Proposal of a Information System Guided To Administration of Hydric Supply Systems

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Abstract: This work offers a practical vision about the application of automation technologies in systems of sanitation and has as objective to expose solutions guided to the management of hydric supply systems. These automated systems are characterized mainly by the necessity of acquisition and information sending of one or more operational control centers to remote stations located in the most several locations as: densely urbanized centers, non urban areas, restricted access places, coastal areas, port areas, underground places and high topography places. This diversity of characteristics demands a group of automation, supervision and administration of information solutions to the control and the administration of the supply system in an integrated and efficient way.

Key words: Management systems, enterprise resource planning, hydric supply systems

1 Introduction

Water and the air are important natural resources because they are vital for humanity. For years, a scenario was constituted in which the hydric resources have been used with no concern, as they were perceived as renewable and, therefore, understood as endless.

With the demographic growth, the urban clusters became more and more dense and had activities that demanded, every day, higher amount of water. From the growing awareness about the depletable nature of hydric resources, it is possible to perceive the need of efficient and effective management of these goods, which, if it is once was evident, it is now imperative.

In this context, the automation of the procedures for collection and management of data about the use of hydric resources any materially contribute to its better used, as it permits its follow-up and control. Besides, the rationalization of these resources also permits the management of their distribution and a more effective control of losses.

Silveira (1998, p.23) describes the automation as being a concept and a group of techniques through which are built active systems capable to act with a great efficiency for the use of received information from the midia which they act. Pereira (1995 apud SOUZA, 2006, p.28) conceives the automation as being "the science that studies and applies methodologies, tools and equipments, aiming to define when and how to convert the control of a manual process for automatic ".

Unhappily, as affirmed by Trojan, Marçal, Resende and Stlader (2005, p.2), in a approach to the conditions of use of the hydric resources , the automation in sanitation is still punctual. That is reflex of the lack of resources of the companies of sanitation, for the most part state [...]".

Associated the that lack of resources, other fetter faced for the adoption of the automation in that segment happens on the geographical aspect, that imposes serious limits to the use of communication means, as resources of data obtaining about the operation of the system of hydric provisioning. The supervising and remote control units that compose the system are usually installed at places that don't possess telecommunication infrastructure or electric power, taking to the use of alternative structures as posts and improvised towers.

The influence of the installment of a good service of basic sanitation has direct impact in the health and environment area area, and, of course, on thedevelopment and economical growth of a

country.

2 Methodology

The development of this work has been guided to the description of automated systems oriented to the management of information about hydric supply systems.

For that purpose, this work constitutes the result of the case study of an emblematic situation within the scope of the hydric supply systems: the case of Companhia de Saneamento Básico do Estado de São Paulo (SABESP). As SABESP constitutes a large system that involves about 366 municipalities and countless configurations of hydric supply, it was necessary to establish a limit to a context that offered sampling characteristics that were typical of different layouts of the elements that comprise such a system. This delimitation permitted to indicate as focus of the study the Business Unit of Baixada Santista, in the coast of the State of São Paulo, as it is a unit that gathers conditions for identification and study of different analysis referentials that may guide de decision making about automated hydric supply systems.

SABESP is a mixed economy company, with open capital, that has as main shareholder the Government of the State of São Paulo. It is a utility company that provides sanitation services, in charge of the planning, construction and operation of water and sewage systems (both domestic and industrial) in 366 municipalities of the State of São Paulo.
SABESP currently has 1,357 production units, divided into 198 Water Treatment Stations, 1,078 Deep Wells and 81 other systems.

These units are responsible for the generation of 100 thousand liter of drinkable water per second (SABESP, 2008).

These production units are spread among the municipalities served by the company that are organized in Business Units, managed by superintendences. Besides the metropolitan region of the city of São Paulo, that has seven Business Units, there are still the regional systems, distributed in ten units.

The case study reported in this work refers to data collected in the Business Unit of Baixada Santista, managed by the Superintendence of the Coast, that covers 9 municipalities: Cubatão, Santos, São Vicente, Praia Grande, Mongaguá, Itanhaém, Peruíbe, Guarujá and Bertioga. These systems have a total production capacity of 8,500 thousand liters per second, enough to supply the fixed and floating population of Baixada Santista and South Coast, currently calculated in about 3 million people. Outside the vacation season, the production/consumption falls to 5,900 thousand liters per second, serving about 1,500,000 people.

