



**JICA SATREPS RESARCH  
PROJECT**



# **Kabwe Mining Pollution Amelioration Initiative Project**

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## Background

# The current state of the environmental pollution of Africa various countries



☀️ **Wildlife, domestic animals and human are suggested to expose to hazardous chemicals from waste.**



## Background

# The current state of the environmental pollution of Africa various countries



**Air pollution due to traffic, industrial and agricultural activities is one of serious environmental problem in African countries.**



# Massive Childhood Lead Poisoning

## The Price of Nigerian Gold

Childhood lead poisoning on a scale unheard of for decades has been detected in rural northwestern Nigeria [EHP 120(4):601–607; Dooyema et al.]. The culprit: lead in gold ore processed using artisanal techniques. Chelation therapy for hundreds of children, soil replacement, and an education campaign to discourage processing ore inside homes may now have radically reduced child mortality in the hardest-hit villages, but the long-term effect of lead poisoning on the surviving children remains to be seen.

The outbreak surfaced in the spring of 2010 when health professionals noticed abnormally high rates of child illness and death among young children in 4 villages of Zamfara State. Blood tests on 8 children returned blood lead levels (BLLs) of 168–370 mg/dL, at least 16 times the



the threshold at which the CDC recommends that 95% of children's BLLs of 85% surpassed the portable X-ray fluorescence (PXRF) detection limit of 65 mg/dL.

A survey of the villagers revealed that 25% of all children under age 5 had died in the previous year, most of them in the half-year before the study. This translates to a mortality rate of 255/1,000 live births, compared with a national average of 157/1,000. The problem was the lead-contaminated gold ore being processed in many of the family compounds. Two-thirds of these families had started the activity within the last year.

Soil samples were collected from nearly all the family compounds where processing occurred, with 85% showing heavy lead contamination. The worst reached 250 times the U.S. Environmental Protection Agency safety limit of 400 ppm for play areas. Similarly, water lead concentrations far exceeded U.S. recommendations.

Not every child's blood could be tested, and a lack of medical data for the deceased meant their deaths could not be definitively linked to lead poisoning. Further, the locally recruited survey staff had limited training in

Background

## Massive Childhood Lead (Pb) Poisoning in 2010 “The Price of Nigerian Gold”

the 2 worst-affected villages.

Blood samples were collected from 59% of children under age 5. Of these, 97% had BLLs of at least 45 mg/dL,

all children tested in the worst-affected villages had blood lead levels high enough to warrant chelation therapy.



or contaminated gold ore.

Adrian Burton is a biologist living in Spain who also writes regularly for *The Lancet Oncology*, *The Lancet Neurology*, and *Frontiers in Ecology and the Environment*.

