

Status of Thyroidal Radioiodine (I-131) Uptake and Urinary Iodine in Bangladesh Population: A re-look following Implementation of Universal Iodination of Salt

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Abstract:

Iodide plays a central role in thyroid physiology and in the production of thyroid hormones, which are essential for normal vertebrate growth and development. Radioiodine uptake test is one of the oldest radionuclide investigations for evaluation of thyroid function. On the other hand useful information about the **iodine** nutritional status of a population can be obtained by measuring **urinary iodine**. **The level of iodine in the urine reflects the prevalence of iodine deficiency in a population.** The main aim of this study was to find out the present status of urinary iodine and thyroid uptake status of people living in and around Dhaka City (Bangladesh). The present study was carried out over a period of three years from 1999 to 2002 involving 300 subjects inclusive of 216 females and 84 males. Efforts were made to randomly include people from a broad spectrum of social and economic strata, starting from people belonging to the lowest to the highest income groups; as well as people representing the urban, rural and suburban populations. Urinary iodine levels and 24 hour percentage radioiodine uptake by the thyroid were estimated in all subjects included in this study. Subsequently patients were grouped into four categories based on the values of their percentage 24-hour radioiodine uptake; e.g., Group-A (N=99) with lowest uptake (0-5%), Group-B (N=100) with uptake ranging between 5-10%, Group-C (N=73) with uptake ranging between 10-30% and Group D (N=28) with uptake above 30%. The median 24 hours RAIU values in groups A, B, C and D were 3, 7, 23 and 34% respectively. The corresponding mean urinary iodine levels in the four groups were 43.31, 33.95, 12.97 and 9.35 μgm/dl respectively. The results have shown that 1.04, 3.48, 16.72

and 78.74% people studied had levels of urinary iodine indicating severe, moderate, mild or no iodine deficiency respectively as per the WHO Criteria (Severe: <2 μgm /dl, Moderate: 2-4.9 μgm /dl, mild: 5.0-9.9 μgm /dl, normal: ≥ 10 μgm /dl). It may be noted that the normal values of Thyroidal I-131 uptake were standardized in Bangladesh about two and half decades ago. The normal range of 24 hr radioactive iodine uptake (RAIU) determined at that time was 10-45%. However in the present study the mean 24 hrs RAIU has been found to be 14.12 % with a SD of 8.33. With regard to urinary iodine, a previous study conducted in the year 1993 had reported that only about 31 % of the Bangladesh population had urinary iodine levels of more than 10gm/dl. But the present study has shown significant increase in the levels of urinary iodine, with more than 78% of people evaluated in the present study having normal levels of urinary iodine (above 10gm/dl). The present study has also demonstrated inverse relationship between urinary iodine level and thyroidal uptake of radioiodine (I-131). These results reflect the effectiveness of universal iodination of common salt in Bangladesh resulting in enhanced iodine status of our population.

Key words: Urinary iodine, radioactive iodine uptake, Iodine deficiency, Universal iodination.

World J Nucl Med 2007;6:29-34

Introduction

Radioiodine uptake (RAIU) test is performed to evaluate thyroid function. It is now very rarely used in the developed countries. But in developing countries its use remains widespread because of long half-life of I-131, low cost and non-availability of alternate sophisticated biochemical tests. Bangladesh has been a country of widespread iodine deficiency for ages. However the introduction of universal iodination of salt in the country has shown significant improvement in the iodine status of its people.

It may be noted that the 24-hour radioactive iodine uptake values are increased substantially in the presence of iodine deficiency because of increased TSH stimulation and reduction in the non-isotopic iodine pool. Therefore, thyroid uptake values in iodine deficient countries like

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Bangladesh are expected to be higher compared to iodine sufficient countries. Universal iodination of table salt and other staple foods has played significant role in improving the iodine status of people living in iodine deficient regions (1,2).

The problem of thyroid disorder is extensive and in many instances serious in Bangladesh, which appears to be even worse than those prevailing in many other developing countries of the world. The latest survey on IDD in Bangladesh in the year 1993 had revealed that 47.1% of the population in Bangladesh had variable degrees of goiter (8.8% visible, 38.3% palpable), 0.5% some degree of cretinism and 68.9% some degree of biochemical iodine deficiency (3). The 1993 study had revealed subnormal level of urinary iodine (<10gm/dl) in 69% of Bangladeshi population (3).

