Standardization of water loss indicators in water supply services: The experience of regulatory agencies in Brazil

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ABSTRACT: Regulators of water supply services have a major challenge to develop and implement a set of indicators to assess effectively water losses. You can find in the literature water loss indicators in different formats, making it difficult to assess the performance in combating losses between different water supply companies. In this context, this article aims to investigate and describe documents that establish the normative basis of water loss indicators for the regulation of water supply services. A questionnaire to 44 regulatory agencies (27 states, 2 inter-municipals and 15 municipals) was sent, requesting information about the internal standards for water loss indicators. Subsequently, the set of indicators identified was compared with loss indicators adopted in the National Sanitation Information System (SNIS), observing variations in terminology, unit and formula indicators. The results show that there is still not a consolidated set of standardized loss indicators in Brazil. The main divergence between the indicators is the delimitation of the volume control, which does not always consider the volume of water imported, exported or service. Moreover, few regulatory sanitation agencies have internal rules for the standardization of loss indicators. Therefore, the Brazilian Association of Regulatory Agencies (ABAR) is still in the development phase of a set of performance indicators that can be used in the regulation of a standardized way of water supply services.

Keywords *Water losses. Indicators. Water Supply.*

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1. INTRODUCTION

The new Brazilian regulatory system, created from the emergence of regulatory agencies for regulatory reform in the 1990s, is still in consolidation phase (Ramalho et al. 2009). In particular, regulators of water services still have a major challenge to develop and implement a set of indicators to assess effectively the quality of services provided (Abar 2006).

From an operational point of view, water losses are important indicators in assessing the operating efficiency of sanitation companies (Abes 2013), as a system with a high losses rate, may require frequent interruptions in supply, compromising the quality of services (Almandoz et al. 2005).

You can find in the literature several loss indicators in different formats (Miranda 2002). As a result, the International Water Association (IWA), in the late 90's, laid the normative basis of the performance indicators for water supply services. The standard of IWA indicators was successful, being adopted by several countries (Kanakoudis et al. 2011).

However, in Brazil there is still no consolidated national standard of loss indicators and therefore a lot of indicators are used by water supply sector, making it difficult benchmark performance in combating losses between different water supply companies (Miranda 2002).

There are initiatives of some sanitation regulatory agencies of standardizing performance indicators on the quality of water supply services. In 2006, the Brazilian Association of Regulatory Agencies (ABAR), which currently brings together 52 partner agencies, held through its Basic Sanitation Technical Chamber an international indicators workshop for regulation of public water and sewer. As a result it was proposed a set of indicators to be used by all regulatory agencies.

In this context, this article aims to investigate and describe documents that establish the normative basis of the loss indicators for the regulation of water supply services and benchmark the proposed methodology for the calculation of indicators, observing variations in terminology, unity and formula.

1.1 Concept of water losses

According to the International Water Association (IWA), water losses are the difference between the given volume of water delivered to the supply system and the authorized consumed water volume (Alegre et al. 2006). The concept of water losses, however, goes further.

In the environmental area, water losses are a waste of water resources. In the context of water bodies severely stressed in the face of growing demand with current consumption patterns, losses are a huge risk to the balance of local ecosystems (Kanakoudis et al. 2011).

In the economic aspect, considering that the cost of treated water is actually made up of several items such as spending on chemicals and energy for water treatment, water losses represent huge operating costs (Giustolisi et al. 2013).

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Thus, the high rate of water losses is a decrease in revenues from sanitation companies and thus decreases their ability to invest in improvements of services and expansion of existing water production systems (Abes 2013).

It follows in many cases the need to increase the water tariff rates, which will increase the social dimension of water losses, when one reflects on the fundamental right of access to drinking water.

In addition, high rates of water losses may indirectly pose risks to public health, as a network with physical failure, low pressure or intermittent supply may be exposed to the intrusion of pathogens and chemical contaminants that affect water quality (Almandoz et al. 2005).