# How is Zambia...?

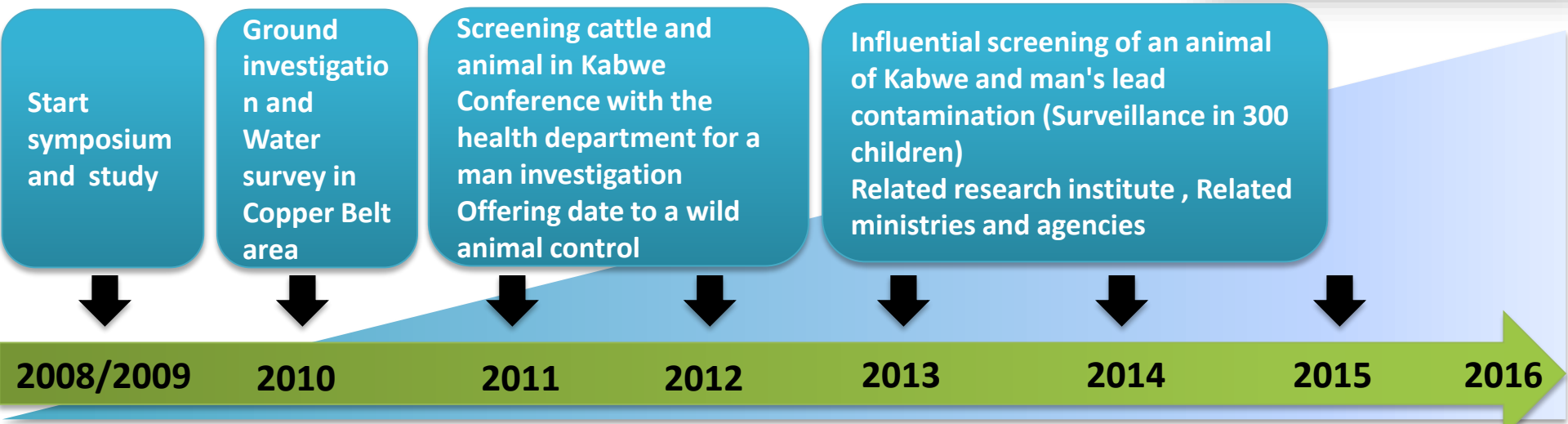


- **Since 2008, researchers from Vet School of Hokkaido University and University of Zambia have been investigating effects of environmental pollution Zambia.**



# Preliminary conditions

## Start of collaborative research with Zambia





# International Toxicology Symposium

to discuss on the environmental pollution in African countries



## ✘ International Toxicology Symposium in Africa

- **2009~2012 in Zambia**
- 2013 in Ghana
- 2014~2015 in South Africa
- 2016 in Egypt



