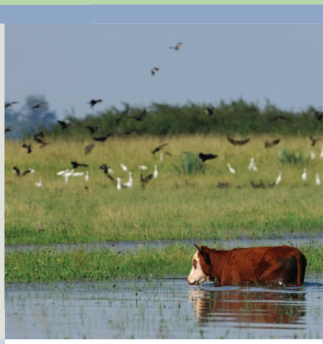
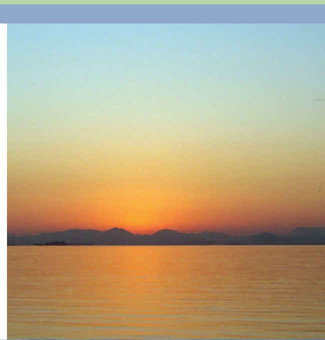
Surface Freshwater Quality in

BRAZIL

Outlook 2012





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NATIONAL WATER AGENCY

Surface Freshwater Quality in

BRAZIL

OUTLOOK 2012

Executive Summary

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Surface Freshwater Quality in

BRAZIL
OUTLOOK 2012
Executive Summary

Brasília - DF
2012

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COGERH - Water Management Company of Ceará
CPRH - State Environmental Agency – Pernambuco
DQA/MMA - Environmental Quality Department - Ministry of Environment
FEPAM - State Environmental Protection Foundation - Rio Grande do Sul
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IGAM - Water Management Institute of Minas Gerais
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INEA - State Environmental Institute - Rio de Janeiro
INEMA - Environmental and Water Resources Institute - Bahia
SANEATINS - Sanitation Company of Tocantins
SEMA - Environmental Secretariat – Mato Grosso
SEMARH - State Environmental and Water Resources Secretariat - Goiás
SPRH - Water and Energy Resources Secretariat – Pernambuco
SUDEMA - Superintendency of Environmental Management – Paraíba

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Paranoá Lake- Brasília/DF

NATIONAL WATER AGENCY PREFACE

Knowledge of surface freshwater quality in Brazil is essential for managing it as well as for achieving the multiple uses of water recommended by the National Water Resources Policy. The existence of clean water is a prerequisite not only for the maintenance of aquatic ecosystems but also for various human activities such as domestic supply, irrigation, industrial use, watering animals, aquaculture, fishery and tourism.

The environmental, social and economic impacts of water quality degradation translate, *inter alia*, into loss of biodiversity, increase in waterborne diseases, higher costs associated with the treatment of water intended for domestic and industrial use, loss of productivity in agriculture and livestock, reduction in fishery and loss of cultural, recreational and aesthetics values.

Carrying out an assessment of water quality in Brazil is a task as big as the area of our country and its huge environmental, cultural and socio-economic diversity. Since its inception, the National Water Agency (ANA) has endeavored to gather, analyze and disseminate information about the quality of Brazilian waters. In 2005, ANA released the publication entitled "Surface Freshwater Quality in Brazil", a groundbreaking study that for the first time ever aggregated data from state monitoring networks. In 2009, ANA began to prepare the report "State of Water Resources in Brazil", which presents a comprehensive diagnosis of the situation of water resources and water management in the country, including an overview of surface freshwater quality.

In 2012, with the support of the Inter-American Development Bank (IDB), ANA is pleased to present the publication "Surface Freshwater Quality in Brazil – Outlook 2012", which provides a diagnosis of the main pressures on surface freshwater quality, its condition in 2010 and the actions that governments, private sector and civil society have implemented to restore and maintain the quality of water bodies. The study also presents a diagnostic of water quality trends during the first decade of this century (2001-2010).

This publication is part of the strategy established by the National Water Quality Evaluation Program (PNQA), which has among its objectives the systematic evaluation and dissemination of freshwater quality in the country. The effort to collect such a huge amount of information was only possible thanks to the contribution of state environmental and water resources agencies, which kindly provided their monitoring data.

Brazilian society faces significant challenges in water quality management, since this is an intersectoral issue that demands strong coordination between the areas of water resources, environment, sanitation, health, industry and agriculture, to name few. Publications like this are essential for increasing civil society's awareness of this important topic, thus contributing for the establishment of an effective agenda based on measurable indicators that enable restoring and maintaining surface freshwater quality in Brazil.

Board of Directors of National Water Agency - ANA

Zig Koch/Image Bank ANA

Iapó River in Guartelá Canyon/PR

INTER-AMERICAN DEVELOPMENT BANK PREFACE

For over fifty years the IDB has supported the development of Latin American and Caribbean countries through actions that seek to reduce poverty, inequality and promote social and economic growth in an environmentally sustainable manner. Imbued with this mission, the Bank combines its efforts with those of the countries in the Region, with a view to meeting the Millennium Development Goals by increasing access to sanitation for the poorest populations; improving the continuity of services; preserving water sources; reducing the contamination of receiving bodies and strengthening institutional and legal frameworks in the Water Resources and Sanitation sectors.

The Water and Sanitation Initiative introduced by the IDB in 2007 is the Bank's response to this challenge. The *Initiative* established specific strategies and targets, according to the needs of each member country, offering new tools and flexible financing to encourage programs that improve water and sanitary conditions in Latin American and Caribbean countries, grouped into four main areas: technical assistance and investment financing to cities with populations over 50,000; service to rural communities; technical assistance and financing for actions to protect springs, water quality improvement and sewage treatment; in addition to support for improving the performance of sanitation companies, thus promoting management transparency.

As a result of the *Water and Sanitation Initiative*, we are pleased to present, jointly with the National Water Agency, the publication "Surface Freshwater Quality in Brazil – Outlook 2012", which provides a picture of the pressures on surface freshwater quality in Brazil, in addition to describing the actions that various public and private entities have put in place to restore and preserve water bodies.

This publication is the result of the Technical Cooperation Agreement signed between IDB and ANA in 2010, to support the implementation of the National Water Quality Evaluation Program (PNQA), which will provide Brazilian civil society with knowledge about the quality of surface freshwater and offer inputs to government agencies at different levels for the design of public policies.

The Outlook, which is the milestone of the PNQA, will enable Brazilian civil society to play its role of overseeing the quality of the country's rivers, following up any changes thereto and being informed of the actions taken.

The Bank is proud to participate in this very important moment for Brazil.

Federico Basañes
Head, Water and Sanitation Division
Inter-American Development Bank – IDB

Letícia Lemos de Moraes

Meandering River on Amazônica Basin

1 INTRODUCTION

Brazil is home to 12% of the surface freshwater available in the world, one of the country's greatest assets. Water availability, however, is not restricted to its quantitative aspect alone. The various uses of water entail quality requirements that when failed to be met represent a limiting factor for its use. Therefore, the main goal of the National Water Resources Policy is to ensure the current generation as well as future generations the necessary water availability, with quality standards suitable for the respective uses.

Knowing the quality of water is an essential factor for managing it. The National Water Agency (ANA) has published information on water quality in the country using data from state monitoring networks. It is important to point out that the support of the Federative Units that monitor water quality has been instrumental in this task. Thus, in 2005 ANA developed the first "Surface Freshwater Quality in Brazil", gathering for the first time ever data from state monitoring networks. Since 2009, the Agency has produced the report on the "Situation of Water Resources in Brazil", an annual publication that provides an updated view of surface freshwater quality in Brazil.

The document "Surface Freshwater Quality in Brazil – Outlook 2012", prepared with the support of the Inter-American Development Bank, (IDB) represents an impressive evolution from the publication of 2005, mainly with respect to the increase in the number of monitoring points and water quality indicators used. The study also uses the Pressure-State-Response model, which enables identifying the cause and effect relationships between sources of pollution, water quality indices and civil society's responses to these problems. The study also presents an unprecedented assessment of water quality in the period 2001-2010.

This Executive Summary presents the national vision of the full version in Portuguese of the "Surface Freshwater Quality in Brazil – Outlook 2012" and is available in both English and Spanish.

"Surface Freshwater Quality in Brazil – Outlook 2012" is the result of efforts of ANA and state management agencies to improve and enhance the monitoring of surface freshwater quality in Brazil. This publication would not have been possible without the support of 19 entities in 17 Federative Units, which contributed their monitoring data.

This is not a definitive diagnosis on the topic, since there is a wide range of pressures on water quality, and monitoring networks do not yet cover the entire country. Notwithstanding these limitations, a diagnosis such as this is important for identifying information gaps, so as to allow knowledge of the quality of surface freshwater in Brazil to grow over the coming years.

2 NATIONAL WATER QUALITY EVALUATION PROGRAM (PNQA)

Surface freshwater quality monitoring networks began to operate in Brazil in the 1970s, when the first state networks were established. Since then, the Federative Units (UF) have used different strategies to implement their water quality monitoring programs. Currently, 17 of the 27 Federative Units monitor their surface freshwaters, totaling 2,167 monitoring points in operation. For the entire Brazilian territory, this represents a density of 0.25 point per 1,000 km². Higher densities are found in other countries such as Canada, for example, with 0.8 / 1,000 km².

The distribution of these monitoring points over the Brazilian territory is very uneven and concentrated in some hydrographic regions. Moreover, since Brazil is a federation, each federative unit adopts in its monitoring regime, specific criteria regarding point location, sample frequency and assessed parameters. Thus, there are gaps to be filled in relation to the distribution of points and the standardization of water quality monitoring in Brazil.

In addition to the 2,167 points monitored by the Federative Units, ANA monitors water quality in 1,340 points within the National Hydrometeorological Network. Sampling frequency at these points is quarterly, but the parameters monitored are limited to pH, electrical conductivity, temperature, dissolved oxygen, and flow determination.

Faced with the need to expand and integrate water quality monitoring in Brazil, in 2010 ANA introduced the National Water Quality Evaluation Program (PNQA), which aims to increase knowledge about the quality of surface freshwater in Brazil, so as to guide the design of public policies to restore environmental quality in inland water bodies, thus contributing to the sustainable management of water resources. The PNQA has the following specific objectives:

- Eliminate geographic and time gaps in water quality monitoring in Brazil;
- Increase the reliability of information on water quality (incentives to laboratory accreditation and intercalibration);
- Standardize and ensure that data and information on water quality are comparable between Brazilian Federative Units and hydrographic regions;
- Evaluate, disseminate and make water quality information available to society.

It is, therefore, a program that aims to provide the country with an integrated monitoring system based on standardized collection and analysis procedures applicable to all Federative Units, which allows the systematic monitoring of the evolution of water quality throughout the national territory.

The PNQA seeks to comply with the provisions of Law 10650/2003, known as the Law on Access to Environmental Information, which states that the competent environmental agencies participating in the National Environmental System (Sisnama) shall prepare and publish annual water quality reports.

PNQA Components

The PNQA is organized into four components, namely:

National Water Quality Monitoring Network

The National Water Quality Monitoring Network (RNMQA) aims to develop actions that enable improving and enhancing the monitoring of surface freshwater quality and making information available to the population at large.

The RNMQA includes regionalized targets relating to the minimum density of sampling points per square km, minimum sampling frequency of parameters by monitoring point, and minimum parameters analyzed by monitoring point, according to water features in different regions of the country.

Due to regional differences, the Brazilian territory was divided into four regions according to the minimum criteria of point density per square km. Density ranges from 0.1 point /1,000 km² in the Amazon basin to 1 point /1,000 km² in the most populated basins. As for monitoring frequency, the aim of the RNMQA is to collect at least half-yearly samples in the Amazon Basin and quarterly samples in the rest of the country.

With regard to the parameters to be analyzed, the target is to analyze, as a minimum, the parameters described in Table 1. The definition of these parameters was established by consensus of the Federative Units under the Brazilian National Environmental Program (BRASIL, 2003b).

Standardization of procedures and parameters

This component seeks to standardize procedures for the collection, preservation and analysis of water quality samples at the entities operating the state networks in all Units of the Federation.

Laboratories and training

This component aims to enhance the structure and quality control of laboratories involved in water quality analysis and train technicians engaged in both field and laboratory activities, in order to improve the reliability of water quality information in the country.

Water quality evaluation and dissemination

The aim of this component is to establish and maintain a national water database available to society through the Water Quality Portal, as well as to systematically evaluate the quality of surface freshwater in Brazil through the publication of periodic reports.

Main PNQA actions and results to date

Project of the National Water Quality Monitoring Network

The project of the National Water Quality Monitoring Network (RNMQA) currently under development is a major component of the PNQA, and its development involves a series of previous studies to identify representative water monitoring points and the establishment of operation logistics for the networks.

An initial proposal for the arrangement of the RNMQA was drafted under this project, based on technical criteria for the location of monitoring points and considering the regionalized monitoring point density

Table 1. Minimum parameters of the National Water Quality Monitoring Network

Category	Parameter
Physical-chemical	Electrical Conductivity
	Air and Water Temperature
	Turbidity
	Dissolved Oxygen
	pH
	Total dissolved solids, suspended solids
	Total Alkalinity
	Total Chloride [1]
	Transparency [2]
	Biochemical Oxygen Demand (freshwater) or Total Organic Carbon (brackish and saline water [1])
	Chemical Oxygen Demand
Microbiological	Thermotolerant Coliforms
Biological	Chlorophyll a [2]
	Phytoplankton - qualitative and quantitative [2]
Nutrients	Phosphorus (soluble reactive phosphorus, total phosphorus)
	Nitrogen (Nitrate, Ammoniacal Nitrogen, Total Nitrogen)

1. Parameters specific to Region 4 reservoirs of RNMQA and for estuarine regions.
2. Parameters specific to lentic environments (reservoirs, lakes).

targets. This initial project is being discussed with representatives of environmental and water resources management agencies, as well as with sanitation companies in all Federative Units.

To develop this RNMQA project, a comprehensive diagnosis was carried out in each institution involved in water quality monitoring with respect to the current situation of their networks (monitoring points, parameters assessed, sampling frequency, itineraries, costs, and information systems among others). The laboratories were evaluated for their analytical capacity, and the needs for infrastructure improvements were assessed.

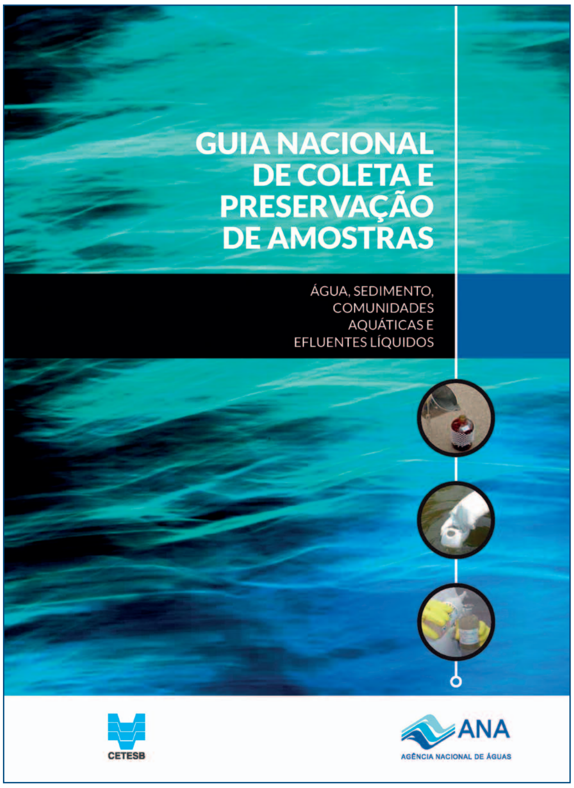
National Field Guide to Water, Sediment, and Biological Sampling

One of the main actions of the PNQA is the standardization of sampling, hence the "National Field Guide to Water, Sediment, and Biological Sampling", prepared by the Environmental Company of the State of São Paulo (CETESB).

The Term of Assignment for Use of the Guide was signed early in 2011, with CETESB as the assignor and ANA as the assignee. The Guide was subsequently submitted to technical consultation led by ANA with state environmental and water resources management agencies and state sanitation companies. The contributions received were consolidated, resulting in the final version of the National Field Guide.

In 2011, the National Guide was regulated by ANA Resolution 724 as the technical reference document establishing the procedures for surface freshwater sampling intended for monitoring water quality throughout the national territory.

On World Water Day in 2012, ANA, with the support of the Inter-American Development Bank (IDB) published 2,000 copies of the National Guide and posted the digital version on the Water Quality Portal. A video showing the main water sampling methods is also available in Portuguese, Spanish and English.



Source: ANA (2012).

Figure 1- Front Cover of the Brazilian National Field Guide to Water, Sediment and Biological Sampling

Water Quality Portal http:/www.ana.gov.br

The Water Quality Portal was established in 2010 as a virtual space within the PNQA for the dissemination of information and the exchange of knowledge on the situation of water quality in the country. This information is derived from the water quality monitoring carried out by ANA and state environmental and water resources agencies.

In its public space, the portal provides the possibility of search and survey in databases, maps and other documents. Information on the PNQA, water quality indices, water quality objetives, and related publications, among others, is also available.

