Groundwater Monitoring in Latin America

Summary report of information shared during the Regional Workshop on Groundwater Monitoring.

igrac

International Groundwater Resources Assessment Centre

This report is a summary on groundwater monitoring practices in Latin America. A brief overview is made for each country to capture the current state of national monitoring networks in Latin America and their challenges. It is a compilation of the information shared during the third regional workshop of the Global Groundwater Monitoring Network. We thank the workshop participants for their active participation and their valuable input. This report would not have been possible without their collaboration and timely contributions.

Content

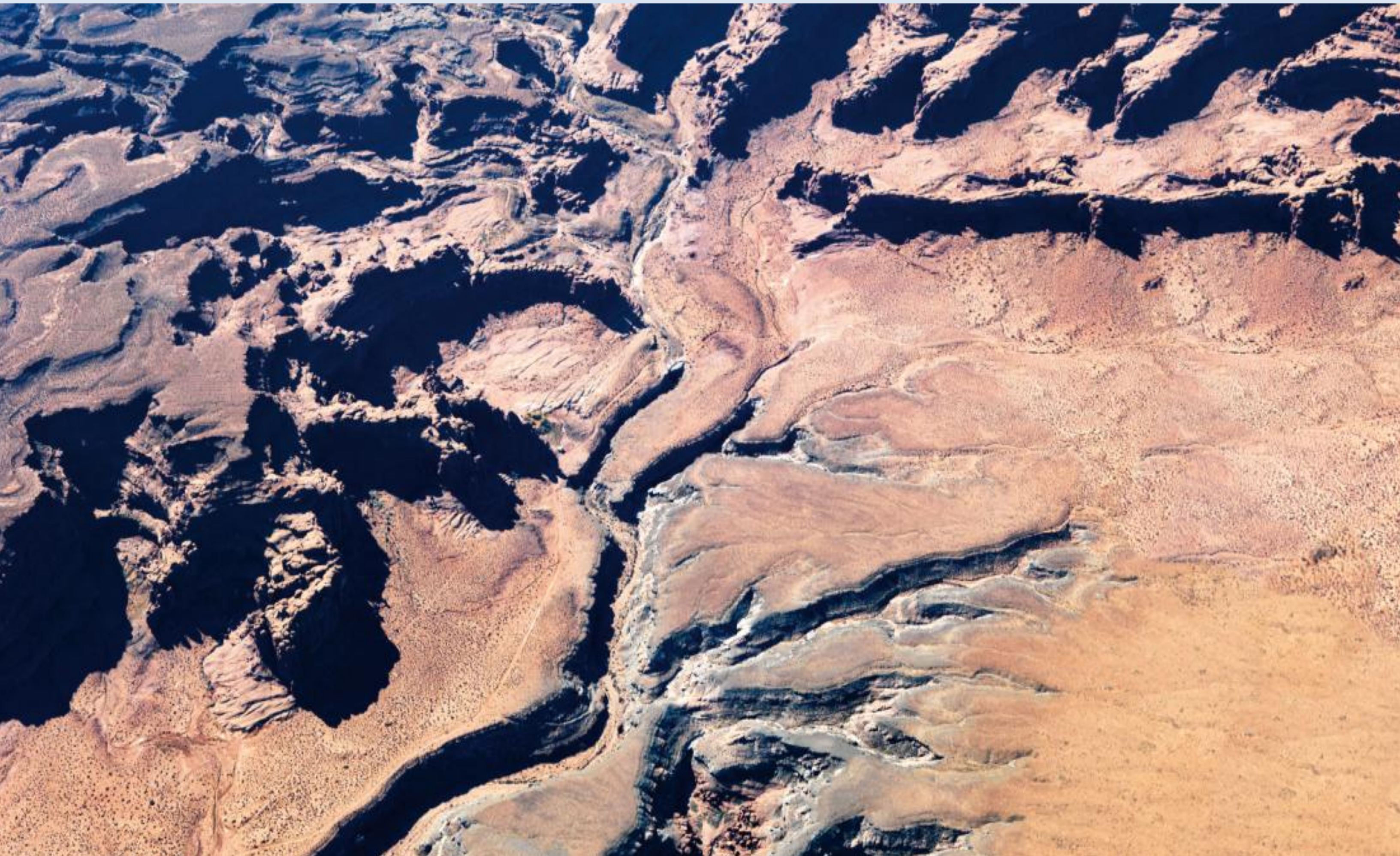
Rationale of the workshop

Recognizing the need for a systematic collection of groundwater data, IGRAC (International Groundwater Resources Assessment Centre) took initiative to develop the Global Groundwater Monitoring Network (GGMN). The GGMN programme is based on the principles of participatory monitoring, in which groundwater data from a global network of groundwater professionals is gathered, processed and made accessible to a range of stakeholders (http://ggmn.un-igrac.org). The programme aims to close the groundwater data gap, enabling periodic assessment of groundwater resources at the transboundary, regional and global scale.

The third regional GGMN workshop took place on 11-12 December 2013 at the UNESCO facilities in Montevideo, Uruguay. The workshop was organized to introduce the GGMN Programme in Latin America. The objectives of the workshop were to set up a GGMN Network and to exchange information, experience and perspectives on groundwater monitoring. More than 25 participants attended the meeting representing most countries of Latin America (Argentina, Belize, Brazil, Colombia, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru and Uruguay).

Throughout the workshop, information was shared by the participants on groundwater monitoring in their countries. This summary report contains the basic information on groundwater monitoring practices in Latin America. It begins by describing the IGRAC GGMN. Next, a brief overview is made for each country to capture the current state of groundwater monitoring networks in Latin America and their main challenges.

- *All workshop presentations are available via: http://www.un-igrac.org/publications/514*