The springs that comprise the Baixada Santista supply system have as main characteristic the capture by water stream, that is, the capture is made directly in the supply spring, with no accumulation dams in place. For better management of these springs, the superintendence of the coast divided its supply systems into regional managements, now called: Regional North Management, that manages the municipalities of Guarujá, including the district of Vicente de Carvalho and Bertioga; Regional Center Management, that covers the municipalities of Santos, São Vicente and Cubatão; and Regional South Management, for the municipalities of Praia Grande, Mongaguá, Itanhaém and Peruíbe.

These managements have supervised operating autonomy, that is, each management has a regional Operating Control Center (CCO) in charge of the local operating control of the cities that comprise it. This CCO establishes the operating parameters of pressure reducing valves, reservoirs and flow of secondary water mains, so as to manage the hydric resources of their area, from the main conduction lines that are the responsibility of the main CCO, located at the Regional Center Management, in the city of Santos.

For the description of the hydric supply information management system, we opted for the organization of the different modules that comprise the system in analysis referentials.

The establishment of analysis referentials contributes to higher productivity and lower effort in decision making as long as it offers criteria in view of which it is possible to evaluate the objective conditions of each component of the system to be configured based on that to make the most proper choices for each condition.

The performance of this study is based on the information collected for more than five years of

experience at SABESP Unit of Baixada Santista in the follow-up of the implementation of solutions focused on the management of information about hydric supply. This information has been matched with theoretical referentials resulting from studies about Corporate Management Integrated Systems (ERPs) and has been extended and deepen through an investigative study about the peculiar needs demanded by the companies providing sanitation systems.

We further counted on information obtained from interviews with specialists from several areas of SABESP, such technicians and engineers of the sector of maintenance and operation of the hydric supply system, technicians from the information technology sector, engineers from the pitometry (macrometering) sector and technicians from the billing administrative sector and the department of analysis and control of hydric losses.

3 Analysis Referentials for the Definition of a Hydric Supply Information Management System

In the 90s, advances were perceived in the areas of telecommunication and information technology. In this period, there was the appearance of the World Wide Web or Internet; from this moment on, it was possible for the companies, regardless of the place where their physical facilities were, to exchange information in an agile manner.

Cerri (2004, p.27) affirms that the "problem of lack of integration of internal information and the departmental software systems was virtually extinguished with the appearance of data communication networks and the ERPs". Medeiros e Ferreira (2003, p.141) expose that the "great gain in ERP is in the integration among its modules. Differently from conventional systems, in which the development technicians must concern about the integration, ERPs take responsibility for that naturally."

Thus, ERP is characterized as a set of integrated information systems that uses a centralized database and that mostly meets the needs of democratization of operating information from a company, making this information available to several sectors that comprise it.

Based on the diversity of the companies that are potential users of ERP systems, one could expect that such systems would offer flexibility to meet the diversified needs. It is known, however, that no matter how flexible such systems are, the option for the adoption of an ERP pack traded by companies that supply that solution implies efforts of adaptation, by the company that made the acquisition, to the pack acquired.

3.1 Development of Information Systems

The Information Systems[1] are defined as [...] the systems that permit the collection, storage, processing, recovery and the dissemination of information" (BARRELLA; BRUNSTEIN, 200, p.3).

Cerri (2004, p.27) explains that "[...] there is no best way or one single way of designing an Information System (IS). Aspects such as applicability, flexibility, size, complexity, and technology are not common to all companies. Moreover, the companies that are going to develop an IS differ in terms of capacity, expertise, management and technological infrastructure. Thus, it is essential that the development be preceded by an understanding of the business for which it will be used[...]".

Based on such need for a deep knowledge about the internal subsystems of the company, and the processes to be integrated, many companies hold the expertise in the development of information integration systems, opt for developing their own, instead of opting for over-the-counter solutions that would end up by causing problems such as: consequent dependence of the supplier of the integration system, lack of knowledge about the ERP pack and need of possible changes in internal processes for adaptation to the acquired system.