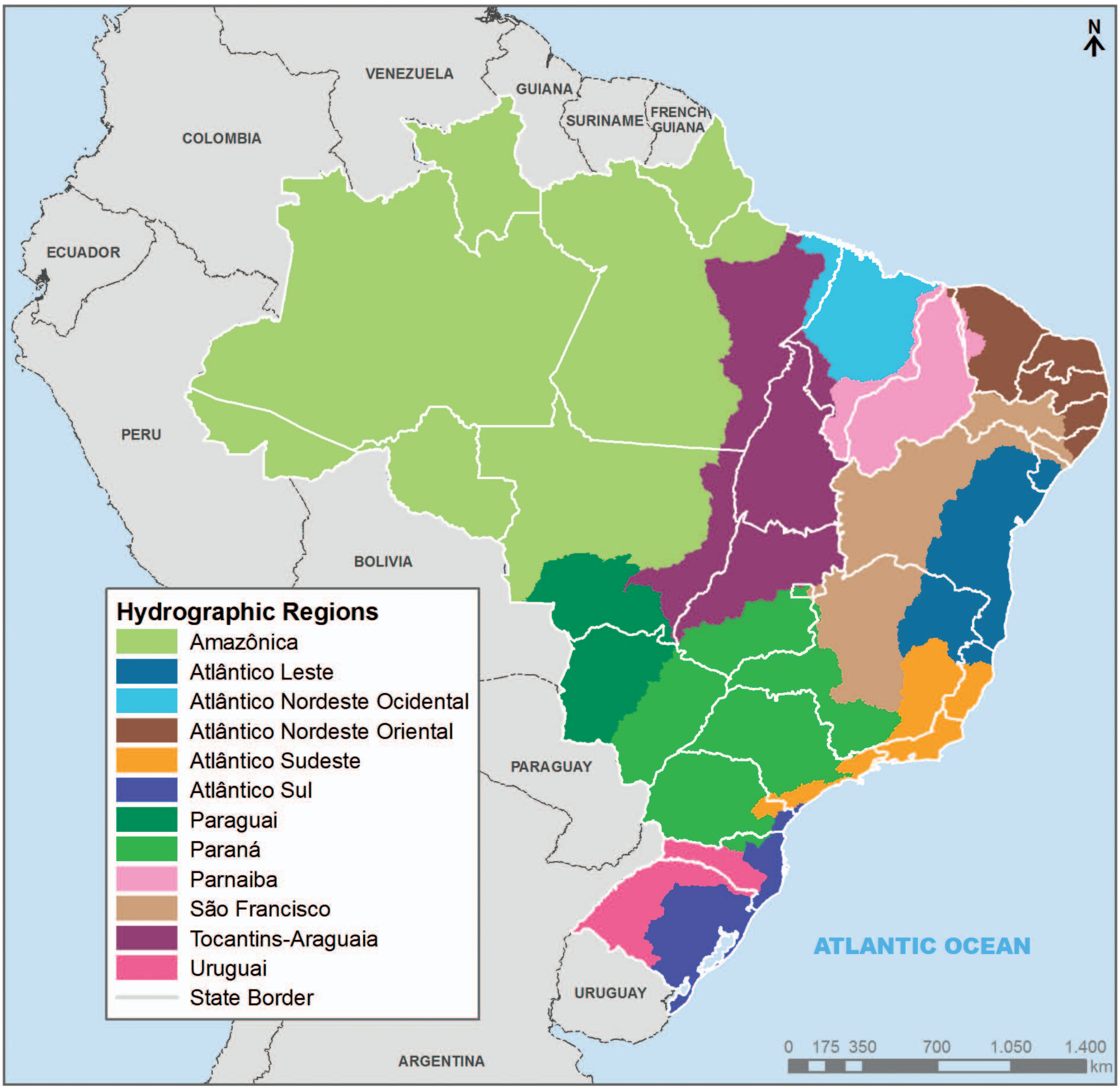
In addition, the portal offers an important tool for searching historic data series of water quality monitoring stored in the database of the of National Water Agency's HIDRO System.

3 METHODOLOGY

This document analyzes the quality of inland surface water in Brazil (rivers, lakes and reservoirs). With respect to groundwater, the National Water Agency, with the support of other federal institutions, Units of the Federation and Civil Society Organizations plans to establish the National Groundwater Monitoring Network (RENAMAS), which over the next years should contribute to the development of a national diagnosis. Coastal waters are monitored in most coastal states by the environmental agencies as regards the bathing quality of the beaches, and the information is disseminated to society. The water distributed for domestic consumption is monitored by the Health Sector under the National Program of Environmental Health Surveillance Related to Water Quality for Human Consumption (VIGIAGUA).

Brazil is divided into 12 Hydrographic Regions, established by Resolution 32 of October 15, 2003 of the National Water Resources Council (CNRH). This national summary of surface freshwater quality in Brazil uses this hydrographic division (Figure 2).

The Pressure-State-Response (P-S-R) model developed by the Organization for Economic Cooperation and Development (OECD) was used to systematize the



Source: ANA/SPR e IBGE

Figure 2 - Hydrographic Regions and Geopolitical Division of Brazil

information. According to the model, human activities exert pressures on the environment, changing its state and affecting the quality and quantity of natural resources. It also considers that society responds to these changes through environmental, economic and sectoral policies, as well as through environmental awareness and behavior change (OECD, 2003).

The diagnosis of pressure is divided into urban and rural environments, due to different pressures observed in these two situations, a fact that also generates differentiated management demands such as, *inter alia*, domestic sewage, urban solid waste and industrial effluents. The diagnosis of pressure is also related to specific pressure sources such as mining and prospecting, environmental accidents and critical events among others.

The survey to identify the pressures gathered secondary data contained in ANA documents (2005, 2009, 2010, 2011), data from IBGE (2010 Census, Sanitation Atlas 2011 and PNSB), National Water Resources Plan, State Water Resources Plans, River Basin plans, specialized literature and official federal, state and municipal websites.

The water quality analysis presented in this publication are based on data provided by the following entities that operate monitoring networks in the country, by Unit of the Federation: CAESB (DF); ADASA (DF); CETESB (SP); COGERH (CE); CPRH (PE); FEPAM (RS); IAP (PR); IEMA (ES); IGAM (MG); IGARN (RN); IMA (AL); IMASUL (MS); INEA (RJ); INEMA (BA); AGUASPARANÁ (PR); SANEATINS (TO); SEMA (MT); SEMARH (GO); and SUDEMA (PB).

The diagnosis of water quality is presented through the following indicators of surface freshwater quality: Water Quality Index (WQI); Trophic State Index (TSI); and CCME Water Quality Index (CCMEWQI).

The Water Quality Index (WQI) was developed in the United States by the National Sanitation Foundation in 1970 and adapted to Brazilian conditions in 1975. Currently, it is the water quality index most used by the Federative Units. The WQI considers nine water quality parameters: dissolved oxygen, thermotolerant coliforms, pH, biochemical oxygen demand, temperature, total nitrogen, total phosphorus, turbidity and total solids. This index assesses the condition of water use for public supply, after a conventional treatment. Therefore, other water uses are not directly covered by the WQI.

The Trophic State Index (TSI) aims to classify water bodies in relation to nutrient enrichment and the growth potential of algae and macrophytes. Although it assesses trophic state, the TSI calculated with total phosphorous does not necessarily reflect the degradation of water quality caused by the eutrophication process (e.g., algae blooms), which is dependent upon other variables such as temperature, turbidity and residence time of water among others. The TSI was estimated based on the total phosphorus, using the formulas proposed by Lamparelli (2004) for lentic (lakes and reservoirs) and lotic (rivers) environments.

The CCME Water Quality Index (CCME WQI) assess water quality relative to its desirable state, which is defined by water quality objectives. This index was developed by the Canadian Council of Ministers of Environment (CCME, 2001). In Brazil the CCME WQI is known as the Index of Attainment of Water Quality Objectives – ICE.

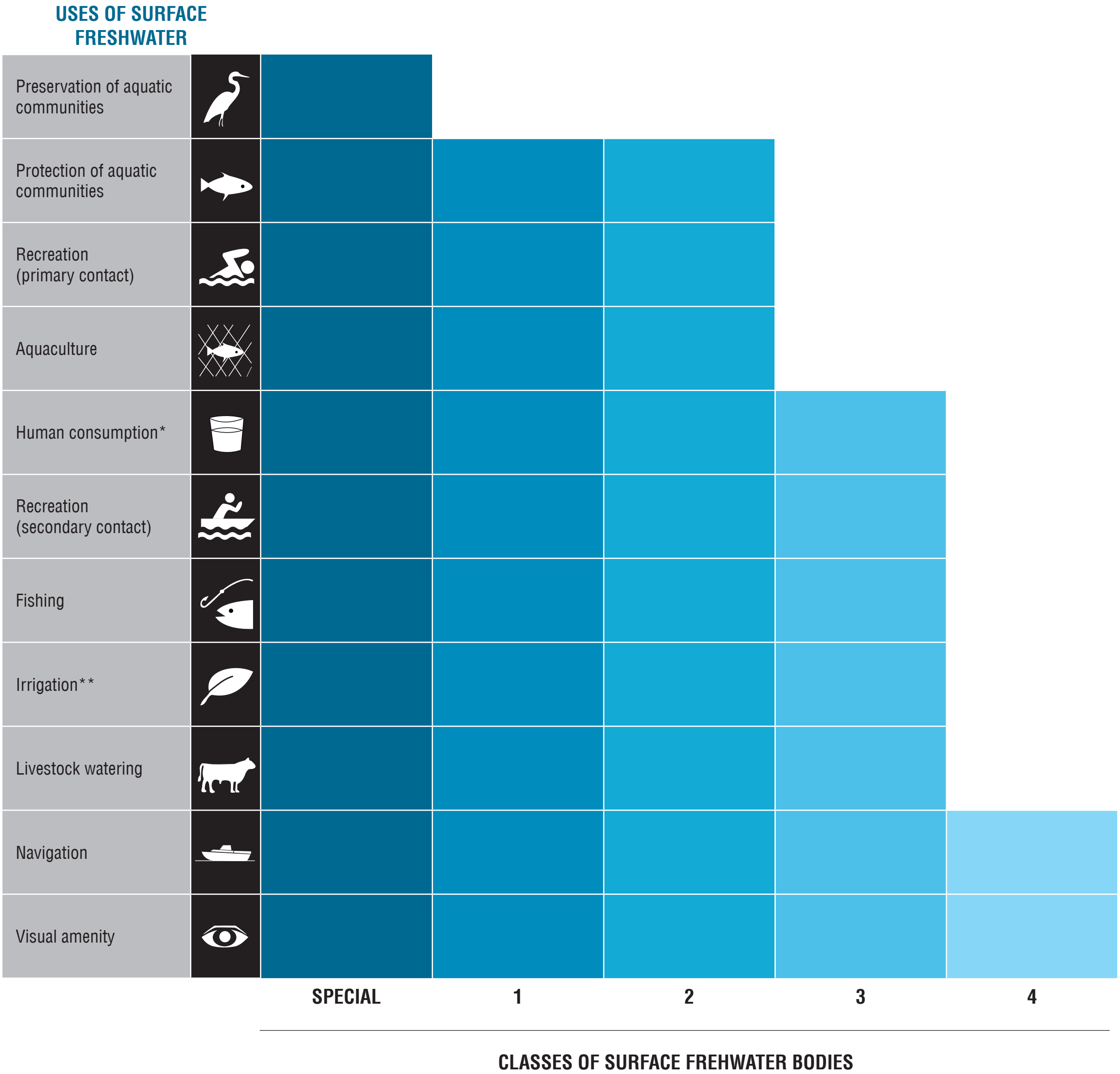
The parameters included in the ICE calculation were pH, dissolved oxygen, biochemical oxygen demand, total phosphorus, turbidity and thermotolerant coliforms.

The ICE calculation considered the classification of freshwater bodies defined by CONAMA Resolution 357/2005. Five classes are established according to water uses (Table 2), and each class has specific water quality guidelines. Surface freshwaters in the special class must be maintained in pristine condition. In classes 1 to 4 an increasing level of pollution is permitted, resulting that only less stringent water uses (eg. Navigation) are possible in class 4.

For WQI and TSI, trend analysis were performed covering the period 2001 to 2010, using the Mann-Kendall test and Linear Regression analysis, as proposed by COSTA *et al.* (2011).

The responses presented refer to management actions, such as the drafting of legislation, planning, monitoring and structural actions such as the construction of Sewage Treatment Plants. The information about these actions was obtained from secondary sources like Basin Plans, reports by water resources and environmental management agencies and reports by sanitation companies among others. Rather than exhausting the subject, this analysis seeks to present the main actions concerning water quality management.

Table 2 - Classes of Surface Freshwater Bodies According to Their Uses



Source: ANA (2011), PORTAL PNQA

Notes:

**: Water treatment level for human consumption varies depending on water quality guidelines for each class of surface freshwater bodies.*

***: Different crops can be irrigated depending on water quality guidelines for each class of surface freshwater bodies.*

The Special Class is mandatory on Conservation Units (eg. National Parks)

The Class 1 is mandatory on Indian Land;

4 MAIN PRESSURES ON SURFACE FRESHWATER QUALITY

4.1 Urban Environment

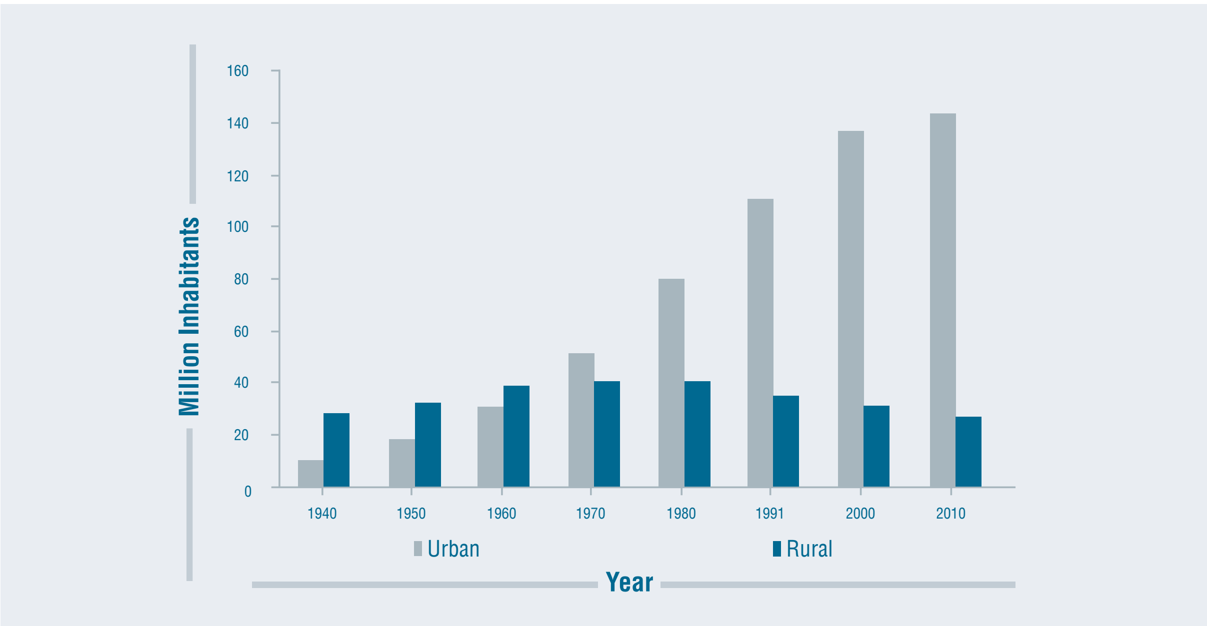
Domestic sewage

Brazil has experienced an intense urbanization process in recent decades. Before the Demographic Census of 1960, the rural population was larger than the urban population. Over the past 50 years, the urban population has grown considerably, while the rural population has declined (Figure 3). In the period 2000 to 2010 alone, the urban population increased by 23 million people, while the rural population decreased by 2 million.

This urbanization process of recent decades was not accompanied by a proportionate increase in domestic sewage collection and treatment services. Over the same period, the country's industrialization process has also contributed, along with domestic sewage, to a significant increase in the pollution load discharged into rivers flowing through urban areas.

The degradation of water bodies has been occurring at different intensities and times in most Brazilian cities. It is worth noting that until the 1940s and 1950s, several rivers in urban areas still maintained a good water quality condition. The "Swim Crossing of São Paulo" was held on the Tietê River until 1944. However, since then the pollution level in the river has prevented the event from being staged.

Currently, domestic sewage is the main source of pressure on water resources in the country, due to the lack of sewage collection and treatment or to ineffective treatment of the sewage collected. As a result, remaining organic domestic loads are released into water bodies, especially in urban areas, leading to the deterioration of water quality, with economic and social consequences.

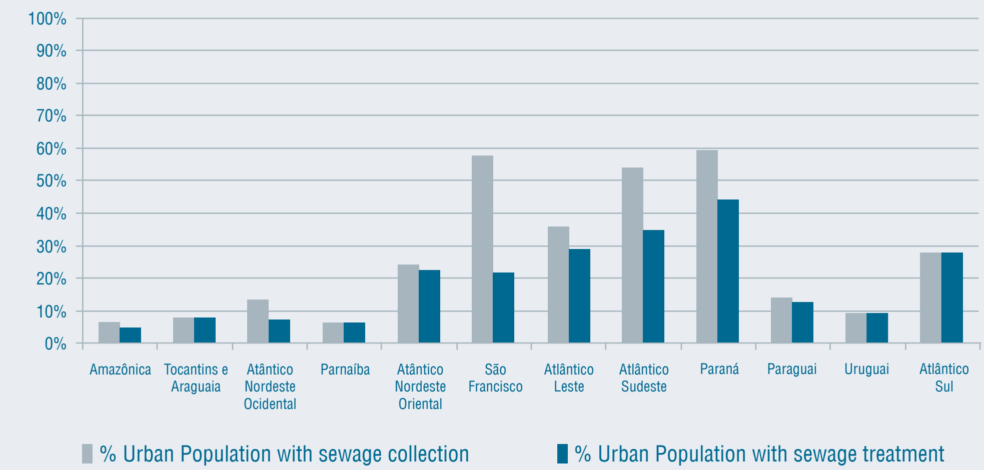


Source: IBGE

Figure 3 - Urban and Rural Populations in Brazil (1940-2010)

According to the National Basic Sanitation Survey (PNSB), the percentage of households with access to the sewer system in the country in 2008 stood at 45.7%, and the percentage of treated sewage in relation to the total sewage generated was 30.5% (IBGE, 2008).

The Hydrographic Regions (HR) with the best sewage system services in urban areas, with collection levels above the national average are Paraná (59.8%), São Francisco (57.4%) and Atlântico Sudeste (53.9%). The first two also boast sewage treatment levels above the national average, of about 44% and 34.5% respectively (Figure 4).

