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Article

The Brazilian National System for Water and Sanitation Data (SNIS): Providing information on a municipal level on water and sanitation services

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Case Report

The Brazilian National System for Water and Sanitation Data (SNIS): Providing information on a municipal level on water and sanitation services

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ABSTRACT

Basic sanitation services are essential for human development, promoting health and inhibiting the spread of waterborne diseases. The availability of information on water and sanitation services at the local level supports the formulation, implementation and improvement of public policies aimed at advancing the provision of basic sanitation services to the population. In Brazil, the National Water and Sanitation Data System (SNIS), administered by the Ministry of Regional Development (MDR), is the largest information system for water and sanitation services in the country. Here we present the significant aspects of SNIS and offer the most recent results of water and sanitation services in the country, which reveals that water supply is the sanitation service closest to achieve the universalization preconized by the United Nations with almost 93% of the population served. The situation of sanitary sewer services reveals that only 61.9% of the Brazilian population have sewer collection systems, while only 78.5% of the collected volume is actually treated. The remaining 22.5% of the raw sewer is directly disposed in the environment. With respect to the generated sewer, only 49.1% of the volume is treated. The solid waste data show that a large part of the urban population is served by home collection services. The major challenge of this component is to ensure that the final destination is environmentally appropriate, since there are still many dumps that receive waste from different municipalities. The urban drainage data show that most Brazilian municipalities still have deficiencies in the planning of drainage services.

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1. Introduction

Basic sanitation services are essential for human development, promoting health and inhibiting the spread of waterborne diseases. Considering its importance, water and sanitation are included in Objective 6 of the Sustainable Development Goals (SDG) (United Nations, 2015), which points to safeguard the availability and sustainable management of water and sanitation for all people. The SDG 12 focuses on solid waste and aims to ensure sustainable consumption and production patterns by reducing waste generation through prevention, reduction, recycling, and reuse. The SDG 11 proposes making cities and human settlements inclusive, safe, resilient and sustainable, with goals linked to urbanization, such as mobility, waste management, and sanitation. This is relevant to water-related disasters and to drainage and urban storm water management. It becomes, thus, imperative for developing nations to provide solid, public information regarding the provisions of water and sanitation services at the local level. The availability of such information promotes public awareness and social control, while supporting the formulation, implementation, and improvement of public policies focused on advancing the provision of basic sanitation services for the population.

At macro levels, the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) has reported country, regional and global estimates of progress on drinking water, sanitation and hygiene (WASH) since 1990 (WHO/UNICEF, 2017). In Europe, information about sanitation services is available in Portugal through PORDATA, a database that collects, organizes, systematizes and disseminates information from multiple areas of society, including data on water and sanitation (PORDATA, 2019). Latin American countries such as Peru, Chile and Argentina are members of the Association of Regulators of Water and Sanitation of the Americas (ADERASA) and have also a database on water and sanitation (ADERASA, 2017). A Regional Benchmarking Working Group (GRTB) has elaborated management indexes for drinking water and sanitary sewer systems that seek to present reliable information about the quality and efficiency of the water and sanitation services (ADERASA, 2017).

In Brazil, the National System for Water and Sanitation Data (SNIS - www.snis.gov.br), managed by the Ministry of Regional Development (MDR), is the largest information system for water and sanitation services in the country. The SNIS database provides information and indices for drinking water supply, wastewater and solid waste management and urban drainage and storm water systems, encompassing thus the four segments of the sanitation services as defined by the Brazilian Law No. 11,445 (BRAZIL, 2007a).

Here in this work, we describe relevant aspects of SNIS, from its history to the process of collecting and making available information from each segment of the water and sanitation services. We also describe the evolution of the sanitation services in Brazil since the implementation of SNIS, and present an overview of the water and sanitation services in Brazil as of 2019, which was produced by the authors and is the most recent information available at this time (BRAZIL, 2019; BRAZIL, 2019a; BRAZIL, 2019b).

We presume that many developing nations across the world lack such information system, and we believe that describing SNIS can be valuable for such nations as well as for researchers in other parts of the world who need access to sanitation service data at local, municipality level. After this introduction, this paper is organized as follows. In the next Section we describe the historical evolution of SNIS, its goals and some applications derived from its dataset. In the following Section we illustrate the methodology of SNIS for the annual data collection. The results related to the evolution of SNIS and the diagnosis data for 2019 are then presented. We finalize with the main conclusions.

2 The Evolution, Goals and Applications of SNIS Data

The Urban Policy Secretariat of the Ministry of Planning and Budget of Brazil (SEPURB/MPO) created SNIS in 1996 through the Program for modernization of the Sanitation Sector (PMSS) (Miranda et al., 2003). The initial activities involved the collection and disclosing of data from the water and sewer service providers (Water and Sewer component - SNIS-AE). In 2002, the solid waste module (SNIS-RS) was established focused on the collection of data from urban cleaning services and solid waste management. In 2016, the pluvial water module (SNIS-AP) was conceived to collect municipal data related to the urban drainage system and to the management of pluvial waters. Today, the SNIS is linked to the National Secretariat of Sanitation of the Ministry of Regional Development (SNS/MDR).

In a broader context, the SNIS was designed to provide information for Brazilian society, including public and private authorities, researchers and sanitation service providers, about variables and indices that quantify and qualify basic sanitation services at the municipal level across the country. In particular, the SNIS seeks to assist in the planning and execution of public policies, guide the public investments (federal, state and municipal), evaluate the service performance, improve management by increasing levels of efficiency and effectiveness, orientate regulatory and supervisory activities and support the social control over public administration.

The use of SNIS data by researchers, stakeholders, institutions and agencies have found broad applications. For instance, Cabral et al. (2018) used the historical series of SNIS to analyze the performance of water supply services performed by public and private agencies in order to subsidize the existing discussion in the country about privatizing or not such services. The SNIS data have also been used to assist investments in the sector (Leoneti et al., 2011, pp. 331–348).

Another relevant use of the SNIS data has been on the estimation of the water loss index, since this is one of the primary performance indices for potable water providers (Brazil, 2008) and can also be used for loss control programs (Andrade Sobrinho & Borja, 2016) as well as to evaluate water management strategies during water crisis scenarios (Kusterko et al., 2018). The SNIS data can also offer subsidies for assessing areas contaminated by the final disposal of solid waste (Pinheiro & Mochel, 2018) or for analyzing the Brazilian solid waste management (Silva et al., 2018). Some relevant features of Brazilian economy have also been revealed by the SNIS data. For instance, the 2017 Solid Waste Diagnosis (Brazil, 2019c) found a direct correlation between the disposal of waste (index for solid waste mass collected per capita) and Brazilian purchasing power over the years. The World Bank (WB) used SNIS data to analyze water, sewer and solid waste performance in Brazil (Brazil, 2007b). The system is considered a worldwide model, including a direct collaboration with the International Benchmarking Network for Water and Sanitation Utilities (IBNET) (Brazil, 2007b).

