

Analysis of the structure and infrastructures of Metrology, Accreditation and Standardization for the Water Sector in the 21st Century A Mexican Perspective

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Abstract.

The paper presents an analysis of the structure and infrastructures of Metrology, Standardization and Accreditation (MSA) for the Water Sector in the 21st Century, from a Mexican perspective.

Water is passing from being 'just' a vital element to become a key element of interest for societies in every field, from economics to politics and technology. The quality structures and infrastructures of every country in terms of Metrology, Standardization and Accreditation have to respond to the new challenges and demands.

The paper analyses the relevant aspects of this sector in the Mexican scene. Within this reference frame it goes to classify the main macro-processes which take place with water, from recollection and extraction, to processing in different ways (desalinization, potabilization, recycling, etc.), to distribution and charging for its consumption.

In every process, there are different social actors involved, from government to private industries and social organizations to the final user. Aspects of standardization, conformity assessment and metrology are typified for the most common of these processes.

In every stage of every process there are critical variables to be measured. This measurements are classified in quantity (volume, flow, mass, etc.), quality (contents, purity, inorganic analysis, organic analysis) and process variables (temperature, pressure, chemical substances, materials, etc).

Finally, some general ideas about the MSA structures and infrastructures are put forward, as well as specific proposals for common work on metrology.

Key words: Water sector, water processes, measurements of quantity and quality of water, standardization, accreditation.

1. Introduction

With the rapid increase of population in the world and the indiscriminate use of natural resources, water has become a factor of vital concern for every sector of every society.

Water is fundamental for the living of human beings, for food production in the agro industry and for many industrial processes.

Despite the many efforts of some academic or environment conscious sectors, the initiatives put forward to solve the water problem rationalizing its use and with artificial methods of water production like desalination, in practical and economical terms water cannot be produced, nor destroyed, only transformed.

In consequence, strong efforts should be devoted to the efficient management and use of water, in every aspect of life. Measurement is fundamental in this endeavour.

In Mexico, the agency in charge of management of public water is the *Comision Nacional del Agua* (CNA). From the year 2000, the National Center of Metrology (CENAM) has worked with the CNA in different projects applying the MESURA Program in some of its most important processes.

The first project was related to the metrological assurance of their reference laboratory (LNR) that verifies the quality of water according to the national regulations (NOM-127-SSA-1994). The LNR gives traceability to the whole country through a network of 13 regional and 32 local laboratories.

In 2003, CENAM developed another MESURA Project for the potabilization process in the largest potabilization plant of the country, which processes about 20 m³/s of water. This produces the water supply for about half of the population of the metropolitan area of Mexico City, this is, about 10 million people.

In 2005, CENAM collaborated in the definition of another project with the CNA to establish the metrological assurance of water extracted from wells for agricultural production. In the span of three years, a mega project has been launched to install about 35000 water meters in the same number of wells and springs and this will be controlled by a central Supervisory Control And Data Acquisition (SCADA). CENAM was invited and made a proposal to establish the reference framework for the metrological assurance of the project.

All these experiences and the work with a number of organizations has led CENAM and the MESURA Interinstitutional Network (RMI) to develop a systemic analysis of the water sector, and to approach in a more effective and efficient way the challenges posted by this critical area in terms of Metrology, Accreditation and Standardization.

2. Objectives

The objective of the paper is to present a systemic analysis and diagnosis of the structures and infrastructures of the water sector, regarding the main types of processes involved:

- i. Recollection and extraction
- ii. Processing
- iii. Distribution
- iv. Disposal and recycling

The analysis and proposals are made in the three dimensions related to quality:

- a. Metrology
- b. Accreditation
- c. Standardization

Similarly, since water is a public good and is mainly controlled through regulations, the analysis and diagnosis is being made in three levels:

- Compulsory regulations (legal metrology)
- Voluntary standards (specific applications)
- Innovations and vanguard improvements.

Also, the main user sectors and stakeholders have been considered:

- Households and individual humans in cities.
- Households in rural areas.
- Agricultural and animal uses in rural areas.
- Industrial use in urban areas.
- Other uses.

Based on these analyses, a number of recommendations should be drawn for general application.

3. Methodology

The methodology of the project is following the MESURA approach, in terms of the following principles:

- An integral and systemic analysis.
- A process oriented diagnosis.
- A modular classification of the elements of the subject matter.
- A cross-cut criterion for equilibrium among the different elements.
- A uniform code of conceptualization and communication.

