SHARING EXPERIENCES
ON THE

WATERS OF MINAS GERAIS

BRAZIL

01

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- BRAZIL -

ORGANIZERS
CAROLINE MATOS DA CRUZ CORREIA
MARÍLIA CARVALHO DE MELO
NÁDIA ANTÔNIA PINHEIRO SANTOS

SHARING EXPERIENCES ON THE
WATERS OF MINAS GERAIS
- BRASIL -

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The State Government of Minas Gerais

Fernando Damata Pimentel

Governor

The State Secretariat of Environment and Sustainable Development – SEMAD

Germano Luiz Gomes Vieira

Secretary

Minas Gerais Water Management Institute – IGAM

Marília Carvalho de Melo

Chief Executive Officer

The State Foundation for the Environment – FEAM

Maria Cristina da Cruz

Chief Executive Officer

The State Forest Institute – IEF

Henri Dubois Collet

Chief Executive Officer

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BELO HORIZONTE / MINAS GERAIS
WWW.IGAM.MG.GOV.BR /+55 (31) 3915-1297

COORDINATION

Marília Carvalho de Melo

ORGANIZATION

Caroline Matos da Cruz Correia
Marília Carvalho de Melo
Nádia Antônia Pinheiro Santos

TECHNICAL TEAM

Adriania de Fátima Teixeira Guimarães
Caroline Matos da Cruz Correia
Marília Carvalho de Melo
Nádia Antônia Pinheiro Santos
Thais de Oliveira Lopes

COLLABORATION

Alexandre Magrineli dos Reis
Daniela Giordano
Giselle Aparecida Teixeira Machado
Juliana Maria Silveira
Lucas Fernandes de Oliveira
Márcia Beatriz Silva de Azevedo
Silvana de Almeida
Sônia de Souza Lima
Thiago Figueiredo Santana
Valquíria Moreira Lopes
Wilson Pereira Barbosa Filho

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THE WATERS OF MINAS GERAIS: PRESERVING A COMMON GOOD

Brazil has always prided itself on being the country with the largest hydrological reserve in the world. Another reason for satisfaction is that Brazil has in its subsoil two thirds of the Guarani Aquifer, the most extensive accumulated freshwater reserve in the planet, in addition to important rivers that share waters with other South American countries.

However, these reasons for pride also require attention. Predictions that men who have fought for oil for decades will one day start a war because of water may be pessimistic, but are certainly not delusional.

This is not simply due to scarcity, but also because access to water is threatened by climate change, pollution, and maldistribution. In other words: the concern is not only about the amount of water available, but above all about its quality.

With a high enough water potential to quench the thirst of millions of people for centuries, Brazil lives under the external threat of greedy corporations who want to become the owners of this wealth. Internally, it is also under the threat of government neglect: authorities that do not act to preserve water as a common good, an asset for everyone.

In the world, water consumption multiplied by 7 in the 20th century, while the population only doubled. In Brazil, consumption per capita increased tenfold over the same period. And yet, in Brazil and around the world, millions of people still have no access to safe drinking water.

As the fifth largest Brazilian state in extension (588,528 km²), the second in population (over 21 million inhabitants), and the first in number of cities (853 municipalities), Minas Gerais has enormous wealth in water resources.

Minas Gerais demands great care in the preservation of its waters, due to the diversity of its climate and some of its most important economic activities, such as mining. The state is still recovering from the Mariana tragedy that has caused great socio-environmental and socioeconomic impact in the Doce River basin.

The state's initiative to demand immediate restoration and to participate in recovery guidelines, in partnership with other governments, has allowed this to become the best monitored basin in the country, providing real indicators to assess its recovery over the next few years.

Water use and preservation are a priority for the State Government of Minas Gerais. Legislation is undergoing modernizations with a focus on integrated land management and on the alliance between environmental and water resources policies to direct measures for reservoir and spring protection and for the promotion of water reuse techniques.

With the participation of the civil society, a separate committee created within the scope of the State System of Environment and Water Resources (Sisema) has great authority to plan interventions that favor water quality and access.

The government has also modernized the Water Management Institute of Minas Gerais and works on strengthening water governance in partnership with a total of 36 River Basin Committees.

Finally, Minas Gerais will become the first Brazilian state to create a regulatory framework for water reuse. The readers of this publication - "Sharing Experiences on the Waters of Minas Gerais" - will gain insight into what is being debated in the current administration and the pluralistic nature of this discussion.