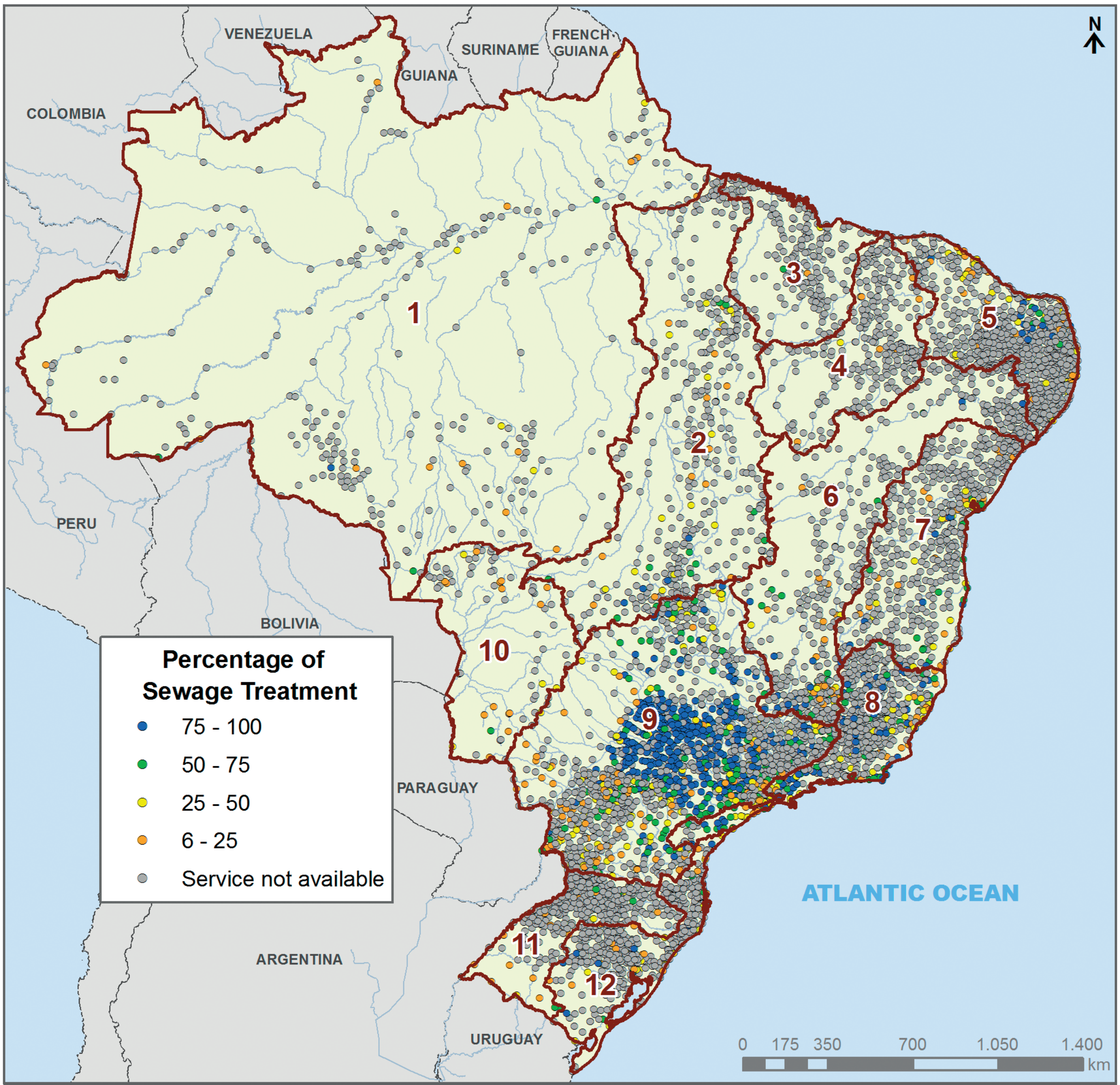


Source: ATLAS BRASIL Data Base - Urban Water Supply (2010). Prepared by the authors

Figure 4 - Sewage Collection and Treatment Index - Urban Population 2010

Paraíba do Sul River in Volta Redonda/RJ

Zig Koch/Image Bank - ANA



1 Amazônica Hydrographic Region
2 Tocantins-Araguaia Hydrographic Region
3 Atlântico Nordeste Ocidental Hydrographic Region
4 Parnaíba Hydrographic Region
5 Atlântico Nordeste Oriental Hydrographic Region
6 São Francisco Hydrographic Region
7 Atlântico Leste Hydrographic Region
8 Atlântico Sudeste Hydrographic Region
9 Paraná Hydrographic Region
10 Paraguai Hydrographic Region
11 Uruguai Hydrographic Region
12 Atlântico Sul Hydrographic Region

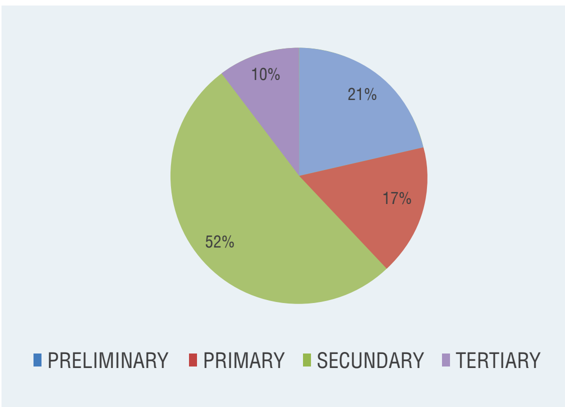
Source: ATLAS BRASIL Data Base: Urban Water Supply (2010). Prepared by the authors

Figure 5 - Situation of Municipalities in Relation to Sewage Treatment

Figure 5 shows the large number of municipalities "with no service", indicating that there is still a great deficiency as regards the provision of sewage treatment services in Brazil. The Paraná and Atlântico Sudeste HRs are the ones with the largest number of municipalities with higher sewage treatment levels.

Of the total volume of sewage treated per day in Brazil (8.5 million m^3), 52% is submitted to secondary treatment and only 10% to tertiary treatment (Figure 6).

The tertiary treatment of sewage is typically characterized by the removal of the nutrient phosphorus, which comes mostly from the use of



Source: IBGE (2008).

Figure 6 - Percentage of Total Volume of Sewage Treated by Type of Treatment

household detergents. This element is the primary responsible for the eutrophication of freshwater.

Based on data from the PNSB for 2008, the estimated volume of remaining domestic organic load realesed into water bodies is approximately 5,500 t BOD / day (IBGE, 2008). Figure 7 shows the estimated remaining domestic organic load in 2008 as well as the average flow rate observed in each HR.

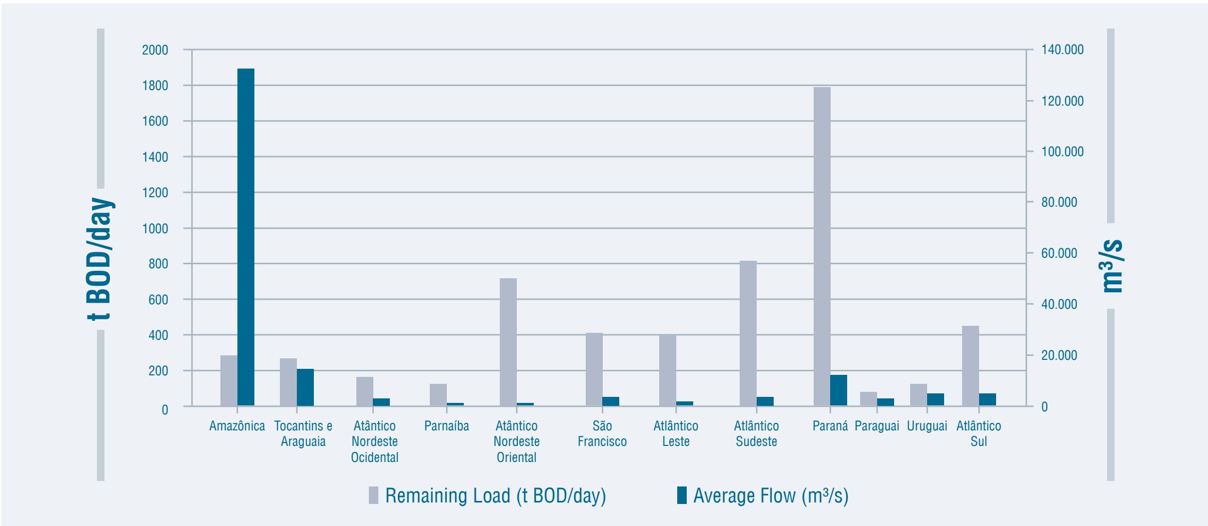
The domestic organic load is located mainly in the Paraná, Atlântico Sudeste e Atlântico Nordeste Oriental Hydrographic Basins, regions that are home to about 64% of the Brazilian urban population.

It is observed that the Amazonica HR has high water availability and low domestic organic load compared with other hydrographic regions. In contrast, the Atlântico Nordeste Oriental HR , located in a semiarid climate, has high domestic organic load and low water availability. These characteristics have important implications in their pollution assimilation capacity and in their surface water quality.

The basins most affected by the organic domestic loads are located in the main metropolitan areas (Figure 8). In the Paraná HR, among the most critical basins are the Upper Tietê and Piracicaba rivers, mainly due to the domestic organic loads originating in the MRs of São Paulo and Campinas, and the River Grande basin, due to the loads relating to the municipalities of São José do Rio Preto (SP) and Uberaba (MG).

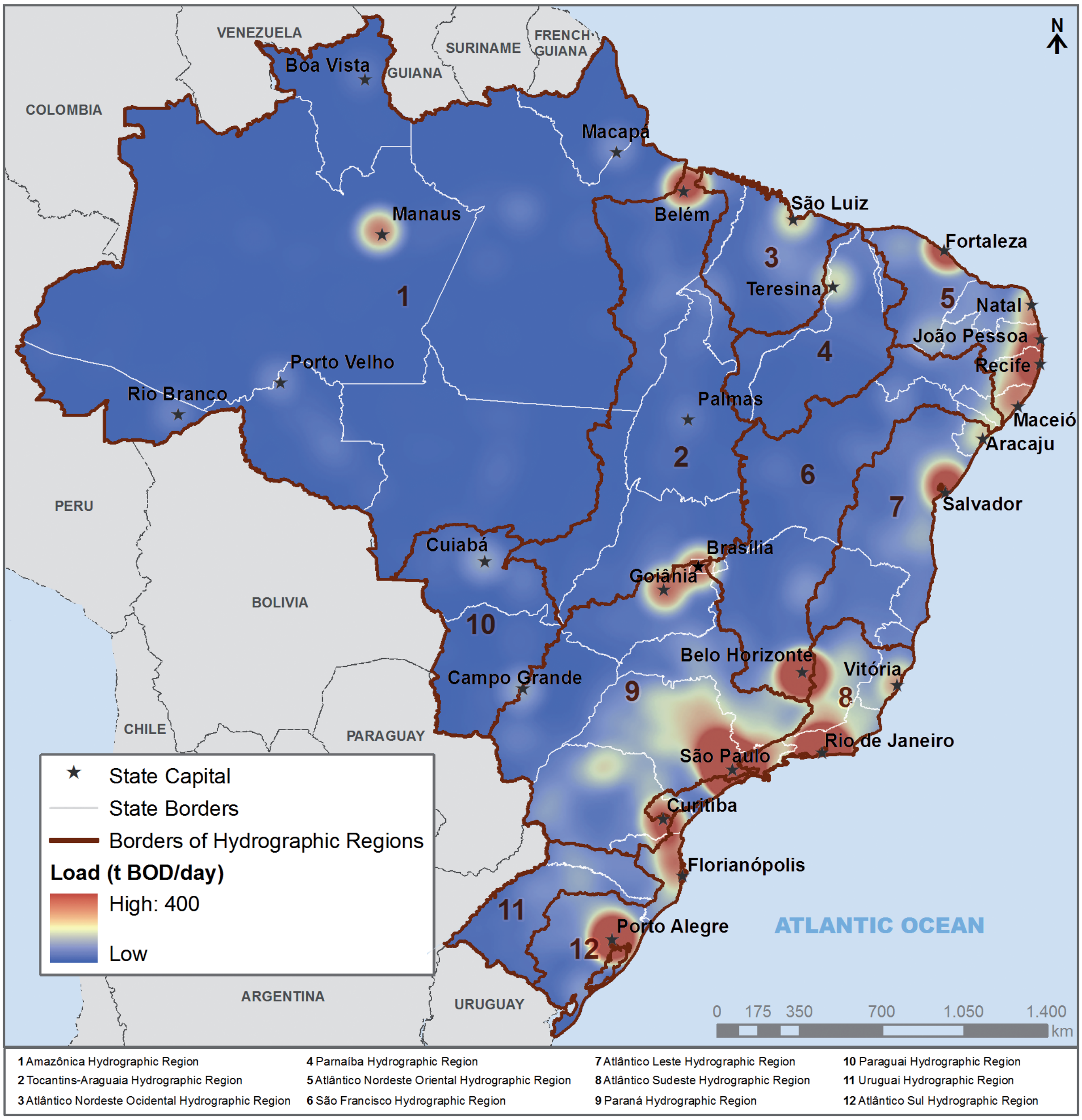
The Atlântico Sudeste HR has two critical hydrographic basins. The Paraíba do Sul river basin, with remaining domestic organic loads generated mainly in the municipalities of Juiz de Fora, in Minas Gerais; São José dos Campos, Taubaté and Jacareí, in the state of São Paulo; and Campos dos Goytacazes, Volta Redonda, Petrópolis, Barra Mansa, Nova Friburgo and Teresópolis, in the state of Rio de Janeiro. The other is the São Paulo / Rio de Janeiro Coastal basin, with the highest loads coming from the MRs of Rio de Janeiro and Baixada Santista.

In the São Francisco HR, the Velhas Basin is the most critical, due to loads from the MR of Belo Horizonte. In the Atlântico Nordeste Oriental HR the most critical is the Pernambuco Coastal basin, due to loads from the MRs of Recife and Caruaru.



Source: ANA (2011a) and PNSB/ (IBGE, 2008). Prepared by the authors

Figure 7 - Remaining Domestic Organic Load in 2008 and Average Flow of Hydrographic Regions



Source: PNSB/IBGE 2008 Prepared by the authors

Figure 8 - Remaining Domestic Organic Load - 2008

Industrial Effluents

In the industrial sector, water use may occur in several ways, both in the industrial process stages and in other parts of the organization. Except for the portions incorporated into the products and for losses, wastewater may be contaminated by different types of pollutants that cause changes in the quality of receiving waters.

Historically, pollution used to result from the inefficiency of industrial processes, coupled with the lack of treatment systems or the inefficiency of existing ones. The need to reconcile industrial production with environmental conservation has led to increased efficiency in production processes and improved systems for effluent treatment, with a view to minimizing the impact of the activity on receiving water bodies.

One of the main examples of significant reduction in industrial loads in Brazil occurred in the sugar and alcohol industry. Vinasse, an effluent left after sugar cane alcohol distillation, has high organic load and its release into rivers used to cause significant impacts, since it consumed dissolved oxygen thus causing mass fish kills. A solution to this problem was found in the 1980s, through the treatment and use of vinasse as a fertilizer in sugar cane cultivation, a process known as fertirrigation.

Environmental control systems are implemented in large industries due to requirements for environmental licensing, as well as for economic and competitiveness reasons, since the socio-environmental responsibility of companies is being increasingly demanded by consumers.

However, in some sectors, especially those represented by small industries, the problem is more critical and more difficult to be solved due to greater economic restrictions for implementing production processes that are less harmful to the environment. Examples include small tanneries, dye houses and slaughterhouses among others.

Urban Solid Waste

According to the document Overview of Solid Waste in Brazil in 2010, the comparison of data from 2009 vs. 2010 shows a significant increase in the generation of municipal solid waste (6.8%), surpassing the urban population growth rate recorded by the IBGE census 2010, which was approximately 1%. On the other hand, municipal solid waste collection grew 7.7% over the same period, indicating a slight improvement in collection services. In turn, the percentage of proper disposal grew less than 1%, with a consequent increase in the amount of municipal solid waste disposed of improperly (ABRELPE, 2010).

Consequently, the amount of urban solid waste improperly disposed of has increased, resulting in damage to the environment, including the water resources. According to the Brazilian Association of Urban Cleaning and Hazardous Waste Collection and Treatment Companies (ABRELPE) of the slightly over 54 million tons of urban solid waste collected in 2010, almost 23 million tons (42.4%) were disposed of in dump yards or controlled landfills (ABRELPE, 2010).

An analysis of the data contained in the Sanitation Atlas shows that the highest amounts of solid waste are found in Paraná, Atlântico Sudeste e Atlântico Nordeste Oriental Hydrographic Regions, which account for about 68% of the country's total, or an estimated volume close to 67 million tons of waste in 2008 (IBGE, 2011).

There are many places in the country where urban solid waste is disposed of in open dumps. In the Paraná, Atlântico Sudeste, Uruguai and the Atlântico Sul Hydrographic Regions, the situation is slightly better because the locations are already using sanitary or controlled landfills as a solution for the final disposal of urban solid waste. In the other HRs, sanitary landfills are found in some larger cities.

A similar situation occurs in relation to the selective collection of urban solid waste, where according to data from the 2008 PNSB, only 18% of municipalities offer this type of service on a regular basis, especially in the Paraná, Atlântico Sudeste, Atlântico Sul and Uruguai HRs (IBGE, 2008).

Diffuse Pollution in Urban Areas

In urban areas diffuse pollution is characterized by the runoff of pollutants deposited on streets, parking lots and other surfaces. Among these pollutants is waste from fuel, brake pads, tires, oils and greases produced by motor vehicles, in addition to solid waste (e.g. plastic bottles), sediment, pet waste, construction waste, pesticides used in parks and gardens and air pollutants that are deposited on urban surfaces.

The variety of diffuse sources of pollution is quite diversified. When washed away by rain water, these pollutants can have various impacts such as siltation of water bodies and toxic effects on the aquatic community. This diffuse load can be significantly high in some urban basins. In countries where the issue of domestic and industrial sewage has already been solved, diffuse pollution in urban areas is a major issue concerning pollution control.

4.2 Rural Environment

Deforestation and Improper Soil Management

The quality of surface freshwater is directly related to the percentage of vegetation in the river basin. The removal of vegetation without the use of soil conservation techniques can lead to erosion, causing the loss of fertile soils and degradation of waterways. This diffuse pollution in agricultural areas is a major water quality problem in rural basins.

The main consequence of this process is the release of sediment into water bodies, which may be associated with fertilizers and pesticides where these are used without proper technical control, causing siltation and affecting water quality. Siltation reduces the useful life of reservoirs used for power generation or domestic supply.

The Paraná, Atlântico Leste, Atlântico Sudeste and Uruguai hydrographic regions are the ones with the largest amount of deforested areas (Figure 9). In the Amazon Region, deforestation is concentrated in the southern portion, in the area known as the “Arc of Deforestation”, affecting the headwaters of the Tapajós, Madeira and Xingu basins. In the Paraguai HR, deforestation is concentrated at the edges, where the headwaters of major rivers in the Pantanal region are located.

Data Source: INPE e MMA. Prepared by the authors

Figure 9 - Status of Native Vegetation

Fertilizers

Agricultural fertilizers can be a source of pollution of surface and ground water bodies, when unsuitable agricultural practices and deforestation of riparian vegetation increase surface runoff. The runoff of fertilizers containing phosphorous can cause the eutrophication of surface freshwater bodies, and the nitrogen can contaminate groundwater.

The states with higher use of fertilizers in the country are those in the Southeast, South and Central-West regions, where intensive agriculture prevails (Figure 10a). The river basins in these states need to be constantly monitored, with a view to determining the trophic degree of their water bodies.

The majority of the phosphorus lost in agricultural soils is caused by surface runoff, and erosion control is the best way to minimize its impact on water quality. In Brazil, the annual loss of soil caused by erosion in crop and pasture areas is about 822 million tons (HERNANI *et al*. 2002 *apud* PRUSKI 2002, 2006).

The data available do not enable quantifying the impact of the phosphorus load from fertilizers in relation to other sources (domestic sewage, industries, etc). However, the experience of other countries that significantly reduced domestic and industrial phosphorus loads shows that achieving lower levels of phosphorus in water bodies also requires reducing this diffuse source of agricultural origin.