1. The Global Groundwater Monitoring Network

Recognizing the lack of groundwater data around the world, IGRAC took initiative to establish the Global Groundwater Monitoring Network (GGMN). The GGMN Programme has been set up to improve global groundwater monitoring, increase sharing of information and thereby improve understanding of changes in groundwater resources. The Programme consists of two components: the GGMN Portal and the GGMN People Network. The GGMN builds a network of networks, structured around national focal points who manage the collection and entry of groundwater monitoring data in the web-portal.

The GGMN Portal

The web-based GGMN application (http://ggmn.un-igrac.org) offers access to time series and spatially aggregated groundwater data in a geographical information system. Members of the GGMN People Network can access the country-dedicated workspace of the portal. This workspace allows users to upload, interpolate, aggregate and analyse the groundwater data from their country. The simplicity of the application and clear information ownership (it remains with the data supplier) ensures that the global groundwater community can readily participate in the GGMN programme.

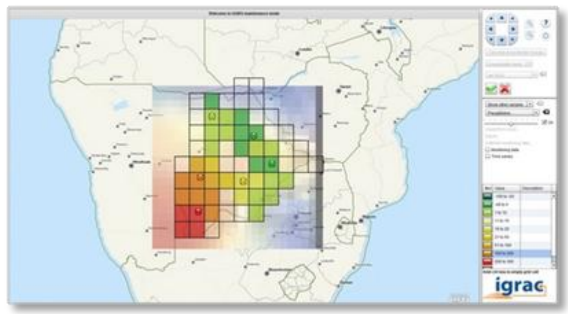


Figure 1. Aggregation of groundwater monitoring data in the GGMN web-application

The GGMN People Network

The GGMN relies on the participation of groundwater specialists, with knowledge of regional hydro-geology. Regional (spatial) aggregation of groundwater point measurements is much more than a numerical interpolation. It needs to be carried out by regional experts with a clear understanding of local hydrogeological conditions, existing monitoring practices, historic developments, socio-economic changes and other relevant factors. During GGMN workshops participants become familiar with the GGMN web-application and subsequently continue to collaborate as national focal points of the GGMN People Network.

The GGMN and transboundary water cooperation

When it comes to management strategies for transboundary aquifers, a participatory approach is essential. National groundwater monitoring networks play a key role in transboundary aquifer management. Connecting national, regional and global networks is a first step towards transboundary water management. Within this framework, the GGMN attempts to contribute to the harmonization of transboundary groundwater information and to promote further dialogue for transboundary cooperation.