Such problems may feed the resistance to change in the operating positioning of the sectors that will be involved in the ERP system. According to SACCOL (2003, p. 329), "the use of ERP by itself does not make a company truly integrated. Similarly, for it to become oriented to processes,

1. Information System is understood as every system that uses or not information technology resources for the treatment, generation and/or handling of information. However, in this work, when discussing IS, the term refers to those that use Information Technology.

a cultural and, mainly, behavioral change will be required. Some companies do not have a history, culture and climate that permit the adoption of such an attitude, while in other companies, ERP will simply contribute to make operational a positioning that is already adopted."

By pondering the aspects about the purchase of an over-the-counter ERP solution and the development of a custom one, the Superintendence of the Coast of SABESP opted for the latter.

The development of an Integrated System for Sharing and Management of Information about Hydric Supply that has its beginning in SABESP Superintendence of the Coast, in the beginning of 2005, contributed to overcome the slowness of the system caused for the fact that, up to then, the process information collected by CCO were shared through "physical" spreadsheets filled based on information obtained from the supervision system, the data collection through radio-communication and through the contact by telephone with the operators of remote stations which were not integrated to the automation system.

Once the information collected by the process used are stored in a database of the supervision system, the development of a sharing system must basically involve the continuous export of the information to a database shared by the several sectors that use them.

The preexistence of a corporate intranet has also come in line with the dissemination of the operating information to the several managements that comprise the SABESP Superintendence of the Coast.

3.2 The Integrated System for Sharing and Management of Hydric Supply Information

This system incorporates aspects demanded by several specialized sectors of the Superintendence. They include:

- **Segmentation of the attributions of the main CCO:** the extension of the supply system managed by SABESP Superintendence of the Coast explains the need of the division of the operating attitudes among the regional managements that comprise it. The nonexistence of an integrated operating information system, however, prevents such division, since, once the hydric basic systems is integrated (the several cities that comprise the system share the same springs), for the operating attitudes to be distributed, it is necessary that the regional CCOs also have information on the systems associated to them.

- **Integration of production and consumption in one single system:** the nonexistence of a continuous link of information between the trade micro-measurement and billing system and the macro-measurement (production) system determines that the data request to the main CCO and to the hydrometry department be timely and that the supply is made in "physical" spreadsheets. The implementation of a system for management and sharing of the information permits that the requested data may be made available in a continuous and instantaneous manner. Thus, the reflexes that the operating attitudes caused in other instances of the company may be analyzed in a more effective manner.

- **Integration of the maintenance activities in one single system:** considering the close link of the maintenance to the operation of the hydric supply system, the delay in identifying the reason of possible falls in the performance of certain sectors of the hydric supply system, as well as the impossibility of prioritizing the maintenance of a system in relation to others, demands that, in order to act in a faster and more effective manner, the maintenance sector be able both to obtain information on the needs of intervention integrated to the operating data of the system and identifying the impacts caused by the loss of systems.

- **Development of a system for the management of hydric losses:** the lack of organized and systematic information about the losses of hydric resources in the system prevents the realization of an articulated work by the sanitation

controllers of the several CCOs and the prioritization of the system balance. The structuring of a system with the function of guiding the operating attitudes based on information made available by it permits that the results obtained can be transformed into operating subsidies such as optimal ranges of operation of reservoirs, flows and pressure points in the major water mains, and thus overcoming the problem of lack of articulation of the several sectors involved.

- **Implementation of a system for comparison between the data obtained from the process of chemical analysis and the analytical process instrumentation:** the impossibility of exercising the continuous analysis of chemical variables that determine the quality of water in a higher number of points of the process is supplied by periodical collections of water in several points of the sanitation system. The lack of integration among the information obtained from the continuous analysis of the chemical variables made by the process instrumentation, and the information from the laboratory analysis ends up by compromising the perception of the possible need of assessment of any process analyzer or the contamination of the water in intermediate points of the system. Subsidizing the sector of maintenance of the process instrumentation systems, upon the implementation of a system for comparison with the data obtained by the laboratory process of chemical analysis, represents the possibility of overcoming such problem and, for that purpose, it is enough that the data from the field instrumentation be made available in the management system in the side of the data resulting from the chemical analysis department.

The clarity in the exposure of the needs of each sector that is a user of the Integrated System for Sharing and Management of Hydric Supply Information and the direct involvement of these sectors in the development of this system permits the construction of an integrated easily adaptable architecture in relation to its operation, a fact that may cooperate for the cultural change from a departmental view to a process view.

