

Ecological Risk Assessment in Communities around Lumwana Mine due to Naturally Occurring Radioactive Materials

NORM X SYMPOSIUM

**FUTURE: RESIDUES APPLIED IN A CIRCULAR ECONOMY
ORGANISED BY**

THE DUTCH SOCIETY FOR RADIATION IN COOPERATION WITH THE IAEA

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Dr. Reuben Katebe

Scientific Officer

(Email: rckatebe@yahoo.com)

National Institute for Scientific and Industrial Research

Lusaka, Zambia

Outline

- Introduction
- Problem Statement
- Objectives
- Methodology
- Results
- Conclusions

Introduction

- Ecological risk caused by Naturally Occurring Radioactive Materials (NORMs) and their decay products is a serious problem worldwide.
- The geology around Lumwana Mine and the surrounding communities contains uranium mineralogy.
- The main aim of this study was to assess the ecological risk to non-human biota posed by NORMs in communities around Lumwana Mine.
- Higher radioactivity in the environmental media is associated with risk to both humans and non-human biota.
- Although humans are considered one of the most radiosensitive species, criteria used for their protection do not necessarily apply for non-human biota.
- Exposure pathways of humans and non-human biota vary greatly, even if they are living in the same environment.

Problem Statement

- Lack of scientific data on the levels of naturally occurring radioactive materials (NORMs) in communities around Lumwana Mine in Zambia has resulted in regulations on pollution by NORMs to be both too strict & disproportional to the associated risks.

Objective

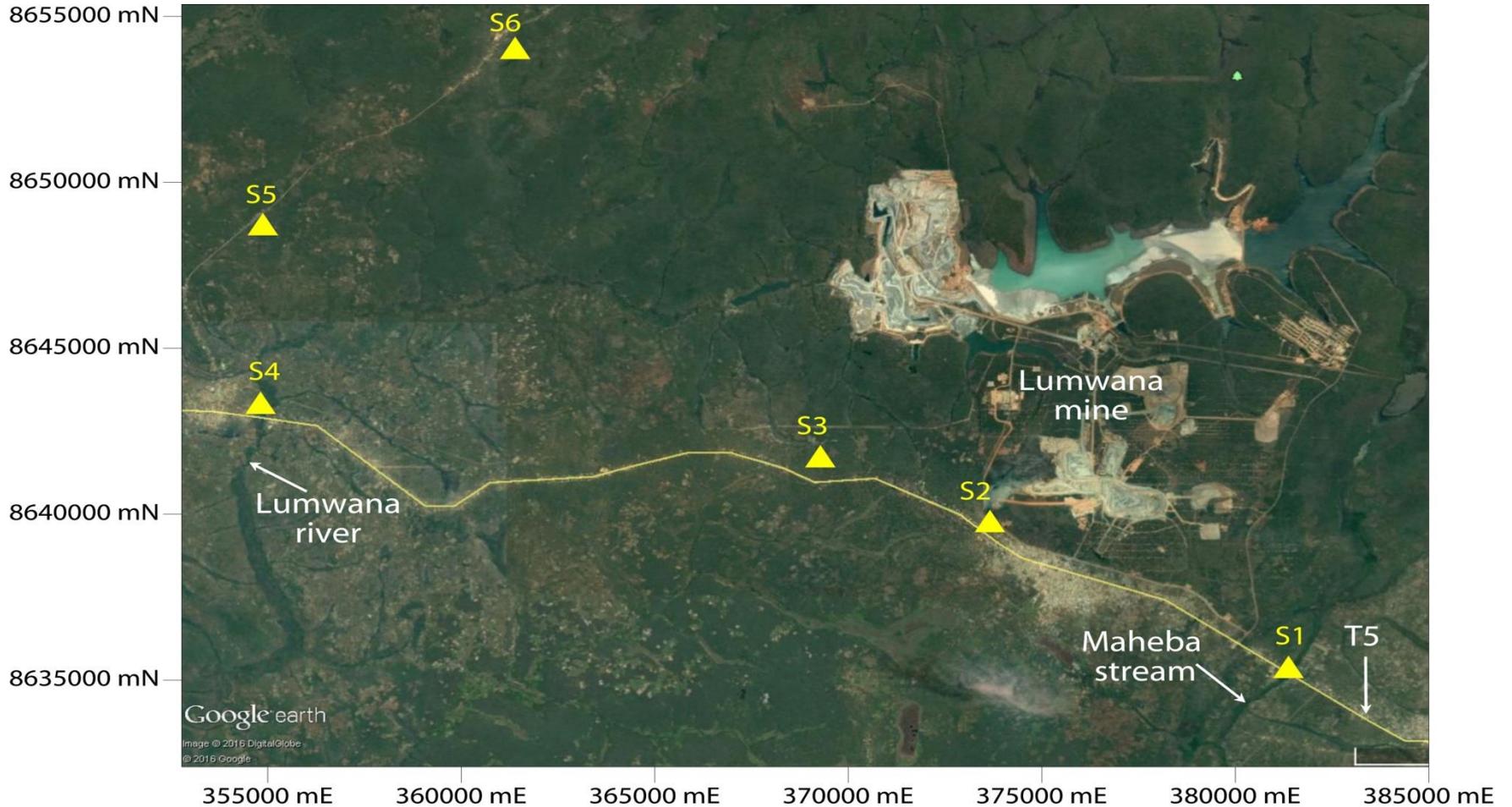
- To use a Threshold Radiation Dose as a tool to estimate adsorbed radiation doses, identifying the most predominant radionuclides and the organisms with highest radiological risks.