2. Current monitoring and assessment practices in the Latin America

Towards improved groundwater management in Latin America

Sustainable use of groundwater in Latin America and the Caribbean (LAC region) is facing a great challenge. With a population of 606 million (Population Reference Bureau - World Population Data Sheet, 2013), the region is experiencing increasing pressure on its natural resources due to intensification of land use, increased urbanization, climate change and natural disasters (Akhmouch, 2012). To improve and support groundwater management in the LAC region the regional centre for groundwater management, CeReGAS, has been established in 2013. CeReGAS is a UNESCO category II centre, located in Montevideo, Uruguay. The centre aims to provide the region with the scientific and technical capabilities to support the sustainable development and management of groundwater, as well as the environmental protection of aquifers. Moreover, it aims to develop the capacity for the application of methods and tools for the sustainable management of groundwater in general, with special focus on the necessary protection of groundwater and the promotion of its rational use at national and transboundary level.

Argentina

Sustainable use of groundwater in Argentina is increasingly coming under pressure due to increased abstraction of groundwater resources. Until several years ago, there was a relatively large dispersion of hydrogeological information and lack of knowledge about groundwater in Argentina. In 2007, as part of the preparation of the federal national water resources plan (PNFRH), members of water authorities of the Federal Water Council (COHIFE) expressed the difficulties to make decisions because of the lack of information and guidelines for sustainable aquifer management; it demonstrated that it was essential for Argentina to develop a specific plan for sound groundwater management. This has led to the National Groundwater Plan, carried out by the Secretariat of Water Resources (SSRH) and with active collaboration of all provinces of COHIFE.

Groundwater monitoring and data management

The plan included the development of a national groundwater monitoring network to harmonize data networks from different federal institutes within Argentina. The development of this network commenced with workshops in each province involving provincial and national agencies to discuss and adjust the methodological guidelines, followed by trainings for technical staff, and the development of the hydrogeological database. Information from different federal institutes has been integrated in one national geographical information system: Sistema Federal de Aguas Subterráneas, SIFAS. SIFAS is now fully operational as Argentina's national groundwater monitoring network and federal institutes continuously upload data to the national system (Figure 2).

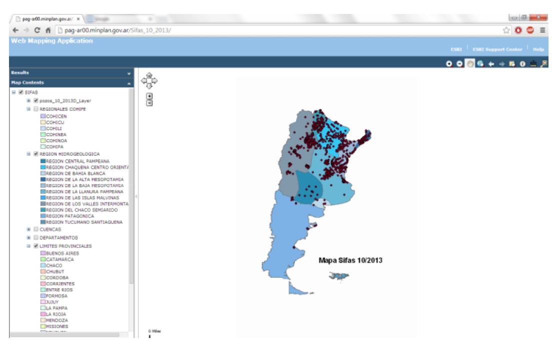


Figure 2. National Groundwater Information System of Argentina, SIFAS. Available via: http://pag-ar00.minplan.gov.ar/

Belize

In Belize 19% of the total population is dependent on groundwater; this increases to 35% for the population in rural areas. Salt water intrusion is a growing problem in the coastal areas of Belize, and some parts have already become irreversibly brackish, with major implications for the (groundwater dependent) ecosystems. Due to Belize's dependency on tourism, which could be affected in response to the deterioration of these vulnerable ecosystems, salt-water intrusion could have major impacts on Belize's economy.

Groundwater monitoring and data management

There is currently no national groundwater monitoring network in place. Water resources management is dispersed throughout government offices and private institutions. In 2010 the National Integrated Water Resources Authority (NIWRA) was legislated to further guide and assess water resources in Belize. This has led to the development of a National Water Master Plan. The plan includes water allocation planning, monitoring of water quality, the development of a data management system, water protection measures, providing technical assistance to staff and increasing public awareness. However it remains difficult to develop a detailed National Water Plan because there is only limited information available and only few regional groundwater assessments have been carried out.