The result from the development of such architecture involves a modular system, in which each sector of the company is responsible for the input of data related to its area of competence. This data is available to other sectors which, in turn, also make available their data.

Based on the case of SABESP Superintendence of the Coast, it is possible to observe that the access to the several modules of the Integrated System for Sharing and Management of Hydric Supply Information is made through the corporate intranet of the company. The access to such intranet, restricted only to locations internal to the company, together with protection measures as firewalls and backup systems implemented in the data servers, assure the security of the information.

Each sector that is a user of the information has access only to the modules of its competence, the data input of which is under its responsibility.<0} When the data are of collective interest, the access is also permitted even to the modules whose responsibility falls on other sectors, provided that passwords are used, that enable only the view of the information, and in specific situations, also its editing.

3.3 Operating control module

This module is directly integrated to the database of the main CCO supervision system of the company. The process information of the hydric supply system is obtained from this database and stored in the SQL server of the Integrated System for Sharing and Management of Hydric Supply Information.

The operating control module has also its database fed with information input by the operators of the regional CCOs. This information remain available to all regional CCOs, besides the main CCO, and supports the operating decisions of each CCO. Based on the increase or reduction in demand for supply in each region, it is possible, through a consultation to the information of each subsystem, to evaluate what implies the deviation of hydric resources from one region to another, an attitude taken by the manager of the macro-system, the main CCO. It is also possible that the main CCO, based on

information made available by regional CCOs, re-guides the operation of each subsystem so that they are not affected by interventions in the main conduction lines that feed them.

The information sharing spreadsheet of the operating control module of the Integrated System for Sharing and Management of Hydric Supply Information, that illustrates how the information are made available, can be seen in Fig. 01.

3.4 Maintenance Request Module

This module is integrated to the operating control module and has its database supplied by data input both from regional and main CCOs and from the central maintenance department of SABESP Superintendence of the Coast.

Upon the occurrence of problems with the remote stations that may compromise the operation of the hydric supply system, the CCO in charge of the operation of the sector where the problem occurs, after taking the operating countermeasures to circumvent the problem, inserts in the maintenance request module the occurrence. The integration of this information with the operating control module is in the fact that the maintenance request information remains linked to the operating data spreadsheet of the sector in which the problem occurred. With these two pieces of linked information, the detection of a significant fall in the performance of the hydric supply system permits the making of a decision that guides the maintenance team in the prioritization of the restoration of a system in relation to another, that has not been causing an impact of the same amplitude to the supply system.

After the maintenance request is requested, the maintenance department schedules the intervention, placing the date on which it will occur on the side of the request. Thus, the CCOs have a dimension of the time in which they need to act as a matter of containment, thus optimizing the use of hydric resources for the situation presented.

Once the maintenance of the defective system is performed, the maintenance department signals the "write-off" of the occurrence in the system, guiding the CCO in charge to start to operate in normal conditions.

3.5 Module for analysis and solution of loss problems

Although the study of hydric loss problems is made on a regular basis, the results of this study not always have a significant operating reflex.

Based on the implementation of the module for analysis and solution of loss problems in the ERP system of the company, the results from these studies, after being transformed in operating parameters, may be disseminated to the several CCOs, guiding the measures to be taken by the operators.

This module consists in a spreadsheet that indicates the limits of operation of the main

FIX | Geral | Suporte | Peruíbe | Itanhaém | Mongaguá | Praia Grande | São Vicente | Cubatão | Santos | V. Carvalho | Guarujá | Bertioga | MASPP | Compl

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Fig. 01 – Spreadsheet of sharing information of the operational control module illustrating the disposition of the operational information obtained from the supervision system - Source: Integrated System for Sharing and Management of Hydric Supply Information of SABESP - Superintendence of the Coast, 2008

points of production, reserve and supply of the system, such as the levels, flows and maximum

and minimum pressures admitted in each point. As the hydric supply system is dynamic and seasonal, such limits vary rather frequently, influenced by the construction of new remote stations (collections, step-up or reservoirs) or even by the movement of the population to the coast cities in the weekends or in vacation periods.

The data that supply this spreadsheet, that may be seen in Fig. 02, is inserted in the studies of hydric losses of SABESP Superintendence of the Coast and remain available to all operating sectors of this superintendence, that use it as parameters for control of the system.