Map of Zambia

Lumwana Mine



Sampling sites



KEY; S1-Maheba Stream, S2-Kiwale Stream, S3- Dan Simo Stream, S4-Lumwana East River, S5- Mukwemba Village Stream, S6-Mukumbi Libinga Stream

Methodology

- **Twelve months sampling campaign**

12 composite samples of soil, sediment & surface water per site were collected over a period of 12 months.

- **Sample Preparation**

Soil & sediments were dried, sieved, weighed & sealed in Petri dishes & stored for 30 days to attain secular equilibrium. Water samples were acidified & stored for 30 days also for secular equilibrium.

- **Sample Analysis**

This was done using a gamma spectrometer with hyper pure germanium detector & spectra analysis using GENE-2000 software to calculate activity concentrations.

- **Total Absorbed Dose**

Estimated using ResRad Computer Code where the activity concentrations were input parameters for the code.

- **Radiological Risk Assessment**

Calculated as a ratio of Total Absorbed Dose to Threshold Radiation Dose

ResRad Biota Computer Code

- Calculates absorbed radiation doses resulting from both external and internal radiation exposures.
- Non-human biota Threshold values (no-effect dose) to adequately protect populations of plants & animals used are as follows;
 - Aquatic Animals – 10 mGy/d
 - Terrestrial Plants – 10 mGy/d
 - Terrestrial Animals – 1 mGy/d
 - Riparian Animals – 1 mGy/d

Results

Radionuclides of interest

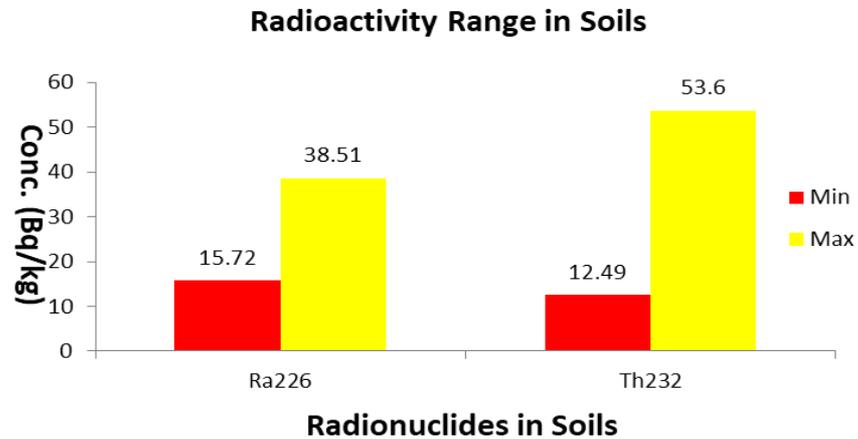
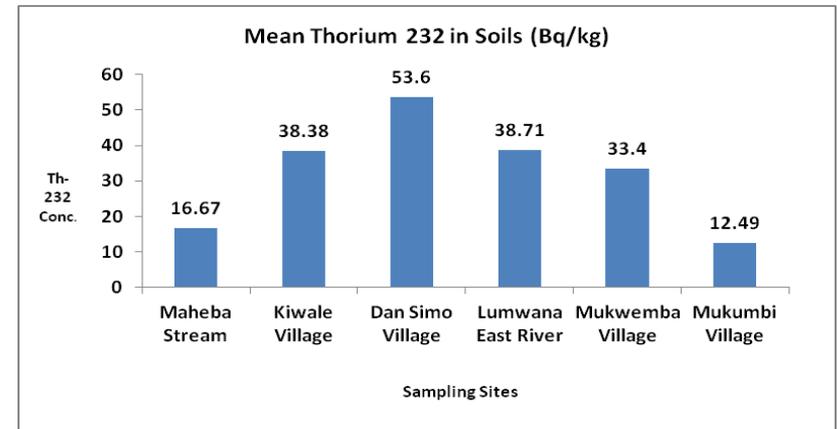
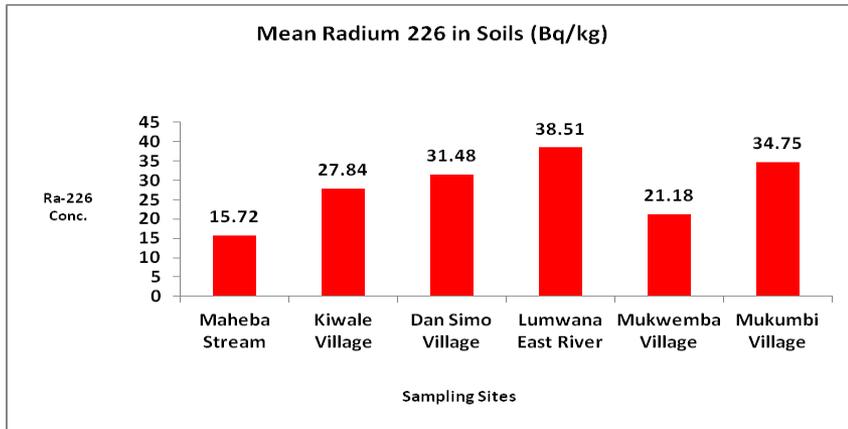
- Radium - 226
- Thorium - 232