SNIS' procedure of collecting data has evolved as available technologies for data collection develops. Initially, paper forms were sent to sanitation companies and the collected data were compiled into data sheets. Thereafter, a desktop version was used, in which spreadsheet forms were sent in diskettes and CD-ROMs to sanitation companies. Currently, data collection is performed using a web application with open-source tools and softwares.

2. Methodology of data collection

The data collection process of SNIS is annual and can be summarized in five steps, as depicted in Fig. 1.

The first stage is the planning process, in which we review the database of water and sanitation companies (public and private), define the collection strategy and the schedule to be followed until the diagnosis is disclosed. Before starting the data collection process, we provide online courses for those interested in learning more about the Water and Sewer, and Solid Waste modules and how the required forms should be filled. The SNIS website also provides various help tools for the users, including manuals, glossaries of information, and description of water and sanitation indices.

The second stage is the data collection itself, in which sanitation companies are notified by email contact to start filling the forms that are available at the SNIS website. During approximately 45 days, the SNIS collecting system remains open and is supplied by sanitation data from different providers. During this period, teams of SNIS technicians are available through phone and e-mail to answer questions from providers. SNIS has two data collection platforms: SNISWEB, used by the Water and Sewage and Solid Waste modules, and SNIS-AP, used by the Rainwater module. Figs. 2–4 display the system interface SNISWEB and SNIS-AP accessed by the service providers.

The website collecting system has the ability to issue notifications, warnings and errors to providers in order to identify inconsistencies. The warnings are designed based on technical parameters or historical averages and allow the providers to double check the data input, and correct them, if necessary (Figs. 5 and 6). The issue of errors is based on inconsistent data input and prevents the completion of the forms (Figs. 7 and 8).

After the 45-day filling period, all data input undergoes a consistency analysis and is approved by a technical SNIS team. A preliminary data and indices report are produced and sent to the respective providers, which have a 15-day period to analyze all data and indices produced by SNIS, and request any adjustment with the respective supporting reason.

After this step, all information is compiled and used to prepare the Annual Diagnosis. Fig. 9 shows a summary of the analysis process.

The diagnosis and collected information are widely disclosed on the SNIS website and the collected data feed the SNIS historical series that publicize the information of previous collections as well. Over time, the collection cycle has experienced substantial improvements, from the SNIS website system to the type of variables and data supplied by sanitation companies.

Due to the complexity of the SNIS system and data supplied, we describe in the following sections each module of the system along with its own peculiarities and methods of data analysis.

2.1. The Water and Sewer Module (SNIS-AE)

The SNIS Water and Sewer Module (SNIS-AE) collects information from water and sanitation companies that include municipal and state agencies, social organizations, and private agencies. The water and sanitation service providers are categorized as i) regional, ii)

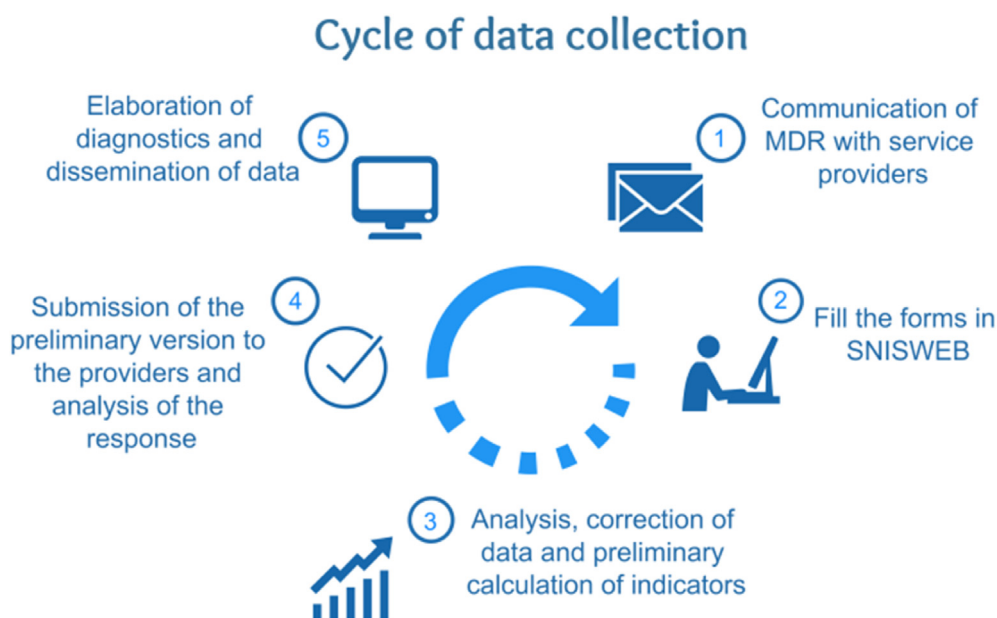


Fig. 1. Data collecting cycle of filling in the forms in SNISWEB.

Fig. 2. SNISWEB Interface: water and sewage services.

Fig. 3. SNISWEB Interface: solid waste services.

micro-regional, and iii) local. Regional providers administer and operate the water or sewer services of several municipalities within an isolated or integrated system, usually in the same state, bordering each other or not. All state companies are classified as regional providers. Micro-regional providers have the same characteristics as regional ones, but differ with respect to the quantity and geographical proximity of the municipalities served. These companies provide water and sanitation services for a few adjacent counties located in the same state. Local providers handle water or sewer services for a single municipality.

Based on the classification above, the SNIS-AE data are grouped into three databases: disaggregated, aggregated and municipal. The disaggregated data comprise municipal information disaggregated by the service provider. The aggregate data correspond to information and indices from each water and sanitation company, regardless of the number of municipalities served by each of them. The municipal database corresponds to the data consolidated by municipalities, regardless of how many providers operate the water and sewer services.