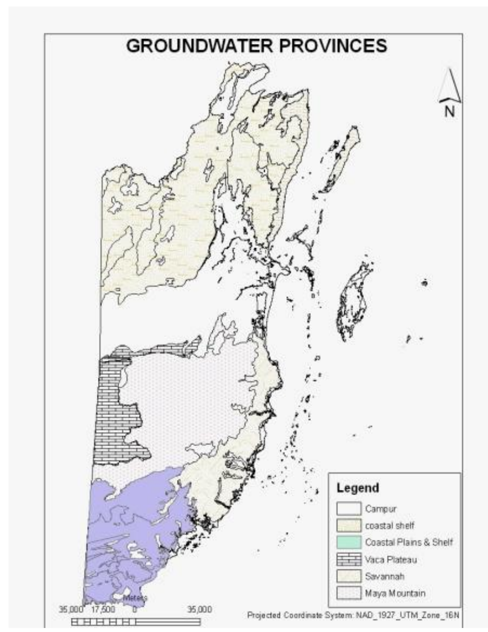


Figure 3. Groundwater provinces of Belize (Hursthorn, 1984)

Challenges

The implementation of the National Water Master Plan and its related activities is challenging. NIWRA is still in its pre-operational stage and lacks the capacity and finance to be fully operational. At present, Belize has only two hydrogeologists at work, while groundwater problems are increasing. There is a need to increase capacity and secure proper documentation of hydrological information for the country.

Brazil

In the last years, increasing volumes of groundwater have been extracted in Brazil, mainly in areas of intensive agriculture and areas with high population density (Mourao, 2012). At the same time, significant attention has been dedicated to define the regional hydrogeology and to assess groundwater development in major aquifer systems. These efforts have yielded valuable information to further guide the management of Brazil's groundwater resources.

Groundwater monitoring and data management

The groundwater monitoring network operated and maintained by CPRM is called RIMAS. The project for a nation-wide network started in 2009 and is implemented with government funds. The planning and implementation of this network was carried out in close collaboration with Brazil's WRM organizations and sanitation companies. The network is gradually evolving and is making use of already existing wells. In the last 30 years municipalities and industrial companies have drilled about 250,000 wells (Zekster and Everett, 2004); however not all of these wells still exist nor are suitable as monitoring stations. CPRM now manage a network of 293 monitoring stations in total, reflecting 26 aquifers, within 16 states. Wells are equipped with automatic data reading applications. Data is validated via a data quality assessment alert and control model before it is entered into the SIAGAS system. SIAGAS is an interactive information system developed by CPRM with the ability to visualize data and to generate graphs and charts. SIAGAS is composed of three modules: Data input, SIAGAS Web and Data Analysis and Interpretation. All data in the system is publically available online. Currently CPRM is discussing in what extent the information system can be adopted by other countries to monitor and manage groundwater.

Challenges

CPRM would like to audit and optimize its groundwater monitoring network. This includes standardization of all procedures. CPRM promotes to strengthen relations between institutions, by creating partnerships and thereby optimizing financial and human resources for groundwater monitoring. Another goal is to transform all data into useful information for a broad variety of users, and to further integrate the groundwater monitoring data with hydro-meteorological data networks for a complete integrated water resources management.

