# Possible Barriers to Quality Assurance of Iodized Salt in Bangladesh

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Iodine Deficiency Disorders (IDD) have long been a public health problem in Bangladesh. The Bangladesh National IDD Survey 1993 showed a 47 percent goiter prevalence (visible and palpable) and 69 percent iodine deficiency as assessed by urinary iodine excretion. The Government of Bangladesh responded to this problem by passing the Universal Salt Iodization (USI) regulations in 1994. Salt Iodization Plants (SIP) were installed in all salt factories in the country (267 plants) during the period of 1993-95 with technical and financial support from UNICEF and the Micronutrient Initiative (MI).

A USI evaluation survey during 1996 showed that about 99% of the salt samples collected at factory level were iodized, but only 5 % were adequately iodized; many factories were producing salt with too low or too high iodine level. During 1998, the Micronutrient Initiative (MI) did an in-depth assessment of some large salt factories with particular emphasis on SIP. That assessment included testing of iodine content of salt collected at various points of production: from the auger-screw mixer at 5, 10, and 15 minutes into a 5 ton production run; from different levels of the post-iodization storage chamber; from 75 kg bags ready for shipping; and from the pre-iodization storage chambers. Iodine content was measured by the semi-quantitative paper strip test used by the industry to monitor production, and by titration. Critical observation of mechanical condition and performance of SIP also was made.

The key findings were: (i) inconsistent iodine level in salt collected at various points of production of same factory, (ii) gross inter-factory variations; (iii) lack of agreement between the semi-quantitative test for iodine content and titration; (iv) mechanical problems at SIP; and (iv) lack of internal monitoring including proper record keeping at factory level. These findings indicate the importance of (i) initiating internal quality monitoring with guidelines on how to take corrective actions, (ii) developing a more reliable yet simple method for quantitative or semi-quantitative assessment of iodine at factory level, and (iii) redoubled attention to factory owner motivation, need-based training and advocacy.

It can be concluded that almost all salt factories were iodizing salt without any proper quality monitoring system. The factory owners should be provided with technical assistance on how to improve internal quality control and how to take corrective actions including mechanical adjustment to the SIP. All SIPs and the overall salt factory situation need to be evaluated to consider if any major renovation or re-organization is required.

## 1. INTRODUCTION

Iodine Deficiency Disorders (IDD) have long been a public health problem in Bangladesh. The Bangladesh National IDD Survey, 1993, showed that 47.1 percent of the population had either visible or palpable goiter (visible, 38.3% and palpable, 8.8%), 0.5 percent of the children are cretins and 68.9 percent of the population were iodine deficient as assessed by urinary iodine excretion.

The Government of Bangladesh was aware of the

IDD problem even before the 1993 survey, and it responded to the problem by passing a law in 1989 and the Universal Salt Iodization (USI) related regulations in 1994. According to the USI regulations, all salts whether produced in Bangladesh or imported from outside must be iodized. Production guidelines under these regulations stipulate iodine levels of 45-50, 20, and 15 ppm at the factory, retail, and household levels respectively.

Salt Iodization Plants (SIP) were installed in all 267 salt factories during the period of 1993-95 with technical and financial support from UNICEF and the Micronutrient Initiative (MI). Prior to iodization, crude salt is washed three times in a saturated brine solution, and dried. The SIP adds a potassium iodate solution to salt, in a pressurized spray, as it exits a hopper by means of an auger-screw mixer. Even flow of salt into the hopper is achieved by means of a revolving feeder. Studies conducted during the design of the SIP indicated that, once calibrated, the machine is robust and will produce salt with a uniform $KIO_3$ concentration at or near 50ppm. Following iodization, the iodized salt is gravity-dried then packaged either in 1 kg plastic bags or 75 kg poly bags.

During SIP operation, factories use a semi-quantitative "paper strip" monitoring kit to estimate iodine content: color change on a paper strip is compared with a guide printed on the kit. Color charts allow iodine content classification into 0-20, 20-30, 50-60, 60-80, and >80 ppm ranges.

A USI evaluation survey during 1996 showed that about 99% of the salt samples collected at factory level contained iodine, but only 5 % were adequately iodized, *i.e.* having iodine concentration between 45-50 ppm. Many were found having too low or even a dangerously high iodine level.

### 1.1. Objectives

In consultation with the Government of Bangladesh project on Control of Iodine Deficiency Disorders (CIDD) and UNICEF, the Micronutrient Initiative, in association with Tufts University, USA conducted an in-depth assessment of the prevailing situation focusing on a few large and medium scale salt industries. The objectives of the assessment were:

1. To determine the causes of wide variations in salt iodine content in Bangladesh.
2. To appraise the operational status of some Salt Iodization Plants used by producers in Bangladesh.
3. To assess salt producer use of production monitoring techniques for iodine content.

