

Comparative Analysis of Iodine Concentration in Water, Soil, Cereals and Table Salt of Horaboka, Mio and Besaso Towns of Bale Robe, South East Ethiopia

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Abstract The iodine content of water, soil, salt and cereals have been analyzed using Atomic Absorption Spectroscopy (AAS), titrimetry, Fusion and ion selective electrode methods at Geological Survey of Ethiopia, Geosciences Laboratory Center, Addis Ababa, Ethiopia. From the view point of analytical result, the chloride, sodium, potassium, calcium, manganese and magnesium, which are considered as goitrogens are with high concentrations while that of iodine is significantly low ($p = 0.055$). Likewise, the concentrations of iodine in all the water samples fall in the ranges of the iodine concentration of the various parts of the world, $15\mu\text{g/l}$. The iodine concentration in the soil samples taken from non-farm lands (no use of chemical inputs) is significantly higher ($p = 0.001$) than that of farm lands. Iodine concentration in wheat and barley samples is observed to be significantly low ($p = 0.002$). This is the major guide to draw the conclusion that community using this water, cereals and salt could face the insufficiencies of iodine in their dietary, which in turn would cause less up-take of iodine by the body resulting iodine deficiency disorder and endemic goiter among the population. Thus, the main approaches to tackle the challenges are the use of iodized salt and oil, fortification of food, water and condiments and distribution of iodine tablets.

Keywords: goiter, iodine, iodine deficiency disorder, thyroid stimulating hormone (TSH), hypothyroid, universal iodized salt, iodinated oil

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1. Introduction

Iodine is an essential nutrient for humans. Although only required in very small amounts, it is an important constituent of thyroid hormones. These hormones maintain the body's metabolic state and support normal growth and development in children. One of the serious health effects of iodine deficiency disorders is goiter (enlargement of the thyroid gland). In very severe iodine deficiency, stunted growth and mental retardation can occur in children [1]. A number of studies have reported adverse effects on hearing capacity, motor and cognitive function in children associated with moderate and severe iodine deficiency.

Symptoms of iodine deficiency are swelling of the thyroid gland (goiter), chronic fatigue, reduced immune system function, dry skin, excessive estrogens production, hypothyroidism, possible links to Parkinson's disease, multiple sclerosis and Alzheimer's disease [2].

The term "goiter" simply refers to the abnormal enlargement of the thyroid gland. It is important to know that the presence of a goiter does not necessarily mean that the thyroid gland is malfunctioning [3]. A goiter can occur in a gland that is producing too much hormone (hyperthyroidism), too little hormone (hypothyroidism), or the correct amount of hormone (euthyroidism). A goiter indicates there is a condition present which is causing the thyroid to grow abnormally [4,5].

One of the most common causes of goiter formation worldwide is iodine deficiency. The primary activity of the thyroid gland is to concentrate iodine from the blood to make thyroid hormone. The gland cannot make enough thyroid hormone if it does not have enough iodine [6]. Therefore, with iodine deficiency the individual will become hypothyroid. Consequently, the pituitary gland in the brain senses the thyroid hormone level is too low and sends a signal to the thyroid. This signal is called thyroid stimulating hormone (TSH). As the name implies, this hormone stimulates the thyroid to produce thyroid hormone and to grow in size. Thus, iodine deficiency is

one cause of goiter development. Wherever iodine deficiency is common, goiter will be common. It remains a common cause of goiters in other parts of the world [7].

Iodine is the only element needed in hormones and in the production of hormones. As clearly jotted down on WHO food additive series 24, iodine is an essential dietary element which is required for synthesis of the thyroid hormones, thyroxine (T₄) and triiodothyronine (T₃). T₄ and T₃, which are iodinated molecules of the essential amino acid tyrosine, regulate cellular oxidation and hence it does have effects on calorigenesis, thermoregulation, and intermediary metabolism. These hormones are necessary for protein synthesis, and they promote nitrogen retention, glycogenolysis, intestinal absorption of glucose and galactose, lipolysis, and uptake of glucose by adipocytes, control the body's idling speed (Basal Metabolic Rate) and support normal growth and development [8, 9].

