ГОДИШНИК НА УНИВЕРСИТЕТА ПО АРХИТЕКТУРА, СТРОИТЕЛСТВО И ГЕОДЕЗИЯ – СОФИЯ

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WATER STRATEGY IN MEXICO AND MEXICAN INSTITUTE OF WATER TECHNOLOGY

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ABSTRACT

Mexico faces important water related challenges. Urban population is growing at a rapid rate and distribution of water resources is very non uniform across the country, with water scarcity in the north and water abundance in the south. Floods in the last 10 years have affected over 13 million inhabitants, but at the same time most of the territory suffers from drought and extreme drought. Water management policy has changed along the time, from approach to offer to approach to demand, and approach to sustainability in the last years. In this context, a brief description of the Mexican Institute of Water Technology is provided.

1. Introduction

Mexico is a country which presents a great diversity of climatic and geographical conditions, as well as significant seasonal variation in rainfall, all of which have a great impact on the availability of water resources. The natural water availability also varies greatly, from arid and semiarid regions in the north and northwest to largely humid regions in the south and southeast. Given the essential nature of water for Mexico's economic, social and industrial development, successive government administrations have declared water a "strategic matter of national security". Freshwater is considered a finite resource, a

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sovereignty guarantor and strategic element. It is a public health and welfare element; vital for ecosystems and biodiversity, food production, industry, energy and economic development. It is a factor for Homeland Security, crucial for social and political stability. Poverty classification in Mexico takes into consideration the access to and quality of public services received, and the provision of adequate water supply and sanitation is considered an important element in the quest to reduce poverty.

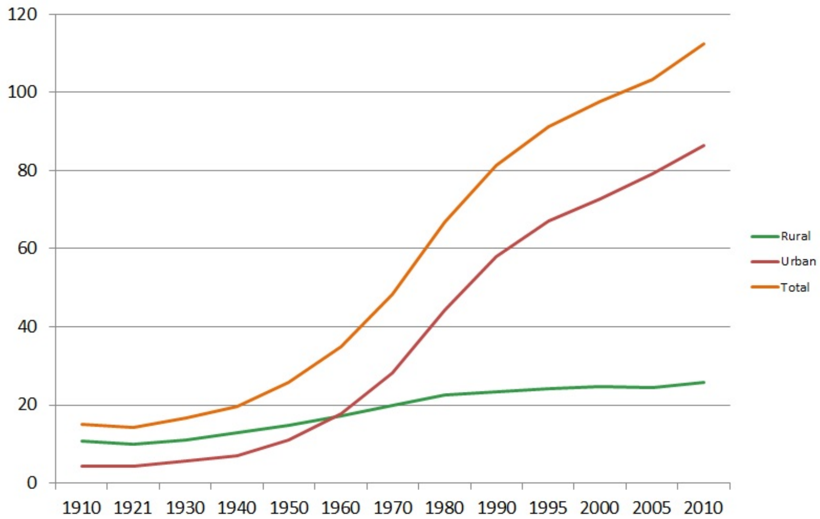

Figure 1. Population growth in Mexico since 1910

The population in Mexico has increased enormously in the last decades, from some 25 million of people in 1950 to more than 123 million now (Figure 1). While in 1950 water availability in Mexico was 18,035 m^3/inhab/year, it is currently close to 4,000 m^3/inhab/year, which is already considered low. This water availability is very non uniform across the country, featuring extreme regional contrasts. The Southeast region, where lives 23% of the population and 21% of the GDP is generated, owns 68% of the water resources, while the northern and central areas, with 77% of the population and 79% of the GDP, own only 32% of the water resource. 8.3% of the territory (161,510 km^2) is prone to flooding. Floods in the last 10 years have affected over 13 million inhabitants, 64 thousand km of road infrastructure, and 3 million hectares of land. The damage amounts to over 215,000 million Mexican pesos (12,400 million euros). At the same time most of the country is under drought in some time. In the 1930–1977 time period six severe droughts occurred. In 2006 nearly 70% of the territory suffered from drought and 15% extreme drought. The years 2011-2012 were the driest in the last 71 years. 80% of the territory suffered from some kind of drought, and nearly in 40% it was extreme.