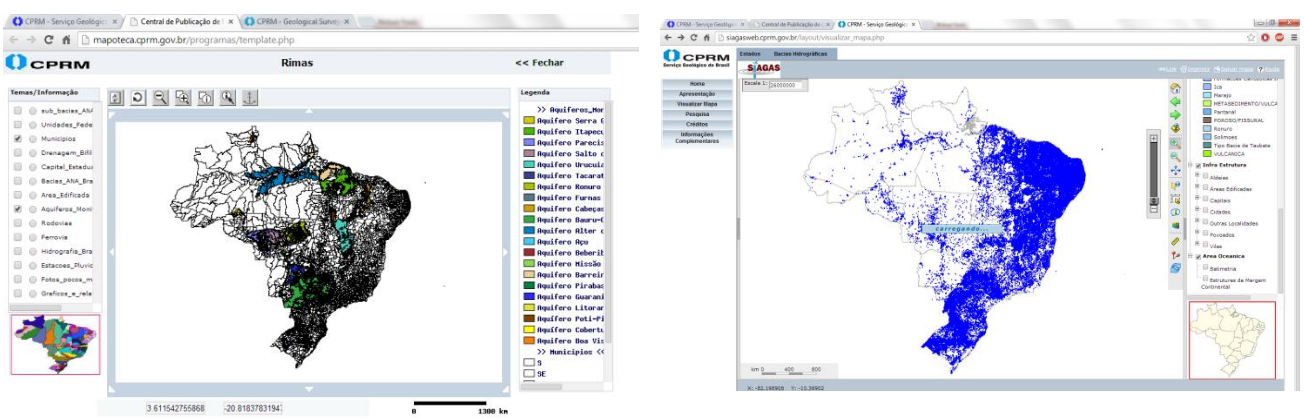


Figure 4. The hydrological information of the RIMAS monitoring network and the hydrogeological information system can be consulted via the online portal, accessible via CPRM website http://siagasweb.cprm.gov.br/layout/index.php

Colombia

Groundwater in Colombia is mainly used for agricultural practices (75%), followed by the domestic sector (9%) and industrial sector (7%) (IDEAM, 2010). The institute for Hydrology, Meteorology and Environmental Studies (IDEAM) is in charge of the production and management of scientific and technical information on the environment. Together with the ministry of environment and sustainable development (MADS) they have formulated a national groundwater program (PNAS). This program includes a national groundwater sampling and monitoring program, as well as the development of a groundwater information system (SIRH). The program is multipurpose and seeks to collect information about the current status and long-term trends in groundwater quantity and quality.

Groundwater monitoring and data management

The national groundwater monitoring network of Colombia has recently been developed and is maintained by IDEAM. IDEAM does not carry out the monitoring themselves, but makes agreements with already existing regional monitoring networks to collect information using national guidelines. IDEAM therefore collaborates with various institutes for groundwater monitoring. The minimal requirements of the collected data include that wells represent the natural hydrogeological conditions and are outside the influence of local sources of groundwater contamination. Another guideline states that all methods and procedures for monitoring are standardized; however it can be adjusted to regional conditions. It aims at having an observation well density of one station per 100 to 10,000 km^2. Furthermore it is agreed upon that the wells are monitored at least twice year.

Data is analysed and compiled into reports to assess and provide information on the state of groundwater resources. However, in many cases the information available is still insufficient to define planning scenarios for decision-making.

Challenges

Colombia wants to further improve the national groundwater monitoring network. From the 33 regional corporations, only five have currently a properly working groundwater monitoring network. Colombia recognizes the need for policy adjustments, technical trainings, and standardization and technical protocols for sampling and the dissemination of information.

Guatemala

Groundwater dependency in Guatemala is high, and can reach up to 70% of the total population. Guatemala is divided into four hydrogeological regions: alluvial plains of the pacific coast, the volcanic plateau, and the crystalline and sedimentary northern highlands. The most suitable aquifers for groundwater abstraction are the floodplains of the pacific coastal plain and the valleys of the volcanic highlands of the Sierra Madre. Although groundwater is generally safer than untreated surface water supplies, many shallow aquifers near populated areas have become contaminated. For example, all wells in the Rio Motagua valley are considered to be biologically contaminated, primarily due to improper waste disposal (Spillman, 2000).

Groundwater monitoring and data management

The ministry for infrastructure and housing, INSIVUMEH, is the national institution responsible for monitoring and assessment of surface and groundwater resources. INSIVUMEH monitors groundwater in different parts of the countries, but mainly in the high plateau and semi-arid areas. There are several institutions and municipal water companies that also monitor groundwater, mainly for drinking water supply purposes. These institutions are independent from the central government and the hydrogeological information is in most cases not publicly available.

Challenges

Municipal water companies follow their own regulations when it comes to groundwater management. A coordinated national groundwater plan could improve groundwater management. INSIVUMEH would like to improve groundwater monitoring and make the overall level of the programs comparable to more comprehensive programs such as collection hydro-meteorological data.