Pesticides

Depending on their chemical features as well as on agricultural practices and environmental features, pesticides can reach surface and ground water bodies through transport by rain water or atmospheric deposition. Specific sources such as accidental spills during the manufacturing and transport operations or the improper disposal of pesticide containers also represent a potential source of water body contamination.

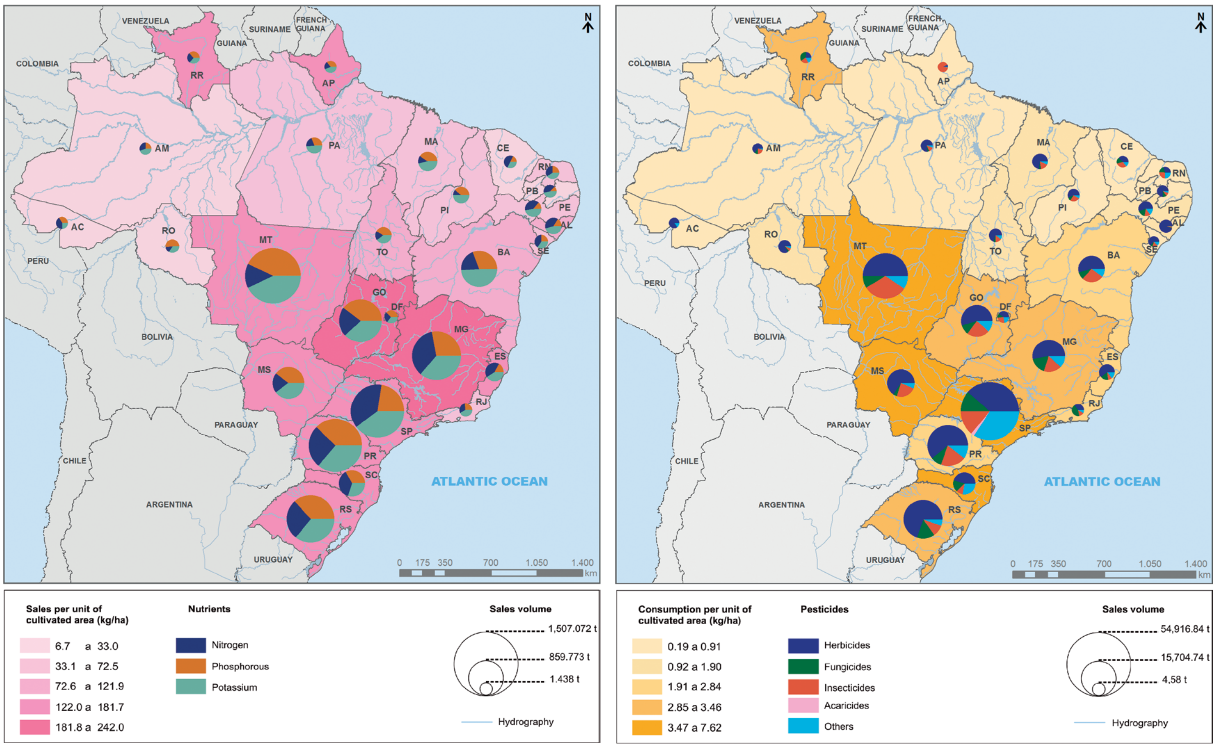
According to their physicochemical and toxicological characteristics as well as concentration, persistence and time of exposure, pesticides can cause adverse effects on human health and the environment. For this reason, pesticides should be evaluated prior to production, marketing and use. Furthermore, registration of these products following an evaluation by federal health, environmental and agricultural agencies is mandatory. The aim of this evaluation is to identify potential adverse effects, with a view to determining prohibitions, restrictions and recommendations on the use of pesticides (IBAMA, 2010).

In 2008, Brazil became the largest consumer market for pesticides in the world, with sales of these products worth US$7,125 billion, an amount higher than the US$6.6 billion reported by the runner-up, i.e., the United States (ANDEF, 2009 *apud* IBAMA, 2010). In 2010, the domestic market of pesticides (formulated products) reached about 790,000 tons, with 1,516 registered trademarks comprising 369 active ingredients (MAPA, 2012).

The data available on the use of pesticides are from 2005 and show that 80% of pesticide use throughout the country occurred in six states (São Paulo, Mato Grosso, Paraná, Rio Grande do Sul, Minas Gerais and Goiás), with four crops accounting for about 75% of pesticide use in Brazil: soybeans (45.3%), corn (12.8%), sugarcane (9.5%) and cotton (7.8%) (IBGE, 2010c). Herbicides stand out in the groups of most commonly used pesticides. This general scenario of use pattern probably has not changed significantly in recent years, except for those crops where there has been either a decrease or increase in cultivated areas (Figure 10b).

A study carried out by EMBRAPA using the Goss method evaluated 236 active ingredients in 450 commercial pesticides registered for use in Brazil, in relation to the potential for transport into surface and ground water. In the case of surface water, 28 active ingredients showed high potential for transport associated with suspended sediment in the water, and 53 had high potential to be transported dissolved in the water (EMBRAPA, 2007).

Among the active ingredients in pesticides most commonly consumed in Brazil in 2009 (Figure 11), those that in the EMBRAPA study showed high or medium potential to reach water bodies, either dissolved in water or associated with sediments,



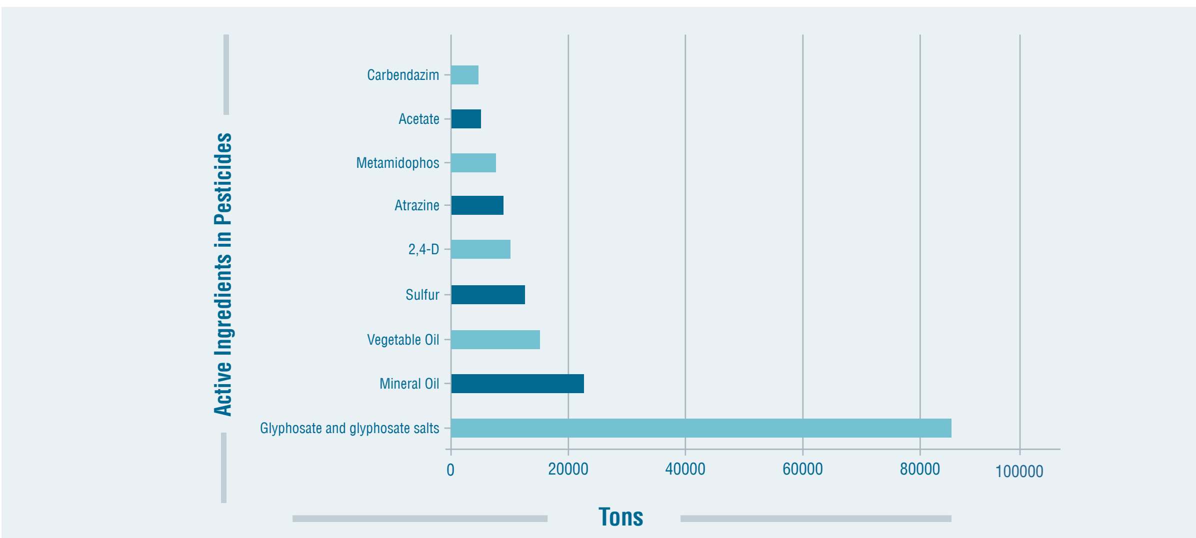
Source: IBGE (2010b).

Figure 10 - (a) Sales of Fertilizers in Federative Units in 2008
(b) Consumption of Pesticides in Federative Units in 2005

are Acephate, Atrazine, Carbendazim, Glyphosate, Methamidophos and 2.4-D. Due to their larger use and greater potential for transport into surface water, these active ingredients should be prioritized in monitoring programs. However, other pesticides less used on a national scale and with high potential for transport into surface waters may also have an impact on a regional or local scale (EMBRAPA, 2007).

Aquaculture

Aquaculture in Brazil has great potential for growth in inland waters. Currently, 100,000 tons of fish are produced each year and the estimated potential is 30 times greater. The prospective growth of Brazilian continental aquaculture is related to the increase in aquaculture areas, due to lower production costs



Source: IBAMA (2011).

Figure 11 - Active Ingredients in Top-Selling Pesticides in Brazil - 2009

and the availability of surface water in dams and multipurpose reservoirs (TUNDISI & MATSUMURA-TUNDISI, 2011).

Intensive aquaculture has led to numerous fish breeding projects under a high density storage method, namely the net-cage fish farming system. In this system, fish feed is the main food source. Consequently, net-cage breeding, unless based on technical criteria, can release feed waste from fish metabolism into the environment, increasing the release of nitrogen and phosphorus into the water and causing eutrophication of water bodies, in addition to drugs used in disease control. In this sense, aquaculture projects in water bodies should be implemented under technical criteria and water quality in the areas of influence of the projects should be monitored.

Intensive Animal Breeding

Intensive animal breeding, when concentrated and noncompliant with environmental control criteria, may cause water pollution through the presence of high organic loads and thermotolerant coliforms in the liquid waste released into water bodies.

This waste can be used as fertilizer, but in many cases small breeders have no infrastructure to store, transport and distribute these effluents and thereby end up dumping them into water bodies.

In the western region of Santa Catarina, in the Chapecó, Antas, Peperi-Guaçu, Irani and Jacutinga basins, the high concentration of swine farms has led to the development of a Term of Conduct Adjustment to reduce their impact on the environment.

4.3 Other Sources of Pressure on Surface Freshwater Quality

Besides the previously mentioned pressures relating to urban and rural areas, water bodies are also subject to other impacts that deserve attention for their nature and scope.

Mining and Prospecting

Water is present in mining activities, usually in large volumes, whether in mineral research, prospecting, processing, transportation by ore pipeline or other handling and processing infrastructure. As a result, a series of impacts may occur in terms of water quality, such as increased turbidity, change in water pH, oil, grease and heavy metal spills, reduced dissolved oxygen and siltation of rivers, among others.

Coal mining can compromise the quality of water resources, with significant impacts on aquatic ecosystems, as is the case in the southern region of Santa Catarina. Soil and water degradation occurs as a result of the acid mine drainage produced when sulfurrich waste is exposed to the action of air and rain.

The presence of mercury in water is caused mainly by mining, especially clandestine gold mines. In the exploitation on both river beds and hillsides and dry land, mercury is used to separate gold particles through the amalgamation process. Open burning and precipitation lead to the release of large amounts of mercury vapors into the air and water respectively. The conditions of rivers in the Amazon region favor the formation of methylmercury, which accumulates in the aquatic food chain. The consumption of fish contaminated with mercury poses a risk to human health (ANA, 2010a).

Sand mining for construction purposes also affects water quality. According to the National Department of Mineral Production (ANP), about 70% of the sand used in Brazil is extracted from river beds. In the country there are about 2,500 companies engaged in the sand production, most of which are small family businesses. This activity is concentrated near urban centers, which are the main consumer market of this material. Among the impacts of sand mining on water bodies are increased turbidity, eutrophication of waters in abandoned pits, pollution by oil and grease and changes in river channels (DNPM, 2007).

Salinization

High levels of dissolved minerals are found in surface and ground water bodies in the semiarid region, comprising mainly the Atlântico Nordeste Oriental and São Francisco HR. The salinity of the waters restricts or even prevents certain uses such as human supply, livestock watering and irrigation (BRASIL, 2006b). Salinity is owed mainly to the semiarid climate of the region - since evaporation exceeds precipitation - and to the geology. The process of progressive salinization of reservoirs is also due to the operational system, since the higher residence time of water increases both evaporation and the concentration of dissolved salts (ANA, 2005a).

Environmental Accidents

Since 2006, reports of environmental accidents have shown that road transport of hazardous products is the major cause of accidents. Therefore, the worst cases occur in areas with high concentration of Industrial centers, concomitant with the presence of an extensive road network, given the predominance of road use in the Brazilian transport matrix, including for the distribution of production generated mainly by the chemical, petrochemical and oil refining industries (IBAMA, 2011).

Besides the accidents associated with transport activities, other events such liquid spills, gas leakages, release of solids, abandoned chemical packages, explosion/fire, rupture of tanks, pipes, among others, may occur during the production, handling and storage of hazardous products.

Brazil has been the setting of some serious accidents, such as the leakage of toxic substances at an industrial waste dam in March 2003 and the accident involving the endosulfan pesticide in November 2008, both in the Paraíba do Sul River Basin. In most cases, the effects of accidents such as these were felt miles away from the focal area, disturbing not only the aquatic ecosystem but also the population at large, due to the disruption of domestic supply.

Waterborne transport can also represent a potential pressure as regards the risk of accidents with impacts on water quality. Although relatively underused in Brazil, this mode of transport is indispensable in the Amazônica HR. The risk of accidents associated with the transport of hazardous cargo through water-ways and the effluents generated by waterborne transport can locally compromise water quality if not properly managed.

Reservoirs

In Brazil there are about 7,000 reservoirs with an area above 20 hectares, which were built to ensure a regular and continuous supply of water for human consumption, irrigation and power generation (FUNCEME, 2008). The main pressures on the quality of these reservoir waters are related to physicalchemical and ecological processes resulting from the reduction in water flows.

Among the different situations that may occur in relation to the implementation of reservoirs, the following can be observed:

- Decrease in dissolved oxygen; water acidification; and release of gases such as carbon dioxide and methane due to decomposition of organic matter submerged during construction of the reservoir;
- Vertical stratification and creation of a lower layer with low levels of dissolved oxygen, rich in nutrients and sometimes acidified in reservoirs with greater depth;
- The eutrophication process, which results from the excessive release of nutrients, especially phosphorus, usually from tributaries already affected by domestic sewage or diffuse pollution. This process can cause the growth of algae and aquatic plants, which can give water an unpleasant taste and odor, thus increasing losses by evapotranspiration and hampering navigation, recreation and the operation of the reservoir itself.

Another impact of reservoirs on water quality occurs by the trapping of sediments and nutrients, which reduces their contribution to downstream stretches.

The construction of reservoirs in Brazil is on the rise as a result of the demands generated by economic growth and the needs to store water for human consumption. The criteria for the planning, construction, operation, regulation and management of these undertakings should not lose sight of the social, economic and environmental dimensions.

Critical Events

In addition to the traditional sources of pollution, extreme natural events such as periods of prolonged drought and heavy rains also contribute to the deterioration of water quality in Brazil.

Reduced flows in various water bodies during drought periods have led to supply problems, among others. The Amazon drought of 2010 was the worst of the last one hundred years and affected an area of three million square kilometers, larger than that affected by the drought of 2005, hitherto considered the worst in decades. Riparian communities in some regions of the Amazon faced hardships, because rivers and streams reached below-normal levels and thousands of families suffered from lack of water.

Introduction of Exotic Species

The intentional or accidental introduction of exotic species represents a significant impact, as it may affect the food chain and the productivity of aquatic ecosystems. Altogether, 1,593 occurrences of invasive exotic species have been identified in freshwater environments in Brazil, totaling 180 species, with fish as the largest group, followed by microorganisms (19 species) and macrophytes (14 species) (BRASIL, 2011f).

One of the main examples of the introduction of species in freshwater environments in Brazil is the invasion of the bivalve mollusk *Limnoperna fortunei,* popularly known as golden mussel. Originally from Asia, the golden mussel arrived in South America transported in the ballast waters of merchant ships, and quickly invaded the River Plate basin. Today it is found in the Paraná, Paraguai and Atlântico Sul Hydrographic Regions.

With high reproduction rates and non-migratory and gregarious habits, this mussel sticks to any hard substrate and because of the absence of predators and parasites to control their population, rapidly invade free surfaces. The impacts of the presence of this species range from ecological to economic consequences in the use of water resources, as they invade pipes used for water supply, rain drainage and agricultural irrigation as well industrial cooling systems, power plant turbines, in addition to causing damages to the operation of motor boats and the loss of netcages.

4.4 Emerging Issues

Climate Change

Over the next decades, climate change can be an important factor of change in water quality. The rise in surface water temperature decreases the amount of dissolved oxygen, with effects on its self-purification ability. In basins where an increase in rainfall is expected, diffuse pollution might also increase as a result of stormwater runoff pollutants (nutrients, pathogens, toxins) (IPCC, 2007).

On the other hand, in basins with reduced rainfall the decrease in river flows can reduce their ability to assimilate pollutants. In coastal areas, the rise in sea level could increase saltwater intrusion, changing the quality of surface and ground water. The systematic monitoring of water bodies will become increasingly important to follow up the effects of climate change on water quality, as a way of contributing to management, adaptation actions and reducing vulnerability (IPCC, 2007).

The prospect of longer droughts and heavier rains for shorter periods contained in the IPCC study make increasing the storage capacity of reservoirs a requirement to ensure water security.

Persistent Organic Pollutants

Persistent Organic Pollutants (POPs) are chemical substances of high persistence, with carcinogenic and mutagenic properties and wide geographical distribution, which remain in the ecosystems for long periods of time and accumulate in the fatty tissue of living organisms, with possible harm to human and animal health and the environment.

Currently, the list of POPs includes eight pesticides (Aldrin, Chlordane, DDT, Dieldrin, Endrin, Hexachlorobenzene, Mirex, Toxaphene), two industrial products (Polychlorinated Biphenyls - PCBs and Heptachlor) and two substances unintentionally formed in some industrial processes, especially during the combustion of organic matter in the presence of chlorine (Dioxins and Furans).

The main source of dioxins and furans in Brazil is the production of ferrous and non-ferrous metals, followed by open burning, chemicals and consumer goods and the disposal of effluents and waste. Therefore, reducing emissions should be a priority action in these source categories (BRASIL, 2012).

With respect to the compartment dioxins and furans are released into, the highest amounts were found are released in the air (42.3%), followed by waste disposal (24.4%), and products disposal (18.7%). These three compartments receive 95.4% of total releases. Only 1% of dioxins and furans in the country are released directly into the water, which is the least significant compartment as regards directly receiving these compounds (BRASIL, 2012).

Although the proportion of dioxins and furans released directly into the water in the country is less significant in relation to other compartments (BRAZIL, 2012), it is important to note that these pollutants released directly into the air or soil may reach the water bodies indirectly, through processes such as atmospheric deposition and runoff by rainwater.

The main activities that may contribute to the direct release of dioxins and furans into water bodies are pulp and paper production and the discharge of untreated effluents into surface waters. Treatment processes and the disposal of treated sewage also release these pollutants directly into water bodies (BRASIL, 2012).

With respect to PCBs, their production and marketing have been prohibited since 1981, but capacitors and transformers containing PCBs are still in use, thus contributing to the release of these contaminants into the aquatic environment (ALMEIDA *et al.*, 2007).

Endocrine Disruptors

Endocrine disruptors are a group of exogenous substances capable of interfering with the physiological functions regulated by hormones, thereby compromising the health of organisms exposed to their action. Several substances have this effect, including natural and synthetic estrogens, plasticizers, polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs) and pesticides.