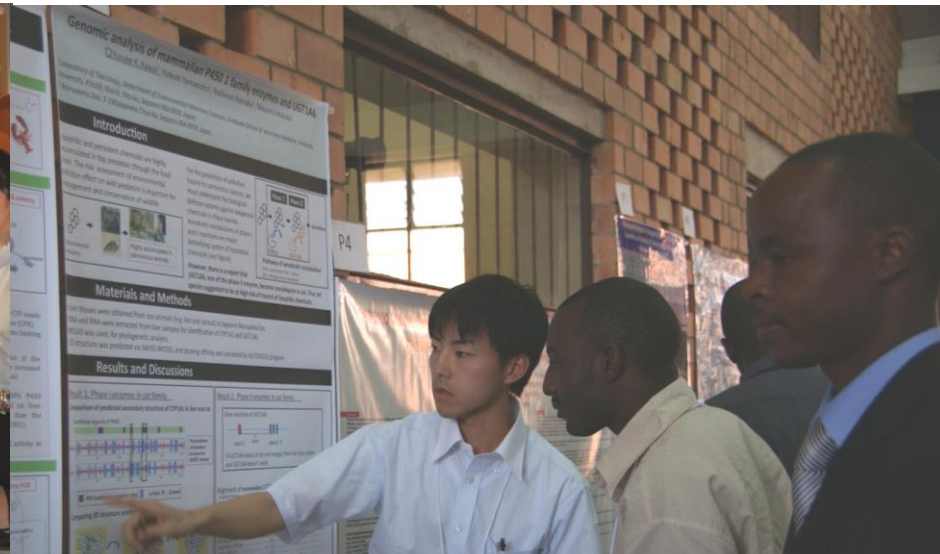
# Researcher / Student Exchanges



	2009	2010	2011	2012	2013	2014
<b>Number of researchers</b>	14/125 n / days	33/462	41/620	69/1501	47/1901	36/660
<b>Outbound countries</b>	3 (from JPN)	4 (from JPN)	5 (from JPN)	5 (from JPN)	4 (from JPN)	4 (from JPN)
<b>Symposium Venue</b>	Zambia (Univ of Zambia, Lusaka)	Zambia (Univ of Zambia, Lusaka)	Zambia (Univ of Zambia, Lusaka)	Zambia (Univ of Zambia, Lusaka)	Ghana (KNUST, Kumasi)	South Africa (Johannesburg University and NWU)
<b>Exchange countries</b>	Zambia Ghana Nigeria South Africa Kenya Tanzania	Zambia Ghana Egypt Nigeria South Africa Botswana Kenya Tanzania Benin	Zambia Ghana Egypt Nigeria South Africa Botswana Cameroon Uganda Sudan	Zambia Ethiopia Ghana Egypt Nigeria South Africa Cameroon Sudan Nigeria Kenya Uganda Zimbabwe Burkina Faso Tanzania	Zambia Ethiopia Ghana Egypt Nigeria South Africa Cameroon Sudan Nigeria Kenya Uganda Tanzania Congo (DRC)	Zambia Ethiopia Ghana Egypt Nigeria South Africa Cameroon Sudan Nigeria Kenya Uganda Tanzania



# Topics: pesticides, mycotoxin, metals, PAHs, POPs, dioxins, etc...





# Preliminary conditions

## Start of collaborative research with Zambia



Copper belt

Kabwe

Start symposium and study

Ground investigation and Water survey in Copper Belt area

Screening cattle and animal in Kabwe  
Conference with the health department for a man investigation  
Offering date to a wild animal control

Influential screening of an animal of Kabwe and man's lead contamination (Surveillance in 300 children)  
Related research institute , Related ministries and agencies

2008/2009

2010

2011

2012

2013

2014

2015

2016





Children



Pb conc. in blood (µg/dL)



Adult

150

Death →

← Encephalopathy  
← Nephropathy

100

Encephalopathy →  
Nephropathy →  
Frank Anemia →  
Colic →

← Frank Anemia

50

← Male Reproductive Effects  
← ↓ Hemoglobin Synthesis and  
Female Reproductive Effects

40

↓ Hemoglobin Synthesis →

← ↓ Nerve Conduction Velocity

30

↓ Vitamin D Metabolism →

← Elevated Blood Pressure

20

↓ Nerve Conduction Velocity →

← ↑ Erythrocyte Protoporphyrin (men)

↑ Erythrocyte Protoporphyrin →  
↓ Vitamin D Metabolism(?) →

← ↑ Erythrocyte Protoporphyrin (women)

Developmental Toxicity →  
↓ IQ, ↓ Hearing, ↓ Growth

10

Transplacental Transfer →

Lead poisoning in Human

Note: ↑ = increased function and ↓ = decreased function.