As the majority of ingested iodine is excreted in the urine, the measurement of urinary iodine excretion (UI) provides an accurate approximation of dietary iodine intake. In most circumstances the determination of UI provides little useful information on the long-term iodine status of an individual, since the results obtained merely reflect recent dietary iodine intake. However, measuring UI in a representative cohort of individuals from a specific population provides a useful index of the iodine level endemic to that region.

Normal value for 24-hour RAIU in most parts of North America is between 5 and 30 percent. In New York City the 24 hours RAIU has been estimated to be 6-20% (4). In most other parts of the world, normal values range from 15 to 50 percent. Lower normal values are due to increase in dietary iodine intake following the enrichment of foods, particularly mass-produced bread with this element (5,6). The 24 hours RAIU values vary from country to country, but nowhere is it below 5% in normal physiological conditions. However, in certain conditions it is reduced below 5%, which may be defined as low or very low uptake. The factors related to low uptake are - hypothyroidism, subacute thyroiditis, silent thyroiditis, a certain stage of Hashimoto's thyroiditis, external radiation therapy, intake of drugs (antithyroid drugs and thyroid hormones), ectopic thyroid, excessive exogenous iodine intake, heart failure, severe Graves' disease (due to high turn over) and deficiency of certain thyroid enzymes (7). In a recently concluded pilot study on Bangladesh population at the Institute of Nuclear Medicine (INM), Dhaka, significantly lower levels of radioactive iodine uptake values were observed in comparison to the existing reference values irrespective of their biochemical status. As noted previously the existing reference values for normal 24 hrs RAIU were estimated almost 25 years ago. Hence the present follow up large scale study was undertaken to reassess the pattern of RAIU by the thyroid gland and to document the changing trends both in the thyroidal uptake of radioiodine as well as levels of urinary iodine in a representative segment of Bangladesh population in and around the Dhaka City.

Material and Method:

The study was carried out at the Institute of Nuclear Medicine, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka and Bangladesh Institute for Research on Diabetes, Endocrine and Metabolic Disorders, Dhaka. The study period was from August 1999 to January 2002. Total study population was 300, consisting of 216 females and 84 males. People from the urban, rural and suburban segments of the mega-city were included randomly irrespective of their habitation.

The following subjects were excluded from the study: pregnant or lactating females; patients on anti-thyroid medication; patients with serious ailment with likelihood of influencing the biochemical parameters; patients with history of recent contrast injection for X-ray studies; high level of iodine intake from known sources and subjects aged below 12 and above 65 years.

Study procedure:

After taking a careful history each patient underwent thorough physical examination including an examination of the neck. All findings were recorded on the SPS data sheet. The important parameters included drug history, family history, economic status, habitation, food habits, iodized salt intake; patients' signs, symptoms and other relevant clinical information

I-131 Uptake test:

Radioactive iodine uptake values were estimated using a standard radioiodine uptake probe attached with a flat-field collimator and coupled to a multi-channel analyzer and scaler, following oral administration of 5-10 μ Ci of I-131. A standard reference dose of I-131 and a neck phantom were used to calculate the exact value of I-131 by the thyroid gland using the standard established formula. The distance from the face of the probe crystal to the anterior aspect of the thyroid and the method of counting the I-131 standard in the phantom were same for all patients. The studies were carried out with the subjects in seating position without much movement. Background corrections were approximated by measuring activity in the patient's thigh, in the same manner as the activity measured in neck. The net counts in the thyroid were then determined by subtracting the background counts from the overall neck counts. All measurements were obtained three times over a period of one minute each and then averaged out before calculating the percentage thyroid uptake.

Urinary iodine estimation:

Urinary iodine level was estimated in the laboratory of the research division of BIRDEM using the Wet Ashing technique. Urine was digested with perchloric acid under mild conditions and iodine level was determined manually by its catalytic role in the reduction of ceric ammonium sulfate in the presence of arsenious acid. The method, described in detail in Annexure-1 at the end of this paper, is fast and inexpensive, and the digestion is less harsh than some other methods but is usually adequate. This method

Groups	Age (Mean \pm SD)	Sex Distribution	
		Male No. (%)	Female No (%)
Group A	30 \pm 11	23 (23.2)	76 (76.8)
Group B	30 \pm 12	30 (30)	70 (70)
Group C	31 \pm 12	21 (28.8)	52 (71.2)
Group D	33 \pm 13	10 (35.7)	18 (64.3)