Enjoy your reading!
The State Government of Minas Gerais

A LETTER FROM SISEMA

The state of Minas Gerais is cut by rivers and water basins whose importance goes way beyond the limits of its territory, both for power generation and for maintenance of the water balance in Brazil. Mighty rivers such as Jequitinhonha, Doce, Grande, and Paranaíba are the means of such significant availability of water in Minas Gerais. The state also has one of the most important basins in the country, the São Francisco River: a river of national integration, as it contributes to the supply, economy, and environment of other Brazilian states.

The waters that run on the Minas Gerais soil are important for trade, mining, hydroelectric power generation, irrigation and drainage, agricultural production, livestock, fish farming, tourism, and human subsistence.

Such an essential resource requires strict and active management. Therefore, the water agenda has become even more important in Minas Gerais. In 2018, actions such as the sustainable use of water resources, water generation through springs preservation, environmental compensation in conservation units, ecological corridors, and the recovery of the Doce river are at the top of the environmental planning agenda of the State System of Environment and Water Resources (SISEMA).

The 8th World Water Forum, to be held for the first time in Brazil (in Brasília) in March 2018, reinforces this mission. In addition to the visibility that the event brings to this matter in the country, the State Government of Minas Gerais has already pledged its commitment to the issue by having the public sector adopt strict, rigorous measures for the conscious use of this important resource.

We know that there is yet much to be done, especially in terms of governance and the scarcity of financial resources and due to the long periods of drought that the state and the country have faced in recent years. Nevertheless, the State Government has been ahead on this matter by creating the Water Situation Monitoring Group (GSH) and by implementing numerous actions for water generation. The list includes restoring forests, springs, riparian forests, Permanent Preservation Areas (PPA), veredas, and many other areas that can serve as water replenishment.

The greatest of all tasks for 2018 is to proceed with the recovery of the Doce River basin, after the rupture of the Fundão Dam in Mariana, in the Central Region of the State. Albeit challenging, the Doce River recovery is possible and has already shown breakthroughs. The basin is now the best monitored water body in the country and improvements in water quality indexes can already be observed. Environmental agencies have set 42 recovery programs to be implemented by the Renova Foundation, most of which have already shown progress.

Finally, just like this theme, all other issues related to the preservation of water resources in the state will be dealt with very seriously and from a governance point of view. This means engaging not only the public authorities, but also users, the civil society, academia, and all other parts involved in this process.

Germano Luiz Gomes Vieira
State Secretary of Environment and Sustainable Development

A LETTER FROM COPASA

When it comes to water, Copasa is a pioneer and reference both in the national and international scope. Because the company has constantly innovated and modernized all the processes of handle, taking into account the health of miners and socio-environmental responsibility.

It has been so since our foundation, long before world public opinion woke up to ecological issues such as the importance of preserving and recovering our springs and all ecosystems around them. This philosophy of action extends to support the indispensable studies and scientific research on this vital theme for all living species on Earth.

Therefore, nothing more natural than to support this beautiful initiative of the Minas Gerais Water Management Institution- IGAM. Which are serious academic studies, within the rigors of the scientific method, carried out in the state and in the country, regarding processes and handles with the most important substance in the world. After all, when astronomers searched for life on other planets, they focused on finding traces of water. Because without water there is no life.

It is with great pride that we are present in this very relevant publication, especially with the approaching date of the World Water Forum, where the book will be distributed to technicians and entities from all corners of Brazil and the world.

Copasa is aware that it is only through science that humanity has been advancing over the centuries in the treatment and distribution of water and in sustainability. And could never be left out of a publication of this magnitude.

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PREFACE

Organized by the World Water Council, the 8th World Water Forum will be held in Brasilia from March 18th to 23rd, 2018, with an expected audience of more than 50,000 participants, including representatives from the government, academia, the civil society, non-governmental organizations, and businesses, as well as individuals interested in environmental and water issues. This is the largest global event on the subject.

Differently from the way scientific, technical, and even political conferences are organized, the Forum is largely built on propositions made by the different sectors interested in committee-led debates. For the 8th World Water Forum, the committees have been divided based on thematic, political, and regional processes and on the Citizen Forum. A transversal committee named the Sustainability Focus Group has dealt with water and sustainability.

Thirty-one years after the publication of the Brundtland Report (Our Common Future, World Commission on Environment and Development, 1987) and three years after the publication of the 17 UN Sustainable Development Goals (SDG), to be implemented by 2030 by all countries of the world, the concept of sustainability is, or at least is expected to be, a major guideline for water use and a challenge for public policies and water governance.