1.2 Types of water losses

Water losses are divided into two types: apparent losses and real losses.

Real losses are physical losses of the water supply system, including leaks in the distribution network (both in system pipes as valves and pumps discharge) and extravasations in the reservoirs (Tabesh et al. 2009).

As for the apparent losses account for the changes in volume of water due to inaccuracies in the measurements or estimates of the volume of water produced and consumed, the unauthorized use, to errors in handling flow data and volume of water and the failures in the commercial register (Alegre et al. 2006). In summary, apparent losses (commercial losses) are produced by human error of measurement and management (Tabesh et al. 2009).

2. METHODS

The first step was to search with the regulatory agencies for water supply services documents that develop methodologies and procedures for the construction of loss indicators in water supply systems in Brazil.

A questionnaire was sent by email to 44 regulatory agencies (27 state, 2 intercity and 15 municipal) requesting information about the internal standards for indicators of water losses, if any.

After the identification and selection of information sources, the research data (types of loss indicators, units and etymologies used and the methods employed) were collected and registered.

In the second stage, the set of water loss indicators collected was compared with the loss indicators group adopted by the National Sanitation Information System (SNIS), which is currently the largest database of the Brazilian sanitation sector.

There are two types of loss indicators[1] currently used in the SNIS:

1 There is some confusion about the meaning of index and indicator, which are often mistakenly used interchangeably. Indicators come from a synthesis of primary data and indexes of aggregate indicators (Brazil 2011). In this article, it was chosen to use the original term of reference even to preserve the nomenclature adopted, for comparison with other references.

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- Revenue loss index (IN013) corresponds to the comparison between the volume of water available for distribution and the billed volume;
- Losses in distribution index (IN049, IN050, IN051) which makes the comparison between the volume distributed and the volume consumed[2].

For the second type, losses in distribution index, SNIS calculates the indicator in three different scales: in percentage (IN049), in liters per connection per day (IN051) and in liters per kilometer network per day (IN050).

Table 1 shows the SNIS loss indicators.

Table 1. SNIS water loss indicators.

Code	Indicator	Equation	Unit
IN013	Revenue loss index	$IN013 = \left(\frac{(AG006 + AG018 - AG024) - AG011}{AG006 + AG018 - AG024}\right) x100$	%
IN049	Losses in distribution index	$IN049 = \left(\frac{(AG006 + AG018 - AG024) - AG010}{AG006 + AG018 - AG024}\right) x100$	%
IN050	Gross linear loss index	$IN050 = \left(\frac{(AG006 + AG018 - AG024) - AG010}{AG005}\right) x \frac{10^3}{365}$	m^3/Km/day
IN051	Losses per connection index	$IN051 = \left(\frac{(AG006 + AG018 - AG024) - AG010}{AG002}\right) x \frac{10^6}{365}$	L/con./day

Parameters:

AG002 - Number of Active Connections (con.) *
AG005 - Water Network Extension (km) *
AG006 - Produced Volume (10^3 m^3 / year)
AG010 - Consumed Volume (10^3 m^3 / year) **
AG011 - Billed Volume (10^3 m^3 / year)
AG018 - Imported Treated Water Volume (10^3 m^3 / year)
AG024 - Service Water Volume (10^3 m^3 / year) ***

Observations:

* Average parameters, considering the value in the reference year and the value of the previous year.

** Volume of consumed water, including the micro-measured volume (AG008), the estimated volume of consumption for the connections devoid of water meter, plus the exported treated water volume (AG019) to another water supply company.

*** Service water volume includes the volume of water for operating activities, the volume of water recovered due to the detection of illegal connections and fraud and the volume of water for special activities that include the consumption of the operator of the water supply service, the volumes transported by tanker trucks, consumed by the fire department, among others.

Source: Brazil 2016.

2 It should be highlighted that the billed volume differs from the consumed volume, as the companies of water supply services adopt minimum or average consumption parameters, which can be higher than the volume actually consumed. Generally, the value of the invoiced amount is greater than or equal to the consumed volume (Brazil 2016).

