Diabetes Mellitus in Mahadev Range of Kashmir Himalayas: A Geographical Analysis

Abstract

Spatial distribution of diabetes in district Srinagar reveals a high intensity zone of diabetes mellitus in the foot hill settlements of Mahadev Range of Kashmir Himalayas where people rely mostly on locally grown vegetables cultivated in the soils deficit in two important trace elements viz Zn and Cu. The paper suggests an ecological approach, involving assessment of trace element deficiencies, modification of soil management practices and soil culture. An attempt has been made to suggest dose-response curves for Zn and Cu to maintain the normal concentration of these elements in the soil to lead to balanced and healthy food chain. This planning may be very helpful for the control of diabetes mellitus in the area.

Keywords: Diabetes Mellitus, Mahadev Range, Kashmir Himalayas, Trace Elements, Standard Requirement.

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Introduction

The geographical environment has a close relationship to endemic diseases and is influenced by climate, geology, landform, soil, food and drinking water. After drinking water that is the key issue, it is the soil that influences human health more directly than lithology of strata because the different elements in the soil can easily be absorbed by plants and lixiviated in water (Pyle, 1979; Lin, 199). Trace elements in the soil are derived from Atmosphere, Hydrosphere, and Lithosphere. Model shows the pathways where by the trace elements may find their way to human body and thus influencing the quality of health (Figure 1).