Pathways

- Soil
- Water
- Sediment

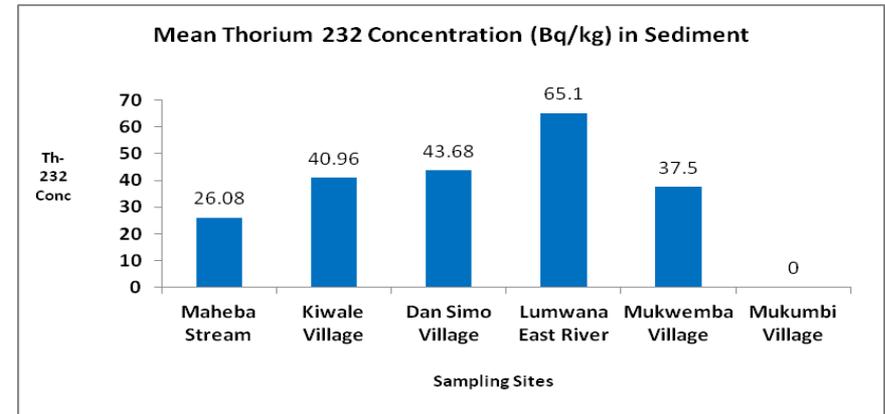
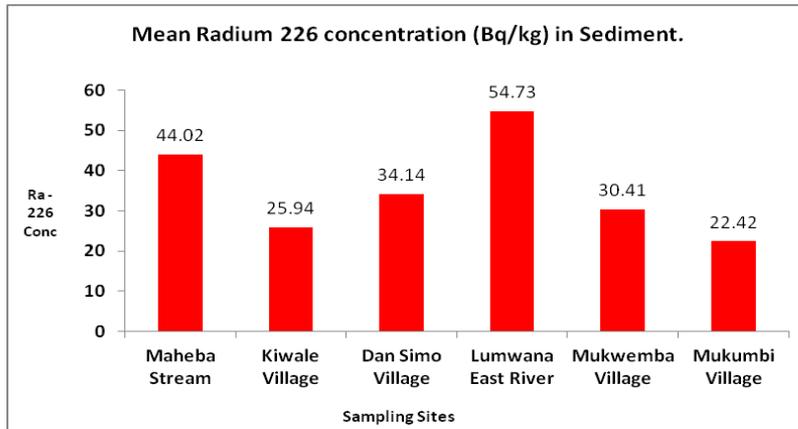
Results Cont'd

