Role of iodine content of drinking water in the aetiology of goitre in Sri Lanka

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Summary

609 samples of drinking water collected from scattered sources from the eight districts of Kandy, Matale, Kalutara, Anuradhapura, Polonnaruwa, Colombo, Puttalam and Gampaha were analysed for iodide content using the Orion electrode method. The median iodide content of all districts except Gampaha were above 10 µg/1, with Anuradhapura showing the highest content. Districts with low prevalence of goitre had a median iodide content of 57.0 µg/1 while districts with intermediate and high prevalence had median values of 11.4 and 15.2 µg/1 respectively. Tube wells were found to have a high iodide content while the surface sources had a relatively low iodide content. The rank order correlation between iodide content and the prevalence of goitre was – 0.64, suggesting that only 40% of the variability of the goitre prevalence can be explained in terms of iodide content of drinking water. It is concluded that some factors other than iodide content of drinking water may contribute to the aetiology of goitre in Sri Lanka.

Key words: Aetiology of goitre, water iodine content.

Introduction

In Sri Lanka only a few studies have been undertaken to determine the iodine content of potable water. Mahadeva and Shanmuganathan in 1963, estimated the iodine content of drinking water from scattered sources throughout the country using the modified method of Aceland (1). In another study 286 samples of water from the Central, Sabaragamuwa, Western and Southern provinces were examined in 1985 using the colorimetric method (2). The Aceland method and the colorimetric method are both tedious and the introduction of the electrode method has made the estimation simpler.

This study was undertaken during 1988-89 to determine the iodide content of drinking water from scattered sources in selected districts using the electrode method, and to relate the prevalence of goitre among school children to the iodide content of drinking water.

Materials and Methods

The overall prevalence of goitre among school children 6-18 years in 17 out of the 24 districts in Sri Lanka has been found to be 18.8% (3). Based on these findings districts were classified as high, intermediate and low prevalent areas. Of the 17 districts 8 were selected for the present study to represent these three levels. They were Kalutara, Colombo and Gampaha in Western province, Kandy and Matale in the Central province, Anuradhapura and Polonnaruwa in the North Central province and Puttalam in the North Western province.

Within districts, central schools (Madya Maha Vidyalayas) were selected for the study. All children in each school were screened for goitre and children with grade 1b and above were selected as "cases" of goitre. For each case, a gender and age matched "control" was selected from the same school. Each case and control so selected was given a dry, iodine-free labelled bottle and requested to bring a bottleful of drinking water from their usual domestic source. These samples were collected at the school the following morning. Water samples were received from 225 cases and 241 controls

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and these will hereinafter be referred to as "Student samples".

In addition, random samples of water from varying sources scattered around the selected schools were collected by the research team and these will be referred to as "Random samples". There were 143 such samples from five districts. In both student and random samples, the source of the sample, whether a well, tube well, pipe borne or others was noted and the samples were transported to the laboratory within 24 hours and stored at 4°C until examined.

The samples were examined for iodide content using an Orion research model 407A/L ionometer coupled to model 90-91 single junction reference electrode and model 94-53 iodide specific electrode purchased from Orion Research Incorporated, Cambridge, MA 02129, USA. All chemicals used were of the analytical grade purchased from Sigma Chemical Co. USA. They were dissolved in double distilled water when reagents were prepared.

All measurements were done in plastic ware, in a dust free, air-conditioned room maintained at 25°C. To test whether there is heat generation during measurements using the electrode method, a solution prepared for iodide measurement was divided into two equal portions. The electrodes were immersed in one for the purpose of iodide estimation. The temperatures of both were monitored over a period of 30 min at 5 min intervals, while iodide concentration was measured in the one with the electrodes. The difference in the temperatures of the two solutions did not vary by more than 0.1°C at any time, the accuracy at which the thermometers could be read, indicating that the heat generation during measurement, if any, is negligible and unlikely to affect the results.

Validation of electrode method was established by recovery studies conducted by adding known amounts of iodine to tap water and measuring the concentration by using the electrode method. Iodine content of the tap

Table 1 – Results of recovery studies

	Sample 1	Sample 2	Sample 3
Volume of Tap Water	50 ml	50 ml	50 ml
Volume of ionic strength adjustor added	1 ml	1 ml	1 ml
Volume of iodine standard added	-	1 ml	2 ml
Volume of distilled water added	2 ml	1 ml	-
Amount of iodine added (μg)	-	1270	2540
Iodine concentration measured (μg/L)	21.59	46.99	72.39
Total iodine in 50 ml (μg)	1079.5	2349.5	3619.5
Percentage recovered	-	100	100

Table 2 – Number of water samples by type and district

District	Random	Student	Total
Kandy	-	190	190
Matale	17	72	89
Kalutara	-	109	109
Anuradhapura	40	47	87
Polonnaruwa	-	48	48
Colombo	24	-	24
Puttalam	41	-	41
Gampaha	21	-	21
	143	466	609