The module for analysis and solution of loss problems has also a component of quantification of the losses in the system and interconnection between the hydric volume produced and one effectively consumed. For that purpose, this component of the module receives data from the macro-measurement department of the company, in charge of the quantification of the hydric volume produced, and the department of micro-measurement, or hydrometry, in charge of the quantification of the hydric volume consumed. Based on such information, the ERP system does the data crossing, producing spreadsheets and charts for the total losses of the system or separated by sector. Such information supports the search for solutions in the control of losses of sectors in which these are high, or even the alert in case any sector comes to present a significant increase in its volume of losses, a fact that may be related to the breaking of water mains, or operating deviations.

3.6 Chemical analysis data module

The operating data on the quality of water is provided by continuous analysis systems, comprised by process analyzers that operate in the remote stations of the hydric supply system, providing information on the pH and turbidity of the water, as well as on the concentration of chlorine and fluorine, among other chemical

variables measured. These analyzers, in spite of their constant maintenance and assessment, may suffer indication deviations.

The department of chemical analyses of SABESP Superintendence of the Coast performs the collection of samples of water in several points of the system for laboratorial analysis and issue of reports for certification of the quality of the water collected and distributed.

In the Integrated System for Sharing and Management of Hydric Supply Information, the information made available by the process analyzers, together with that resulting from the laboratorial analysis, permit higher efficacy in the evidence of the following aspects:

- The need of assessment, maintenance or replacement of the process analyzer that present deviations in relation to the laboratorial analysis.

- The detection of contaminations caused in intermediate points of the supply system. Such fact is evidenced when the place of laboratorial collection, in points of the system through which the water passes after the analysis of the continuous process analyzers, presents deviations in relation to their readings. After the verification of these continuous analyzers and the finding that they are in perfect conditions, it is enough to delimit the space between them and the point in which the laboratorial deviation was found, for one to be able to perform a search for the cause of the problem.

The information that supply the chemical analysis

Definição de Limites de Controle

Implantação: 2/1/2008 Período: 1/1/2007 à 31/1/2007
Ponto: Nivel R1 (TXT1)

Gráfico	Limite Superior Controle	Limite B+	Limite A+	Limite Médio	Limite A-	Limite B-	Limite Inferior Controle	Meta Técnica	Auto correlação	Observação	Editar	Exc
DESVIO	0,79	0,00	0,00	0,55	0,00	0,00	0,30	0,00	0,000000	*	✔	✂
X-BARRA-S	3,56	3,44	3,33	3,22	3,10	2,99	2,88	0,00	0,000000	*	✔	

Fig. 02 – Spreadsheet of the Module for analysis and solution of loss problems illustrating the layout of information on the limits of operation of the main points of the system - Source: Integrated System for Sharing and Management of Hydric Supply Information of SABESP - Superintendence of the Coast, 2008

data module of the ERP comes from the database of the supervision system, that does the collection of data of the continuous process analyzers, and the department of chemical analysis of SABESP Superintendence of the Coast, which inserts in the ERP the results from the analyses, according to the date on which they were made. The management system allocates such data in the same spreadsheet that includes the information from the process analyzers, permitting the comparison. Fig. 03 below illustrates the layout of the data.

4 Conclusion

The evolution of the technologies is more and more fast, and the appearance of new techniques and equipments provide more options for the integration of systems of great load and for the one of reduced proportion, as the presents in small cities.