## 2. METHODOLOGY

### 2.1. Selection of Salt Industries

The criteria for selection of salt industries for this assessment were: (a) regular production of iodized salt throughout the year, (b) willingness of the owner for extending cooperation and allowing critical examination of their production facilities and methods, (c) agreement by to provide and extend physical facilities needed for establishing a small demonstrational iodine testing laboratory at the factory level, (d) agreement by the owner to provide required and permanent manpower to receive training and continue with the quality control activities in long run, (e) annual production capacity of the industries, in case of both small and the large producers. For logistical reasons and supervision, salt industries from one out of five zones were purposely selected in consultation with GOB officials responsible for supporting and monitoring salt industries. A total of five iodized salt producing industries were selected for this in-depth assessment.

### 2.2. Salt sample collection

For the detection of iodine content in different stages of iodized salt production, salt samples were collected from stages such as, (1) from the center of the SIP auger-screw mixer in running condition at an interval of 5, 10, and 15 minutes respectively from the beginning of a 5 ton production run, (2) from the post iodization storage chamber before packing into small packets for marketing, (3) from 75 kg poly bags, stored for marketing, and (4) from non-iodized salt storage before iodization. All salt samples were collected and analyzed by the Institute of Nutrition and Food Science (INFS), Dhaka University, under the supervision of the project consultant. A Government counterpart, the Project Manager of the "Control of Iodine Deficiencies Disorders" Program was also involved during process.

### 2.3. Analysis of iodine content

The salt samples were analyzed at the IDD laboratory of INFS. Both titration and semi-quantitative paper strip methods were used to determine iodine content. The C.V. for iodine testing results was less than 3%.

### 2.4. Assessment of mechanical condition and performance of SIP.

A checklist was used to determine any mechanical problem with SIP. An experienced mechanical engineer was assigned to examine and report on the technical condition and performance of the SIP. The same engineer was involved during the original fabrication and installation of SIPs in Bangladesh during 1990-1994.

## 3. FINDINGS

### 3.1. Iodine content of salt during SIP operation

Iodine contents of the salt samples taken during iodization salt at SIP at five minutes interval, i.e. on fifth, tenth and fifteenth minutes varied greatly as shown in Figure 1.

In some cases iodine contents were found much less (15.51 ppm ) or much higher (226.22 ppm) than the prescribed standard of 50 ppm at the production level.

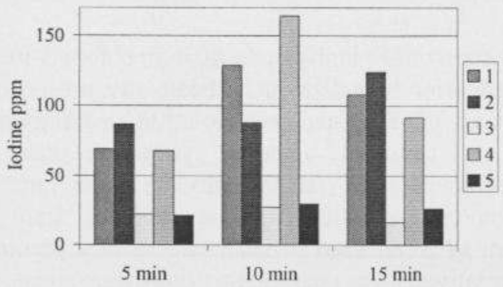


Figure 1. Iodine Content Variation During Production for 5 Producers

### 3.2. Iodine content of salt in post-iodization storage

Inconsistency in the iodine concentration was found in iodized salt at different levels of post-iodization storing chambers.

Iodine in solution can migrate downward with moisture during gravity drying, so the stage of drying may influence the relative concentrations at each level. This study did not control for this factor, at it may be that the unusual pattern of relative concentration seen for producer 3 would have been more similar to the others had samples been taken from all producers after equal duration of drying.

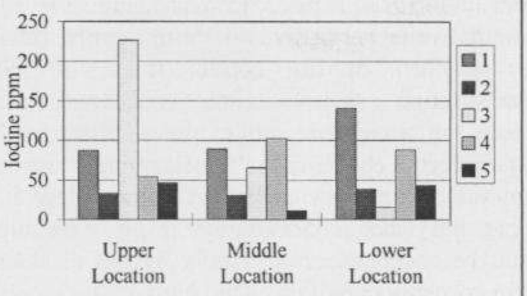


Figure 2. Iodine content variation by location in storage pile for 5 producers.

### 3.3. Iodine content of salt taken from storage before iodization.

In the process of cleaning, refining and crushing of crude salt the super saturated brine was found to be contaminated with iodine. The iodine level ranged between 2 ppm and 91 ppm in the refined non-iodized salt before passing through the SIP.