2. Water Management Policy in Mexico

The biggest offstream user of water in Mexico is agriculture, which accounts for 77% of all offstream water withdrawals. Nationwide, only 14% of water used offstream is employed for public drinking water supply. Of the 78.9 billion cubic meters of water used for offstream uses, 63% comes from surface water and 37% from groundwater resources. Hydropower (an instream use) accounts for 122,800 million cubic meters per year. Mexico is a country with a great hydraulic tradition, as demonstrated by the fact that the country has the world's sixth largest area under irrigation, 6.46 million hectares, and the world's 19th highest per capita storage capacity in dams, 1 189 m^3.

Water policy has been changing in time. From 1926 to 1983 the approach was to offer. This was the period of greater development of the country's water infrastructure. From 1983 to recent times the reduced water availability made necessary to manage demand through economic-financial instruments (tax, market and water use rights), i.e. the approach changed to demand. The current and future approach is to sustainability. Mexico must undertake the process of implementing fundamental reforms that foster major changes in the water sector and contribute to the improvement of water resources management.

The National Water Program 2012–2018 encapsulates the vision of the water sector in Mexico for the current government administration. This program comprises the following objectives, for each of which relevant strategies and goals have been established:

- Strengthen the integrated and sustainable management of water resources.
- Protection in the face of extreme hydro meteorological events
- Strengthen water supply and access to safe drinking water, sewerage and sanitation services
- Increase the technical, scientific and technological capacities of the sector
- Ensure agricultural irrigation, water for energy, industry, tourism and other productive activities in an adequate and sustainable manner
- Consolidate Mexico's participation in the international water arena

In drinking water the 2013–2018 scenario is to increase coverage from 92% to 94%. This means 8 million inhabitants incorporated. The required investment is 114,600 million Mexican pesos (6,600 million euros). In sewerage, for the same time period, the scenario is to increase coverage from 90.5% to 93%. This means 8.4 million inhabitants incorporated, and the required investment is 80,900 million Mexican pesos (4,700 million euros).

One of the main aims of the current National Water Program is to treat and reuse more wastewater. The 2013-2018 scenario is to increase coverage from 47.5% to 63%. This means to treat additionally 34.5 m^3/s, and 46,700 million Mexican pesos (2,700 million euros) are required. In the irrigation sector the 2013-2018 scenario is to surface modernize 1.38 million hectares, with 42,490 million Mexican pesos (2,450 million euros) required. For flood control the scenario is to protect 6.62 million inhabitants and 300 thousand hectares of land, with an investment of 45,400 million Mexican pesos (2,620 million euros).

The Water Agenda up to 2030 promotes a long-term vision for the future of water resources in Mexico. For the four main aims (clean rivers, balanced river basins, universal coverage and settlements safe from floods), 14 specific targets have been defined with their expected years of completion, so as to boost the efforts of the water sector in Mexico.

The institution in charge for administrating these programs is mainly the National Water Commission (CONAGUA). Created in 1989, it is an administrative, normative, technical, consultative and decentralized agency of the Mexican government, whose mission is to "manage and preserve [Mexico's] water and its inherent public goods to achieve a sustainable use of these resources, with the co-responsibility of the three levels of government and society-at-large".

3. The Mexican Institute of Water Technology

3.1. Background

The Mexican Institute of Water Technology (in Spanish Instituto Mexicano de Tecnología del Agua, IMTA) was created in 1986 as an autonomous public organization linked to the former Ministry of Agriculture and Water Resources with the main objective of developing technology and training the necessary qualified human resources in order to ensure the rational utilization and integrated management of water resources. As a result of modifications to the country's Public Administration in 1994 IMTA became part of the Ministry of Environment, Natural Resources and Fisheries. Today, by a presidential decree published on October 2001, IMTA is a state-owned organization, with its own legal personality and assets, coordinated by the Ministry of Environment and Natural Resources. The official mission of the institute is "to produce, instill, and disseminate knowledge and technology for the sustainable management of water in Mexico", and its vision is "to be a leading, world-class institution that fosters the transformation of the water sector and furthers the sustainable management of water resources in the country".

