

*Full Length Research Paper*

## Geomedical study of thyroid disorders in the foot hill settlements of Pir Panjal Range

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The present study is an attempt to find out the concentration of Iodine (I) in soil and water phases of the natural environment, and its relationship with the human health in the foot hill settlements of Pir Panjal Range in Anantnag district of Kashmir valley. Also, socio-economic determinants of health were taken into due account. Firstly, the area was divided into altitudinal zones and soils classes. Then, the soil and water samples were taken from each soil type in each altitudinal zone and were analyzed by Atomic Absorption Spectrophotometer. The socio-economic character of the area was analyzed through surveying the area by using structured household schedules. In this area, people rely mostly on locally cultivated food items because of their economic condition. The study highlights that about 19.5, 42.9 and 37.6% households in the study area have low (Rs. <5, 000 month<sup>-1</sup>), medium (Rs. 5, 000-10, 000 month<sup>-1</sup>) and high (Rs. >10, 000 month<sup>-1</sup>) income status respectively. The study reveals that iodine content in all the soil (0.970 to 1.230 mg kg<sup>-1</sup>) and water (1.6 to 4.2 µg L<sup>-1</sup>) samples in all the altitudinal zones is less than the average values in the world soils (2.8 mg kg<sup>-1</sup>) and fresh waters (8.7 µg L<sup>-1</sup>). About 17.6% of the population in sample villages suffers from Iodine Deficiency Disorders (IDDs). These IDDs can be ascribed to the scarcity of iodine in soils, drinking waters (and hence diet) and lifestyle. Attempts have been made to suggest certain remedial measures to minimize the magnitude of IDD sufferers in the study area.

**Key words:** Iodine, thyroid disorders, foot hills, cooking methods.

### INTRODUCTION

Trace elements are the elements present in the earth's crust in concentrations less than 0.1% (<1000 mg kg<sup>-1</sup>) or those elements that are ordinarily present in plant or animal including human beings tissues in concentrations less than 0.01% (<100 mg kg<sup>-1</sup>) of the organism's dry weight (Adriano, 2001). Trace elements are necessary for life in small amounts. They are components of haemoglobin, Deoxyribonucleic acid, Ribonucleic acid,

and various enzymes (Warren, 1991). Trace metals play an important role in the synthesis of both proteins and nucleic acids. There is a standard requirement of each trace element for human health (WHO, 1996). All essential trace elements either in excess states or in deficit states are known to create serious health problems particularly in the areas where these are regionally deficit (Hunter and Akhtar, 1991) or surplus. The

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concentration of trace elements in soil, water or food items is mainly determined by the geological conditions of the area (Keller, 1999; Pyle, 1979).

The human body does not make its own iodine and is dependent on dietary sources, and thus making it an essential part of our diet. The healthy adult human body contains 15 to 20 mgs of iodine, of which about 70 to 80% is in the thyroid gland. The normal intake and requirement of iodine is 100 to 150  $\mu\text{g d}^{-1}$  (Masoodi, 2012; Fuge, 2005).

It is an essential element that is critical for the normal growth and development, and well being of all humans. Iodine deficiency is associated with reduced thyroid hormone synthesis, leading to increased thyroid stimulating hormone levels, which stimulates thyroid over growth and goiter (Jamescon and Weetman, 2005). The distribution of iodine is uneven in the biosphere. Its deficiency does not cause a mere enlargement of thyroid gland (endemic goiter), it can cause a variety of disorders called iodine deficiency disorders (IDDs) or thyroid disorders consisting of hypothyroidism, endemic cretinism, still-births, mental retardation, defects in vision, hearing and speech, and neuromuscular weakness.

These disorders are mainly found in those people who live away from coastal areas, in mountainous areas, previously glaciated areas and the like. Even people living in coastal areas and on islands suffer from IDDs because sea salt does not contain iodine content as much as required by the people and due to their unsuitable habits (UNICEF, 2002). World health organisation estimated that about 20 to 60% of the world's population is iodine deficient (Zimmermann, 2009) with most of the burden in developing countries. Mayer while working out the goiter incidence in Kashmir Valley during 2004 to 2005 found that Anantnag district (a part of foot hills) has the highest incidence of goiter, and he suggested that nature of bedrock and soils is responsible for the variable goiter incidence in the valley.

According to a recent research conducted on school children of Kulgam district which is a part of the foot hills of Pir Panjal range, it was found that 18.9% suffer from Total Goiter Rate (TGR); 21.2% boys and 16.7% girls (Khan et al., 2014). Since, the incidence/prevalence of thyroid disorders is a significant health problem covering an appreciable section of the society in the foot hills of Pir Panjal range, the present study was attempted to investigate its the possible causes and factors of both geochemical and socio-economic origins in the area.

### Study area

The area taken in this study is a part of the Kashmir region located roughly between the elevations of 1,800 meters to 3,000 meters above the mean sea level (m AMSL). The area lies between 33°23' 08" N to 33°65' 90" N latitudes and 74° 55' 75" 10' 05" to 75° 35'

20" E longitudes, covering an area of about 547.04  $\text{km}^2$  (Figure 1) with a population of about 1, 88,055 (Census, 2011). The soils of the concerned area vary in origin from alluvial to lacustrine and glacial (Figure 2 and Table 1).