Table 1. Normal amounts of iodine in the diet

Age	µg/day
Children (0 - 1 year)	40 - 70
Children (1 - 10 years)	70 - 120
11 yrs + (including adults)	150
Pregnancy	175
Lactation	200

Iodine is found in igneous rocks 3×10^{-5} % by wt. and in sea-water 5×10^{-8} % by wt. The study of its organoleptic properties shows that the taste and odor threshold for iodine are 0.147-0.204mg/L in water and 9mg/m³ in air. The mean concentration of total iodine in drinking water, for example, in the USA is 4µg/litre, and the maximum concentration is 18µg/litre. This is presumably predominantly iodide [10,11].

Table 2. Sources of dietary iodine

Source	µg/100g
Iodized salt	7000
Kelp, dried	5350
Cooked haddock	200
Mackerel	133
Cod	100
Canned Pilchards	64
Plain yoghurt	60
Hard cheese	50
Cooked plaice	33
Salami	15
Roast Chicken	5

The main natural sources of dietary iodide are seafood (200-1000µg/kg) and seaweed (0.1-0.2% iodide by weight). Iodide is also found in cow's milk (20-70µg/litre) and may be added to table salt (100µg of potassium iodide per gram of sodium chloride) to ensure an adequate intake of iodine [12,13]. The estimated dietary iodine requirement for adults ranges from 80 to 150 µg/day [14].

This study is targeted to analyze the concentration of iodine in sample of: soil at different site of Hoaboka, Mio and Besaso, on farm land where man-made fertilizers and weed killers are regularly being used and not used, water in 'Mio' spring where the piped drinking water of the rural Kebeles sourced, Horaboka mineral water and Shaya River and cereals (wheat and barley).

2. Material and Methods

2.1. Study Area

Horaboka, Mio and Besaso Kebeles, Sinana Werada, Bale Zone, Oromia Regional state, South East Ethiopia.