Group-A=uptake up to 5%, Group-B = 5-10%, Group-C =10-30%, Group-D = above 30%

Table 1. General characteristics of the study population in relation to different groups (based on the 24 hrs Radio Active Iodine Uptake values)

Groups	Uptake (%) Median (Range)
Group A	3.0 (0.3 to 4.5)
Group B	7.0 (5.0 to 9.9)
Group C	23.0 (10.0 to 29.0)
Group D	34.5 (30.0 to 64.0)

Mean for groupA B C & D = 14.5 \pm 8.33

NB: Range- for group-B , C and D is 5-28%

Table-2. RAIU (%) in Different Groups of Subjects studied

emphasizes urinary iodine in the range of 0-150 μ g/l (0-1.19 μ mol/l) but can be expanded to cover a wider range of values.

After obtaining the results of both radioactive iodine uptake studies as well as urinary iodine estimation procedures, the study population was divided into four groups as given below according to the levels of RAIU values obtained:

Group-A: subjects with RAIU of less than 5%

Group-B: subjects with RAIU ranging between 5 - 10%

Group-C: subjects with RAIU ranging between 10 - 30%

Group-D: subject with RAIU more than 30%

Results of the RAIU studies were correlated with the results of urinary iodine and the data were analyzed using SPS program.

Results:

The study was conducted on 300 subjects consisting of 216 females and 84 males. The study population was divided into four groups on the basis of RAIU results; e.g., Groups A (N=99), B (N=100), C (N=73) and D (N=28) as described above (Table-1).

The median 24 hrs RAIU in Groups A, B, C and D were 3% (Range=0.3-5.0%), 7% (Range= 5.0-9.9), 23% (Range=10.0-29.0) and 34.5% (Range=30.0-64.0) respectively (Table-2). Table -3 shows the relationship between the habits of intake of iodized salt with levels of estimated 24 hrs RAIU in the subjects studied. Out of the 39 people whose intake of iodine was solely through the process of cooking (i.e., iodized salt used in cooking) there were 13 (46%) in Group-A, 11 (39%) in Group-B, 11 (39%) in Group-C and 4 (14.3%) in Group-D. Out of the 154 people in the study population whose sources of daily iodine consisted of iodized salt used in cooking plus the salt

on the table, there were 52 (33.8%) in Group-A, 58 (37.7%) in Group-B, 29 (18.8%) in Group-C and 15 (9.7%) Group-D. There were 110 people who were not aware of the type of salt they were using (Unknown category). Out of these 110 people in the "unknown" group there were 30 (28%) in Group A, 29 (27%) in group-B, 39 (36.4%) in group C and 9 (8.4%) in group D.

Table-4 shows the status of urinary iodine level in different uptake groups (Data available in 294 subjects). There were 3 patients who revealed severely low urinary iodine. All these three patients belonged to Group-A of the 24 hrs RAIU categories. There were 17 patients who demonstrated moderately low levels of urinary iodine; 7 (40%) of this group belonged to Group-A of the uptake category, 3 (17%) to Group-B, 3 (17%) to Group-C and 4 (23.4%) to Group-D. There were 48 patients who demonstrated mildly low level of urinary iodine; 7 (15.2%) of this group belonged to Group-A, 6(13.0%) to Group- B, 25 (50.1%) to Group- C and 10 (21.7%) to Group-D. Finally there were 226 patients who demonstrated normal levels of urinary iodine; of these 82 (36.3%) belonged to Group -A, 87 (35.5%) to Group-B, 43 (19.0%) to Group -C and 14 (6.2%) to Group- D.

Discussion

The normal 24 hrs radioactive iodine uptake of our population was last standardized in the year 1980 and was calculated to be in the range of 10-45% (8). This value has since been in use in clinical practice at all nuclear medicine centers of Bangladesh without any review. In the past decades there has been substantial decrease in this value in the normal population all over the world with the introduction of fortification of food materials (salt, bread, sugar etc.) with iodine (1,5). RAIU values have also been reported to be reduced significantly following iodine supplementation in patients as a part of their treatment (9).

In the present study, the median 24 hrs RAIU was found to be 3.0, 7.0, 23.0 and 34.0% in Groups A, B, C, and D respectively (Table-4). Combining all the groups the mean 24 hours RAIU was estimated to be 14.12% (SD=8.33) (Table-1). This value is significantly reduced compared to the previously estimated normal 24 hrs RAIU in the Bangladesh population in the year 1980. Similar results have also been reported in a few other studies (8).