### METHODOLOGY

A comprehensive methodology has been adopted to carry out the present study. Figure 3 shows the general data base and methodological scheme divided into many related steps in order to accomplish the objectives of the present work.

#### GIS techniques

The study area was delineated from Survey of India (SOI) toposheets of 1:50,000 scale of 1971 with numbers as 43 O/2, 43 O/3, 43 O/6 and 43 O/7 with the help of Arc View 3.2a software. The base contour was taken as 1,800th m AMSL and top one as 3,000th m AMSL (Raza et al., 1978). These two contours were connected on the lateral sides by taking the watershed limits through digitization.

By digitizing 2,400th m contour, the area under study was divided into two altitudinal zones, namely, Lower Foot Hills (LFHs) and Upper Foot Hills (UFHs) varying in altitude from 1,800th-2,400th m and 2,400th-3,000th m respectively. The LFHs are characterized by good permanent human occupancy, while as the UFHs experience mostly seasonal human inhabitations. By digitizing 2,100th m contour, the LFHs were further sub-divided into two sub-zones namely, LFHs-1 and LFHs-2 varying in elevation from 1,800th-2,100th m and 2,100th-2,400th m (Figure 4a) for comparative analysis.

Stratified random sampling technique was used for the selection of sample sites (sample villages, soil and water sample sites), and sample households as shown in Tables 2 and 3 and Figures 4b, 5a and 5b.

#### Field Work

The soil samples were collected in clean unused polythene bags and were labeled properly. A clean spade was used to take the soil samples. In order to reduce variability, a composite sample was obtained from each sample site. A composite sample comprised of five sub-samples taken from each sample site in 10 m x 10 m grid format. Four sub-samples were taken from four corners of the square and one from the center. Soil samples were taken from depths of 0 to 20, 0 to 40 and 0 to 60 cm in relation to different major land uses that is, agricultural, horticultural and forest respectively (Brady, 1991; Pennock et al., 2008). Water samples were collected in clean unused plastic bottles from the selected sample sites and were labeled properly, and were taken to the lab within 24 h. Both types of samples were analyzed in Research Centre for Residue and Quality Analysis Lab, SKUAST, Shalimar. The socio-economic survey was done through the structured schedules to give the socio-economic picture of the area and to assess the dependence of people on local food items, income status, methods of cooking, households using iodized salt and boiled drinking water and percentage of households purchasing food from the market. The data regarding the prevalence of IDDs was collected from the prescriptions given by the registered practitioners.

#### Lab work

The soil samples were air-dried, crushed with a wooden roller,

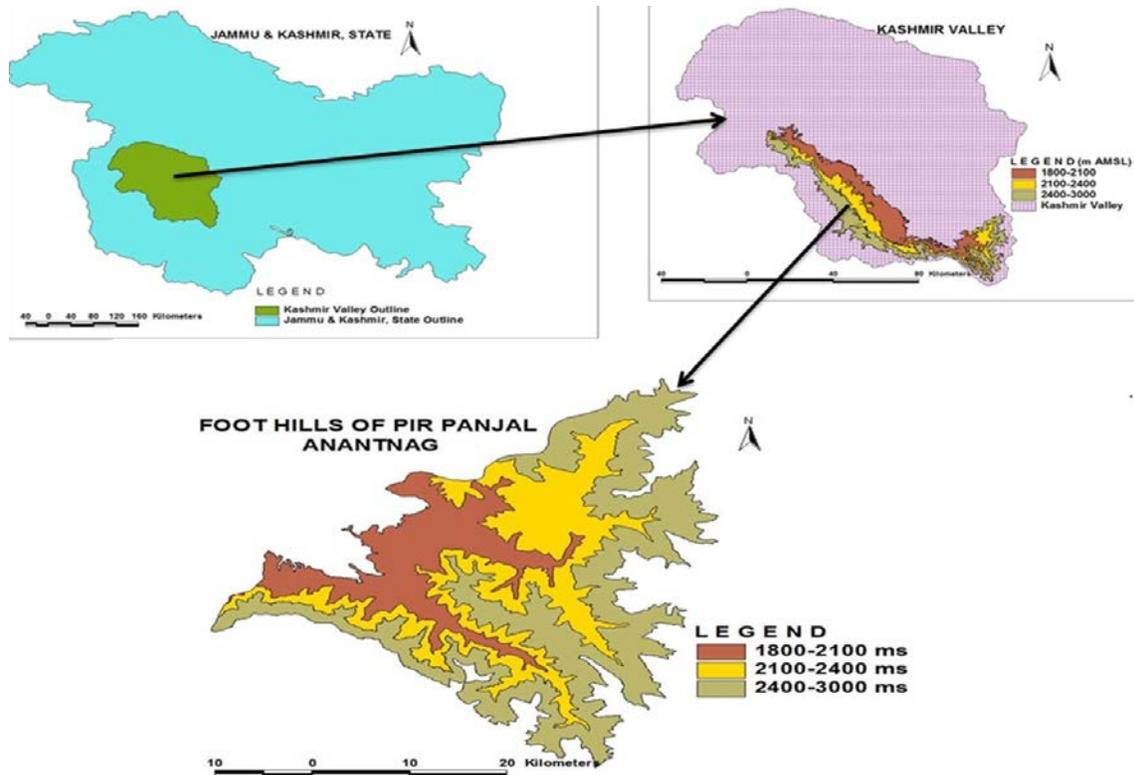


Figure 1. Location map of foot hills of Pir Panjal range in Anantnag (Generated from SOI toposheets, 1971).