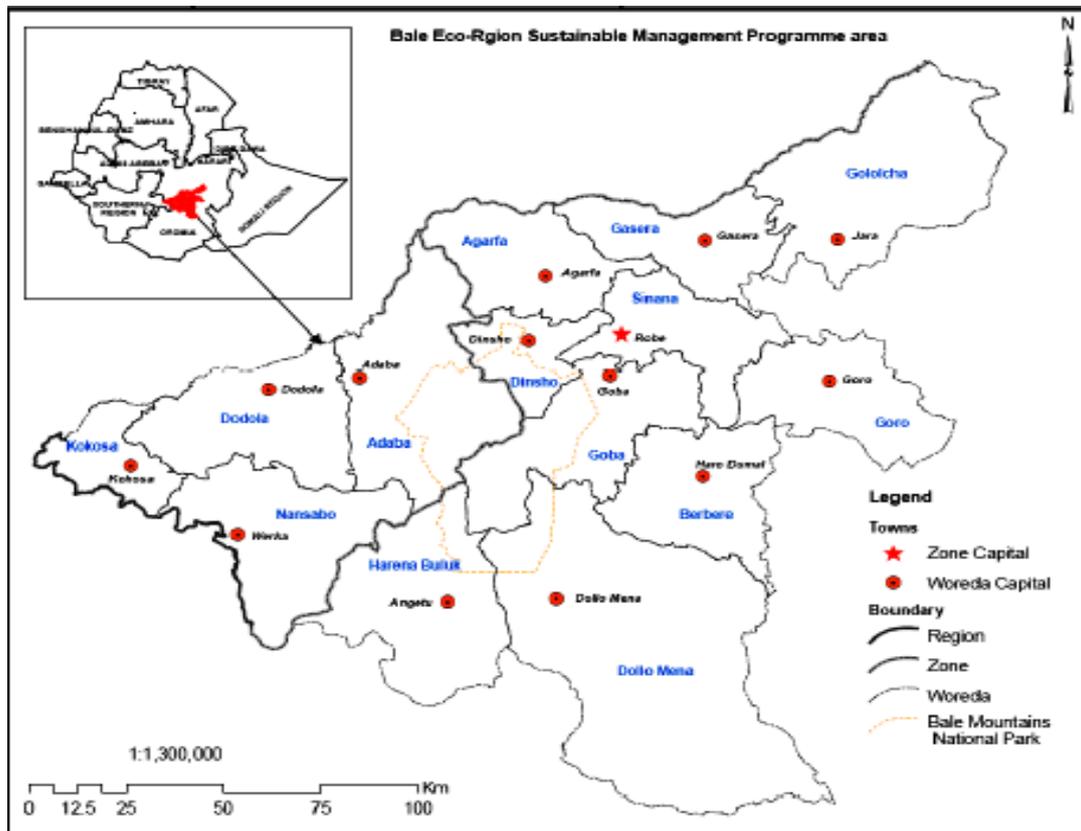


Figure 1. Map of Bale Zone

2.2. Sampling and Sample Preparation

Standard procedures have been used for sampling and sample preparation. Sample containers had been washed using detergents until they become laboratorial clean enough. The entire sample collected have been stored at standard conditions and preserved until scientific analyses had carried out. Triplicate samples have been collected for: water, soil, salt and cereals from targeted study areas.

2.2.1. Water Samples, Samples from

- Shaya River: 3 triplicate samples from up the river, 3 samples from the middle area and 3 samples from down the river
- Spring water samples: 3 triplicate samples from each source at the interval of an hour from the sources: Jeldu – Gasera, Chale and Mio.
- Mineral water samples: 3 triplicate samples at the interval of an hour from Horaboka mineral water.

2.2.2. Soil Samples

Following soil sampling standard procedure, one meter depth, 50cm by 50cm area was dug and at the depth of 25cm to 50cm, (a total of 27 samples from different sites) 3 triplicate samples from each farm area which fertilizers and weed killers have been used and 3 triplicate samples from non – farming land from far away from fertilizer and weed killer applied land have been collected.

2.2.3. Cereal Samples

A total of thirty six, 3 triplicate samples for each cereal (wheat and barley) harvested from the farm land where fertilizers and weed killers have been applied and 3 triplicate samples for each cereal harvested from the land not using fertilizers and weed killers.

2.2.4. Salt Samples

Robe town market day, out of 62 retail traders of table salt, 50% (31 in number) of them were randomly selected and from each 100gm was sampled. There were three different types of salt in the market, Afder and Afker (first and second quality) in which their prices decreases respectively.

2.3. Analytical Methods and Materials

Salt samples from Robe public market, (on Thursday), drinking water samples (river and spring waters from Mio and Horaboka villages), and soil samples from Besaso and Horaboka rural kebeles have been collected through random sampling. Salt, water, cereal and soil iodine were detected by AAS, ion-selective electrode and fusion methods at Geological Survey of Ethiopia, Geosciences Laboratory Center, Addis Ababa. The detection limit for iodine is 10 µg/liter [7,9]. Statistical analysis was expressed as mean ± SD.

3. Results and Discussion

Total of forty five, twenty seven, thirty six and nine water, soil, cereal and salt samples respectively have been collected procedurally. The iodine content of water, soil, salt and cereals have been analyzed using Atomic

Absorption Spectroscopy (AAS), Titrimetry, Fusion and Ion selective Electrode methods.

3.1. The Water Samples

The water was collected from Horaboka mineral water, Shaya River, Jeldu, Chale and Mio spring waters in Sinana woreda around Robe town within 25 km radius of Madawalabu University. These waters are the sources where the goiter infected populations are living. For each water sample the chemical components (parameters) which do have direct influences on the concentration of iodine, like chloride (Cl⁻), fluoride (F⁻), sodium (Na⁺), potassium (K⁺), calcium (Ca²⁺), magnesium (Mg²⁺), manganese (Mn²⁺), perchlorate (ClO₄⁻) and pH have been analyzed (Table 3).