In order to fulfill its mission, the Mexican Institute of Water Technology will carry out the following functions:

- Develop, guide, foment, and promote research and development, technology adaptation and transfer, and qualified human resources training programs and activities that will contribute to the sustainable and integrated utilization and management of water.
- Develop specialized research, education, and training projects of interest to other institutions, which are to be carried out under specific agreements and contracts.
- Offer technology development, adaptation and transfer services, as well as specialized training and consulting, and scientific and technological information divulgation.
- Give graduate studies in the areas related to the objectives of the Mexican Institute of Water Technology in coordination with the Ministry of Public Education; develop and apply the corresponding curricula, and issue certificates and grant academic diplomas, titles, and degrees.
- Offer specialized laboratory services, technical consulting, and other services related to standards, design, information, quality assurance, and assimilation of technology to private and social sectors within the country, as well as to foreign and international institutions and organization, in the areas related to the management, conservation, rehabilitation and treatment of water.
- Promote a water education and culture that will create awareness in the society that water is a scarce resource which requires a careful management in terms of both quantity and quality, as well as of its sustainable exploitation and the mitigation of its destructive effects.
- Contribute to the development, diffusion and implementation of those water technologies that are better suited for the country.
- Carry out the technological developments demanded by the productive sector or those considered necessary by the Federal Public Administration.

- Participate in the development of draft projects of Mexican official standards and to develop Mexican standards related to water.
- Offer support to the Ministry of Environment and Natural Resources for the implementation, according to the Federal Law on Metrology and Standardization, of regulation mechanisms for the quality standards compliance assessment and for the certification of quality standards of systems, material, equipment and machinery associated to the water use, exploitation, and treatment.
- Promote and transfer the technologies developed, as well as the results of research projects carried out by the Institute.
- Establish academic and technological interchange relationships with Mexican, foreign or international institutions and organizations.
- Grant scholarships to pursue studies at the Mexican Institute of Water Technology, as well as in other national or international water-related institutions.
- Propose orientations for national policies on hydraulics, contribute to the strengthening of the institutional capacity of the water sector in Mexico, and assist in the solution to hydraulic problems faced in the country.
- Perform all kinds of acts and to enter into all kinds of contracts and agreements as might be necessary in order to achieve its objective, as well as others foreseen herein and in other legal ordinances.

3.2. Organizational Structure

More than 400 persons work at IMTA. More than 300 of them are researchers or specialists in some discipline. Figure 2 shows the organizational structure of the institute.

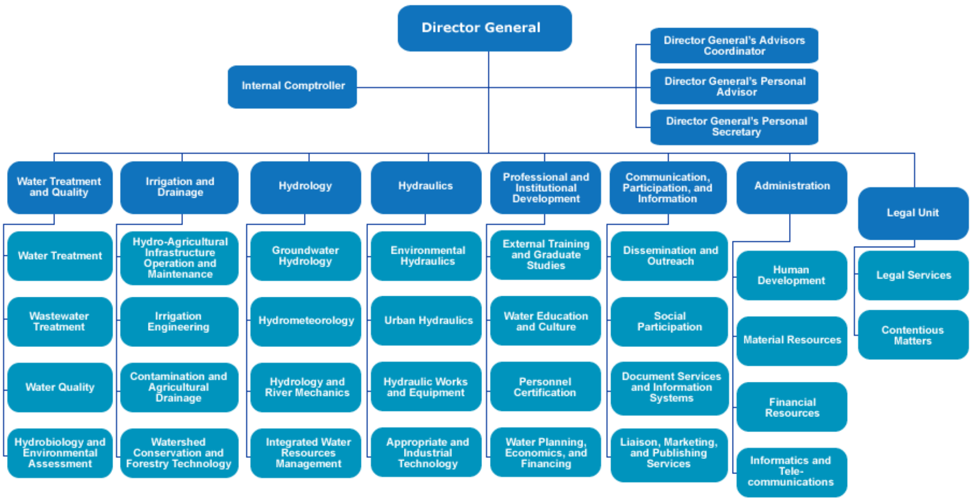

Figure 2. Organizational structure of the Mexican Institute of Water Technology

3.3. Infrastructure

Located in Jiutepec, near the city of Cuernavaca, the capital of the State of Morelos, IMTA occupies an area of 20 ha and has 23,000 m^2 of facilities. Its modern infrastructure includes 14 specialized laboratories; a training center, an environmental education area, a Water Knowledge Center, and a Training Center. The laboratories and their infrastructure are:

