Environmental factors for transmission of Soil Transmitted Helminthiasis in school age children in Zambia

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Abstract— *We conducted a study to establish the environmental factors that favour the transmission of two Soil Transmitted helminthes, namely hookworm and ascariasis, in school age children in two districts, Luanshya and Nchelenge, of Zambia in July 2015. Soil samples were collected from selected sites in Nchelenge and Luanshya districts and analysed for chemical and physical properties. The climatic patterns for the two districts were also analysed. Nchelenge district lay at a lower altitude (934m) than Luanshya district (1218m). The average monthly temperatures were significantly higher for Nchelenge than Luanshya (P=0.004). Other climatic factors analysed were comparable between the two districts (P>0.05). Comparison of soil physical properties between the two districts demonstrated that Bulk density was significantly higher for Nchelenge district than Luanshya district (P=0.004), Solid was higher for Nchelenge than Luanshya (P=0.015), Moisture content was higher for Luanshya than Nchelenge (P=0.003), Clay content was higher for Luanshya than Nchelenge (P=0.005), Total Sand was higher for Nchelenge than Luanshya (P=0.024), while Silt content was comparable between the two districts (P>0.05). Comparison of the soil texture between the two districts demonstrated that Nchelenge significantly had more Sand soil than Luanshya while Luanshya had Loamy-sand soil than Nchelenge (P=0.005). Comparison of Soil chemical properties between the two districts revealed similarities in pH, Total Nitrogen, Phosphorous, Potassium, Sodium, Calcium, Organic carbon, Organic matter, Total carbon, and Lead (P>0.05) while mineral contents were higher for Luanshya than Nchelenge for Magnesium (P=0.018), Manganese (P=0.003), and Copper (P=0.007).*

Keywords— ***children, climate, helminthes, minerals, soil.***

I. INTRODUCTION

Soil Transmitted Helminthes (STHs) infections fall under a group of diseases known as Neglected Tropical Diseases (NTDs). STHs are among the commonest infections occurring worldwide and affect the poor in developing countries [1]. STHs infections are transmitted via the worm eggs which are present in human faces which contaminate soil in areas where personal hygiene and sanitation are poor. STHs comprise the following worms; *Ascaris lumbricoides* (large intestinal round worm), *Trichuris trichiura* (whipworm), and *Necator americanus* and *Ancylostoma duodenale* (hookworm). It is estimated that two billion people globally are infected with STHs [2]. Another 3.5 billion people worldwide are at risk of contracting these infections. School age children are most affected persons in endemic areas. About 1.4 billion people are infected with *A.lumbricoides* [3)] while 576 to 740 million individuals are infected with hookworm [4, 5]. With ascariasis, the most affected populations are in Sub-Saharan Africa, Latin America, and Asia [4, 6, 7]. Infection with STHs may lead to disease depending on the number of worms in the infected individual. Individuals with light infections usually are asymptomatic while individuals with heavy infections may have symptoms such as intestinal manifestations (diarrhea, abdominal pains, and intestinal obstruction), general malaise, weakness, impaired cognitive function and physical development, and anaemia [8].

With STHs there is neither direct person to person transmission nor infection from fresh faeces (WHO, 2015). This is because the eggs of these worms that are passed in faeces need about three weeks, depending of the species, to either mature into infectious stage or develop into larvae in the soil. *A.lumbricoides* eggs, for example, can survive in the soil for prolonged periods and prefer warm, shady, moist conditions under which they survive sometimes up to ten years [9]. Therefore soil and climatic conditions will determine the distribution of particular STHs in any given locality [10].

In our previous the study entitled "Evaluation of Dipstick Dye ImmunoAssay in the diagnosis of *Schistosoma haematobium* infection in school children in Zambia" that we conducted in July 2014 in Nchelenge and Luanshya districts of Zambia, whose findings are reported somewhere, we found that the prevalence of ascariasis in school children was significantly higher in Luanshya than in Nchlenge (P<0.05) while the prevalence of hookworm infection in the same school children was significantly higher in Nchelenge than in Luanshya (P<0.05). This observation leads us to propose that there are environmental factors responsible for the differences in the transmission of the two worm infections in school age children in the two districts.

Following the above observations we conducted a study entitled "Identification of soil and climatic factors responsible for the varied distribution of Soil Transmitted Helminthes in Nchelenge and Luanshya districts of Zambia" in July 2015. The aim of this study was to establish environmental factors responsible for the varied transmission of soil transmitted helminthes (STHs) in school children in Nchelenge and Luanshya districts of Zambia. The objectives of the study were to: compare the selected soil properties between Nchelenge and Luanshya districts, characterize the geographical positions of Nchelenge and Luanshya districts in terms of latitude, longitude and altitude, compare the selected climatic variables between Nchelenge and Luanshya districts, and make appropriate recommendations on how to effectively control STHs, based on the identified environmental factors, to the Ministry of Health and Ministry of Community Development Mother and Child health.