With these principles, the proposal is being developed according to the MESURA methodology:

The basic work consists in gathering of information of the sector, reference framework, main infrastructures and resources, main processes and preliminary detection of needs. The first analysis is about the whole sector, its status, trends, and main challenges in the immediate future and key stakeholders. Second, the basic quality triangle is analysed and diagnosed: metrology, accreditation and standardization. Third, the analysis focuses on the most common processes of this industry, mapped in three critical dimensions: a) Measurement equipment and standards; b) Methods and procedures and c) Human competences.

After the specific analysis and diagnosis, there will follow a series of recommendations for each of the addressed key segments and processes, and a suggested program for achieving the metrological assurance of the whole sector.

4. Development

The following sections make a succinct description of the main process types of the water sector in México. Along them, some critical points about the MSA system will be mentioned.

4.1 Recollection and extraction.

Recollection is made of rain water from rivers, dams and other reservoirs. Extraction of underground water is made from wells and springs.

As in most parts of the world, in Mexico there has been overexploitation of these sources, with a number of consequences:

- Shortage of water for basic uses in some areas.
- Harm to the environment where sources dry.
- Sinking of ground due to over-extraction.
- Social problems for the right to exploit sources.
- Threats for future development, human, social and industrial, for the previewed shortage.

Recollection. The surface water of dams and other reservoirs is controlled on the basis of quotas, usually by the CNA and other public authorities or by different public or private agencies that have specific permits. Recollection depends on rain and non controlled meteorological conditions, and continuous studies are made to inventory and forecast water availability, since this conditions distribution.

The metrological infrastructure is very relevant to continuously measure and monitor:

- Meteorological conditions.
- Water levels in dams and reservoirs.
- Water quantity that is supplied to every user.
- Water quality (free from heavy metals, etc.)

Extraction. The underground water is a limited, non-necessarily-renewable resource that belongs to the country. This resource is also controlled on the basis of quotas, by the CNA. The underground water reservoirs have been overexploited for many years and now there is strong concern in society for the problems, actual and future, that this situation will convey.

The metrological infrastructure is important for measure and monitor:

- Reservoir location, situation and conditions.
- Well conditions in every location.
- Water quantity that is extracted for every user.
- Water quality (free from heavy metals, etc.)

In both cases, for surface water and for underground water, the MSA infrastructure must complete the circle with specifications, standards and regulations, and with mechanisms and people to inspect those conditions.

4.2 Processing.

Superficial water that comes from rain, dams and reservoirs, brings usually dissolved substances from ground dust, organic material and, sometimes, garbage and other contaminants.

The processes for this water depend on the future use it will have. The two main uses are:

- Urban areas, for human consumption and industry.
- Country, for agriculture, cattle and farm purposes.

Country. Water intended for agriculture, cattle and farm purposes is most times used without any treatment, unless strange materials or substances were detected. The process here is just some rough monitoring of quality and measuring in the distribution stage.

Cities. Water intended for urban areas is usually filtered and further potabilized to become drinkable. The initial filtering processes are usually simple with physical means. The potabilization processes are also simple, but require large infrastructures when it is done for large quantities of water.

The metrological infrastructure is very relevant along the process to measure, monitor and control:

- Water flow and volume along the process.
- Speed and filtration parameters.
- Quantity of chemicals to be added for flocculation and precipitation.
- Quantity of organic material for chlorine addition.
- Water quality before, during and after the process.

Ref. [1] is the standard that the process fulfilled and Ref. [5] reports on the largest potabilization plant of the country and the MESURA project developed by CENAM and its network for their metrological assurance.

Water from wells is also used both, for cities and for country places. The main process is usually the pumping for extraction, that can be rather hard in places where water is very deep, down to 500 m, below the surface. Appropriate measurements are important for control of the pumping process.

Underground water is usually free from large particles of suspended material and their treatment is simpler, unless strange substances are found. Monitoring of toxic or non desired substances is important. Depending on its source and use, water from wells could be submitted to different cleaning or treatment processes, physical or chemical. The infrastructures for these processes are usually established and operated by particular owners or specific communities, under their own cost and control.

If the water is to be for human use, it must fulfill the standard of Ref. [1]. The fulfillment of this standard is verified, at its time, by the Laboratorio Nacional de Referencia (LNR) of the Comisión Nacional del Agua (CNA) and its network of laboratories. They have established a metrological assurance program according to MESURA, Ref. [3].