Endocrine disruptors found in water bodies come from point sources (e.g. domestic sewage, industrial effluents) or diffuse sources (e.g. pesticides). Typically, endocrine disruptors are detected at very low concentrations in rivers and springs. However, their adverse effects may occur even at low concentrations, since small hormonal variations are sufficient to trigger an endocrine reaction.

Water bodies that cross large urban centers receiving domestic sewage from a large population are more subject to contamination by these endocrine disruptors. Water contamination through the release of domestic sewage, whether treated or not, containing hormones and drugs excreted by humans has become a concern.

The development of scientific research on this topic can make important contributions to the more effective control of these contaminants, either through the use of sanitation technologies or regulation of their production and use through more comprehensive legislation.

Zig Koch/Image Bank ANA

São Francisco River in Petrolina

5 DIAGNOSIS OF SURFACE FRESHWATER QUALITY

The diagnosis of surface freshwater quality and its trends for the period 2001-2010 presented below are based on the information available in the monitoring networks of the Units of the Federation. This is not a complete diagnosis of surface freshwater quality in the country, since several states mainly in the Amazônica HR do not have monitoring networks yet. In this sense, ANA has been developing, together with the states, the National Water Quality Evaluation Program, with the aim to expand the monitoring networks and standardize their procedures.

Despite the limitations of existing monitoring networks, a diagnosis such as this, which is based on information available, is important to indicate the needs to enhance monitoring, with a view to ensuring more complete diagnoses in the future.

5.1 Water Quality Index

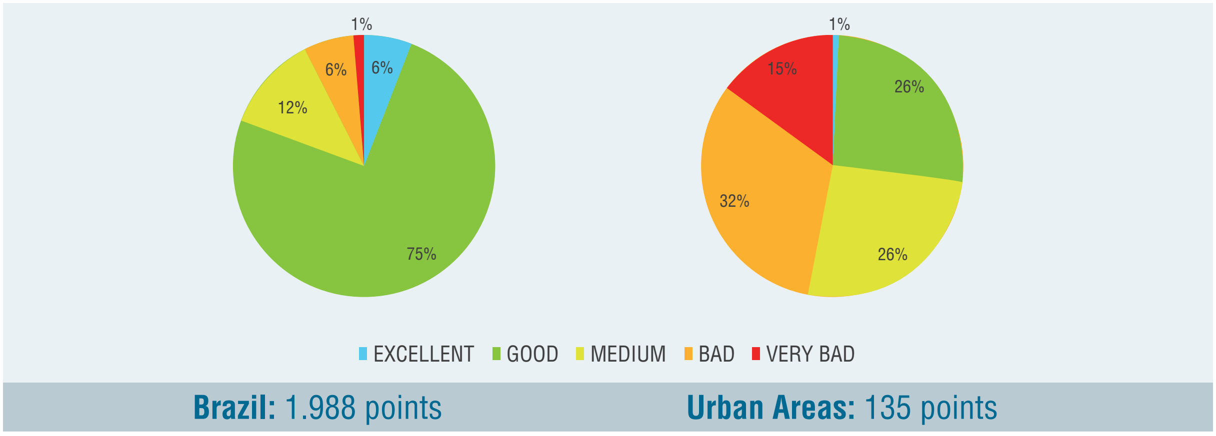
Considering the 1,988 points monitored in the country in 2010 for which it was possible to perform the WQI assessment both in urban and rural areas, 6% of the points monitored were found to be in “excellent” condition; 75% in “good” condition; 12% in “medium” condition; and 7% in “bad” or “very bad” condition (Figura12).

The assessment of water bodies in urban areas alone shows that in 2010, 47% of the points monitored were in “very bad” or “bad” condition, a reflex of the country’s high urbanization rate as well as of the low levels of collection and treatment of domestic sewage.

The basins of these urban rivers are for the most part usually impermeable, polluted by domestic sewage, industrial effluents, solid waste and diffuse loads that impact the quality of life in Brazilian cities, as they degrade the urban landscape, reduce leisure opportunities and enable the transmission of diseases.

Water bodies which in 2010 showed monitoring points with “bad” and “very bad” WQI are located near capital cities (São Paulo, Curitiba, Belo Horizonte, Salvador, Goiânia, Vitória) or near medium and large cities (e.g. Campinas, Juiz de Fora) (Figure 13).

Likewise, most points (61%) with “bad” and “very bad” WQI are concentrated on the Paraná Hydrographic Region, which holds 32% of the domestic organic load of in the country. The cities of São Paulo, Curitiba, Goiânia and Campinas are located in this Hydrographic Region, and the first three are located in the headwaters of rivers Tietê, Iguaçu and Meia Ponte respectively. This fact actually ends up worsening the situation of water quality, since the headwaters of rivers have less flow and therefore reduced capacity to dilute pollutant loads. The same situation occurs in Belo Horizonte, which is located in the upper portion of the Velhas river basin, in the São Francisco Hydrographic Region.



Sources: ADASA (DF), AGUASPARANÁ (PR), CETESB (SP), COGERH (CE), CPRH (PE), FEPAM (RS), IAP (PR), IEMA (ES), IGAM (MG), IGARN (RN), IMA (AL), IMASUL (MS), INEA (RJ), INEMA (BA), SANEATINS (TO), SEMA (MT), SEMARH (GO), SUDEMA (PB).

Note: Points in urban areas are located in 35 municipalities and were identified based on a map of built environment, Ministry of Planning, Budget and Management (BRASIL, 2009c).

Figure 12 - Water Quality Index (WQI) - Mean value in 2010 in Brazil and Urban Areas

Sources: ADASA (DF), AGUASPARANÁ (PR), CETESB (SP), COGERH (CE), CPRH (PE), FEPAM (RS), IAP (PR), IEMA (ES), IGAM (MG), IGARN (RN), IMA (AL), IMASUL (MS), INEA (RJ), INEMA (BA), SANEATINS (TO), SEMA (MT), SEMARH (GO), SUDEMA (PB)

Figure 13 - Water Quality Index (WQI) – Mean Value in 2010

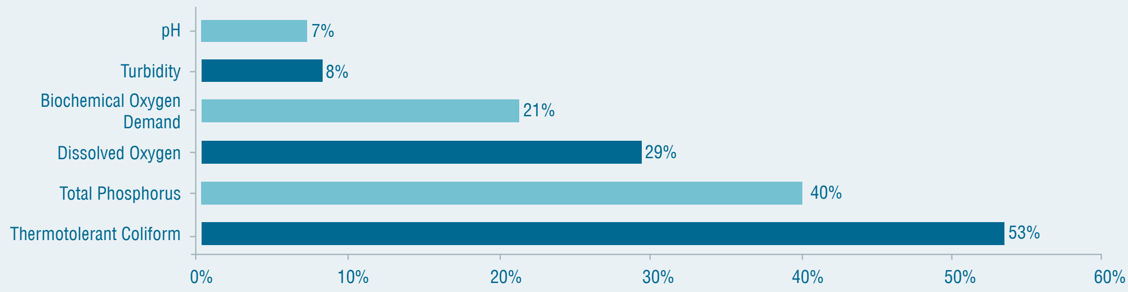
It is worth noting that several of these water bodies have water quality improvement programs, which are presented in Section 6.4. Monitoring the condition of these water bodies over the years ahead is important to verify the effectiveness of water quality improvement initiatives.

The analysis of some of the parameters that make up the WQI (Thermotolerant Coliforms, Total Phosphorus, Dissolved Oxygen, Biochemical Oxygen Demand, Turbidity and pH) shows that, in 2010, 53% of the 8,019 analyses of Thermotolerant Coliforms were above the guideline (1,000 NMP/100ml) set forth in CONAMA Resolution 357/2005 (Figure 14).

Thermotolerant Coliforms are indicators of microbiological contamination and the possible occurrence of pathogens associated with waterborne diseases, thus affecting the use of these waters for various purposes such as primary contact recreation.

With respect to phosphorus, the percentage of analyses above the guideline (40%) is also high and will be analyzed more deeply in the item 5.2.

These two parameters (Thermotolerant Coliforms and Phosphorous) reflect mainly the lack of domestic sewage treatment in the country.



Sources: ADASA (DF), AGUASPARANÁ (PR), CETESB (SP), COGERH (CE), CPRH (PE), FEPAM (RS), IAP (PR), IEMA (ES), IGAM (MG), IGARN (RN), IMA (AL), IMASUL (MS), INEA (RJ), INEMA (BA), SANEATINS (TO), SEMA (MT), SEMARH (GO), SUDEMA (PB)

Note: The following numbers of samples were tested for each parameter: Dissolved Oxygen (8,379); pH (8,622); Turbidity (7,751); Thermotolerant Coliforms (8,019); Biochemical Oxygen Demand (8,383); Total Phosphorus (7,622).

Figure 14 - Percentage of Non-compliant Results in 2010 in Relation to the Quality Standards of Class 2 Water Bodies

Over the period 2001 – 2010, the number of monitoring points with WQI data more than doubled in the country, increasing from 708 to 1,989 points (Figure 15a).

Despite this increase, no significant change has been found in the ratio between WQI classes over this period, and classes good (between 67% and 75% of points) and medium (between 10% and 15%) have prevailed. The WQI classes very bad (between 1% and 3%), bad (6%-8%) and excellent (4%-9%) remained among the lower frequency classes during the entire period (Figure 15b).

Regarding the trend analysis of WQI values over the period 2001 - 2010, it was found that of the 658 points with historical data series, 92 showed a trend, with 47 points with a trend towards water quality improvement (increased WQI) and 45 with a trend towards water quality worsening (reduced WQI).

Sources: ADASA (DF), AGUASPARANÁ (PR), CETESB (SP), COGERH (CE), CPRH (PE), FEPAM (RS), IAP (PR), IEMA (ES), IGAM (MG), IGARN (RN), IMA (AL), IMASUL (MS), INEA (RJ), INEMA (BA), SANEATINS (TO), SEMA (MT), SEMARH (GO), SUDEMA (PB)

Figure 15 - Evolution of the Water Quality Index in Absolute Numbers of Monitoring Points (a) and in Class Percentages (b) in the Period 2001 to 2010.

Of the 47 points showing a trend towards WQI increase, 25 are in the Paraná HR, mainly in the state of São Paulo (24 points). Of the remaining 22 points, 17 are in the Atlântico Sudeste HR, mostly in the Paraíba do Sul river basin (10) and on the northern coast of São Paulo (4), and five points are in the São Francisco HR, in the Velhas river basin (Figure 16).

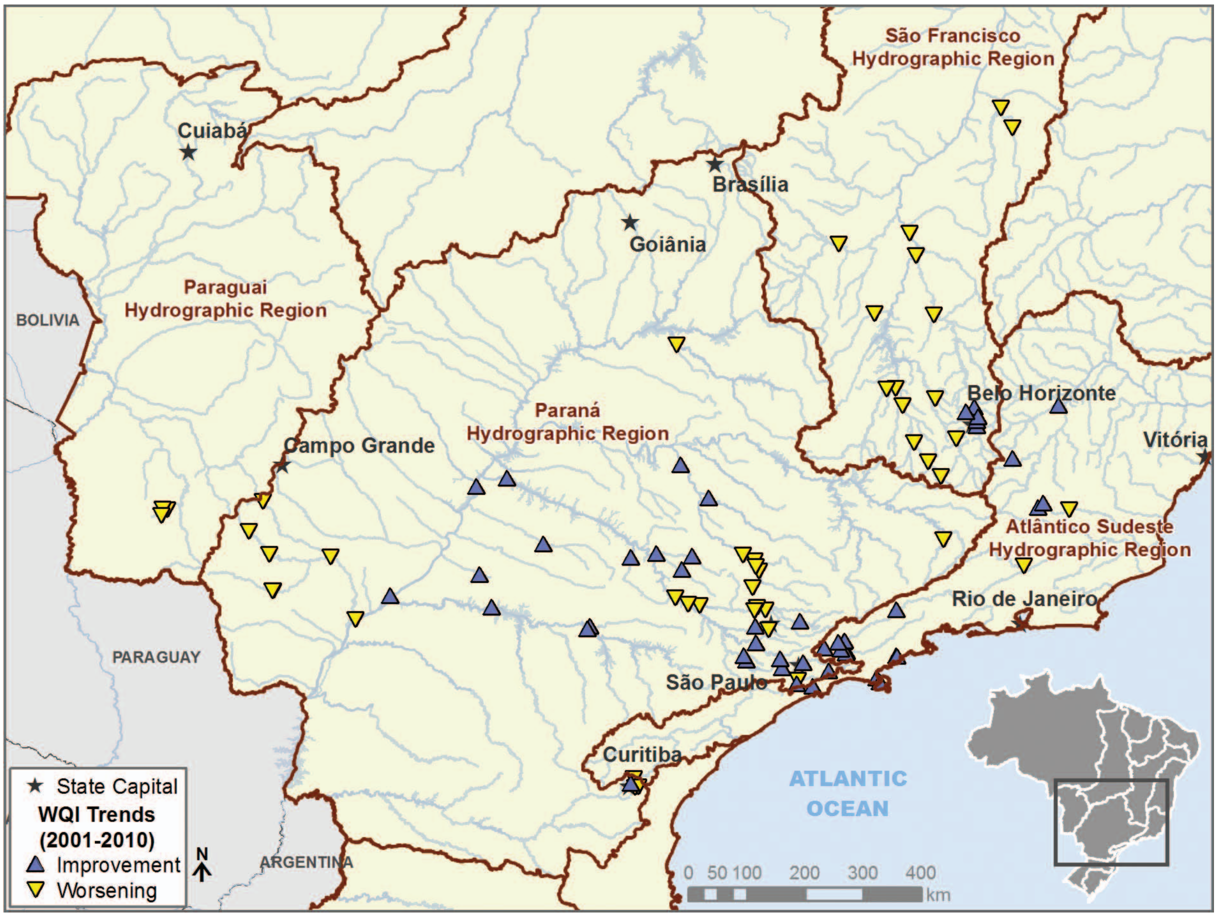
The main cause behind the increase in WQI identified by state management agencies is the investment in sanitation, through actions such as expansion of sewage collection systems, implementation of Sewage Treatment Plants (STP) or their increased efficiency, and the closing of open dump yards. The control of industrial sources and increased reservoir outflows are also factors listed as probable causes of quality improvement.

Among the basins where sanitation measures are the likely cause of increased WQI are the basins of rivers Velhas, Sorocaba, Piracicaba, Jundiaí, Capivari and Paraíba do Sul, where Sewage Treatment Plants have been built under the River Basin Decontamination Program (PRODES). Also noteworthy are the sanitation actions carried out by the Sanitation Company of the State of São Paulo (SABESP) in various basins in the state (Upper Tietê, Paraíba do Sul, Baixada Santista, Cotia) that showed an increase in WQI.

Of the 45 points with a trend towards a reduction in WQI, the majority (27) is located in the Paraná HR, particularly on the basins of rivers Tietê (8 points), Ivinhema (7 points) and Grande (6 points). In the São Francisco HR, 15 points with a tendency towards a reduction in WQI were identified, especially in the Pará River basin (5 points) (Figure 16).

Among the main probable causes of the reduction in WQI identified by state management agencies are population growth - which has not been accompanied by investments in sanitation, industrial sources and agricultural and mining activities.

In general, the points with a tendency towards an increase in WQI are those in the very bad, bad and medium categories and are located close to urban



Sources: AGUASPARANÁ (PR), CETESB (SP), IAP (PR), IGAM (MG), IMASUL (MS)

Figure 16 - Trends in Water Quality Index (WQI) in the Period 2001-2010

centers that received investments in sanitation and control of industrial effluents. Examples are the Tietê and Velhas rivers.

On the other hand, points with a tendency towards a reduction in WQI in most cases show a good quality condition and are generally located in basins with high population growth or significant increases in industrial and agricultural activities. Examples are the Ivinhema and Pará rivers.

These data indicate the need to enhance monitoring and deepen the trend analysis, in order to quantify the impacts of pollution sources and the effectiveness of management actions on water quality. Analyses of this type will be important over the coming years, vis-à-vis the prospect of increased investment in sanitation in the country and the need to follow-up the implementation of water quality objectives.

5.2 Trophic State Index

Eutrophication is a process characterized by the increase of nutrients in water bodies, especially phosphorus and nitrogen, which can cause the growth of algae and other aquatic plants. Untreated sewage and fertilizers are the major cause of artificial eutrophication. Eutrophication is an environmental problem that affects aquatic biodiversity, human health and multiple water uses, causing environmental and economic damages.

Eutrophication is particularly more common and more pronounced in water bodies of reduced flow, such as lakes and reservoirs. These environments are known as lentic environments, as opposed to higher flow environments such as rivers, known as lotic environments.

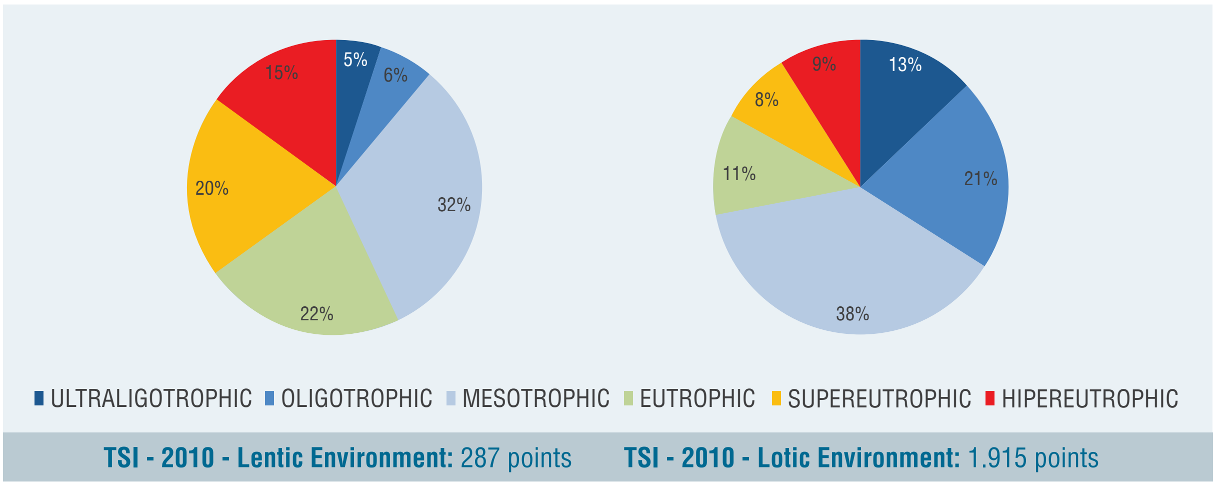
Considering the lentic (287 points) and lotic (1915 points) environments, it is obsreved that the situation is more critical in lentic environments, where 57% were in the “eutrophic”, “supereutrophic” and “hypereutrophic” classes, while in lotic environments this percentage stands at 28% (Figure 17).