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3. RESULTS AND DISCUSSION

Among the 44 surveyed agencies, only 13 answered the questionnaire. Of these 13 agencies, only 6 have resolutions that establish procedures for assessing losses of water supply services.

The sanitation regulatory agencies and their resolutions of loss indicator standards are presented in Table 2.

Table 2. Regulatory agencies and their resolutions with water loss indicators.

State	Agency	Resolution	State	Agency	Resolution
RS	AGERGS	051 / 2014	CE	ARCE	167 / 2013
ES	ARSI	034 / 2014	AL	ARSAL	137 / 2014
BA	AGERSA	001 / 2012	SC	AGR	007 / 2013

Source: Brazil 2016.

State regulatory agencies of Maranhão (ARSEMA); Minas Gerais (ARSAE); São Paulo (ARSESP); Santa Catarina (ARESC); Mato Grosso do Sul (AGEPAN); Distrito Federal (ADASA) and the municipal agency of Porto Ferreira (ARPF) in São Paulo answered the questionnaire stating that they did not have rules that established water loss indicators at the time. These agencies use as a reference for regulation of water supply services concession contracts with companies, according to Art. 10 of the Federal Law 11445/2007, national policy of basic sanitation.

The state regulatory agency of Espírito Santo (ARSI) adopts the SNIS indicators (IN013, IN049 and IN051) for the evaluation of water losses, excluding only the gross linear losses index (IN050).

The state regulatory agency of Alagoas (ARSAL) establishes indicators (IA09 and IA10) that refer to SNIS indicators (IN013 and IN051, respectively), although they differ in the calculation of the indicators.

Table 3 shows the ARSAL water loss indicators.

Table 3. The ARSAL water loss indicators.

Code	Indicator	Equation	Unit
IA09	Revenue Loss Index	$IA09 = \left(\frac{DA17 + DA18 - DA19}{DA17 + DA18 - DA20}\right) x100$	%
IA10	Losses per connection index	$IA10 = \left(\frac{DA17 + DA21 + DA18 - DA20}{DA04}\right) x \frac{10^3}{dias}$	L/con./day

Parameters:

DA17 - Produced water volume (m^3)
DA18 - Imported treated water volume (m^3)
DA19 - Billed water volume (m^3)
DA20 - Service water volume (m^3)
DA21 - Consumed water volume (m^3)
DA04 - Number of active connections (con.)

Source: ARSAL Resolution N°. 137/2014.

Thus, when comparing the formulas of the indicators IA09 and IA10 with the indicators of SNIS (013 and IN051, respectively), it is observed that:

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- In IA09, the service water volume (DA20) is only deducted from the available volume in the denominator of the formula, different from the SNIS indicator IN013 that deducts the service water volume (AG024) from the available volume in both the numerator as the denominator of the formula;
- In IA10, instead of making the difference between the available volume (+ DA17 DA18) and consumed volume (DA21), it is considered the sum of these amounts in the calculation of the indicator.

The same inconsistencies were identified in the formulas of the state regulatory agency of Ceará (ARCE)[3] indicators. The ARCE establishes the loss indicators (IAG11 and IAS16), which are associated with indicators of SNIS IN013 and IN051, respectively, coinciding only in nomenclature and unity of the indicators.

It should be highlighted that an email to the ARSAL and ARCE agencies was sent questioning the differences in the formulas of loss indicators of the agencies with the SNIS indicators. In response, the technical sectors of both agencies confirmed the error in the formulas of the indicators and the resolutions ARCE 167/2013 and ARSAL 137/2014 will be reviewed and an erratum will be issued including the same observations herein.

The state regulatory agency of Bahia (AGERSA) adopts the indicator "losses per connection" corresponding to IN051 indicator of SNIS. However, the definition of the indicator in the resolution CORESAB No. 001/2012 is rather vague, it does not define clearly whether the water volumes imported and service should be considered for the calculation of the indicator, as well as detailed for the IN051 indicator SNIS .