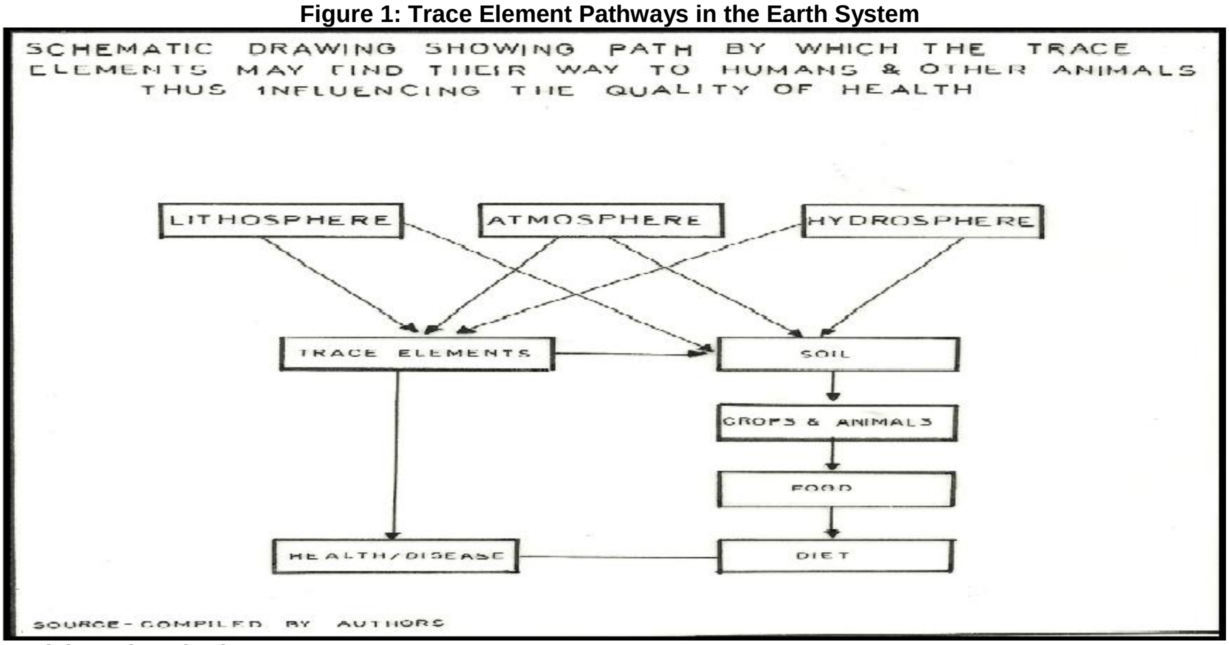
Review of Literature

Trace elements in the soil are becoming recognized as vital to human health (Warren, DeVault and Cross, 1967). Each trace element has a standard requirement adequate for human health recommended by W. H.O. (Fishbein, 1986). All essential trace elements either in imbalance states (Warren, 1991) or in deficiency states are known to create serious health problems particularly in the areas where these are regionally deficit (Hunter and Akhtar, 1991). Diabetes mellitus commonly referred to as diabetes is a group of metabolic diseases characterized by high blood sugar level that results from defects in insulin secretion (www.medicinenet.com, Diabetes mellitus index). The disease is a chronic one caused by inherited and/or acquired deficiency in the production of insulin by Pancreas or by the ineffectiveness of the insulin produced (Wikipedia.org./wiki/Diabetes mellitus) and is characterized by recurrent or persistent hyperglycemia. The disease is diagnosed by demonstrating fasting plasma glucose level at or above 7.0 m mol/l or 126 mg/dl (Wikipedia.org./wiki/Diabetes mellitus). Diabetes mellitus, once a Western disease (Learmonth, 1988) is now one of the most daunting challenges worldwide. Near about 135 million people suffer from diabetes mellitus worldwide and the number will rise to 300 million by 2025 (WHO, 2004). Though the disease is more common in tropical areas but has also been reported since long in Kashmir Valley with increasing trend (Zargar, Shah and Laway, 1996). In addition to this some outstanding contribution has been made by Shaw, J. E., Sicree, R. A., & Zimmet, P. Z. (2010), American Diabetes Association. (2014), Hu, F. B. (2011), Ruta, et al. (2013), Ginter, E., & Simko, V. (2013), Pieso, M. N., Nzaro, G. M. & Njagi, J. M. (2015), Chaidir, R., Wahyuni, A. S., & Furkhani, D. W. (2017).

Aim of the Study

Present study is an attempt to investigate the ecological causes and impact of geo-chemical and soil variables on anomalies of trace elements leading to higher incidence of diabetes in the foothill settlement of Mahadev Range of Kashmir Himalayas falling within the slope range of 10^0-30^0 (Raza, Ahmad and Mohammad, 1978) (Figure 2).

Figure 1: Trace Element Pathways in the Earth System



Materials and Methods

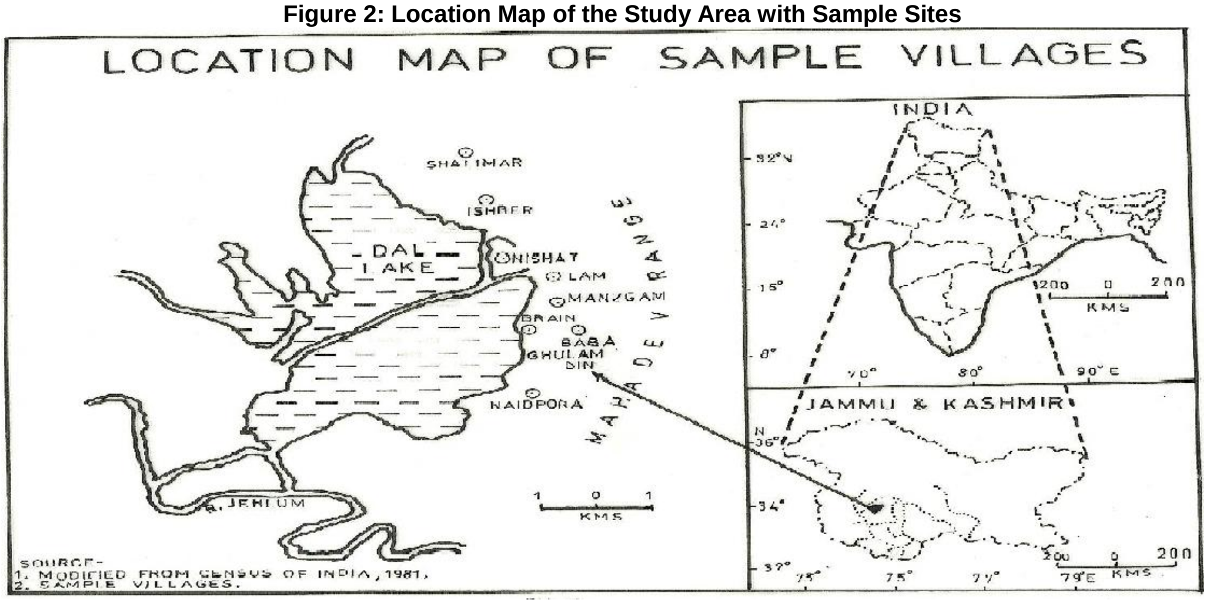