- The Enzo Levi Hydraulics Laboratory. It offers services for experimentation in basic hydraulics, scaled-down physical models, development and testing of hydraulic measuring and control devices, and assessment of commercially available hydraulic devices. It also supports experimentation for research, design, evaluation, and learning activities in the field of hydraulics. Accredited by the Mexican Accreditation Agency for 122 tests. Its main infrastructure includes an indoor experimental area of 3,200 m^2 and an outdoor experimental area of 2,000 m^2; water supply by a closed circulation system with a pumping capacity of 200 l/s and a 12-meter-high constant head replenishing tank; variable slope and Rehbock canals:; annular canal for calibration of free surface water meters; experimental benches for hydraulic models and water meter testing, and instruments for the automated acquisition of information.
- Water Quality Laboratory. This laboratory is accredited by the Mexican Accreditation Agency for 35 tests. Performs analyses of water, sediment, soil, vegetal tissue, and other environmental matrixes for more than 200 chemical, organic, metal, and microbiological parameters. Upon request, analytical methodologies for specific compounds or environmental matrixes are developed, adapted, and implemented. This laboratory has been classified as class I by the Atomic Energy Organization. Its main infrastructure includes ultraviolet and visible spectrophotometers, gas chromatographers coupled to mass spectrometers for the analysis of organic compounds, high-pressure liquid chromatographers, atomic absorption and plasma emission spectrophotometers for the analysis of trace metals, equipment for the quantification, and identification of bacteria, parasites and viruses; and equipment for specialized sampling.
- Hydrobiology Laboratory. Has special equipment for detecting mutagenic and genotoxic compounds and toxicity present in environmental samples, for identifying biological indicators of contamination, for the control of aquatic weeds, for determining chlorophyll and organic material content in sediments, and for granulometry estimations. Includes area and equipment for toxicological analyses, area and equipment for mutagenesis analyses, atomic absorption area and metal content measuring in several matrixes (water, sediment, tissue, sludge), an airboat and outboard motorboats for the monitoring of dams, lakes, estuaries, etc.; quarantine area, ponds, and greenhouse for the biological control of aquatic weed.
- Municipal Wastewater Treatment Laboratory. Has a high-level infrastructure for performing research and technology development for the removal of organic material, nutrients, and pathogenic microorganisms, as well as for the reuse of effluents in agriculture and aquaculture. Offers technological services for the characterization of discharges, and assessment of package

and centralized treatment plants. Its main infrastructure includes an experimental plant and greenhouse for the treatment and reuse of municipal wastewater; an area of physical models for performing treatability tests and obtaining kinetic coefficients in laboratory-scale reactors; a microbiology area for the analysis of coliforms and parasite eggs; on-line measurement equipment and multiparametric probes for unattended sampling; automated equipment for microanalysis determination of nitrogen, phosphorus, and other parameters; robotic equipment for batch analysis; and equipment for quality control in filtration processes: turbidimeter and laser particle counter.

- Industrial Wastewater Treatment Laboratory. Allows the identification of the main pollutants in industrial wastewater through its physicochemical and biological characterization, and its biodegradation potential, using treatability tests at a laboratory level, and scaling them up to a pilot plant level. Its infrastructure allows performing applied research and development of technologies for industrial wastewater treatment, and offers technological services for determining the treatability of wastewater or comparing different treatment alternatives for the same effluent, achieving the quality of treated water that complies with discharge standards for specific reuses and/or recycling. Its main infrastructure includes a pilot plant with 12 unitary processes, structured in 15 modules which, through flexible interconnections, permits the simulation and study of up to 80 different treatment series.
- Water Treatment Laboratory. It has the necessary technology for sampling water treatment plants and water supply sources, for researching, simulating water treatment processes, evaluating water treatment plants and disinfection processes, and for measuring field and laboratory parameters related to water treatment processes. Its main infrastructure includes a transportable water treatment plant for in situ treatability tests, complete water clarification, or removal of specific contaminants and pollutants, such as iron, manganese, and arsenic, among others; equipment for measuring total organic carbon as an accredited test; equipment for measuring the z-potential; UV spectrophotometer; equipment and methodologies for performing jar, coagulation, flocculation, and sedimentation tests; equipment for measuring field and laboratory parameters related to water treatment processes; portable equipment for the chemical analysis of water; sieves, peristaltic pumps, filtration columns, pilot sedimentator, and potentiometers; and setting up of treatability tests in water treatment process prototypes.
- Isotopic Hydrology Laboratory. Develops methodologies for the application of stable and radioactive isotopes, as well as artificially added chemical, fluorescent, and radioactive tracers in order to characterize and simulate the behavior of hydrologic systems. Creates scaled-down physical models for simulating the phenomenology of the underground environment and develops digital recording instrumentation for monitoring of the physicochemical quality of groundwater. Includes facilities for measuring the content of environmental tritium in natural water samples, the content of carbon-14 in groundwater samples and the content of light stable isotopes in natural water samples; instrumentation electronics for identifying and measuring radioactive isotopes of environmental concentration, sampling in aquifers and characterization of flows in karstic regions and parameters in

water through ion chromatography and spectrophotometry; infrastructure for the development of instrumentation for monitoring and real-time automatic recording of the physical and chemical variables of aquifers; and scaled sand box models for simulating and reproducing aquifer phenomenology.