Following intergenerational commitments, it is possible to state that sustainability can be ensured as long as there is no reduction in the total stock of capital, natural or artificial, between successive generations. Natural capital is understood as the natural, renewable and nonrenewable resources available in the planet, which includes water. Artificial capital is the set of goods and production factors developed by man. The exploitation of natural resources, which could lead to the reduction of natural capital, would be offset by improvements in the quality of life, in education levels, in the development of new technologies, and in other factors that can generate equivalent wealth by means of replacing natural capital for artificial capital.

Water is, to a large extent, a natural renewable resource, but it is also an irreplaceable substrate for life on the planet. In regards to capital conservation, the use of water demands certain requirements for the maintenance of its physical and chemical characteristics and for compliance with the environment's renewal capacity. Even in the case of a restricted concept of sustainability, there is still much to be done in terms of sustainable water management in Brazil and in the world.

The 17 SDG are more comprehensive and more demanding in economic, environmental, and social aspects than the notion of sustainability as understood on the grounds of maintaining total capital over time. SDG 6, "Ensure the availability and sustainable management of water and sanitation for all", is the most explicit water-related goal. However, sustainable water management is a requirement for the achievement of several other SDG, such as 1: "End poverty in all its forms everywhere", 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture", 3: "Ensure healthy lives and promote well-being for all at all ages", 7: "Ensure access to affordable, reliable, sustainable and modern energy for all", 8: "Promote inclusive and sustainable economic growth, employment and decent work for all", 11: "Make cities inclusive, safe, resilient and sustainable". It would not be difficult to argue that water permeates all 17 SDG.

In addition to persisting problems and decade-long water management failures such as water body pollution by domestic and industrial waste, biodiversity endangerment, intense erosive processes in rural and urban environments, the super-exploitation of aquifers, as well as inefficient use and water losses in supply systems, in agricultural production, and in industries, there has been an increasing concern about about diffuse pollution and its impacts on the environment, par-

ticularly in urban areas; emerging pollutants such as endocrine disrupters and microplastics found in freshwater and oceans; water-related risks associated with climate change; and technological risks - dam rupture, more specifically.

On the other hand, there have been important advances on water governance, development, and technological innovation, with the potential to contribute to sustainability in water use. This book reports on several such examples, in the form research outcomes, development and innovation, public policies, and actions developed and implemented in the state of Minas Gerais, Brazil.

The concept of ecosystem services, used in water management programs and environmental basin restoration, contributes to a richer, holistic view of the relationships between water and the environment: water is a support to life in ecosystems and ecosystems are a means of quality water supply that can ensure resilience to climate change impacts.

From the point of view of water management and its instruments, the concept of ecosystem services associates the payment for environmental services (PES) with the polluter and paying user principle - the founding reasons for charging water use in the Brazilian legislation. PES is a highly employed instrument in Minas Gerais, embodied in local experiences such as the ones in the municipality of Extrema and, more recently, in the municipality of Igarapé. At the state-level, PES is also strong: in an example is the Bolsa Verde Program. Despite not entailing direct payments, the Pro-Mananciais Program under COPASA's implementation aims, to develop income generation alternatives that contribute to the protection of strategic watersheds for water supply, bring advantages of a socioeconomic and environmental nature, and in water and food security, such as

Cultivando Água Boa Program implemented by Itaipu Binacional in the state of Paraná.

Some citizens and social movements have expressed concern about the use of economically based instruments for water management, fearing that these instruments could lead to what is often called water commodification, thereby jeopardizing or hindering the guarantee of the right to water. This is an important issue in the debate on water management, even if the use of economic instruments does not immediately and automatically lead to a "privatization" of the resource or to water use restrictions of collective interest. When properly employed, in a transparent manner and subject to social control, these instruments contribute to a more efficient and sustainable use of natural resources. It is also important to emphasize that universal access to basic sanitation has not been achieved yet and that water security as well as food security require public and private policies and actions in line with the 17 SDG, in regards to current and future needs.

The chapters of this publication also illustrate significant technological progress in various areas, such as improving the means of data monitoring, processing, and statistical analysis; simpler and more efficient technologies for wastewater treatment and for the recovery of by-products such as gas and sludge; soil and water conservation techniques in agriculture; solutions based on green and blue infrastructure, among others. There is also evidence of significant advances in knowledge about extreme events, risk management of water scarcity and flood, and water security.

Initiated by the Water Management Institute of Minas Gerais (IGAM), the management body of water resources of Minas Gerais, on the occasion of the 8th World Water Forum to be held in Brazil, this book illustrates and expands many of the issues I have mentioned here, with examples and proposals to promote sustainability in water management.