- Soil Samples

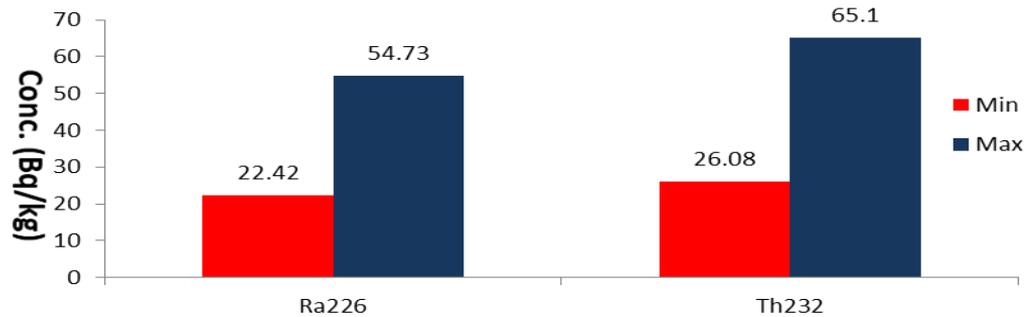


Results Cont'd

•Sediment Samples

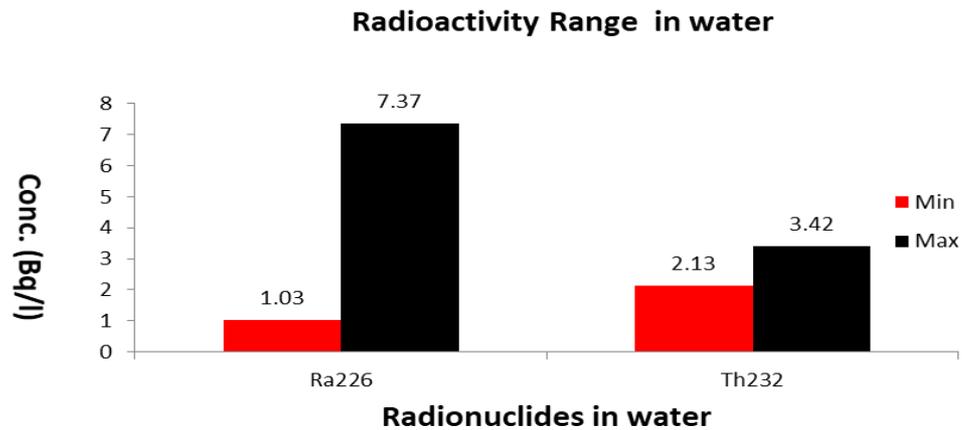
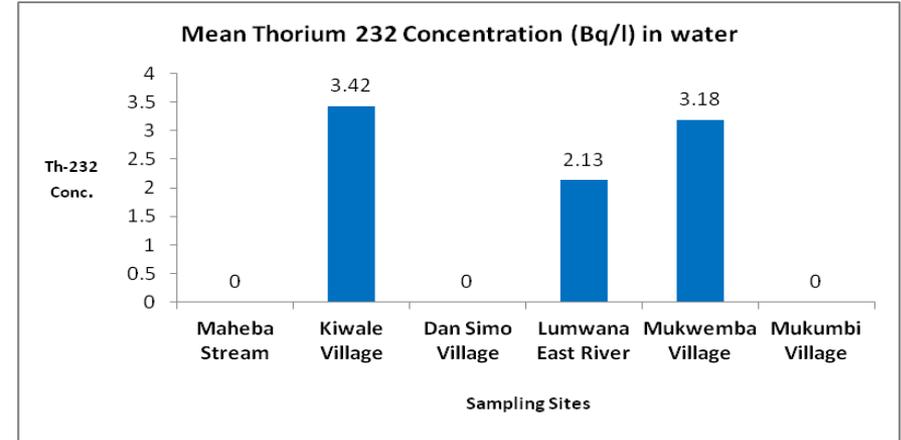
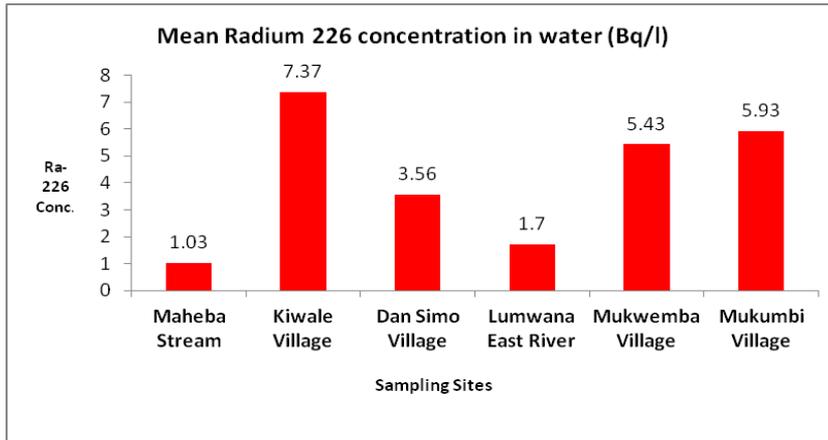