There are basically two different forms that are filled by the service providers in SNIS-AE program: i) the complete form, that is filled by providers whom the municipality has a public system of water or sewer, and ii) the simplified form, that is filled when the municipality does not have a public system and uses alternative and individual solutions for water supply and sanitation. In the complete form, water and sanitation companies have to provide descriptive, general, financial and operational information for both water and sewer, quality of services, balance sheet data and analysis of tariff structures. The simplified form has information on sanitation solutions, such as septic tanks, rudimentary cesspits, rainwater galleries, and untreated sewer discharge into rivers and streams. The

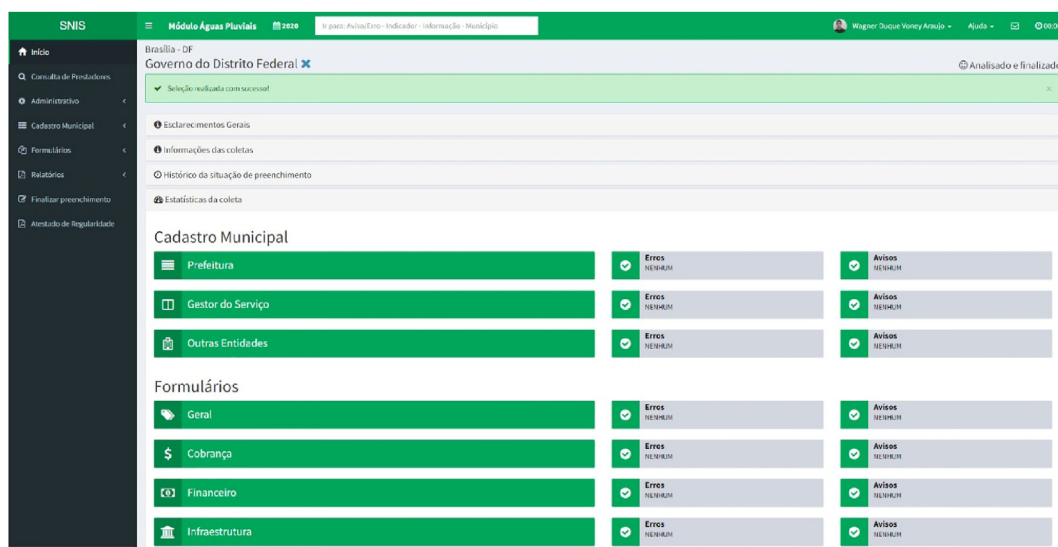


Fig. 4. SNIS-AP Interface: rainwater services.

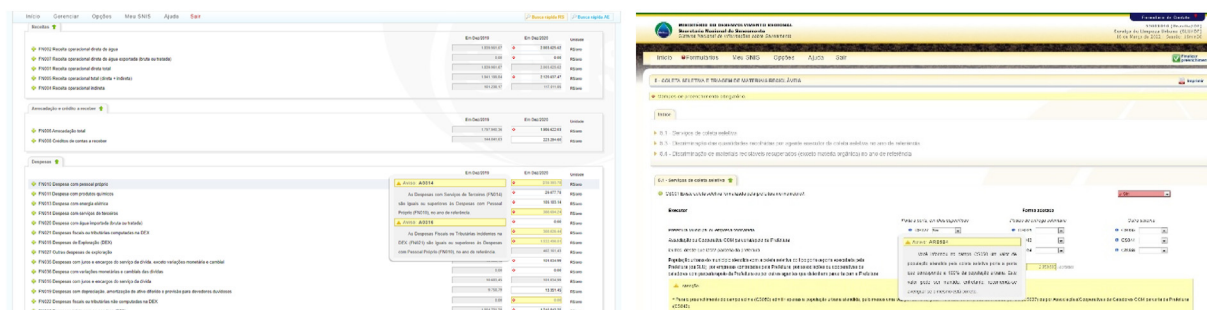


Fig. 5. Example of warnings in SNISWEB.

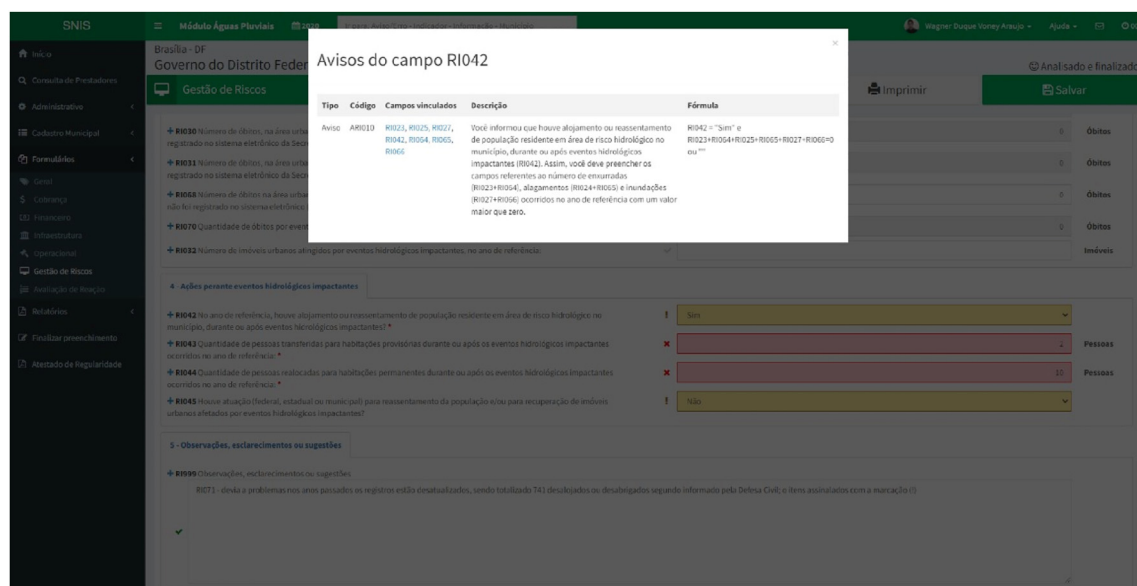


Fig. 6. Example of warnings in SNIS-AP.

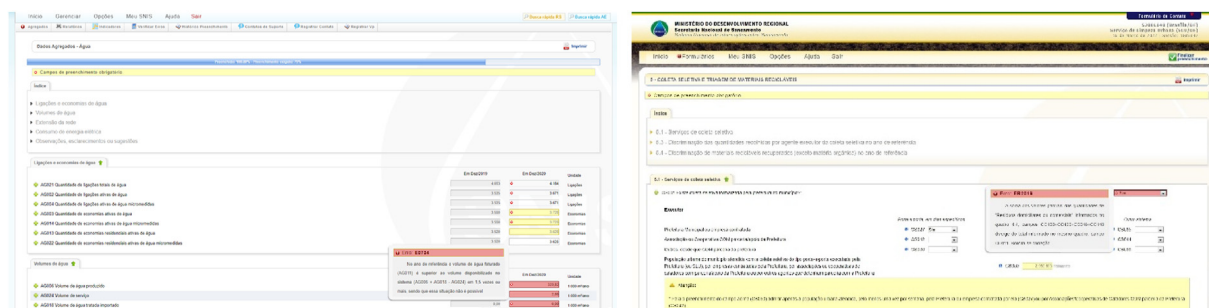


Fig. 7. Example of errors in SNISWEB.