The state regulatory agency of Rio Grande do Sul (AGERGS) adopts “revenue loss index” which differs from the SNIS indicator IN013 because it does not consider in the indicator formula the imported treated water volume. The exported treated water volume is embedded in the variable "consumed volume ", as recommended in SNIS.

The regulatory agency of Tubarão (AGR), a municipal agency in the state of Santa Catarina, defined as a performance indicator for the assessment of losses: “losses in distribution index”, in percentage, which is the SNIS indicator IN049 of both the nomenclature adopted as the unit. However, it is observed that the definition of the indicator in the agency's standard is rather vague. For example, the AGR Resolution n°. 07/2013 does not define if imported, exported and service water volumes should be considered to calculate this indicator.

Among the group of regulatory indicators of sanitation services recommended by the Brazilian Association of Regulatory Agencies (ABAR), there is only one loss indicator: the "revenue loss index" IN013 the SNIS, coinciding in the nomenclature, formula and unity.

In 2008, the Sanitation Technical Chamber of ABAR included another indicator to assess the losses specifically in the production of treated water, the "losses in production index,"

[3] Another initiative worth to be mentioned by the ARCE, is the Regulatory Information System for Water & Wastewater - SIRAE. Implemented in 2004, a pioneer in Brazil, this system had as a result a set of sanitation indicators directed to the regulation of water supply and sanitation in the state of Ceará (Abar 2008). No one can investigate the loss of indicators of this system because in 2009 the SIRAE was discontinued, and even the information stored in the system during the period of its operation, is no longer available, as reported by the technical team of ARCE.

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given by the difference between the captured water volume and the treated water volume. In SNIS there is no indicator to specifically assess water losses in production.

Table 4 lists loss indicators adopted by sanitation regulatory agencies and summarizes the main differences compared to SNIS indicators.

Table 4. Sanitation regulatory agencies and their water loss indicators compared to SNIS indicators.

Agency	Indicator	SNIS	Comparative analysis
ARCE	IAG11	IN013	The service water volume is only deducted from the available volume in the denominator of the formula.
	IAS16	IN051	The production volume is added to the volume consumed.
ARSAL	IA09	IN013	The service water volume is only deducted from the available volume in the denominator of the formula. It does not define whether the exported treated water volume should be considered for the calculation of the indicator.
	IA10	IN051	The production volume is added to the volume consumed. It does not define whether the exported treated water volume should be considered for the calculation of the indicator.
AGERGS	Revenue loss index	IN013	The imported treated water volume is not used in the formula, although it coincides in the nomenclature and unit of the SNIS indicator IN013.
AGERSA	Losses per connection	IN051	Does not define if imported, exported and service water volumes should be considered for the calculation of the indicator.
AGR	Losses in distribution	IN049	

Source: Own authorship.

4. CONCLUSIONS AND RECOMMENDATIONS

The results of this research show that there is still not a consolidated set of standardized loss indicators in Brazil. The main divergence between the indicators is the delimitation of the volume control, which does not always consider the imported, exported or service water volume.

At the state level, few sanitation regulatory agencies have internal rules for the standardization of loss indicators. And ABAR, together with partner regulatory agencies, are still in the development phase of a set of performance indicators that can be used in the regulation of water supply services.

It should be emphasized that there is no perfect indicator, because the set of indicators should be analyzed and decided which best portray the situation of losses. And there should be standardization in the indicators calculation methodology across all process agents (water supply companies and regulatory agencies) for a clearer definition of the loss indicators, in order to allow a coherent assessment of the effectiveness of the water supply companies as to combat losses.

It is suggested that research be conducted with larger samples, ie, with the participation of more sanitation regulatory agencies for the effective design of the current situation of the problem. Finally, this study does not intend to exhaust the theme of the research, but draw attention to the need for further studies for an appropriate proposal of standardization of the water loss indicators to Brazilian needs.

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