Radioactivity Range in Sediments

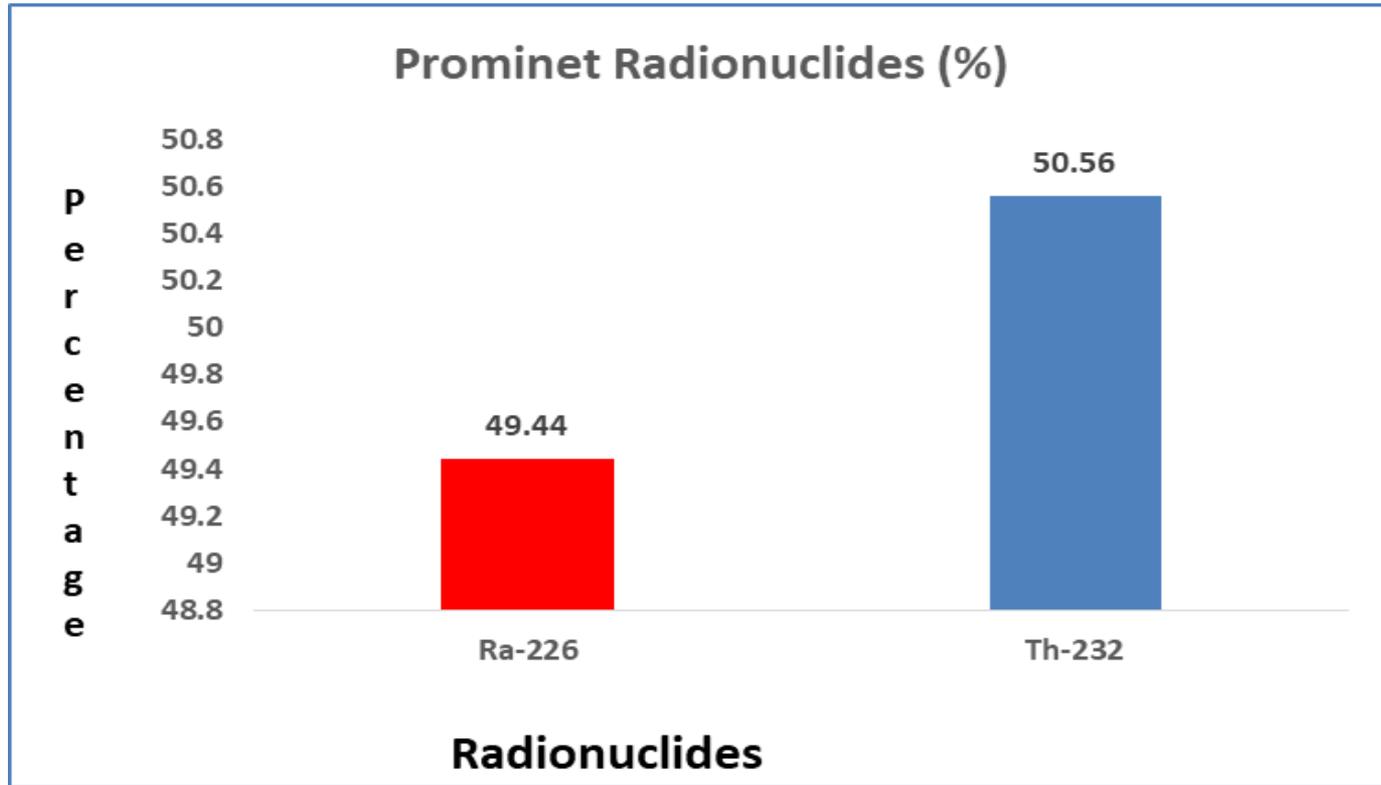


Results Cont'd

■ Water Samples

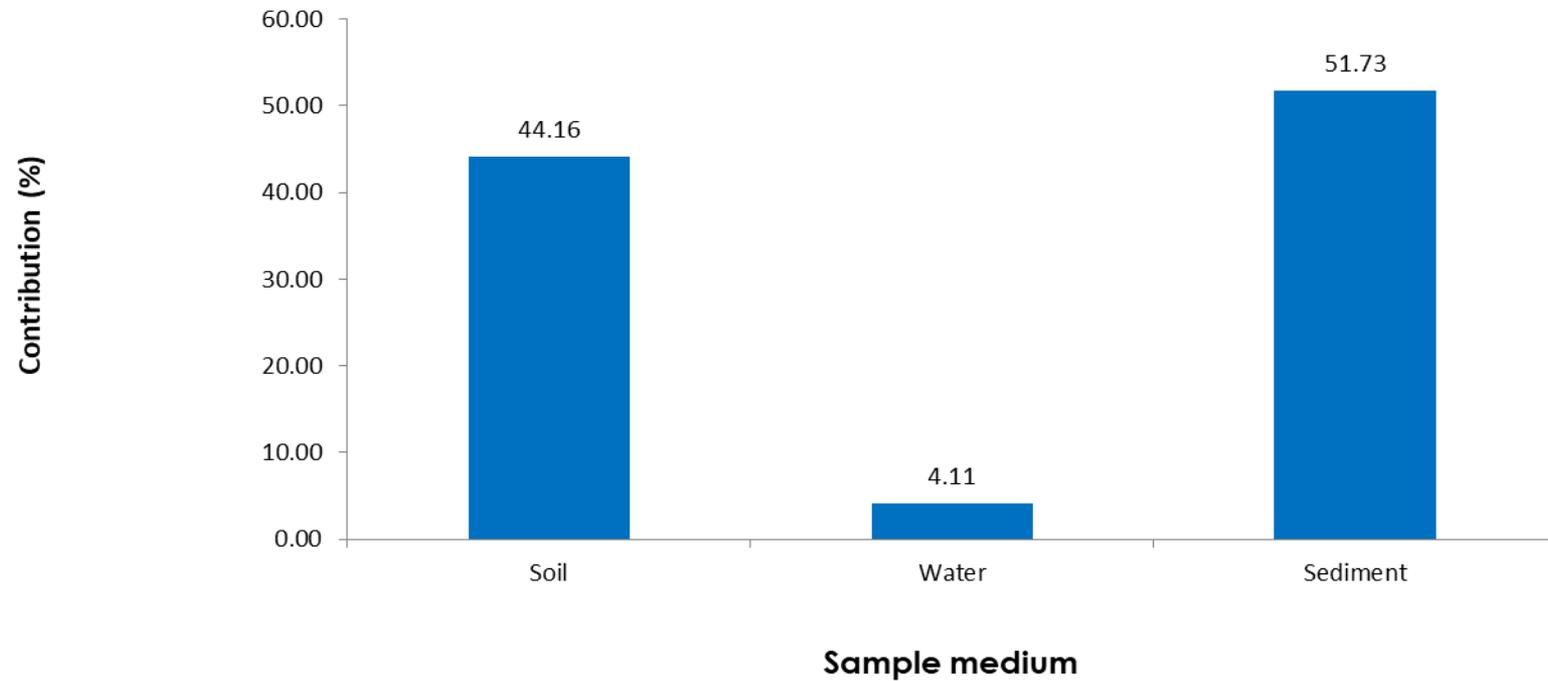


