

# On the watch for lurking danger

THE history of drinking water in Bangladesh is a history of 'non monitoring' of water quality. Thirty years ago, the country did not monitor for arsenic in drinking water because 'they had no knowledge' of it then. Twenty years ago, the World Health Organisation (WHO) guidelines for drinking water quality were formulated still drinking water remained unmonitored. Ten years ago despite our new found knowledge and awareness drinking water monitoring still remained a far cry. Today it is still not being done as per standard acceptable protocols.

"Amidst their enthusiasm to drill tube-wells in Bangladesh in the 1970s, the Unicef forgot about the Taiwan experience. The deadly water went untested for two decades," says Gourishankar Ghosh, chief of the Unicef's water and sanitation division.

Since the country is poor and did not have the resource or the technical ability to 'monitor' its water it needed international financial and technical aid to develop its (drinking) water resources. Some of the biggest water agencies globally known for their expertise had come forward to assist. Yet water remained scientifically unmonitored.

Over the years Bangladesh was unable to develop its capacity to monitor water quality. It also missed opportunities to monitor its water quality as per standard protocol within the various water-related projects in the country. Huge amounts of underground water were extracted for irrigation to grow high yielding rice. Yet this water was never monitored. The World Bank has been providing assistance to this programme for the last thirty years. Was there any systematic water quality monitoring mechanism in place? Some examples show opportunities for an earlier warning were possible and sadly missed.

A multimillion dollar deep tube-well project for irrigation under the World Bank called IDA 4000 DTW Project II: The Pilot Study into Optimum Well Design (1987-1992) provided an opportunity for water quality test. One of the major water contractors worldwide and the largest contractor for water sector in the country for the last 20 years was assigned to sink 13,000 deep tube wells (DTW) in Comilla and Manikganj (1987-1992). Some localised salinity was identified. The project continued. Comilla is one of the most highly arsenic contaminated areas in the country. Water quality monitoring would have given direction to policies, which could have saved lives. In the context of the new water crisis in the country it is essential that impact of ground-water-related projects on people and agriculture need to be assessed.

Another major project between was the Flood Action Plan. A component of this research included studying the impact of water quality on humans and pisciculture. It is hard to understand why such studies, involving huge sums of money and which aimed to look at water quality failed to identify arsenic in water? One reason could be not testing for water quality as per the WHO guideline.

"I cannot understand how and why the WHO and the Unicef made this mistake. Anybody familiar with the map of the region should have immediately realised that the problem has implications for Bangladesh," a key WHO official acknowledges.

The future of monitoring water quality has serious implications for the country's development. This is at the heart of the present failure and will remain at the heart of any future success in securing water in the country. Standard protocols and procedures can be developed and have to be developed by our scientists both in the lab and in the field. And it has to be done within the framework of a total quality management system, write **Sharmeen Murshid, KM Mostafa Anwar and Mala Khan**

Yet another case at hand is the 1992 Bangladesh Geological Survey report which also failed to identify arsenic. The 1997-98 survey-report, however, did finally assess the spread of arsenic in groundwater but the study raised serious questions about the methodology, quality of data and procedure. The BGS report has been extensively quoted and applied for both policy decisions and strategic focus. Therefore, the reliability of the BGS data was of utmost importance. It also faced tremendous criticism from international scientists for not sharing data and for not being transparent. Statements like - wells are only "26-29 per cent" - led to the continued sinking of wells by all the major donors, NGOs and DPHE without any restrictions, thus, causing distress and confusion amongst people that had been told that wells are unsafe.

A major weakness in the BGS report is the attempt to arrive at an average (26-29 per cent unsafe tube wells). Since one does not know which of the 26 per cent tube wells is unsafe this information serves little purpose in operational terms other than to make one complacent about the crisis. This data is incorrectly interpreted (Ref: the Unicef representative's letter to Brotee, July 30, 2000) leading to incorrect strategies when such agencies as the Unicef says "only between 26-29 per cent" are unsafe and conclude that "conversely estimated 71-74 per cent (tube-wells) draw water from aquifers that are safe from arsenic." Can a system that is 27 per cent defective be termed "safe"?

The first BGS report did not identify arsenic while the second report raises questions on the reliability and traceability of data and quality of monitoring. In the absence of a national monitoring policy each of these projects and researches were, on the one hand, opportunities to survey (not monitor!) the water quality, on the other hand, produce reliable and traceable data that could have helped determine correct water policies and strategies.