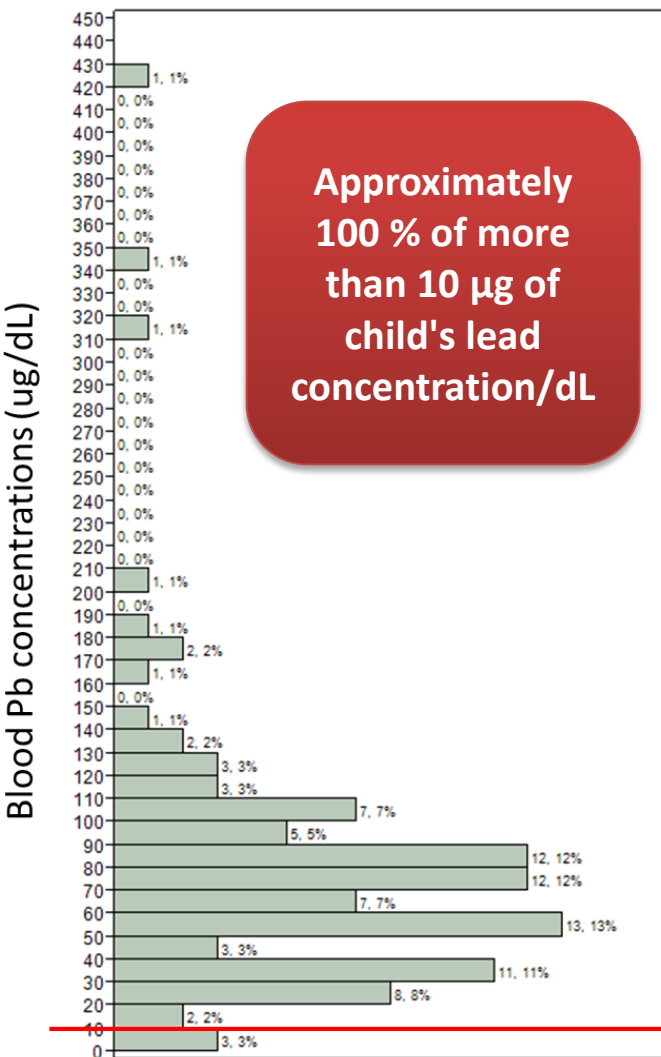
Source: ATSDR, 1992

# Pb conc. ( $\mu\text{g}/\text{dL}$ ) in child blood at two Kabwe areas in Zambia

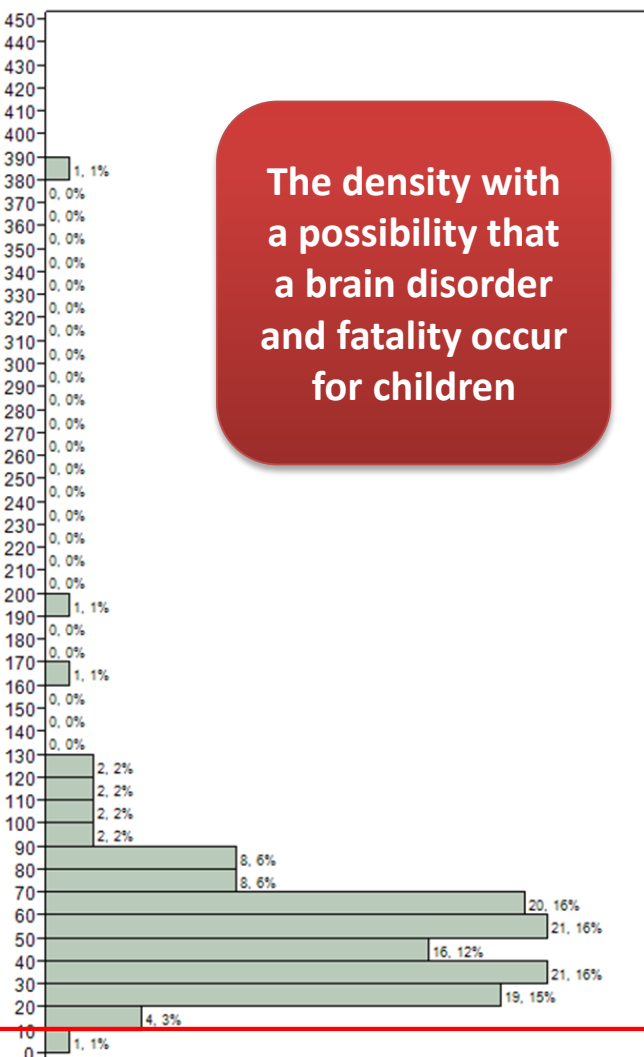


Kasanda (n=100)

Makululu (n=129)



Approximately 100 % of more than 10  $\mu\text{g}$  of child's lead concentration/dL



The density with a possibility that a brain disorder and fatality occur for children

Children's Zambian blood level exceeds the toxic manifested level.