Prominent Radionuclide



Radioactivity in Medium

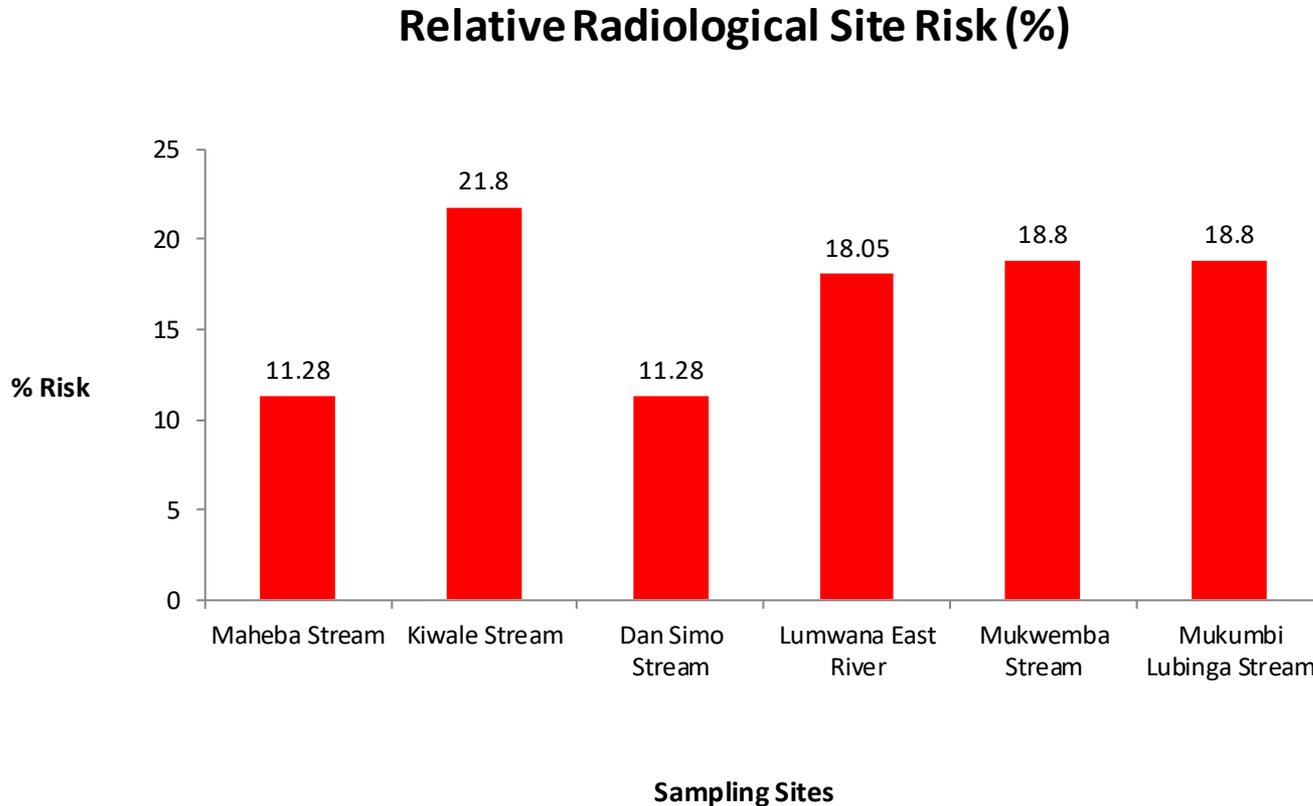
Medium Activity Concentration (%)



