-third into the latter.

This is not a critical problem for analysing the determinants of education in further research because whether a person becomes 10 years old before or after the survey is basically exogenous to households. However, it would be problematic for calculating some frequently used measurements of school attendance, such as the gross and net attendance (enrolment) ratios, whose estimation requires a complete and accurate set of children in each official school age group. Therefore, we avoid presenting these measurements.

3.2. School Attendance and Education Expenditure

The school attendance ratio (SAR) is the percentage of children attending any school grade among all children in a given age group. Notably, the SAR is higher among children in upper primary education ages than among those in lower primary education ages, and the same tendency is also observed in the LCMS 2017 data. This suggests the possibility that some children start attending school at the age of 8 years old or above. Despite being urban, the SAR in Kabwe district is almost the same as the Zambian average although the SAR for male children in senior secondary and tertiary school ages are slightly higher than the Zambian average for male.

Table 3.1: School Attendance Rate (SAR) and Estimated Number of Students

Age group		Kabwe district			Total Zambia *		
		Total	Male	Female	Total	Male	Female
Pre-school	5-6 years	40.9	37.7	44.5	29.8	28.2	31.4
Lower primary	7-10 years	79.1	76.4	82.2	77.2	75.5	78.9
Upper primary	11-13 years	89.4	89.4	89.4	90.9	88.9	92.8
Junior Secondary	14-15 years	82.5	79.1	85.9	85.7	86.1	85.3
Senior Secondary	16-18 years	70.0	78.7	61.3	65.3	70.9	60.9
All primary	7-13 years	83.1	81.0	85.2	83.1	81.3	84.8
All secondary	14-18 years	74.4	78.8	70.1	75.7	78.4	73.4
Higher education	19-22 years	30.8	40.1	22.2	29.4	36.3	22.5
Estimated number of students		92,699	47,081	45,619	4,697,435	2,327,154	2,370,281

Sample weights used. * From LCMS 2015.

Table 3.2: Education Expenditure (Kwacha)

	Total in the last three terms	2nd term, 2017 school year	1st term, 2017 school year	3rd term, 2016 school year
Total expenditure	1365.6	417.2	601.6	346.8
School fees	1193.8	362.0	508.9	322.9
Private tuitions	36.7	19.6	10.4	6.7
Textbooks	44.0	16.4	19.0	8.6
School uniforms	91.1	19.2	63.3	8.6

Sample weights used.

Table 3.2 shows education expenditure for each school-attending child. The KHSS asked about expenditure on school fees, private tuitions, textbooks and school uniforms for each school-attending child—these items of expenditure were asked separately from the general household expenditure. Total education expenditure is K1,365.6 per year (K113.8 per month), and school fees constitute 87.4% of this expenditure. The remaining columns show the breakdown of education expenditure by school terms. Expenditure is the largest in the first term of a school year, possibly because that is when the household prepares school uniforms or when some parents pay the yearly education expenditure.

Table 3.3: The Frequency of Missing Classes; %

	Never	A little (once or twice a month)	Often (3 to 10 times a month)	Very often (more than 10 times a month)
Total Kabwe	53.2	34.5	9.8	2.5
Male	52.1	33.7	11.1	3.0
Female	54.3	35.3	8.5	1.9
Primary	49.8	35.6	11.4	2.9
Primary and junior secondary	49.9	36.4	10.7	3.0
Secondary	54.1	35.5	8.4	1.9

Sample weights used.

3.3. Absenteeism

The quality of education is partly affected by the rate at which pupils attend school. The KHSS 2017 asked how often children enrolled in school had, on average, missed attending classes in the last term preceding the survey (i.e. the second term of the 2017 school year). Table 3.3 presents the absence rate of students by sex and age group. In any grade, approximately half of the students attend all classes, and 85-90% of students missed once or twice a month at most. Male children miss school more frequently than female children did. The incidents of missing classes are less frequent among secondary school students than among students in other grades, perhaps because children having difficulty attending classes fail to advance to secondary school in the first place.

3.4. Education Levels of population

In this section, we describe education levels individuals have attained. Following the LCMS 2015 report, which presents the percentage distribution of the population five years or older who were not attending school at the time of the survey, we present the same distribution for the Kabwe population in Panel A of Table 3.5. In Kabwe, the proportion of individuals having completed primary education or lower is smaller but the proportion above primary education is larger than the Zambia's average. Male education is higher than female education. Note that the proportion of those without any education, 14.6% for the Kabwe total, includes children at pre-school ages. Note also that exclusion of children currently attending school would also underestimate the education levels of the Kabwe residents.

Then, Panel B presents the distribution including children attending school. For children attending school, the grades they were attending at the time of the survey is treated as their highest level of education. In addition, since inclusion of very young children would complicate the interpretation, all calculations in Panel B focus on those aged 10 years or above. With this change, the proportion of individuals without education decreased. For those aged 16-29 years, the largest proportion has attained senior secondary education. For those aged 40-59 years, the proportion peaks at upper primary education. For those aged 10-15 years, 82.2% of them have completed upper primary education or lower—the majority of those having not completed were attending primary school at the time of the survey, rather than having left school without completing primary education.

Table 3.4: Education Levels of Population

	No education	Primary education		Secondary education		Grade 12 A-level/ Certificate/ Diploma/ Under-graduate	Post-graduate and above
		Grades 1-4	Grades 5-7	Grades 8-9	Grades 10-12 (O-level)		
Panel A: 5 years or above who were not in education							
Total Kabwe	14.6	7.3	20.7	19.5	24.9	12.2	0.8
Male	15.5	6.3	15.9	17.2	28.9	15.3	0.9
Female	13.8	8.3	24.9	21.6	21.4	9.4	0.6
Total Zambia*	27.0	10.8	24.0	16.3	15.7	4.7	1.4
Male*	25.2	9.0	21.8	16.6	19.5	5.9	2.0
Female*	28.7	12.5	26.1	16.1	12.1	3.7	0.8
Panel B: 10 years or above, including children in education							
Total Kabwe	4.6	9.9	25.1	21.5	26.2	12.1	0.6
Male	3.5	9.4	21.9	20.3	30.1	14.1	0.7
Female	5.6	10.3	28.0	22.5	22.8	10.3	0.5
10-15	5.4	29.2	47.6	14.9	2.9	n/a	n/a
16-18	2.3	1.7	14.1	38.0	42.5	1.4	n/a
19-22	2.8	1.7	15.2	17.5	52.5	10.3	n/a
23-29	1.0	3.4	14.1	20.9	40.0	20.4	0.2
30-39	4.2	5.5	21.6	22.6	22.0	23.0	1.1
40-49	5.3	4.4	28.1	26.5	18.2	16.8	0.7
50-59	5.6	6.1	31.1	17.8	21.7	15.8	1.9
60+	18.3	18.1	16.5	12.9	18.8	12.7	2.7

Sample weights used. * Data from LCMS 2015.

Chapter 4
Health

4.1. Introduction

The KHSS 2017 collected data on the health status of all persons. Health is directly related to welfare for its own sake. It may also have implications for economic activities, such as labour activity, consumption and productivity, which would ultimately affect welfare. In addition, the health status could be a useful measurement for assessing the causes and consequences of lead exposure.

In Chapter 4.2 to 4.4, we focus on the health status of all individuals and summarise self-reported illness and injury and medical expenditure. The reference period is the last two weeks preceding the survey. Chapter 4.5 focuses on child health and presents thebreastfeeding status and history and other feeding status for children younger than 5 years old.

4.2. Prevalence of Illness or Injury

Table 4.1 shows the proportion of persons who were ill or injured in the two weeks preceding the survey by sex and ward. At the district level, 19.1% of the population in Kabwe reported being ill or injured in the two weeks preceding the survey. This is higher than the national average of 14.2% and the urban average of 9.1% in the LCMS 2015. While this result could be a consequence of lead poisoning, it could also be a consequence of the socioeconomic characteristics of Kabwe residents. In line with the tendency in the national data, women are more likely to be ill or injured (20.3%) than men (17.8%).

Table 4.1: The Proportion of the Ill or Injured Persons, %

The KHSS 2017	**Total Kabwe**		**Male**		**Female**	
	19.1		17.8		20.3	
The LCMS 2015	**Total Zambia**	**Male**	**Female**	**Urban**	**Rural**	
	14.2	13.4	15.0	9.1	17.9	
Proportion reporting illness or injury for each ward						
Bwacha	19.9	Highridge	21.5	Moomba	16.9	
Chililalila	26.4	Kalonga	24.1	Mpima	11.7	
Chinyanja	7.0	Kangomba	29.2	Munyama	17.7	
Chirwa	21.2	Kaputula	11.5	Muwowo East	7.0	
David Ramushu	21.9	Makululu	22.0	Waya	15.4	
				Zambezi	31.6	

Sample weights used.

Table 4.2: Breakdown of Sickness, %

	Total	Male	Female	Age group (years)			
				0-9	10-19	20-49	50+
Fever / malaria	17.6	16.7	18.5	19.0	18.2	17.2	16.2
Cough / cold / chest infection	50.9	55.3	47.3	65.0	52.9	46.2	38.0
Tuberculosis	0.1	0.1	0.1	n/a	n/a	0.3	n/a
Asthma	1.2	1.2	1.3	0.8	n/a	1.9	1.6
Bronchitis	0.8	1.0	0.6	2.3	0.4	0.2	0.3
Pneumonia / chest pain	1.7	1.9	1.5	0.2	1.4	1.9	4.0
Diarrhoea without blood	4.4	5.1	3.7	7.0	6.3	3.4	0.5
Diarrhoea with blood	0.7	1.1	0.3	2.0	n/a	0.3	n/a
Diarrhoea and vomiting	1.8	2.6	1.2	4.6	n/a	1.5	n/a
Vomiting	0.6	0.5	0.8	0.9	1.3	0.4	n/a
Abdominal pains	7.4	5.7	8.8	3.3	6.7	8.4	11.9
Constipations	1.2	1.0	1.3	1.3	2.0	1.2	0.3
Anaemia	0.3	n/a	0.5	n/a	0.3	0.2	0.8
Boils	0.4	0.8	n/a	1.3	n/a	n/a	n/a
Skin rash / skin infection	2.2	1.4	3.0	4.8	2.6	0.4	2.1
Shingles / herpes zoster	0.1	n/a	0.1	n/a	n/a	0.2	n/a
Paralysis	0.7	0.5	0.9	0.2	0.8	0.8	1.5
Stroke	0.1	0.1	1.4	n/a	n/a	n/a	0.8
Hypertension	4.6	3.3	5.7	n/a	n/a	4.2	17.3
Diabetes / sugar disease	0.7	0.7	0.7	n/a	n/a	n/a	4.0
Eye infection	3.0	3.1	2.9	2.7	1.9	4.1	2.0
Ear infection	0.1	n/a	0.1	0.2	n/a	n/a	n/a
Toothache / mouth infection	2.9	1.2	4.4	1.3	2.1	4.8	2.0
Headache	17.7	17.6	17.7	6.0	25.1	22.0	18.6
Measles	0.1	n/a	0.1	n/a	n/a	n/a	0.5
Backache	3.1	1.3	4.7	n/a	0.9	3.5	9.3
Cancer	0.4	n/a	0.8	0.3	n/a	n/a	1.9
Other	8.4	7.2	9.4	6.2	2.6	10.2	13.2
Total	133.2	129.4	137.8	129.4	125.5	133.3	146.8

Total percentage exceeds 100 since some persons report multiple sicknesses. Sample weights used.

At the ward level, Zambezi ward had the highest proportion of population ill or injured at 31.6%, followed by Kangomba (29.2%), Chililalila (26.4%) and Kalonga (24.1%). Wards with the lowest proportion of the population ill or injured were Muwowo East and Chinyanja (7.0%), followed by Kaputula (11.5%) and Mpima (11.7%).

4.3. Main illness

Table 4.2 shows the distribution of self-reported illnesses by cause over the last two weeks prior to the survey. Overall, regardless of sex and age, the most common cause was cough/cold/chest infection, followed by headache and fever/ malaria. Some illnesses are more common among young children than among adults, such as cough/ cold/chest infection, and diarrhoea of any kind.

4.4. Consultation for illness/ Injury and Medical Costs

All persons who reported illnesses or injuries were asked to give the amount paid for medical consultation or medication. Table 4.3 gives the proportions of those consulting medical doctors, clinical officers, nurses or midwives and community health workers, and the average amount spent on consultations and/or medication by persons consulted. The average amount spent on consultation and/or medication was K161.2 for persons who consulted medical doctors, K9.3 for persons who consulted clinical officers, and K6.5 for persons who consulted nurses/midwives. If we restrict our focus to patients making any payment, the average expenses become K319.8, K49.4, and K38.5 for those consulting medical doctors, clinical officers, and nurses/midwives, respectively. One person consulted a community health worker but did not pay at all.

The bottom rows of Table 4.3 show the payment methods. The majority did not pay at all. Excluding them, the majority covered the medical expenses by themselves. The use of pre-payment schemes and payments by employers or insurance were also reported, especially for patients who consulted medical doctors.

Table 4.3: Medical Expenditure and Methods of Payment

	Medical doctors	Clinical officers	Nurses / midwives	Community health workers
Proportion of those consulting, %	23.4	53.7	22.6	0.2
Average expenses (Kwacha)	161.2	9.3	6.5	0
Among those who paid	319.8	49.4	38.5	n/a
Method for payment, %				
Pre-payment scheme (low cost)	3.2	0.8	n/a	n/a
Pre-payment scheme (high cost)	5.9	1.8	n/a	n/a
Paid by employer	8.6	0.4	0.7	n/a
paid by insurance	2.3	n/a	n/a	n/a
Paid directly	39.9	14.8	8.8	n/a
Paid by others	n/a	1.8	1.5	n/a
Did not pay	38.2	83.2	86.1	100
No information	6.3	3.7	2.9	n/a

Sample weights used.

4.5. Child Health (Age under 5 years)

In addition to the health measurements described so far, the KHSS 2017 measured breastfeeding and other dietary statuses and histories for children younger than 5 years old. Breastfeeding is closely related to infants' nutritional statuses and plays a significant role in child development. However, it can also be related to lead exposure if mothers are exposed to high levels of lead.

Table 4.4 shows the proportion of children under 5 years old who were being breastfed by sex and age group. Overall, the proportion of infants aged 0-11 months who were breastfed is similar to the national average in the LCMS 2015. Among young children aged 13-24 months, the proportion is higher in Kabwe than the national average. The proportion is higher for male than for female among those aged 0 years (0-11 months old), but higher for female than for male among those aged 1 years (12-23 months old). Note that the sample size becomes small if we split the sample by age and sex. Therefore, these figures do not necessarily point out a gender difference in breastfeeding statuses.

Table 4.4: Proportion of Infants Who Were Breastfed at the Time of the Survey

Age	Total	Male	Female	Total Zambia*
0 year	94.4	97	90.8	95.6
1 year	71.5	67.1	76	50.5
2 years	3.2	4.4	1.3	6.9
3 years	3.8	3.6	4.1	2.8**
4 years	5.2	6.2	3.8	

Sample weights used. * Data from the LCMS 2015. ** The proportion among children aged 3 or 4 years.

Table 4.5: History on Breastfeeding and Other Foods

	Never breastfed, %	Lengths of breastfeeding, months	Age in months when given any food other than breastmilk
Total	1.3	15.8	5.5
Male	0.9	15.4	5.5
Female	1.7	16.4	5.5

Sample weights used.

In Table 4.5, we focus on children who were not being breastfed at the time of the survey. Among them, 1.3% had never breastfed. Children are breastfed for 15.8 months on average and this is consistent with the figures in Table 4.4 where almost all children stop being breastfed by the time they reach 2 years of age. Children start consuming any food other than breastmilk at the age of 5.5 months on average. No significant gender difference is found.

Finally, Table 4.6 shows how frequently children were given solid food. For all sexes and age groups, 45.2% of the children were given solid food thrice a day. Females were given solid foods less frequently than males, with the proportion of children given solid food twice a day being higher for females and the proportion of children given solid food thrice a day being higher for males. Regarding the age groups, the dietary characteristics of children aged 1, 2 and 3 years old are similar.

Table 4.6: The Distribution of the Numbers of Times Given Solid Food Per Day

	Once	Twice	Thrice	Four times	Five times	More than five times	Not yet started on solids
Kabwe total	3.8	22.3	45.2	15.2	4.6	2.1	6.8
Male	3.4	19.3	48.4	15.3	4.2	2.1	7.1
Female	4.2	25.9	41.2	15.2	5.0	2.0	6.4
Aged 0 year	4.4	31.1	20.0	6.2	1.9	3.5	33.1
Aged 1 year	4.7	23.8	46.6	18.1	3.4	2.5	0.8
Aged 2 years	3.7	22.7	48.3	18.0	5.7	0.7	0.8
Aged 3 years	4.5	23.6	48.0	15.1	5.6	2.7	0.5
Aged 4 years	1.6	10.8	60.9	18.3	6.4	0.7	1.2
Zambia*	3.4	23.9	44.0	12.4	3.0	2.5	10.7

Sample weights used. * Data from the LCMS 2015.

Chapter 5
Economic Activity

5.1. Introduction

The KHSS 2017 collected detailed information regarding the economic activities of household members. The economic participation of the population in various economic activities can directly influence households' well-being. The topics covered by the survey are as follows:

- Economic activity status including labour force participation, type of job and sector of employment for the main economic activity, second job, and other income-generating activities.
- Wage income, which includes regular monthly wages or salary, allowances, other income in-cash/in-kind.
- Labour time, which includes actual working hours in the last seven days, usual working hours, missed working days due to illness in the last 12 months.

With regards to economic activity status and wage, the KHSS 2017 adopted a similar format to that used by the LCMS 2015. The topic of labour time was new.

5.2. Economic Activity Status

Table 5.1 shows the percentage distribution of the main economic activity status for the population aged 12 years or older in Kabwe district. The percentage distributions aggregated at ward levels are also presented. The sample weights are applied in calculations. The categorical classification follows the definition adopted by the LCMS 2015. "Economically active population (labour force)" consists of "paid employment (including self-employed)", "un-paid family worker," and "not working". The category of "not working" is constructed from two types of status: "looking for work/means to do business but available for work/business" and "not looking for work but available for work/means to do business." The percentages for all Zambia and urban Zambia based on the results of the LCMS 2015 are also listed for reference.

The share/proportion of economically active population and that of paid employment in Kabwe are estimated at 57.7% and 39.6%, respectively. These shares are similar to those of the urban averages in all Zambia (58.6% and 40.0%, respectively). However, the breakdown of the economically inactive population in Kabwe district shows some different features. The proportion of full-time students, accounting for 21.4%, is lower than that of Zambia or urban Zambia. Additionally, the proportion of the population that is retired, too old or too young to work in the Kabwe district is 10.6%, which is more than two times the averages for all Zambia and urban Zambia.

The regional variation of economic activity

within Kabwe district is recognizable in Table 5.1. The ratios of "not working" are relatively low, less than 10%, in wards located in the peripheral regions of the district such as Chililalila, Chinyanja, Mpima, and Munyama where a large proportion of households engage in agricultural activities. Nevertheless, the worst ratio of "not working" is observed in Makululu ward and reaches 25.5%.

Table 5.1: Percentage Distribution of the Population Aged 12 Years or Older by Main Economic Activity, and Ward

	Economically active population (Labour Force)				Economically inactive population					Total
	Paid Employment	Unpaid Family Worker	Not Working	Total (active)	Full Time Student	Home-Maker	Retired/ Too Old/ Too Young	Other	Total (inactive)	
Kabwe district	39.6	0.6	17.5	57.7	21.4	9.1	10.6	1.1	42.2	100
*Zambia**	*43.0*	*6.3*	*9.2*	*58.5*	*27*	*10.3*	*3.8*	*0.4*	*41.5*	*100*
*Urban**	*40.0*	*1.2*	*14.2*	*55.4*	*27.8*	*12.3*	*4.3*	*0.2*	*44.6*	*100*
WARD										
Bwacha	37.1	0.6	20.4	58.1	19.9	6.1	14.0	1.9	41.9	100
Chililalila	40.3	0.0	4.2	44.5	20.8	19.4	15.3	0.0	55.6	100
Chinyanja	50.0	1.6	4.8	56.5	21.0	14.5	8.1	0.0	43.6	100
Chirwa	39.8	0.3	20.7	60.7	23.4	8.4	7.1	0.4	39.3	100
David Ramushu	36.2	0.0	21.2	57.4	28.1	7.6	5.7	1.2	42.6	100
Highridge	34.2	0.0	21.5	55.7	26.6	7.6	8.9	1.3	44.3	100
Kalonga	39.4	0.0	16.6	56.0	25.8	5.3	10.1	2.8	44.0	100
Kangomba	48.0	2.9	11.4	62.3	20.8	5.3	9.1	2.5	37.7	100
Kaputula	33.0	0.0	19.2	52.2	15.9	12.9	18.1	0.9	47.8	100
Makululu	38.8	0.0	25.5	64.2	20.4	8.8	6.6	0.0	35.8	100
Moomba	39.1	1.0	15.8	56.0	22.8	9.7	11.3	0.2	44.0	100
Mpima	60.6	0.0	6.1	66.7	7.6	12.1	12.1	1.5	33.3	100
Munyama	40.2	3.8	8.7	52.7	24.6	15.2	7.0	0.5	47.3	100
Muwowo East	40.2	0.0	16.8	56.9	22.8	10.9	8.4	1.0	43.1	100
Waya	33.3	1.1	17.8	52.2	16.7	6.7	21.1	3.3	47.8	100
Zambezi	46.2	1.3	17.0	64.5	15.7	9.0	10.3	0.4	35.5	100

Sample weights used. * Data from the LCMS 2015.