Nilo de Oliveira Nascimento
Full Professor at the Federal University of Minas Gerais

FOREWORD

As a contribution of the State Environment and Water Resources System (SISEMA) through the Minas Gerais Water Management Institute (IGAM), "Sharing Experiences on the Waters of Minas Gerais - Brazil" was created to dialogue with the 8th World Water Forum, a highly relevant international event held in the Southern Hemisphere for the first time, in Brasilia, Brazil.

With "Sharing Water" as its main theme, the event aims at promoting the exchange of experiences in good practices, public policies, and integrated water resources management. It also seeks to develop awareness and build political commitments on issues related to conservation, protection, development, planning, management, and efficient use of water resources.

From this perspective, IGAM sought to integrate the reflections and experiences undertaken in Minas Gerais by groups from different sectors of society. These practices are in line with the Forum's cross-sectional themes: climate; people; ecosystems; development; governance; sharing; finance; and training

To this end, a public call was made and widely publicized in Minas Gerais. In view of the contributions received, this publication was organized in two volumes: this first one, in which 20 technical-institutional productions of public and private entities, universities, companies and non-governmental organizations (NGOs) are published and grouped into three main themes: governance, ecosystem, and sharing, and the supplementary volume composed of 43 texts. Together, this body of work reflects the different views, approaches, positions, and practices in the area of water resources in a state as diverse as Minas Gerais.

With a multitude of solutions and shared knowledge, we are certain that this publication will be an important tool for understanding some aspects of the state's water situation. An understanding of the vulnerabilities and the progress made in our society, companies, and governments can be gained, as these are the very people who must act integratedly and cooperatively to promote improvements in the democratic management of our natural resources, and to guarantee water supply to meet the needs of nature and the human species.

Enjoy your reading!
Marília Carvalho de Melo
Chief Executive Officer
Minas Gerais Water Management Institute

SISEMA – MINAS GERAIS

The State System of Environment and Water Resources of Minas Gerais (SISEMA/MG), instituted by Law 18.365 of September 1, 2009, is composed of bodies and entities responsible for environmental and water resources policies. Its purpose is to conserve, preserve, and recover environmental resources, and to promote sustainable development and improvements in the environmental quality of Minas Gerais.

SISEMA/MG is formed by the State Secretariat of Environment and Sustainable Development (SEMAD) and associated entities: the Water Management Institute of Minas Gerais (IGAM), the State Forest Institute (IEF), the State Foundation for the Environment (FEAM), the State Council for Environmental Policy (COPAM-MG), and State Council for Water Resources (CERH-MG).

THE STATE SECRETARIAT OF ENVIRONMENT AND SUSTAINABLE DEVELOPMENT (SEMAD)

SEMAD is responsible for formulating, coordinating, executing, and supervising public policies for the conservation, preservation and recovery of environmental resources, aiming at the sustainable development and improvement of the environmental quality of Minas Gerais.

Instituted by State Law 11.903/1995
State Decree 47.042/2016

MINAS GERAIS WATER MANAGEMENT INSTITUTE (IGAM)

Responsible for developing and implementing the State Policy on Water Resources, with actions aimed at preserving the quantity and quality of the waters of Minas Gerais, this entity integrates the National System for the Environment (SISNAMA) and the National System of Water Resources Management (SINGREH) at the federal level. At the state level, it integrates SISEMA and the State System of Water Resources Management (SEGRH).

Management is done through instruments such as water use permits; water body classification; water resources information systems; water use service charging; and water resources planning. The state's surface and groundwater quality monitoring is another management tool.

The Institute has as its guideline a shared, decentralized, and participative administration involving different social segments. This is how IGAM acts in the consolidation of Water Basin Committees (CBHs) and Water Basin Agencies. This work is interlocked with the activities carried out by SEMAD, CERH/MG, as well as state and municipal agencies and entities whose attributions are related to the management of water resources.

Instituted by State Law 12.584/1997
State Decree 47.343/2018

THE STATE FOREST INSTITUTE (IEF)

It is responsible for planning and implementing the state's forest and biodiversity policies of, aiming at maintaining ecological balance, preserving and conserving vegetation, promoting biomass research, and mapping the state's vegetation coverage.

Instituted by State Law 2.606/1962
State Decree 47.344/2018

THE STATE FOUNDATION FOR THE ENVIRONMENT (FEAM)

FEAM is responsible for implementing policies for the protection, conservation, and improvement of environmental quality, in relation to air, renewable energy, soil, liquid effluents and solid waste management. It is also responsible for preventing and correcting pollution and environmental degradation caused by industrial, mining, and infrastructure activities. FEAM promotes and conducts initiatives, projects, and research programs for environmental technology development and technically supports the SISEMA member organizations, aiming at environmental quality preservation and improvement in Minas Gerais.