The money was there, the experts were there but quality water monitoring was not there. The importance of monitoring cannot be over emphasised. The efficacy of any technology - the two-bucket system, the three-kolshi or for that matter any arsenic removing filter must be subjected to rigorous water quality monitoring before it is widely promoted/marketed and before communities are asked to share cost. The definition of monitoring water quality has to be established. Needless to say that what has been going on in the country for the last thirty years is basically ad hoc surveys and short-term surveillance and not water quality monitoring and the same has been happening for the last decade which is inexcusable in any terms. With all our concerns, governments over the period have failed to manage the problem.

## Analytical QA/QC

From the above it has been made clear that in order to assume a holistic approach of water quality and quality management, environmental protection and policy formu-

lation, technology adoption and hence to attain a sustainable development of the country, water quality monitoring (WQM) must be incorporated within the basic structure of policy decisions and management priorities of the government.

As per the International Organisation for Standardisation (ISO) monitoring is defined as "the programmed process of sampling measuring and subsequent recording or signalling or both of various water characteristics, often within the aim of assessing conformity to specified objectives". The ISO also defined three kinds of activities related to this issue.

"Monitoring is the long-term, standardised measurement and observation of the aquatic environment in order to define status and trends.

"Surveys are finite duration, intensive programs to measure and observe the quality of the aquatic environment for a specific purpose.

"Surveillance is continuous, specific measurement and observation for the purpose of water quality management and operational activities."

To establish an effective monitoring programme several principal components are already discussed elsewhere. A detailed plan and description as well as guideline on WQM has been explained in the book published by Chapman & Hall on behalf of the WHO, the UNEP (Edited by Jamie Bartram and Richard Ballance, 1996).

It is expected that in the detailed WQM Plan the following main components must be present and maintained:

λ a clear statement of aims and objectives

λ information exceptions and intended uses

λ a description of the study area concerned

λ a description of the sampling sites

λ a listing of the Water Quality Variables/Parameters that will be measured

λ proposed frequency and timing of sampling,

λ an estimate of the resources required to implement the WQM design and

λ a plan for QC/QA of the laboratory (and or field) analytical process involved in the WQM programme.

It is worthwhile to note that the emphasis has been given to collection of reliable data for a WQM management purpose in turn to achieve objectives to control the physical, chemical and biological characteristics of water. Analytical data without reliability and traceability can not be considered as a source of information but only garbage. Again reliability of data for a WQM Program depend on strict adherence to a wide range of Standard Operating Procedures (SOPs) and Total Quality Management (TQM) system for water sampling, transporting, storing, running analysis, disposal, report generating and archiving. In order to demonstrate that a laboratory system is producing data of acceptable precision, accuracy and sensitivity, it is necessary to assess all laboratory procedures at all stages from sampling to reporting.

As per AWWA/APHA, "Quality assurance is the definitive program for laboratory operation that specifies the measures required to produce defensible data of known precision and accuracy." Thus, QA is "the system of documenting and cross referencing the management procedures of the laboratory" with the objective to have a clear concise and traceable records of all procedures in such a manner that the whole laboratory process can be monitored to achieve the quality goal.

## QA system

An organised laboratory QA system must define the quality policy with respect to the data quality goal and it must establish a quality system consists of written administrative procedures (APs), Standard Operating Procedures (SOPs), work instructions, analysis log, Material Safety Data Sheets (MSDS), data records and quality documentation. The quality system defines clearly the organisational structure, management responsibility, staff responsibilities, analyst training and performance requirements (IDC & ODC). It also defines the availability/capability of analytical services in terms of specified accuracy, precision and traceability of measurements.

Major equipment with their qualification (EQ) record consist of IQOQPQ describing the instrumentation status e.g. calibration, maintenance and suitability for the specified uses. Description of laboratory facilities, measures of occupational safety, emergency action plan and waste disposal program should also be incorporated in the QA system.

A well-defined applicable and secured Laboratory Information Management System (LIMS) maybe employed. LIMS is a automated computer, Local Area Network (LAN) internet and or intranet support database management system comprising a chain of cross-referenced paper based and or automated electronic documentation/Parameters that will be measured

λ proposed frequency and timing of sampling,

λ an estimate of the resources required to implement the WQM design and

λ a plan for QC/QA of the laboratory (and or field) analytical process involved in the WQM programme.

control. In short QA system achieves these objectives by establishing planned and systematic protocols and quality criteria for every aspect of laboratory work and thus providing a framework within which Quality Control (QC: Internal QC) and quality Assessment (EQC: External QC) programs can be effective. It is solely a management system and analyte-independent, because it deals with the overall running of the laboratory rather than focusing on individual analyses.