Figures 5.1 and 5.2 show distributions of labour force participation rates by age group among persons aged 12 years or older. Here, the labour force participation rate is the ratio of the "economically active population" as defined above to the total population for each age group. Figure 5.1 compares labour force participation across age groups in Kabwe district to those of Zambia total and urban Zambia. The distribution for Kabwe shows a similar tendency to that of urban Zambia, and the participation rate starts declining rapidly after age 50. Figure 5.2 shows the gender difference of the distributions within Kabwe.

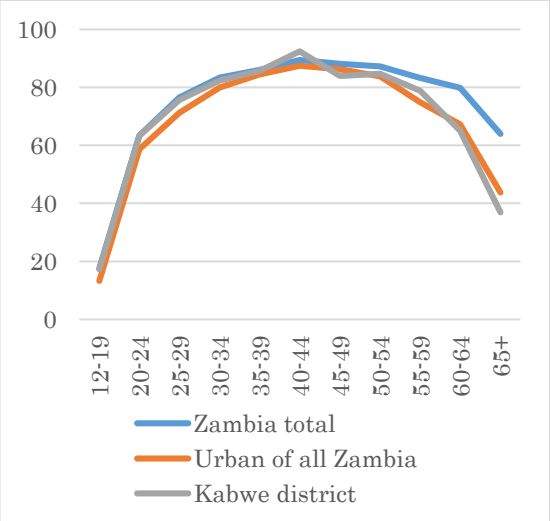

Figure 5.1: Labour Force Participation Rates among Persons Aged 12 Years or Older by Age Group

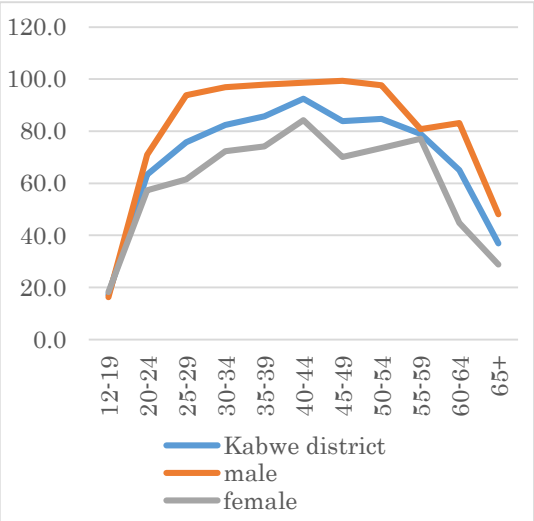

Figure 5.2: Labour Force Participation Rates among Persons Aged 12 Years or Older by Age Group and Gender.

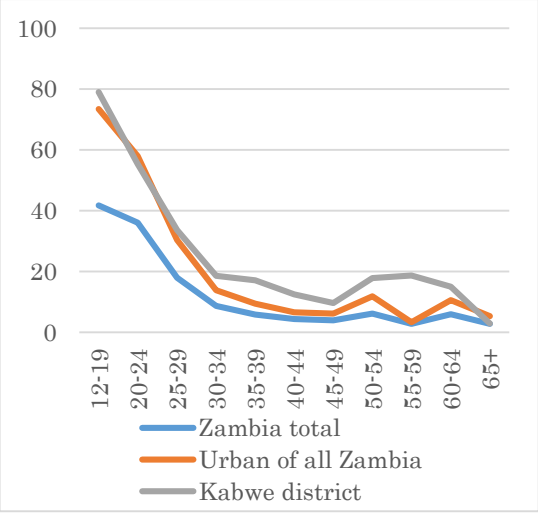

Figure 5.3: Unemployment Rates among Persons Aged 12 Years or older by Age Group

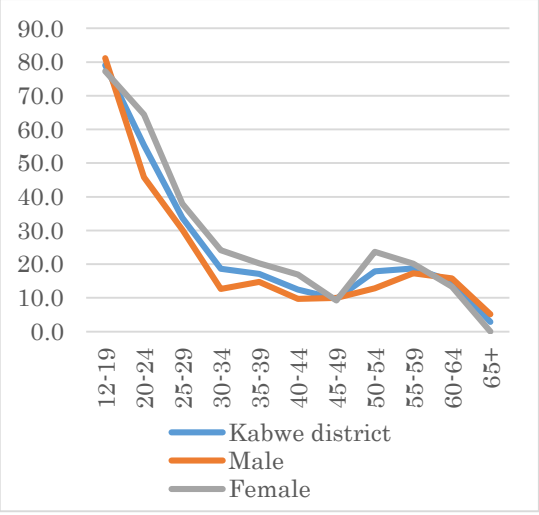

Figure 5.4: Unemployment Rates among Persons Aged 12 Years or older by Age Group and Sex

Figures 5.3 and 5.4 present distributions of unemployment rates by age group among persons aged 12 years or older. Here, the unemployment rate is estimated as the ratio of "not working" to the "economically active population". The pattern of the distribution in Kabwe district resembles that of the urban average of Zambia more closely than that of all Zambia, but the unemployment ratio in Kabwe becomes slightly higher after age 30 than the Zambian urban average. In particular, a high ratio of unemployment is observed in the 55–59 age group in Kabwe, at 17.3%. This appears to be a peculiar feature of employment status. Figure 5.4 confirms that the high ratios of unemployment in the 50–54 and 55–59 age groups in Kabwe are more distinct in the female population, accounting for 23.7% and 20.1%, respectively.

Table 5.2: Percentage Distribution of Employed Persons Aged 12 Years or Older by Industry

			Kabwe district		
	Zambia total*	***Urban of all Zambia****	**Both sexes**	**male**	**female**
Agriculture, forestry and fisheries	*58.7*	*11.2*	19.8	21.4	17.7
Mining and quarrying	*1.7*	*4.0*	1.7	2.8	0.2
Manufacturing	*4.2*	*8.2*	1.9	2.8	0.8
Electricity, gas, steam and air condition	*0.4*	*1.1*	1.2	2.2	0.0
Water supply sewerage, waste management	*0.1*	*0.2*	0.3	0.2	0.3
Construction	*3.7*	*8.1*	10.2	17.5	0.7
Trade, wholesale and retail distribution	*14.9*	*31.1*	20.2	12.3	30.5
Transportation and storage	*2.5*	*5.8*	5.6	9.6	0.3
Accommodation and food service activities	*1.0*	*2.3*	4.5	1.4	8.6
Information and communication	*0.4*	*1.1*	0.3	0.3	0.3
Financial and insurance activities	*0.8*	*2.0*	1.1	1.3	0.9
Real estate activities	*0.1*	*0.3*	0.2	0.3	0.0
Professional, scientific and technical	*0.3*	*0.8*	0.9	1.0	0.7
Administrative and support services	*1.1*	*2.4*	0.6	0.3	1.1
Public administration and defense, comp	*1.7*	*4.2*	2.6	2.9	2.2
Education	*3.3*	*6.4*	6.5	5.1	8.4
Human health and social work	*1.4*	*2.9*	2.4	2.3	2.5
Arts, entertainment and recreation	*0.1*	*0.3*	1.3	1.2	1.3
Other service activities	*1.5*	*3.5*	7.7	7.3	8.3
Activities of household as employers	*1.8*	*4.0*	1.3	0.0	3.0
Activities of extraterritorial organization	*0.0*	*0.0*	0.7	0.8	0.6
Other / not stated	*0.0*	*0.0*	9.0	7.0	11.6
Total	100.0	100.0	100.0	100.0	100.0

Sample weights used. * Data from the LCMS 2015.

Table 5.3 shows the proportion of employed persons by occupation type. In Kabwe, occupation types such as service and sales workers (24.5%), skilled agricultural (16.4%) or craft and related trades workers (11.7%) are the most common. When compared with those of averages in all Zambia and urban Zambia, the proportions of these occupation types in Kabwe fall in the middle. It is also found that more females in Kabwe are employed as service and sales workers (33.1%), and more males are employed as craft and related trades workers (18.2%) in Kabwe.

Table5.3: Percentage Distribution of Employed Persons Aged 12 Years or Older by Occupation and Sex

			Kabwe District		
	Zambia total*	***Urban of all Zambia****	**Both sexes**	**Male**	**Female**
Managers	*1.8*	*3.6*	2.1	1.8	2.4
Professionals	*5.2*	*9.9*	10.8	9.4	12.6
Technicians and associate professionals	*1.7*	*4.1*	2.1	3.1	0.7
Clerical support workers	*0.9*	*2.3*	2.3	1.8	2.8
Service and sales workers	*16.9*	*36.9*	24.5	18.0	33.1
Skilled agricultural, forestry and fishery	*51.8*	*9.6*	16.4	17.8	14.7
Craft and related trades workers	*6.4*	*13.0*	11.7	18.2	3.2
Plant and machine operators, and assembly	*3.4*	*7.5*	1.2	2.1	0.0
Collecting minerals from black mountain	-	-	0.3	0.5	0.0
Other elementary occupations	*11.6*	*12.6*	10.9	11.5	10.1
Armed forces	*0.2*	*0.5*	2.7	3.5	1.7
Other / Not stated	*0.0*	*0.0*	15.1	12.3	18.8
Total	100.0	100.0	100.0	100.0	100.0

Sample weights used. * Data from the LCMS 2015.

5.4. Labour Time

Table 5.4 summarises the results of labour time data. Among those in Kabwe who have jobs (paid or unpaid), the proportion of those who actually worked in the last seven days was 77.1%, and their average working time was 44.4 hours. However, 14.3% of those who worked claimed that they worked shorter hours than usual. Regarding the last 12 months, 18.2% of those who had jobs reported missing more than five days owing to illness or injury. Table 5.4 also illustrates the regional differences of those data.

Table 5.4: Labour Time (Aged 12 Years or Older)

For those who have jobs (paid or unpaid) aged 12 years or older				
	Last 7 days			Last 12 months
	% who actually worked	Average working hours	% who worked shorter than usual	% who missed more than 5 days due to illness and injuries
Kabwe district	77.1	44.4	14.3	18.2
Bwacha	78.9	44.4	24.6	16.9
Chililalila	79.3	47.1	17.4	6.9
Chinyanja	56.3	40.1	44.4	12.5
Chirwa	82.8	44.9	11.4	13.2
David Ramushu	85.2	44.8	5.2	15.9
Highridge	74.1	39.4	10.0	7.4
Kalonga	66.8	42.7	9.2	34.0
Kangomba	54.3	42.7	17.4	28.9
Kaputula	68.9	41.6	17.1	22.5
Makululu	83.0	53.7	9.1	18.9
Moomba	83.9	45.7	6.3	21.1
Mpima	72.5	30.1	51.7	12.5
Munyama	81.5	45.2	19.9	16.2
Muwowo East	86.7	44.2	24.7	19.1
Waya	61.3	46.5	5.3	25.8
Zambezi	81.4	46.7	7.2	3.7

Sample weights used.

Chapter 6
Household Crop and Livestock Production

6.1. Introduction

The KHSS 2017 collected information on agricultural activities relating to the 2016/2017 farming season. The collected data include the following:

- Household participation in agricultural activities
- Production of crops such as maize, sweet potatoes, potatoes, and soya beans among agricultural households
- Livestock and poultry ownership
- Use and cost of various crop and livestock inputs
- Size of farms and home gardens

6.2. Agricultural Households

The percentage of households engaged in agricultural activities in Kabwe (41.7%) was lower than the national average (58.7%), as reported in the LCMS 2015 (Table 6.1). However, the percentage was higher than the average of the urban areas in the whole country (17.9%).

Rates of participation showed a heterogeneous picture by ward (Figure 6.1). Wards with the highest participation in agriculture were Chinyanja (95%), Munyama (88%), Mpima (81%), Kangomba (75.5%), and Chililalila (68%). The remaining wards had lower than average (41.7%) participation rates with Moomba (11.7%), Makululu (20.4%), and David Ramushu (20.6%) showing the lowest participation rates.

6.3. Crop Production

About half of all agricultural households were engaged in hybrid maize production, which is the same as the national average recorded by the LCMS 2015 (Figure 6.2). However, the share of agricultural households growing local maize in Kabwe was higher (44.1%) than the national average (35.9%) but close to the average for the urban areas in Zambia (46.4%). A higher share of households in Kabwe grew sweet potatoes and soya beans than in the whole country (22.8% vs. 8.2 % and

Table 6.1: Proportion of Households Engaged in Agricultural Activities

	All households	Agricultural households	
		Number	Per cent
Whole Kabwe district	49,056	20,456	41.7
*Zambia total**	30,15,000	1,769,805	58.7
*Urban area of all Zambia**	12,97,000	232,163	17.9

Sample weights used. * Data from the LCMS 2015.

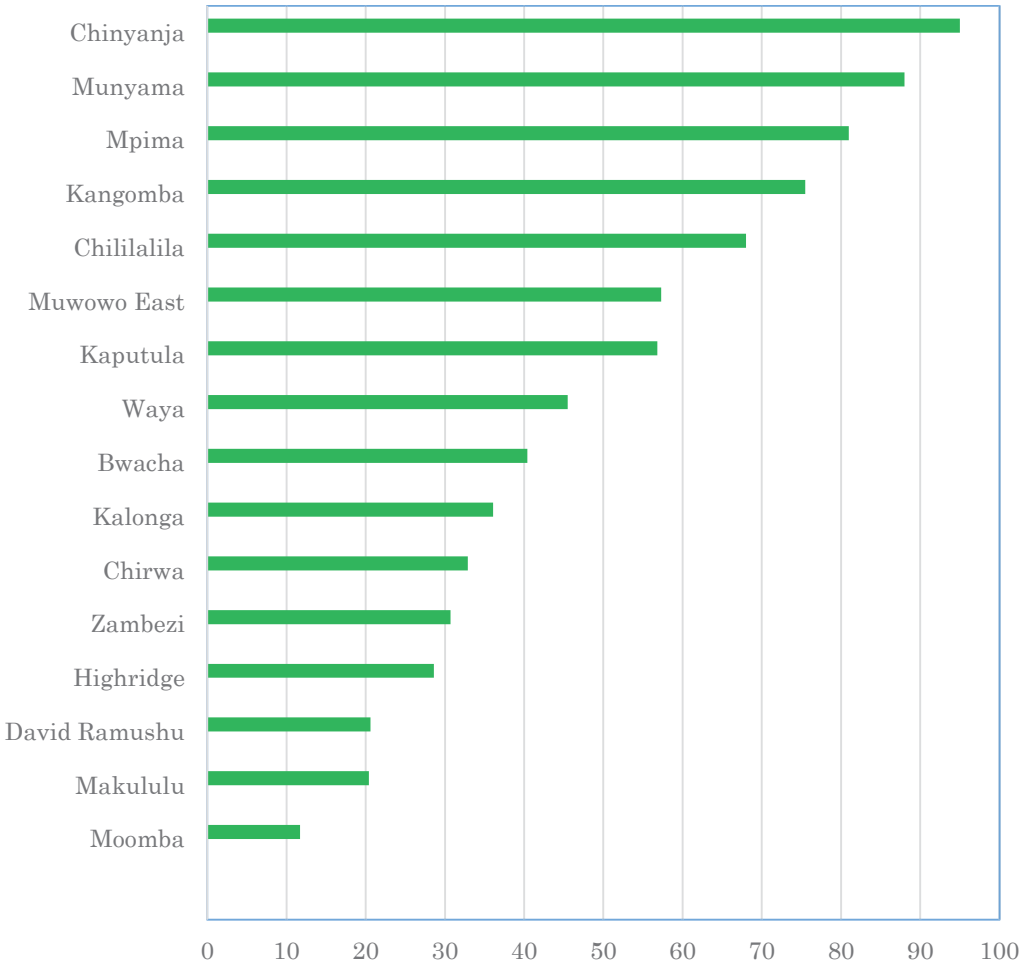

Figure 6.1: Percentage of Households Engaged in Agricultural Activities by Ward

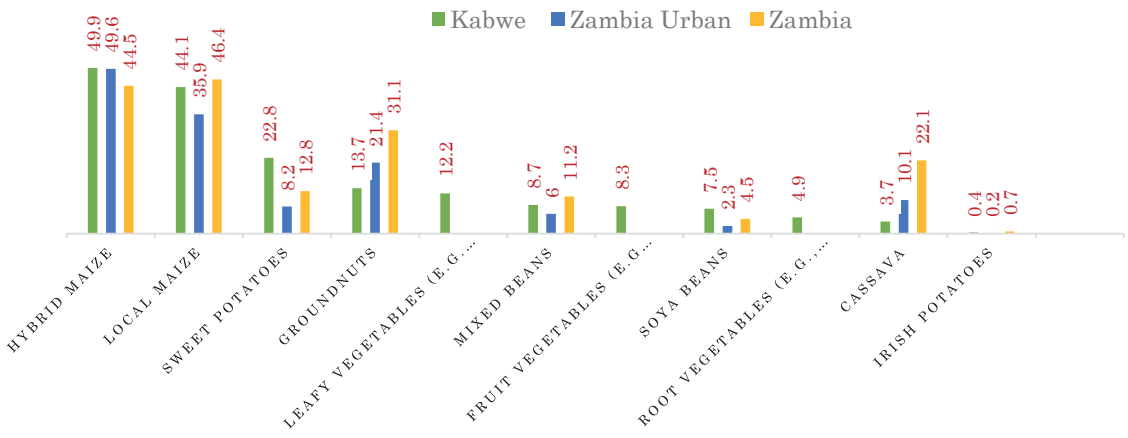

Figure 6.2: Proportion of Agricultural Households Producing Each Crop in Kabwe, Urban Areas of Zambia, and the whole Zambia

7.5% vs. 2.3%, respectively). Nonetheless, the proportion of households growing groundnuts and cassava was lower in Kabwe than the national or urban averages.

On average, each household produced 57 bags of hybrid maize (Table 6.2). The average production of soya beans was 31 bags (90 kg per bag) per household. A typical agricultural household in Kabwe produced about 11 bags (25 kg per bag) of sweet potatoes. The quantity produced for fruit vegetables (e.g., tomatoes) was 106 bags (25 kg per bag) per household.

6.4. Livestock and Poultry Production

At the time of the survey, most households in Kabwe district owned chickens (86.7%) and each household owned an average of 66 birds. Goats were the second most owned type of livestock (25.1%), followed by cattle (23%). Each household kept an average of 13 goats and 26 cows.

Table 6.2: Agricultural Households Producing Each Crop and Quantity Produced

Crop	Proportion of agricultural households growing the crop, %	Average household production	
		Units	Quantity
Maize (all types)	88.4	50kg Bag	57.0
Hybrid Maize	50.0	50kg Bag	77.0
Local Maize	44.1	50kg Bag	25.0
groundnuts	13.7	90kg Bag	4.4
Mixed Beans	8.7	90kg Bag	0.4
Soya Beans	7.5	90kg Bag	31.0
leaf vegetables (e.g. cabbage)	12.2	50kg Bag	17.5
Root vegetables (e.g carrots)	4.9	10kg Bag	2.8
fruit vegetables (e.g. tomatoes)	8.3	25 kg Bag	106.0
cassava	3.7	90kg Bag	0.2
Irish potatoes	0.4	10kg Bag	10.0
Sweet Potatoes	22.7	25 kg Bag	11.0
Sunflower	1.4	90kg Bag	2.4

Sample weights used.

Table 6.3: Livestock and Poultry Owned by Agricultural Households

Livestock or poultry	Percentage of households owning livestock and poultry	Average numbers owned per household
Cattle	23.0	26
Chicken	86.7	66
Ducks and Geese	14.4	6
Goats	25.1	13
Guinea fowls	6.0	17
Pigs	9.1	18
Quails	1.7	19
Rabbits	1.8	9
Sheep	1.2	7
Turkeys	3.1	7
Pigeons	1.0	12

Sample weights used.

