

## REGULATED MONITORING OPERATING SYSTEM OF GROUNDWATER EXTRA WITHDRAWALS IN MEXICO

### SURVEILLANCE REGLEE DU SYSTEME D'EXPLOITATION DE PRELEVEMENTS SUPPLEMENTAIRES D'EAU SOUTERRAINE AU MEXIQUE

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#### ABSTRACT

The importance of groundwater, in Mexico, is reflected in the coverage to supply water to more than 75 million people in urban and rural areas and provide 37% of the volume used for agriculture in irrigated areas of the country; therefore, water is considered a national security and strategic resource. The balance of groundwater estimates a recharge of 75,000 million of cubic meters (Mm<sup>3</sup>), extracting about 28,349 Mm<sup>3</sup> from the 653 aquifers of the country. In the center and north of Mexico, with medium to low rainfall, the imbalance is critical due to the strong over exploitation, in which there is a negative imbalance annually that is estimated in the order of 5,400 Mm<sup>3</sup>. The problem of overexploitation of aquifers is becoming more serious, since according to the National Water Commission (Comisión Nacional del Agua, CONAGUA) in Mexico, in 2007, there was a total of 104 overexploited aquifers; the most important indicates that over-exploitation occurs in aquifers with greater volume and greater strategic importance. The National Water Commission in Mexico has implemented an intensive program to install flow and volume meters in wells, the effort made is not enough to cover all wells; it is estimated that there is only a coverage not greater than 10% of all meters required. The main problem of Mexican aquifers is the low intensity of users to measure the water extracted from the well, due to lack of motivation of care and importance coupled with weak institutional monitoring for not having enough people to perform such control. Moreover, it is necessary to raise the problem of handling the large amount of information that must be analyzed, to supervise, control and monitor water withdrawals, this requires to use this information as a complement in measurement made by users, indirect measurement through the Energy Indices that relate kWt/hours consumed to the volume extracted for each pumping system. The transfer of this technology and its legal support is driven by the Mexican Institute of Water Technology (Instituto

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Mexicano de Tecnología del Agua, IMTA) and the National Water Commission of Mexico implementing a new system of supervision, monitoring and regulation of water withdrawals on aquifers, using the platform called Withdrawals Control and Regulation (SOCRATEX), which can lead indirectly cumulative volumetric measurement of water withdrawals from each well and each set of wells from each aquifer. SOCRATEX is a support tool in the supervision and monitoring of groundwater withdrawals, by geo-referring the position of each well and allowing to extract only the volume allowed of water, based on the sustainable volume available in each aquifer. The importance of this system focuses primarily on transparency and to inform water users and the institutions responsible for their care, that water withdrawals must necessarily be subjected to the measurement, applying a comprehensive and sustainable management policy for this water resource. Secondly, SOCRATEX allows and supports its use, based on complementing management and governance among water users and the institutions responsible for their care, providing solutions in order to stop the overexploitation of aquifers and promote the recovery, optimizing economically the use and management of water, without losing the sustainability of aquifers.

**Keywords:** Groundwater, over-exploitation, aquifers, monitoring, Mexico.

## RESUME

Au Mexique, l'importance des eaux souterraines se reflète dans la fourniture de l'eau à plus de 75 millions de personnes dans les zones urbaines et rurales et la réponse à 37% de la demande d'irrigation. Par conséquent, l'eau est considérée comme une ressource stratégique et de sécurité nationale. Le bilan d'eau souterraine estime une réalimentation de 75 000 millions de mètres cubes (Mm<sup>3</sup>) et un prélèvement de 28349 Mm<sup>3</sup> des 653 aquifères du pays. Au centre et au nord du Mexique, ayant une précipitation de moyenne à faible, le déséquilibre est critique en raison de la forte surexploitation, en raison duquel chaque année on constate un déséquilibre négatif de l'ordre de 5400 Mm<sup>3</sup>. Le problème de la surexploitation des aquifères est de plus en plus grave, puisque, selon la Commission nationale de l'eau (Comisión Nacional del Agua, CONAGUA) du Mexique, en 2007, en tout 104 aquifères ont été surexploités; la plus forte surexploitation se produisant dans les aquifères ayant plus grand volume et plus grande importance stratégique. La Commission nationale de l'eau au Mexique a mis en place un programme intensif pour installer le compteur pour calculer le débit et le volume dans les puits. Cependant, l'effort n'est pas suffisant pour couvrir tous les puits. Il est estimé qu'il y existe seulement une couverture supérieure de 10% de tous les compteurs nécessaires. Le problème principal des aquifères du Mexique est le manque d'intérêt chez les utilisateurs pour calculer l'eau prélevée du puits. Il y a un manque de motivation dans les soins des aquifères accompagné d'une faible surveillance institutionnelle et d'un manque de personnel qualifié pour effectuer cette surveillance. En outre, il est nécessaire de résoudre le problème de la manutention de la grande quantité d'informations qui doit être analysée. Il existe des méthodes de mesure indirecte à travers les indices de

l'énergie qui se rapportent KWT / heures consommés au volume prélevé pour chaque système de pompage.