In general, the processes used for water potabilization or treatment could be:

- Physical: filtration, sedimentation, decantation, UV radiation, etc.
- Chemical: chlorination, sulfatization, etc.
- Biological: bacterial action, etc.

Whatever is the process, an appropriate MSA structure and infrastructure is important due to several reasons:

- To protect human life and safety and the environment.

- To ensure effectiveness of the process achieving the required parameters in the water.
- To ensure efficiency of the process avoiding waste in energy and materials.

4.3 Distribution.

When the availability of a resource is limited and the need of it very strong, distribution, quotas and payment of the costs become a major question that have economical, technological, social and political implications.

In country places, distribution is made usually by channels or by direct extraction from wells. In both cases, authorities or agencies in charge establish quotas and prices for individual or collective owners of fields or farms. Due to shortage, the question of quotas and their measurement is a major one.

Measurement and control of water flow in channels is a major concern that has weak controls and has to be addressed in the near future.

In Mexico it is estimated that there are more than 70 000 wells, many of them without meters. The proposal of metrological assurance of wells referred in the introduction [7] has been put forward to support a program of the CNA that will install or renew 50% of the water meters in the period 2005-2008 and 50% later. The main aspects of the proposal are:

- Homologation of criteria for measurement systems: specifications, installation and operation.
- Definition and implementation of the water meter type approval process.
- Installation, verification and quality assurance, including service post operation.
- Integral control of the measurement network by the SCADA.

If the proposal is implemented properly, the measurement network would be a great asset for the country and the use of underground water could be better rationalized.

In cities, water comes from afar places by piping or is extracted from wells. For some industries and communities, the agencies in charge may grant permits for exploiting wells with specific quotas. The measurement problem, then, would be addressed with the measurement network in the same way as in every water source. When water is obtained or stored by a public agency and distributed by piping, water meters are very important for quotation and payment. However, there is not a type approval process for these meters.

Other serious problems associated to the distribution processes are the waste, due to leaks and other defects of the infrastructure, and robbery, since a large amount of water is taken from the network without permit nor payment. Correct measurements in the appropriate control points could provide the necessary information for later solving these problems.

The MSA structures and infrastructures are most important in the distribution processes of water due to several reasons:

- To know where the water is and where it goes, thus providing information for its appropriate administration.
- To apply properly criteria for its use, allowance, equity, tariffs and so on.
- To make, as a country, better use of this resource.

The infrastructure of Metrology, Standardization and Accreditation for distribution of water is still incomplete in México, and one of the challenges for the near future is to fill the gaps in the system.

4.4 Disposal, treatment and recycling.

After distribution, water is used for several uses and purposes, among them:

- Human: drinking, cooking, washing, etc.
- Agricultural: watering of fields, feeding of cattle, supporting farm processes.
- Household: washing, heating, gardening, scum carrying, etc.
- Urban: cleaning, washing, gardening, etc.
- Industrial: consuming as raw material or supporting physical, chemical or biological industrial processes.

Depending on the use, water comes out with different types of contamination by physical, chemical or biological agents.

The possible destinies of water that has been used are:

- Disposal: to be thrown away to the drains, gutters or drainage.
- Recycling: to be treated for the same or different use.

Disposal. As in most countries, in Mexico there are problems with disposal water in two main cases:

- Black waters from large cities.
- Contaminated waters from industrial processes.

Proper administration and control of these situations must be supported by the appropriate MSA infrastructures. When disposal of contaminated water is, apart from the intrinsic waste damage or loss, a danger for human health, society or the environment, compulsory regulations must be enforced. This is the

case of water of industrial or other use thrown to the drains, river or other national assets. In México, there are two standards that control its quality, Refs. [8,9].

Appropriate measurements are due of the quantities and quality of waters in every case. For these measurements, CENAM and the National Accreditation Entity (EMA) support 148 accredited testing laboratories, Ref. [10], that can perform the required analysis and demonstrate conformity to the standards.

Recycling. Whenever possible, treatment and recycling of water is most desirable, but it requires infrastructure and involves costs. Depending on the types of contaminants will be the infrastructure to be needed. Decision will usually depend on a benefit-cost ratio, though the side of benefit should be analyzed both, in economical and social terms.

Water treatment can be for posterior disposal, if it is only for fulfilling the minimum of the standard, or for reuse, like recycling in industrial processes, garden watering or else.

The main processes for recycling treatments of water are also physical, chemical and biological. There are few public infrastructures in Mexico for this purpose. Most facilities are installed and operated by industrial companies to fulfill compulsory regulations. Recently, some more facilities have been installed by environment friendly companies that show social responsibility. It is believed that this tendency should be reinforced and supported by government stimulus.