6.5. Crop and Livestock Inputs

Among the crop inputs used by more than 40% of households, the costliest were inorganic fertilizer (K1,834), hired labour (K1,437), and seeds/seedlings (K810) (Table 6.4). In general, regardless of how many farmers used the input, the costliest crop inputs were fuel (K5,888), irrigation equipment (K4,518), repair and maintenance of agricultural equipment (K1,458), insecticides (K1,369), and transport (K723). Hand tools were the cheapest crop input.

Table 6.4: Percentage Using Different Crop and Livestock Inputs and Average Cost

	Percentage of agri-cultural households using input by type	Average cost of input (ZMW)
Crop Inputs		
Transport	23.3	722.6
Sack or bags/containers	50.1	245
Fertilizer (Inorganic)	60.8	1,834
Fertilizer (organic)	24.0	1,857
Herbicides	9.8	1,773.6
Hired animals	13.0	402
Hired equipment	6.9	602
Hired labour	48.9	1,437
Imported hand tools	1.6	109.3
Storage facility	14.0	196.2
Local hand tools	41.6	104.4
Insecticides	28.0	1,369
Irrigation Equipment	2.5	4,518
Fuel	5.3	5,888
Seed, seedling, etc.,	64.6	810
Repair/maintenance of agricultural equipment	6.6	1,458
Livestock Inputs		
Transport	14.3	1,004
Animal Feed	48.3	4,784
Hired labour	11.9	2,926
Maintenance of pens/stables	15.5	321
Veterinary services	41.4	667
Penalties for damage caused by animals	6.7	323
Animal sales agents	4.1	357
Other livestock related inputs	7.0	3,157

Sample weights used.

For livestock inputs, animal feed was the most expensive (K4,784) and most commonly used input (48.3% of all agricultural households). About 11.9% of households used hired labour, costing them an average of K2,926. Agricultural households that used transport services for their livestock (14.3%) spent K1,004 on average. Veterinary services were used by about 41.4% of households and it cost K667 on average.

6.6. Size of Farm and Home Gardens

The average farm size in Kabwe district was 33.4 acres (13.2 hectares), and home gardens were 2.6 acres on average.

Households in Munyama had the largest farm sizes (134 acres), followed by Moomba (96 acres), Chinyanja (48.1 acres), and Zambezi (47 acres). Households in Highridge had no farms while those in the Makululu area had tiny farms.

Households in Kangomba had the biggest home gardens (11.9 acres) followed by those from Zambezi (4.2 acres), Mpima (2.1 acres), Munyama (1.8 acres), Chinyanja (1.5 acres), and Chililalila (1.1 acres). The remaining wards had gardens smaller than one acre.

Table 6.5: Average Size of Farm Land and Home Garden by Ward (Acres)

Region	Farm	Home garden
Whole Kabwe district	33.4	2.6
Wards		
Bwacha	11	0.3
Chililalila	10	1.1
Chinyanja	48.1	1.5
Chirwa	44	0.35
David Ramushu	5	0.62
Highridge	0	0
Kalonga	8	0.39
Kangomba	14	11.88
Kaputula	6	0.242
Makululu	3	0.46
Moomba	96	0.62
Mpima	8.98	2.11
Munyama	134	1.88
Muwowo East	16	0.397
Waya	4	0.453
Zambezi	47	4.19

Sample weights used.

Chapter 7
Household Income and Assets

7.1. Introduction

The KHSS 2017 collected data on income for persons aged five years or older. The calculation of household income includes the following income sources:

- Wage income of all household members, including both cash and in-kind payments
- Income from non-agricultural business of all household members
- Profit from agricultural production, including the foregone profit of domestic consumption
- Rental income from properties owned
- Income from interest or dividends on shares, bonds, securities, etc.
- Income from pensions and grants
- Income from remittances, gifts, and other external sources

While income captures monetary flow, ownership of assets and durable goods is also useful for measuring the cumulative wealth levels of households. Asset ownership also provides information on the ability of households to produce further income and buffer against income shocks. The survey asked whether a household owns each of 63 items. Borrowed or permanently broken items were not counted.

7.2. Household Income

The survey asked about monthly wage income and income from non-agricultural business in the last month prior to the survey. Income from the other sources listed above was asked in the yearly basis in the survey but is rescaled to a monthly equivalent here. Throughout this section, we focus on 860 households that reported positive household incomes — 35 households (3.9% of the total sample households) are dropped from calculation. All the monetary terms are expressed in Kwacha, the national currency of Zambia abbreviated to K. All the calculations here use sampling weights.

Table 7.1 first shows the monthly household income and per capita household income. The means of total monthly household income and its per capita variation are K3,492.7 and K764.9, respectively. These figures are larger than the Zambian average but are similar to the average of urban Zambia in the LCMS 2015 data.

The remainder of Table 7.1 shows the breakdown of the mean household income. The two largest income sources are wage income and non-farm business income, constituting 53.6% and 25.5% of the total income, respectively. The share of agricultural profit is small, constituting only 4.6% of the total income, partly because Kabwe district is basically an urban area. Although 41.7% of households engage in farming (see Chapter 6), most of them do their farming in home

gardens and small-scale farms. The shares of pension, rental income and remittances receipt are not very large, either, although these sources of income would be crucial for households that do not have labour income.

Figure 7.1 shows the distributions of total and per capita household incomes. For both total and per capita household incomes, a large proportion of households are concentrated at the tail end. This uneven distribution would be partly because incomes of temporarily unemployed persons and persons whose businesses were in off season were recorded as zero. However, quite a large proportion of households had total household income larger than K10,000 and per capita household income larger than K2,000 (both are roughly three times larger than the means and six times larger than the medians). Thus, income inequality seems severe within Kabwe district.

Table 7.1: Average Monthly Household Income and its Breakdown (In Kwacha)

	Total Household Income	**Per Capita Household Income**
Total Kabwe	3,492.7	764.9
Zambia total*	1,801.3	444.2
Urban area of all Zambia*	3,152.4	796.4

Breakdown of Total Household Income in Kabwe				
Labour income		2,998.0	Pension	50.7
	Wage income	1,871.3	Grants	12.7
	Irregular allowances	188.4	Rental income	100.3
	Non-farm business income	889.0	Interests	13.9
	In-kind labour income	49.2	Dividends of shares, bonds, securities, etc.	17.9
Agricultural profit		160.4		
	Sales	283.9	Remittances receipt	92.0
	Domestic consumption	36.1	Gifts receipt	13.6
	Costs	159.6	Income from any other source	33.2

Sample weights used. * Data from the LCMS 2015.

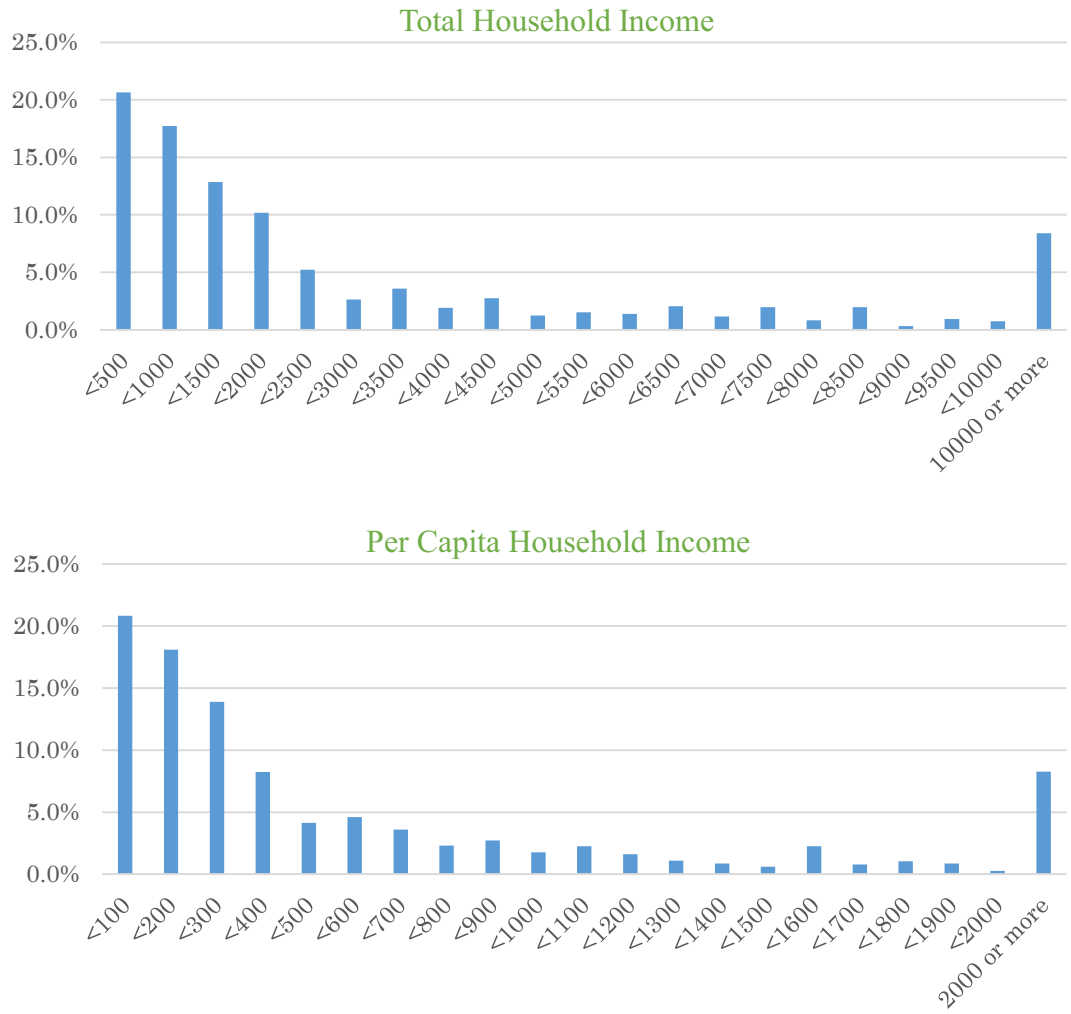

Figure 7.1: Distributions of Monthly Total and Per Capita Household Income (Weights Used)

Table 7.2 shows heterogeneity in household income and per capita household income with respect to gender of the household head and ward. As it may be expected, both total and per capita household incomes are larger in male-headed households than in female-headed households. Total and per capita household incomes also show substantial variation across wards. The wards with the highest mean incomes are located east and within a short kilometre distance from Kabwe town centre. Meanwhile, in wards located in Makululu compound, west of the city centre, which include Makululu, Moomba and Zambezi wards, household income is less than half of the entire Kabwe mean.

7.3. Ownership of Household Assets and Durables

Table 7.3 shows the proportion of households owning each of 63 items of assets and durable goods, where the sampling weights are used. Items owned by more than 80% of households include beds, mattresses, cellular phones, and braziers (*mbaula*). Electronic

Table 7.2: Total and Per Capita Monthly Average Household Income by Gender of Head of Household and Ward

	Total household income				Per capita household income		
	All households	Male headed	Female headed		All households	Male headed	Female headed
Total Kabwe	3,492.7	3,901.9	2,179.1		764.9	827.6	563.5
Bwacha	5,513.3	6,159.2	4,245.8		1,174.2	1,090.3	1,338.9
Chililalila	1,452.5	1,552.3	355.4		506.3	538.7	150.1
Chinyanja	1,071.1	1,174.1	710.5		291.7	334.9	140.5
Chirwa	6,343.1	7,235.4	3,247.0		1,577.3	1,784.6	857.8
David Ramushu	3,888.5	4,142.2	3,157.5		835.3	745.8	1,093.3
Highridge	11,449.2	11,649.6	10,313.9		3,376.5	3,682.6	1,641.7
Kalonga	3,903.6	4,218.2	3,124.2		815.1	805.4	839.1
Kangomba	2,171.0	2,379.6	1,307.6		441.3	495.4	217.2
Kaputula	3,022.5	3,287.4	1,779.4		596.3	604.0	559.7
Makululu	1,500.6	1,655.6	1,167.3		342.3	372.7	276.9
Moomba	1,556.7	1,912.5	832.0		282.5	337.4	170.8
Mpima	581.7	636.4	344.6		124.7	139.8	59.6
Munyama	2,648.4	2,657.2	2,575.1		557.6	574.5	415.7
Muwowo East	2,914.8	3,640.9	648.7		473.8	583.0	132.7
Zambezi	1,237.7	1,422.2	481.3		218.7	242.0	122.9
Waya	6,241.1	6,548.3	5,319.6		1,319.8	1,417.4	1,027.0

Sample weights used.

durables, such as televisions, electric stoves and refrigerators were owned less. Proportions of ownership of these items are close to the urban averages in the LCMS 2015 data. Ownership of cars is limited, and its ownership rate is lower than the urban average in the LCMS 2015 data. Meanwhile, bicycle ownership is almost twice the urban average in the LCMS 2015 data. Ownership of agricultural production instruments is limited basically because few households engage in middle to large-scale farming. Among all items, no households own boats and donkeys (indicated as n/a in table).

Table 7.3: The Ownership Rates of Various Assets and Durables

Assets / durables	The rate (%)	Assets / durables	The rate (%)	Assets / durables	The rate (%)
Bed	87.9	Electric stove	34.4	Fishing net	2.7
Mattress	91.8	Refrigerator	24.0	Hunting gun	1.2
Mosquito net	68.1	Deep freezer	33.4	Plough	6.0
Table (dinning)	53.6	Washing machine	1.5	Crop sprayer	7.6
Lounge suit / sofa	63.6	Dish washer	4.8	Knitting machine	0.9
Radio / Stereo	62.4	Air conditioner / ventilator	2.2	Lawn mowers	0.7
Television	58.9			Generator	3.0
Satellite dish / decoder (free to air)	21.9	Electric iron	38.8	Small / hand-driven tractor	0.5
		Non-electric iron	28.0		
Satellite dish / decoder (DSTV)	31.6	Private water pump	4.0	4-wheel tractor	0.9
		Sewing machine	3.9	Wheel barrow	18.0
Other pay TV	20.0	Hand hammer mill	2.9	Scotch cart	2.2
DVD / VCR	37.6	Grinding / hammer mill (powered)	1.3	Bicycle	39.5
Home theater	25.9			Motor cycle	1.9
Land phone	1.9	Sheller	1.2	Large truck	0.7
Cellular phone	84.5	Ramp presses / oil expellers	0.5	Small / pick-up truck	1.4
Computer	14.1				
Watch	26.6	Hand saw	4.5	Van / minibus	1.8
Clock	33.8	Carpentry plane	3.7	Car	10.1
Residential building	48.8	Axe	50.7	Canoe	0.7
Non-residential building	8.5	Pick	45.2	Boat	n/a
		Hoe	77.6	Oxen	3.0
Brazier / Mbaula	92.8	Hammer	37.3	Donkey	n/a
Gas stove	1.9	Shovel / spade	48.2		

Sample weights used.

Chapter 8
Expenditure

8.1. Introduction

Household expenditure, which plays a vital role in household welfare, is the most commonly used measure for assessing living standards or poverty of households in developing countries. The KHSS 2017 collected data on the following household consumption expenditures:

- Expenditure on food, which includes expenses for cereals, crop products, meats, dairy, fish, and domestic consumption on self-produced foods.
- Educational expenditure, which includes expenses on fees, tuition, textbooks and uniforms.
- Medical expenses, which include expenses for medicine, fees for doctors, and fees for hospital stays.
- Expenditure on housing and utility, which includes expenses on rents of dwelling, electricity, water.
- Remittances, which include cash and in-kind remittances sent to inside and outside Zambia.
- Other expenditure, which includes expenses for consumer goods, transport, mobile phones, etc.

Food expenditure consists of food purchased in the marketplace, self-produced food, food items received as gifts, relief food or food-for-work, and food taken or eaten outside the home. These items were asked for two recall periods: the last two weeks and the last four weeks prior to the survey, depending on whether the items were frequently or infrequently purchased. In this section, all items were converted into monthly values.

The estimated expenditure on housing services was based on the data for the rental value of the dwelling. Even if the household occupies their own dwelling, we asked them to estimate how much it would earn per month if they were to rent out that house. Their estimate was imputed to be the rental value of their dwelling.

8.2. Average Monthly Expenditure

Table 8.1 shows means of monthly household expenditures, food and non-food expenditures, and per capita expenditure. We calculated mean values for the entire Kabwe district and for each ward investigated by the KHSS 2017 using the sample weights. The values for all Zambia and urban Zambia derive from the results of the LCMS 2015.

Table 8.1: Average Monthly Household Expenditure

	Household Expenditure				Per capita expenditure
	Total	Food	% of Food/Total	Non-Food	
Whole Kabwe district	3,532	1,264	36	2,268	773
*Zambia total**	*1,588*	*645*	41	*943*	*388*
*Urban area of all Zambia**	*2,680*	*930*	35	*1,750*	*675*
WARD					
Bwacha	4,284	1,291	30	2,993	918
Chililalila	1,389	566	41	823	329
Chinyanja	2,214	840	38	1,374	673
Chirwa	5,413	1,649	30	3,763	1,313
David Ramushu	3,052	1,043	34	2,010	658
Highridge	9,995	2,207	22	7,788	2,688
Kalonga	3,653	1,194	33	2,459	817
Kangomba	3,670	2,024	55	1,646	849
Kaputula	4,138	2,015	49	2,122	719
Makululu	1,793	921	51	872	424
Moomba	1,559	694	44	865	294
Mpima	866	499	58	367	177
Munyama	3,719	860	23	2,859	798
Muwowo East	3,673	1,291	35	2,383	761
Waya	5,495	1,768	32	3,727	1,106
Zambezi	1,447	596	41	851	286

Sample weights used. * Data from the LCMS 2015.

The means of monthly household expenditure and per capita expenditure in the Kabwe district are estimated as K3,532 and K773, respectively. These values are considerably higher than the averages of all Zambia, which suggests that the residents in Kabwe enjoy a relatively higher living standard compared to other locations in Zambia. The share of food expenditure to the total expenditure in Kabwe accounts for 36% and shows a similar ratio to that of the urban average in Zambia (35%).

However, the regional gap of expenditure levels across wards within Kabwe are large. Overall, wards with highest expenditure levels are concentrated in the city centre, located northeast from the mining site, including wards such as Highridge, Chirwa, or Waya. The average monthly household expenditures in these wards exceeds K5,000. Conversely, most of the wards with lowest expenditure levels spread toward the northwest from the mining site, such as Moomba, Makululu, Zambezi, and Chililalila. Their average monthly household expenditure does not reach K2,000. In the outer southern rural areas,

such as Munyama, the expenditure level equals the average level of Kabwe.

Figures 8.1 and 8.2 show the distributions of monthly household expenditure and monthly per capita household expenditure, respectively. Compared to the income distributions (Figures 7.1 and 7.2), the expenditure distributions show slightly more moderate variation. Nevertheless, substantial inequality is confirmed in terms of expenditure levels in Kabwe.

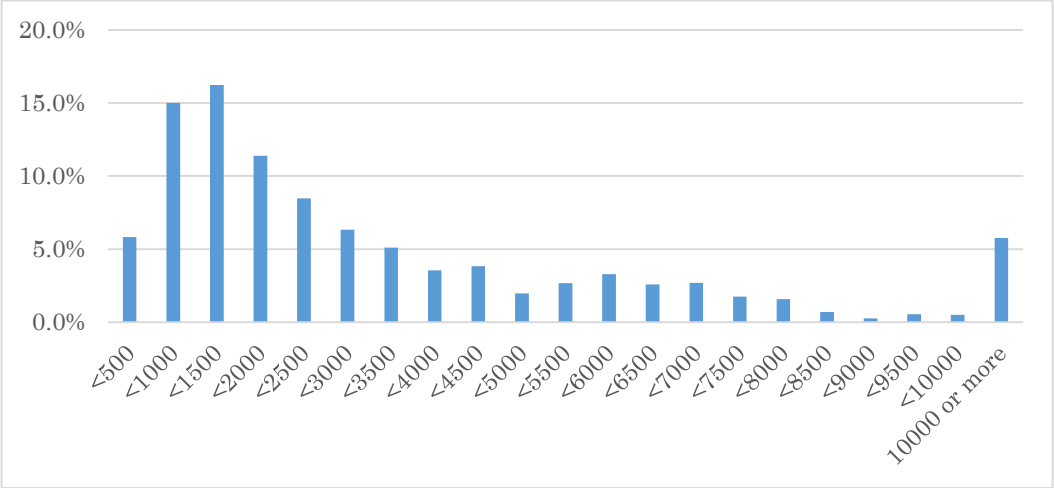

Figure 8.1: Distribution of Monthly Household Expenditure (total household)

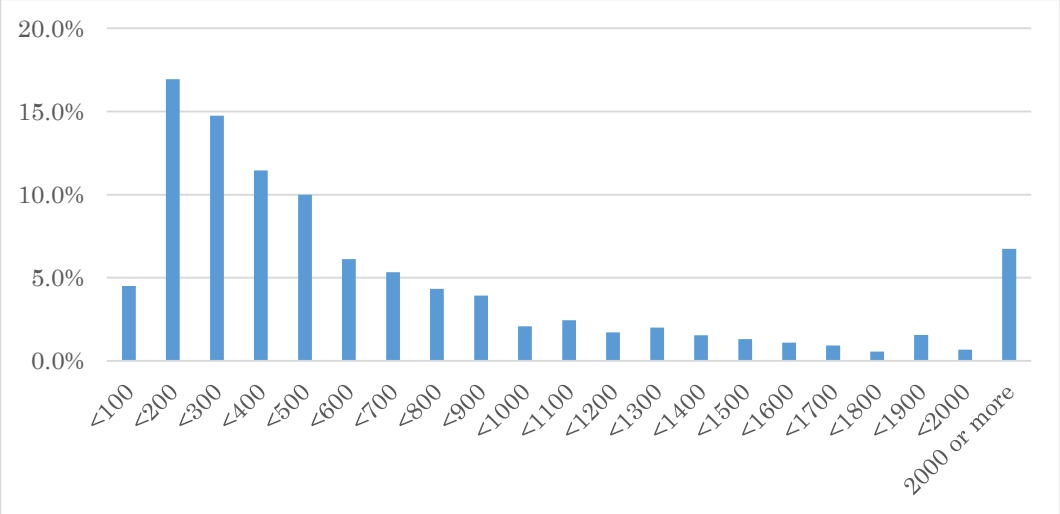

Figure 8.2: Distribution of Monthly Household Expenditure (per capita)

8.3. Percentage Share of Household Expenditure by Expenditure Type

Table 8.2 shows the expenditure pattern of households in Kabwe. The values in all Zambia and urban Zambia derive from the results of the LCMS 2015. The average shares of food and non-food expenditures in Kabwe are similar to those of the urban average in Zambia. However, the breakdown of non-food expenditure indicates some peculiar features. In Kabwe, the expenditure share for housing, which includes expenses on rental of dwellings and fees for electricity or water, is relatively low, while the share for health expenditure is relatively high compared with the averages in all Zambia and urban Zambia.