Mexico

Water resources are unevenly distributed in Mexico, leading to significant differences in the water availability per region. Between 2001 and 2009, surface water use has increased by 15%, while for groundwater the increase was 21%. In 2009, 37% of the water used in the country for consumptive use came from groundwater (CONAGUA, 2010). Mexico has been divided into 653 aquifers whereof 101 were indicated as overexploited in 2010. Furthermore, 32 aquifers with saline soils and brackish groundwater have been identified, primarily located in the Peninsula of Baja California and the Mexican highlands. Another 17 aquifers are affected by salt water intrusion (CONAGUA, 2010).

Groundwater monitoring and data management

Water in Mexico is considered a national asset. The National Water Commission (CONAGUA) is an administrative, technical, consultative and decentralized agency of the Ministry of the Environment and Natural Resources (SEMARNAT). CONAGUA is responsible for the administration of the national waters, management and control of the hydrologic system and promotion of social development. Its national groundwater monitoring network consists of more than 12.000 wells. These wells monitor in total 370 aquifers, which represent 57% of the total aquifers in Mexico. CONAGUA also performs the management and evaluation of the data collected. Some data is publicly available through reports published online which provide information on the state of groundwater resources.

Challenges

Mexico would like to implement groundwater monitoring networks in all of its 653 aquifers. The reason this has not yet been realized is mainly due to financial and human recourses restrictions.

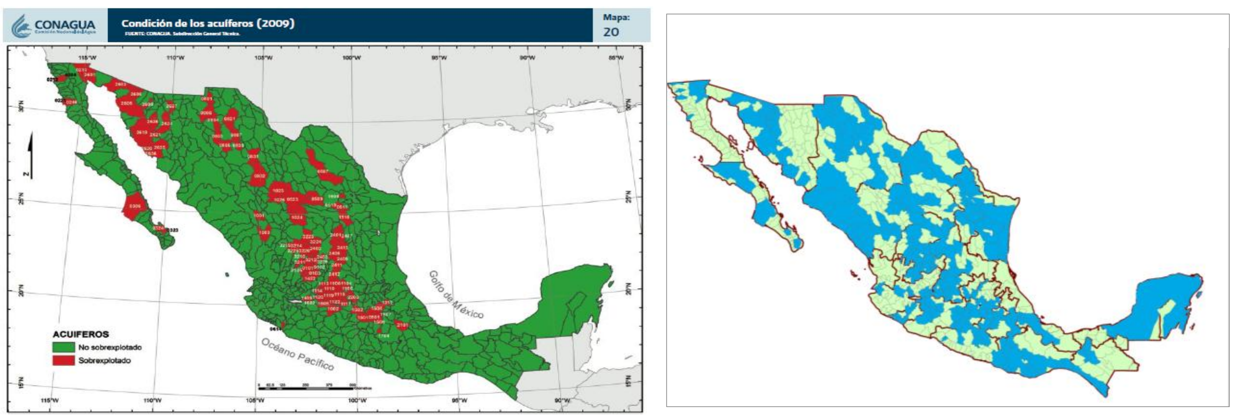


Figure 6 a) overview of overexploited aquifers indicated in red. 6 b) aquifers with monitoring networks

Nicaragua

Nicaragua has a lot of freshwater supply throughout most of the country. The most abundant supplies are in the quaternary age alluvial aquifers in the Nicaraguan Depression and in the Caribbean and Pacific lowlands (Webster, 2001). Although water covers ten percent of Nicaragua's surface, environmental degradation and pollution threatens the country's ability to provide potable water to sustain its population and productivity.

Groundwater Monitoring and data management

The Ministry of Environment and Natural Resources (MARENA) is responsible for policies, strategies, rules and regulations for the protection and conservation of natural resources; this also includes the groundwater component. A national water law was approved in 2007 that focuses on water resources and regulates water use in different sectors. The law recognizes water as a public good, and proposes a decentralized model for water management. According to the water law, the newly created National Water Authority (ANA) is in charge of planning, managing, administering, and controlling the use of water resources countrywide. The national water research council (NWRC) is responsible for supervising ANA and updating the national water policy. At the moment, water consumption for irrigation in not regulated and the extraction of groundwater is free of charge. Information on groundwater is very fragmented within different institutes. The data is not publically available, and is generally not shared among institutes.