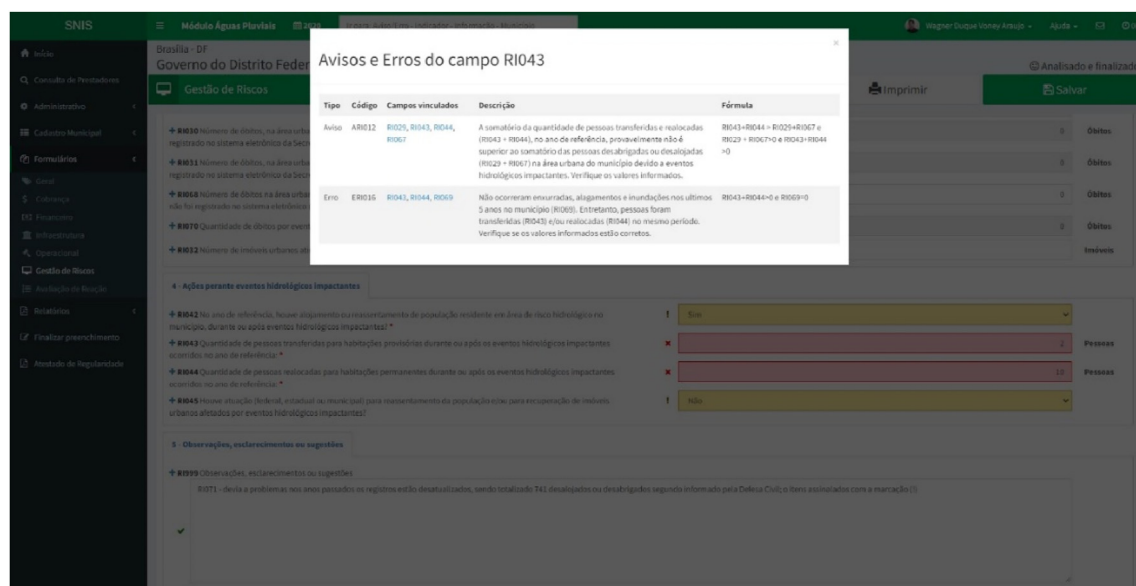


Fig. 8. Example of errors in SNIS-AP.

individual water supply solutions include water delivered by wells, springs, fountains, cisterns, weirs and potable water trucks. (Brazil, 2020a).

The core of the data analysis process is focused on the data provided by regional and micro-regional companies, which serve various municipalities with water supply and wastewater collection and treatment systems. These data have a large impact on the consolidated data by state, macro-regions and national level. The analysis directs to i) comparing information that directly impact the main indices that will be disclosed in the diagnosis report, ii) evaluating the arguments offered by the service providers for the errors identified by the system, and iii) consistency analysis of specific information by comparison across current and past year data.

2.2. The stormwater module (SNIS-AP)

The information provided to the Storm Water Module (SNIS-AP) is the responsibility of the municipalities, as they are the only service providers across the country. These municipalities carry out the control of the drainage and urban stormwater management services (DMAU) through direct administration by the municipality or other institution delegated by Municipal Law, or through a concession agreement or contract.

Regarding data collection, it is important to emphasize some peculiarities that directly impact the collection of information from DMAU in Brazil. The first is the difficulty of getting data and information by the service providers themselves, since the vast majority of them do not have systematic information systems, databases, technical data or data collection procedure. The second is the municipal staff, who often lacks adequate technical training and has a high rate of job replacement. The third is the terminology heterogeneity and the diversity of technical knowledge throughout the national territory, which impacts on the understanding and completion of the information requested.

In addition to the data supplied by the service companies, we also collect related data from other Brazilian institutions, such as the Brazilian Institute of Geography and Statistics (IBGE), the Integrated Disaster Information System (S2ID), the National Water Agency

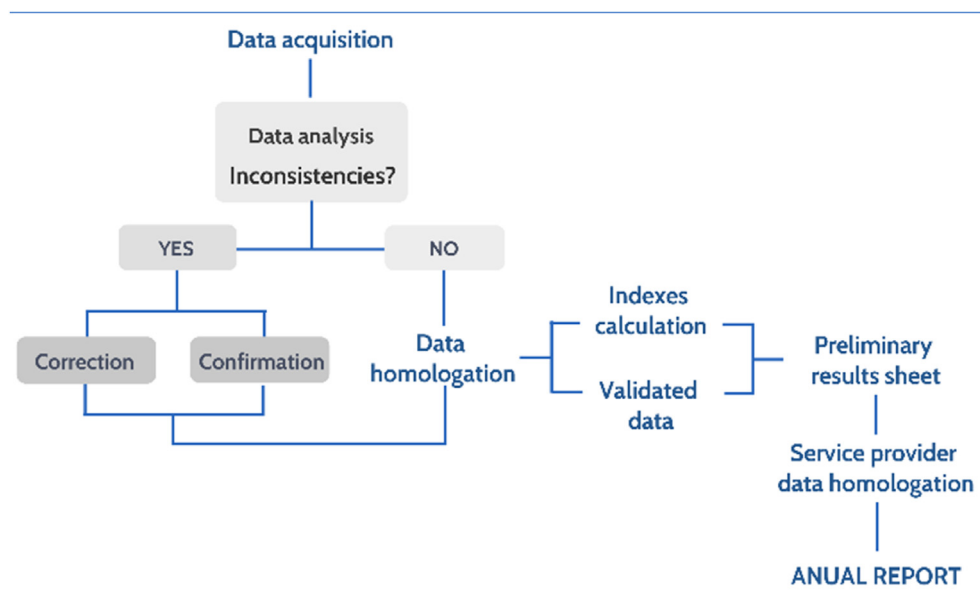


Fig. 9. Cycle of information analysis.

(ANA) and the Brazilian Geological Survey (CPRM). The data collection system is categorized into six forms that providers must answer. Each form is directed to a specific area of the DMAPU services, namely: i) general overview, ii) collection, iii) financial data, iv) infrastructure, v) operational results and vi) risk management. The collection forms for the year of 2020 comprised 106 questions that, together with 19 inputs from other sources, result in the acquisition of 125 variables by SNIS-AP.

After all data are supplied by providers and collected from other sources, we start the data analysis process in two steps: i) automatic analysis and ii) manual analysis.

The automatic analysis comprises the data scanning by the system, where the data input is checked for large inconsistencies. The manual analysis comprehends a series of other criteria, elaborated by the technical team in order to refine the data consistency. Both analyses are sent out to service providers so that, if necessary, they can correct any inconsistencies.

After these two stages of consistency analysis, we estimate several indices derived from the supplied data. A third stage of consistency analysis is performed on the estimated indices, as they can also yield to unrealistic values.

2.3. The solid waste module (SNIS-RS)

The municipalities are responsible for providing all data input related to solid wastes. This includes the cases where the municipality provides the services itself as well as when it delegates to private providers, including the provision of services to other municipalities and large quantity generators that have their territory as part of the system, such as transshipment areas or final destination of these materials. Due to that, the peculiarities reported that directly impact the acquisition of information by SNIS-AP and SNIS-RS are very similar, such as the lack of municipal information systems or service planning and monitoring, lack of municipal technical staff training and qualification and, finally, the lack of equipment and structures for measuring and constant monitoring the variables related to the data input.