Statute: State Decree 45825/2011
State Decree 47.347/2018


GOVERNANCE

THE APPLICATION OF A REGULARIZATION AND INSPECTION INSTRUMENT FOR WATER SCARCITY SITUATIONS - THE CASE OF THE VELHAS RIVER BASIN

Marília Carvalho de Melo[1]
Marcelo da Fonseca[2]
Flávio Augusto Aquino[3]
Heitor Soares Moreira[4]

ABSTRACT

In spite of the high natural water availability, the state of Minas Gerais has experienced water scarcity since 2014 in the public water supply sources of the Metropolitan Area of Belo Horizonte (RMBH). The main effect of this water crisis is the reduction in rainfall indices in this period, which, along with water resources irregular use in the producing basins, have accentuated the reduction in available flows. The RMBH is supplied by two basins: the Paraopeba River basin, in which three reservoirs are inserted, and the Velhas River basin, which has greater run-of-river capacity and accounts for 41% of the supply in the RMBH and 80% in the capital. As a run-of-the-river system, this source is more vulnerable to changes in rainfall frequency and volume. The water shortage statement, regulated by Normative Deliberation 49/2015 of the State Council of Water Resources, is an instrument that allows water use restrictions in basins experiencing flow issues; however, its effectiveness is observed when restriction is associated to environmental inspection actions. This paper presents the regulation and inspection actions carried out in the Velhas River basin to minimize the impact of the water crisis. From 2015 to 2017, a total of 16,3 and 59 days were under water shortage warning in the Velhas River basin. 1,374 inspections were done in the period, resulting in R$ 1,058,744.92 in fines. The main irregularities identified were irregular surface allocation (45%), irregular groundwater allocation - unauthorized tubular wells (24%), and other irregularities (31%).

Keywords: Regulation. Inspection. Water shortage. The Velhas River.

1. INTRODUCTION

Just as with the Brazilian Southeast, the state of Minas Gerais has been experiencing a period of lower precipitation rates, which, since 2014, has shown less water availability for multiple use. This situation has been termed “Water Crisis”, which culminated in the need for water resources management companies and water supply providers to rethink their water management style. Water supply in times of scarcity has become their main focus, with actions that guarantee short-term solutions. Parallelly, the emerging concept of Water Security dominated the management system's agenda, in the remodeling and adaptation of a model that was not able to respond to a prolonged drought.

[1]Civil Engineer, PhD in Water Resources, Environmental Analyst and CEO at IGAM, marilia.melo@meioambiente.mg.gov.br
[2]Civil Engineer, Master in Civil Engineering, Environmental Analyst. marcelo.fonseca@meioambiente.mg.gov.br
[3]Environmental Engineer, graduate student in Environmental Technology and Innovation, Environmental Analyst. heitor.moreira@meioambiente.mg.gov.br
[4]Environmental Engineer, specialist in Geoprocessing. flavio.aquino@meioambiente.mg.gov.br

In the literature, the concept of water security has been widely discussed and international organizations such as the UN and the OECD already have consolidated concepts. According to the UN (2013), water security is "The capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability." The OECD (2013) conceptualizes water security as managing risks associated with water, including storage risks, water excess and pollution, as well as the risks of freshwater systems resilience weakening or debilitation.

Melo (2016) states that when analyzing the main published concepts it is possible to identify four important axes for action planning, proposition, and implementation to guarantee water safety in urban and metropolitan environments:

1) Reliable database;
2) Coordination by the government agencies;
3) Supply management.
4) Demand management - restrictions and efficiency of use;

Based on this theoretical framework, the Minas Gerais Water Management Institute (IGAM) proposed a mechanism to restrict use in critical situations to allow short-term responses to the crisis. Because the water use regulation and restriction regulatory mechanisms require control and inspection, an initiative integrated with the State Secretariat for the Environment and Sustainable Development (SEMAD) was created to ensure effectiveness.

2. CONTROL AND REGULATION MECHANISMS

Through a technical proposal from the IGAM, the State Water Resources State Council (CERH) issued Normative Resolution (DN) No. 49 on March 26, 2015, setting general guidelines and criteria to determine what a critical water scarcity situation and water use restriction situation entail. The deliberation provides three status warnings for which society should be prepared:

- Attention Status: when the average daily flow rates of 7 (seven) consecutive days, as observed in the reference fluviometric monitoring stations, are lower than 200% of the $Q_{7,10}$. At this stage no restriction of use for water allocation will be made. Water resources users should be attentive to any changes in the respective flow rate conditions;
- Alert Status: when the average daily flow of 7 (seven) consecutive days observed at the reference fluviometric monitoring station(s) is equal to or less than 100% of $Q_{7,10}$;
- Use Restriction Status: when the average daily flow of 7 (seven) consecutive days observed in the reference fluviometric monitoring stations is less than 70% of $Q_{7,10}$. There will be restriction of use.