Challenges

Development of the groundwater resources is difficult due to contamination of the shallow ground-water near villages, saltwater intrusion in areas along the Pacific and Caribbean coasts, and poor access to sites due to dense vegetation, steep slopes, and lack of an established road network (Webster, 2001). Deforestation also has a negative impact on the groundwater resources of the country by reducing the amount of water that recharges the aquifers, resulting in lower groundwater levels. Contamination due to mining activities is also a growing problem. Lack of technical capacity and inconsistent leadership of water resource management institutions poses a significant and ongoing challenge (Webster, 2001). Nicaragua is facing lack of human resources and there are not enough financial resources for sound groundwater management.

Panama

Panama has a tropical climate with high temperatures and humidity all year round. The driest part of Panama is called the Dry Arc of Azuero, Arco Seco, and is situated southwest of Panama City. Low precipitation in combination with poor land use in this area, contribute to water problems during the dry seasons (Sjunnesson and Svendenius, 2004). The hydrological characteristics of the geological formations in Panama are little known because of the lack of systematic studies. The majority of the aquifers that are exploited are of a type of fissure flow in volcanic rocks and of sedimentary and fissured conglomerates (Ballestero et al., 2007).

Groundwater monitoring and data management

There is no national groundwater monitoring network in place in Panama. The National Environmental Authority (ANAM) does have a laboratory for environmental water quality monitoring, and currently 33 of the 52 river basins are monitored. ANAM is discussing possibilities with the Environmental Quality department to also include groundwater monitoring in some basins. A National Plan of Integrated Management Water has been developed. This is a strategic plan with a planning horizon of 20 years (2010-2030).

Challenges

For the set-up of a national groundwater network challenges include training of technical staff for the design, construction, operation and maintenance of piezometric networks. This also involves identifying economic resources to design and implement the piezometric and water quality network. The main challenges encountered relate to lack of financial resources, a deficiency of logistical support and limited staff.

Peru

Groundwater is mainly used for domestic supply and for irrigation in the arid coastal zones of Peru. The national water authority of Peru (ANA) is the governing body responsible for technical and regulatory authority of the national water resources management. Over the last decades more than 50,000 wells have been drilled in Peru; over 32.000 of these wells are still in use while the other wells are no longer functional. Of the total functional wells, most are used for households (>21.000) and agriculture (7.000).

Groundwater monitoring and data management

Groundwater monitoring includes measurements of water levels, EC, Ph, TDS, and the collection of water samples. The current monitoring network consists of 6,901 wells, of which 3,491 are piezometric wells and 3,410 are part of the hydrogeochemical network. Data is processed and analysed to assess the basic groundwater conditions and to identify spatial and temporal changes. Assessments and numerical modelling studies are carried out to provide the required recommendations for improved aquifer management.

Challenges

The main groundwater concerns in Peru are related to water quality problems. Aquifers polluted by acid mine drainage are the most problematic. Aquifer assessments are important for the understanding and to minimize the impacts from mining (heave metals), agriculture (fertilizers) and salt water intrusion.

Figure 7. Coastal aquifer assessment Peru (ANA)

Paraguay

Groundwater is mainly used for domestic supply and industrial purposes in the metropolitan area of Asuncion (Zekster and Everett, 2004). SEAM is the governmental agency responsible for policymaking, coordination, supervision and implementation of environmental actions, programs and projects concerning the preservation and management of natural resources. For water management SEAM collaborates with SENASA, Paraguay's ministry of public health and social welfare. SENASA has developed and coordinates several programs to improve environmental sanitation services. SEAM furthermore executed several pilot projects in the Patino aquifer in cooperation with international research institutes, among others TNO (Netherlands) and BGR (Germany).

<u>*Groundwater monitoring and data management*</u>

550 piezometric observation wells have been drilled for groundwater monitoring. Wells are equipped with data loggers for automatic and high frequency electronic recording of water levels. All hydrogeological data available at SENASA has been assembled in the "Paraguay Well Information System" (PWIS) database. Each well has a unique identity number, with a corresponding name. PWIS contains information on water level, discharge and water quality, but also information on the lithology, and well characteristics.