Data regarding incidence of diabetes and Case history of 228 diabetic patients was collected from SKIMS and SMHS- the specialized medical institutions for diabetes treatment in the valley. Since the disease is related to deficiency of Zn and Cu (Zargar, Shah and Laway, 1998) and the trace elements are not synthesized by the human body as such, they must be provided through the diet (Nath, 2000). Above all the region was relying heavily on locally grown vegetables and more exposed to diabetes lead to an analysis of Zn and Cu trace elements in the soil. A strategy of stratified sampling was devised in order to reduce the variability of the sample (EPAUS, 1992). This strategy is the most appropriate for heterogeneous areas (Boulding, 1994). Eight (8) sample villages (Table1) were selected and in order to reduce variability, a composite sample was obtained from each sample village, from five soil cores collected in crossing directions, with the help of soil sampler. Soil samples were taken only from surface soil (depth of 0-30 cm) for the reason that these soils are intensively under the cultivation of vegetables and this is the major zone of root development of crops (Brady, 1991). Soil samples were collected into different specimen bags and were numbered after the sample village from where the sample was taken. The soil samples were air-dried, crushed with a wooden roller, passed through a 10 mesh (<2 mm) sieve, and then ground in an agate mortar. The recovered <63 μm particles were separated for chemical analysis. Soil samples were analyzed for Zn and Cu in soil testing laboratory, SKUAST–K. Total concentrations of Cu and Zn were determined after 4-acid digestion (HF, $HClO_4$, HNO_3 and HCl) by Atomic Absorption Spectrophotometer (AAS). pH value of soil was also determined for the reason of being most important factor affecting availability, mobility and behavior of trace element in the soils. The data obtained was then analyzed statistically to calculate the surface range, average concentration, and standard deviation for Zn and Cu in each sample village. Water quality analysis was not needed because all the sample villages were provided with clean tap water. Socio-economic field survey of 500 Households in 8 sample villages was carried out to find out the incidence of diabetes and dependency on locally cultivated vegetables and the households were graded on the basis of dependency. Carl Pearson's method of coefficient was employed to find out coefficient of correlation between the two variables.