When a basin experiences restricted use, IGAM issues a directive determining that all users reduce the volume captured in the following percentages: 20% for human consumption, animal watering or public supply; 25% for irrigation; 30% for industrial and agroindustrial consumption; 50% for other purposes, except non-consumptive uses. In addition to the reduction of the volumes granted, the restriction orders also determine the temporary suspension of new grants for right of use, as well as requests for flow increase in permits already granted.

The water scarcity status statement is an instrument that allows IGAM to determine the restriction of use in basins in critical flow rate conditions. However its effectiveness is only observed when

water use restriction is combined with environmental promotion and inspection. Failure to comply with the restrictions imposed will result in a total suspension of the violators' water use rights until the final term of the water shortage critical situation, without prejudice to the other penalties provided for in current legislation.

3. THE VELHAS RIVER BASIN SITUATION

The basin of the Velhas River has a drainage area of 27,850 km2 (CBH Velhas, 2015). The city of Belo Horizonte and part of its metropolitan region are located in Alto Velhas section . As one of the main sources of water supply for the metropolitan region, the Bela Fama system rests in the Velhas River, in the municipality of Nova Lima, and is responsible for approximately 40% of the RMBH' supply (COPASA, 2016).

In this study, two monitoring points in the Velhas River basin have been considered: the Santo Hipólito station, located in geographical coordinates 18°18'22"S latitude 44°13'33"W longitude, and the Honório Bicalho station, at the geographic coordinates 20°01'29"S latitude 43°49'26" W longitude, as shown in Figure 1.

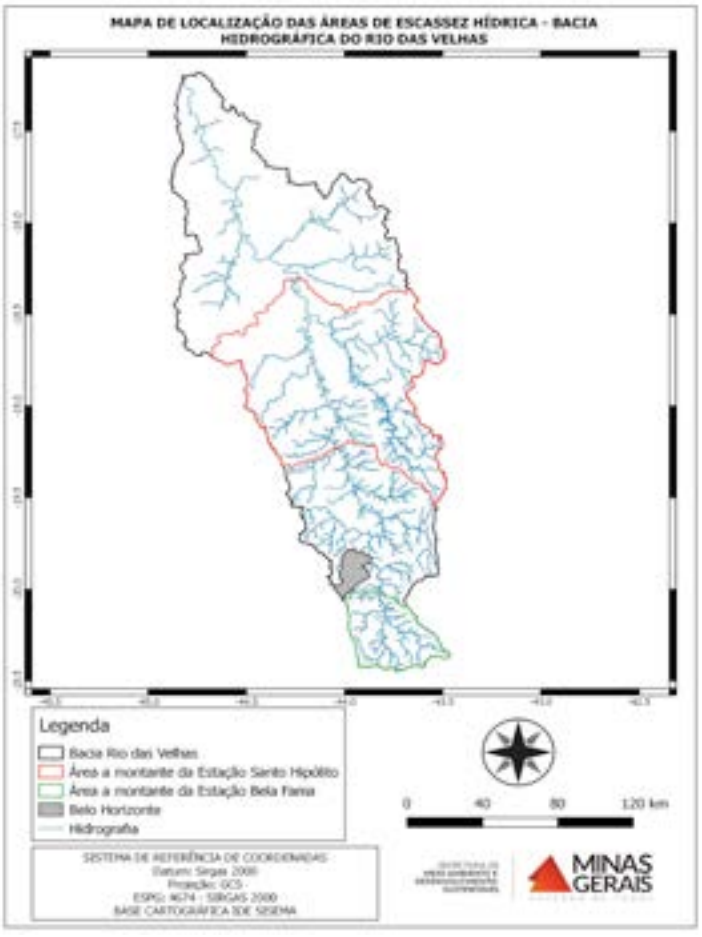

Figure 1 - Hydrographic sections upstream of the stations in Use Restriction Status.
Source: the authors, 2018.

The behavior of the aforementioned plants was analyzed in regards to the Attention, Alert, and Use restriction warnings established in the DN CERH 49/2015.