10 $\mu\text{g}/\text{dL}$



# Published Papers with UNZA



- ✦ Yabe J et al. Lead poisoning in children from townships in the vicinity of a lead-zinc mine in Kabwe, Zambia. *Chemosphere*119:941-7 (2015)
- ✦ M'kandawire E et al. Molecular characterization and mRNA expression of cytochrome P450 1A1 and cytochrome P450 3A in liver of Kafue Lechwe (*Kobus leche kafuensis*) as potential biomarkers of pollution of the Kafue River basin, Zambia. *Engineering* 6:51-58 (2014)
- ✦ Nakayama SMM, et al. Accumulation and biological effects of metals in wild rats in mining areas of Zambia. *Environmental Monitoring and Assessment* 185:4907-4918 (2013)
- ✦ Yabe J et al. Metal distribution in tissues of free-range chickens near a lead-zinc mine in Kabwe, Zambia. *Environ Toxicol Chem.* 2013 Jan;32(1):189-192.
- ✦ Nakayama SMM, et al. GIS-based source estimation of Cu pollution in Lake Itzhi-tezhi and metal accumulation profiles in *Oreochromis* spp. from both field and laboratory studies. *Arch Environ Contam Toxicol.* 2013 Jan;64(1):119-129.
- ✦ Nakayama S.M.M, et al. Metal contaminated soil from mining area caused metal accumulation and biological responses in rats. *JJVR*, 61:S77-S79 (2013)
- ✦ Yabe J et al. Accumulation of metals in the liver and kidneys of cattle from agricultural areas in Lusaka, Zambia. *J Vet Med Sci.* 2012 Oct;74(10):1345-7.
- ✦ M'kandawire E, et al. The nucleotide sequence of metallothioneins (MT) in liver of the Kafue lechwe (*Kobus leche kafuensis*) and their potential as biomarkers of heavy metal pollution of the Kafue River. *Gene.* 2012 Sep 15;506(2):310-6.
- ✦ Ikenaka Y et al. Effects of environmental lead contamination on cattle in a lead/zinc mining area: changes in cattle immune systems on exposure to lead in vivo and in vitro. *Environ Toxicol Chem.* 2012 Oct;31(10):2300-5.
- ✦ Nakayama SMM, et al. Metal and metalloid levels and bio-accumulation characteristics in soil, sediment, land plants and hippopotami (*Hippopotamus amphibius* L) from the South Luangwa National Park, Zambia. *Ecotoxicol Environ Saf.* 2012 Jun;80:333-8.
- ✦ Yabe J et al. Uptake of lead, cadmium, and other metals in the liver and kidneys of cattle near a lead-zinc mine in Kabwe, Zambia. *Environ Toxicol Chem.* 2011 Aug;30(8):1892-7.
- ✦ Nakayama SMM et al. Metal and metalloid contamination in roadside soil and wild rats around a Pb-Zn mine in Kabwe, Zambia. *Environmental Pollution* 159 (2011) 175-18.
- ✦ Ikenaka Y, et al. Heavy metal contamination of soil and sediment in Zambia. *African Journal of Environmental Science and Technology* 4 2010 (11) : 729-739.
- ✦ Yabe J, et al. Current levels of heavy metal pollution in Africa. *J Vet Med Sci.* 2010 Oct;72(10):1257-63.
- ✦ Nakayama MMS, et al. Heavy metal accumulation in lake sediments, fish (*Oreochromis niloticus* and *Serranochromis thumbergi*) and crayfish (*Cherax quadricarinatus*) in Lake Itzhi-tezhi and Lake Kariba, Zambia. *Arch Environ Contam Toxicol.* 2010 Aug;59(2):291-300.