Table 1: Sample Villages with Geo-Coordinates

Sample Village	*Geo-coordinates*	*Altitude (meters a.m.s.l.)*
Nishat	*$34^0$07'20.70" N -$74^0$52'49.36" E*	*1605*
Ishber	*$34^0$25'51" N-$75^0$04'55" E*	*1600*
Manzgam	*$34^0$06'56.22" N-$74^0$53'20.68" E*	*1700*
Lam	*$34^0$06'56.22" N-$74^0$53'01.53" E*	*1620*
Brain	*34^0 06'30.71" N-$74^0$52'49.43" E*	*1610*
Naidpora	*34^0 06'30.71" N-$74^0$52'49.43" E*	*1603*
Baba Gulamudin	*34^0 06'30.71" N-$74^0$52'49.43" E*	*1902*
Shalimar	*$34^0$09'01.43" N-$74^0$52'55.59" E*	*1600*

Source: Data Generated During Field Survey by using GPS

Figure 2: Location Map of the Study Area with Sample Sites



Results

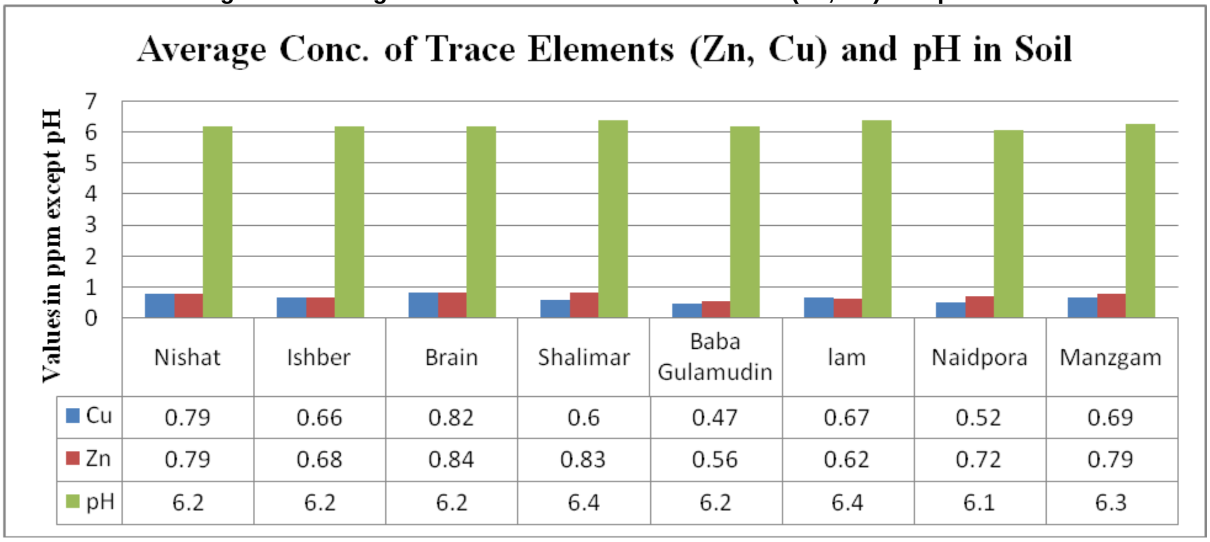
Table 2 summarizes the surface range, average concentration and standard deviation from mean for Cu and Zn trace elements in the soil of the sample villages. Analysis of data reveals the trend of soil reaction towards acidity with pH value ranging from 5.2 to 6.9. It is evident from the results that out of two trace elements; Cu is having not only high range (0.33 pp m- 0.93 ppm) as compared to Zn (0.46 ppm - 0.88ppm) in the study area in general but such variation has also been noted in each sample village. Mean values of Cu and Zn in the sample villages are shown in figure 3.

Table 2: Concentration of Trace elements (Zn and Cu) and pH value of soils in sample villages

Sample Village		Surface range ppm)	Average conc. (ppm)	Standard deviation from X
Nishat	Zn	0.74- 0.85	0.79	0.047
	Cu	0.67-0.86	0.790	0.033
	pH	5.9-6.5	6.2	-
Ishber	Zn	0.61- 0.77	0.68	0.058
	Cu	0.53-0.84	0.66	0.063
	pH	5.7-6.4	6.2	-
Manzgam	Zn	0.65- 0.88	0.79	0.083
	Cu	0.64-0.83	0.69	0.087
	pH	5.5-6.6	6.3	-
Lam	Zn	0.58- 0.66	0.62	0.046
	Cu	0.61-0.73	0.670	0.044
	pH	5.4-6.9	6.4	-
Brain	Zn	0.80- 0.86	0.84	0.021
	Cu	0.76-0.93	0.82	0.018
	pH	5.6-6.4	6.2	-
Naidpora	Zn	0.66- 0.82	0.72	0.93
	Cu	0.43-0.63	0.52	0.065
	pH	5.5-6.5	6.1	-
Baba-Gulumdin	Zn	0.46- 0.61	0.56	0.062
	Cu	0.33-0.56	0.47	0.066
	pH	5.5-6.5	6.2	-
Shalimar	Zn	0.80- 0.87	0.83	0.25
	Cu	0.55-0.68	0.60	0.049
	pH	5.2-6.8	6.4	-
Total	Zn	0.46- 0.88	0.73	0.102
	Cu	0.33-0.93	0.66	0.0142
	pH	5.2-6.9	6.2	-

Source: Based on soil test data-2017

Figure 3: Average Concentration of Trace Elements (Zn, Cu) and pH in Soil



Analysis of table 3 regarding the incidence of diabetes shows that over all incidence of disease (5.18%) to total population. Very high incidence of diabetes has been reported in the sample village Baba Gulamudin (9.89% to total population) and the lowest incidence in the sample village Manzgam (2.76% to total population). The incidence of diabetes in the sample villages ranges from 2.76-9.89% (figure 4).

Table 3: Incidence of Diabetes in Sample Villages

Sample Village	No. of Cases	% to total Population
Nishat	21	4.07
Ishber	14	5.34
Brain	18	6.71
Shalimar	16	3.23
Baba Gulamdin	31	9.89
Lam	27	6.12
Naidpora	18	3.32
Manzgam	12	2.76
Total	157	5.18