The hydrographic section upstream of the Santo Hipólito Station reached the Use Restriction Status twice (Figure 3), the first in the month of October 2015 (Portaria IGAM 33, of October 20,

2015, a 30-day term) and the second in August 2017 (Portaria IGAM 45, dated August 31, 2017 30-day term). The Honório Bicalho Station did not experience this Status during the period evaluated (Figure 2)

Figure 2 shows the number of days per year in which the flows monitored at the Honório Bicalho fluviometric station equaled or were lower than the conditions of surface water resources use restriction: normal, alert, attention, and restriction[5]. It should be noted that the area upstream of the station has undergone an "alert" state on two occasions:in 2015 and 2017, seeing that for this evaluation the 7-day average daily flow rate is used, not an isolated daily-basis measurement.

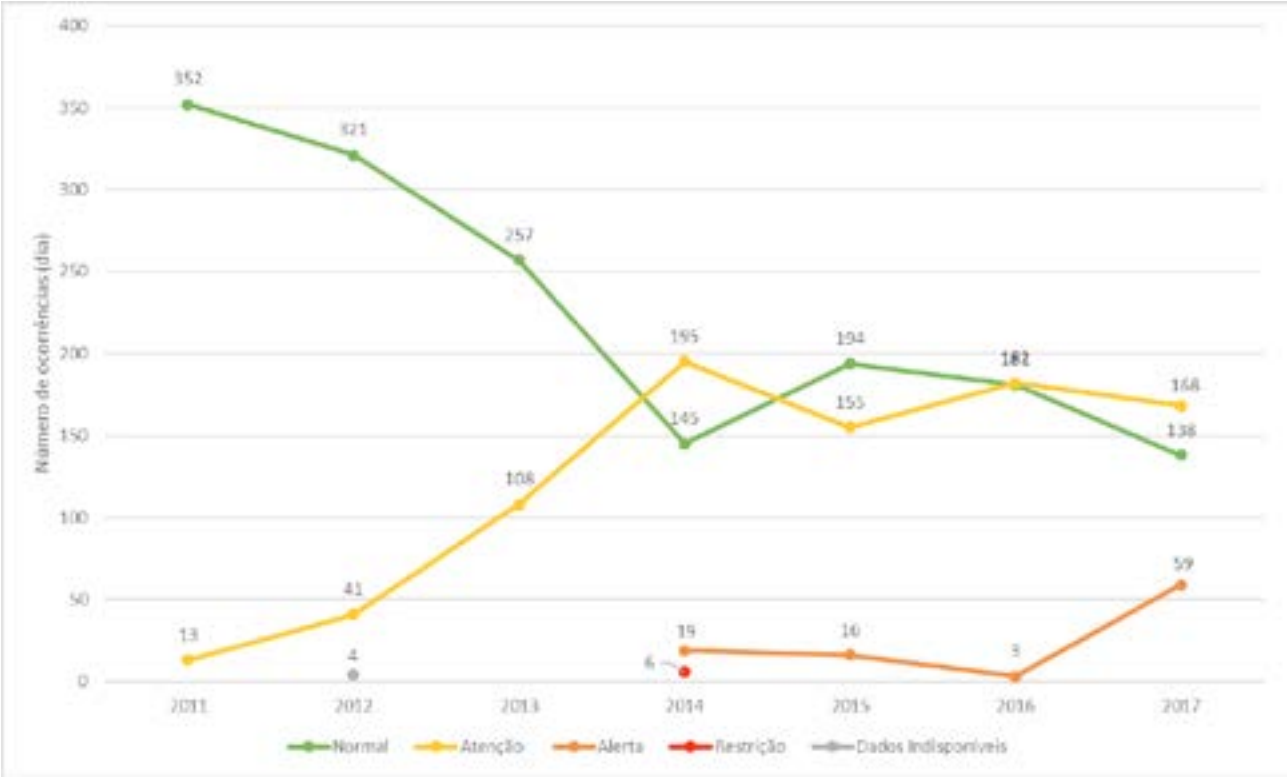

Figure 2 - Behavior of the Honório Bicalho Station in relation to the warning status framework established in DN 49/2015.
Source: the authors, 2018.

The hydrographic area where the Santo Hipólito station is located has recorded low flow rates in recent years. Since 2015, the flow rate has been equal or inferior too 200% of $Q_{7,10}$ in at least 250 days of the year, as shown in Figure 3. The area upstream of the station was put under use restriction status in two opportunities, in 2015 and 2017.

[5]Classification corresponding to the station's conditions taking 7 consecutive days into account, that is, following the rule described in Normative Deliberation No. 49/2015.