Le transfert de cette technologie et son soutien juridique est entraîné par l'Institut mexicain de la technologie de l'eau (Instituto Mexicano de Tecnología del Agua, IMTA) et la Commission nationale de l'eau du Mexique. Ils sont en train de mettre en œuvre un nouveau système de contrôle, de surveillance et de règlement des prélèvements d'eau des aquifères, en utilisant la plate-forme appelée Surveillance et règlement de prélèvement (Withdrawals Control and Regulation) (SOCRATEX). Cela peut conduire à l'estimation indirecte des prélèvements d'eau de chaque puits et chaque ensemble de puits de chaque aquifère. L'importance de ce système se concentre principalement sur la transparence et l'information aux utilisateurs de l'eau et institutions chargées de leurs soins, que les prélèvements d'eau doivent nécessairement être soumis au calcul. Deuxièmement, SOCRATEX permet et soutient son utilisation, sur la base de compléter la gestion et la gouvernance entre les usagers de l'eau et les institutions chargées de leurs soins tout en fournissant les solutions pour mettre fin à la surexploitation des aquifères et promouvoir la récupération, l'optimisation économique de l'utilisation et de la gestion de l'eau, sans perdre la durabilité des aquifères.

**Mots clés:** L'eau souterraine, la surexploitation, les aquifères, la surveillance, le Mexique.

## 1. Introduction

The importance of groundwater resources is reflected in the coverage to supply water to more than 75 million people in urban and rural areas and provide 37% of the volume used in agriculture irrigated areas of the country; therefore, water is considered as a national security and strategic resource. The problem of overexploitation of aquifers is becoming more serious, since according to CONAGUA, in 1975, a total of 32 aquifers were overexploited, in 1981 the number rose to 36, in 1985 the number was 80, in 2000 it was 96, in 2007 the number of aquifers was 104, and for 2012 the likely number of overexploited aquifers may exceed 120 out of the 620 aquifers recorded in the country. Although the National Water Commission of Mexico has implemented an intensive program to install flow and volume meters in wells, the effort made is not enough to cover all wells, since according to estimations not more than 10% of all meters required have been placed. Moreover, there is a strong wave of boreholes along and across the country, because despite the fact that exist the National Water Law, its Regulations and the Water Rights Act, these are hardly applicable, and companies continue drilling wells. Today these companies are known as "*Hydro-subterranean Termites*", which increase the problem of overexploitation. It is also known the fact of having more than one concession agreement of water rights in many of the aquifers, which has led to a negative imbalance, because water withdrawals exceeds the recharge generated by normal rainfall in the area that feeds these aquifers.

Data from the public registry of water rights in Mexico (2008) shows 344,700 concession agreements recorded with a concessioned volume of 233,000 million cubic meters, with an increase of 9% in the last decade. In December 2011, the Statistical Compendium of Water Management in Mexico (Compendio Estadístico de Administración del Agua CEEA, 2012), indicates that there is 457,895 Concession agreements, which cover a volume of 243,955 million Mm<sup>3</sup>, i.e., an increase of 32.8% in only three years, indicating the rapid pace of granting or eliminating concessions. However, the increase in concessioned volumes is only 4.7 % in the same period. To this we must add the large number of wells drilled without approval of the National Water Commission in Mexico, made without any control by the *Hydro-subterranean Termites*; these wells are outside the law and are considered illegal.

## 2. The problem

The large number of wells in each aquifer, and the records of water withdrawals through flow measurement and cumulative volume according to time, for crop irrigation or to supply water to urban areas and industry, and the comparison with respect to the concessioned annual volume, periods of validity, volumes used, etc.. There is not enough technical personnel of the National Water Commission in Mexico to take updated and constant information to take actions and decisions in the supervision and control of groundwater withdrawals.

The main problem in aquifers of the country is, on the one hand, low or no intention of users to measure the water extracted from the well, due to lack of motivation for water care and in many cases the limited supervision by the National Water Commission of Mexico for not having enough persons to perform such control. On the other hand, it is necessary to consider the problem of handling the large amount of information that has to be structured and analyzed, to supervise, control and monitor withdrawals, because even though users provide data from their meters on volumes extracted, this takes too long and there will be no time to take action in the short term to know and control the magnitude of volume extracted.