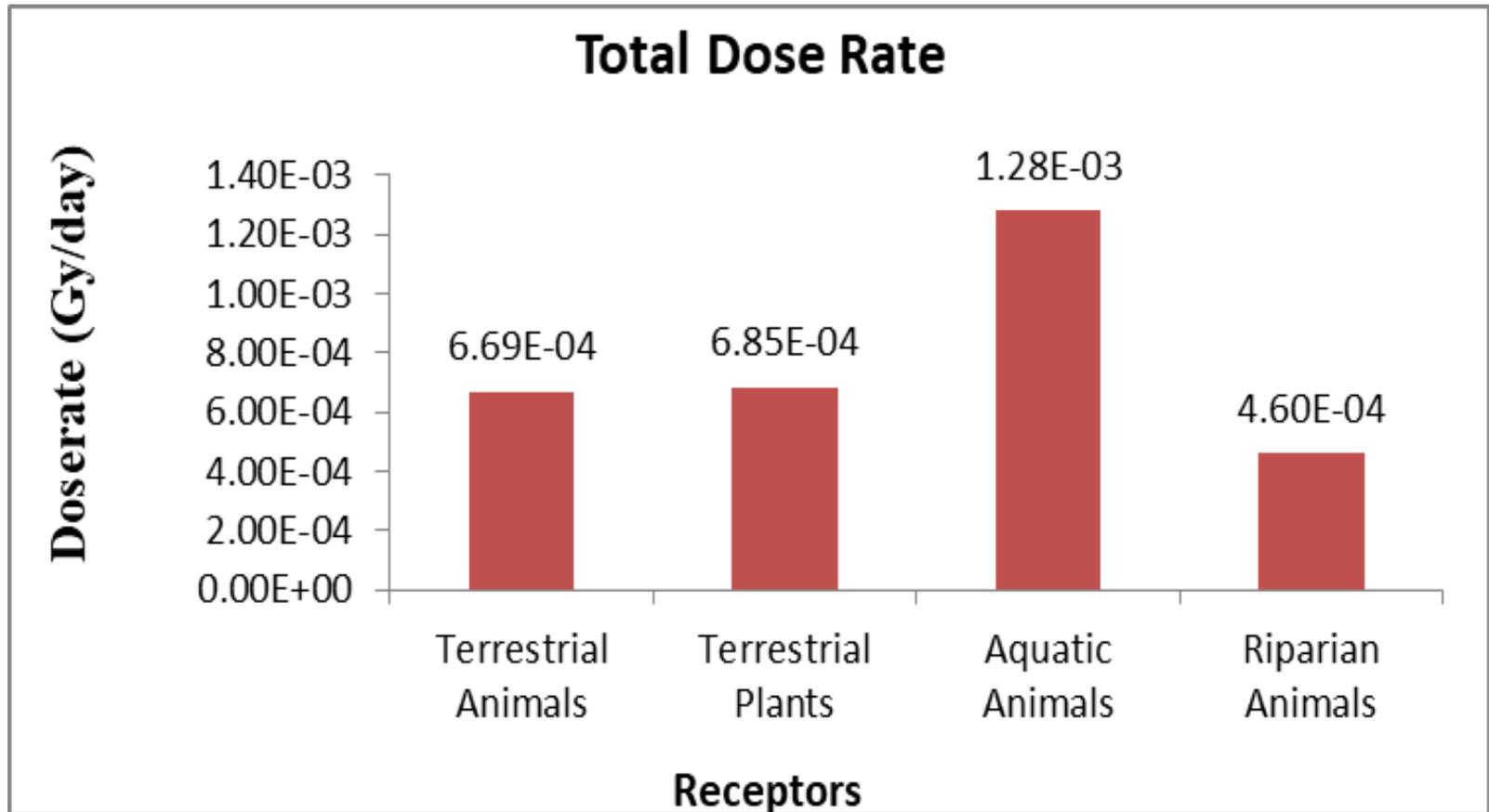
Calculated Hazard Ratio & Relative Percentage Risk for Receptor

NO.	Sampling Site	Receptor	Hazard Ratio by Receptor	Relative Risk (%)
1	Maheba Stream	Terrestrial Animal	0.09	60.00
		Terrestrial Plant	0.01	6.67
		Aquatic Animal	0.01	6.67
		Riparian Animal	0.04	26.67
		SUMMED	0.15	100
2	Kiwale Stream	Terrestrial Animal	0.11	37.93
		Terrestrial Plant	0.01	3.45
		Aquatic Animal	0.04	13.79
		Riparian Animal	0.13	44.83
		SUMMED	0.29	100
3	Dan Simo Stream	Terrestrial Animal	0.09	60.00
		Terrestrial Plant	0.01	6.67
		Aquatic Animal	0.01	6.67
		Riparian Animal	0.04	26.67
		SUMMED	0.15	100
4	Lumwana East River	Terrestrial Animal	0.14	58.33
		Terrestrial Plant	0.02	8.33
		Aquatic Animal	0.01	4.17
		Riparian Animal	0.07	29.16
		SUMMED	0.24	100
5	Mukwemba Stream	Terrestrial Animal	0.11	44.00
		Terrestrial Plant	0.02	8.00
		Aquatic Animal	0.03	12.00
		Riparian Animal	0.09	36.00
		SUMMED	0.25	100
6	Mukumbi Lubinga Stream	Terrestrial Animal	0.12	48.00
		Terrestrial Plant	0.01	4.00
		Aquatic Animal	0.03	12.00
		Riparian Animal	0.09	36.00
		SUMMED	0.25	100