Table 8.2: Percentage Expenditure Share by Expenditure Type

Expenditure Share	*Zambia**	*Urban**	Kabwe District
Total	***100***	***100***	**100.0**
Food	***40.3***	***34.2***	**35.8**
Non-food	***59.7***	***65.8***	**64.2**
Education	*6.3*	*6.7*	6.1
Housing	*26.9*	*30.4*	20.3
Health	*0.3*	*0.3*	0.8
Other	*26.2*	*28.4*	36.7

Sample weights used. * Data from the LCMS 2015.

Chapter 9
Household Housing Condition

9.1. Introduction

The KHSS 2017 collected information on the housing conditions of people in the Kabwe district. Housing conditions have a direct bearing on well-being. For example, poor housing conditions such as lack of access to clean drinking water or undeveloped housing units may increase exposure to environmental aspects that could be harmful to health. The KHSS 2017 collected the following information:

- Type of housing unit: This was as defined in the LCMS 2015, broken down into traditional huts, improved traditional huts, detached houses, flat/apartment/multi-units, semi-detached houses, and other. A traditional hut referred to a housing structure usually made of mud walls with a thatched roof. If some material used for either the wall or roof is improved (e.g., burnt bricks for walls or iron sheets for roofing), then the housing unit is said to be an improved traditional hut. Detached house refers to a housing unit that stands on its own, unconnected to another house. A flat/apartment/multi-unit is defined as "a housing unit that had a set of rooms and its accessories in a permanent building". A semi-detached house is referred to as a housing structure or building that is split into two or more housing units, which do not stand independently but are separated by a wall. The "other" category refers to a housing unit not captured in the above definitions.
- Tenancy Status: this was determined by asking the head of household the basis on which the household occupied the housing unit in which they lived.
- Main source of drinking water: the main source of drinking water was categorized as safe (improved) and unsafe (unimproved), consistent with the 2015 LCMS.
- Electricity connection: this was determined by whether a housing unit was connected to electricity via the grid.

9.2. Type of Housing Unit

The most common type of housing unit in Kabwe is a detached house (53.9%) (Table 9.1), which reflects the results for all urban areas of Zambia, as captured in the LCMS 2015. However, Kabwe district has a much higher share of households with improved traditional huts (22.7%) compared to the average of all urban areas in Zambia (10.2%). The third most common housing type in the district is a flat/apartment/multi-unit (14.6%).

By ward, Highridge, Bwacha, and Waya were the most urbanized with most households (90-100%) living in either detached houses or flats, and with few or no households living in traditional or improved traditional huts (0-

4.5%). Kalonga, Chirwa, and Kaputula were next in terms of households living in either detached houses or flats (70-80%). These wards also had a good share of households living in improved traditional huts (9-23%). Although located close to Kabwe town centre, a substantial share of households living in Makululu area, namely, Moomba, Makululu, and David Ramushu wards, lived in improved traditional huts (24%-46%). Although this could also be said of wards like Mpima, Chililalila, Chinyanja, Kangomba, Munyama, and Zambezi, these wards are mainly agricultural and located a little further, on average, from the town centre.

9.3. Tenancy Status of Housing Unit

Most households in Kabwe occupied their own housing units (64.4%) or rented them from private individuals (25.7%), reflecting the national picture obtained in the LCMS 2015 (Table 9.2). Ownership levels were

Table 9.1: Percentage Distribution of Households by Type of Housing Unit by Ward

Region	Traditional hut	Improved traditional hut	Detached house	Flat/ apartment/ multi-unit	Semi-detached house	Other
Whole Kabwe district	5.8	22.7	53.9	14.6	2.0	0.0
Zambia total*	32.0	21.5	28.5	10.4	5.5	0.8
Urban area of all Zambia*	4.3	10.2	47.4	22.5	11.4	1.4
Wards						
Bwacha	0	2.4	62.1	29.5	6.0	0
Chililalila	4	28	52.0	16	0.0	0
Chinyanja	9.5	38.09	47.6	4.76	0.0	0
Chirwa	1	23.3	52.2	18.54	4.1	1.2
David Ramushu	0	45.67	38.1	15.5	0.7	0
Highridge	0	0	80.9	19.05	0.0	0
Kalonga	0	12.97	53.8	26.71	3.2	3.24
Kangomba	4	27.45	46.4	13.07	6.9	2.29
Kaputula	1	9.56	72.1	14.23	3.4	0
Makululu	9	22.68	49.9	18.26	0.0	0
Moomba	2	34.49	43.8	17.95	1.8	0
Mpima	14.28	38.09	14.3	33.3	0.0	0
Munyama	18	23.95	46.4	9.875	2.0	0
Muwowo East	6	16.5	77.0	0.44	0.0	0
Waya	0	4.5	63.6	22.7	0.0	9.09
Zambezi	29	35.03	34.93	1.41	0	0

Sample weights used. * Data from the LCMS 2015.

generally higher than the average rates for urban Zambia, which may be explained by the fact that Kabwe district has a higher than national urban average of traditional and improved traditional huts; these are the predominant housing units in rural areas that tend to have higher ownership rates.

Ownership rates are highest (more than 70%) in wards with more traditional or improved traditional housing, e.g., Kangomba, Moomba, Mpima, Munyama, Muwowo East, and Zambezi. In general, households in more urban wards, e.g., Bwacha, Chirwa, Kalonga, and Waya, occupy housing units on a rental basis (more than 35%) from either individuals or institutions. However, some wards, such as Chinyanja and Makululu, have a substantial share of households occupying either traditional or improved traditional huts on a rental basis, which might indicate the depth of poverty in these areas.

Table 9.2: Percentage Distribution of Households by Tenancy Status by Ward

Region	Owner	Rented from Institution	Rented from Private Person	Free Housing	Other
Whole Kabwe district	64.4	1.7	25.7	8.2	0.0
Zambia total*	*69.5*	*1.8*	*22.2*	*5.9*	*0.5*
Urban area of all Zambia*	*41.4*	*2.8*	*49.0*	*6.1*	*0.8*
Wards					
Bwacha	51	7.25	27.7	14.5	0.0
Chililalila	40	0	0.0	60	0.0
Chinyanja	52.38	0	47.6	0	0.0
Chirwa	54	2.67	36.88	6.05	0.0
David Ramushu	63	0	30.7	6.42	0.0
Highridge	62	9.52	23.8	4.76	0.0
Kalonga	49	0	41.7	9.73	0.0
Kangomba	78	0	16.0	6.21	0.0
Kaputula	57	0	34.5	8.01	0.0
Makululu	55	2.26	38.7	4.52	0.0
Moomba	71	0.84	27.0	1.26	0.0
Mpima	76.19	0	0.0	23.81	0.0
Munyama	74	1.98	2.0	21.87	0.0
Muwowo East	80	3.4	8.0	8.43	0.0
Waya	63	0	36.4	0	0.0
Zambezi	75	0.71	22.3	2.12	0.0

Sample weights used. * Data from the LCMS 2015.

9.4. Main Source of Drinking Water

The proportion of households with a safe/improved water source in Kabwe (88.9%) is the same as the average for urban Zambia (89.1%), which is much higher than the national average (67.7%). Nevertheless, the sources of water between these areas differ somewhat. For example, fewer people use their own faucets in Kabwe (28.8%) compared to urban areas of Zambia (37.5%), with more people in Kabwe depending on protected wells (17.8% vs 10.3%) and rain water (2.5% vs. 1.1%).

By ward, all households in Highridge, David Ramushu, Moomba, and Zambezi have access to an improved water source. However, unlike Highridge, where the source of water for all households was their own faucet, the source for Moomba and Zambezi was a public spigot or water kiosk, and most households in David Ramushu depended on public facilities and their own faucets. Other wards with a high proportion of households depending on their own faucets are Bwacha (83.7%), Chirwa (58.6%), Waya (59%), and Kalonga (34.3%).

Wards with a large share of households using protected wells were Mpima (71.42%), Muwowo East (56.6%), Kaputula (47.7%), and Kangomba (32%). More than 12% of households did not have access to safe water, mostly depending on unprotected wells in Chinyanja (14.2%), Kangomba (13.7%), and Kalonga (12.9%).

9.5. Connection to Electricity

The proportion of households connected to electricity in Kabwe (52.3%) was higher than that in the rest of Zambia as captured in the LCMS 2015 (31.4%), although lower than the urban areas in the whole of Zambia (67.3%).

By ward, more than 95 per cent of households in Bwacha, Highridge, and Waya were connected to electricity. The proportion connected to electricity was also high in David Ramushu (72.1%), Chirwa (70.1%), and Kalonga (67.6%). Electricity connection in Chililalila, Chinyanja, Mpima, Kangomba, Munyama, Moomba, Makululu, and Zambezi was below the Kabwe average (52.3%).

Table 9.3: Percentage Distribution of Households by Main Source of Drinking Water by Ward

	Safe-Improved										*Unsafe*					
Region	**Rain Water**	**Protect well**	**Borehole**	**Protected spring**	**Public tap**	**Own tap**	**Other tap(e.g., from nearby building)**	**Water Kiosk**	**Bottled Water**	**Total safe-Improved**	**Directly from river/lake/ stream/dam**	**Unprotected well**	**Unprotected spring**	**Other**	**Total unsafe**	**Total**
Whole Kabwe district	2.5	17.8	4.8	0.2	18.8	28.8	7.92	7.97	0.23	88.9	0.18	10.8	0	0	10.98	100
Zambia total*	0.5	10.4	23.5	0.4	9.8	16.9	3.5	2.6	0.1	67.7	10.7	19.6	1.2	0.7	32.2	100
Urban area of all Zambia*	1.1	10.3	8.0	0.2	18.5	37.5	7.5	5.8	0.2	89.1	0.7	8.6	0.3	1.2	10.8	100
Wards																100
Bwacha	0	7.19	0.0	0	2.4	83.75	4.22	0	0	97.6	0	2.42	0	0	2.42	100
Chililalila	0	0	40.0	0	44.0	0	12	0	0	96.0	0	4	0	0	4	100
Chinyanja	0	19.04	52.4	0	0.0	9.52	4.76	0	0	85.7	0	14.28	0	0	14.28	100
Chirwa	0	3.58	4.83	0	17.8	58.59	5.38	0	1.2	91.4	0.7	7.86	0	0	8.56	100
David Ramushu	2	1.77	2.0	0	35.3	42.35	11.62	4.95	0	100.0	0	0	0	0	0	100
Highridge	0	0	0.0	0	0.0	100	0	0	0	100.0	0	0	0	0	0	100
Kalonga	7	9.7	0.0	0	3.2	34.35	29.19	3.24	0	87.0	0	12.97	0	0	12.97	100
Kangomba	0	32.02	2.0	1.96	9.2	34.31	6.86	0	0	86.3	0	13.73	0	0	13.73	100
Kaputula	0	47.77	3.9	0.73	2.7	32.27	3.42	0	0	90.7	0	9.26	0	0	9.26	100
Makululu	0	2.28	0.0	0	47.7	0	9.04	38.7	0	97.7	2.26	0	0	0	2.26	100
Moomba	14	0	2.7	0	24.8	1.43	5.82	51.31	0	100.0	0	0	0	0	0	100
Mpima	0	71.42	0.0	0	0.0		0	0	0	71.4	0	28.57	0	0	0	100
Munyama	0	8.1	28.1	0	5.9	11.85	1.975	0	1.975	57.9	0	40.05	0	2.02	0	100
Muwowo East	0	56.63	1.9	0	0.0	6.8	0	0	0	65.3	0	34.66	0	0	0	100
Waya		9	13.6	0	4.5	59.09	4.54	0	0	90.8	0	9.09	0	0	0	100
Zambezi	0	0	8.39	0	69.21	0	14.66	7.733	0	100.0	0	0	0	0	0	100

Sample weights used. * Data from the LCMS 2015.

Table 9.4: Percentage Distribution of Households by Electricity Connection by Ward

Region	Proportion connected to electricity	Proportion not connected to electricity	Total	Total number of households
Whole Kabwe district	52.3	47.7	100	49,056
Zambia total*	31.4	68.6	100	30,14,965
Urban area of all Zambia*	67.3	32.7	100	12,97,000
Wards			100	
Bwacha	95.8	4.2	100	2,256
Chililalila	20.0	80.0	100	710
Chinyanja	14.3	85.7	100	624
Chirwa	70.1	29.9	100	6,490
David Ramushu	72.1	27.9	100	3,677
Highridge	95.2	4.8	100	1,209
Kalonga	67.6	32.4	100	4,234
Kangomba	43.5	56.5	100	2,448
Kaputula	57.6	42.4	100	4,483
Makululu	43.2	56.8	100	1,920
Moomba	44.5	55.5	100	4,762
Mpima	0	100	100	998
Munyama	31.9	68.2	100	1,536
Muwowo East	52.4	47.6	100	6,442
Waya	95.5	4.6	100	2,016
Zambezi	2.8	97.2	100	5,252

Sample weights used. * Data from the LCMS 2015.

Chapter 10
Blood Lead Levels

10.1. Introduction

The KHSS 2017 is a joint survey with the surveys by the health assessment sub-group of the KAMPAI project. The health assessment sub-group invited individuals—up to two children and their parents from each household—for blood sampling and measured the blood lead level (BLL) using the testing kit LeadCare II.

BLL is a useful biomarker for measuring the extent of lead exposure, which is frequently used to examine lead poisoning around the world. Generally, 10μg/dL has been regarded as the level of concern: BLL higher than this level is associated with significant health risks, such as metabolic, neuronal, reproductive and circulatory disorders and death (The Centers for Disease Control and Prevention, CDC, 2002). However, recent researches show that individuals, especially children, with a BLL less than 10μg/dL still face certain risks of lead poisoning, such as decreased IQ levels (Canfield et al. 2003). Some experts began setting the level of concern at 5μg/dL, while the very concept of the level of *concern* has been recently questioned because no measurable level of blood lead is known to be safe (CDC 2012). For convenience, this chapter treats 10μg/dL BLL as the *reference* level, rather than as the level of *concern*, to describe the current situation in Kabwe, although the possibility of health risks for BLL below that level must not be overlooked. Figure 10.1 summarises the major health risks associated with BLL.

Previously, three major sets of surveys have examined the BLL of Kabwe residents: the Copperbelt Environment Project, the Pure Earth Projects, and the projects conducted by the University of Zambia in collaboration with Hokkaido University. These surveys primarily focused on children living in highly contaminated areas and illustrated severe lead exposure among these children (results are summarised by Bose-O'Reilly et al., forthcoming). Meanwhile, the BLL data of the KAMPAI project aims to describe a general picture of lead exposure in the entire Kabwe district. The sample includes children from lowly contaminated areas and adults from any area.

Regarding the use of BLL, note the following two cautions. First, as discussed in Chapter 1, BLLs are not available for all the sampled individuals in the KHSS 2017. Therefore, this chapter focuses on the subsample of the KHSS 2017 main sample for whom the BLL data are available. Since the sample set here differs from the main samples of the KHSS 2017, we do not use the sample weights throughout Chapter 10. Secondly, because the detection limit of the LeadCare II is 3.3μg/dL, the precise values of BLLs cannot be determined for individuals with true BLLs below this detection limit. We

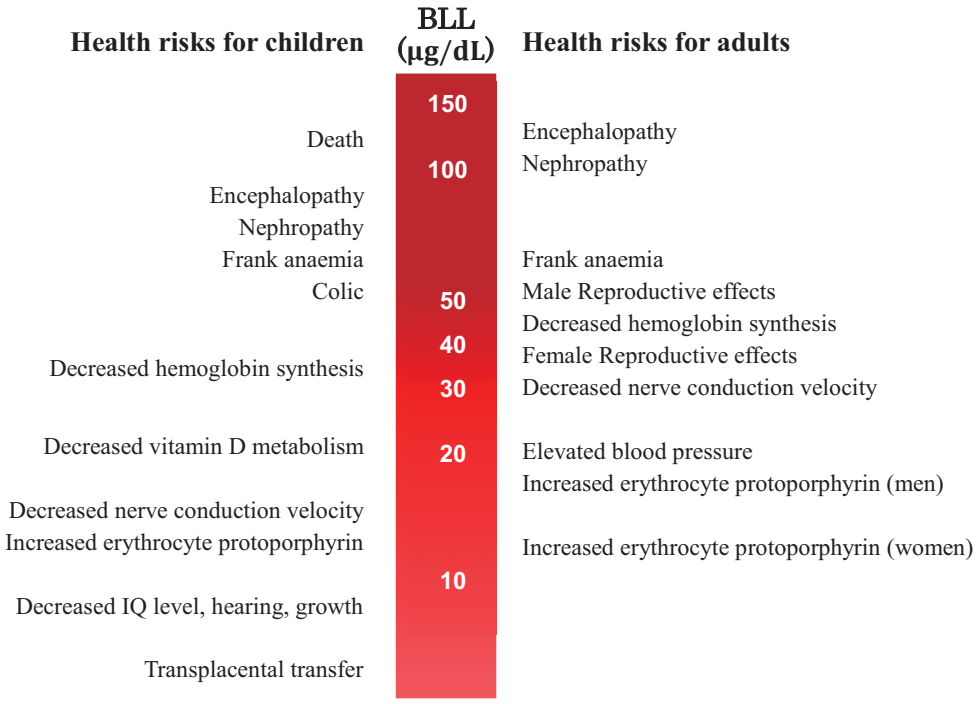

Figure 10.1: The BLL and Associated Health Risk (Authors' Creation Following Meyer Et Al. (2008)).

Table 10.1: The Mean BLLs (µg/dL)

	Total (N=827)		Male (N=361)		Female (N=446)	
	Mean (Std. dev.)		Mean (Std. dev.)		Mean (Std. dev.)	
All sample	20.9	(21.4)	23.1	(23.1)	19.1	(19.8)
0-4 years	28.4	(27.9)	26.8	(29.6)	30.2	(25.8)
5-9 years	29.1	(23.2)	28.8	(22.8)	29.5	(24.0)
10-19 years	19.8	(17.2)	21.5	(16.3)	18.4	(18.2)
20-49 years	13.9	(14.7)	15.0	(16.8)	13.4	(13.6)
50 years or older	18.4	(18.4)	22.3	(20.7)	14.9	(15.5)

conventionally treat the BLLs of such individuals as 1.65µg/dL, a mean of 0 and 3.3.