Source: - Household Survey-2017

Figure 4: Incidence of Diabetes in Sample Villages

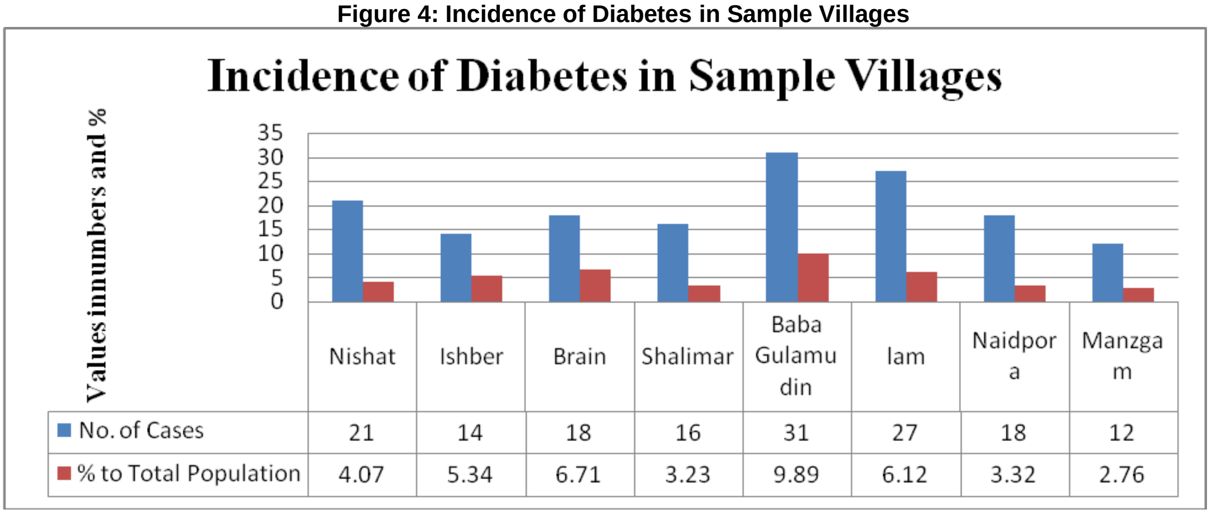


Table 4 shows the case histories of some diabetic persons from the sample villages. Out of the total number of diabetic patients (228), the incidence was found greater in males (119) than the females (109) with different diabetic case history.

Table 4: Case History of Diabetic Patients from Sample Villages (Hospital Record)

Total number of diabetic patients	= 228
G.T.T (2 hour glucose > 200mg/dL).	= 100%
After overnight fasting (>126 mg/dL).	= 100 %
Male	= 119(52%)
Female	= 109(48%)
Diabetes mellitus type I	= 21 cases (09%)
Diabetes mellitus type II	= 207 cases (91%)
Family diabetic hereditary cases	=15%
Non-family diabetic hereditary cases	= 85%
Age of the patients	
>40 years	= 88%
< 40 years	=12%
Obesity	= 14%
Hypertension	= 20%

Source: - SKIMS, Soura Srinagar-2017.

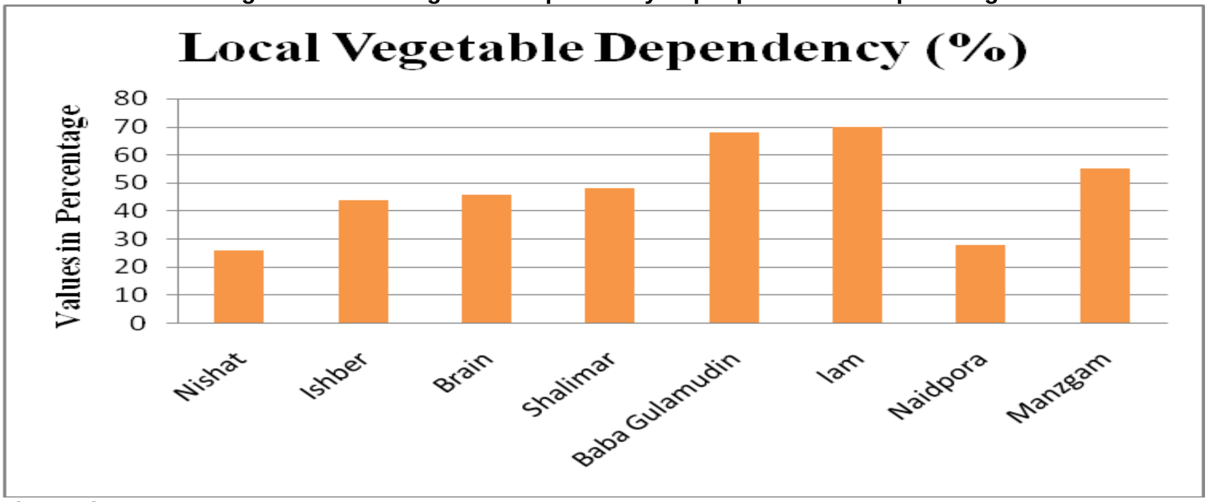
Table 5 and figure 5 show dependence of the people on locally cultivated vegetables. The dependence of people at household level on locally cultivated trace element deficit vegetable varies from 26-70%. The dependency carried were out as well.