## Quality control

As a part of the QA program, quality control (QC) is indeed included in each of the individual analytical method and SOP pertinent to each analysis. Literally QC starts from the selection of a valid analytical method through considering all the aspect of the validation e.g. scope, specificity, linearity, accuracy, range, precision, bias, MDL, PQL, stability and robustness etc. ends with the measurement data having known accuracy, precision and recovery information. QC program consist of at least the following elements:

λ Initial demonstration of capability (IDC),

λ Ongoing demonstration of capability (ODC),

λ Determination of method detection limit (MDL) and practical quantitative limit (PQL);

λ Analysing blanks e.g. reagent blank also known as method blank (RB), laboratory fortified blank (LFB) known as blank spike,

λ Analysing laboratory fortified matrix (LFM) also known as matrix spike,

λ Analysing LFM Duplicates, sample matrix duplicates and triplicates,

λ Running internal standards as well running QC check samples to check correlation coefficient as well as linearity and calibration, drift and sensitivity of the instrumentation.

λ Continuous monitoring procedures for checking quality of laboratory reagent grade water (say, ASTM-type laboratory reagent and glassware).

λ Application of required statistical process control (SPC) charts and corrective action plan,

λ Establishing frequency of QC check samples/indicator analysis,

λ QC acceptance criteria and defini-

tion of a batch/ lot and or stratification rule should be mentioned in the QC procedures.

## Quality assessment

To maintain the QA system it is necessary to check periodically each area of the laboratory for compliance with the QA system. This assessment is to ensure that IQC measures are being performed and maintained properly to reach the quality goal declared. This is the final analytical result validation process through a comprehensive study, compilation and reduction of data produced via the laboratory processes on the basis of the analysis plan. Data quality checking starts by defining and determining the measurement uncertainty and comprehending all the sources of uncertainties. In this case an internationally accepted guidelines for evaluating and expressing the uncertainty of measurement results can be followed. Two types of standard uncertainty Type-A & Type-B are to be assumed. Type-A uncertainty is considered to be arising from the random effect and can be determined using statistical process and probability distribution techniques. Type-B uncertainly, sometimes known as systematic uncertainty or bias etc. is originated from non-random sources and hence can not be calculated only via statistics. A Type-B evaluation of standard uncertainty is usually based on scientific judgement using all the relevant information available and this may include the knowledge of:

λ previous measurement data

λ experience with, or general knowledge of the behaviour and property of relevant materials, matrix, instrumentation, techniques,

λ manufacturer's specifications,

λ data provided in calibration and other reports, and

λ uncertainties assigned to reference data taken from hand books, literature, certificates etc.

Featuring and determining a complete scenario of data quality from holistic approach is to be established. The data quality assessment process includes checking anion-cation balance among the major ions, checking correlation among the ions through statistical multivariate data analytical and or ANOVA process, checking consistency and correlation among TDS, EC, bicarbonate alkalinity etc. assessing repeatability, reproducibility, source of correctness an intensive study is required from the mathematical, statistical, computational and chemometrics point of view. Analysing CRMs periodically, to establish traceability of measurement result with the national and or international standards, is definitely an integral part of data quality assessment. Running proficiency test sample and laboratory inter comparison samples can also be considered as the quality assessment program to establish the laboratory performance as a whole. These can be considered as External Quality Control. Accreditation is also one way of implementing QA program. Alternatively, QA can be implemented with reference to international standards such as ISO-9000 without necessarily going to the expansive way of accreditation.

## Conclusion and recommendation

The future of monitoring water quality has serious implications for the country's development. This is at the heart of the present failure

and will remain at the heart of any future success in securing water in the country. Standard protocols and procedures can be developed and has to be developed by our scientists both in the lab and in the field. And it has to be done within the framework of a total quality management system.

In view of the confusions and uncoordinated actions the government must be the central driving and guiding force. We urgently need a strategic plan (the results of the international workshop organised by the government has been a good starting point), a (Ground) Water Act within which there will be a (Ground) Water Regulatory Body that will protect, conserve and regulate water use and ensure that all agencies and laboratories are bound to abide by the laws of the Body.

Lastly, in view of an existing 'culture of secrecy', the authors would like to assert that data belong to the people. The government as the custodian must protect and preserve this data in the interest of the nation, particularly on issues of environment and development that must be made easily accessible to the public. Agencies conducting research, under credit program (such research is with people's money) or under grants, do so on the people and on the soil of the country and therefore must hand over the data to the government. Furthermore, research practice by international research agencies must follow international ethical standards that again must be ensured by the government without being obstructive. Data gathered in Bangladesh is first and foremost the property of the people.