

LINKING SOILS AND HUMAN HEALTH: GEOSPATIAL ANALYSIS OF PODOCONIOSIS OCCURRENCE AND CAUSE IN CAMEROON



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1: Background

Podoconiosis is a form of elephantiasis, a geochemical disease which occurs in individuals exposed to red-clay soil from alkalic volcanic rock (Price, 1976). It is estimated that globally around **4 million** people suffer from podoconiosis (Tekola Ayele et al., 2012). The exact causal agent is unknown and has been previously linked to elements such as aluminium (Price and Henderson, 1978), zirconium, beryllium (Frommel et al., 1993), silica (Molla et al., 2014) and minerals such as quartz (Molla et al., 2014).



A foot affected by podoconiosis, showing typical nodules and mossy changes. Photo by: Gail Davey

The aim of this study was: to investigate the associations between soil element and soil mineralogical data, and podoconiosis prevalence and occurrence data in Cameroon, using geostatistical analysis.

Study site: The research was conducted in the Northwest region of Cameroon, figure 1.

2: Data collection- Secondary Data

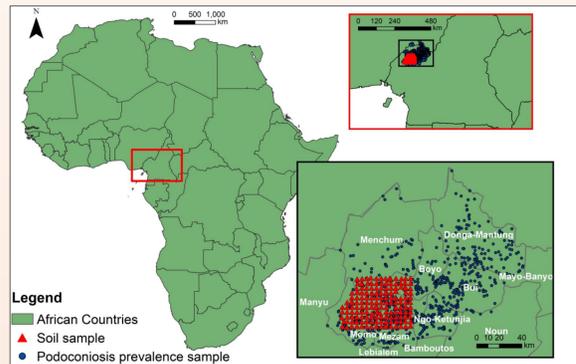


Figure 1: Map of Africa, with two inset maps of Cameroon. Inset map shows location of soil and podoconiosis prevalence sample locations.

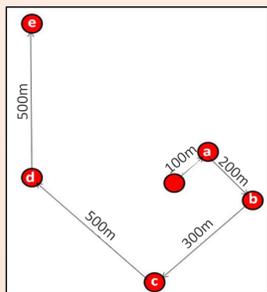


Figure 2: Sampling technique used for multiple sampling, (a-e) represent additional sampling points, from the centre point. Distances showed in m (Le Blond, unpublished).

Soil sampling data: Soil sampling data were collected at 152 sampling sites equally spaced along a grid, samples were taken in the centre of each grid square (Le Blond, unpublished). There were 10 grid squares that contained 5 extra sampling sites, to capture the soil variability at a greater resolution. The sampling technique seen in figure 2 was utilised for the 10 grid squares with the multiple samples. Soil samples were tested for elemental content using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) in mg/kg and mineral content was measured as a percentage using X-ray diffraction (XRD).

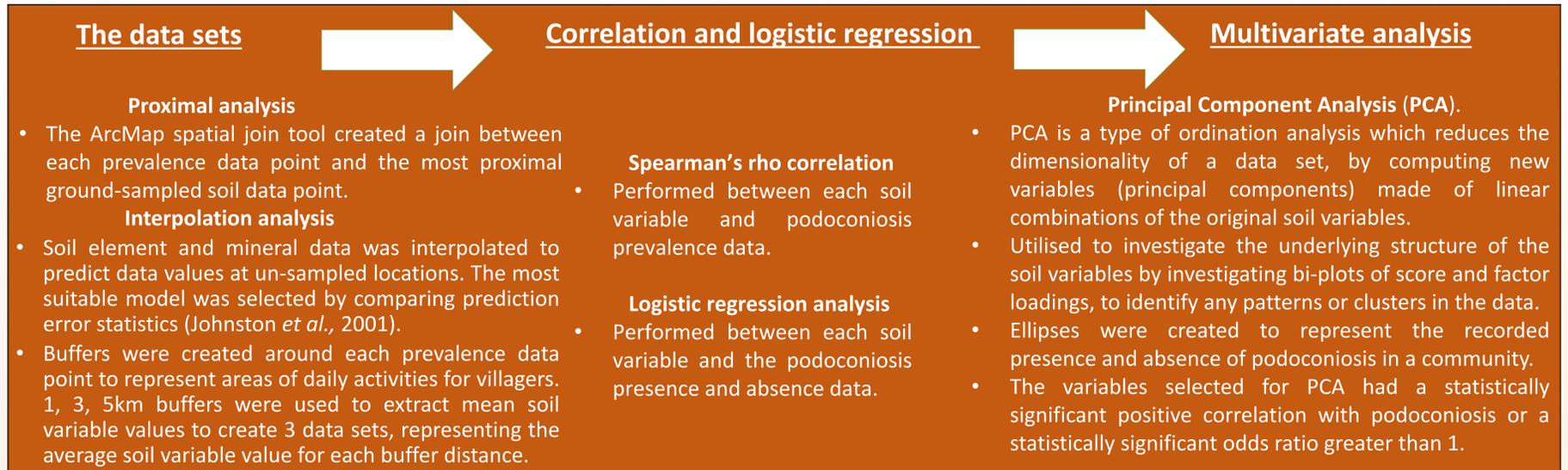
Podoconiosis prevalence data: The podoconiosis prevalence data were collected by trained Community Health Implementers (CHI) at a community level representing a total of 672 sample points. At each community, GPS coordinates, eligible population and number of podoconiosis cases was recorded. Prevalence data were adjusted due to recognised inaccuracies of the CHI's in identifying cases of podoconiosis (Wanji et al., 2016). The 168 prevalence data points most proximal to soil samples were utilised for this analysis.