Table 5: Local Vegetable Dependency in Sample Villages

Sample Village	Dependency Category	Households with %
Nishat	Low	26
Ishber	Medium	44
Brain	Medium	46
Shalimar	Medium	48
Baba Gulamdin	Very High	68
Lam	Very High	70
Naidpora	Low	28
Manzgam	High	55

Source: Based on data obtained from household Survey-2017

Figure 5: Local Vegetable dependency of people in the sample villages



Discussions

The deficiency of Zn and Cu with marked variation in all the sample villages (Table 2) can be attributed to the fact of downward deviation of pH value from the normal (Brady, 1991), high intensity of soil erosion, steepness of slope and low organic content of soils (Biswas and Mukherjee, 1994; Kanth and Bhat, 1991) leading to leaching, a natural process of removal of trace elements in the soil (Keller, 1988). It is very interesting to note that all the three statistics techniques employed for analysis of Zn and Cu yield almost identical result depicting considerable variation in concentration with degree of slope. The deficiency of Cu is more than that of Zn and although this deficiency of Cu more than that of Zn is rare in nature but when it occurs, leads to serious ailments (Graham and Cordan, 1986). Under such conditions the soils of the study area are not expected to produce crops which can provide safe and adequate dietary intake of 15mg/ day of Zn and 2-3 mg/day of Cu for adults as recommended by W.H.O (WHO, 1997) and this deficiency of Zn and Cu may be the cause of the disease. Considerable variation in sample villages may be because of altitudinal variation (Table 2) as altitude plays an important role in soil erosion that in turn leads to loss of trace elements. These two trace elements are having a close relationship with diabetes mellitus (Retnam and Bhandarkar, 1981). A causative relationship between trace elements Zn and Cu and secretion of Insulin have been demonstrated by clinical research and can be analyzed by the fact that Cu has a particular role in cytochome oxidize function and the deficiency of same effects the metabolic activity of pancreas. Similarly Zn, another essential trace element plays an important role in the maintenance of several tissue functions and the deficiency of same has been associated with defects in insulin release (Retnam and Bhandarkar, 1981; Zargar, Shah and Laway, 1988; Mills, 1989) and Cu have also synergetic interaction, that is toxicity is much higher when the elements are present together (Leckie and Park, 1978).

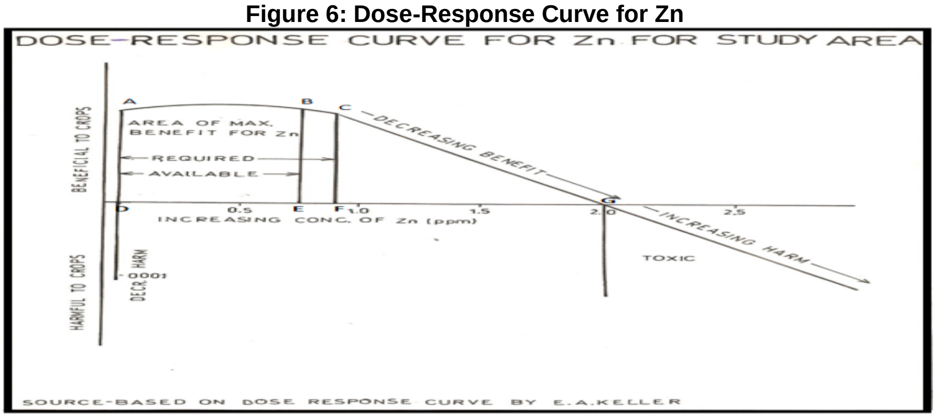
Case history of diabetic patients reveals that out of the total 228 patients diagnosed as diabetic patients, Non-family diabetic hereditary cases were 85% of the total diabetes cases which is a clear indication of recent incidence of the disease in the area (table 4) and may be because of deficiency of Zn and Cu. Male and female incidence of the disease does not display much greater difference. However, there is a slight predominance of a male incidence over the females. The disease generally strikes after the age of 50 but has been noted in the age group of 40-50 years and even below 40 years as something alarming. Almost all the patients were Muslim and mostly vegetarian relying on locally grown vegetables (table 5 and figure 5). However, the consumption of meat which could have been substitute of Zn was occasionally taken.