## 3. The Solutions

Present technology can solve problems of handling large amounts of data, and to structure software packages appropriate to the needs to control variables, depending on the requirements herein. Moreover, the application of laws and regulations that permit indirect measurement of flow and cumulative volume in wells is required to implement regulatory measures to manage and control groundwater withdrawals in aquifers. It is necessary to have information of the location of wells, flow control measurement and its relation to power consumption, in order to obtain the Energy Index that represents the volume extracted expressed as kWh/m<sup>3</sup>. Under this scheme, the Federal Electricity Commission (Comisión Federal de Electricidad, CFE) of Mexico provides monthly electricity consumption records of each pumping system,

which means CFE provides the information of consumption from the Personal Customer Record, through agreements between CONAGUA-CFE granting electricity, solely and exclusively, the amount of kilowatts needed to extract the volume allowed, volume that is measured indirectly through its power consumption to prevent that users overexploit a strategic good such as the water from aquifers.

It is important to organize users in Technical Groundwater Committees (Comites Tecnicos de Aguas Subterranas, COTAS), who are the most interested in the implementation of this project, and who will use this program the most, monitor and control withdrawals in their respective aquifer. In support of the above, CONAGUA presented at the *6th World Water Forum in Marsella 2012*, what was called "WATER CHALLENGE IN MEXICO" indicating that in the case of water management, "volumes extracted directly and indirectly will be measured using modern measuring systems and remote data transmission systems on volumes extracted to continuously, truthfully and monitor and evaluate in real time the behavior of watersheds and aquifers and lead acts of authority and penalties on irregular users for extracting volumes higher to those permitted or due to lack of concession agreement..."

To achieve the above challenge, the Mexican Institute of Water Technology and the National Water Commission have implemented a new system of supervision, monitoring and regulation of water withdrawals on aquifers using a program called Withdrawals Control and Regulation Operating System (Sistema Operacional de Control Y Regulación de Extracciones, SOCRATEX), that has been tested in the aquifer of the Guadalupe stream in Baja California, which allows achieving the objectives in information management as described as follows:

Consult, the Concession agreement of the owner and user of the well, number, volume concessioned (VC), cumulative volume (CV), period of validity, completion date, aquifer, municipality and state by users.

The system allows to store information of each well and get indirectly the monthly or bimonthly cumulative volume extracted, through the consumed energy, called Energy Index, showing in graphs the cumulative volumes per well, user, group of wells, area, section, etc. See Figure 1.

Describe graphically the progress in water withdrawals per well, facilitating consultation from a laptop or pc and sending this information to users who request it, and to Technical Groundwater Committees or group of users who require this information to monitor and control withdrawals in aquifers. Allows monthly monitoring of all wells in each aquifer, through its geo-referred location, well type, user name, area and section that corresponds to the plot that gives irrigation service in the aquifer area. See Figures 2, 3 and 4.

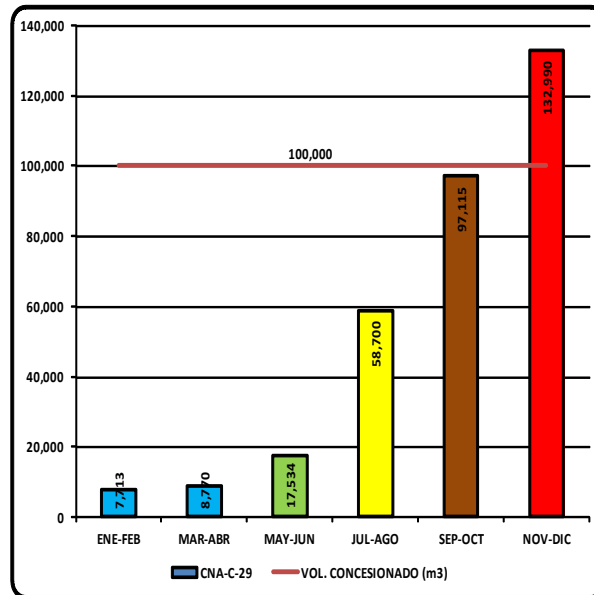
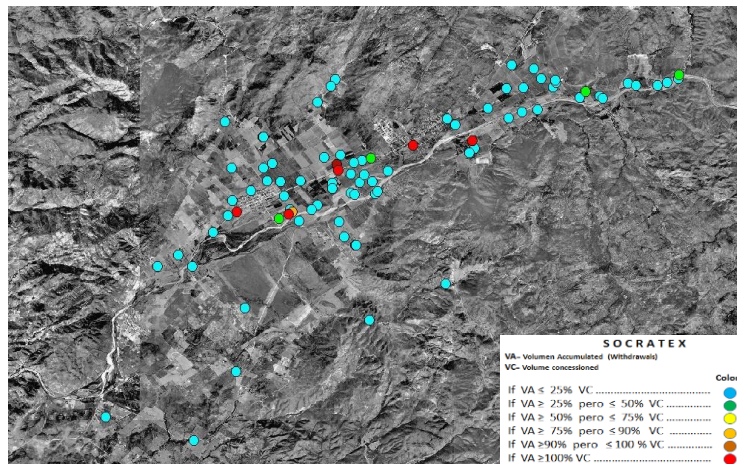