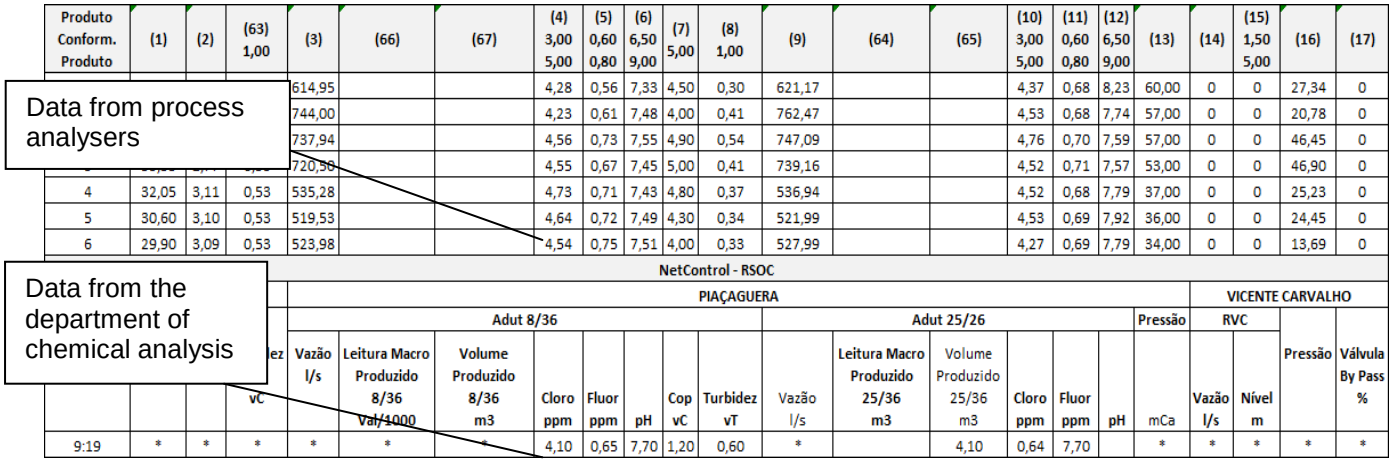
Technologies that are already reality in the systems of telecommunications as WiMAX and 3G nets of cellular telephony still have its applicability little explored in the section of automation of distributed systems and they can constitute the reason of new researches with relationship to its use in the automation of systems of hydric supply.

The importance of the popularization of these solutions and technological knowledge is given, also, in function of the constant and growing evolution and of the natural applicability of these techniques in the diversity of configurations, topologies and existent architectures in the nets of water supply. It is expected, therefore, that this work supplies indicators of the need of plunge into researches in the section of sanitation and that comes to contribute for the diffusion of available technological knowledge in this area.

The solutions presented in this research have been implemented in SABESP Superintendence of the Coast for over eight years. This time permitted the techniques and methods presented to reach the degree of maturity required in order to establish an efficient model for dissemination of information, not only as regards the technological aspects, but also its management and expansion.

The segmentation of the architecture of supervision of the company opened possibilities to the inevitable need of expansion of the automation system, making possible a better control of the whole system of hydric suplly, through the diffusion of operational data provided by the introduction of a information administration system that came to facilitate the access of regional CCOs to the informations on the hydric suplly system associated to its areas of performance.

Such information dissemination system also permitted the improvement of several aspects



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				737,94			4,56	0,73	7,55	4,90	0,54	747,09			4,76	0,70	7,59	57,00	0	0	46,45	0
				720,96			4,55	0,67	7,45	5,00	0,41	739,16			4,52	0,71	7,57	53,00	0	0	46,90	0
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5	30,60	3,10	0,53	519,53			4,64	0,72	7,49	4,30	0,34	521,99			4,53	0,69	7,92	36,00	0	0	24,45	0
6	29,90	3,09	0,53	523,98			4,54	0,75	7,51	4,00	0,33	527,99			4,27	0,69	7,79	34,00	0	0	13,69	0
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9:19	*	*	*	*	*	*	4,10	0,65	7,70	1,20	0,60	*		4,10	0,64	7,70		*	*	*	*	*

Figure 03 – *Spreadsheet of the chemical analysis data module, illustrating the layout of the information obtained from the data of the process analyzers, in comparison to the data obained through laboratory analsysis - Source: Integrated System for Sharing and Management of Hydric Supply Information of SABESP – Superintendence of the Coast, 2008*

related to the hydric supply system, such as efficacy in communication of the needs of maintenance of components of the system, integration among the production and consumption sectors, and improvement in the control of hydric losses, reducing their indexes according to information from the department of hydric loss studies of SABESP Superintendence of the Coast from a level near 40% to level near 32%. This index has been decreasing every year and it is estimated that, with the expansion in the implementation of the resources of automation and management of hydric supply systems, it reaches amounts near 24%.

However, the reality through which the basic sanitation system passes in many parts of Brazil does not reflect yet such improvement indexes. The difficulties are many, such as: low index of coverage, poor quality of the services, political interference problems, low investments by the government (by lack of financial availability), etc.

Thus, mechanisms must be sought to permit the development of research for the sector, so that the solutions developed and the techniques implemented may be disseminated and made available, constituting a set of tools that, if correctly used, imply better management of the distribution and control of losses of hydric resources.

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