10.2. Mean BLLs

Table 10.1 shows the mean BLLs, all measured in µg/dL. The first row shows the means over all age groups. The mean of all sample individuals is 20.9µg/dL, twice the reference level of 10µg/dL. The mean BLL is higher for males than for females, suggesting the possibility that men tend to have more occasions of lead exposure. The remaining rows show the means by age groups. A clear

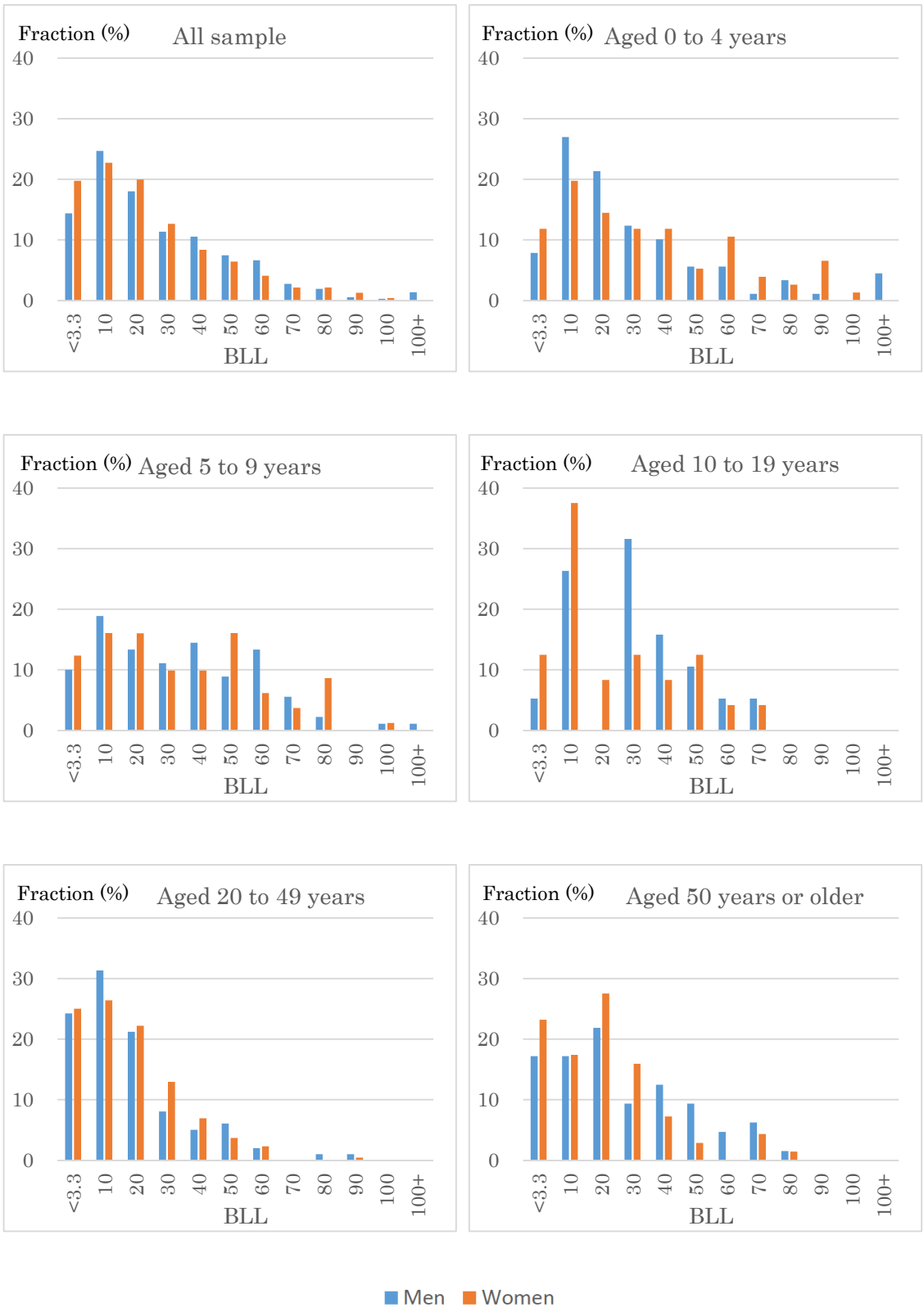

Figure 10.2: The Distributions of The Blls, by Age Group and Gender

tendency is that children aged 9 years or younger have high BLLs—28.4 μg/dL for children aged 0-4 years and 29.1 μg/dL for children aged 5-9 years. These figures are roughly three times the reference level. However, they are lower than the mean BLL obtained in the previous surveys because our sample includes children in low contamination areas. The mean BLL is the lowest for individuals aged 20-49 years in both genders although it is still higher than 10μg/dL. Such a relationship between BLL and age is reasonable. Young children often swallow lead-containing objects, such as dust, through their hand-to-mouth behaviours, and their rate of lead absorption is higher than that of adults (WHO 2010).

Figure 10.2 shows the distributions of BLLs by age group and gender. Overall, the distributions tend to follow a log normal distribution (larger mass in the left tail). Among young children aged 9 years or younger, while a substantial proportion of them have BLLs less than 10μg/dL, the proportion of those having very high BLLs is also substantial. Some even have BLLs associated with a considerable risk of death. Among adults aged 20-49 years, more than half of them have BLLs less than 10μg/dL. Nevertheless, adults with high BLLs are also observed.

10.3. Regional Difference of the Mean BLL

Finally, we examine how the mean BLL differs across regions within the Kabwe district. Figure 10.3 shows the mean BLLs of the whole sample, young children aged 9 years or younger, and other individuals in each ward. We see a substantial difference in the mean BLLs across wards. General tendencies are summarised as follows.

- High BLL wards (David Ramushu, Kangomba, Moomba, Zambezi, and Makululu): The mean BLLs in these wards exceed 20μg/dL. These wards are located either right next to or a few kilometres to the west—the direction of the prevailing wind—of the mine and mine waste dumping site. They are also relatively poor areas, including the Makululu Compound. These geographic and socioeconomic circumstances seemingly lead to high BLLs in these areas. The mean BLLs are high regardless of the age group. Yet, a substantial difference exists between the BLLs of young children and the other individuals in Moomba, Zambezi and Makululu.

- Middle BLL wards (Waya, Chililalila, Chirwa): The mean BLLs in these wards exceed 10 μg/dL. Although Waya and Chirwa are close to the mine and dumping site, they are located to the west of these sources of lead. Some geographic characteristics, perhaps directions of wind and water flow, seemingly reduce lead exposure in these wards compared to high BLL wards located to the west of the mine. Chililalila is located to the west of the mine but further to the west than the high BLL wards. Note, however, that the mean BLL for children still exceeds 20 μg/dL and that substantial risks of lead poisoning

would exist in these wards.

- Low BLL wards (the other wards): The mean BLLs in these wards are less than 10 μg/dL . Generally, these wards are located far from the mine and dumping site. In Bwacha ward, however, the mean BLL of young children is relatively high. In the other wards, the mean BLLs are low regardless of age groups, suggesting that the risk of lead exposure is limited compared to the high and middle BLL wards.

Unfortunately, no observation is available for Highridge ward. However, as Highridge ward is located between Chirwa and Kalonga wards, the level of lead exposure would likely not be very high.

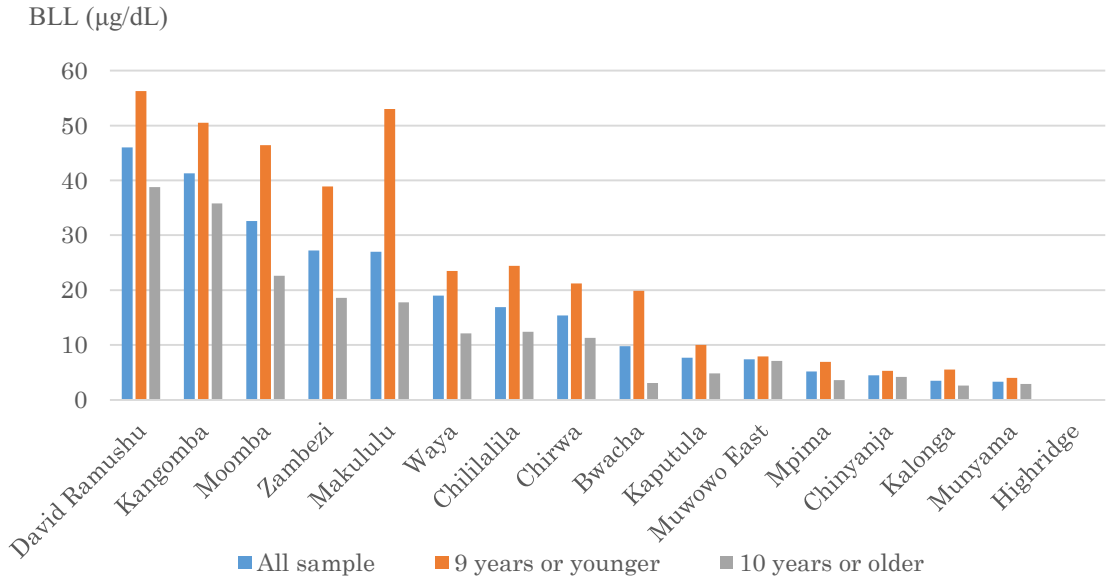

Figure 10.3: The Mean BLLs by Age Group and Ward

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Kabwe Household Socioeconomic Survey 2017 Questionnaire

Notes

This is the printable version of the questionnaire. The interviews were conducted in the form of Computer Assisted Personal Interviewing (CAPI) using the application Survey Solutions (version 5.22.20) developed by the World Bank.

Contents

HOUSEHOLD IDENTIFICATION		
HHID	HHID	PROVIDED BY SUPERVISOR
SEA	SEA CODE	
HEAD_NAME	THE NAME OF THE HOUSEHOLD HEAD	
TEL	Telephone number (if available)	
DATE_B	DATE OF THE BEGINNING OF THE INTERVIEW	
GPS	GPS coordinate	

For all persons. Answer cells omitted.

SECTION 1: HOUSEHOLD ROSTER

INTRODUCTION: I would like to start the interview by asking you questions about yourself and other usual members of the household

SERIAL NUMBER OF HOUSEHOLD MEMBERS (personID)	Please give me the names of all persons who usually live with this household (START WITH THE HEAD OF THE HOUSEHOLD). **[Preferred order: HEAD, SPOUSE of head, CHILDREN of head (elder to younger), OTHER MEMBERS. Include visitors who have lived with the household for sixmonths or more. Include usual members, who are away visiting, in hospital, at boarding schools or college or university, etc.]**	**1A** How old is [NAME] now? **[RECORD AGE IN COMPLETED YEARS. RECORD 0 FOR THOSE 0-11 MONTHS OLD.]**	**1B** Record exact age in completed months for those 0-59 months old (0-4 years old). **[USE UNDER FIVE CLINIC CARD IF AVAILABLE. RECORD 99 IF DON'T KNOW]** **Asked if Q1A<5**	For children aged 5-9 years, ask about their birthdays and check whether they were born BEFORE AUGUST 2011. **This note appears if Q1A=5,6,7,8,9.**	**2A**	**2B**	**2C**	**3A**
					The date of birth for children aged 0-4 years old **Asked if Q1A<5**			Is [NAME] a Zambian national? 1: YES 2: NO
					DAY	MONTH	YEAR	

SECTION 1: HOUSEHOLD ROSTER (Continued)

3B	**4**	**5**	**6A**	**6B**
What is [NAME]'s ethnicity? 1: BEMBA 2: TONGA 3: CHEWA 4: LOZI 5: NSENGA 6: TUMBUKA 7: NGONI 8: LENJE 9: LAMBA 10: WHITE 11: OTHER ETHNICITY **Asked if Q3A=1**	What is the relationship of [NAME] to the head of the household? 1: HEAD 2: SPOUSE 3: OWN CHILD 4: STEP CHILD 5: ADOPTED CHILD 6: GRAND CHILD 7: BROTHER/SISTER 8: COUSIN 9: NIECE/NEPHEW 10: BROTHER/SISTER-IN LAW 11: PARENT 12: PARENT-IN-LAW 13: OTHER RELATIVE 14: MAID / NANNY / HOUSE-SERVANT 15: OTHER	Is [NAME] Male or Female? 1: MALE 2: FEMALE	What is [NAME]'s primary language? 1: BEMBA 2: NYANJA 3: TONGA 4: LOZI 5: KAONDE 6: LUVALE 7: LUNDA 8: LENJE 9: LAMBA 10: ENGLISH 11: OTHER **[THE LANGUAGE MAINLY USED AT HOME.]**	Please state [NAME]'s level of English proficiency. 1: EXCELLENT (he/she speaks English like his/her primary language) 2: GOOD (he/she speaks English without any problem in most cases) 3: FAIR (he/she speaks English without any problem in daily conversation) 4: POOR (he/she understands simple conversation) 5: DOES NOT SPEAK AT ALL **Asked if Q6A is not English AND Q1A≥5.**

SECTION 1: HOUSEHOLD ROSTER (Continued)

7	**8A**	**8B**	**9**	**10A**	**10B**
Is [NAME].an albino 1: YES 2: NO	Does [NAME] have any disability? 1: YES 2: NO	Is [NAME] blind, partially sighted, deaf, dumb, crippled, mentally retarded, mentally ill, ex-mental? 1: BLIND 2: PARTIALLY SIGHTED 3: DEAF 4: DUMB 5: PHYSICALLY DISABLED 6: MENTALLY RETARDED 7: MENTALLY ILL 8: EX-MENTAL **[RECORD UP TO THREE DISABILITIES]** **Asked if Q8A=1.**	Where was [NAME] born? 1: KABWE DIST 2: CENTRAL PROV. OTHER THAN KABWE 3: COPPERBELT PROVINCE 4: EASTERN PROV 5: LUAPULA PROV 6: LUSAKA PROV 7: MUCHINGA PROV 8: NORTHERN PROV 9: NORTH WESTERN PROV 10: SOUTHERN PROV 11: WESTERN PROV 12: OTHER COUNTRIES	How many years has [NAME] been living in Kabwe district? **[GIVE TOTAL YEARS IN LIFE]**	How many years has [NAME] been living in this dwelling? **[GIVE LENGTH YEAR]**

SECTION 1: HOUSEHOLD ROSTER (Continued)			
11A	**11B**	**12**	**13**
Where was [NAME] residing before? 1: HAS NEVER MOVED 2: DIFFERENT DWELLING/ SAME WARD 3: DIFFERENT WARD/KABWE DIST 4: DIFFERENT DISTRICT/ CENTRAL PROVINCE 5: DIFFERENT PROVINCE 6: DIFFERENT COUNTRY 7: DON'T KNOW/ REFUSED	Was the previous residence rural or urban? 1: RURAL 2: URBAN 3: DIFFICULT TO SAY / DON'T KNOW **Asked if Q11A=3,4,5,6.**	Why did [NAME] move from his/her previous residence? 1: FOR SCHOOL 2: BACK FROM SCHOOL/STUDIES 3: TO SEEK WORK/ BUSINESS 4: TO START WORK/ BUSINESS 5: TRANSFER OF HEAD OF HOUSEHOLD 6: PREVIOUS HOUSEHOLD COULD NOT AFFORD TO KEEP HIM/HER 7: DEATH OF PARENT/GUARDIAN 8: GOT MARRIED 9: NEW HOUSEHOLD 10: RETIREMENT 11: RETRENCHMENT 12: DECIDED TO RESETTLE 13: ACQUIRED OWN/DIFFERENT ACCOMODATION 14: FOUND NEW AGRICULTURAL LAND 15: REFUGEE/ASYLUM SEEKER 16: ENVIRONMENTAL POLLUTION 17: OTHER 18: DON'T KNOW **[CHOOSE THE MAIN OR THE MOST IMPORTANT REASON.]** **Asked only if Q11A==2,3,4,5,6.**	What is the marital status of [NAME]? 1: NEVER MARRIED 2: MARRIED 3: SEPARATED 4: DIVORCED 5: WIDOWED 6: CO-HABITING **ASKED IF Q1A>=12**

For all persons aged 0-20 years. Answer cells omitted.

SECTION 2: BIOLOGICAL RELATIONSHIP					
1	**2**	**3**	**4**	**5**	**6**
Is the biological mother of [NAME] in this household? 1: YES 2: NO	Who is the biological mother of [NAME]? **LIST OF HOUSEHOLD MEMBERS TO BE AUTOMATICALLY MADE.** **Asked if Q1=1**	Is the biological mother of [NAME] still alive? 1: YES 2: NO 3: DON'T KNOW **Asked if Q1=2**	Is the biological father of [NAME] in this household? 1: YES 2: NO	Who is the biological father of [NAME]? **LIST OF HOUSEHOLD MEMBERS TO BE AUTOMATICALLY MADE.** **Asked if Q4=1**	Is the biological father of [NAME] still alive? 1: YES 2: NO 3: DON'T KNOW **Asked if Q4=2**

For all persons. Answer cells omitted.

SECTION 3: HEALTH - FOR ALL PERSONS

INTRODUCTION: I am now going to ask about the health status of each member of your household.

1	2	3
Has [NAME] been sick or injured during the **last two weeks?** 1: YES SICK 2: YES INJURED 3: YES BOTH 4: NO 5: DON'T KNOW	What was [NAME] mainly suffering from? **[MULTIPLE ANSWERS ALLOWED. RECORD UP TO THREE ILLNESSES.] Asked if Q1=1 or 3** 1: FEVER/MALARIA 2: COUGH/COLD/CHEST INFECTION 3: TUBERCULOSIS (TB) 4: ASTHMA 5: BRONCHITIS 6: PNEUMONIA/CHEST PAIN 7: DIARRHOEA WITHOUT BLOOD 8: DIARRHOEA WITH BLOOD 9: DIARRHOEA AND VOMITTING 10: VOMITING 11: ABDOMINAL PAINS 12: CONSTIPATION/STOMACH UPSET 13: LIVER INFECTION/SIDE PAIN 14: LACK OF BLOOD/ANEAMIA 15 : BOILS 16 : SKIN RASH/SKIN INFECTION 17: PILES/HAEMOROIDS 18: SHINGLES/HERPES ZOSTER 19: PARALYSIS OF ANY KIND 20: STROKE 21: HYPERTENSION 22: DIABETES/SUGAR DISEASE 23: EYE INFECTION 24: EAR INFECTION 25: TOOTHACHE/MOUTH INFECTION 26: HEADACHE 27: MEASLES 28: JAUNDICE/YELLOWNESS 29: BACKACHE 30: CANCER OF ANY KIND 31: MENINGITIS 32: OTHER	Did [NAME] consult any health or other institution/personnel for this illness/injury or did he/she only use self-administered medicine? 1: CONSULTED 2: USED SELF ADMINISTERED MEDICINE ONLY 3: NONE OF THE ABOVE **ASKED IF Q1=1, 2, 3**

SECTION 3: HEALTH (CONT'D)

4	5	6	7	8
How much in total was spent on [NAME]'s medication/ consultation in the last two weeks? **[GIVE AMOUNT IN KWACHA]** **Asked if Q3=1,2.**	Where did [NAME] get the medicine from? 1: GOVT INSTITUTION 2: MISSION INSTITUTION 3: INDUSTRIAL INST. 4: PRIVATE INSTITUTION 5: PHARMACY/ CHEMIST 6: RELATIVES 7: NEIGHBOURS 8: FRIENDS 9: TRADITIONAL HEALERS 10: OTHER **Asked if Q3=1,2.**	Which health or other institution/personnel did [NAME] visit first for this illness/injury? 1: GOVT HOSPITAL 2: GOVT HEALTH CENTRE/CLINIC 3: GOVT HEALTH POST 4: MISSION INST 5: INDUSTRIAL INST 6: PRIVATE INST 7: INSTITUTION OUTSIDE ZAMBIA 8: MEDICAL PERSONNEL 9: TRADITIONAL HEALER 10: FAITH / SPIRITUAL / CHURCH HEALER 11: OTHER **Asked if Q3=1.**	Who attended to [NAME] during this visit? 1: MEDICAL DOCTOR 2: CLINICAL OFFICER 3: NURSE/MIDWIFE 4: COMMUNITY HEALTH WORKER 5: TRADITIONAL HEALER 6: FAITH HEALER 7: SPIRITUAL HEALER 8: CHURCH HEALER 9: OTHER **Asked if Q3=1.**	What was the method used for paying for the services of the facility on this visit? 1: PRE-PAYMENT SCHEME (LOW COST) 2: PRE-PAYMENT SCHEME (HIGH COST) 3: PAID FOR BY EMPLOYER 4: PAID BY INSURANCE 5: PAID PART AND THE OTHER PART BY OTHER; (e.g. EMPLOYER, FRIENDS, INSURANCE) 6: PAID DIRECTLY 7: PAID FOR BY OTHER 8: DIDN'T PAY 9: NOT APPLICABLE **[Multiple answers allowed]** **Asked if Q3=1.**

SECTION 3: HEALTH (CONT'D)

9	10	11
Has [NAME] been continuously ill, for at least 3 months in the last 12 months? 1: YES 2: NO	What was [NAME] mainly suffering from? **[MULTIPLE ANSWERS ALLOWED. RECORD UP TO THREE ILLNESSES.] Asked if Q9=1** 1: FEVER/MALARIA 2: COUGH/COLD/CHEST INFECTION 3: TUBERCULOSIS (TB) 4: ASTHMA 5: BRONCHITIS 6: PNEUMONIA/CHEST PAIN 7: DIARRHOEA WITHOUT BLOOD 8: DIARRHOEA WITH BLOOD 9: DIARRHOEA AND VOMITTING 10: VOMITING 11: ABDOMINAL PAINS 12: CONSTIPATION/STOMACH UPSET 13: LIVER INFECTION/SIDE PAIN 14: LACK OF BLOOD/ANEAMIA 15 : BOILS 16 : SKIN RASH/SKIN INFECTION 17: PILES/HAEMOROIDS 18: SHINGLES/HERPES ZOSTER 19: PARALYSIS OF ANY KIND 20: STROKE 21: HYPERTENSION 22: DIABETES/SUGAR DISEASE 23: EYE INFECTION 24: EAR INFECTION 25: TOOTHACHE/MOUTH INFECTION 26: HEADACHE 27: MEASLES 28: JAUNDICE/YELLOWNESS 29: BACKACHE 30: CANCER OF ANY KIND 31: MENINGITIS 32: OTHER	Has [NAME] been able to carry out his/her normal activities during the period of the illness? 1: YES 2: NO **Asked if Q9=1**

For all persons. Answer cells omitted.