The 24 hrs RAIU has been reported in the past to be in the

Groups	History of Intake of Iodized Salt by people in the study		
	Cooking No (%)	Table & Cooking No (%)	Unknown No (%)
Group A	13 (46.4) ^a	52 (33.8) ^x	30 (28)
Group B	11 (39.3) ^{ab}	58 (37.7) ^x	29 (27)
Group C	11 (39.3) ^b	29 (18.8) ^y	39 (36.4)
Group D	4 (14.3)	15 (9.7) ^z	9 (8.4)
Total	39 (100)	154 (100)	110 (100)

a and b are significantly ($p < .05$) different using proportion test, y and z are also significantly ($p < .05$) different using proportion test

Table 3. History of Intake of Iodized Salt by people belonging to different groups in the study

range of 20-70% in people living in the iodine deficient areas of the world (6). In most instances the 24 hrs RAIU levels have shown significant reduction with the improvement in dietary iodine content. In our present study we have observed that in more than 99% of subjects belonging to Group-A the level of 24 hrs RAIU was observed to be below 5%, which is lower than the lower level of normal in countries like United States of America. In these patients some other underlying thyroid disease could have been the reasons for such very low 24 hrs RAIU. But to find out the exact cause of such low uptake was beyond the scope of this study.

The present study revealed RAIU uptake to be significantly lower in those people who were consuming iodized salt regularly with their food, than those who were not. It has also been observed that only 182 of our subjects were aware of their iodized salt intake (Table-3), while the rest were not very sure about it. It is further observed that majority of the people (>71%) in the low uptake (less than 10%) groups (A + B) were noted to be consuming iodized salt routinely both in cooking as well as on the table. It may be noted that iodine is a volatile substance, hence during open cooking a substantial amount of it is lost. It is therefore felt that table salt would serve the purpose of iodine supplementation better than the salt added to the food during the cooking process. It has been reported that iodine-131 uptake is reduced in people only when they continue to take iodized salt over a certain optimum period of time (9).

Another proof of enhanced iodine intake and improved nutritional status of the subjects in our study was increased levels of urinary iodine. It is further observed that there is

inverse relationship between RAIU and level of urinary iodine (Tables-4) (Figure-1). As for example, in Group A subjects in whom the median RAIU was very low at 3 %, the median urinary iodine level was found to be 43.31 $\mu\text{g}/\text{dl}$. On the other hand in subjects belonging to Group-D with median RAIU of 34.5%, the mean level of urinary iodine was found to be 9.5 g/dl (Table-4).

It is known that urinary iodine excretion reflects the status of dietary iodine intake. It has been reported to be proportional to the thyroid iodine content (10). If there is no other problem in thyroid cell or associated conditions, Iodine-131 uptake depends on thyroidal iodine supply. If iodine supply is adequate, uptake would be low or normal. On the contrary iodine uptake is high in case of inadequate iodine supply.

It is good to know that urinary iodine content of the present study population was significantly higher than the previous studies conducted on the Bangladesh population. The acceptable normal level of urinary iodine is above 10 $\mu\text{g}/\text{dl}$. Urinary iodine level of less than 2 $\mu\text{g}/\text{dl}$ is considered critically low. In the present study we found only 3 persons with urinary iodine levels of less than 2 $\mu\text{g}/\text{dl}$ and 226 persons with urinary iodine levels above 10 $\mu\text{g}/\text{dl}$. These results suggest significant improvement in the iodine status of the Bangladesh population in comparison to the 1993 study conducted by the IDD survey group in Bangladesh, which had revealed urinary iodine level of less than 10 $\mu\text{g}/\text{dl}$ in over 69% of the population (3). The study also has revealed an inverse relationship between the levels of urinary iodine and RAIU by the thyroid gland. The improvement in the iodine status in this

Groups	Urinary Iodine			
	Severe No (%)	Moderate No (%)	Mild No (%)	Normal No (%)
Group A	0	7 (41.3)	7 (15.2)	82 (36.3) ^a
Group B	0	3 (17.6)	6 (13.0)	87 (35.5) ^a
Group C	3 (100)	3 (17.6)	25 (50.1)	43 (19.0) ^b
Group D	0	4 (23.5)	10 (21.7)	14 (6.2) ^b
Total	3 (100)	17 (100)	48 (100)	226 (100)

Severe = <2 $\mu\text{g}/\text{dl}$, Moderate = 2-4.9 $\mu\text{g}/\text{dl}$, mild = 5.0-9.9 $\mu\text{g}/\text{dl}$, normal = $\geq 10 \mu\text{g}/\text{dl}$
a and b are significantly ($p < 0.05$) different when using proportion test

Table-4. Relation of urinary iodine and RAIU in Different Groups.