The Paraná HR has the highest concentration of points with Trophic State Index in the “supereutrophic” and “hypereutrophic” classes, about 39% of the total (167) points. Of these points, 80 are in the “hypereu-trophic” class, mainly in water bodies close to large urban clusters (Figure 18).

Figure 19 shows the evolution of TSI between 2001 and 2010.

The main impact of eutrophication of water bodies are algae blooms. Several episodes have been recorded in Brazil over the past years, causing impacts on multiple water uses.

Two cases can be mentioned as examples: in 2006, toxic algae blooms in the Foz de Areia reservoir, in the Iguaçu River basin, led to the banning of fishing



Sources: ADASA (DF), AGUASPARANÁ (PR), CETESB (SP), COGERH (CE), CPRH (PE), FEPAM (RS), IAP (PR), IEMA (ES), IGAM (MG), IGARN (RN), IMA (AL), IMASUL (MS), INEA (RJ), INEMA (BA), SANEATINS (TO), SEMA (MT), SEMARH (GO), SUDEMA (PB)

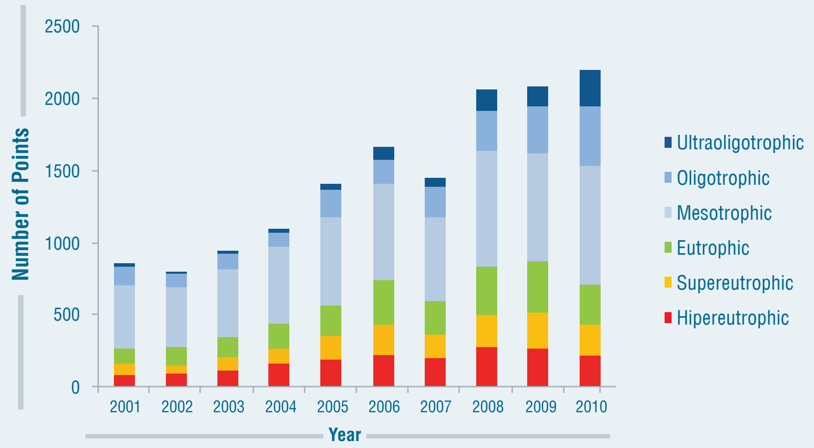
Figure 17 - Percentage of Monitoring Points in Trophic State Index (TSI) Classes in 2010 by Type of Environment

Sources: ADASA (DF), AGUASPARANÁ (PR), CETESB (SP), CPRH (PE), FEPAM (RS), IAP (PR), IEMA (ES), IGAM (MG), IGARN (RN), IMA (AL), IMASUL (MS), INEA (RJ), INEMA (BA), SANEATINS (TO), SEMA (MT), SEMARH (GO), SUDEMA (PB)

Figure 18 - Trophic State Index (TSI) in 2010

and swimming. The Environmental Institute of Paraná (IAP), the Electricity Company of Paraná (COPEL) and the Sanitation Company of Paraná (SANEPAR) warned the population close to the margins of the reservoir to avoid contact with water as well as the consumption of fish from the reservoir and tributary rivers.

In 2007, the Water Management Institute of Minas Gerais State (IGAM) confirmed the presence of cyanobacteria in the Velhas river, in the area between Curvelo and the mouth of the São Francisco river. Fishing in the Velhas and São Francisco rivers was banned until the beginning of the spawning season in November, due water contamination, which posed a risk to the health of the populations of some 60 cities in the Central and Northern portions of the State. A warning was also issued by the State Health Secretariat for people to avoid using water and consuming fish in all municipalities where quality testing points indicated a critical situation.



Sources: ADASA (DF), AGUASPARANA (PR), CAESB (DF), CETESB (SP), COGERH (CE), CPRH (PE), FEPAM (RS), IAP (PR), IEMA (ES), IGAM (MG), IGARN (RN), IMA (AL), IMASUL (MS), INEA (RJ), INEMA (BA), SANEATINS (TO), SEMA (MT), SEMARH (GO), SUDEMA (PB)

Figure 19 - Trophic State Index - Evolution in the Number of Monitoring Points from 2001 to 2010

In 2005, CONAMA Resolution 359 (BRASIL, 2005) regulated the phosphorus content in powder detergents for use throughout the national territory. According to data reported by manufacturers to IBAMA, the release of phosphorus in the environment in the period 2005 - 2008 fell from 40.5 tons / day to 31.8 tons / day.

This resolution established a working group to identify strategic monitoring points and follow up compliance with the resolution by manufacturers. The group's report recognized that the resolution represented a breakthrough in the preventive control of pollution in the country's water bodies and that the producers of powder detergent for household use have met the established requirements. (BRASIL, 2010c).

However, data available from the monitoring networks evaluated by the working group did not enable isolating phosphorus in powder detergents from other phosphorus sources (domestic sewage and diffuse load from agricultural areas). In addition, other variables such as levels of sewage treatment, population growth and the economic context of the country interfere in phosphorus levels in water, hindering an assessment of the environmental gain achieved by the resolution alone. (BRASIL, 2010c).

Significant reductions in phosphorus levels in water bodies in Europe were achieved after the sewage treatment was raised to the tertiary level and phosphorus was banned from detergents. In the period 1992-2008, 42% of monitoring points in EU Member States showed a trend towards a reduction in phosphorus levels (EEA, 2010).

It should be pointed out that the main sources of the phosphorus found in water bodies are domestic sewage and diffuse pollution from agricultural areas. Depending of the characteristic of the basin (agricultural, urban), these sources represent a larger or smaller contribution, and consequently management actions should be different.

Trend data on TSI in the period 2001 - 2010 indicated 43 points with a trend towards water quality improvement (reduced TSI) and 26 with a trend towards worsening (increased TSI) (Figure 20). It is not possible to determine whether the predominance of points with a TSI reduction is related to the enforcement of CONAMA Resolution 359/2005,since other factors may also have had an influence in this reduction such as the establishment of Sewage Treatment Plants. This issue should be investigated over the coming years in order to verify the effectiveness of management actions regarding phosphorus levels in surface waters.

Sources: AGUASPARANÁ (PR), CETESB (SP), FEPAM (RS), IAP (PR), IGAM (MG), IMASUL (MS), INEA (RJ), SEMARH (GO)

Figure 20 - Trends in Trophic State Index (TSI) in the Period 2001-2010

5.3 Index of Attainment of Water Quality Objectives

Unlike WQI and TSI, which assess water quality in relation to specific aspects, the Index of Attainment of Water Quality Objectives, or ICE, assesses the gap between current water quality and the water quality objectives. These water quality objectives does not necessarily reflect current water quality, but rather the water quality that should exist for meeting the intended uses in the water body.

Since water quality objectives are established by classes with different levels of quality, the same monitoring point might present a WQI in the “bad” class and an ICE in the “good” class. This can occur, for example, in class 4 rivers, which have less restrictive water quality standards because they are intended solely for navigation and visual ammenities. If the river has a high level of pollution, the ICE can be classified as “good”, since the classification target (class 4) is less restrictive. However, the WQI, which evaluates water quality for domestic supply after conventional treatment, will show a bad value, since the reference adopted is more stringent.

Calculation of the ICE took into account only the points with at least four samples in 2010. Therefore, whereas the WQI was calculated for 1,988 points, ICE was calculated for only 52% of this total (Figura. 21).

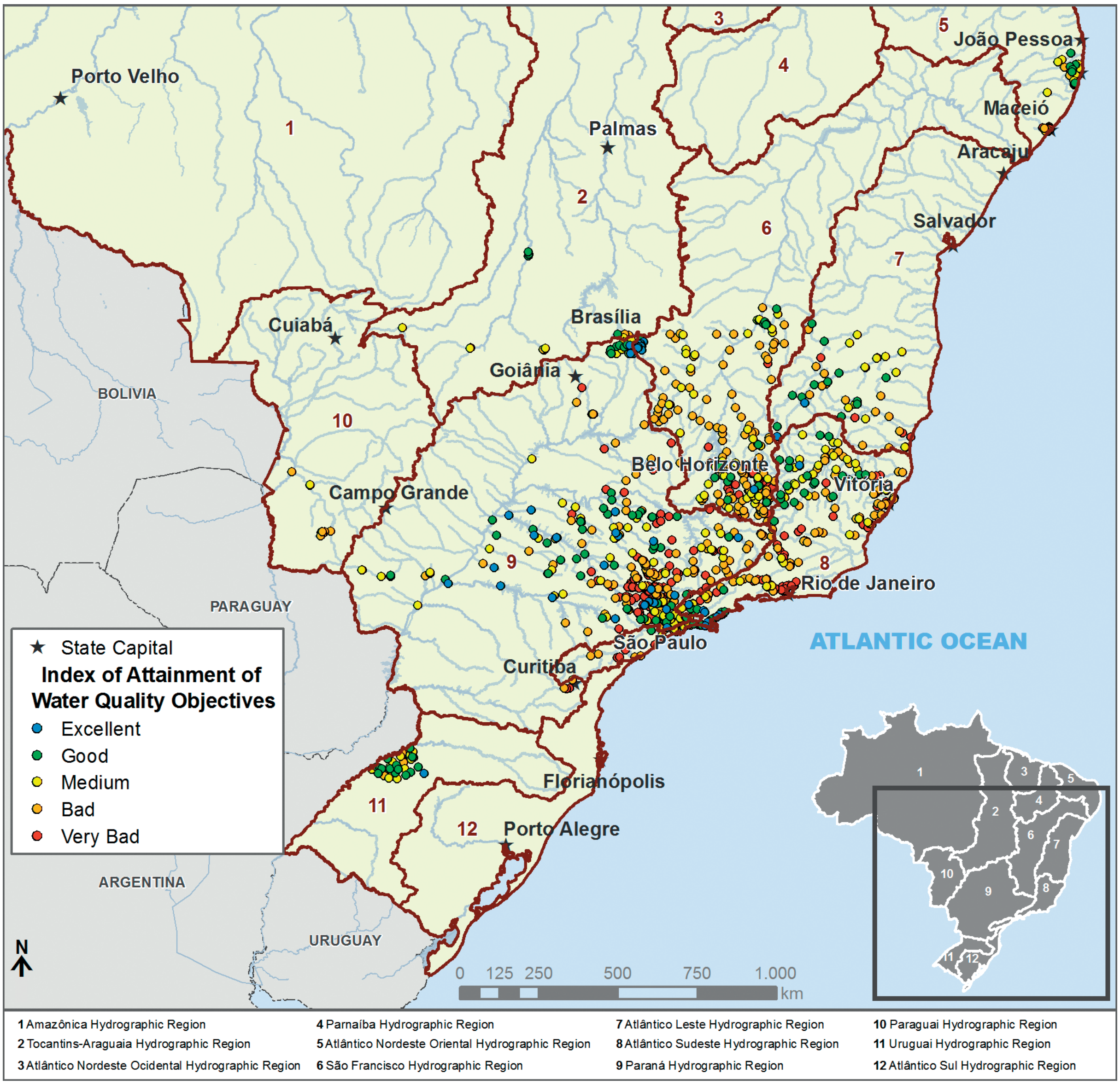
It is observed that points with ICE in a “very bad” condition are concentrated near major urban centers (São Paulo, Belo Horizonte, Rio de Janeiro, Vitória), a result of the release of domestic effluents. However, points with low ICE in rural basins are also observed, indicating that this index is also sensitive to the diffuse pollution that prevails in these areas.

Of the total of points for which the ICE was calculated, 18% are in classes “good” and “excellent”, while 61% are in classes “very bad” and “bad.” Comparing these results with those of the WQI presented above, it is observed that the ICE presents the most critical values, certainly due to the fact that this is a most sensitive index (Figure 22).

The Paraná Hydrographic Region is one with the highest number for which the ICE has been calculated (382 points). This region has the highest percentage of points with ICE in the “excellent” class (7%) and the largest percentage in the “very bad” class (32%).

The points with a “bad” ICE will probably require greater investment in pollution control action than a point with a “good” ICE, since the former is farther from meeting the water quality objectives.

Overall, the results highlight the need for the implementation of water quality objectives throughout the country. These programs, besides involving the construction of Sewage Treatment Plants, can also entail many other actions, such as command-control mechanisms (monitoring of pollution sources,

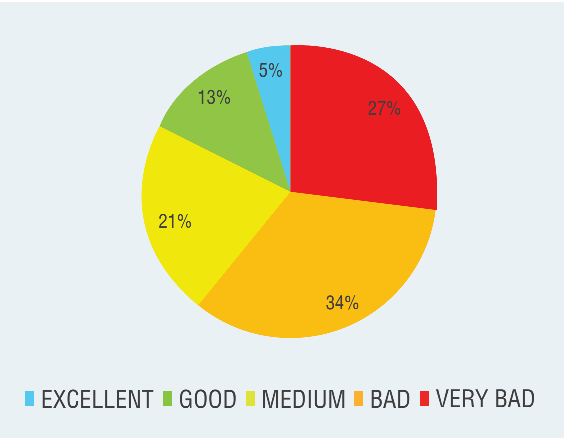


Sources: ADASA (DF), AGUASPARANÁ (PR), CETESB (SP), COGERH (CE), CPRH (PE), FEPAM (RS), IAP (PR), IEMA (ES), IGAM (MG), IMA (AL), IMASUL (MS), INEA (RJ), SEMA (MT), SEMARH (GO), SUDEMA (PB)

Figure 21 - Index of Attainment of Water Quality Objectives

fines, concessions, terms of conduct adjustment), regulatory mechanisms (zoning of land use, creation of Conservation Units) and economic mechanisms (charge for the release of effluents, subsidies for pollution reduction) (ANA, 2009b).

This is the first time the ICE is used as a surface water indicator at the national level. The ICE analysis can help understand and verify compliance with the water quality objectives, as well as management actions for achieving the water quality recommended for each water body. A trend analysis of this index will enable monitoring the implementation of water quality objectives programs.



Sources: ADASA (DF), AGUASPARANÁ (PR), CETESB (SP), CPRH (PE), FEPAM (RS), IAP (PR), IEMA (ES), IGAM (MG), IMA (AL), IMASUL (MS), INEA (RJ), SEMA (MT), SEMARH (GO).

Figure 22 - Percentage of Monitoring Points in ICE Classes in 2010.

5.4 Other indicators

In addition to the water quality indicators used in this study (WQI, TSI, ICE), determining the presence of other pollutants in water is also important because it may be associated with other types of risks, not only to the ecological protection but also to public health. Among these pollutants are pesticides, endocrine disruptors and persistent organic pollutants. In Brazil, this has increased the importance to expand not only the monitoring network but also the number of parameters analyzed, so as to enable a broader assessment of the actual impact of different sources of water pollution, considering its multiple uses, notably public supply.

Pesticides

Despite the widespread use of pesticides in Brazil, studies on the contamination of water bodies by these substances are still occasional. Among the more recent studies on the presence of pesticides in surface waters, special mention should be made of the studies by MARQUEZ *et. al* (2007a, 2007b) in the Ribeira de Iguape river basin (SP); ARMAS *et al.* (2007) in the Corumbataí river basin (SP); LAABS *et al.* (2002) in the Pantanal basin; MARCHESAN *et al.* (2010) in Rio Grande do Sul river basins; and ALVES *et al* (2010) in several basins in the State of Goiás.

Although the use of organochlorine pesticides (e.g. BHC, DDT) in agriculture has been prohibited in Brazil since 1985, some products in this chemical group were still formulated and used in the country for more than two decades for wood preservation (heptachlor, banned in 2004; lindane and pentachlorophenol, banned in 2007). Organochlorine products and their by- products are still detected in soil and water bodies, due to their high persistence in the environment (ALVES *et al.*, 2010; ANDREOLI *et al.*, 2000).

The main source of water pollution by pesticides is their use in agricultural areas, but accidents in industries that produce these products and road accidents during transport can also cause significant impacts. In 2008 there was an accident in the filling procedure of the endosulfan pesticide in the industry Servatis located in Resende (RJ), leading to the discharge of at least 8,000 liters of the product into the Pirapetinga river, a tributary of river Paraíba do Sul. Approximately 500 km in river Paraíba do Sul between the city of Resende and the mouth or the river were affected, causing the death of hundreds of tons of fish and the interruption of domestic supply in many cities.

Persistent Organic Pollutants

There are few studies on the presence of persistent organic pollutants (POPs) in aquatic environments in Brazil. Data on water, sediments and aquatic organisms in the Cubatão river and the estuaries of Santos and São Vicente (São Paulo State) analyzed by CETESB indicated the presence of Polychlorinated Biphenyls in all points assessed, suggesting a diffuse contribution of these pollutants to the aquatic environment, with concentrations in the sediments of some points above the threshold that causes toxic effects to the biota. The accumulation of PCBs in some organisms collected in the Santos estuary was observed especially in sessile and filtrating organisms (oysters and mussels), with some values above the criterion established for human consumption (CETESB, 2001).

With regard to dioxins and furans, sediments in the Santos estuary showed higher values when compared to the other areas studied, and this fact is probably due to the proximity of combustion sources (CETESB, 2001).

With respect to POP pesticides (Aldrin, Chlordane, DDT, Dieldrin, Endrin, Hexachlorobenzene, Mirex, Toxaphene), some of the main studies that detected their presence in Brazilian surface waters have alredy been presented in the section on pesticides.

Endocrine Disruptors

Studies on the presence of endocrine disruptors in surface waters are still scarce in Brazil, since detecting them requires sophisticated analytical methods due to the small concentration at which these substances occur in water, effluents and sediments. Thus, it is not yet possible to produce a more comprehensive diagnosis of the presence of endocrine disruptors in surface waters.

Some studies have investigated the presence mainly of estrogens in water intended for human consumption (raw and treated water) and treated effluents in the State of São Paulo (GHISELLI, 2006; GEROLIN, 2008; GUIMARÃES, 2008). TERNES *et al* (1999) studied the concentrations of estrogens in the Penha STP, in Rio de Janeiro, as well as their reductions following the use of different treatment methods. In another study conducted in Rio de Janeiro, endocrine disruptors from industrial sources, mainly polycyclic aromatic hidrocarbons (TORRES, 2012) were found in basins of the Paraíba do Sul and Guandu rivers.