The mineral water has been used by the local surrounding community from the long past to date. According to the local elder informant, in the past, the water has been flowing from underground and the communities were using for drinking and as medicinal (spa) purposes for themselves and their domestic animals intensively. As it has been tasted during sampling, the water is sour and salty. Before two decades, the water was made to be piped using metallic pipe. From the view point of analytical result, the chloride, sodium, potassium, calcium, manganese and magnesium, which are considered as goitrogens are with high concentrations while that of iodine is significantly low (p=0.055); even less than the world's average drinking water iodine concentration level (15 µg/l). The concentrations of Na⁺, K⁺, Ca²⁺, Mg²⁺ and Mn²⁺ are statistically higher than the bottled Ambo mineral water; the concentration of sodium, potassium, calcium, magnesium and manganese respectively are nearly: 40x, 1.5x, 2x, 2x, and 17x than that of bottled Ambo mineral water (Table 3) and this mineral water is not recommended for drinking purpose for the reason that it can cause health problems. The goitrogens have potential of suppressing iodine uptake by thyroid hormone. Fluoride in tap water and toothpastes as well as chlorine in tap water both block iodine receptors in the thyroid gland that result in lowered thyroid hormone production [15].

The occurrence of endemic goiter in hard-water areas has often been noted. Experimental work in rats supports the idea that calcium salts exacerbate an underlying state of iodine deficiency. Where iodine is not plentiful, the hardness of water may be more important in determining goiter prevalence than the absolute level of iodine, for instance, in the U.K., hard waters containing a greater concentration of iodine, are associated with higher goiter prevalence than soft water. Furthermore, possibly the influence of fluoride is upon the amino acid precursors of thyroxin-tyrosine and its metabolites-rather than upon iodine and increased urinary loss of tyrosine is known to occur in men living in a high-fluoride area and in monkeys receiving low daily doses of fluoride, tyrosine deficiency has been shown to cause thyroid hypofunction in rats [16].

On the other hand, the presence of high chloride concentration in the water enhances the formation of perchlorates. As much as 35% of the chlorate found in a distribution system can be attributed to the type and performance of the chlorine dioxide generator. If chlorite ion is present in water and is not removed, it will react

with any applied free chlorine to produce chlorate and chloride ions [17]. Per chlorate is easily water soluble and ionizes, which makes the water pH (6.583) less than seven in case of Horaboka (Table 3). Per chlorate, like other goitrogens, does have potential to suppress iodine absorption by the body and iodine deficiency develops when iodide intake is < 20 µg/day [18].

Perchlorate interests general readers because risk assessments suggest that the babies of pregnant and nursing vegan mothers are, theoretically, at greatest risk for perchlorate toxicity. There is a scientific consensus that children of pregnant and nursing mothers with low levels of dietary iodine represent the population most susceptible to perchlorate problems [19]. The concentration of chlorine, fluorine, sodium, potassium, calcium, magnesium, iodine and manganese ions in Horaboka mineral water are higher than that of Jeldu spring water, Shaya River water, Chale and Mio spring waters Which this mineral water can be considered as hard water (Table 3). Except for Mio spring water, the pH of all the water samples is greater than seven. The physical geography of the water sources is hilly except for Horaboka spring water with grass coverage. In terms of acidity, the waters from Mio, Jeldu, and Chale springs are neutral, excellent for drinking. All are naturally protected where there are no chances of contamination from the surrounding environment. If not supplemented by other food types and mechanisms, a population using these waters for drinking purposes might face goiter visiting.