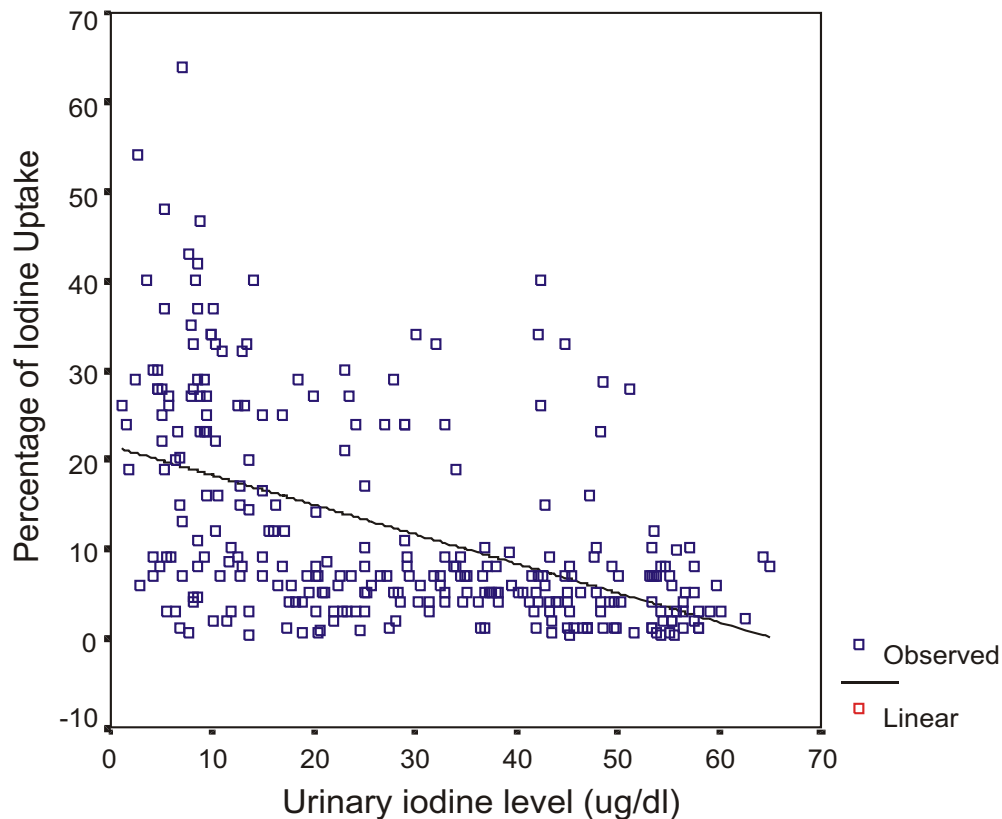


Figure-1. Relationship of urinary iodine with radioactive iodine uptake values in the subjects

representative sample of Bangladesh population is most likely due to the universal iodination of common salt in the country.

Conclusion:

The study was performed with mixed variety of population belonging to different age, sex, habitation and economic conditions. The current study has demonstrated a significant reduction in the range of 24 hrs RAIU and significant increase in the level of urinary iodine in the representative Bangladesh population. This is indicative of an overall improvement on the iodine status of the Bangladesh population, which could be attributed to the success of universal iodination of common salt in the country.

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Annexure-1

Estimation of Urinary Iodine

A. Equipment:

Heating block, colorimeter (or simple spectrophotometer, vented frame hood with perchloric acid trap (or the simple substitute apparatus described in text), thermometer, test

tubes (13mm 100 mm) reagent flasks and bottles, pipettes and a laboratory balance.