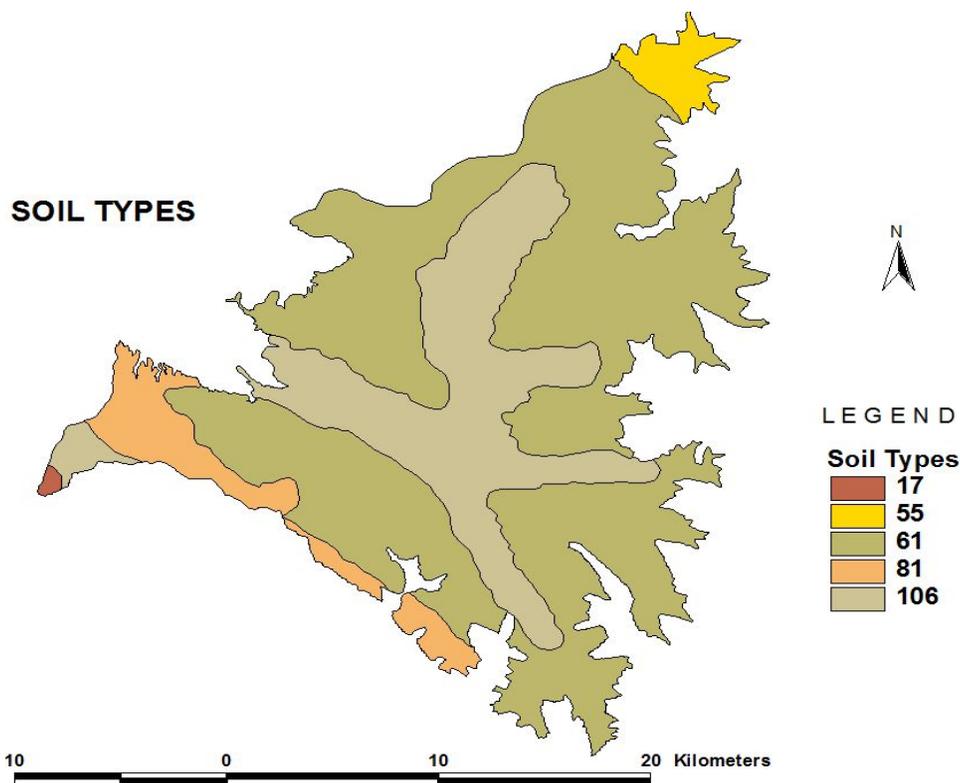
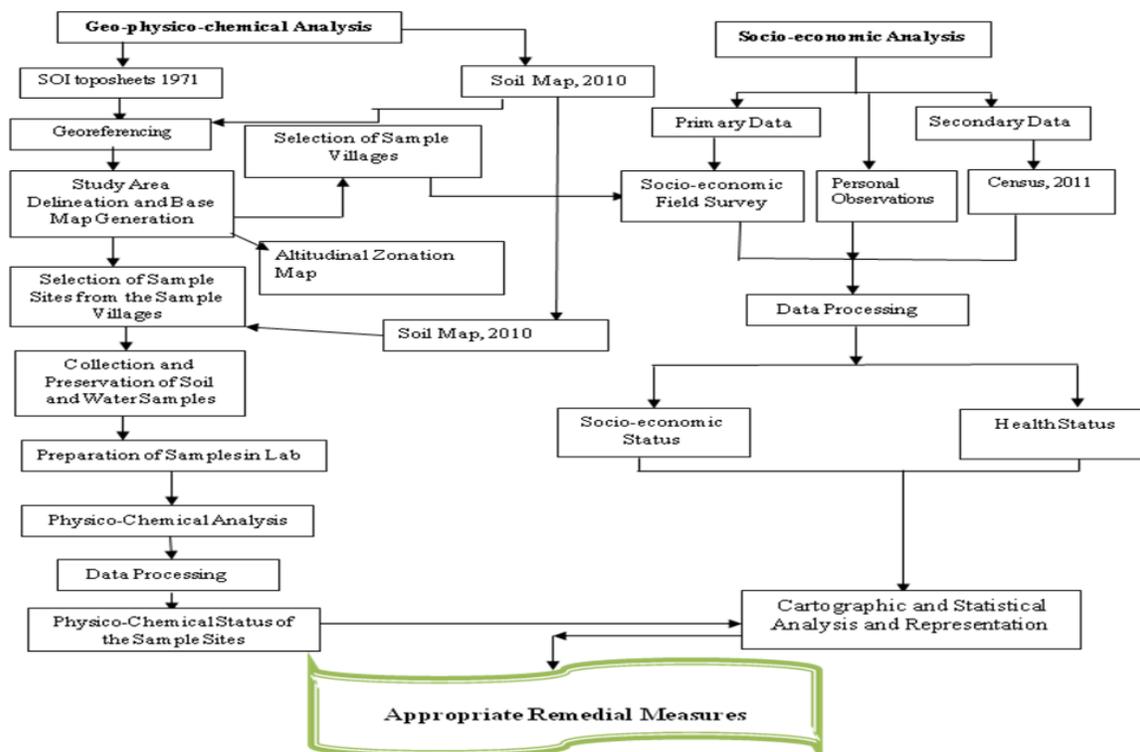


Figure 2. Soil map of the study area (Generated from Soil Map of J & K, ICAR, Nagpur-2010).