According to the world's Food and Nutrition Board, the daily iodine requirement for prevention of goiter in adults

is 0.050-0.075 mg, or approximately 0.001 mg/kg body weight [20]. To ensure an adequate supply of thyroid hormones, the thyroid must trap about 0.060 mg of iodine per day [21]. For example in USA, to provide a margin of safety, an allowance of 0.150 mg is recommended for adolescents and adults. The recommended allowances are 0.040-0.050 mg/day for infants and 0.0700-0.120mg/day for children 1-10 years old. Additional allowances of 0.025 and 0.050 mg/day are recommended for pregnant and lactating women, respectively [22]. Thus, for instance, a person using Jeldu, Chale or Shaya water for drinking purposes has to drink six to seven Liters per day to accommodate the daily requirement of iodine from water only. Iodine intakes consistently lower than 0.050 mg/day usually result in goiter which put especially women and adolescent girls at risk [23].

Concentrations of iodine in unpolluted surface waters in various parts of the world have been found to be generally less than 3 µg/l. The concentration of iodine in all the water samples falls, in the ranges of the iodine concentration of the various parts of the world. Except in a few cases where much higher levels were reported in various parts of the world, drinking water has been shown to contain iodine levels of less than 15 µg/l, assuming daily consumption of 1.5 to 2.0 liter of water, iodine intake from this source would usually be less than 30 µg/day [21,24]. World's Food and Nutrition Board, ensures that to accommodate an adequate supply of thyroid hormones, the thyroid must trap about 0.060 mg of iodine per day [21].

Table 3. Concentration of chemicals in water samples collected from different sites

Parameters	Concentration (mg/l ± SD)				
	Horaboka mineral water	Jeldu spring water	Shaya river water	Mio spring water	Chale spring water
Chloride (Cl ⁻)	326.33 ± 5.773	1.00 ± 0.000	1.500 ± 0.500	1.000 ± 0.000	0.90 ± 0.10
Fluoride (F ⁻)	1.067 ± 0.007	0.183 ± 0.038	0.140 ± 0.000	0.200 ± 0.01	0.09 ± 0.01
Sodium (Na ⁺)	926.667 ± 21.939	6.733 ± 1.939	4.466 ± 0.251	7.533 ± 0.057	4.863 ± 0.047
Potassium (K ⁺)	55.000 ± 1.000	1.567 ± 0.404	1.100 ± 0.100	1.933 ± 0.057	1.176 ± 0.058
Calcium (Ca ²⁺)	139.667 ± 4.932	5.267 ± 1.616	4.233 ± 0.153	6.550 ± 0.086	9.106 ± 0.101
Magnesium (Mg ²⁺)	96.00 ± 4.359	2.100 ± 0.693	1.267 ± 0.057	1.166 ± 0.057	1.830 ± 0.01
Manganese (Mn ²⁺)	2.567 ± 0.057	0.1 ± 0.000	0.100 ± 0.000	0.09 ± 0.01	0.013 ± 0.005
pH	6.583	7.07	7.225	6.98	7.03
Iodine (I)	0.017 ± 0.0057	0.008 ± 0.0028	0.0083 ± 0.0015	0.009 ± 0.001	0.009 ± 0.001

3.2. Soil Samples

The chemical composition of the soil changes with time and space reflecting biological and chemical processes during transport and storage of the soil water.

The soil samples have been collected from the three Kebeles: Horaboka (North of Robe), Mio (North West of Robe) and Besasso (South of Robe), located within 25km range of distance from Robe town. All are rural Kebeles. The major agricultural products of the area are wheat, barley, bean, pea, and maize to very small extent. Animal rearing is the second agricultural activity. The physical geography of Horaboka and Besasso Kebeles is plain while that of Mio Kebele is hilly which is highly exposed to flood erosion. The area entertains heavy rainfall almost throughout the year (9 to 12 months). The soil types of the areas are: loam, peat, alluvium, pod soil, and rendzina. The farmers use chemical inputs, fertilizers and pesticides to increase their farm yield periodically. The fertilizers used to enrich the fertility of the soil, pesticides used to control the pests and the weed killers to

control weeds do have potential in suppressing the solubility of the iodine in the soils beyond their target.