Dose-Response Curves

Every organism thrives and develops well only in a certain set of geochemical conditions. It has been proved that the effect of a certain trace element on a particular organism depends on the dose or concentration of the element. So, dose-response curves as shown in figures 6 and 7 are used to represent the dose-dependency of life (crops) on a particular trace element.

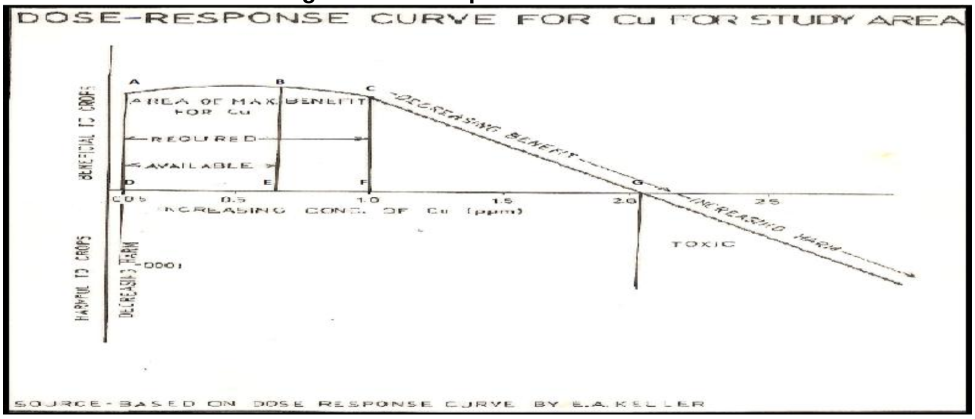
The figure 6 shows dose-response curve for Zn. Like every other trace element Zn as a nutrient in the soil is harmful, beneficial and toxic for crops grown in a particular area. The concentration of Zn below 0.0001 is harmful to crops. The ACDF shows the maximum benefit plateau in which crops of the study area can thrive very best but unfortunately, there is lack of concentration of available Zn, BCEF. So, maximal-optimal benefit can be achieved by supplying BCEF concentration of Zn to the soil. The threshold concentration where harmful effects to life start varies with concentration greater than at point G (and less than at point D).

Figure 6: Dose-Response Curve for Zn



The figure 7 shows dose-response curve for Cu. The ACDF shows the maximum benefit plateau in which crops of the study area can thrive very best but unfortunately, there is lack of concentration of available Cu, BCEF. Since the soils are deficient in Cu concentration, best and maximum overturns can be achieved only supplementing Cu to soil culture through fertilizers or directly to crops through sprays. The threshold concentrations where harmful effects to life start varies with concentration less than at point D and greater than at point G.

Fig. 7: Dose-Response Curve for Cu



It has been noted that there is a positive correlation (+0.6350) between incidence of diabetes and dependency on locally cultivated vegetables in sample villages which indicates that soil management practices needs to be modified in order to minimize the risk of trace element deficiency in the soils. Besides this, there is need of application of micronutrients through fertilizers like Cu SO_4 $5H_2O$ (Copper Sulphate) for Cu deficiency and $ZnSO_4$ 7 H_2O (Zinc Sulphate) for Zn deficiency, either as foliar spray or directly in the soil (Kaleem, 1991), but in accordance with deficiency, as mega dose of Zn and Cu above the standard requirement can induce Cu imbalance further. So far as the cropping pattern in the area is concerned, variability of trace element signifies a need of change in the cropping pattern of the study area.

Conclusions and Suggestions

1. Mountainous areas are notorious for trace element related deficiency diseases and the study area is no exception to it where the incidence of diabetes is 5.18% to total population of the study area.
2. Incidence of diabetes shows an increasing trend with the increasing altitude in the study area.
3. Out of the total number of patients suffering from diabetes, 91% suffer from Diabetes Mellitus-II and that is because of trace element deficiency in the soil.
4. Since the area of interest is a mountainous area, both Cu and Zn are deficient in the soils like in other mountainous soils of the world.
5. The soil culture needs to be modified and managed properly through sustainable farming practices.

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