SECTION 4: EDUCATION – FOR ALL PERSONS

INTRODUCTION: I am now going to ask about the educational status of each member of your household

1	2	3A	3B
Is [NAME] currently attending school? 1: YES, NURSERY/ PRE-SCHOOL 2: YES, OTHER GRADES FULL TIME 3: YES, OTHER GRADES PART TIME 4: YES, COMM. SCHOOL FULL TIME 5: YES, CORRESPONDENCE 6: YES, ADULT LITERACY CLASS 7: YES, TERTIARY SCHOOL 8: OTHER 9: NO **[INCLUDING THOSE IN COLLEGES AND UNIVERSITIES. ASK ABOUT THE PREVIOUS SCHOOL TERM (OR THE PREVIOUS SCHOOL YEAR) IF IT IS TIME FOR VACATIONS.]**	What grade / level of education is [NAME] currently attending? 1 to 11: Grade 1 to 11 12: Grade 12 GCE (O-level) 13: Grade 12 GCE(A-level) 14: College students 15: Undergraduate University students 16: Post-graduate Certificate / Diploma students 17: Master Degree students 18: Doctoral level and above students **Asked if Q1=2,3,4,5,7,8**	Is the school [NAME] is currently attending, a Central Government, Local Government (council), Mission/Religious, Industrial or private school? 1: CENTRAL GOVT 2: LOCAL GOVT (council) 3: MISSION/RELIGIOUS 4: INDUSTRIAL 5: PRIVATE 6: OTHER **Asked if Q1=1,2,3,4,5,7,8**	Please give the name of the school **Asked if Q1=1,2,3,4,5,7,8**

SECTION 4: EDUCATION (CONT'D)

4	5	6
How often did [NAME] miss classes (on average in the last term)? 1: NEVER 2: A LITTLE (ONE DAY OR TWO PER MONTH) 3: OFTEN (THREE TO TEN DAYS PER MONTH) 4: VERY OFTEN (MORE THAN TEN DAYS PER MONTH) **In case of part time students:** **A LITTLE: ONE DAY OR TWO OUT OF 20 SCHOOL DAYS.** **OFTEN: THREE TO TEN DAYS OUT OF 20 SCHOOL DAYS.** **VERY OFTEN: MORE THAN TEN DAYS OUT OF 20 SCHOOL DAYS.** **Asked if Q1=1,2,3,4,5,7,8**	Has [NAME] ever attended school? 1: YES 2: NO **Asked if Q1=6,9**	What is the highest grade [NAME] attained? 1 to 11: Grade 1 to 11 12: Grade 12 GCE (O-level) 13: Grade 12 GCE (A-level) 14: CERTIFICATE 15: DIPLOMA 16: DEGREE 17: MASTER DEGREE 18: DOCTORAL DEGREE 19: NONE (went to school but did not complete any grade) **Asked if Q5=1**

SECTION 4: EDUCATION (CONT'D)

7	8
What was the main reason for [NAME] leaving school at the time? **Asked if Q5=1** 1: STARTED WORKING / BUSINESS 2: EXPENSIVE 3: TOO FAR 4: NOT SELECTED/FAILED 5: PREGNANCY 6: MADE GIRL PREGNANT 7: COMPLETED STUDIES / SCHOOL 8: GOT MARRIED 9: NO NEED TO CONTINUE SCHOOL 10: SCHOOL NOT IMPORTANT 11: UNSAFE TO TRAVEL TO SCHOOL 12: EXPELLED 13: LACK OF FINANCIAL SUPPORT 14: NEEDED TO HELP OUT AT HOME 15: ILLNESS/INJURY/DISABLED 16: OTHER 17: DON'T KNOW	Why has [NAME] never attended school? 1: UNDER-AGE 2: COULDN'T GET A PLACE 3: EXPENSIVE 4: NO FINANCIAL SUPPORT 5: NO SCHOOL / SCHOOL TOO FAR 6: ILLNESS/INJURY 7: SCHOOL NOT IMPORTANT 8: UNSAFE TO TRAVEL TO SCHOOL 9: OTHER 10: DON'T KNOW **Asked if Q5=2**

SECTION 4: EDUCATION (CONT'D)

From now on I would like to ask about the expenditure to various school items in the LAST 12 MONTHS.

9A	9B	9C	10A	10B	10C	11A	11B	11C	12A	12B	12C
How much did your household spend on SCHOOL FEES for [NAME] during… **[INCLUDE EXAMINATION FEES AND BOARDING FEES. ENTER 0 IF NOT SPENDING ANY MONEY]** **Asked if Q1=1,2,3,4,5,6,7,8**			How much did your household spend on PRIVATE TUITIONS for [NAME] during… **[ENTER 0 IF NOT SPENDING ANY MONEY]** **Asked if Q1=1,2,3,4,5,6,7,8**			How much did your household spend on TEXTBOOKS for [NAME] during… **[ENTER 0 IF NOT SPENDING ANY MONEY]** **Asked if Q1=1,2,3,4,5,6,7,8**			How much did your household spend on SCHOOL UNIFORMS for [NAME] during… **[INCLUDE SOCKS, TIES, MATERIALS, TAILORING CHARGES. ENTER 0 IF NOT SPENDING ANY MONEY]** **Asked if Q1=1,2,3,4,5,6,7,8**		
2nd term this year	1st term this year	3rd term the last year	2nd term this year	1st term this year	3rd term the last year	2nd term this year	1st term this year	3rd term the last year	2nd term this year	1st term this year	3rd term the last year

For all persons aged 5 years or above. Answer cells omitted.

SECTION 5: ECONOMIC ACTIVITY AND NON-FARM INCOME

INTRODUCTION: I am now going to ask about the economic activity status of each member aged 5 or above of your household.

1	2
What is [NAME]'s main current economic activity status? **[FOR THOSE ENGAGING IN FARMING, FISHING and FORESTRY: If he/she works for non-household members and receives wages, choose IN WAGE EMPLOYMENT.** **IF HE/SHE IS MAID/NANNY/HOUSE-SERVANT IN THIS HOUSEHOLD: Record OTHER even if he/she receives wages.]** 1: IN WAGE EMPLOYMENT 2: RUNNING A BUSINESS/ SELF EMPLOYED BUT NON FARM 3: FARMING 4: FISHING 5: FORESTRY 6: PIECEWORK 7: UNPAID FAMILY WORKER / ASSISTING NON-FARM FAMILY BUSINESS WITHOUT WAGE 8: NOT WORKING BUT LOOKING FOR WORK/MEANS TO DO BUSINESS 9: NOT WORKING AND NOT LOOKING FOR WORK/MEANS TO DO BUSINESS (BUT AVAILABLE TO DO SO) 10: FULL TIME STUDENT 11: HOME MAKER / HOUSEWIFE 12: RETIRED / TOO OLD TO WORK 13: TOO YOUNG TO WORK 14: OTHER	What type of job/business is [NAME] doing? **Asked if Q1=1,2,6,7** 1: MANAGERS 2: PROFESSIONALS 3: TECHNICIANS AND ASSOCIATE PROFESSIONALS 4: CLERICAL SUPPORT WORKERS 5: SERVICE AND SALES WORKERS 6: SKILLED AGRICULTURAL, FORESTRY AND FISHERY WORKERS 7: CRAFT AND RELATED TRADES WORKERS 8: PLANT AND MACHINE OPERATORS, AND ASSEMBLERS 9: COLLECTING MINERALS FROM BLACK MOUNTAIN 10: OTHER ELEMENTARY OCCUPATIONS 11: ARMED FORCES 12: OTHER/ NOT STATED

SECTION 5: ECONOMIC ACTIVITY AND NON-FARM INCOME (CONT'D)

INTRODUCTION: I am now going to ask about the economic activity status of each member aged 5 or above of your household.

3	4	5
What sort of business/service is carried out by [NAME]'s employer / establishment / business? **Asked if Q1=1,2,6,7** 1: AGRICULTURE, FORESTRY & FISHERIES 2: MINING AND QUARRYING 3: MANUFACTURING 4: ELECTRICITY, GAS, STREAM AND AIR CONDITIONING SUPPLY 5: WATER SUPPLY, SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES 6: CONSTRUCTION 7: TRADE, WHOLESALE, AND RETAIL DISTRIBUTION 8: TRANSPORTATION AND STORAGE 9: ACCOMMODATION AND FOOD SERVICE ACTIVITIES 10: INFORMATION AND COMMUNICATION 11: FINANCIAL AND INSURANCE ACTIVITIES 12: REAL ESTATE ACTIVITIES 13: PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES 14: ADMINISTRATIVE AND SUPPORT SERVICES 15: PUBLIC ADMINISTRATION AND DEFENSE, COMPULSORY SOCIAL SECURITY 16: EDUCATION 17: HUMAN HEALTH AND SOCIAL WORK 18: ARTS, ENTERTAINMENT AND RECREATION 19: OTHER SERVICE ACTIVITIES 20: ACTIVITIES OF HOUSEHOLD AS EMPLOYERS 21: ACTIVITIES OF EXTRATERRITORIAL ORGANIZATION AND BODIES 22: OTHER / NOT STATED	What is [NAME]'s employment status? 1: CENTRAL GOVT EMPLOYEE 2: LOCAL GOVT/COUNCIL EMPLOYEE 3: PARASTATAL/ QUASI-GOVT EMPLOYEE 4: PRIVATE SECTOR EMPLOYEE 5: NGO EMPLOYEE 6: INT'L ORGANISATION/ EMBASSY EMPLOYEE 7: HOUSEHOLD EMPLOYEE 8: OTHER **Asked if Q1=1**	How much is [NAME]'s regular gross monthly salary/wage from this job? **[INCLUDE REGULAR ALLOWANCES (HOUSING, TRANSPORT, ETC) AND REGULAR OVERTIME RETENTION ALLOWANCE.]** **Asked if Q1=1**

SECTION 5: ECONOMIC ACTIVITY AND NON-FARM INCOME (CONT'D)

6	7	8	9	10
How much non regular allowances did [NAME] receive last month from this job? **[E.g. OVERTIME PAYMENTS, SUBSISTENCE ALLOWANCES, BONUSES, ETC.]** **Asked if Q1=1**	**How much income did [NAME] receive from this business in the last one month?** Asked if Q1=2, 6	How much income in-kind do [NAME] receive per month (e.g. bags of mealie meal, charcoal) from this job / business? **[CONVERT TO KWACHA EQUIVALENT]** **Asked if Q1=1, 2, 6**	In this job/business, is [NAME] entitled to pension, gratuity or social security? 1: YES 2: NO **Asked if Q1=1,2,3,4,5,6**	Is [NAME] entitled to paid leave in this job / business? 1: YES 2: NO **Asked if Q1=1,2,3,4,5,6**

SECTION 5: ECONOMIC ACTIVITY AND NON-FARM INCOME (CONT'D)					
11A	**11B**	**12**	**13**	**14**	**15**
Does [NAME] employ any worker in this business? 1: YES 2: NO [DO NOT COUNT FAMILY MEMBERS ASSISTING THE BUSINESS WITHOUT PAYMENT.] Asked if Q1=2	Are there five (5) or more people working in this company/business including the owner? 1: YES 2: NO [INCLUDING ALL WORKERS IN ALL BRANCHES OF THE SAME COMPANY/BUSINESS] Asked if Q1=1,6 OR Q11A=1	Does [NAME] have another job/business? 1: YES 2: NO **Asked if Q1=1-7**	In this job/business, is [NAME] …? 1: IN WAGE EMPLOYMENT 2: RUNNING A BUSINESS/ SELF EMPLOYED BUT NON FARM 3: FARMING 4: FISHING 5: FORESTRY 6: PIECEWORK 7: UNPAID FAMILY WORKER / ASSISTING NON-FARM FAMILY BUSINESS WITHOUT WAGE 14: OTHER **Asked if Q12=1**	What type of job/business is this? **The same answer options as in Q2** **Asked if Q13=1,2,6,7**	What sort of business/service is carried out by [NAME]'s employer/ establishment/ business in this job/ business? **The same answer options as in Q3** **Asked if Q13=1,2,6,7**

SECTION 5: ECONOMIC ACTIVITY AND NON-FARM INCOME (CONT'D)					
16	**17**	**18**	**19**	**20**	**21**
What is [NAME]'s employment status in this job? **The same answer options as in Q4.** **Asked if Q13=1**	How much is [NAME]'s regular gross monthly salary/wage from this job? **[INCLUDE REGULAR ALLOWANCES (HOUSING, TRANSPORT, ETC) AND REGULAR OVERTIME RETENTION ALLOWANCE.]** **Asked if Q13=1**	How much non regular allowances did [NAME] receive last month from this job? **[E.g. OVERTIME PAYMENTS, SUBSISTENCE ALLOWANCES, BONUSES, ETC.]** **Asked if Q13=1**	**How much income did [NAME] receive from this business in the last one month?** Asked if Q13=2, 6	How much income in-kind do you receive per month (e.g. bags of mealie meal, charcoal, etc) from this job / business? **Asked if Q13=1, 2, 6**	In this job/business, is [NAME] entitled to pension, gratuity or social security? 1: YES 2: NO **Asked if Q13=1,2,3,4,5,6**

SECTION 5: ECONOMIC ACTIVITY AND NON-FARM INCOME (CONT'D)				
22	**23A**	**23B**	**24**	**25**
Is [NAME] entitled to paid leave in this job/business? 1: YES 2: NO **Asked if Q13=1,2,3,4,5,6**	Does [NAME] employ any worker in this business? 1: YES 2: NO [DO NOT COUNT FAMILY MEMBERS ASSISTING THE BUSINESS WITHOUT PAYMENT.] Asked if Q13=2	Are there five (5) or more people working in this company/business including the owner? 1: YES 2: NO [INCLUDING ALL WORKERS IN ALL BRANCHES OF THE SAME COMPANY/BUSINESS] Asked if Q13=1,6 OR Q23A=1	Is [NAME] currently engaged in any other income generating activities or farming? 1: YES 2: NO **Asked if Q12=1**	What type of job/business is [NAME] doing as the other income generating activities or farming? 1: IN WAGE EMPLOYMENT 2: RUNNING A BUSINESS/ SELF EMPLOYED BUT NON FARM 3: FARMING 4: FISHING 5: FORESTRY 6: PIECEWORK 7: UNPAID FAMILY WORKER / ASSISTING NON-FARM FAMILY BUSINESS WITHOUT WAGE 14: OTHER **Asked if Q24=1**

SECTION 5: ECONOMIC ACTIVITY AND NON-FARM INCOME (CONT'D)					
26	**27**	**28**	**29**	**30**	**31**
During the last 7 days, did [NAME] engage in any of the following economic activities? -WAGE LABOUR -A BUSINESS/ SELF EMPLOYED WORK -FARMING -FISHING -FORESTRY -PIECEWORK -UNPAID FAMILY WORK 1: YES 2: NO **[INCLUDE THE MAIN, SECOND AND THIRD JOBS / BUSINESSES (IF ANY).]** **Asked if Q1=1-7.**	How many hours did [NAME] work for those economic activities during the last 7 days? **[RECORD THE NUMBER OF HOURS IN TOTAL]** **Asked if Q26=1**	Are the hours worked during the last 7 days …? 1: LONGER THAN USUAL 2: THE SAME AS USUAL 3: SHORTER THAN USUAL 4: NOT APPLICABLE / DON'T KNOW **Asked if Q26=1**	(FOR THOSE NOT WORKING OR WORKING LESS THAN USUAL DURING THE LAST 7 DAYS) How many hours per week would [NAME] usually work? **[[RECORD THE NUMBER OF HOURS IN TOTAL.]** **Asked if Q26=2 OR Q28A=3**	What was the main reason that [NAME] did fewer hours than usual/away from the economic activities in the last 7 days? 1: NUMBER OF HOURS WORKED VARIES BY THE NATURE OF THE WORK 2: STUDY, TRAINING 3: HOUSEWORK 4: PREGNANCY 5: OWN ILLNESS (PHYSICALLY/MENTALLY) 6: FATIGUE, EXHAUSTION, LACK OF CONCENTRATION 7: INJURY, DISABILITY 8: CARING FOR (PHYSICALLY / MENTALLY) ILL MEMBERS 9: CARING FOR INJURED OR DISABLED MEMBERS 10: CARING FOR OTHER ELDERLY / CHILDREN 11: OFF-SEASON 12: OTHER REASONS 13: DON'T KNOW **Asked if Q26=2 OR Q28A=3**	In the last 12 months, how many days of the economic activities did [NAME] miss owing to his/her own or family members' illness and injuries? 1: 0 days 2: 1–2 days 3: 3–5 days 4: 6–10 days 5: 11–15 days 6: 16+ days **Asked if Q1=01-07.**

SECTION 5: ECONOMIC ACTIVITY AND NON-FARM INCOME (CONT'D)					
32	**33**	**34**	**35**	**36**	**37**
During the last 12 months, did [NAME] change employment/ businesses? 1: YES 2: NO **Asked if Q1=1-7.**	What was the main reason for leaving that job/business? 1: LOW WAGE./SALARY 2: FIRED/DISMISSED 3: ENTERPRISE CLOSED 4: ENTERPRISE PRIVATISED 5: ENTERPRISE LIQUIDATED 6: RETRENCHED/DECLARED REDUNDANT 7: GOT ANOTHER JOB 8: BANKRUPTCY 9: LACK OF PROFIT 10: WAS A TEMPORARY JOB 11: RETIRED 12: CONTRACT EXPIRED 13: POOR WORKING CONDITIONS 14: ILNESS/ DISABILITY 15: PREGNANCY 16: OTHER **Asked if Q32=1**	Did you have a job or business in the last 12 months? 1: YES 2: NO **Asked if Q1=8-14.**	What was the main reason for leaving that job/business? 1: LOW WAGE./SALARY 2: FIRED/DISMISSED 3: ENTERPRISE CLOSED 4: ENTERPRISE PRIVATISED 5: ENTERPRISE LIQUIDATED 6: RETRENCHED/DECLARED REDUNDANT 7: GOT ANOTHER JOB 8: BANKRUPTCY 9: LACK OF PROFIT 10: WAS A TEMPORARY JOB 11: RETIRED 12: CONTRACT EXPIRED 13: POOR WORKING CONDITIONS 14: ILNESS/ DISABILITY 15: PREGNANCY 16: BECAME A STUDENT 17: OTHER **Asked if Q34=1**	How much did you receive as pension payment per month? **[TYPE 0 IF NOT RECEIVING ANY PENSION.]**	How much income in form of grants do you receive per month (both cash and in-kind)? **[CONVERT IN-KIND TO CASH. TYPE 0 IF NOT RECEIVING ANY GRANT.]**

SECTION 6: AGRICULTURAL PRODUCTION

Q1A	Did any member of this household grow or anybody grow on their behalf any food crops in the last twelve (12) months?	1: YES / 2: NO
Q1B	Did any member of this household own any livestock or poultry in the last twelve (12) months?	1: YES / 2: NO
Q1C	Did any member of this household engage in fish farming, forestry, or any other income generating activity related to agriculture in the last twelve (12) months?	1: YES / 2: NO

SUB-SECTION 6A: FOOD CROP PRODUCTION (asked if Q1A==1)