6: References

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3: Methodology

The analysis was conducted by creating two data sets: the first utilising proximity analysis, with no intermediary modelling or synthesis, the second utilising interpolation analysis to create continuous surface to extract mean soil values. **The flow diagram explains the analysis steps.**



4: Results and Discussion

The variables barium (Ba), beryllium (Be), potassium (K), potassium feldspar (K-felds), mica, sodium (Na), quartz, rubidium (Rb), strontium (Sr) and thallium (Tl) were identified to be statistically significant either with a positive correlation with podoconiosis prevalence or with a statistically significant odds ratio greater than 1 or both, from either the proximity analysis or those identified from the interpolated buffered variable analysis. An odds ratio greater than 1 suggests, with a unit increase in the soil variable, the likelihood of an area having at least one case of podoconiosis increases. Type I error inflation was assessed by applying the Benjamini-Hochberg correction. Only barium remained significantly associated following type 1 error correction. PCA was used to further examine the data and all variables identified as significantly associated (prior and post type 1 correction) were included. PCA was used to reduce the dimensionality of the data and displayed the final association and ordination of the data (figure 3). Two confidence ellipses were created, 'Yes' for those representing areas with podoconiosis and 'No' those without. The ellipses were found to overlap, which may highlight the uniformity between sample areas, and the complexity of the relationship between soil composition and the occurrence of podoconiosis. The ellipse representing podoconiosis ('Yes') was, however, strongly associated with increased values of all soil variables.

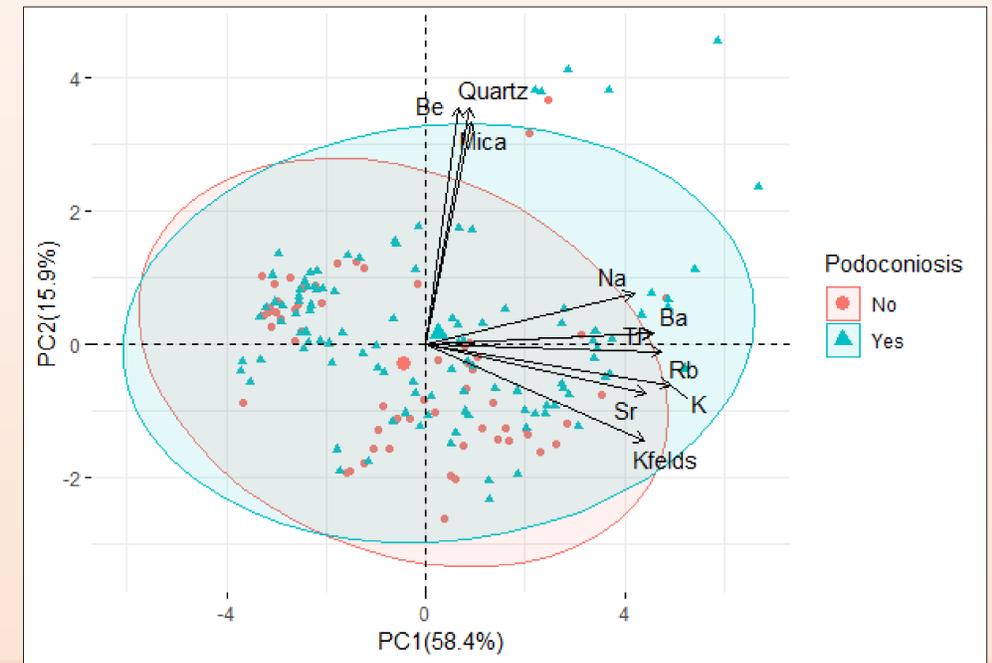


Figure 3: Bi-plot of principal component scores and factor loading on principal components 1 and 2 from the PCA analysis of the 3km buffer distance soil variables suggested to be associated with podoconiosis through correlation or/and logistic regression analysis. PC1 eigenvalue = 5.84, explaining 58.4% of the variation in the data. PC2 eigenvalue = 1.59, explaining 15.9% of the variation in the data. Ellipses are created with a 95% confidence level.

5: Conclusion

The findings suggest that the key minerals and elements identified in this study may play a role in the pathogenesis of podoconiosis or could be disease covariates. These significant results have led to ongoing research within this project to examine the utilisation of hyperspectral remote sensing data to identify if podoconiosis-associated soil variables, such as quartz, are detectable remotely. This can then be utilised to predict areas at risk by theorising a link between prevalence, presence, and combinations of multiple soil related variables.

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