Table 3 – Mean, standard error and 95% confidence intervals and median of water iodide levels (μg/l) of cases and of controls

Source	Mean	Standard error	95% confidence interval	Median
Cases	35.05	3.29	28.6 - 41.6	16.5
Controls	48.76	4.90	39.1 - 58.4	17.8
Total	41.70	2.92	35.96 - 47.54	16.5

Table 4 – Mean, median and mean rank of water iodide by district

District	Mean μg/l	Median μg/l	Mean Rank (Kruskal Wallis)
Kandy	30.96	19.1	323
Matale	16.91	11.1	212
Kalutara	15.50	12.2	218
Anuradhapura	118.03	101.6	496
Polonnaruwa	47.21	33.0	396
Colombo	16.86	11.4	194
Puttalam	34.68	21.6	312
Gampaha	11.90	5.0	96
	38.90	16.5	

Table 5 – Water iodide by level of endemicity of goitre

Level of endemicity	Number of samples	Mean μg/l	Median μg/l	Mean Rank
Low	135	92.8	57.0	460
Intermediate	219	20.5	11.4	219
High	284	25.3	15.2	284

Table 6 – Water iodide levels by source

Source	Number of samples	Mean μg/l	Median μg/l	Mean Rank
Dug well	476	36.7	15.6	297
Tube well	32	66.1	37.4	415
Pipe borne	87	44.0	20.6	319
Others	14	19.6	11.5	224

water used was 21.59 μg/L and the results of these studies given in Table 1 show that recovery is 100%, bearing testimony to the accuracy of the method.

Data analysis was done by computer.

Results

A total of 609 samples of water were analyzed for iodide content. This consisted of 466 student samples and 143 random samples. The former group comprised 225 cases and 241 controls. Table 2 gives the distribution of the samples by district. The only two districts with both types of samples were Matale and Anuradhapura. As the study was conducted during the period of political unrest the field workers were unable to collect samples from some districts.

Water Iodide Level by Cases and Controls

The mean, standard error and 95% confidence interval of the mean and the median iodide content of water is given in Table 3. Iodide content is always expressed in μg/l.

The mean values and the 95% confidence interval between the cases and controls show significant differences on parametric tests ($t = 2.3229$; $0.02 < p < 0.05$). However the medians show only small differences. Examination of the distribution revealed that it is not normal (Skewness = 3.51; Kurtosis = 16.56; Mean = 38.9; Median = 16.5; Trimmed Mean = 29.7). Non parametric tests were therefore applied and Mann Whitney U and Wilcoxons Rank sum W for the differences between cases and controls gave value of 24782.5 for U and 51683.5 for W, with a P value of 0.3994, indicating that the difference between cases and controls was not significant.

In the case of student samples the values ranged from a low 1.4 to a high 450 while the range of random sample was from 3.9 to 185. In both types of samples the higher iodide concentration was observed in Anuradhapura district and the distributions of iodine levels in both instances were found to be non-normal. Therefore the data was analyzed using non-parametric tests.

Since there were no significant differences between cases and controls these were pooled together with the random samples and analyzed district-wise, for differences in the iodide content, sources and endemicity.

The medians are presented as the measure of central tendency and the significant testing were based on Kruskal Wallis one way analysis of variance. Mean values are also given for comparison.

Differences between Districts

The Kruskal Wallis test showed highly significant differences between districts ($p < .001$). The means of all districts were higher than the medians. The highest mean, median and mean rank was for Anuradhapura and the lowest for Gampaha. A surprising finding was the relatively high median and the mean rank of Kandy which is very close to that of Puttalam. Gampaha was the only district with the median value of less than 10 μg/l (Table 4).

Water Iodide by Level of Endemicity of Goitre

The eight districts were classified into three groups based on the prevalence of goitre of grade la and above from a previous study (3). Those with low prevalence (< 10%) were Polonnaruwa and Anuradhapura while those with high prevalence (> 30%) were Kandy and Kalutara. Other districts were classified as intermediate. The low prevalent districts had extremely high mean, median and mean rank (Table 5) and Kruskal Wallis test was highly significant ($x_2 = 151.06$: $P < 0.001$). The median and mean values of intermediate and high prevalent areas were about the same.

It is interesting to note that the median value of the high prevalent area is in excess of 10 μg/l which was the recommended cut-off point for Sri Lanka (1).