The samples subjected to analysis were analyzed using fusion method and titration method for soluble iodine in the soil. From the results of the analysis, the iodine concentration in the samples taken from non-farm lands (no use of chemical inputs) is significantly higher (p = 0.001) than that of farm lands. Almost in all samples analyzed, the concentration of chlorine, fluorine, sodium, potassium, calcium, and magnesium ions is high (Table 4). The pH of the samples due analysis varies from 6.26 to 7.15, which is slightly acidic. The iodine solubility increases with decrease of pH value of the medium. Since nitrogen and phosphorus fertilizers are usually applied, increase of the concentration of nitrates (NO₃⁻¹), phosphates (PO₄⁻³), nitrites (NO₂⁻¹), etc. is expected. Additionally, the increase of the concentration of K⁺, Ca²⁺, Mg²⁺ and Na⁺; 345.51, 153.01, and 62.23 respectively might be attributed to the fertilizers applied (Table 4). Because there is a great difference between the concentrations of the aforementioned cations from farm lands using fertilizers and non-farm land not using

chemical inputs which is the indication of the influential power of chemical inputs on iodine.

On the farmland where chemical inputs are applied, the roles of microbial activities in the accumulation of iodine in soils and its loss from soils are affected. From different studies conducted on determination of concentration of stable iodine, high iodine concentrations were found in upland soils, particularly in andosol, whereas the concentrations in lowland soils were considerably lower. Accumulation of iodine in soils was explained by the effects of microorganisms or their products, for instance enzyme activities. Iodine was observed to be desorbed from the flooded soils because of the reducing conditions created by the microbial activities. Evaporation of biogenerated organic compound, methyl iodide, from the soil plant system, specifically from rice or wheat plants, may also decrease the iodine concentrations in lowland soils [25]. Because of the heavy rainfall, repeated leaching effects on iodine occurs and crops grown in this soil, therefore, do not provide adequate amounts of iodine when consumed.

Soil iodine content is also strongly influenced by the distance from sea/ocean body where with coastal soils being much enriched and central continental soils being depleted. Topography has a marked influence with soils in rain shadow areas being relatively depleted in iodine. While iodine input is a major controlling influence on its geographical distribution in the soil's ability to retain iodine is also an important factor, for example, organic matter together with iron and aluminum oxides and clays are the important sinks of soil iodine [26] and in most cases, the iodine content is expected to present in soil at 5ppm. In the case of the study areas, except for the

samples from non-farm lands, the concentration of iodine is less than this expected result.

An additional factor in the distribution of iodine in the secondary environment, and its subsequent availability to the biosphere, relates to its speciation in soils. In acid oxidizing conditions, iodine is likely to be present as I⁻ ion and as such liable to be volatilized as I₂. In near-neutral or alkaline conditions iodine is likely to be present as the IO₃⁻ ion which is not volatilized. Soils in limestone areas, with pH values of seven and above, have thus been found to be much enriched in iodine compared to acidic soils in neighbouring areas. It is suggested that iodine from oceanic sources migrates in a series of 'steps' across landmasses by deposition followed by revolatilization. High pH soils and organic-rich soils then act as a migration barrier for iodine. In addition, it is suggested that volatilized iodine is bioavailable and any geochemical barrier to such volatilization deprives the biosphere of a major source. In this context it is interesting to note that several goiter endemias occurred in areas with limestone bedrock [27,28] and the study area is rich in calcium which enhances the formation of limestone (Table 4).

Nature completes the cycle of iodine when ions are oxidized by sunlight into elemental iodine in the atmosphere and then returned to the soil by rain. However, the return of iodine back to the soil is not only very small in amount compared to the original loss of iodine; it is also very slow too. Thus the natural correction of iodine content of the soil does not always take place. In relation to this, cereals/crops grown in any iodine-deficient soil are also iodine deficient. Partly, in that humans are dependent on cereals/crops for iodine, they too can become iodine deficient if they eat food that is grown in iodine-deficient soil [29].