Golden mussel incrustation in pipes

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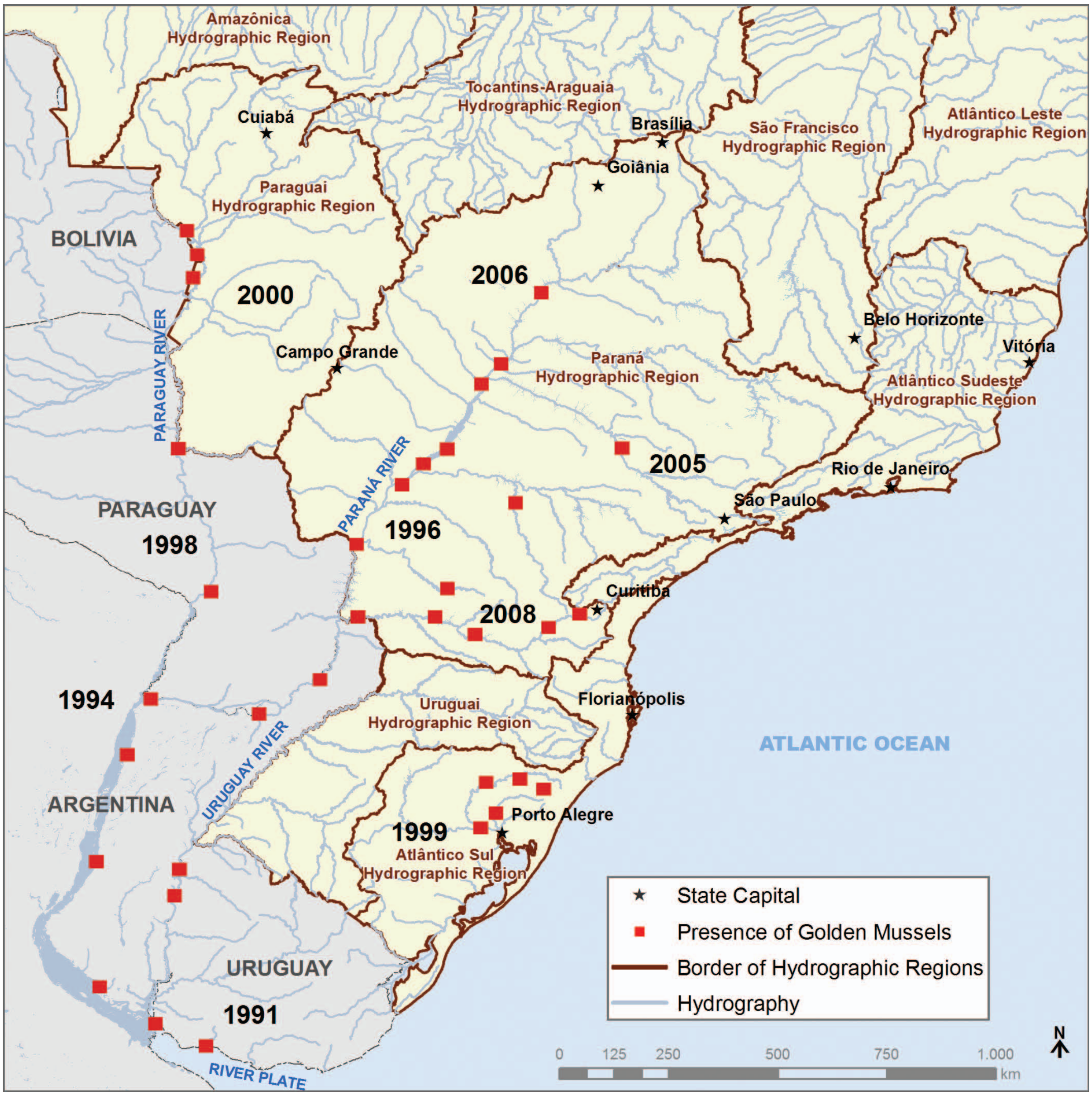
Introduction of Exotic Species

The main indicator of the impact of the introduction of exotic species is the presence of the golden mussel in inland waters. Figure 23 shows the evolution of the presence of the golden mussel in inland waters of the Plata Basin for the period 1991-2008, where this organism can already be detected in the Paraná, Paraguai, Uruguai and Atlâtico Sul Hydrographic Regions.

The main problems caused by the golden mussel are a reduction in the diameter of pipes – due to clogging; an increase in the corrosion process; and a deceleration of water flow in pipes. Moreover, the presence of the golden mussel causes damages to water supply; water taking for irrigation purposes; rain water drainage; cooling systems in industries and power plants; floating structures (due to overweight); and boat engines (due to overheating).



Sources: EMBRAPA (2004) AND VERMULM JÚNIOR & GIAMAS (2008)

Figure 23 - Evolution in the Presence of the Golden Mussel in Inland Waters of the River Plate Basin (1991-2008)

6 RESPONSES TO PRESSURES ON SURFACE WATER QUALITY

The responses of public administration, water users and civil society to the deterioration of surface water quality are more significantly seen in management actions such as the implementation of public policies, programs, actions and civil works to protect the environment.

Government agencies at both federal and state level, as well actors in the River Basin Committees and the private sector have provided specific responses intended to improve water quality, among which are the National Water Resources Plan (PNRH); the National Basic Sanitation Plan (PLANSAB); River Basin Plans; government programs such as the National River Basin Decontamination Program (PRODES); and the Growth Acceleration Program (PAC).

Some of these nationwide actions are briefly described below. This is not an exhaustive analysis of all actions related to the surface water quality issue, but rather an attempt to summarize the main actions being implemented at national level.

6.1 Legislation

Since the publication of the Water Code of 1934, which stated in Article 109 that “no one can lawfully degrade or contaminate the water they do not consume to the detriment of others”, there has been a major effort to upgrade and expand the legislation on water quality.

In this process, special mention should be made of Law 9433/1997, known as the Water Law, which sets as one of the goals of the National Water Resources Policy “... ensure current and future generations the necessary availability of water with quality standards appropriate to the respective uses”, and Law 9605/1998, known as the Environmental Crimes Law, which establishes criminal and administrative sanctions for the pollution of water bodies.

Various sectors (e.g. water resources, sanitation, health) have regulations on surface water quality in place. Some of these regulations are summarized below.

Resolutions by the National Environmental Council (CONAMA) and the National Water Resources Council (CNRH).

The main regulations for the management of surface water quality in the country are provided by for Resolutions by the National Environmental Council (CONAMA) and the National Water Resources Council (CNRH).

The CONAMA Resolution 357/2005, already mentioned in the Methodology defined the classification of surface freshwaters on five classes, according to their uses, and established their respective water quality guidelines. In 2011, this resolution was amended and complemented by CONAMA Resolution 430/2011, which establishes the conditions and standards for the discharge of effluents into water bodies.

Bathing criteria and standards (primary contact recreation) for fresh, brackish and salt water are provided for in CONAMA Resolution 274/2000.

In 2005, CONAMA Resolution 359 established criteria for the use of phosphorus in the formulation of powder detergent for use in the domestic market, aiming to reduce the phosphorus income from this source into water bodies.

Regarding the National Water Resources Council, special mention should be made of Resolution 16/2001 establishing the criteria for the acquisition of the right to use water resources, and Resolution 91/2008, which defines the general procedures for the establishment of water quality objectives of surface and ground water bodies.

Besides these, other CONAMA and CNRH resolutions are either directly or indirectly related to the water quality issue, such as those establishing criteria for the discharge of effluents for the purpose of dilution in surface water bodies; monitoring; water reuse; and licensing of polluting activities.

Sanitation

The new law establishing the national guidelines for basic sanitation and for the federal basic sanitation policy in the country (Law 11.445/2007) was enacted in 2007. The Law sets out the fundamental principles according to which the provision of basic sanitation services should be based on the principles of universality and adequacy to public health, environmental protection, economic efficiency and sustainability.

The Law emphasizes the concept of progressiveness in the attainment of water quality objectives by setting targets for the quality of effluents from sewage treatment facilities to meet the parameters of the classes of the water bodies into which they are released.

The recently enacted Law 12305/2010 establishes the National Solid Waste Policy. Its objectives also include public health and environmental quality protection. By providing guidelines for the development of Solid Waste Plans, the legislation has also been a guiding element for the development of Plans and Programs aimed at promoting improvements in the sector.

Pesticides

Pesticide control actions involve the areas of health, environment and agriculture. Federal Law 7802/1989, regulated by Decree 4074 of January 4, 2002, determines that pesticides can only be researched, produced, exported, imported, marketed and used when granted registration after prior approval by the competent federal authorities. For this registration to be granted, the products must meet guidelines and requirements of the federal agencies responsible for the sectors of health (National Health Surveillance Agency - ANVISA), environment (Brazilian Institute for the Environment and Renewable Natural Resources - IBAMA) and agriculture (Ministry of Agriculture, Livestock and Food Supply - MAPA).

ANVISA has been responsible for the toxicological reevaluation of active ingredients used in the country. In 2008, the Agency reevaluated 14 active ingredients used in the composition of more than 200 pesticide formulations, some of which have been banned in other countries, and established a Technical Committee for this purpose formed by representatives of ANVISA, IBAMA and MAPA. Of these ingredients, the Committee has already issued its decision to remove from the Brazilian market: Endosulfan, Methamidophos, Cyhexatin and Tricloform.

With regard to monitoring, programs need to be established to evaluate the levels of pesticides in surface and ground water bodies. According to the United Nations Food and Agriculture Organization (FAO), a pesticide monitoring program requires highly flexible field and laboratory routines that can respond periods of pesticide application, which can sample the most appropriate medium (water, sediment, biota), are able to apply detection limits for the protection of human health and ecosystems, and can discriminate betwen those pesticides currently in use and those that are historical registrations of past use (FAO, 1996).

Finally, it should be noted that according to the Brazilian Agricultural Research Corporation (EMBRAPA) there are active pesticide ingredients in the Brazilian market, some of them with high potential to reach water bodies, for which maximum limit standards acceptable in water are not provided for in the Brazilian legislation (EMBRAPA, 2007). In order to update these regulations, water quality standards need to be developed for these pesticides (CETESB, 2010b).

Health Sector

Ordinance nº2914/2011 issued by the Ministry of Health establishes procedures for control and surveillance of water quality for human consumption and its potability standards, and determines the obligation to monitor cyanobacteria in surface water-taking points.

The Ordinance prohibits the use of algicides to control the growth of microalgae and cyanobacteria in the supply source, or any intervention causing cell lysis, so as to prevent the release of larger amounts of toxins into the water. Thus, the prevention of algae blooms is the most suitable approach to avoid potential problems of water toxicity and unpleasant odor and taste. Preventing these events entails the proper management of the river basin as a whole and aims to reduce nutrient input into water bodies through the adoption sanitation measures, controlled use of agricultural fertilizers and preservation of the marginal vegetation of rivers and lakes.

Introduction of Exotic Species

To prevent the introduction of exotic species, ANVISA Resolution 217/2001 establishes that the release of ballast water taken from a geographic area considered as a risk to public health or the environment is subject to prior authorization by the health authority, after consultation with the Federal Environmental Agency and the maritime authority, and all vessels are subject to the collection of ballast water samples for analysis. Rule 20 of the Directorate of Ports and Coasts of the Brazilian Navy determines that the exchange of ballast water should be conducted at a minimum of 200 nautical miles from the nearest land as well as in waters at least 200 meters deep, and with an efficiency level of at least 95%.

The presence of the golden mussel in reservoirs has led electricity companies to take control and prevention measures to avoid the impacts of this organism. In 2003, concern with this issue led the Brazilian government to establish, through the Ministry of Environment, the National Task Force for Golden Mussel Control (Ordinance 494 of December 22, 2003), formed by representatives of various institutions, to evaluate the control measures on an emergency basis, with a view to reducing the spread of golden mussels throughout the national territory.

Persistent Organic Pollutants

In 2001 the Brazilian government signed the Stockholm Convention on Persistent Organic Pollutants-try (POPs). The convention, which aimed to promote the protection of human health and the environment against the effects of POPs, entered into force internationally on February 24, 2004. On May 7 of that year the Brazilian Congress approved the Convention through Legislative Decree 204. Brazil ratified the Convention through Decree 5472/2005. The first national inventory of the emission of dioxins and furans was conducted in 2011. This was one of the tasks undertaken by Brazil as a signatory to the Stockholm Convention.

6.2 Planning

Planning actions relating to water quality are also implemented in several sectors (environment, sanitation, water resources, etc.). The main actions in this area are summarized below.

Water Resources Plans and Water Quality Objectives

Among the various instruments provided for in Law 9433/97 are Water Resources Plans, which are developed at the national, state and basin levels, and Water Quality Objectives.

National Water Resources Plan

The National Water Resources Plan (PNRH), coordinated by the Ministry of Environment, was approved by Resolution 58 of the National Water Resources Council (CNRH) in 2006. Its first revision was approved by CNRH through Resolution 135/2011. The PNRH was developed under an extensive participatory planning process “to establish a national pact for the definition of guidelines and policies aimed to improve water supply in both quantity and quality, by managing demands and considering water as a structuring element for the implementation of sectoral policies from the perspective of sustainable development and social inclusion” (BRASIL, 2006a).

The National Water Resources Plan defines, in its revision, 22 priorities for the period 2012-2015. Three of these priorities are directly related to water quality: structuring, expansion and maintenance of national hydrological monitoring; support for the establishment of water quality objectives and recovery and conservation of River Basins in urban and rural areas. The revision of the PNRH is a breakthrough in that it conciliates the 22 priorities listed in the PNRH with the federal government planning contained in the Multiyear Plan (PPA 2012-2015) (BRASIL, 2011e).

State Water Resources Plans and River Basin Plans

These plans define priorities for investments in river basins, authorizations for the use of water resources, main criteria for charging for water use and the water quality objectives. The River Basin Committee and its executive arm, the Water Agency, are responsible for approving and monitoring the implementation of the plan, offering suggestions and alternatives to the targets proposed therein (BRASIL, 2006a).

Of the 12 Brazilian Hydrographic Regions, water resources plans have been prepared for the São Francisco and Tocantins-Araguaia HRs, among other plans covering interstate basins (Figure 24a). Virtually all Brazilian states already have a state Water Resouces Plan in place and basin plans are being developed at an increasingly faster pace, mainly as regards basins with qualitative and quantitative issues and where there are conflicts involving the use of water (Figure 24b).

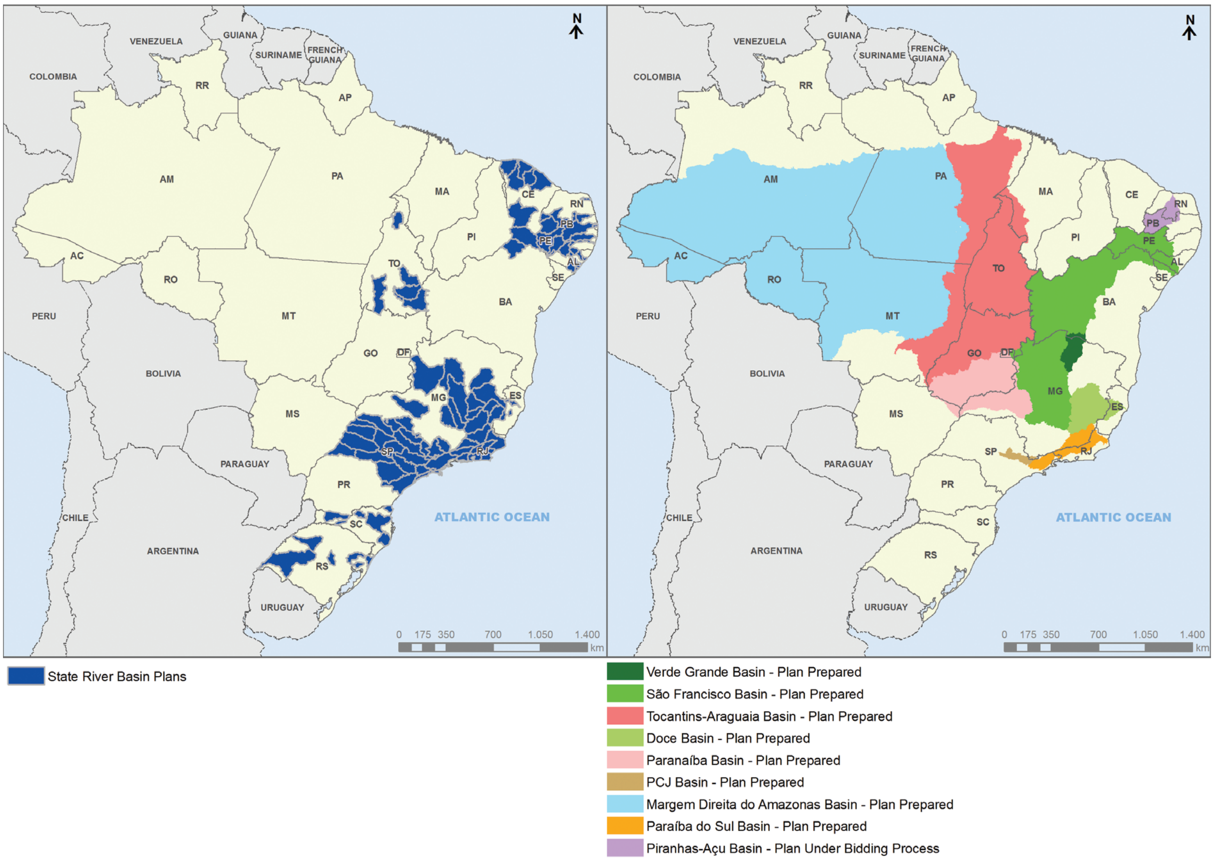
Water Quality Objectives

The establishment of water quality objectives is the main reference for water management and should be the end result of a process that takes into account environmental, social and economic factors (MARGULIS *et al*., 2002) .

The first water quality guideline system at the federal level was Ordinance 13 of 15 January, 1976, issued by the Ministry of Interior (BRASIL, 1976). After its publication, some states established water quality objectives: São Paulo (1977), Alagoas (1978), Santa Catarina (1979), Rio Grande do Norte (1984), Paraíba (1988), Paraná (between 1989 and 1991), Rio Grande do Sul (between 1994 and 1998), Minas Gerais (between 1994 and 1998), Bahia (1995 and 1998) and Mato Grosso do Sul (1997) (ANA, 2007).

These water quality objectives established between the 1970s and 1990s usually did not count on social participation and failed to present costs, deadlines and responsibilities associated with the quality targets. In general, management agencies have focused on effluent emission standards, and water quality objectives have served primarily as reference for environmental licensing and monitoring actions.

In 1997, with the enactment of Federal Law 9433, water quality objectives became an instrument of the National Water Resources Policy, representing a link between the National Water Resources Management System and the National Environmental System. Water quality objectives proposals became the



Sources: ANA (2012).

Figure 24 - (a) Status of State River Basin Plans in 2011; (b) Status of Interstate River Basin Plans in 2011

responsibility of River Basin Committees and should have an Implementation Program detailing the actions planned as well as costs and schedules.

In 2005, CONAMA Resolution 357 represented a breakthrough in the area by stating that water quality objectives expresses the ultimate targets to be met and authorizing the establishment of mandatory intermediary progressive targets for its implementation.