MSA infrastructures are important for the recycling processes, and have an effect on their effectiveness and efficiency.

5. Conclusions

5.1 Strengths of the MSA structures in Mexico.

The MSA structures and infrastructures in México have very valuable components that have been strengthened the last years. Among their main strengths are:

Metrology. At the primary level CENAM has developed more than 20 Reference Materials for analysis of water, both drinkable and residual. Besides, the National Reference Laboratory (LNR) of the CNA has first level analytical capabilities for the sector, and the National Institute of Technology of Water (IMTA) has strong testing capabilities for physical quantities related to the water processes.

At the secondary level there are 4 calibration laboratories for flow meters and 148 accredited testing

laboratories with demonstrated capabilities for analysis according to standards Refs. [10]. Among them, 18 of these laboratories belong to the LNR-CNA network.

At the third level there are more than X accredited verification units.

Standardization. There are 57 regulations or compulsory standards related to water in Mexico and 260 voluntary standards. Of the regulations, 6 are from CNA related to national water administration, 6 from the environmental protection ministry, 9 from the health ministry related to water quality and 4 related to instrumentation and measurement equipment.

Of the other compulsory and voluntary standards, they have to do with many aspects of the water sector as its applications in different processes and sectors.

Accreditation. As mentioned before, the number of accredited laboratories in Mexico is 4 for calibration of water flow meters, 148 for testing or analytical measurements of water, 82 verification units for environmental audits and 1 certification body for water bottled for human consumption. Many of these laboratories have been accredited in the last few years and are the result of multiple efforts of the organizations involved, both private and public, the EMA, CENAM, the General Direction of Standards (DGN), the CNA and other agencies.

It is considered that these strengths of the MNA are a good basis for confronting the weaknesses and challenges that the water sector still has to face in the immediate and mediate future.

5.2 Weaknesses and main challenges of the MSA structures in Mexico.

Metrology. Though CENAM has the basic standards for measurement of quantity (flow) and quality (composition), at the secondary level there are only very few laboratories with technical capabilities to measure flow with traceability and uncertainty estimations. Only 4 of these laboratories are accredited to calibrate flow meters and it is necessary to increase this number and strengthen their competencies. Ref. [7] includes a proposal for this purpose. On the other hand, though the main reference materials required for measurement of composition have been developed, they are not always available. Since CENAM cannot continuously produce and certify these materials, an association with other agency like LNR-CNA is being sought to satisfy the national needs.

Standardization.

Of the universe of topics to be covered by standards is still incomplete. The main area that is not properly covered is legal metrology. As an example, standards for type approval of the different measurement equipment and systems are needed. For instance, those needed for water meters for large flows as those used for agricultural or industrial processes. A similar need exists for specifications and type approval of other systems used in the different water processes.

On the other hand, many standards, though they exist, do not have the appropriate metrology considerations to be verified and the appropriate accreditation schemes for supervision. This happens mainly with old standards and the necessary corrective actions must be taken for their updating in the relative standardization committees.

Accreditation. The EMA has made strong progress in the accreditation system in Mexico since its creation in 1999. The number of accredited laboratories and verification units is a measure of that. Now the main weakness of the accreditation system in Mexico is the need for higher technical competency of the EMA assessors and the need of more competent personnel in laboratories and units. Another weakness is the lack of enough verification units to supervise all the aspects of public interest related to the water sector in the country.

6. Final considerations and acknowledgements.

Final considerations. The problems and challenges of the water sector in Mexico have their main components in the social, political and environmental areas. However, a proper MSA infrastructure could support the sector to face in a better way those challenges in the present and future.

For this purpose, the MSA system must increase and complete its coverage and strengthen its technical backbone of metrology. The coverage should be increased and completed both, in the universe of technical matters and in the geographical extension of the country. The technical competence of the different actors of the MSA system should be strengthened in every level, from the assessors of the accreditation body, to the metrologists and technicians of the secondary laboratories and verification units, to the users and operators of the water processes, every one in their required level.

The foregone requires of the coordinated effort of many organizations and agencies, both public and private, from the main actors of the MSA system (CENAM, EMA, DGN) to the superior agencies of the government (CNA, SEMARNAT, SAGARPA), to the

intermediate organizations as laboratories and the final users.

A proposal in this direction would be submitted to the next administration in Mexico and it is hoped to develop a consensus plan with specific actions for the period 2006-2012.

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