The Solid Waste Management module of the SNIS-RS has the largest set of forms among the other SNIS modules, regarding the amount of data requested from the providers. The SNIS-RS collection comprises 15 forms with 372 fields, which compose 47 indices. The forms are categorized into: i) description, ii) registration, iii) general information, iv) financial information, v) paid workers, vi) household and public collection, vii) recycling collection and sorting, viii) healthcare waste collection, ix) construction waste collection, x) sweeping, xi) weeding and mowing, xii) other services, xiii) sanitation worker's conditions, xiv) processing units, and xv) policy/sanitation plan.

Unlike the other components, the SNIS-RS uses in its analysis the partitioning of municipalities into populational strata: up to 30,000 inhabitants, 30,001 to 100,000 inhabitants, 100,001 to 250,000 inhabitants, 250,001 to 1,000,000 inhabitants, 1,000,001 to 4,000,000 inhabitants, above 4,000,000 inhabitants. This is done, among some reasons, to understand the complexity of municipal solid waste management systems according to population sizes, to make comparisons between cities with similar population characteristics and to monitor the development of shared solutions among Brazilian cities. The analysis phase of the data input is similar to that performed in the SNIS-AP: i) automatic analysis, and ii) manual analysis. The system performs an automatic analysis of data consistency that basically seeks to find values outside a pre-specified range, which can be defined based on historical values or average statistics accepted by the sector. In the second step, all collected data are manually analyzed by the SNIS team, which performs the treatment and disclose the data information supplied by the providers and the indices calculated by the system.

3. Results and discussion

3.1. Evolution of municipalities taking part in the SNIS

The number of Brazilian municipalities assisting the SNIS database has evolved considerably over the years. Fig. 10 shows, for the period of 1995–2019, the number of municipalities taking part in each of the SNIS modules.

The sample size of the SNIS-AE module across the years reveals the changes in the collecting procedures. From 1995 to 2005, aggregated information was requested to state companies along with limited disaggregated information requested from some municipalities.

As of 2006, all water and sanitation companies that had a water pipeline network and a sewer collection system were invited to take part in the SNIS. Since 2009, all municipalities, including those that did not have a water supply network or sewer collection system, started to provide data through simplified forms.

In the last data collection, referring to 2019, the SNIS-AE had a sample size of 5191 municipalities represented by water companies, corresponding to 98.2% of Brazil's urban population (174.2 million inhabitants). Regarding sanitary sewer services, the SNIS-AE module obtained data from 4226 municipalities, corresponding to 92.9% of the urban population (165.4 million inhabitants).

The SNIS-RS was created in 2002 and had the initial input from 108 municipalities. Since then, there has been a steady evolution of sample size, and the current information for the year 2019 corresponds to the input from 3712 municipalities, totaling an urban population of 86.6% in relation to the total urban population of Brazil.

Historically, it is worth mentioning that, until 2008, only a restricted sample of municipalities was invited to respond to the SNIS-RS. As of 2009, the invitation was extended to all Brazilian municipalities, which explains the 428% increase in the number of municipalities in the sample (it increased from 372 in 2008 to 1964 in the following year). In 2012, it was also possible to identify a significant growth in the sample size. One possible reason for this large increase relates to the municipal elections of 2012, after which the data was collected by the new municipal managers who took office in 2013. In addition to that, the compliance with SNIS became a requirement in 2013 for the municipalities to request funds from the National Secretariat of Sanitation, which reinforced the need of municipalities to supply the requested data (although remaining completely voluntary).

Finally, the stormwater module (SNIS-AP) had its first data collection in 2015. In 2019, the fourth year of collection (there was none in 2016), the SNIS-AP received information on DMAPU services from 65.6% (3653) of the total municipalities in the country. The information cover services provided to 83.0% of the urban population. There was an increase of almost 50.0% of participating municipalities, compared to the first SNIS-AP data collection cycle carried out in 2015. In that year, 45.6% (2541) of the total municipalities took part in the collection, corresponding to 66.0% of the Brazilian urban population. In addition, in 2019, 26 state capitals out of 27, and the Federal District took part in the collection process. These cities concentrate a large part of the Brazilian population and often need effective drainage solutions for the stormwater runoffs.

3.2. Overview of water and sewer services

The most recent information on water supply and sanitation services in Brazil was collected and analyzed in 2020 and refers to 2019. Considering the urban population in the municipalities that supplied the requested data, 92.9% are served by water supply services, while only 61.9% are offered sewer services. This shows a clear deficit in the country in providing sewer collection services, which is a key factor in the control of waterborne diseases, such as intestinal parasites, gastroenteritis, typhoid fever, diarrhea, hepatitis, and

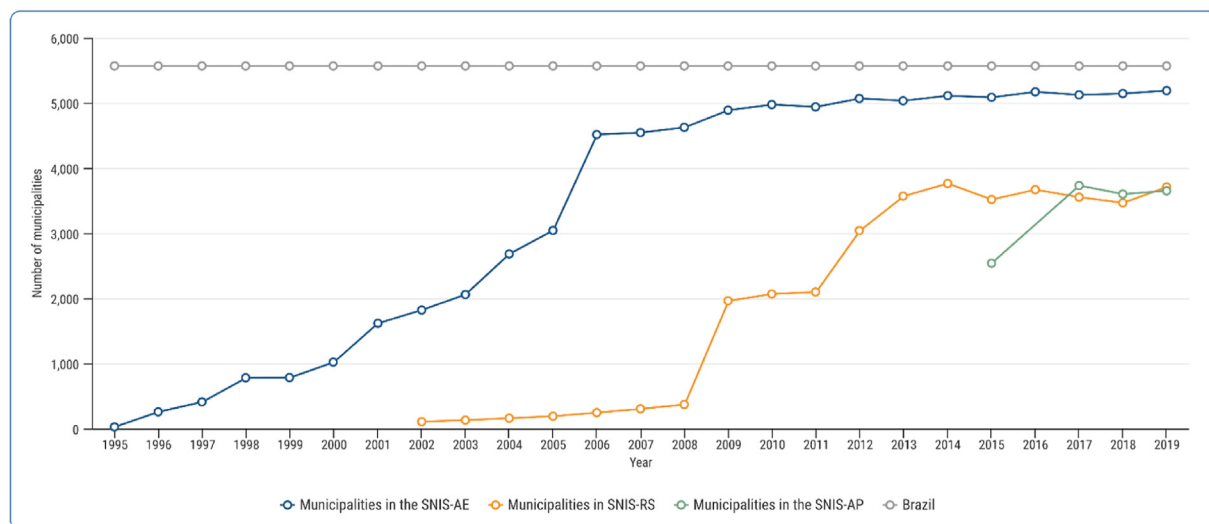


Fig. 10. Evolution of the municipalities in the SNIS.

cholera (Tucci, 2005).