Relative Radiological Site Risk (%)



Total Absorbed Dose Rates (Gy/d)



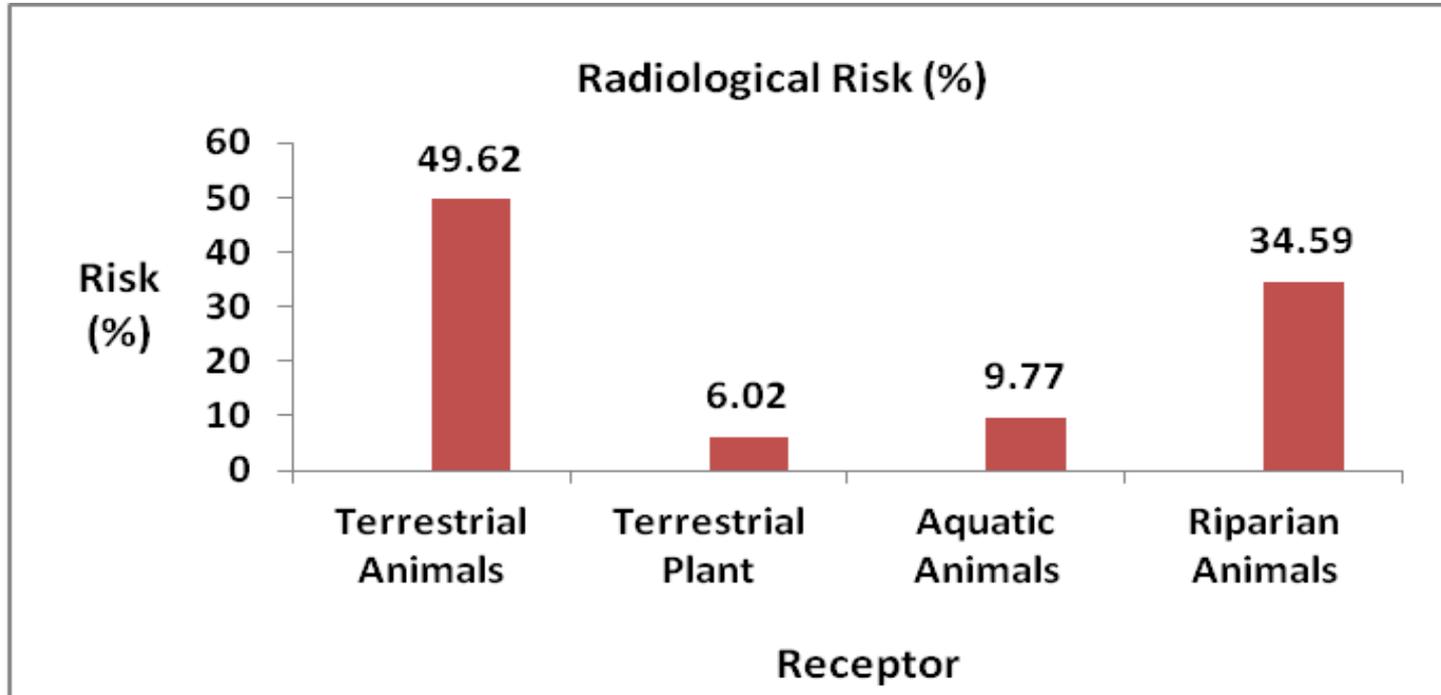
Radiological Risk Assessment

Hazard Quotient (HQ) =

Estimated Absorbed Dose/Threshold Dose

- If less than or equal to 1, no potential risk
- If more than 1, radiological risk exists

Radiological Risk (%) for Reference organisms



Conclusions

- Lumwana East River site had the highest radioactivity concentration and Mukumbi Lubinga site had the lowest.
- Thorium-232 was the most prominent.
- Sediment pathway had the highest activity concentration followed by soil and then water.
- Aquatic animals had the highest absorbed dose rate followed by terrestrial plants then terrestrial animals & the least was Riparian animals.
- Terrestrial animals had the highest risk followed by riparian animals then aquatic animals & terrestrial plants were the least.
- All sampling sites had HQ less than 1 hence there is no serious radiological risk in the study area.

- **THANK YOU**