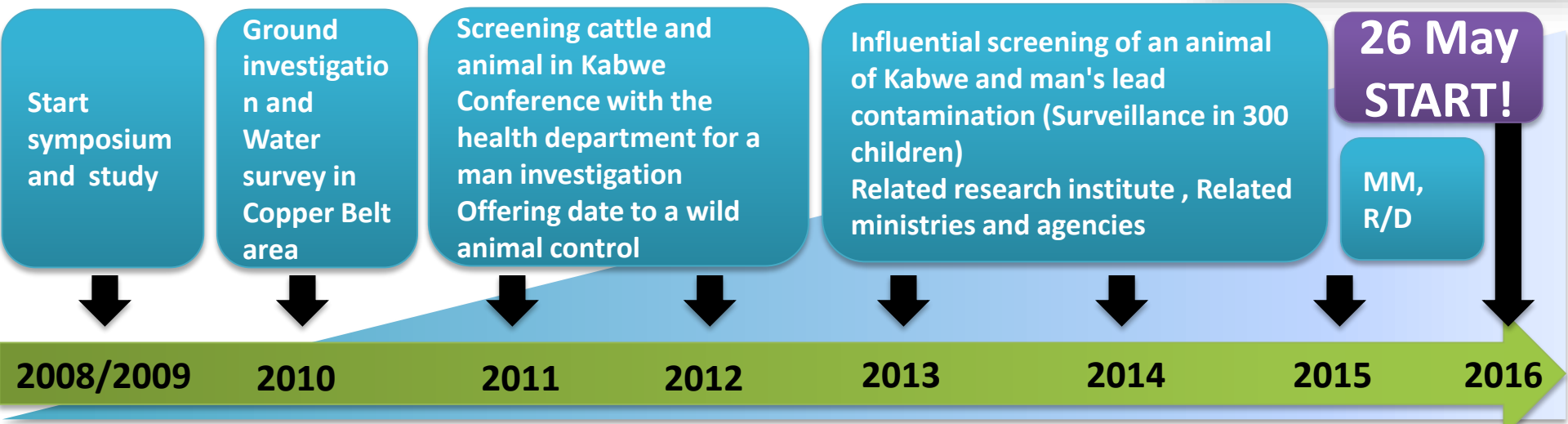
# Next Step...



- **Our latest research activities revealed that childhood lead (Pb) poisoning is a serious public health concern in Kabwe.**
- **Based on the previous research activities, we desire to extend our work to include remediation and use Kabwe as a model for areas with similar environmental problems in Africa.**



# Preliminary conditions



# The outline of SATREPS project



- 1. Elucidating the pollution mechanism of lead in ecological system, human and animals**
- 2. Follow up study to the harmful metal pollution in children**
- 3. Development and evaluation of the on-demand environmental remediation technology**