The SNIS database uses the IN023 and IN024 indices to represent the index of urban service by the water network and by the sewer collection network, respectively (Fig. 11).

The North and Northeast macro-regions, which have low economic development in Brazil, are the ones with the lowest rates of urban water service, with values under 90%. These regions are also those with the lowest number of municipalities taking part in the SNIS. Regarding the sewer service index, the North macro-region presents the lowest value, 13.8%, followed by the Northeast macro-region with 36.7%. These two regions also have a larger number of municipalities with no information provided to the SNIS.

A cross-comparison of the 2019 index for water supply (IN023) with the 2010 index reveals a slight increase in the water supply service from 92.5% para 92.9%. As for the sewer services index (IN024), we observed an increase from 53.5% to 61.9% in the last nine years. Although these numbers show a clear expansion in the provision of water and sewer services in the country, the temporal rates of growth still fall below those indicated in the National Plan for Sanitation Services for 2033 (Brazil, 2014).

Table 1 presents information that further describes the water and sewage systems in Brazil, according to the data provided by the water and sanitation companies to the SNIS-AE module.

The relation between the volumes of water consumed and produced indicates the percentage of water volume that is *produced* (i.e., delivery to the supply system) and effectively consumed by the population. From it, we can estimate the distribution loss index (IN049), which is the percentage of produced water that is lost throughout the system and therefore not adequately charged by water companies. It is estimated a loss of 39.2%. Some losses are associated with leakages over transmission and/or distribution systems leakages and overflows at utility's storage tanks, and leakages in connections up to the point of customer metering. Additional losses arise from metering inaccuracies (inoperative hydrometers, sub-metering, reading errors, frauds, calibration problems with water meters, etc.), clandestine connections, inaccuracies in the commercial register and other situations (Brazil, 2020a).

Regarding the sewer services, we observed that only 78.5% of what is collected is effectively treated (index IN016). We estimate that the remaining 21.5% is directly disposed in the environment. When we consider the percentage of the entire sewer produced (estimated based on the amount of water consumed) that is effectively treated (index IN046), this rate drops to 49.1%.

Besides large sewer systems, there is also the use of individual solutions and alternative systems. According to the National Basic Sanitation Plan (PLANSAB), appropriately designed and constructed post-treatment septic tanks or final disposal units are considered an adequate sewer treatment as well (Brazil, 2014). The SNIS does not collect information on volumes and specific characteristics of these smaller systems.

Considering that there is still a large amount of generated sewer without proper treatment, the inadequate disposal of the untreated sewer is of concern. This points to the need of further investments in sewer collection and treatment systems. PLANSAB estimated the need for investments of about US\$ 53.6 billion in sanitation from 2010 to 2033 (Brazil, 2014). From 2007 to 2020, the SNIS data show an accumulated investment in sanitation of about US\$ 22.8 billion, corresponding to 42.5% of the planned investment.

3.3. Overview of solid waste services

The coverage of household collection for 2019 is displayed in Fig. 12, which shows the percentage of the total population (SNIS index IN015) with household collection services (door-to-door as well as indirect collection with drop-off depots, bins and containers).

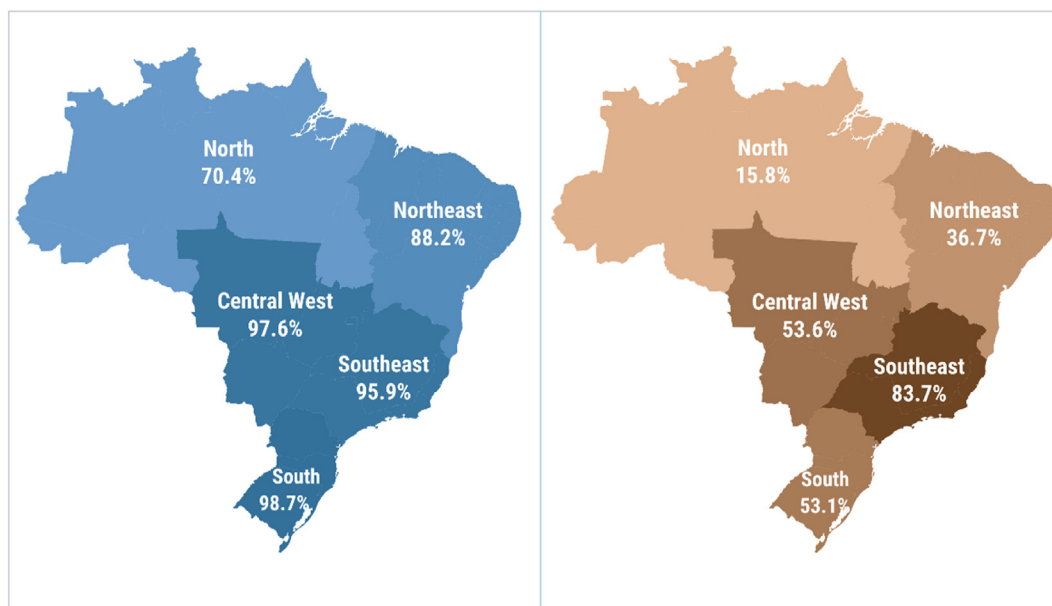
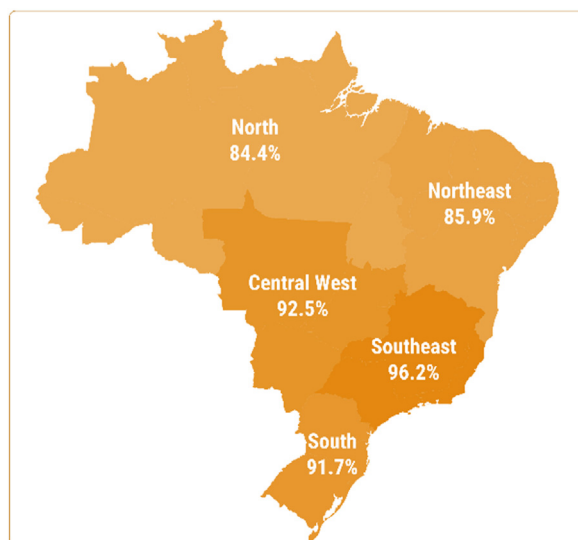


Fig. 11. Spatial representation of IN023 and IN024.

Table 1

Further aspects of the water and sanitation systems (Adapted from Brazil, 2020a).