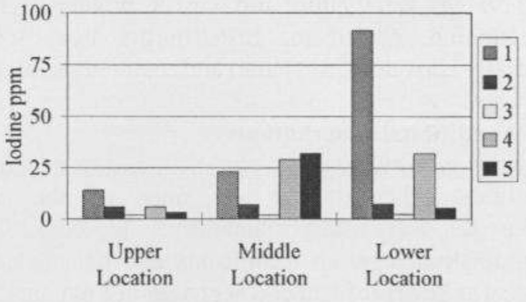


Figure 3. Iodine content variation of pre-iodization salt by location in storage pile for 5 producers.

### 3.5. Titration and Paper strip test of iodine

Significant differences in iodine content of salt were found by comparing results obtained by titration against those from the semi-quantitative paper strip monitoring kit used by industry. Especially in the case of very high concentration of iodine, the lack of precision in the monitoring kit prevents clear interpretation of test results.

For samples taken during SIP operation (5, 10, and 15 minutes of operation in a production run) and from iodized salt prior to packaging, the semi-quantitative test classified 46.7% of samples (total of 30 samples) in the correct range of iodine concentration. When iodine concentration was below the acceptable range, the semi-quantitative test correctly classified 85% of samples "too low" (any test result showing concentration below 50-60 ppm), but when concentration levels were higher than the acceptable range, only 37.5% of samples were correctly classified as too high.

### 3.6. Assessment of mechanical condition and performance of SIP

None of the five salt industries kept a SIP maintenance schedule, although the majority were maintaining and cleaning iodine solution tanks regularly. The condition of SIP gear oil and oil seals, and greasing/chain sprockets were found at satisfactory condition in four out of five SIPs. The salt feeder apparatus of three SIPs was not in good condition in three out of five SIPs checked. Spray nozzles and screw conveyer were found in unsatisfactory condition in two out of three SIPs checked. In almost all the SIPs, the pressure gauge and valves were either missing or broken or not functioning. All of the SIPs in the study were partially corroded (iron parts) and required painting.

### 3.7. Additional observations

General observations of the SIP and production facilities indicated that: (a) none of the salt industries was using maintenance log-book; (b) coordination between technicians and management staff was poor; (c) management was not paying due attention to the importance of proper iodization of salt; (d) operators are not well conversant with preparation of $KIO_3$ solution; (e) standard $KIO_3$ solution measuring containers and weighing facilities did not exist; and (f) inadequate practical training was offered for the technicians.

During the study, the SIPs were being repaired under the supervision of the project engineer with the active participation and contribution of the owners.

## 4. CONCLUSIONS AND RECOMMENDATIONS

Since none of the samples taken directly from the SIPs were adequately iodized, it is possible to infer that $KIO_3$ solution preparation may not be proper or that SIPs may need repair and/or re-calibration. The BSCIC has recently provided all salt mills with standard containers to improve $KIO_3$ solution preparation, and UNICEF is embarking on a nation-wide assessment of the mechanical condition of SIPs.

Either one or more mechanical problems were found in all the SIPs examined, particularly in pressure gauge, rubber seals, bearings, motors, chain sprocket, salt feeders. There were problems in alignment of the plant, compressors and overall maintenance. Since salt production likely does not cease when SIP equipment fails, proper maintenance of SIP equipment thus appears to be a constraint to proper salt iodization.

Wide variations in iodine content taken from different levels of the post-iodization storage chamber indicate that mixing of salt after post-iodization drying, but before packaging, may improve uniformity of iodized salt sold in the market.

The suprizingly high levels of iodine found in salt stored prior to iodization indicate the presence of iodine in the saturated brine solution washing tanks. The salt factory is a closed system, recycling all water used in the factory into the tanks, and the iodine contamination may be resulting from the return of water used to clean the factory premises. Alternatively, it is possible that potassium iodate has been added to the washing tanks to ensure a positive result during inspection (inspectors currently test only for the presence of iodine, not for actual concentration).

Regardless of the reasons for significant iodine concentrations in salt stored prior to iodization, the presence of iodine prior to iodization makes proper iodization using the SIP impossible because the machine is calibrated to iodize iodine-free salt.

Awareness among management and technicians about the importance of proper iodization of salt was inadequate, reflected by the poor maintenance of SIPs, the absence of any standard measuring containers and weighing facilities, and the absence of any monitoring record keeping and quality assurance mechanism. Without motivated involvement of producers at the time of production, properly iodized salt will be difficult to achieve in Bangladesh.

The "paper-strip" monitoring tools were found to be to inaccurate and difficult to use for use as a tool for internal factory level quality monitoring. Laboratory-based assessment tools would improve accuracy of monitoring information, but they would be even more time-consuming than paper-strip testing, would require intensive training, and represent a level of investment for iron content monitoring that seems unlikely without improved motivation among producers for proper iodization.