**Table 1.** Soil types with codes and description.

Code	Description	Soil type
17	Dominantly rock outcrops; associated with shallow, loamy, calcareous soils on steep to very steep slopes with loamy surface, strong stoniness and severe erosion	Lithic. Cryorthents
55	Deep, well drained coarse-loamy soils on gentle slopes with loamy surface, moderate erosion and slight gravelliness; associated with deep, well drained, coarse loamy, calcareous soils with loamy surface, moderate erosion and slight gravelliness	Typic Cryofluvents
61	Medium deep, well drained, loamy-skeletal soils on moderate slopes with loamy surface, severe erosion and strong stoniness; associated with medium deep, well drained, fine-loamy soils with loamy surface, moderate erosion and moderate stoniness.	Typic Udorthents/ Dystric Eutrochrepts
81	Deep, moderately well drained, fine soils on very gentle slopes with loamy surface; associated with deep, well drained, fine-loamy soils with loamy surface	Typic Hapludalfs/ Dystric Eutrochrepts
106	Medium deep, well drained, fine loamy soils on moderate slopes with loamy surface and moderate erosion; associated with shallow, excessively drained, loamy soils with loamy surface, moderate erosion and strong stoniness	Dystric Eutrochrepts/ Lithic Udorthents

Source: Modified from Soil Map of J & K, ICAR, Nagpur-2010.



**Figure 3.** Flow chart of methodology.

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. The samples were analyzed under Atomic Absorption Spectrophotometer (AAS-4141, Electronic Corporation

**Table 2.** Sample frame.

Macro regions (Altitudinal zones in meters AMSL)	Micro regions (Sub-altitudinal zones in meters AMSL)	Sample villages	Total No. of households in the sample villages	Number of households Surveyed	Percentage of surveyed Households to total Households	Soil type (Codes)	Number of samples taken	Main water source	No. of samples taken
Lower foot hills (LFHS)- 1,800-2,400	LFHS-1 (1,800-2,100)	Bidder Hayat Pora	77	08	>10	61	01	TSg	01
		Bindoo Zalan Gam	519	52	>10	106	01	TSm	01
	LFHS-2 (2,100-2,400)	Hala Pora	292	29	<10	61	01	TSm	01
		Gaw Ran	252	25	<10	106	01	TSg	01
Upper foot hills (UFHS)- 2,400-3,000	UFHS (2,400-3,000)	Raing Mandoo	143	14	<10	61	01	Sg	01
		Chuntwar	00	00	00	106	01	00	00
Total	-	-	1,283	128	10	-	06	-	05

Source: Generated by the authors.

**Table 3.** Sample villages and sample sites with codes and geo-coordinates.

Macro regions (Altitudinal zones in meters AMSL)	Micro regions (Sub-altitudinal zones in meters AMSL)	Sample villages/sites	Sample village/site (Codes)	Geo-coordinates (Lat./Long.)
Lower Foot Hills (LFHS)-1,800-2,400	LFHS-1 1,800-2,100	Bidder Hayat Pora	SS1-ANG	33°36'23" N & 75° 17'54"E
		Bindoo Zalan Gam	SS2-ANG	33° 34'45"N & 75° 18'17"E
	LFHS-2 2,100-2,400	Hala Pora	SS3-ANG	33° 30'40"N & 75° 21'07"E
		Gaw Ran	SS4-ANG	33°35'24"N & 75° 21'26"E
Upper Foot Hills (UFHS)-2,400-3,000	UFHS 2,400-3,000	Raing Mandoo	SS5-ANG	33° 26'38"N & 75° 22'24"E
		Chuntwar	SS6-ANG	33°34'15"N & 75° 24'08"E

Source: SOI toposheets, 1971.

Limited, India). A total concentration of I was determined after 4-acid digestion (HF, HClO<sub>4</sub>, HNO<sub>3</sub> and HCl) by AAS. The samples were analyzed for iodine, pH and organic matter (OM).

## RESULTS AND DISCUSSIONS

### Concentration of iodine in the soil and drinking water sources

The study showed that the soils and drinking

water sources of the foot hills of Pir Panjal range in Anantnag district are deficient in iodine content in all the altitudinal zones (Tables 4 and 5), and have iodine content less than the world averages.

From Table 4, it is obvious that the soils are iodine deficient at all the elevation levels in the study area. The organic matter and pH influence the concentration of iodine in the soils. In soil type-61, iodine content first increases with altitude because of increase in OM in the soil, and then slightly decreases with altitude due to increasing slope and coarser texture of soil. OM binds up iodine

ions in the soil but the increasing slope and coarser texture cause iodine ions flow and translocate easily during rainfalls. In soil type-106, iodine content first decreases with altitude because of increase in the acidity of the soil and then increases with altitude. The acidic pH in soil catalyzes the loss of iodine ions in soil through leaching.