Table 4. Concentration of chemicals in soil samples collected from different sites

Parameters	Concentration (mg/l ± SD)					
	Horaboka farm land I	Horaboka farm land II	Besaso non-farm land	Besaso farm land I	Besaso farm land II	Mio non-farm land
Chloride (Cl ⁻)	97.33 ± 3.05	98.33 ± 2.08	97.00 ± 3.00	97.33 ± 2.51	90.00 ± 6.244	98.00 ± 2.00
Fluoride (F ⁻)	43.51 ± 0.65	46.93 ± 1.60	50.43 ± 2.06	35.50 ± 0.50	36.00 ± 2.00	41.67 ± 1.53
Sodium (Na ⁺)	62.23 ± 0.66	62.32 ± 0.45	50.10 ± 1.95	43.16 ± 0.22	36.12 ± 0.95	120.33 ± 1.53
Potassium (K ⁺)	345.51 ± 3.73	599.68 ± 0.18	283.00 ± 3.00	336.08 ± 0.13	407.33 ± 2.41	193.33 ± 3.05
Calcium (Ca ²⁺)	153.01 ± 0.90	41.59 ± 0.21	106.08 ± 3.01	135.12 ± 0.03	77.10 ± 1.32	58.33 ± 3.15
Magnesium (Mg ²⁺)	76.50 ± 1.10	44.80 ± 0.20	39.63 ± 1.67	46.67 ± 0.15	32.17 ± 0.99	52.00 ± 4.35
Manganese (Mn ²⁺)	20.33 ± 0.57	19.00 ± 1.00	16.67 ± 2.08	18.33 ± 1.52	15.66 ± 1.52	17.67 ± 2.08
pH	6.92	6.85	6.83	6.52	6.74	7.11
Iodine (I)	1.73 ± 0.15	1.86 ± 0.11	6.00 ± 1.00	1.83 ± 0.15	1.56 ± 0.152	5.5 ± 0.10

3.3. Cereal Samples

Samples of wheat and barley were collected from both location, Horaboka and Besasso rural Kebeles. The cereal samples were from the farmlands which were/not applying chemical inputs, fertilizers and weed killers. From the results of analysis conducted on the samples of wheat and barley, the observed concentrations of potassium, magnesium, calcium and sodium are high while that of iodine concentration in the same samples is observed to be significantly low ($p = 0.002$) (Table 5). pH values of the cereals in all samples ranges from 6.26 to 6.95 minimum for barley from Besasso farm land and maximum for wheat from Horaboka farm land not using chemical inputs (Table 5).

But on the other hand, the concentrations of iodine in barley and wheat sampled from farm land which do not

use chemical inputs are significantly higher than that of farm land using fertilizers (Table 5). It is also prudent not forget the iodine uptake by plants is not only from soil but also from atmosphere. Inorganic and organic gaseous iodine are present in the atmosphere [19,30,31,32,33].

From food consumption point of view, vegans are perceived to be at greater risk than the general public, including lacto-vegetarians, because plant-based diets are generally relatively low in iodine. The iodine content of most fruits, nuts, and vegetables is low but can vary depending on soil iodine content, irrigation, and fertilization practices [34].

Iodine is found naturally in topsoil but in most areas of the country and especially the highlands, top soil has been lost due to deforestation, erosion, and flooding, and thus food crops lack iodine resulting in dietary iodine deficiency [35].