- Hydrogeochemistry Laboratory. Offers services for estimating and assessing environmental risks and for developing concepts of water sanitation, sedimentation, and contaminated soils. The following activities can be performed within the facilities of this laboratory: identification and hierarchical classification of transport vectors of environmental contaminants, research on the mechanisms that determine the behavior and biodegradation of substances in the environment; development, calibration, and validation of models to describe the migration of contaminants in water, sediments, and soils; research on and recommendation of appropriate environmental remediation technologies.
- Meteorological Sensors Calibration Laboratory. Its objective is to offer support for obtaining reliable atmospheric measurements, referring them to traceable standard instruments. The sensors of automatic meteorological stations and stand-alone electronic sensors are calibrated in order to validate the quality and reliability of their measurements. Each calibration system has a standard reference instrument traceable to the standard instruments of the National Metrology Center. Includes calibration systems for environmental temperature sensors, relative humidity sensors, barometric pressure sensors and digital pluviometers.
- Quality Control and Industrial Hydraulics Laboratory. Offers services for evaluation of water meters and domestic water devices. Accredited since 1994 by the Mexican Accrediting Agency for 10 tests of water meters. Its main infrastructure includes a test benches for 0.5” to 12” water meters; calibration of ultrasonic transit-time devices, ultrasonic Doppler effect devices, flanged electromagnetic flow meters, insertion flow meters, hole plates, turbine and propeller flow meters, manhole flumes, ultrasonic-type level flow meters, and Parshall flumes; and an universal bench for testing showers, fittings and others.
- Multimedia Communications Laboratory. It develops communication methods and tools in order to support technology transfer and training processes. It is in charge of the dissemination of water-related projects.

The facilities of the Morelos Campus for Postgraduate Studies in Engineering of the Mexican National Autonomous University (the largest university in the country) are also located within the premises of the Institute. It offers Master in Science and PhD Degree Programs in hydraulic engineering, environmental engineering and integrated water resources management. The Campus has hydraulics laboratory and water quality laboratory. Besides these postgraduate studies, IMTA by itself offers Master in Science Programs in Integral Water Management of Watersheds and Aquifers and in Operative Hydrometeorology and Meteorology.

3.4. Bulgarian presence in IMTA

The first author of this paper was the first Bulgarian citizen to join IMTA in 1991, in the first years of institute's existence. Since then, six Bulgarians have worked at IMTA. Currently there are 2 Bulgarians in IMTA: the first author of this paper, working in the area of Urban Hydraulics and a woman working in the area of Wastewater Treatment. There have been intents to establish some collaboration with Bulgarian institutions through the corresponding mechanisms of the Mexican Secretary (Ministry) of Foreign Affairs and the Bulgarian Ministry of Foreign Affairs, but these have not materialized. The signing of an agreement for collaboration between IMTA and the University of Architecture, Civil Engineering and Geodesy is under way now.

СТРАТЕГИЯ ЗА ВОДИТЕ В МЕКСИКО И МЕКСИКАНСКИЯ ИНСТИТУТ ПО ВОДНИ ПРОБЛЕМИ

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Ключови думи: *водно стопанство, водни проблеми, технология на водите*

Научна област: *хидравлика и водно стопанство*

РЕЗЮМЕ

Мексико среща сериозни предизвикателства във водния сектор. Градската популация нараства с високи темпове, а неравномерността в териториалното разпределение на водните ресурси е значителна, като в северните райони е налице недостиг, а в южните – изобилие. Наводненията в последните 10 години засягат над 13 милиона жители, като същевременно по-голямата част от територията на страната страда от засушаване и екстремно засушаване. Политиката на управление на водните ресурси претърпя изменения с течение на времето от политика на предлагане към политика на търсене, а в последните години – на осигуряване на устойчивост. В този контекст е представено кратко описание на Мексиканския институт по водни проблеми.

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