Likewise, Table 5 shows the concentration of iodine in drinking water sources in the area. Iodine content in drinking water sources first increases with altitude and then decreases. It shows affinity

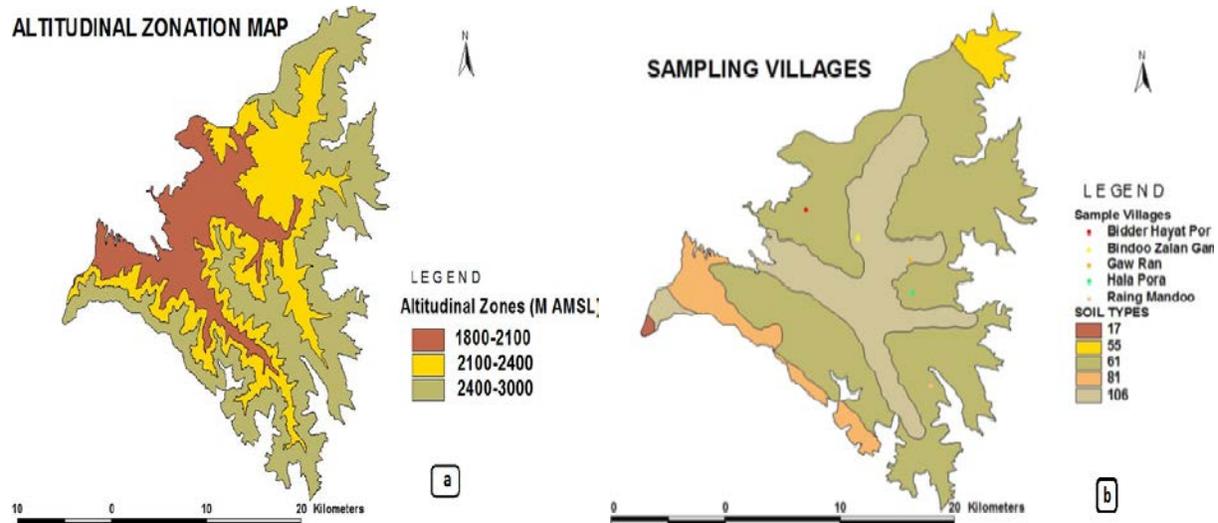


Figure 4. (a) Altitudinal zonation map and (b) Sampling villages.

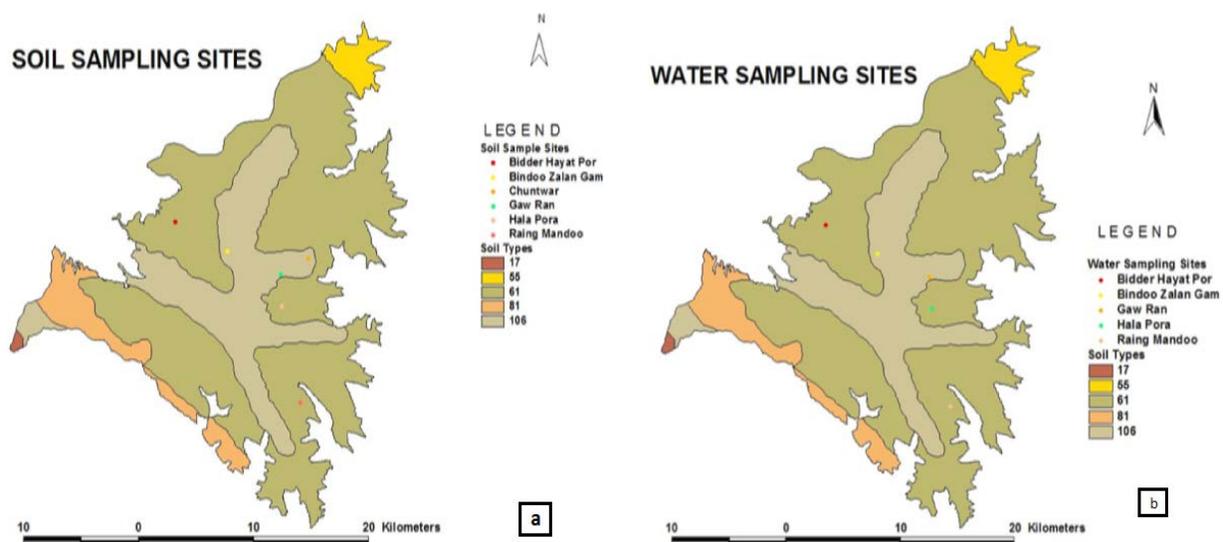


Figure 5. (a) Soil Sampling Sites and (b) Drinking water sampling sites.

to the surrounding soils and their physico-chemical character.

### Prevalence of Iodine deficiency diseases

The study revealed that about 17.6% people suffer from different IDD in all the age-sex groups (Table 6). These people have greater (66.89%) dependence on locally cultivated food items because of their disadvantaged economic condition. More than 62.4% households comprising low and medium income status households fall below poverty line as per international standards of

income-based poverty lines (Rs. 2371.5 month<sup>-1</sup> person<sup>-1</sup>). They also have inadequate income as per the local economic scenario is concerned.