CROPS	**AQ1** Did any member of this household or anybody grow on their behalf any [ITEM] in the last twelve months? 1: YES 2: NO	**AQ 2** Is [ITEM] planted in 1: Home garden 2: Farm land **Asked if AQ1=1**	**AQ 3A** What was the area planted under [ITEM]? **UNIT** 1: LIMA 2: ACRE 3: HECTARE **Asked if AQ1=1**	**AQ 3B**	**AQ 4A** From what you planted, what quantity of [ITEM] did all the members of the household harvest? **[Unit codes from the list below]** **Asked if AQ1=1**	**AQ 4B**	**AQ 5A** What quantity of [ITEM] did all the members of the household sell in the last twelve (12) months? **[Unit codes from the list below]** **Asked if AQ1=1**	**AQ 5B**	**AQ 6** How much was realised from the sale of [ITEM]? **[Total value in KWACHA]** **Asked if AQ1=1**	**AQ 7** Did your household consume own-produced [ITEM] in the last twelve months? 1: YES 2: NO **Asked if AQ1=1**	**AQ 8** How much would you receive for own-consumed [ITEM] if you were to sell them? **[Total value in KWACHA]** **Asked if AQ7=1**
			AREA	UNIT	Amount	Unit	Amount	Unit			
1 Local Maize											
2 Hybrid Maize											
3 Cassava											
4 Millet											
5 Sorghum											
6 Rice											
7 Mixed beans											
8 Soya beans											
9 Sweet potatoes											
10 Irish Potatoes											
11Groundnuts											
12 Root vegetable (e.g. carrot)											
13 Fruit Vegetable (e.g. tomato)											
14 Leaf vegetable (e.g. cabbage)											
15 Cotton											
16 Tobacco											
17 Sunflower											
18 Paprika											
19 Flowers											
20 Other crops											

[UNIT CODES]	KG…1	20 Ltr Tin…2	25KG Bag...3	50KG Bag…4	90KG Bag...5

SUBSECTION 6B: LIVESTOCK AND POULTRY (asked if Q1B==1)

Livestock and poultry	BQ 1 Did any member of your household own / produce [ITEM] in the last twelve months? 1: YES 2: NO	BQ 2 How many [ITEM] does your household own NOW? **Asked if BQ1=1**	BQ 3 Did your household sell any [ITEM] in the last twelve months? 1: YES 2: NO **Asked if BQ1=1**	BQ 4 How many [ITEM] did your household sell in the last twelve months? **Asked if BQ3=1**	BQ 5 How much income did your household receive from the sale of [ITEM] in the last twelve (12) months **[VALUE IN KWACHA]** **Asked if BQ3=1**	BQ 6 Did your household consume own-produced [ITEM] in the last twelve (12) months? 1: YES 2: NO **Asked if BQ1=1**	BQ 7 Hou much would you receive for own- consumed [ITEM] if you were to sell them? **[VALUE IN KWACHA]** **Asked if BQ6=1**
1 Cattle							
2 Goats							
3 Sheep							
4 Pigs							
5 Chickens							
6 Guinea fowls							
7 Ducks and geese							
8 Turkeys							
9 Rabbits							
10 Pigeons							
11 quails							
12 Other livestocks and poultry							
13 Eggs		[redacted]		[redacted]			
14 Other livestock products (e.g. milk, yoghurt, fat, cheese, hides)							

SUBSECTION 6C: FISH FARMING, FORESTRY, AND OTHER FARMING PRODUCTION (asked if Q1C==1)

CQ 1	Did your household harvest or collect in FISH FARMING in the last twelve months?	1: YES / 2: NO
CQ 2	How much did your household harvest or collect in FISH FARMING in the last twelve months? [in KG] **[VALUE IN KWACHA] Asked if CQ1=1**	
CQ 3	How many fish did your household sell in the last twelve months? [in KG] **Asked if CQ1=1**	
CQ 4	How much did your household receive from the sale of FISH? **[VALUE IN KWACHA] Asked if CQ1=1**	
CQ 5	Did your household consume own-harvested (collected) FISH in the last twelve months? **Asked if CQ1=1**	1: YES / 2: NO
CQ 6	How much would you pay for own-consumed FISH if you were to buy them? **[VALUE IN KWACHA] Asked if CQ5=1**	
CQ 7	Did your household harvest or collect in FORESTRY in the last twelve months?	1: YES / 2: NO
CQ 8	How much did your household receive from the sale of FORESTRY PRODUCT? **[VALUE IN KWACHA] Asked if CQ7=1**	
CQ 9	Did your household consume own-harvested (collected) FORESTRY PRODUCTS in the last twelve months? **Asked if CQ7=1**	1: YES / 2: NO
CQ 10	How much would you pay for own-consumed FORESTRY PRODUCTS if you were to buy them? **[VALUE IN KWACHA] Asked if CQ9=1**	
CQ 11	In the last twelve months, did your household receive any other source of farming income (lease of tractor, agricultural land, scotch cart, lease of transport for produce, hiring out of draught animals, etc.)	1: YES / 2: NO
CQ 12	How much income did your household receive from those activities? **[VALUE IN KWACHA] Asked if CQ11==1**	

SUBSECTION 6D: FARMING COSTS & EXPENSES [ASKED IF Q1A=1]					
	DQ 1	**DQ 2**	**DQ 3**	**DQ 4**	**DQ 5**
ITEMS	Did you use /incur [ITEM] during the last twelve months? 1: YES 2: NO	How much was spent in cash and in kind on [ITEM] in the last twelve months? **[VALUE IN KWACHA. CONVERT IN KIND TO CASH EQUIVALENT]** **Asked if DQ1=1**	What was the source of the [ITEM]? 1: PRIVATE SECTOR 2: COOPERATIVES 3: MIN OF AGRICULTURE 4: MIN COMMUNITY DEVT 5: NGOs 6: OTHER **Asked if DQ1=1**	Was/were the [ITEM] obtainable / available during the last twelve months when needed? 1: YES SOMETIMES 2: YES ALL THE TIME 3: NO 4: NOT APPLICABLE / DON'T KNOW	Why was the [ITEM] unobtainable? 1: INPUT MARKET TOO FAR 2: INPUTS WERE NOT ENOUGH 3: LATE DELIVERY OF INPUTS 4: TOO EXPENSIVE 5: OTHER **Asked if DQ4=1, 3**
1. Fertilizer (Inorganic)					
2. Organic Fertilizer					
3. Insecticides					
4. Herbicides					
5. Any crop storage facility					
6. Purchased seed, seedlings etc					
7. Irrigation equipment					
8. Bags, containers, strings					
9. Petrol/ diesel/ oil					
10. Repairs/ maintenance of agricultural equipment including purchase of spare parts					
11. Hired labour					
12. Any transport costs					
13. Hired animals					
14. Hired equipment					
15. Local hand tools					
16. Imported hand tools					
17. Any other crop production related costs					

SUBSECTION 6E: LIVESTOCK & POULTRY COSTS [ASKED IF Q1B=1]

	EQ 1	EQ 2	EQ 3	EQ 4	EQ 5
ITEMS	Did you use /incur [ITEM] during the last twelve months? 1: YES 2: NO	How much was spent in cash and in kind on [ITEM] during the last twelve months? **[CONVERT IN KIND TO CASH EQUIVALENT]** **Asked if EQ1=1**	What was the source of the [ITEM]? 1: PRIVATE SECTOR 2: COOPERATIVES 3: MIN OF AGRICULTURE 4: MIN COMMUNITY DEVT 5: NGOs 6: OTHER **Asked if EQ1=1**	Was/were the [ITEM] obtainable/available during the last twelve months when needed? 1: YES SOMETIMES 2: YES ALL THE TIME 3: NO 4: NOT APPLICABLE / DON'T KNOW	Why was the [ITEM] unobtainable? 1: INPUT MARKET TOO FAR 2: INPUTS WERE NOT ENOUGH 3: LATE DELIVERY OF INPUTS 4: TOO EXPENSIVE 5: OTHER **Asked if EQ4=1,3**
1. Animal Feed including salt					
2. Veterinary services (incl vaccination & medicine)					
3. Any hired labour					
4. Maintenance of pens, stables					
5. Transport costs					
6. Commission on sale of animals					
7. Compensation for damage caused by animals					
8. Any other livestock production related costs					

SUBSECTION 6F: FISH FARMING & FORESTRY COSTS [ASKED IF Q1C=1]

	FQ 1	FQ 2	FQ 3	FQ 4	FQ 5
ITEMS	Did you use /incur [ITEM] during the last twelve months? 1: YES 2: NO	How much was spent in cash and in kind on [ITEM] during the last twelve months? **[CONVERT IN KIND TO CASH EQUIVALENT]** **Asked if FQ1=1**	What was the source of the [ITEM]? 1: PRIVATE SECTOR 2: COOPERATIVES 3: MIN OF AGRICULTURE 4: MIN COMMUNITY DEVT 5: NGOs 6: OTHER **Asked if FQ1=1**	Was/were the [ITEM] obtainable/available during the last twelve months when needed? 1: YES SOMETIMES 2: YES ALL THE TIME 3: NO 4: NOT APPLICABLE / DON'T KNOW	Why was the [ITEM] unobtainable? 1: INPUT MARKET TOO FAR 2: INPUTS WERE NOT ENOUGH 3: LATE DELIVERY OF INPUTS 4: TOO EXPENSIVE 5: OTHER **Asked if FQ4=1,3**
1. Purchase of fingerlings					
2. Feed					
3. Hired labour					
4. Repairs & Maintenance of fish ponds					
5. Repairs & Maintenance of fish pond related equipment					
6. Medicines for fish					
7. Transport costs					
8. Hand tools					
9. Other fish farming production related costs					
10. Forestry costs					

SECTION 7: OTHER INCOME	
INTRODUCTION: I would like to ask about income from other sources in the last twelve months.	
1	RENT: What was the value of rent your household received in the twelve months? [Rent for houses, other buildings, non-agricultural equipment and non-agricultural land you own] **[VALUE IN KWACHA. ENTER 0 IF NO INCOME FROM THIS SOURCE]**
2	SAVING INTEREST: What was the value of interest on savings your household received in the last twelve months? **[VALUE IN KWACHA. ENTER 0 IF NO INCOME FROM THIS SOURCE]**
3	SHARES, SECURITIES, BONDS: What was the value of interest or dividends on shares, securities, bonds, treasury bills, etc your household received in the last twelve months? **[VALUE IN KWACHA. ENTER 0 IF NO INCOME FROM THIS SOURCE]**
4	REMITTANCES: What was the value of remittances your household received in the last twelve months? **[VALUE IN KWACHA. ENTER 0 IF NO INCOME FROM THIS SOURCE]**
5	GIFT: What was the value of gifts your household received in the last twelve months? (E.g. Ceremony gifts, small food gifts from neighbors, relief food. DO NOT include in-kind payment from jobs) **[VALUE IN KWACHA. CONVERT IN-KIND GIFTS INTO KWACHA EQUIVALENT. ENTER 0 IF NOT RECEIVE THIS SOURCE OF INCOME]**
6	Does your household receive income from any other source? If so, how much was it in the last twelve months? **[VALUE IN KWACHA. ENTER 0 IF NOT RECEIVE THIS SOURCE OF INCOME]**
7	(CHANGE IN REFERENCE PERIOD) Did you borrow in cash or in kind in the LAST MONTH? If so, how much did your household borrow, including both CASH and IN-KIND? **[VALUE IN KWACHA. CONVERT IN-KIND BORROWING TO KWACHA EQUIVALENT. INCLUDE BORROWING THAT WAS ALREADY REPAID. TYPE 0 IF NOT BORROWING.]**

Section 8: HOUSEHOLD ASSETS & DURABLES

I would like to ask you about whether your household owns the following assets or durable goods. Does your household own ...?
[DO NOT COUNT PERMANENTLY BROKEN ITEMS OR ITEMS BORROWED FROM SOMEONE]
1: YES
2: NO

GENERAL ITEMS		
1	Bed	
2	Mattress	
3	Mosquito net	
4	Table (dinning)	
5	Lounge suit / sofa	
6	Radio / Stereo	
7	Television	
8	Satellite dish / decoder (free to air)	
9	Satellite dish / decoder (DSTV)	
10	Other pay TV	
11	DVD / VCR	
12	Home theater	
13	Land phone	
14	Cellular phone	
15	Computer	
16	Watch	
17	Clock	

KITCHEN / HOUSEHOLD		
18	Residential building	
19	Non-residential building	
20	Brazier / Mbaula	
21	Gas stove	
22	Electric stove	
23	Refrigerator	
24	Deep freezer	
25	Washing machine	
26	Dish washer	
27	Air conditioner / ventilator	
28	Electric iron	
29	Non-electric iron	
30	Private water pump	

TOOLS & MACHINES		
31	Sewing machine	
32	Hand hammer mill	
33	Grinding / hammer mill (powered)	
34	Sheller	
35	Ramp presses / oil expellers	
36	Hand saw	
37	Carpentry plane	
38	Axe	
39	Pick	
40	Hoe	
41	Hammer	
42	Shovel / spade	
43	Fishing net	
44	Hunting gun	
45	Plough	
46	Crop sprayer	
47	Knitting machine	
48	Lawn mowers	
49	Generator	

TRANSPORT		
50	Small / hand-driven tractor	
51	4 wheel tractor	
52	Wheel barrow	
53	Scotch cart	
54	Bicycle	
55	Motor cycle	
56	Large truck	
57	Small / pick-up truck	
58	Van / minibus	
59	Car	
60	Canoe	
61	Boat	

ANIMALS		
62	Oxen	
63	donkey	

SECTION 9: HOUSEHOLD AMENITIES AND HOUSING CONDITIONS

INTRODUCTION: I am now going to ask you about various amenities and housing conditions

No.	QUESTION	CATEGORY AND CODE		ANSWER
1	What kind of dwelling does your household live in?	1: TRADITIONAL HUT 2: IMPROVED TRADITIONAL HOUSE 3: DETACHED HOUSE 4: FLAT/APARTMENT/MULTI-UNIT 5: SEMI-DETACHED HOUSE 6: SERVANTS QUARTERS 7: GUEST WING 8: COTTAGE	9: HOUSE ATTACHED TO/ ON TOP OF SHOP ETC 10: HOSTEL 11: NON-RESIDENTIAL BUILDING (EG SCHOOL CLASSROOM, ETC) 12: UNCONVENTIONAL (EG KANTEMBA, STORAGE CONTAINER, ETC) 13: OTHER	
2	How many rooms are occupied by this household excluding bathrooms and toilets? (For rural areas count the number of rooms in each hut belonging to the household collectively)			
3	On what basis does your household occupy the dwelling you live in? Is it […]?	1: Owner-occupied 2: Rented from local Government (District council) 3: Rented from Central Government 4: Rented from Private Company	5: Rented from Parastatal (e.g. ZSIC, NAPSA, NHA, ZIMCO, etc) 6: Rented from private persons (landlord) 7: House owned and provided free by employer 8: Other free housing 9: Other	
4	How is the rent paid? Is it […]? **Asked if Q3=2-6**	1: Deducted from salary but paid in full 2: Deducted from salary and subsidized by employer 3: Paid directly by the household	4: Paid by employer 5: Other 6: Not applicable 7: Don't know	
5A	In what installments or period do you pay your rent? **Asked if Q4=1-3**	Monthly Every two (2) months Every three (3) months	Every six (6) months Other Not applicable	
5B	How much rent do you pay per month? **Asked if Q4=1-3**		AMOUNT IN KWACHA	
5C	Does this rent include charges for electricity? 1: YES / 2: NO **Asked if Q4=1-3**			
5D	Does this rent include charges for water? 1: YES / 2: NO **Asked if Q4=1-3**			
6	If you were to rent out this house, how much would it fetch per month (excl water and electricity)?		AMOUNT IN KWACHA	
7A	How much do you pay for ground rates per year? **Asked if Q3=1**		AMOUNT IN KWACHA	
7B	How much do you pay for property rates per six months? **Asked if Q3=1**		AMOUNT IN KWACHA	
7C	Do you pay mortgage for your dwelling? 1: YES / 2: NO **Asked if Q3=1**			
7D	How much do you pay for mortgage per month? **Asked if Q3=1**		AMOUNT IN KWACHA	
8A	What kind of building materials is the ROOF of this dwelling made of?	1: ASBESTOS SHEETS 2: ASBESTOS TILES 3: OTHER/ NON-ASBESTOS TILES 4: IRON SHEETS 5: GRASS/STRAW/THATCH	6: CONCRETE 7: OTHER 8: NOT APPLICABLE 9: DON'T KNOW	
8B	What kind of building materials is/are the WALLS of this dwelling made of?	1: PAN BRICK 2: CONCRETE BRICK 3: MUD BRICK 4: BURNT BRICK 5: POLE 6: POLE & DAGGA 7: MUD 8: GRASS/STRAW	9: IRON SHEETS 10: STEEL 11: HARDBOARD 12: A MIXTURE OF HARDBOARD, TIN SHEET, PLASTIC, ETC 13: OTHER 14: NOT APPLICABLE 15: DON'T KNOW	
8C	What kind of building materials is the FLOOR of this dwelling made of?	1: CONCRETE ONLY 2: COVERED CONCRETE 3: MUD 4: WOOD ONLY	5: OTHER 6: NOT APPLICABLE 7: DON'T KNOW	
9	What is the **main** source of water supply for this household? **[ASK ABOUT NON-DRINKING WATER.]**	1: DIRECTLY FROM RIVER/ LAKE/ STREAM/DAM 2: RAINWATER 3: UNPROTECTED WELL 4: PROTECTED WELL 5: BOREHOLE 6: UNPROTECTED SPRING	7: PROTECTED SPRING 8: PUBLIC TAP 9: OWN TAP 10: OTHER TAP (EG FROM NEARBY BUILDING) 11: WATER KIOSK 12: BOUGHT FROM OTHER VENDORS 13: OTHER	
10	How far is this source of water from this house? **[RECORD 'LESS THAN 1 KM' IF OWN TAP]**	1: LESS THAN 1 KM (LESS THAN 15-MINUTE WALK) 2: ABOUT 1 KM (15-MINUTE WALK) 3: ABOUT 2 KM (30-MINUTE WALK)	4: ABOUT 3 KM (45-MINUTE WALK) 5: ABOUT 4 KM (1-HOUR WALK) 6: GREATER THAN 4 KM (GREATER THAN 1-HOUR WALK) 7: NOT APPLICABLE / DON'T KNOW	

SECTION 9: HOUSEHOLD AMENITIES AND HOUSING CONDITIONS (cont'd)			
No.	QUESTION	CATEGORY AND CODE	ANSWER
11	What is the **main** source of **drinking water** for this household?	1: DIRECTLY FROM RIVER/ LAKE/ STREAM/DAM 2: RAINWATER 3: UNPROTECTED WELL 4: PROTECTED WELL 5: BOREHOLE 6: UNPROTECTED SPRING 7: PROTECTED SPRING 8: PUBLIC TAP 9: OWN TAP 10: OTHER TAP (EG FROM NEARBY BUILDING) 11: WATER KIOSK 12: BOUGHT FROM OTHER VENDORS 13: BOTTLED WATER 14: OTHER	
12	Do you treat your drinking water? 1: YES / 2: NO **[YES ONLY IF TREATMENT IS DONE BY HOUSEHOLD.]**		
13	How do you treat your drinking water? 1: BOIL / 2: ADD CHLORINE / 3: OTHER **Asked if Q12=1**		
14	How much on average are you charged for water per month? **[ENTER "0" IF HOUSEHOLD IS PROVIDED WITH WATER FOR FREE]** **Asked if Q5D is not YES**	AMOUNT IN KWACHA	
15	What is the main type of energy used for lighting in your household?	1: KEROSINE/PARAFFIN 2: ELECTRICITY 3: SOLAR PANEL 4: CANDLE 5: DIESEL 6: OPEN FIRE 7: TORCH 8: NONE 9: OTHER	
16	What is the main type of energy that your household uses for cooking?	1: COLLECTED FIREWOOD 2: PURCHASED FIREWOOD 3: CHARCOAL OWN PRODUCED 4: CHARCOAL PURCHASED 5: COAL 6: KEROSINE/PARAFFIN 7: GAS 8: ELECTRICITY 9: SOLAR 10: CROP/LIVESTOCK RESIDUES 11: OTHER	
17	What is the main type of cooking device used by your household?	1: STOVE/COOKER…1 2: BRAZIER (MBAULA) 3: CLAY STOVE (MBAULA) 4: BRICK/STONE STAND ON OPEN FIRE 5: METAL STAND ON OPEN FIRE 6: VEHICLE TYRE RIM 7: HOT PLATE WITHOUT STAND 8: HOT PLATE ON WELDED STAND 9: OTHER	
18	Is your house connected to electricity? 1: YES / 2: NO		
19	How much on average are you charged for electricity per month? [ENTER "0" IF HOUSEHOLD IS PROVIDED WITH ELECTRICITY FOR FREE] **Asked if Q18 is YES but Q5D is not YES**	AMOUNT IN KWACHA	
20	What is the main type of toilet facility used by this household?	1: OWN FLUSH TOILET INSIDE THE HOUSEHOLD 2: OWN FLUSH TOILET OUTSIDE THE HOUSEHOLD 3: OWN PIT LATRINE WITH SLAB 4: COMMUNAL PIT LATRINE WITH SLAB 5: NEIGHBOUR'S/ ANOTHER HOUSEHOLD'S PIT LATRINE WITH SLAB 6: OWN PIT LATRINE WITHOUT SLAB 7: COMMUNAL PIT LATRINE WITHOUT SLAB 8: NEIGHBOUR'S/ ANOTHER HOUSEHOLD'S PIT LATRINE WITHOUT SLAB 9: BUCKET/ OTHER CONTAINER 10: AQUA PRIVY 11: NONE 12: OTHER	
21	If flush/ pour flush: Where is the sewerage piped into? **Asked if Q20=1,2**	1: PIPED SEWER SYSTEM 2: SEPTIC TANK 3: PIT LATRINE 4: OTHER 5: DON'T KNOW	
22	What is the main method of garbage disposal that this household uses?	1: REFUSE COLLECTED 2: PIT 3: DUMPING 4: BURNING 5: OTHER	
23	Is there a farm land where any member of this household can cultivate any food crops on their behalf? 1: YES / 2: NO		
24A	What is the total size of the farm land? **Asked if Q23=1**	[AREA]	
24B		[UNIT] 1: LIMA / 2: ACRE / 3: HECTARE	
25	Is there a home garden where any member of this household can cultivate any food crops on their behalf? 1: YES / 2: NO		
26A	What is the total size of home garden? **Asked if Q25=1**	[AREA]	
26B		[UNIT] 1: LIMA / 2: ACRE / 3: HECTARE	

SECTION 10 HOUSEHOLD EXPENDITURE

Cereals DURING LAST 4 WEEKS

	ITEMS	Q1 Did your household purchase / consume [ITEM] during the last 4 weeks? 1: YES 2: NO	Q2A How many (much) [ITEM] did your household purchase? Asked if Q1=1 — QUANTITY	Q2B — UNIT CODE	Q3 How much did your household spend on [ITEM]? (IN TOTAL) Asked if Q1=1 — VALUE IN KWACHA	Q4 When purchasing, was [ITEM] shelled or unshelled? 1: SHELLED 2: UNSHELLED 3: BOTH 4: DON'T KNOW Asked if Q1=1
1	Maize grain					
2	breakfast mealie meal					
3	Roller meal					
4	Hammer mealie meal					
5	Pounded maize meal					
6	Cost of milling					

SECTION 10 HOUSEHOLD EXPENDITURE (Cont.)

