Assessment of the Soil Micronutrient Status in Northern Ghana Applying Gamma Ray Spectroscopy

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Introduction & Objective

- Moderate to severe **food insecurity**, including **hidden hunger** attributed to micronutrient deficiency, is as high as **67 %** in sub-Saharan Africa (FAO, *et al*., 2023).
- In consequence, it is reported that 37 % of the world's stunted children live in sub-Saharan Africa (FAO, *et al*., 2021).
- However, no consistent data exist that systematically cover the micro-nutrient transfer from the soil over plants to humans and animals.
- In particular, **information on the soil micronutrient status are virtually non-existent in sub-Saharan Africa**, necessitating the development of an efficient and site-specific mapping approach.
- This latter – based on the use of **gamma spectrometry** - is the first objective on the way to better understand the **micro-nutrient chain** in the intervention zone.

Approach

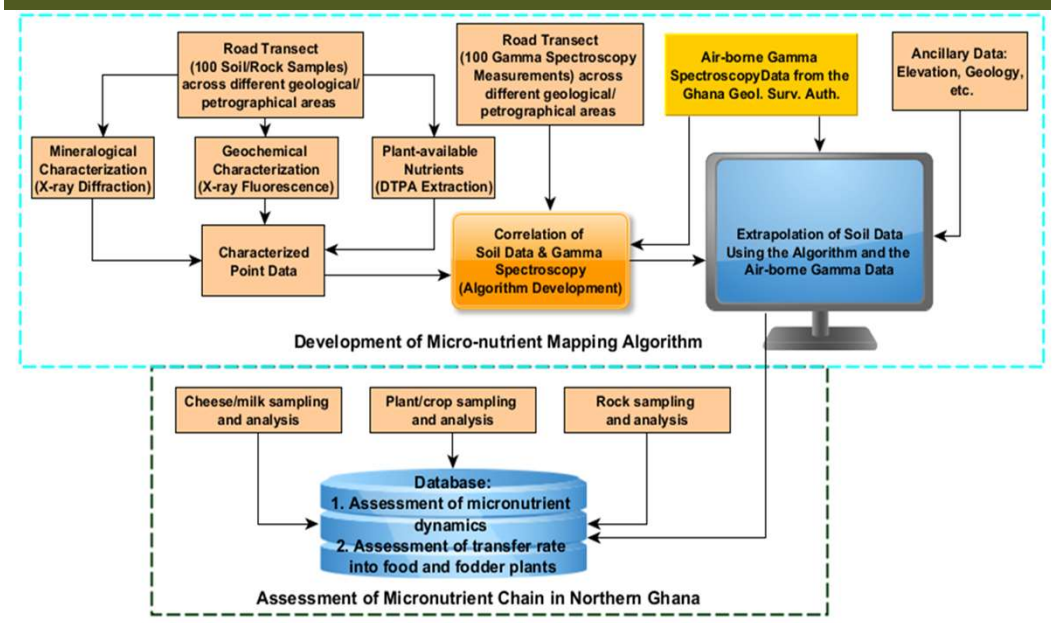

Fig. 1: Framework for the micro-nutrient chain assessment

1. The geologic map shows the granite basement in the West contrasting the sedimentary Volta basin in the east.
2. The 90 sampling points cover both terrains on an E-W and S-N oriented transect each.