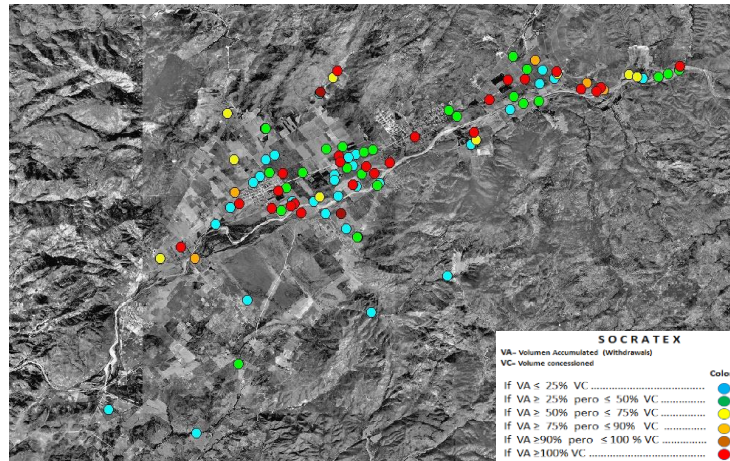
Figure 1. Monthly volumetric withdrawals of a pumping system

**Valle de Guadalupe Aquifer**  
 Volume accumulated from Janvier to February



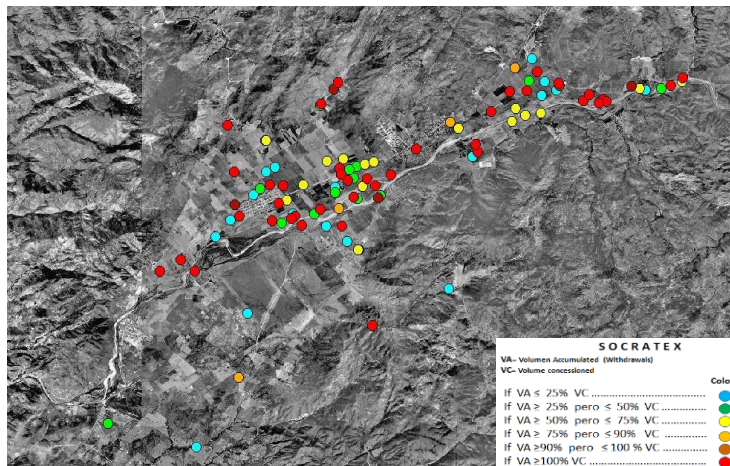
**Figure 2.** Well withdrawals at the beginning of the year (January)

**Valle de Guadalupe Aquifer**  
**Volume accumulated from July to August**



**Figure 3.** Accumulated volume of water withdrawals (January to August)

**Valle de Guadalupe Aquifer**  
**Volume accumulated from November to December**



**Figure 4.** Accumulated volume per well at the end of the year (January-December)

#### **4. Conclusion**

The results showed by the SOCRATEX system used in the basin of the Guadalupe stream in Baja California Mexico, provide a specific methodology of the appropriate process to be used in the monitoring and control of water withdrawals in aquifers.

The SOCRATEX system allows handling large amounts of information, something almost impossible by traditional methods of supervision for meter readings already installed, because the system allows to have practically in real time indirect information of withdrawals per well, also supporting the program already started by the federal government of installing meters in wells, which should continue and accelerate the installation of meters in wells, integrating over time both measurement systems in one scheme of supervision and control of water withdrawals depending on the time.

The system is designed to shape and integrate a national platform of aquifers and geo-referred location, allowing to consult separately the database generated for each irrigation area, user, concession agreement, well, withdrawal and monthly cumulative volume according to time.