In this article we present the findings from the above study.

II. MATERIAL AND METHOD

1.1 Study design

This was a cross-sectional survey involving analysis of soil samples collected from selected sites around the two selected schools, study of climatic patterns, and geographical characterization of the two districts.

1.2 Study site and duration.

The field work was conducted from 15th to 24th July 2015 while soil analysis was carried out soon after that. Soil sample collection was done around Kenani primary school in Nchelenge district and Kawama primary school in Luanshya. These were the same schools where the prevalence of Hookworm and *A.lumbricoides* in the preceeding study was determined in July 2014.

1.3 Details of the fieldwork

1.3.1 Geographical characterization of the two districts

Coordinates and altitudes of the two districts were recorded using the Global Positioning System (GPS) machine (Garmin).

1.3.2 Collection of soil samples

In Nchelenge district seven samples from different sites were collected around the school. The seven sites were at least 10m apart. In Luanshya district six samples were collected from sites located 10m apart. At each site the soil was collected down to the depth of 20cm and weighing up to 1kg. The soil samples were each secured individually in Ziploc bags and stored in cool conditions before being sent for analysis at the soil Laboratory at the Copper belt University, School of Natural Resources within one to two days of collection. The soil samples were analysed for soil physical properties and soil chemical properties. The soil physical properties analysed were as follows; Bulk density, Solid, Moisture, Clay, Silt, Total Sand, and Texture. The soil chemical properties analysed were as follows; pH, Total Nitrogen, Phosphorus, Potassium, Sodium, Calcium, Magnesium, Organic carbon, Organic matter, Total Carbon, Manganese, Copper, and Lead.

1.3.3 Climatic conditions of Nchelenge and Luanshya districts

Using Google Search we collected the available data on the monthly weather averages summary for Luanshya and Nchelenge districts [11, 12]. The data collected was as follows: Average Temperature, Average precipitation, Average Number of Days of Precipitation, Average Length of Day, Average Relative Humidity, Average Dew Point, and Average Wind Speed.

1.3.4 Data entry and analysis

Data was entered and analysed in Epi Info version 6.04d (2001). Since the quantitative data was not normally distributed Kruskal wallis test was used to compare the medians and the 25% tile and 75% tile. For the qualitative data Fisher exact test was applied with the level of significance being 5%.

III. RESULTS

3.1 Comparison of the geographical characteristics of the two districts.

The position of Nchelenge district is altitude of 934m, longitude of E-28 43.920, and latitude of S-9 20.729. The position of Luanshya district is altitude of 1218m, longitude of E-28 18.764, and latitude of S-13 07.241.