B. Reagents (analytical grade only):

1. KClO_3 (potassium chlorate), dry powder
2. HClO_4 (perchloric acid, 70%) comes as 70% liquid solution- do not dilute
3. As_2O_3 (arsenic trioxide, dry powder)
4. NaCl (sodium chloride, dry powder)
5. H_2SO_4 (Sulfuric acid, concentrated-100%, 36 N, liquid)
6. $\text{Ce}(\text{NH}_4)_4(\text{SO}_4)_4 \cdot 2\text{H}_2\text{O}$ (ceric ammonium sulfate), dry powder
7. H_2O (deiodinized water must be free from iodine and other contaminants)
8. KIO_3 (potassium iodate), dry powder

C. Solutions

1. Chloric acid solution: In a 2000 ml Erlenmeyer flask dissolve with heating 500g KClO_3 in 910 ml H_2O until solubilized. This may take several hours and does not always dissolve completely into solution. Then add slowly (about 15 ml/minute) 375 ml HClO_4 (perchloric acid, 70%) while constantly stirring, this preparation is best carried out in vented fume hood. Store in a freezer overnight. The next day filter using filter paper (Whatman # 1 or similar product), preferably on a Büchner funnel. The volume of filtrate is approximately 850 ml. Store in refrigerator (40).
2. 5 N H_2SO_4 : Slowly add 139 ml concentrated (36 N) H_2SO_4 to about 700ml deiodinized water (this produces heat) and when cool, adjust with deiodinized water to a final volume of 1 litre.
3. Arsenious acid solution: In a 2000 ml Erlenmeyer flask, place 200 g As_2O_3 and 50 g NaCl , then slowly add 400 ml 5N H_2SO_4 . Add water to about 1 liter, heat gently to dissolve, cool to room temperature, dilute with water to 2 liters, filter and store in dark bottle away from light at a room temperature. The solution is stable for months.
4. Ceric ammonium sulphate solution: dissolve 48 g ceric ammonium sulfate in 1 litre 3.5 N H_2SO_4 . Store in dark bottle away from light at a room temperature. The solution is stable for months
5. Standard iodine solution 1 μg iodine/ml (7.9 $\mu\text{mol/l}$): Dissolve 0.168 mg KIO_3 in deiodinized water to final volume of 100 ml. (1.68 mg KIO_3 contains 1.0 mg iodine). It may be more convenient to make a more concentrated solution, e.g., 10 or 100 mg iodine/ml, then dilute to 1 $\mu\text{g/ml}$. Store in dark bottle away from light at a room temperature. The solution is stable for months
6. Standard curves for each assay can either be prepared fresh each time by appropriate dilutions of the 1 $\mu\text{g/ml}$ solution of KIO_3 , or individual stock solutions of the desired iodine concentrations can be made. The following are useful standard: 2, 5, 10, 15, $\mu\text{g/dl}$.

D. Procedure:

1. Mix the urine sample to suspend evenly any sediment, and then pipette 250 μg of each urine sample into a 13 x 100 mm test tube. Prepare standards from the 1 $\mu\text{g/ml}$ (7.9 $\mu\text{mol/l}$) iodine solution by taking aliquots of 0, 5, 12.5, 25, or 37.5 μl , then add water to a final volume of 250 μl for each tube. These give iodine standards corresponding to 0, 2, 5, 10, and 15 $\mu\text{g/dl}$ (0.16, 0.40, 0.79 and 1.19 $\mu\text{mol/l}$, respectively). Additional standards can be prepared if desired.
2. Add 750 μl of chloric acid solution to each tube (samples, blank and standards), mix gently, and heat all tubes for 50-60 minutes under a heating block at 110^o-115^o C in a fume hood with perchloric acid trap. The extract time and temperature are not critical as long as all tubes are heated the same way. Usually there will be very little volume change during heating. If the volume has decreased, make to 1.0 ml with deiodinized water (pre-marked tubes are useful for this). Some samples may become faintly yellow.
3. Cool the tubes to room temperature, then add 3.5 ml arsenious acid solution to each tube, mix (by inversion or vortex) and let stand for about 15 minutes.
4. Add 350- μl ceric ammonium sulfate solutions to each tube and quickly mix by vortex. Use a stopwatch to keep a constant interval between additions to successive tubes, usually 20 seconds.
5. Exactly 20 minutes after addition of ceric ammonium sulfate to the first tube, read its absorbency at 405 μM in a colorimeter, and read successive tubes at the same interval as that used for addition of the ceric ammonium sulfate (at 20 seconds as recommended above), so that the time between addition of ceric sulfate and reading is exactly the same for each tube (e.g. 20 minutes).