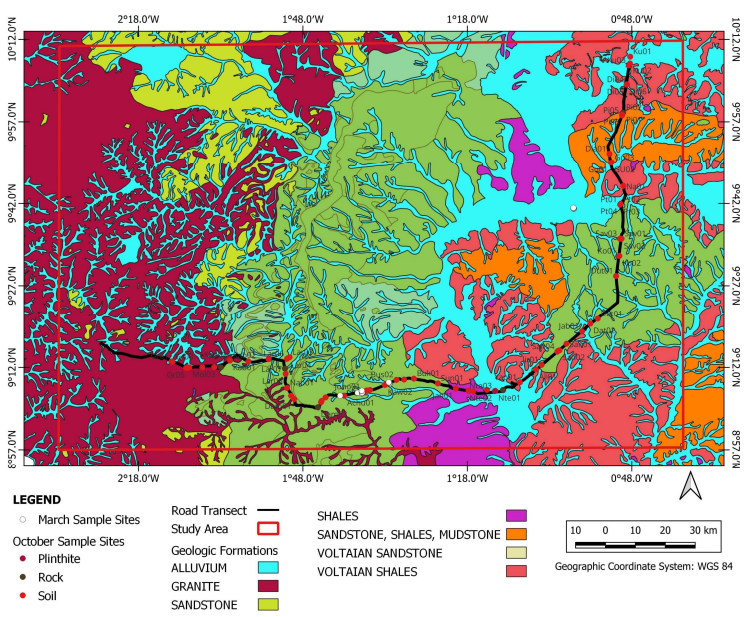

Fig. 2: Sampling sites (soil 0-0.1m) projected on a geologic map

Take-home Message

- Plant available micronutrients in topsoils are variable across the study area, particularly for Cu and Zn, with Zn and Mo being most limiting.
- Potentially the soil micro-nutrient status can be mapped using gamma ray spectroscopy added by further co-variables like pH, organic C and clay content and applying multi-linear regression.
- Transfer rates from soils over plants to humans and animals will be assessed in the next step.

Results & Discussion

- Plant available iron and manganese was generally high in the soils.
- Plant available copper was adequate in 61% of the sampled sites, while about 91% of the sites have either deficient or moderate zinc content.
- Up to 95% of the sites show deficiency with respect to plant available molybdenum.

Table 1: Plant available micronutrient rating in the study area

		Low	Medium	High
Fe	(mg kg^{-1})	<4.5	4.5–7.5	>7.5
	Proportion (%)	**0**	**0**	**100**
Mn	(mg kg^{-1})	<2.0	2.0–4.0	>4.0
	Proportion (%)	**0**	**0**	**100**
Cu	(mg kg^{-1})	<0.20	0.20–0.40	>0.40
	Proportion (%)	**7**	**32**	**61**
Zn	(mg kg^{-1})	<0.75	0.75–1.50	>1.50
	Proportion (%)	**74**	**17**	**9**
Mo	(mg kg^{-1})	<0.1	0.1-0.2	>0.2
	Proportion (%)	**95**	**1**	**4**

- In order to map the spatial micronutrient distribution and food security, a simple linear regression between the airborne (AB) gamma spectrometry (K, U and Th) and the analysed (XRF) K, U and Th was generated.

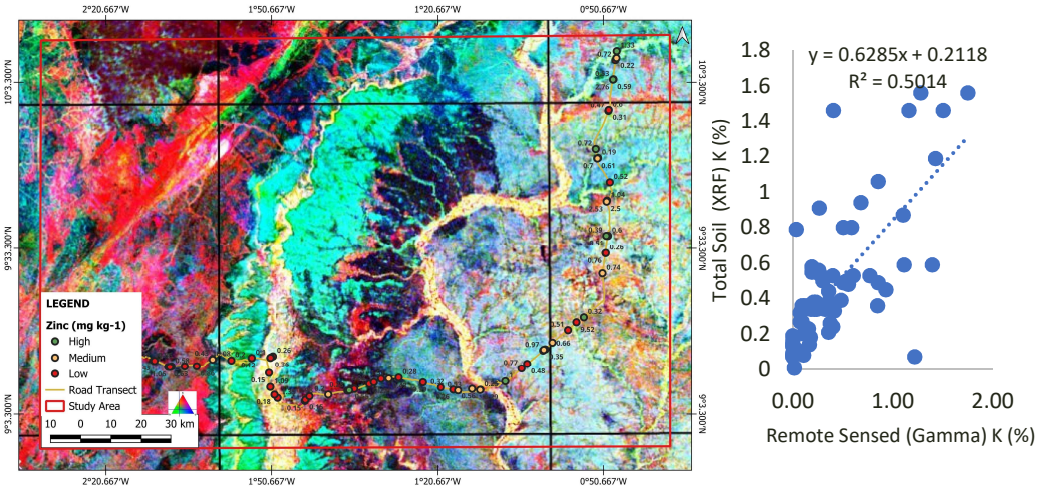

Fig. 3: Ternary (K, U, Th) gamma map and regression for K

- Extrapolation of soil micronutrient content to the entire study area using gamma spectroscopy appears feasible since the latter reflect the petrographic situation (compare figures 2&3).
- Nevertheless, so far correlation is relatively weak for Th and U; probably due to non-systematic spatial effects (i.e. soil moisture).
- Therefore, 1) **proximal gamma spectroscopy, and** 2) **multi-linear regression** will be applied using in addition 3) the **co-variates** soil moisture, organic carbon, clay and pH.

References

FAO, IFAD, UNICEF, WFP and WHO. 2021. *The State of Food Security and Nutrition in the World 2021*. *Transforming food systems for food security, improved nutrition and affordable healthy diets for all*. Rome, FAO.

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