Over the past years, many water quality objectives proposals have been prepared by the River Basin Committees and in their absence by managing agencies, especially with respect to the preparation of River Basin Plans. Among them are the basins of rivers São Francisco, PCJ (Piracicaba, Capivari and Jundiaí), Tocantins-Araguaia, Doce, Itajai, Verde Grande, Gravataí, Caí and Guandu.

Despite the resumption of water quality objectives as a planning instrument observed in recent years, its effective implementation will depend on strong coordination with the Sanitation Sector, since in most Brazilian basins the main source of water pollution is domestic sewage. One of the main challenges for implementing the water quality objectives is ensuring compatibility between sanitation plans and river basin plans and their respective targets.

National Basic Sanitation Plan (PLANSAB)

PLANSAB is the result of a process planned in three stages. The following plans are currently under development: i) "Pact for Basic Sanitation: better health, quality of life and citizenship," which marked the beginning of the participatory process for preparation of the Plan in 2008; ii) "Overview of Basic Sanitation in Brazil," launched in 2011; and iii) "Public Consultation", in which the preliminary draft of the Plan is submitted to society, with a view to promoting a broad discussion to consolidate its final format for further referrals and implementation (BRASIL, 2011b).

The challenge of providing universal basic sanitation services lies in the supply of drinking water and the collection of household waste in all urban areas by 2020 and 2030 respectively. As for sewage, the targets include a significant reduction in the number of households not served by a collection system or septic tank, and a considerable increase in the percentage of sewage treatment. It also includes the eradication of dumps yards in the country by 2014, in compliance with the National Solid Waste Policy (BRASIL, 2011b).

National Program of Surveillance of Water Quality for Human Consumption

The surveillance of water quality for human consumption is a responsibility the Health Sector and consists in a set of actions to be taken by public health authorities with the aim to ensure that the water consumed by the population meets the standards and rules laid down in the legislation in force.

In 1999 the Ministry of Health's Health Surveillance Secretariat, through the General Coordination for Environmental Health Surveillance (CGVAM) started the implementation and coordination of the National Program of Environmental Health Surveillance Related to Water Quality for Human Consumption (VIGIAGUA).

The Program establishes actions and strategies for the surveillance of water quality for human consumption by the three government spheres (federal, state and municipal), in compliance with the principles that guide the Unified Health System (SUS) in Brazil.

Objectives of VIGIAGUA include systematically monitoring the quality of water consumed by the population; reducing morbidity and mortality due to waterborne diseases and related conditions; informing the population about water quality and health risks; assessing and managing the risk to health related to the sanitary conditions of the various forms of water supply; and improving the sanitary conditions of the various forms of water supply for human consumption. Another objective of VIGIAGUA is to coordinate the Water Quality Surveillance Information System (SISAGUA).

National Solid Waste Plan

The National Solid Waste Policy introduced by Law 12305/2010 and regulated by Decree 7404/2010 established the National Solid Waste Plan as one of its main instruments.

The Decree establishes the obligation of preparing a Draft Plan to be put up for discussion with civil society, through democratic participation of all citizens in the decisions involving the necessary changes. Thus, the text underwent a process of public consultation, culminating in the final hearing held in Brasilia in late 2011.

The outcome of the public consultations is a document regarded as a new pact between government and civil society, which considers the various types of waste generated, management alternatives, targets for different scenarios, programs, projects and related actions, for the purpose of compliance with the National Solid Waste Policy.

The concepts and proposals contained in the Plan take into account the interface between the various sectors of the economy, aligning the economic, environmental and social dimensions with sustainable development. The Plan is also closely related to other instruments concerning the environmental theme, such as the National Climate Change Plan (PNMC), the National Water Resources Plan (PNRH), the National Basic Sanitation Plan (PLANSAB) and the Plan of Action for Sustainable Production and Consumption (PPCS).

6.3 Monitoring

The main sources of information on water quality in the country are state agencies responsible for water resources management and state environmental agencies. Additionally, companies operating public supply systems and hydropower plants are required to monitor their springs and reservoirs, respectively. Industries are also responsible for monitoring their effluents and, in some cases, also receiving water bodies. Besides these, volunteer monitoring activities with society are also carried out by Non-Governmental Organizations and some government entities.

The National Water Quality Evaluation Program (PNQA), already described in Chapter 2, is one of the main actions in progress in the country aimed to integrate existing data on surface water quality for the purpose of obtaining an effective analysis and better current knowledge of the evolution of water quality trends throughout the national territory. One of the achievements of the PNQA is the "National Field Guide to Water, Sediment and Biological Sampling." Another important action was the ANEEL-ANA Joint Resolution 3 of August 10, 2010, establishing the conditions and procedures to be followed by hydropower concessionaires and authorized companies for the installation, operation and maintenance of hydrometric stations, with a view to monitoring the rainfall, limnimetric, fluviometric, sedimentometric and water quality parameters associated with hydropower developments. The instrument also defines the water quality parameters to be monitored in hydropower plants with flooded areas larger than 3 km².

With regard to the monitoring of public supply operators, the procedures for control and surveillance of water quality for human consumption are provided for in Ordinance 2914, issued by the Ministry of Health on December 12, 2011.

With respect to the monitoring of pesticides, it should be recognized that there is a body of evidence, which however is not sufficiently systematized and lacks its own monitoring program. This program should be designed and implemented taking into account the active ingredients with higher consumption rates and greater potential for reaching the surface water bodies as well as river basins with higher consumption levels of these ingredients.

Today it is common knowledge that physical-chemical water quality indicators alone are insufficient to assess the ecological integrity of aquatic ecosystems. Therefore, besides the challenge of increasing the number of monitoring points, standardizing protocols and integrating information on water quality, it is also necessary to further the use of new indicators. Among these are bioindicators and ecotoxicological tests, both provided for in CONAMA Resolution 357/2005. Currently, the states of São Paulo, Minas Gerais and Paraná are already using bioindicators in monitoring programs.

The use of ecotoxicological tests is also very effective in the assessment and quality control of effluents discharged as well as in the analysis aimed at the protection and preservation of aquatic communities. These tests consist in determining the potential toxic impact of a chemical agent or a complex mixture on aquatic organisms. Currently the states of Minas Gerais and São Paulo perform ecotoxicological tests in their monitoring networks. The states of Rio Grande do Sul, Paraná, Santa Catarina, São Paulo and Rio de Janeiro have already established in their legislation the toxicity criteria and standards for the discharge of effluents, setting limits based on the toxic load of the effluent and the supporting capacity of the receiving body .

As in previous sections on legislation and planning, it is once again observed that a large number of actors perform water quality monitoring. The major challenge for the moment is the integration of this information for the production of more thorough diagnoses, which will provide inputs for better management procedures.

Another issue that must be addressed in the coming years is the adoption of common criteria and the integration of water quality monitoring with neighboring countries, under the Plata Basin Treaty and the Amazon Cooperation Treaty.

6.4 Structural actions

The diagnosis presented on item 4 reveals that the main problem regarding surface water quality in Brazil is the discharge of domestic sewage, a result of low collection and treatment levels.

Expanding the areas served by sanitation is essential for the recovery of water bodies in the country, especially those located in urban areas. Sewage treatment at the tertiary level with the removal of the phosphorus nutrient is necessary to control existing eutrophication processes and prevent new ones from occurring. These targets can only be met through the implementation of structural actions.

Investments in the sanitation sector have been resumed in recent years. Special mention should be made of the importance of the sectoral legislation that has been developed to meet environmental demands, as well as of technological advances and economic changes resulting from Law 11445/2007 - which establishes the national guidelines for basic sanitation and for the federal basic sanitation policy in the country - and Law 12305/2010 creating the National Solid Waste Policy.

Besides the legal aspect, major programs involving sanitation actions have been implemented by the federal government (with an emphasis on the Growth Acceleration Program - PAC) and state and municipal governments, whether through costly of noncostly resources, own resources or loans from international organizations like the Inter-American Development Bank (IDB) and the International Bank for Reconstruction and Development (IBRD) (Figure 25).

Another form of society's response to the water quality issues are the river decontamination programs, which can be understood in general as a set of basic sanitation and socio-environmental actions and articulations. The goal is to restore the quality of water resources in order to improve health and environmental conditions in the river basins, with positive impact on the quality of life of local populations. Among the main decontamination programs in the country are PRODES; the Tietê Project ; the Program for Decontamination of the Guanabara Bay; and the Velhas River Revitalization Program.

It is observed that, at the local level, several actions aimed at improving water quality have been successfully implemented in the country, besides those related to basic sanitation, including reforestation and the control of erosion and deforestation. These actions represent the effort of civil society organizations such as the River Basin Committees and non-governmental agencies (NGOs) and are capable of reversing critical local situations.

6.5 Summary of investments in actions to improve surface water quality

In addition to surveying the structural actions in progress aimed to improve surface water quality in Brazil, this study has also sought to quantify, in general, the values associated with actions completed since 2001 and those for which resources have been secured.

Although these numbers can not be compared with one another for reasons associated with time lag, calculation methodologies and criteria and, mainly, with differences between the proposition of each action, they are an indication of the scale of magnitude. It should also be noted that other investments in sanitation are made in Brazil with private sector resources, service provider resources and, to a lesser extent, resources from state and local governments, which are not accounted for in this summary estimate. It is observed that the amounts corresponding to sanitation and water improvement programs also

1 Amazônica Hydrographic Region
2 Tocantins-Araguaia Hydrographic Region
3 Atlântico Nordeste Ocidental Hydrographic Region
4 Parnaíba Hydrographic Region
5 Atlântico Nordeste Oriental Hydrographic Region
6 São Francisco Hydrographic Region
7 Atlântico Leste Hydrographic Region
8 Atlântico Sudeste Hydrographic Region
9 Paraná Hydrographic Region
10 Paraguai Hydrographic Region
11 Uruguai Hydrographic Region
12 Atlântico Sul Hydrographic Region

Source: MINISTRY OF PLANNING, BUDGET AND MANAGEMENT AND PRODES/ANA. Prepared by the authors.

Figure 25 - Location of the Most Significant Investments in Sanitation and Water Quality Improvement Projects

include actions related to urban drainage, road systems, relocation of families and final disposal of solid waste, among other reurbanization actions and sewagerelated initiatives.

The Brazil Atlas - Water Urban Supply conducted a survey of the investment needed to implement collection networks and STPs aimed to protect surface waters used as intake sources for urban supply. Investments have been proposed for 52% of Brazilian municipalities totaling R$47.82 billion, of which 77% are located in densely populated hydrographic regions such as Paraná, Atlântico Nordeste Oriental, Atlântico Sul and Atlântico Leste (ANA, 2010b).

On the other hand, studies conducted by the Ministry of Cities estimated that the investments required for the provision of universal water supply and sewage services in Brazil by 2020, including funds for the renovation of existing infrastructures, would total R$178,40 billion. However, when considering investments in the urban area alone for the provision of universal sewage collection and treatment services, this amount falls to R$46.82 billion (BRASIL, 2003a).

Resources earmarked for water sanitation and decontamination in Brazilian river basins provided by both the Union and international organizations, especially the larger ones, for the period 2001-2010 have been estimated at R$52.0 billion, of which 76% are from the Growth Acceleration Program - PAC.

In a way, these figures can lead to the interpretation that, if all the actions planned are actually implemented, a water resources decontamination level close to that necessary will be achieved, at least in relation to sanitation in large urban centers. However, relevant issues such as the efficiency of existing sewage treatment plants and their operating and maintenance conditions as well the investments required for sanitation in rural areas, for the proper final disposal of solid waste and for controlling the effects of land use on surface water quality are not quantified here.

There is no system in place for assessing the results of this set of actions aimed to recover and maintain the quality of water bodies. This system should be implemented progressively, as a consequence of the establishment of the PNQA. Nevertheless, the use of the water quality trend analysis in this document has enabled associating water quality improvements with management actions undertaken in certain basins. This analysis could be subsequently extended and systematized in a management evaluation system through result indicators.

Amazonas River in Nhamunda/AM

Letícia Lemos de Moraes

7 ECONOMIC IMPACTS OF WATER QUALITY DEGRADATION

The environmental and social impacts of water quality degradation has economic reflexes which are not always measured, such as higher costs for treating water intended for domestic supply and industrial use, higher hospital costs as a result of waterborne diseases loss of productivity in agriculture and livestock, reduction in fishery and loss, of biodiversity and tourist, cultural and landscape assets. A more detailed analysis of these costs is beyond the scope of this document.

The deterioration of water quality causes steady increases in the treatment costs of water intended for domestic supply, especially costs associated with the use of chemicals. The design of a Water Treatment Plant (WTP) takes into account both the volume and quality of the water to be treated. The better the parameters that indicate if the water is suitable for undergoing the purification process, the simpler the process chosen to treat the water and therefore the lower the costs of implementation and operation of the WTP.

In Brazilian municipalities that have protected supply springs, the costs of water treatment range from R$0.50 to R$0.80 per 1,000 cubic meters of treated water. In municipalities that have underpreserved springs, costs can reach as high as R$35.00 to R$40.00/1,000 cubic meters (TUNDISI & MATSUMURA-TUNDISI, 2011).

With respect to waterborne diseases, the reduction in hospitalizations associated with these diseases, among other benefits, could be significant if sanitation services were universal. In 2009, of the 462,000 patients hospitalized for gastrointestinal infections, 2,101 died in the hospital. This year, the average cost of hospitalization for gastrointestinal infection in the Unified Health System (SUS) was about R$350.00. This entailed public expenditures worth R$161 million. If access to sanitation were universal, hospitalization and mortality rates would fall 25% and 65% respectively, resulting in significant economic gains (FGV / TRATA BRASIL INSTITUTE, 2010).

Recreation in surface water is usually a low cost activity, very often found in the interior of the county, where rivers and reservoirs are widely used by the population. This activity plays an important economic role in some regions and requires good quality water. Eutrophication, the occurrence of water-borne diseases

Author unkown/Image Bank COPASA

Arrudas Sewage Treatment Plant in Sabará/MG and the loss of aesthetic quality are factors that contribute to a negative economic impact on this type of activity (TUNDISI & MATSUMURA-TUNDISI, 2011).

In agricultural areas, it is estimated that soil loss in crop and pasture land caused by erosion generate an impact nearly R$1.31 billion / year, due to increased water treatment costs, reduced storage capacity of reservoirs and reduced recharge of aquifers, among other impacts (HERNANI *et al*. 2002 *apud* PRUSHI, 2006).

The establishment of the National Policy on Payment for Environmental Services, currently under discussion, would remunerate initiatives to conserve and improve the quantity and quality of water, among other actions. In this sense, consideration of services provided by aquatic ecosystems will be an important factor for their management in the coming years.

Actions related to payment for environmental services already exist in Brazil. The Water Producer Program, developed by the National Water Agency, provides support, guidance and certification of projects that reduce erosion and siltation of water sources in rural areas, thus improving water quality and increasing the regularization of flows. Among the program's actions are the reforestation of areas of permanent preservation and legal reserves, the recovery and protection of springs, the stability enhancement of unpaved rural roads and the construction of terraces and infiltration basins.

Areas where vegetation has been preserved, whether in Conservation Units or private properties, play an important role in maintaining water quality, with economic consequences, for example, for human supply systems.

Several Brazilian cities depend wholly or partly on supply sources located in protected areas. According to (MEDEIROS *et al*. 2011), 34.7% of the annual non-seasonal volume in 2,727 catchment areas is related to water collected in Conservation Units or downstream of these units.

In São Paulo, State Law 9866/97 established guidelines and rules for the protection and restoration of environmental quality in the river basins used for public supply, by establishing Areas of River Basin Protection and Recovery - APRMs. These areas are defined in a proposal from the River Basin Committees and by deliberation of the State Water Resources Council. After approval, they are established by specific legislation preceded by a Development and Environmental Protection Plan.

Amolar Mountain/MS

Zig Koch/Image Bank ANA

8 CHALLENGES FOR WATER QUALITY MANAGEMENT

Water quality management in Brazil has been historically done in a centralized manner in management agencies, through the use of command-control instruments and based on effluent emission standards. The implementation of the National Water Resources Management System is geared towards a decentralized and participatory system that includes command-control, planning (water quality objectives, water resource basin plans) and economic instruments (payment for effluent dilution and for environmental services).

The legal and institutional evolution of water resources management in Brazil has been significant over the past years. As an example, in 2000 there were 58 river basin committees in place; today there are 178. River Basin Committees discuss and help define water quality objectives and follow up the implementation of these targets. This process should be participatory, in that it should include all the actors concerned (civil society, water users and government agencies) in the discussion of the uses intended for water bodies and respective actions related to decontamination, costs and timelines, so as to make these targets feasible.

Improving the quality of surface freshwater in Brazil over the coming decades will depend on the joint effort of various sectors of society and require significant resources. The main challenge is to improve sanitary conditions, since the main source of surface freshwater pollution is the disposal of domestic sewage. The improvement in water quality in the country in the coming decades will be directly linked to higher sewage collection and treatment levels. The various water improvement programs identified in this document indicate the resumption of significant investments in the sanitation sector.

The National Sanitation Plan (PLANSAB), currently under discussion, aims to provide universal household waste collection services in all urban areas by 2030. The universal nature of this service, alongside sewage treatment, will have significant effects on water quality. In this sense, it is essential to evaluate the quality of surface water, and disseminate the information for society.

Several sectoral plans have an impact on water quality, such as sanitation plans, water resources plans and municipal master plans. Coordination between these plans is essential to reduce the fragmentation of public policies.

In agricultural areas, preventing soil erosion through the adoption of management practices and proper use of fertilizers and pesticides is essential to reduce impacts on the quality of water bodies. The implementation of the National Policy on Payment for Environmental Services can contribute significantly to water quality improvement by providing incentives to landowners for the recovery and maintenance of forest remnants.

In the industrial sector, the reduction in water consumption, the use of cleaner production methods and the reuse of wastewater have produced significant impacts on effluent reduction and resulted in economic gains. Several examples already exist in the country, and actions such as these must be encouraged.

Over the next decades, climate change could have an impact on water quality. Hence the importance of the systematic monitoring of water bodies as a way of contributing to management and adaptation actions.

Finally, another challenge is the fact that Brazil needs to know the quality of its waters better. In this sense, the implementation of the National Water Quality Assessment Program (PNQA) is of great importance for the adoption of a water management system based on indicators that enable evaluating the effectiveness of water quality-related actions.

Wide dissemination of information on water quality to the population should be a priority, using means and forms of communication that enable social participation in the water quality improvement and maintenance process.

In a country of continental dimensions, this task can only be achieved through the integration of the various entities that monitor and disseminate information on water quality. The present document, which counted on the support of organizations from various Units of the Federation, is proof that this integration is indeed possible.

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