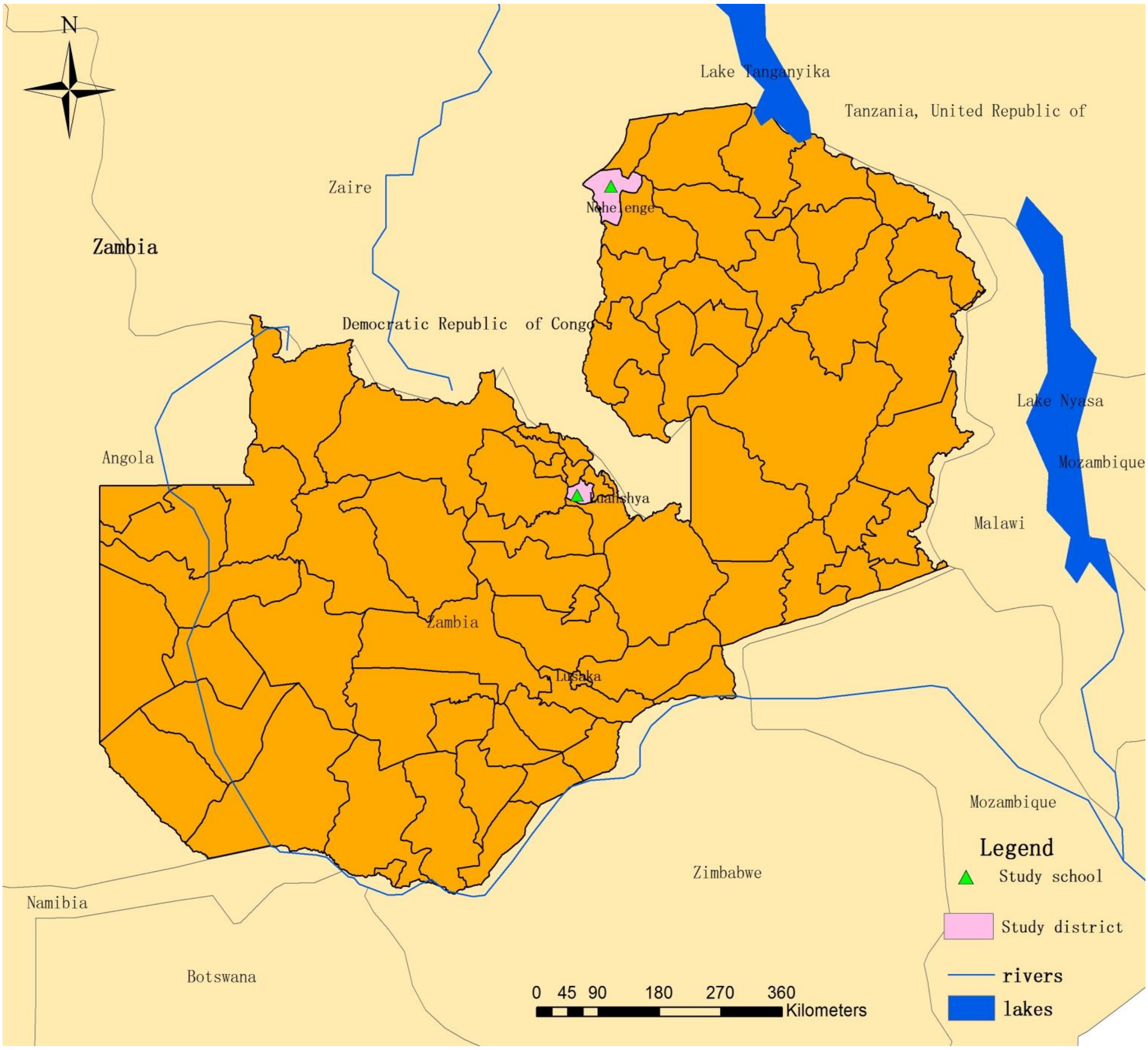

FIG. 1. SHOWS THE LOCATION OF LUANSHYA AND NCHELENGE DISTRICTS ON THE MAP OF ZAMBIA.

3.2 Climatic conditions for the two districts

The two districts were identical in all the variables analysed apart from the monthly average temperature. The monthly average temperature was significantly higher for Nchelenge than Luanshya districts ($P<0.05$).

TABLE 1
COMPARES THE MONTHLY AVERAGE WEATHER SUMMARIES BETWEEN NCHELENGE AND LUANSHYA DISTRICTS.

	Characteristic (units)	Nchelenge Median (Q1, Q3)	Luanshya Median (Q1, Q3)	P-value
1	Average monthly Temperature (^{o}C)	23.6 (22.7, 21.9)	21.9 (18.4, 22.2)	0.004
2	Average Precipitation (mm)	91.2 (6.5, 188)	38.8 (1.7, 210.3)	0.862
3	Average days of precipitation(days)	10.4 (0.8, 17.9)	4.9 (0, 17.9)	0.815
4	Average length of day (hours)	12.5 (12.2, 12.9)	12.5 (12.0, 13.0)	0.966
5	Average Relative humidity (%)	68.1 (55.3, 77.2)	65.2 (51.2, 79.5)	0.954
6	Average dew point (^{o}C)	17.3 (13.2, 19.4)	13.9 (8.3, 18.4)	0.073
7	Average wind speed (km/h)	5.4 (4.2, 6.5)	5.2 (4.7, 6.5)	0.684

3.3 Soil physical properties and chemical analyses for the two districts

TABLE 2
COMPARISON OF SOIL PHYSICAL AND CHEMICAL PROPERTIES BETWEEN NCHELENGE AND LUANSHYA DISTRICTS.