Service	Information	Units	Value
Water	Volume of produced water (AG006)	1.000 m ³ /year	16.613.022
	Volume of consumed water (AG010)	1.000 m ³ /year	9.761.352
Sanitation	Volume of collected wastewater (ES005)	1.000 m ³ /year	5.826.685
	Volume of treated wastewater (ES006)	1.000 m ³ /year	4.516.114

**Fig. 12.** Spatial representation of the IN015 index.

The North and Northeast regions present the lowest rates of household collection services and the largest absence of response to the SNIS-RS collection (not shown here). There is an inequality in the coverage values of these regions in relation to the others, since their average coverage is around 85.0%, while the other regions exceed 91.0% (Brazil, 2020b).

Regarding selective collection in the country, we noticed that 38.7% of the municipalities taking part in the SNIS-RS have selective collection services, corresponding to 25.8% of the municipalities in Brazil. When comparing this number with the values collected for 2018 (38.1%) and 2017 (35.3%), we observed a small increase. Considering the final disposal of solid waste collected, 75.1% were disposed of in landfills, 12.0% in dumps covered by soil or other material and 12.9% in open dumps. Regarding the final disposition adopted, 2.170 municipalities (39.0%) disposed solid waste in environmentally adequate landfills and 30.7% deliver to environmentally inadequate sites, with 1055 (18.9%) municipalities disposing their waste in open dumps and 655 (11.8%) in dumps covered by soil or other material, leaving the portion of 1690 (30.3%) municipalities without information. Out of the 64.1 million tons of waste collected in 2019, it is estimated that 48.1 million tons of waste were properly disposed while 15.9 million tons were sent to the abovementioned inadequate disposal sites. About the recovery of selectively collected urban solid waste, the diagnosis found that 1163 sorting units received about 1.6 million tons and recovered approximately 1 million tons of recyclable waste, while counting 73 composting units that recovered about 304.6 thousand tons of organic waste.

In addition to these data, the numbers on dry recyclables recovery (paper, plastic, glass, and metals) also highlight the challenges of the environmentally appropriate disposal of waste in the country. Approximately 1.0 million tons is recovered, which represents only 2.1% of the total domestic and public waste collected in the country, or 7.0% of the total potentially recoverable mass of dry recyclables, which produces the index of recovered residue of 7.5 kg/inhabitant/year.

As for the financial information, the total expenses of the Municipalities with the management of solid waste in 2019, when prorated by the urban population, resulted in about US\$ 23.59 per inhabitant, an approximate expenditure of US\$ 4 billion for the urban solid waste management throughout the country, employing 256k workers. Still, the fragility of financial sustainability remains in the sector, since only 44.8% of municipalities charge for services and the amount collected covers only 57.2% of costs.

Although the SNIS-RS is in constant evolution, we highlight the need to improve the quality of data supplied by the sanitation companies. One example is the inaccuracy of data on quantities of household and public waste collected, mainly because much of this information is estimated (and not measured) by municipal officials, since the use of a scale for the routine weighing of waste is restricted to 39.3% of the participants, as seen in the diagnostic information for 2019.

3.4. Overview of drainage and urban water management services

To offer a high quality DMAPU, prior planning of the local infrastructure is decisive. The Stormwater Management Plan is one of the

fundamental tools of service planning, since it contains the analysis of water distribution over time and space, based on the urban occupation (Tucci, 1993). Among the service providers that took part in the SNIS-AP 2015 collection, 20.2% (513) stated that they have a Stormwater Management Plan. In the SNIS-AP 2019 collection, the value was 19.6% (715). Even though the sample size increased, the percentage of municipalities with a Drainage Management Plan is limited, showing that most of the Brazilian municipalities still have deficiencies in planning drainage services.

About the DMAPU infrastructure, 62.8% of the public roads are paved and have curbs in the urban area (index IN020), while 15.1% of the roads have underground rain gutters or channels in the urban area (index IN021).

Regarding the layout of drainage systems in relation to the sanitary sewage network, sanitation experts often indicate that a separate sewerage system is traditionally adopted in the country. The SNIS-AP 2019 survey shows that 54.3% (1985) of Brazilian municipalities have separate systems. This percentage is practically the same as the one collected in 2015, when it reached the value of 53.1% (1349). These data confirm the idea that this system is widely used in Brazilian municipalities.

However, a significant portion of the samples of 2015 and 2019, 23.9% (785) and 22.5% (822) respectively, shows the existence of a combined system. This situation may be associated with the lack of planning, since the overall infrastructure of cities had not been previously planned and, thus, sewage systems are often executed after the expansion of cities. In addition, due to the lack of financial resources, they are not connected to a sewage treatment plant, with the sewage being discharged directly into the rainwater networks and thereafter into water bodies. From the data obtained from SNIS-AP, there is a considerable part of municipalities whose effluents are not adequately treated.

To assess DMAPU services deficiencies, the SNIS-AP identifies the share of households at risk of flooding using the IN040 index. Regarding the results for the service providers that participated in the collections, we observed the following results: in 2015, 4.1% (465,274) of the households were at risk, while in 2019 the value reduced to 3.5% (1,661,255), however we should analyze carefully this indicator. This is because many service providers are not yet aware of hydrological events that are likely to affect their population and that information RI013 - number of municipalities subject to flood risk - became a mandatory field in the collection of 2017. Out of the 2132 municipalities that engaged in the two collections, 1775 did not report the value of field RI013 in the 2015 collection, but reported it in 2019. It is possible to infer that the indicator change is likely due to the increase in the number of municipalities that took part in its calculation.

In 2019, only 1.1% (40) of the municipalities participating in the SNIS-AP charged indirect fees for the provision of services. Of this group, 20.0% (8) charged specific fees. The SNIS-AP data confirm that charging drainage provision in Brazil is entirely limited, although being supported by Law no. 11.445/2007 (BRAZIL, 2007a).

In 2019, only 7.5% (273) out of the 3653 municipalities engaged in the SNIS-AP reported a surplus in the revenues. They reported values for total municipal revenues with DMAPU services (index FN009) higher than the total expenditures of the municipality with the services of DMAPU (index FN0016). The percentage of municipalities with deficit was 50.5% (1846 participants).

4. Conclusions

The SNIS is an important database platform with consolidated routines for the collection, administration, analysis, treatment, storage, organization and provision of information and indices related to water and sanitation services across municipalities in Brazil. In addition, it summarizes the provision of basic sanitation services, making it possible to identify the main aspects for which it is necessary to define goals and measures capable of improving the basic sanitation scenario in Brazil. Over time, the historical data series minimizes distortions and improves the quality of information and indices.

The sanitation service that is closest to achieve the preconized universalization by the United Nations is water supply, with almost 93% of the population served. However, there is still a need to improve the water supply systems to prevent large volume losses, which nowadays exceed 39% on average. The situation of sanitary sewer services reveals the need to give more attention to this component. Only 61.9% of the Brazilian population have sewer collection systems, while only 78.5% of the collected volume is actually treated. The remaining 22.5% of the raw sewer is directly disposed in the environment. In relation to the generated sewer, the situation becomes even more alarming, since only 49.1% of the volume generated is treated.