Water Iodide Level by Source

The sources of drinking water were shallow wells (depth of less than 10 meters), tube wells,

Table 7 – Distribution of samples with water iodide less than 10 μg/l by district

District	No. of samples with low values	Percentage
Kandy	26	13.7
Matale	34	38.2
Kalutara	30	27.5
Anuradhapura	02	2.3
Polonnaruwa	01	2.1
Colombo	11	45.8
Puttalam	12	29.2
Gampaha	17	80.9
Total	133	21.8

Table 8 – Rank order of median water iodide levels and goitre prevalence of the eight districts

District	Rank order of median water iodide	Rank order of goitre prevalence
Kandy	5	7
Matale	2	5
Kalutara	4	8
Anuradhapura	8	1
Polonnaruwa	7	2
Colombo	3	4
Puttalam	6	3
Gampaha	1	6

Rank order correlation = – 0.64

Table 9 – Water source by cases and controls

Source	Cases	Controls
Dug well	192 (79.7)	177 (78.6)
Tube well	10 (4.2)	15 (6.7)
Pipe borne	30 (12.4)	30 (13.3)
Others	9 (3.7)	3 (1.3)
Total	241	225

pipe borne and others (springs, rivers, streams etc.). Kruskal Wallis test gave highly significant differences between sources ($x^2 = 17.2131$: $p < 0.001$). This may be due to the higher iodide content of water from tube wells and the low iodide content of water from "other sources" (Table 6).

Water Iodide Levels of < 10 μg/l by District

133 (21.8%) of the 609 samples had water iodide of less than 10 μg/l. The proportion of the samples with such values varied from 80.9% at Gampaha to around 2% in Anuradhapura and Polonnaruwa (Table 7).

43 (19.1%) of the 225 cases of goitre and 41 (17.0%) out of 241 controls had iodide levels below 10 µg/l, again showing a minimal difference between the cases and controls.

Rank Order Correlation between Water Iodide and Goitre Prevalence among School Children by District

This analysis was undertaken using the prevalence of goitre of grade la and above for each district based on a previous study (3). Spearman's rank order correlation so calculated was – 0.64 (Table 8) indicating that only about 40% of the variability of goitre prevalence between districts can be explained in terms of water iodide content.

Discussion

This study had some limitations. Firstly, the water samples collected may not be really representative of the districts. They were from scattered sources within the district but the majority is expected to be from sources within 5-10 miles of the school. The distance from the school to the source was not obtained, but previous studies in Sri Lanka too were based on scattered samples. Secondly, it is possible that water from one source would have been brought by more than one child, as each child was asked to bring a sample from his/her source of drinking water. These limitations, though not of very serious nature, should be kept in mind in interpreting the results.

The important findings could be stated as follows:

1. There is a geographic variation in the iodide content of drinking water.
2. Iodide content is related to the depth of the source.
3. The difference in iodide content of drinking water of cases of goitre and controls is minimal.

Geographical Variation

The highest water iodide levels were in Anuradhapura which agrees with the findings of a previous study (1). The lowest values were noted at Gampaha. Ranking of districts by water iodide levels shows that it is similar to the rankings observed in previous studies (1, 2).

The median iodide content of districts with low goitre prevalence was nearly four times higher than the medians of districts of high and intermediate prevalence, again agreeing with the findings of a previous study (1). The rank order correlation of goitre prevalence and median iodide content of the eight districts was – 0.64, suggesting a good negative correlation of goitre prevalence to iodide content of drinking water.

Iodide Content and Depth of Source

The depth from where the water comes was found to determine the iodide content. Highest levels were seen in water from deep wells and the lowest from surface water. The low levels in the surface water may be either due to leaching or due to contamination with organic matter or both.

Iodide in Cases and Controls

The differences between the cases and controls were found to be very small. Mahadeva and Shanmuganathan have suggested the value of 10 µg/L as the value below which goitre becomes endemic for Sri Lanka. When this value is used as a cut-off point, of the 84 subjects who had values lower than this, 43 were cases and 41 were controls. Further, when the prevalence of goitre was correlated with the prevalence of low iodide levels in the districts, the rank order correlation of 0.58 observed suggests that only 33% of the variability of the former can be explained by the latter. This indicates that a low iodide level is only one factor among many in the causation of goitre in Sri Lanka.

In general, iodide levels observed in this study are higher than the levels reported from other endemic countries (4, 5) and only 20% of the sample had values below 10 µg/L. The lowest iodide levels were seen in surface water. As plants derive most of the iodine from surface water, it is possible that the iodine content of food grown may be low, even if the iodine content of water from deep sources is high. However this deficiency cannot be that great as the mean iodine content of surface water (others – Table 6) was 19.6 μg/L.

The cases and controls did not differ significantly when the source of water was considered (Table 9).

The occurrence of goitre in regions where there is no shortage of iodine in the water has been reported from many countries (6) and also from Sri Lanka as far back as 1968 (7). Further, during a recent study on iodine uptake in Sri Lanka, the uptake by goitrous subjects in a non-endemic area was seen to be less than the uptake of the non-goitrous in the endemic area (8). It seems reasonable to postulate that factors other than low iodine intake from drinking water may play a part in the aetiology of goitre in Sri Lanka.

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