It is evident from the Table 6 that in the sample village of UFH region, about 30.2% people suffer from IDD as compared to 24.0% of LFH region. This variation can be attributed to the greater dependence of people on locally cultivated iodine deficit food items, and less use of iodized salt in UFHs than the people in LFHs (Table 7). In the sample village in UFHs, about 92.9% households fall in low and medium income groups (Table 8) which forces them to rely on whatever food items they cultivate locally. About 92.85% households have >50% dependence on

**Table 4.** Iodine content, pH and organic matter of soil types.

Macro regions	Micro regions	Sample sites	Soil type	Iodine conc. (mg kg <sup>-1</sup> )	pH	Organic matter (OM in %)
Lower foot hills	LFHs-1 (1,800-2,100 m AMSL)	SS1-ANG	61	0.980	6.42	2.15
		SS2-ANG	106	1.000	6.51	3.76
	LFHs-2 (2,100-2,400 m AMSL)	SS3-ANG	61	1.230	6.28	3.76
		SS4-ANG	106	0.970	5.88	3.42
Mean				1.05	6.27	3.27
Upper foot hills	UFHs (2,400-3,000 m AMSL)	SS5-ANG	61	1.050	6.42	4.90
		SS6-ANG	106	1.000	6.56	1.34
Mean	-	-	-	1.03	6.49	3.12
Mean	-	-	-	1.04	6.35	3.22
Standard deviation	-	-	-	0.0893mg kg <sup>-1</sup>	-	-
Coefficient of SD	-	-	-	0.0859	-	-
Coefficient of variation	-	-	-	8.6003%	-	-

Source: Based on soil sample analysis done by the authors, 2013.

**Table 5.** Iodine content and pH of water sources.

Macro regions	Micro regions	Sample sites	Water source	Iodine Conc. (µg L <sup>-1</sup> )	pH
Lower foot hills	LFHs-1 (1,800-2,100 m AMSL)	SS1-ANG	TSg	1.6	7.53
		SS2-ANG	TSm	2.5	7.85
	LFHs-2 (2,100-2,400 m AMSL)	SS3-ANG	TSm	3.9	7.87
		SS4-ANG	TSg	4.2	7.54
Mean				3.05	7.70
Upper foot hills	UFHs (2,400-3,000 m AMSL)	SS5-ANG	Sg	4.1	7.75
Mean	-	-	-	4.1	7.75
Mean	-	-	-	3.26	7.71
Standard Deviation	-	-	-	1.6600 µg L <sup>-1</sup>	-
Coefficient of SD	-	-	-	0.5092	-
Coefficient of Variation	-	-	-	50.920%	-

Source: Based on water sample analysis done by the authors, 2013, Note: TSg=Tap fed by a spring, TSm=Tap fed by a stream, Sg=Spring.

local iodine deficit foods, and 42.8% people used iodized salt in UFHs as compared to the LFHs in which about 81.76% households in the sample villages have >50% reliance on local foods and 75.4% people use iodized salt (Table 7).

The prevalence of IDD in LFHs shows a decline from LFHs-1 to LFHs-2. About 17.4% people suffer from IDD in LFHs-1 as compared to 16.4% in LFHs-2 (Table 6). This variation seems to be outcome of the differential lifestyles especially the food cooking methods. In LFHs-1, about 96.7% households surveyed are accustomed to inappropriate cooking methods such as long period

boiling, braising, blanching and frying as compared to LFHs-2 in which the value is 83.4% (Table 7).

The prevalence of IDD in the sample villages in the sub-zones decreases with altitude with respect to changing iodine, pH and OM content in the respective soil types and socio-economic conditions with the exception of SS5-ANG. In the LFHs-1, SS1-ANG (soil type-61) records 21.4% and SS2-ANG (soil type-106) records 16.9% of patients and in LFHs-2, SS3-ANG (soil type-61) records 16.4% and SS4-ANG (soil type-106) records 16.5% of patients and in UFH sub-zone, SS5-ANG (soil type-61) experiences 22.2% of patients to its

**Table 6.** Prevalence of IDD in different altitudinal zones (by age and sex).

Macro region	Micro region	Sample villages	Number of persons surveyed (100%)	Age groups	Sex	Number of persons suffering from IDD (% cases to total)		
						Person suffering from IDD (Thyroid)	Person suffering from no IDD	
LFH	LFHs-1	SS1-ANG	6	Children	M	1 (16.6)	5 (83.4)	
			4	(1-14)	F	1 (25)	3 (75)	
			8	Adults	M	2 (25)	6 (75)	
			8	(15-50)	F	2 (25)	6 (75)	
			1	Olds	M	0 (0)	1 (100)	
			1	(>50)	F	0 (0)	1 (100)	
			28	-	-	6 (21.4)	22 (79.6)	
			36	Children	M	7 (19.4)	29 (80.6)	
			40	(1-14)	F	8 (20.0)	32 (80.0)	
			52	Adults	M	7 (13.5)	45 (86.5)	
	52	(15-50)	F	9 (17.3)	43 (82.7)			
	27	Olds	M	3 (13.1)	20 (86.9)			
	23	(>50)	F	5 (18.5)	22 (81.5)			
	230	-	-	39 (16.9)	191 (83.1)			
	Total	-	-	258	-	-	45 (17.4)	213 (82.6)
	LFHs-2	SS3-ANG	Total	14	Children	M	3 (21.4)	11 (78.6)
				9	(1-14)	F	1 (11.1)	8 (88.9)
				29	Adults	M	5 (17.2)	24 (81.8)
				28	(15-50)	F	5 (17.8)	23 (82.2)
				15	Olds	M	2 (13.4)	13 (85.6)
15				(>50)	F	2 (13.4)	13 (85.6)	
110				-	-	18 (16.4)	92 (83.6)	
16				Children	M	3 (18.7)	13 (81.3)	
12				(1-14)	F	1 (8.4)	11 (91.6)	
25				Adults	M	4 (16.0)	21 (84.0)	
24	(15-50)	F	5 (20.8)	19 (79.2)				
7	Olds	M	1 (14.3)	6 (85.7)				
7	(>50)	F	1 (14.3)	6 (85.7)				
91	-	-	15 (16.5)	76 (83.5)				
Total	-	-	201	-	-	33 (16.4)	168 (83.6)	
Total	-	-	459	-	-	78 (17.0)	381 (83.0)	
UFHs	UFHs	SS5-ANG	14	Children	M	3 (21.4)	11 (78.6)	
			11	(1-14)	F	2 (18.2)	9 (81.8)	
			14	Adults	M	4 (28.6)	10 (71.4)	
			14	(15-50)	F	2 (14.3)	12 (85.7)	
			5	Olds	M	2 (40)	3 (60.0)	
			5	(>50)	F	1 (20)	4 (80.0)	
Total	-	-	63	-	-	14 (22.2)	49 (77.8)	
Grand total	-	-	522	-	-	92 (17.6)	430 (82.4)	