# The outline of a project



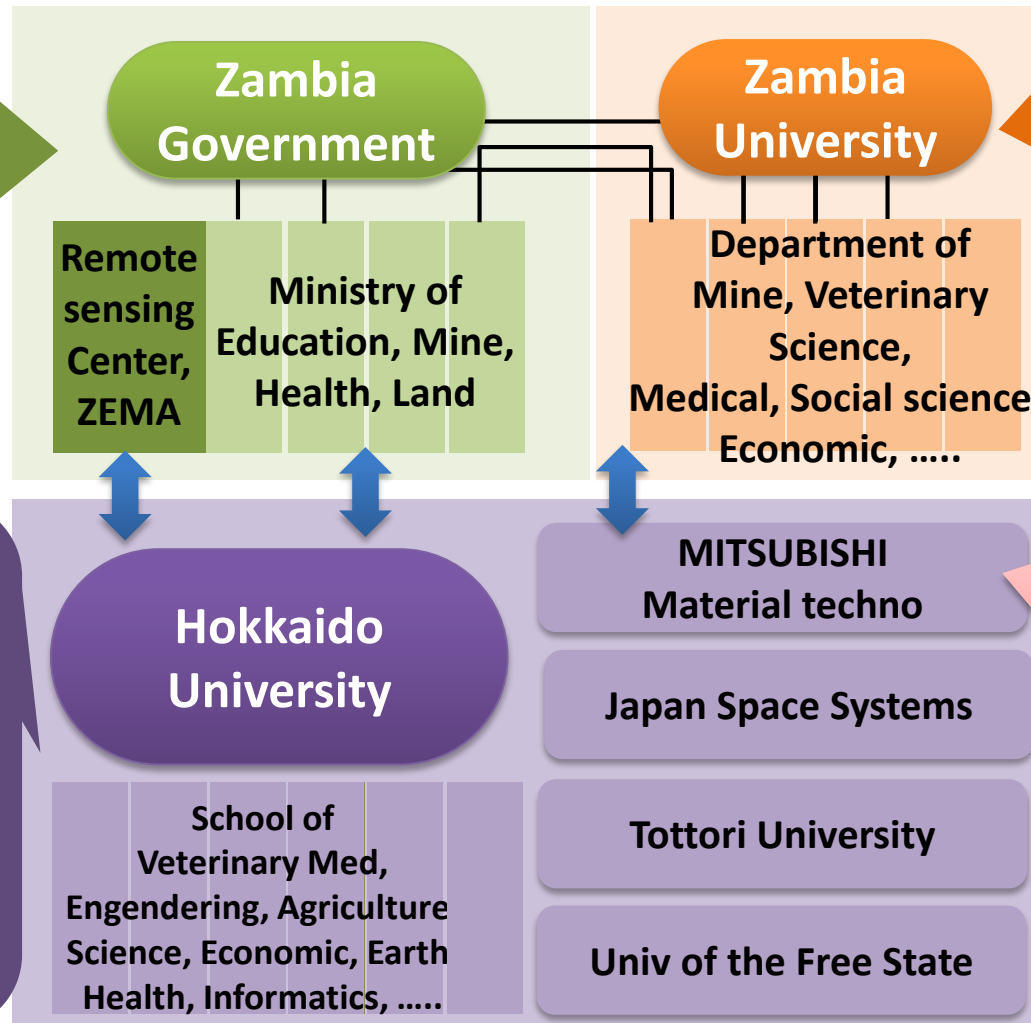
Contents (Group)	Approach	Outputs
Elucidating a pollution mechanism in ecological system and human <b>1</b>	<ol style="list-style-type: none"><li>Measurement of lead in soil and environment samples</li><li>Wide area surveillance of lead (remote sensing)</li></ol>	<ul style="list-style-type: none"><li>Elucidation of the shift mechanism of lead to human</li><li>New vegetation index</li><li>Simulation of the pollution diffusion</li></ul>
Follow up study to the harmful metal pollution in children <b>2</b>	<ol style="list-style-type: none"><li>Risk assessment of the hazard with lead</li><li>Economic assessment of the hazard with lead</li></ol>	<ul style="list-style-type: none"><li>Elucidation of the toxic mechanism of lead</li><li>The expert training</li><li>Therapy protocol of the chronic poisoning</li></ul>
Environmental remediation <b>3</b>	<ol style="list-style-type: none"><li>Physical remediation</li><li>Chemical remediation</li><li>Bio-remediation and phytoremediation</li></ol>	<ul style="list-style-type: none"><li>New environmental remediation technology of the soil</li></ul>

# The Organization chart



Capacity building,  
Proposing policy,  
Making standard  
and  
Making,  
Distributing and  
implementing  
protocol

Making, mechanism  
explication and  
environmental  
remediation of a  
pollution data base,  
Health and financial  
risk evaluation



Pollution data  
base  
Environmental  
remediation  
Health and  
financial risk  
evaluation

Practical use of  
environmental  
purification  
technology  
(industrialization)

World Bank,  
Pure Earth  
(Black Smith)



# Setting of monitoring laboratory and capacity building



- ☀ **Establishment of monitoring laboratory at UNZA**
  - Install equipment
  - Training of young researchers, staffs and officers of UNZA and Ministries
- ☀ **Short training and graduate program (Master / PhD) in Japan**
- ☀ **Seminar and workshop**



**July 14, 2016**



**KICK OFF SYMPOSIUM  
for project**

**Kabwe Mining Pollution Amelioration Initiative**

**KAMPAI**