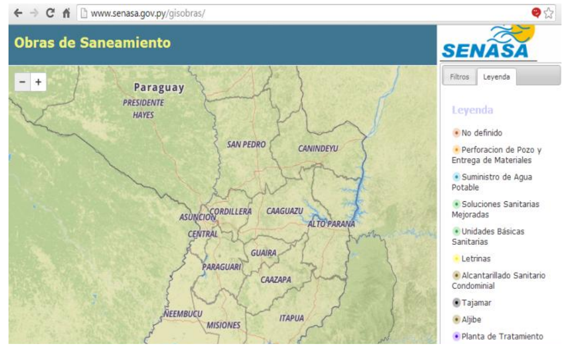


Figure 8: SENASA Groundwater information system of Paraguay. Available at: http://www.senasa.gov.py/gisobras/

<u>*Challenges*</u>

One of the main challenges for Paraguay is that data is dispersed among different institutions. Over 20 institutions in Paraguay are involved in water monitoring. Inter-institutional relationships regarding database management do not yet exist. There is no law that regulates national groundwater management.

Uruguay

In the metropolitan area of Montevideo around 20% of the water supply is provided by groundwater (Zekster and Everett, 2004). Groundwater is increasing in importance in Uruguay's water supplies, as a response to the growing costs and other constraints in storing and treating surface water.

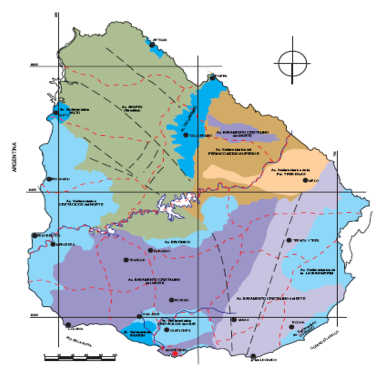


Figure 9: Map of Aquifers of Uruguay

<u>*Groundwater monitoring and data management*</u>

The Ministry of Housing, Infrastructure and the Environment (MVOTMA) is the national environmental agency of Uruguay. MVOTMA has drawn a national water policy to control water resources. The National Water Board is responsible for the assessment, management and control of water resources. Individuals or legal entities that require the use of surface and groundwater throughout the national territory for any purpose other than domestic cattle must obtain an evaluation of the National Water Board. To facilitate national administration, Uruguay has 8 Regional Offices. Regional heads act as local representatives of the water authority. Monitoring of groundwater is mainly connected to specific projects. This means that groundwater is not monitored on a continuously basis, but only during the time of the project.

<u>*Challenges*</u>

The increased development in groundwater use, mostly in the areas of Tacuarembó aquifer, Ragon aquifer and Mercedes aquifer, resulted in an increasing need for skilled professionals in the field of resource evaluation, well technology, and water use and protection (Zekster and Everett, 2004).

3. Conclusions and workshop outcomes

Argentina, Brazil and Colombia recently established national groundwater monitoring networks to improve data availability on a national level. The workshop has supported the development of the GGMN People Network in Latin America. The participants expressed their interest and support for a global groundwater monitoring network. Furthermore, it was stated that a global network is essential to raise awareness on the importance of groundwater monitoring and that it will be valuable to enhance international water cooperation. Recommendations from the participants to the GGMN Programme were to improve GGMN's web-application by providing additional functionalities. By easing the process to upload and analyse groundwater data, there will also be more commitment from national focal points to the programme.

The GGMN programme advocates establishment of national groundwater networks in all countries in Latin America in order to advance groundwater monitoring and acquire the required observations of this vital resource. This workshop has provided an entrance point for a shared vision on groundwater monitoring. The participants will continue in their role as GGMN national focal points, who manage the collection and entry of groundwater monitoring data in the web-portal. This engagement is one of the key developments for a successful GGMN programme. A continuous and collaborative effort will contribute to the assessment and management of the groundwater resources.

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