Source: Sample survey, 2013.

**Table 7.** Showing households drinking boiled water, households using iodized salt, dependence of people on locally cultivated food items and methods of cooking.

Macro region	Micro region	Sample villages	Number of households surveyed (100%)	Households drinking boiled water (%)	Households using iodized salt (%)	Dependence on local food items (%)		Food purchased from market (%)	Methods of cooking foods (%)	
						<50%	>50%		Deep <sup>1</sup>	Light <sup>2</sup>
LFHs	LFHs-1	SS1-ANG	8	6 (75)	6 (75.0)	37.5	62.5	37.8	8 (100)	0 (0)
		SS2-ANG	52	35 (67.3)	40 (76.9)	00	100	23.85	50 (96.2)	2 (3.8)
		Total	-	60	41 (68.3)	46 (76.7)	18.75	81.25	30.83	58 (96.7)
	LFHs-2	SS3-ANG	29	14 (48.3)	19 (65.5)	3.45	96.55	30.17	25 (86.2)	4 (13.8)
		SS4-ANG	25	10 (40)	21 (84.0)	32	68	43.00	20 (80.0)	5 (20.0)
		Total	-	54	24 (44.4)	40 (74.1)	17.73	82.27	36.58	45 (83.4)
Total	-	-	114	65 (57.02)	86 (75.4)	18.24	81.76	33.71	103 (90.4)	11 (9.6)
UFHs	UFHs	SS5-ANG	14	0 (00)	6 (42.8)	7.14	92.85	32.5	12 (85.7)	2 (14.3)
Grand total	-	-	128	65 (50.7)	92 (71.8)	12.69	87.31	33.11	107 (93.8)	13 (6.2)

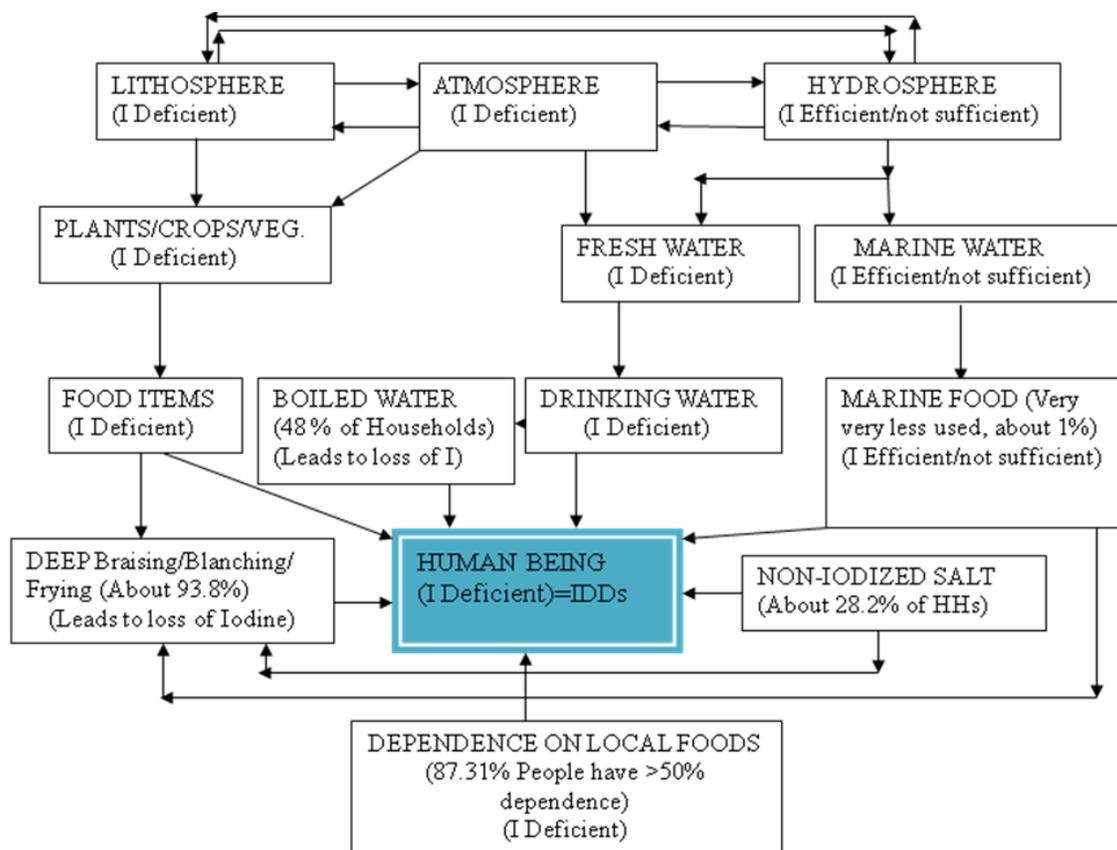
Source: Sample survey, 2013; Note: Deep<sup>1</sup>=Long period Boiling/Braising/Blanching/Frying, Light<sup>2</sup>=Short period Boiling/Braising/Blanching/Frying.