Characteristic (units)	Nchelenge Median (Q1, Q3)	Luanshya Median (Q1, Q3)	P-value
1. Bulk density (g/cm^3)	1.478 (1.421, 1.688)	1.202 (1.139, 1.272)	0.004
2. Solid (%)	55.8 (50.0, 68.7)	45.4 (43.0, 46.6)	0.015
3. Moisture (%)	1.34 (0.55, 3.15)	5.70 (4.70, 9.30)	0.003
4. Clay (%)	5.6 (4.6, 5.6)	7.1 (6.6, 10.6)	0.005
5. Silt (%)	3.6 (2.6, 4.1)	3.1 (2.6, 3.6)	0.825
6. Total sand (%)	91.8 (90.8, 91.8)		
7. pH	5.5 (4.4, 6.0	6.3 (5.6, 6.5)	0.116
8. Total Nitrogen (%)	0.026 (0.017, 0.0029)	0.036 (0.027, 0.039)	0.061
9. Phosphorus (%)	0.056 (0.016, 0.073)	0.036 (0.027, 0.051)	0.775
10. Potassium (Ppm)	110 (90, 250)	211 (106, 239)	0.475
11. Sodium (Ppm)	61 (46, 68)	75 (62, 84)	0.074
12 Calcium (me/100g))	3.15 (1.45, 3.95)	3.35 (2.80, 3.80)	0.616
13. Magnesium (me/100g)	2.60 (2.50, 3.30)	3.83 (3.40, 5.70)	0.018
14. Organic carbon (%)	0.356 (0.226, 0.931)	0.447 (0.251, 0.588)	0.943
15. Organic matter (%)	0.711 (0.453, 1.862)	0.895 (0.523, 1.177)	0.943
16. Total Carbon (%)	0.473 (0.301, 1.238)	0.595 (0.348, 0.783)	0.943
17. Manganese (Ppm)	0.48 (0.42, 0.60)	2.76 (2.14, 3.24)	0.003
18. Copper (Ppm)	0.70 (0.60, 0.89)	1.89 (1.08, 3.72)	0.007
19. Lead (Ppm)	0.34 (0.16, 0.68)	0.42 (0.16, 0.50)	0.614

3.3.1 Soil physical properties

There were significant differences in all the variables ($P<0.05$) apart from Silt ($P>0.05$) between the two districts. Bulk density, Solid, and Total Sand were significantly higher in Nchelenge than in Luanshya districts while Moisture and Clay were higher in Luanshya than in Nchelenge districts.

3.3.2 Texture of the soil between for the two districts

There was a significant difference in the soil texture between the two districts ($P<0.05$). The soil for Nchelenge district was exclusively Sandy while for Luanshya it was predominantly Loamy-Sand.

3.3.3 Soil chemical properties.

All the parameters analysed were identical between the two districts apart from Manganese, Magnesium, and Copper levels in the soil ($P>0.05$). The Manganese, Magnesium, and Copper levels in the soil were significantly higher for Luanshya than Nchelenge ($P<0.05$).

IV. DISCUSSION

Specific environmental conditions are required for the survival of the eggs and larvae of STHs. These conditions will therefore directly influence which worm species will be transmitted in what geographical location and soil conditions. The results from our study, to some extent, have demonstrated that certain geographical characteristics, soil physical properties, soil chemical properties, and climatic conditions influence the uneven transmission of STHs in particular geographical locations. It may therefore be argued that higher altitudes and hence cooler temperatures favour the survival and transmission of ascariasis while lower altitudes, accompanied by warmer temperatures, will favour the survival and transmission of hookworm infection. This finding has been demonstrated elsewhere [10]. Our study demonstrated that high average monthly temperatures favoured survival and transmission of hookworm more than of *A.lumbricoides*. For hookworm, high temperatures are important for the period of hatching of the eggs and maturation of the larvae in the soil [13].

On the soil physical properties, our study has demonstrated that sandy soil conditions seem to favour survival, maturation, and transmission of hookworm when compared with *A.lumbricoides*. Well drained and aerated sandy soil has been shown to favour larva development for hookworm [14]. High clay content and loamy sandy soil in our study seem to promote survival, maturation, and transmission of *A.lumbricoides* when compared with hookworm. This has been demonstrated elsewhere [10].

In addition, high moisture content in loamy- sandy soil and soil with high clay content as observed in our study seemed to favour survival and transmission of *A.lumbricoides* when compared with hookworm and demonstrated elsewhere [13].

The findings from our study on the soil chemical properties showed that high levels of copper, manganese, and magnesium favoured the survival, maturation, and transmission of *A.lumbricoides* when compared with hookworm infection. This therefore means that high levels of these minerals are required for the development of the of *A.lumbricoides* eggs to infective stage in the soil. It may also be argued that high levels of these minerals in the soil hinder the development and transmission of hookworm larva in the soil. Such findings haven't been reported in literature.

V. CONCLUSION

Geographical characteristics, soil physical and chemical properties, and climatic condition do influence survival, maturation, and hence uneven transmission of STHs in different geographical localities. This information will enable health policy makers design effective evidence based interventions against STHs in affected communities. There is need for more research to define the role of minerals in the development of eggs and larvae of STHs in the soil.

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