Table 5. Concentration of chemicals in cereals sample collected from different sites

Parameters	Barley			Wheat		
	Concentration (mg/l \pm SD)			Concentration (mg/l \pm SD)		
	Horaboka farm land	Horaboka farm land (without chemical use)	Besaso farm land	Horaboka farm land	Mio farm land II	Besaso farm land
Chloride (Cl ⁻)	98.33 \pm 1.52	78.33 \pm 1.52	98.33 \pm 1.52	87.66 \pm 2.08	98.01 \pm 2.00	98.01 \pm 2.00
Fluoride (F ⁻)	4.01 \pm 0.01	3.01 \pm 0.01	4.01 \pm 0.005	30.15 \pm 0.25	3.97 \pm 0.05	5.02 \pm 0.14
Sodium (Na ⁺)	74.21 \pm 0.09	64.21 \pm 0.09	87.21 \pm 0.99	118.22 \pm 0.15	53.14 \pm 0.25	56.20 \pm 0.26
Potassium (K ⁺)	4338.11 \pm 0.84	433.11 \pm 0.84	4937.10 \pm 0.04	221.45 \pm 0.10	3223.11 \pm 0.11	3931.11 \pm 0.11
Calcium (Ca ²⁺)	260.22 \pm 2.95	210.22 \pm 2.95	254.12 \pm 0.06	274.02 \pm 0.03	305.12 \pm 0.6	222.10 \pm 0.59
Magnesium (Mg ²⁺)	665.31 \pm 0.10	465.31 \pm 0.10	658.56 \pm 0.015	78.34 \pm 0.08	617.34 \pm 0.12	523.46 \pm 0.011
Manganese (Mn ²⁺)	18.33 \pm 1.52	15.33 \pm 1.52	18.33 \pm 1.52	13.67 \pm 2.08	38.27 \pm 0.52	18.33 \pm 1.52
pH	6.31	6.31	6.26	6.95	6.58	6.88
Iodine (I)	1.8 \pm 0.20	5.7 \pm 0.20	1.83 \pm 0.15	4.8 \pm 0.20	5.03 \pm 0.14	1.83 \pm 0.15

3.4. Salt Samples

From the analysis undergone on the samples of salts sampled from Robe market, on Thursday, all results from the three samples have observed to fall in the range 4.25 – 11.89mg/l of soluble iodine (Table 6). According to Ranganathan, the iodized salt at the consumer level should have iodine content more than 15 ppm [1].

Nevertheless, there is considerable loss of iodine during transportation and storage under prevailing environmental conditions, on the basis of human daily salt consumption, iodized salt containing at least 15 μ g of iodine per gram could easily meet the daily requirement. Stability of iodized salt may be adversely affected by moisture, humidity, sunlight, heat, acidity and presence of impurities. Hence a higher level of initial iodization up to 30ppm has been recommended to take care of these losses. For optimal health our body needs 12.5mg to 37.5mg per day, or 2 to 6 drops of Lugol solution per day

Ethiopia is at risk of iodine deficiency disorder. For instance, 24.3 percent palpable and 11.5 percent visible goiter are observed on our population [35]. In Ethiopia, one out of every 1,000 people is affected and about 50,000 prenatal deaths occur yearly due to iodine deficiency disorder. Twenty-six out of every 100 Ethiopians have goiter and 62% are at risk of IDD and only 28% of households with children use salt with adequate iodine to prevent IDD. For instance, Gambella and Benishangul-Gumuz regions have the highest rates of households using iodized salt (46%) and the Tigray, Somali, and SNNPR have the lowest percentages 10%, 17% and 18%, respectively [27].

Table 6. Concentration of iodine in samples of Afder salt

Salt sample	pH	Iodine (mg/l \pm SD)
Afder	8.49	11.89 \pm 0.132
Afker Ist quality	8.33	5.05 \pm 0.23
Afker IInd quality	8.05	4.26 \pm 0.73

4. Conclusion

The concentration of iodine is found to be low in water, soil, and cereals and as well salt samples collected from the market do have the iodine content less than the

required limit. This is the major guide to draw the conclusion that community using this water, cereals and salt could face the deficiency of iodine in their dietary, which in turn would cause less up-take of iodine by the body resulting iodine deficiency disorder and endemic goiter among the population.

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