**Table 8.** Income levels of households surveyed (Rs. %).

Macro region	Micro region	Sample villages	Number of households surveyed (100%)	Average family size (numbers)	Income levels of households surveyed (Rs.%)		
					Low (<5,000)	Medium (5,000-10,000)	High (>10,000)
LFHs	LFHs-1	SS1-ANG	8	6	2 (25.0)	2 (25.0)	4 (50.0)
		SS2-ANG	52	7	8 (15.4)	24 (46.1)	20 (38.5)
		Total	60	6.5	10 (16.7)	26 (43.3)	24 (46.0)
	LFHs-2	SS3-ANG	29	7	6 (20.7)	10 (34.4)	13 (44.9)
		SS4-ANG	25	6.5	5 (20.0)	10 (40.0)	10 (40.0)
		Total	54	6.75	11 (20.4)	20 (37.0)	23 (42.6)
Total	-	-	114	6.63	21 (18.4)	46 (40.4)	47 (41.2)
UFHs	UFHs	SS5-ANG	14	7.3	4 (28.6)	9 (64.3)	1 (7.10)
Grand total	-	-	128	6.96	25 (19.5)	55 (42.9)	48 (37.6)

Source: Sample survey, 2013.

total surveyed population. The increase in the percentage of patients suffering from IDD in SS5 -ANG is due to high (4.90%) OM in soil (Table 4).



**Figure 6.** Schematic diagram showing transfer and loss of iodine at different stages of iodine transfer and the consequent results in human beings (Developed by the authors).

Though the concentration of iodine at SS5-ANG is relatively greater than some of the other sites, it has the disadvantage of having high OM. The OM decreases the bioavailability of iodine for the plants/crops resulting in iodine deficient foods. It may also be attributed to the greater dependence of the people on local foods (Table 7). Difference in the percentage prevalence of IDD with respect to age and sex groups can be attributed to the relative differences in the life styles.

A diagrammatic model (Figure 6) has been developed related to the present study that shows cyclic movement of the iodine in the different phases of environment, the pathways on how iodine reaches the human body, its losses at different stages of movement at the dual hands of nature and humankind and the consequent results that is, IDD. The diagram also highlights the role of natural pools of iodine transfer and the life style of the people of the area under study in contributing the causation of the different IDDs. The lithospheric and atmospheric pools of natural environment are iodine deficient while as the hydrospheric pool is efficient in iodine content but not sufficient to save human beings from IDDs. So, the food derived from the soil is deficient in iodine. An individual human being derives only about  $0.5 \mu\text{g d}^{-1}$  of iodine from inhalation (Nordic Project Group, 1995). The marine food

is rich in iodine but unfortunately people make less use of marine foods perhaps because of their low income status and high price of the food. The problem of iodine deficiency and loss from whatsoever food and water is used is further coupled by the unsuitable and unhealthy cooking methods and other lifestyles.

## CONCLUSION

In all the altitudinal zones, the iodine content in the soil ( $0.970$  to  $1.230 \text{ mg kg}^{-1}$ ) and fresh (drinking) water ( $1.6$ - $4.2 \mu\text{g L}^{-1}$ ) sample sites is less than the world level averages in soils ( $2.8 \text{ mg kg}^{-1}$ ) and drinking water ( $8.7 \mu\text{g L}^{-1}$ ) sources. The iodine content in soils showed a close association with OM and pH. Iodine in soils has direct relationship with OM and inverse relationship with pH. Iodine content in water samples showed a relationship with iodine content in surrounding soils. Leaching and run-off play an important role in the transfer of iodine from surroundings soils to water bodies. About 17.6% people surveyed suffer from thyroid disorders. There is decrease in the prevalence of IDDs from LFHs to UFHs and from LFHs-1 to UFHs-2 because of the lifestyle of people. At sample village level, there is also a decrease in the

percentage prevalence of IDD with altitude in respective soil types except SS5-ANG of UFH region. This is due to high (4.90%) OM in soil at SS5-ANG and dependence on vegetarian food.

## RECOMMENDATION

Certain simple and low cost suggestions to minimize the magnitude of IDD sufferers in the area under study are needed for the area is rural in character. The people of the area should make 100% use of iodized salt by the whole population. Special care should be taken of pregnant and nursing mothers after consulting a registered medical practitioner. They should avoid long period boiling, braising, blanching and frying of foods to avoid the loss of nutrients especially iodine. Iodine should be added to drinking water and the irrigational water through fertigation to increase the content of iodine in the natural systems of soil and water. More and more sea foods, eggs, dairy products, watercresses, iodized salt, grains and fruits should be used. The people should also avoid drinking of boiled water in coliform risk free areas.

## Conflict of interest

Authors have none to declare.

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