Crops & Crop Products DURING LAST 2 WEEKS

	ITEMS	Q5 Did your household purchase / consume [ITEM] during the last 2 weeks? 1: YES 2: NO	Q6A How many (much) [ITEM] did your household purchase? Asked if Q5=1 — QUANTITY	Q6B — UNIT CODE	Q7 How much did your household spend on [ITEM]? (IN TOTAL) Asked if Q5=1 — VALUE IN KWACHA	Q8 When purchasing, was [ITEM] shelled or unshelled (unpeeled or peeled)? 1: SHELLED/UNPEELED 2: UNSHELLED/PEELED 3: BOTH 4: DON'T KNOW Asked if Q5=1
7	Millet					
8	Sorghum					
9	Rice					
10	Wheat / Flour					
11	Bread / Breadrolls					
12	Buns / scones					
13	Fritters					
14	Other cereal / bread items					
15	Sweet potatoes					
16	Potatoes					
17	Cassava (tubers)					
18	Cassava (flour)					
19	Other roots / tubers					
20	Fresh beans (excl green beans)					
21	Sunflower					
22	Soya beans					
23	Dried beans					
24	Groundnuts					
25	Bambara					
26	Cowpeas					
27	Peas					
28	Other pulses, legumes					
29	Onions					
30	Tomatoes					
31	Cabbages					
32	Rape					
33	Okra					
34	Pumpkin leaves (chibwabwa)					
35	Cassava leaves					
36	Kalem bula					
37	Bondwe					

SECTION 10 HOUSEHOLD EXPENDITURE (cont.)						
Crops & Crop Products DURING LAST 2 WEEKS (cont.)						
ITEMS		**Q5** Did your household purchase / consume [ITEM] during the last 2 weeks? 1: YES 2: NO	**Q6A** How many (much) [ITEM] did your household purchase for these amounts? **Asked if Q5=1** QUANTITY	**Q6B** UNIT CODE	**Q7** How much did your household spend on [ITEM]? (IN TOTAL) **Asked if Q5=1** VALUE IN KWACHA	**Q8** When purchasing, was [ITEM] shelled or unshelled (unpeeled or peeled)? 1: SHELLED/UNPEELED 2: UNSHELLED/PEELED 3: BOTH 4: DON'T KNOW **Asked if Q5=1**
38	Impwa					
39	Cucumber					
40	Green beans					
41	Carrot					
42	Pumpkin					
43	Green maize					
44	Other vegetables					
45	Oranges					
46	Apples					
47	Mangoes					
48	Bananas					
49	Pawpaws					
50	Water melons					
51	Lemons					
52	Pinapples					
53	Pears					
54	Guavas					
55	Avocados					
56	Other fruits					

SECTION 10 HOUSEHOLD EXPENDITURE (cont.)						
Meat, Dairy & Fish DURING LAST 2 WEEKS						
ITEMS		**Q9** Did your household purchase / consume [ITEM] during the last 2 weeks? 1: YES 2: NO	**Q10A** How many [UNITS] of [ITEM] did your household purchase for these amounts? **Asked if Q9=1** QUANTITY	**Q10B** UNIT CODE	**Q11** How much did your household spend on [ITEM]? (IN TOTAL) **Asked if Q9=1** VALUE IN KWACHA	**Q12** When purchasing, was [ITEM] fresh, frozen, dried or smoked? 1: FRESH 2: FROZEN 3: DRIED / SMOKED 4: DON'T KNOW **Asked if Q9=1**
57	Kapenta					
58	Bream					
59	Buka Buka					
60	Other fish					
61	Fish products					
62	Chicken					
63	Other Poultry					
64	Beef					
65	Pork					
66	Goat meat					
67	Sheep meat					
68	Game meat					
69	Other meat					
70	Fresh milk					
71	Powdered milk (excl baby milk)					
72	Eggs					
73	Cheese					
74	Other dairy products					

SECTION 10 HOUSEHOLD EXPENDITURE (cont.)					
MICELLANEOUS DURING LAST 2 WEEKS					
ITEMS		**Q13** Did your household purchase / consume [ITEM] during the last 2 weeks? 1: YES 2: NO	**Q14A** How many [UNITS] of [ITEM] did your household purchase for these amounts? **Asked if Q13=1**	**Q14B**	**Q15** How much did your household spend on [ITEM]? (IN TOTAL) **Asked if Q13=1**
			QUANTITY	UNIT CODE	VALUE IN KWACHA
75	Butter				
76	Margarine				
77	Peanut butter				
78	Other fats (excl cooking oil)				
79	Sugar				
80	Honey				
81	Jam				
82	Cocoa and chocolate				
83	Cremora				
84	Other sweets				
85	Tea leaves / tea bags				
86	Coffee (fresh, blend or instant)				
87	Drinking chocolate / Milo / cocoa				
88	Juice				
89	Soft drinks				
90	Mineral water				
91	Munkoyo				
92	Maheu				
93	Other non-alcoholic beverages				
94	Spirits				
95	Wines				
96	Ciders				
97	Clear beer				
98	Opaque beer				
99	Traditional brews				
100	Other alcoholic beverages				
101	Baby foods (e.g. Cerelac, vitaso, baby milk)				
102	Food from kiosks, cafes, restaurants				
103	Other foods & beverages				
104	Cigarettes				
105	Tobacco				

UNIT CODES	UNITS		UNIT CODES	UNITS
B90	90 KG BAG		BOT500	BOTTLE 500 ML
B50	50 KG BAG		BOT750	BOTTLE 750 ML
B25	25 KG BAG		BOT2.5	BOTTLE 2.5 LT
B10	10 KG BAG		BP	BP
T20	20 LITRE TIN		HP	HEAP
T10	10 LITRE TIN		PL	PLATE
T5	5 LITRE TIN		CU	CUP
P	PIECE/NUMBER		GAL	GALLON
KG	KILOGRAMS		BK	BUCKET
GR	GRAM		BD	BUNDLE
LT	LITRE		MD	MEDA
ML	MILLILITER		OT	OTHER

SECTION 10 HOUSEHOLD EXPENDITURE (cont.)			
MICELLANEOUS DURING LAST 4 WEEKS			
ITEMS		**Q16** Did your household purchase / consume [ITEM] during the last 4 weeks? 1: YES 2: NO	**Q17** How much did your household spend on [ITEM]? (IN TOTAL) **VALUE IN KWACHA** **Asked if Q16=1**
106	Salt		
107	Spices		
108	Cooking Oil		
109	Charcoal		
110	Firewood		
111	Paraffin		
112	Diesel (for lighting and cooking only)		
113	Home repairs (plumbing, painting, stove repaires etc)		
114	Cable/pay TV (DSTV, My TV, SATELITE, ZNBC, etc)		
115	Garbage collection (solid waste)		
116	Gas		
117	Kerosene / fuel for cooking / lighting		
118	Coal, excl charcoal		
119	Batteries, lightbulbs, lighters, matches, candles		
120	Other housing expenses		
121	Bath / hand-washing soap		
122	Laundry detergent		
123	Toothpaste & toothbrushes		
124	Sanitary towels		
125	Toilet paper and other tissues		
126	Cosmetics (eg. lotion, creams, glycerin, make-up, petroleum jellies etc)		
127	Hair care (eg perming, braiding hair, conditioning, shampooing, haircuts, etc)		
128	Laundry service (eg dry cleaning, washing at the laundry, etc)		
129	Baby diapers		
130	Cleaning agents, excl soap and laundry detergents (eg ajax, dish washing liquids or pastes, toilet cleansers, handy andy, air freshners, cobra/polish, etc)		

SECTION 10 HOUSEHOLD EXPENDITURE (cont.)			
MICELLANEOUS DURING LAST 4 WEEKS (cont.)			
ITEMS		**Q16** Did your household purchase / consume [ITEM] during the last 4 weeks? 1: YES 2: NO	**Q17** How much did your household spend on [ITEM]? (IN TOTAL) **VALUE IN KWACHA** **Asked if Q16=1**
131	Insecticides		
132	Other hygiene expenses		
133	Public transport to/from work		
134	Public transport to/from school incl boarding school and abroad		
135	Other public transport		
136	Petrol / diesel / oil		
137	Vehicle maintenance & repairs		
138	Motorbike repairs (tyres, tubes, oil, etc)		
139	Bicycle repairs (tyres, tubes, oil, etc)		
140	Boat / canoe repairs		
141	Other private transport		
142	Mobile phones (connection fees. air time excluding cost of phone)		
143	Landline phones (connection fees, prepaid & postpaid)		
144	Internet (connection and subscription fees)		
145	Postal expenses		
146	Other communication expenses		
147	Entertainment excl alcohol (eg cinema, disco, watching soccer/boxing, video hire, visits to entertainment centres)		
148	Domestic servants		
149	Stationary (eg copies, printing paper, envelopes. excl stationary for education)		
150	Typing services, filling in official forms		

SECTION 10 HOUSEHOLD EXPENDITURE (cont.)			
MICELLANEOUS LAST TWELVE MONTHS			
ITEMS		**Q18** During the last twelve months, did your household purchase / pay for [ITEM]? 1: YES 2: NO	**Q19** How much did your household spend on [ITEM]? (IN TOTAL) VALUE IN KWACHA **Asked if Q18=1**
151	Purchase of medicines		
152	Fees for doctors		
153	Fees for nurses, midwives		
154	Fees for dentists		
155	Fees for hospital stays		
156	Fees for health assistant		
157	Fees for traditional healers		
158	Payment to hospital / health centre / surgery		
159	Pre-payment scheme		
160	Other health expenses		
161	Water Treatment tablets, chemical etc		
162	Other water treatment		
163	Chitenges		
164	Children's clothing		
165	Men's clothing		
166	Women's clothing (excl chitenges)		
167	Fabric / material		
168	Tailoring chitenges		
169	Footwear (eg shoes, sandals, pata pata, sofias)		
170	Loan payments		
171	Contributions to church, mosques, etc		
172	Insurance (car, life, health)		
173	Funerals, gifts, dowries		
174	Contribution to school / PTA		
175	School stationary (exercise books, pens, pencils, rulers, rubbers, math sets, paper)		
176	Purchase of other school requisites (for boarders snacks, mazoe, biscuits, tinned foods)		
177	Other education expenses (graduation ceremonies, tuck shop money, pocket money for students, boarding and lodging for students, remittances to students outside of house)		

SECTION 10 HOUSEHOLD EXPENDITURE (cont.)	
REMITTANCES LAST TWELVE MONTHS	
Q20A	During the last twelve months, did your household send remittances in cash or in kind to person in rural area of Zambia (excluding any member of your household)? 1: YES / 2: NO
Q20B	What is the value of CASH REMITTANCES to person in rural area of Zambia? **[VALUE IN KWACHA. ENTER 0 IF NO CASH REMITTANCES] Asked if Q22A=1**
Q20C	What is the value of IN-KIND REMITTANCES to person in rural area of Zambia? **[VALUE IN KWACHA. CONVERT TO KWACHA EQUIVALENT. ENTER 0 IF NO IN-KIND REMITTANCES] Asked if Q22A=1**
Q21A	During the last twelve months, did your household send remittances in cash or in kind to person in urban area of Zambia (excluding any member of your household)? 1: YES / 2: NO
Q21B	What is the value of CASH REMITTANCES to person in urban area of Zambia? **[VALUE IN KWACHA. ENTER 0 IF NO CASH REMITTANCES] Asked if Q23A=1**
Q21C	What is the value of IN-KIND REMITTANCES to person in urban area of Zambia? **[VALUE IN KWACHA. CONVERT TO KWACHA EQUIVALENT. ENTER 0 IF NO IN-KIND REMITTANCES] Asked if Q23A=1**
Q22A	During the last twelve months, did your household send remittances in cash or in kind to person outside of Zambia (excluding any member of your household)? 1: YES / 2: NO
Q22B	What is the value of CASH REMITTANCES to person outside of Zambia? **[VALUE IN KWACHA. ENTER 0 IF NO CASH REMITTANCES] Asked if Q24A=1**
Q22C	What is the value of IN-KIND REMITTANCES to person outside of Zambia? **[VALUE IN KWACHA. CONVERT TO KWACHA EQUIVALENT. ENTER 0 IF NO IN-KIND REMITTANCES] Asked if Q24A=1**

For children aged 0-59 months only. Answer cells omitted.

SECTION 11: CHILD HEALTH AND NUTRITION [FOR CHILDREN AGED 0 - 59 MONTHS ONLY]						
1	**2A**	**2B**	**3A**	**3B**	**3C**	**3D**
Is [NAME] being breastfed now? 1: YES 2: NO	How long after birth did you put [NAME] to the breast? (IN DAYS) **[IF LESS THAN 24 HOURS, RECORD 0. IF DON'T KNOW, RECORD 99.]** **Asked if Q1=1**	(IF LESS THAN 24 HOURS TO THE PREVIOUS QUESTION) How long IN HOURS? **[IF LESS THAN 24 HOURS, RECORD 0.]** **Asked if Q2A=0**	In addition to breast milk is [NAME] fed on any of the following? **Asked if Q1=1**			
			Any other milk other than breast milk [e.g. S26, lactogen, promil or other baby formula, Fresh milk, Soya milk, Goat milk] 1: YES 2: NO	Water 1: YES 2: NO	Other fluids 1: YES 2: NO	Solids [e.g. custard, cerelac or other cereal, vitaso, porridge, nshima] 1: YES 2: NO

SECTION 13: CHILD HEALTH AND NUTRITION [Cont'd]			
4	**5**	**6**	**7**
Has [NAME] ever been breastfed? 1: YES 2: NO 3: DON'T KNOW **Asked if Q1=2**	For how many months did you breastfeed [NAME]? **Asked if Q6=1**	At what age did you first give [NAME] water or other fluids or food? (IN MONTHS) **ENTER 0 IF LESS THAN ONE MONTH.** **ENTER 88 IF NOT STARTED ON WATER, OTHER FLUIDS OR FOOD.** **ENTER 99 IF DON'T KNOW.**	How many times is [NAME] currently given solids foods in a day (nshima, rice, potatoes, porridge, cerelac, other cereals, vitaso, custard, etc)? 1: ONCE 2: TWICE 3: THRICE 4: FOUR TIMES 5: FIVE TIMES 6: MORE THAN FIVE TIMES 7: NOT YET STARTED ON SOLIDS

SECTION 12: DEATHS in HOUSEHOLD		
1	Have there been any deaths in the household (OF USUAL MEMBERS) in the last 12 months? 1: YES / 2: NO / 3: REFUSED	
2	How many people died in the last 12 months?	
I am going to ask about the first deceased person. **Asked if Q2≥1**		
3	How old was he/she? [RECORD AGE IN COMPLETED YEARS. RECORD 0 IF LESS THAN 1 YEAR. RECORD 888 IF NO RESPONSE]	
4	Wat was his/her sex? 1: MALE / 2: FEMALE / 8: REFUSED	
5	What was the main cause of death? [CHOOSE FROM THE LIST BELOW]	
I am going to ask about the second deceased person. **Asked if Q2≥2**		
6	How old was he/she? [RECORD AGE IN COMPLETED YEARS. RECORD 0 IF LESS THAN 1 YEAR. RECORD 888 IF NO RESPONSE]	
7	Wat was his/her sex? 1: MALE / 2: FEMALE / 8: REFUSED	
8	What was the main cause of death? [CHOOSE FROM THE LIST BELOW]	
I am going to ask about the third deceased person. **Asked if Q2≥3**		
9	How old was he/she? [RECORD AGE IN COMPLETED YEARS. RECORD 0 IF LESS THAN 1 YEAR. RECORD 888 IF NO RESPONSE]	
10	Wat was his/her sex? 1: MALE / 2: FEMALE / 8: REFUSED	
11	What was the main cause of death? [CHOOSE FROM THE LIST BELOW]	
I am going to ask about the fourth deceased person. **Asked if Q2≥4**		
12	How old was he/she? [RECORD AGE IN COMPLETED YEARS. RECORD 0 IF LESS THAN 1 YEAR. RECORD 888 IF NO RESPONSE]	
13	Wat was his/her sex? 1: MALE / 2: FEMALE / 8: REFUSED	
14	What was the main cause of death? [CHOOSE FROM THE LIST BELOW]	
I am going to ask about the fifth deceased person. **Asked if Q2≥5**		
15	How old was he/she? [RECORD AGE IN COMPLETED YEARS. RECORD 0 IF LESS THAN 1 YEAR. RECORD 888 IF NO RESPONSE]	
16	Wat was his/her sex? 1: MALE / 2: FEMALE / 8: REFUSED	
17	What was the main cause of death? [CHOOSE FROM THE LIST BELOW]	
I am going to ask about the sixth deceased person. **Asked if Q2≥6**		
18	How old was he/she? [RECORD AGE IN COMPLETED YEARS. RECORD 0 IF LESS THAN 1 YEAR. RECORD 888 IF NO RESPONSE]	
19	Wat was his/her sex? 1: MALE / 2: FEMALE / 8: REFUSED	
20	What was the main cause of death? [CHOOSE FROM THE LIST BELOW]	

THE LIST OF THE CAUSES OF DEATH					
1	FEVER/MALARIA	13	CONSTIPATION/STOMACH UPSET	24	STROKE
2	CEREBRAL MALARIA	14	LIVER INFECTION/SIDE PAIN	25	HYPERTENSION
3	COUGH/COLD/CHEST INFECTION	15	LACK OF BLOOD/ANEAMIA	26	DIABETES/SUGAR DISEASE
4	TUBERCULOSIS	16	BOILS	27	HEADACHE
5	ASTHMA	17	SKIN RASH/SKIN INFECTION	28	MEASLES
6	BRONCHITIS	18	PILES/HAEMOROIDS	29	JAUNDICE/YELLOWNESS
7	PNEUMONIA/CHEST PAIN	19	SHINGLES/HERPES ZOSTER	30	CANCER OF ANY KIND
8	DIARRHOEA WITHOUT BLOOD	20	PARALYSIS OF ANY KIND	31	MENINGITIS
9	DIARRHOEA WITH BLOOD	21	SUICIDE	32	STILL BIRTH
10	DIARRHOEA AND VOMITTING	22	MURDERED	33	OTHER (INCL NATURAL DEATH)
11	VOMITTING	23	ACCIDENT	34	DON'T KNOW / REFUSED
12	ABDOMINAL PAINS				

CONCLUDING REMARK		
DATE_E	DATE OF THE END OF THE INTERVIEW	
INTERVIEWER	NAME OF THE INTERVIEWER	