The solid waste data show that a large part of the urban population is served by home collection services. The selective collection indices had a small increase in the last three years of SNIS collection, however, the country has only 38.7% of the municipalities with this service. The major challenge of this component is to ensure that the final destination is environmentally appropriate, since there are still many dumps that receive waste from different municipalities. Only 2.1% of the total mass of domestic and public waste collected in the country, or 5.6% of the total potentially recoverable mass of dry recyclables, are recovered and 24.9% of the total mass of collected waste is disposed in environmentally inadequate sites.

The increase of nearly 50% in the number of sanitation companies taking part in the SNIS-AP from 2015 to 2019 reflects the sanitation industry's recognition of the need for a DMAPU database. The results obtained in the first three surveys show three important facts. First, a reduced number of service providers have a Stormwater Management Plan as a tool for planning services. Second, the number of households at flooding risk is extremely relevant for overcoming the service deficit. Finally, the economic and financial sustainability of the system is a fragile aspect, since service providers do not charge for services and are often in financial deficit.

The results obtained for the AE, RS and AP SNIS components and presented here show the fragilities and the advances of the water and sanitation services in Brazil, being a reference to support the planning of public policies for basic sanitation at the national level as well as to subsidize the development of studies that involve the sector. It is evident, however, the importance of data collection and systematization for service owners, regulators, stakeholders and general users to work towards achieving the legal objectives, planning, implementation and monitoring of compatible actions for the evolution of the water and sanitation sectors. Therefore, we stress that

qualified and relevant information and access to them are fundamental allies not only for achieving legal requirements, but also for maintaining environmental, economic and social health in the municipalities, as well as promoting society engagement and social control.

The entire SNIS database is available at ww.snis.gov.br. Suggestions to improve indices, variables and the overall collection process are welcome and can be addressed at <http://www.snis.gov.br/entre-em-contato>. A transition to a larger system (SINISA) is already underway.

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Availability of data and material

All SNIS data are freely available at www.snis.gov.br.

Code availability

Not applicable.

Contribution

Each named author has substantially contributed to conducting the underlying research and drafting this manuscript.

Ethics approval

Not applicable.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Declaration of competing interest

The authors declare that they have no conflict of interest, financial or otherwise.

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References

- ADERASA. (2017). *Regional benchmarking working group (GRTB). Annual report - 2016 (data from 2015)*. Spanish. Lima. 80pp.
- Andrade Sobrinho, R., & Borja, P. C. (2016). Energy loss engineering and embaesa energy system: A study of the intervening factors in the RMS. Dec 2016 *Engenharia Sanitária Environment*, 21(4), 783–795. ISSN 1413-4152. In: Portuguese.
- BRAZIL. (2007a). *Law No. 11,445 of January 5, 2007. Establishes national guidelines for basic sanitation*. Brasília: Official Gazette of the Federative Republic of Brazil. Portuguese.
- BRAZIL, Ministry of Cities, National Secretariat for Environmental Sanitation. (2007b). *SNIS Public management instrument*. Brasília (p. 48). 3th: Sanitation for all. Portuguese.
- BRAZIL, Ministry of Cities, National Secretariat for Environmental Sanitation. (2014). *Plansab - national plan for basic sanitation more health with quality of life and citizenship*. Brasília: Portuguese.
- BRAZIL. Ministry of Cities. National Secretariat for Environmental Sanitation. (2008). *Water supply: Management of water and electricity losses in supply systems. Professional training guide: Level 2* (p. 139). Salvador: ReCESA. p. In: Portuguese.
- BRAZIL. Ministry of Regional Development. National Secretariat of Sanitation – SNS. (2019a). *National sanitation information system: 24th diagnosis of water and sewage services - 2018* (p. 180). Brasília: SNS/MDR. p : il. In: Portuguese.
- BRAZIL. Ministry of Regional Development. National Secretariat of Sanitation – SNS. (2019b). *National sanitation information system: Diagnosis of urban solid waste management - 2018* (p. 247). Brasília: SNS/MDR. p.: il. In: Portuguese.
- BRAZIL. Ministry of Regional Development. National Secretariat of Sanitation – SNS. (2019c). *National sanitation information system: 3rd drainage diagnosis and management of urban rainwater - 2018*. Brasília: SNS/MDR. 195 p.: il. In: Portuguese.

- Cabral, L. S. L., Rodrigues, E. C., & Fonseca, A. (2018). Privatize or not privatize? A longitudinal analysis of water supply services in Brazil. Aug 2018 *Engenharia Sanitária e Ambiental*, 23(4), 811–822. ISSN 1413-4152. In: Portuguese.
- Kusterko, S., et al. (2018). Loss management in water supply systems: A constructivist approach, 2018 *Engenharia Sanitária Ambiental*, 23(3), 615–626. ISSN 1413-4152. In: Portuguese.
- Leoneti, A. B., Prado, E. L., & Oliveira, S. V. W. B. (2011). *Basic sanitation in Brazil: Considerations on investments and sustainability for the 21st century*. April 2011. Public Administration Magazine. ISSN 0034-7612. In: Portuguese.
- Miranda, E. C., Tagliari, M., & Gabriel, J. (2003). Sanitation information system the SNIS experience. In *21st Brazilian congress of sanitary and environmental engineering*. ABES, 26pp. In: Portuguese.
- Pinheiro, N. C. A., & Mochel, F. R. (2018). Diagnosis of areas contaminated by the final disposal of solid waste in the municipality of Paço do Lumiar (MA). Dec 2018 *Engenharia Sanitária e Ambiental*, 23(6), 1173–1184. ISSN 1413-4152. In: Portuguese.
- Pordata. (2019). About pordata. Portuguese <https://www.pordata.pt/Sobre+a+Pordata>. (Accessed May 2019).
- Silva, A. H. M., et al. (2018). Evaluation of urban solid waste management in municipalities using multicriteria: Northern region of rio de Janeiro. Apr./Jun. ISSN 2525-8761 *Brazilian Journal of Development Curitiba*, 4(2), 410–429 (Portuguese).
- Tucci, C. E. M. (1993). Urban drainage master plan: Principles and conception. *Brazilian Journal of Water Resources, Brasília*, 2(2), 5–12 (c In: Portuguese).
- Tucci, C. E. M. (2005). *Urban rainwater management/carlos E. M. Tucci* - Ministry of Cities - Global Water Partnership - Wolrd Bank - Unesco. Portuguese.
- UNITED NATIONS IN BRAZIL - UN BR. (2015). The 2030 agenda. In: Portuguese <https://nacoesunidas.org/pos2015/agenda2030/>. (Accessed May 2019).
- WHO/UNICEF. (2017). *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines* (Vol. 116p). USA.