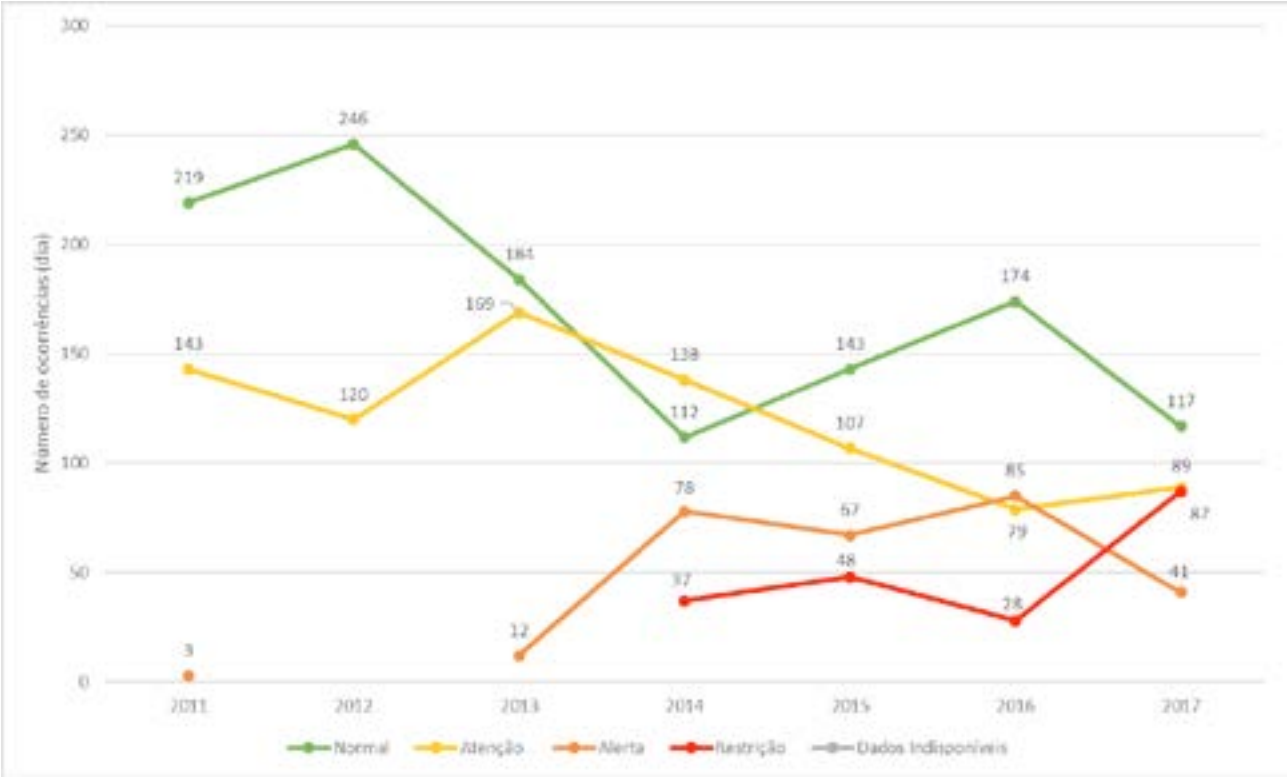

Figure 3 - Behavior of the Santo Hipólito Station in relation to the warning status framework established in DN 49/2015.
Source: Authors, 2018

Regulatory actions are only effective when integrated with enforcement: the command/control binomial widely used in public policies. Water resources inspection is aimed at ascertaining the regularity of surface or underground water bodies interventions and uses, as well as assessing compliance with permit requirements, that is, if water allocation is being conducted according to the permit granted. This is the exercise of administrative police power to ensure the regular and rational use of water resources.

The effectiveness of control instruments, such as inspections, is directly linked to the way they are planned and executed. In terms of use control, the water crisis management methodology is based on intensifying user inspection in the basin under restrictions. This guideline is reflected in the Annual Inspection Plan, which includes two inspection phases. The first is of preventive nature, held in the no-restriction period, when inspections are focused on irregular users. In the second phase, when the basin is under restriction, inspections are directed at regular users, with the main purpose of verifying compliance with the restrictions (allocation reduction) established by DN CERH 49/2015, without prejudice to the inspection of clandestine users not previously verified. Whenever irregularities are detected, administrative penalties (warning, simple fine, suspension of activities and restriction of rights) are applied in accordance with the provisions of State Decree 44.844/2008.

Due the current water shortage situation, in the Velhas River Basin alone a total of 1,374 inspections were carried out in 2015/2017 (Table 01), totaling R$ 1,058,744.92 in fines for irregular uses of water resources, 45% of which were related to irregular surface collection, 24% to irregular groundwater collection - unauthorized tubular wells, and 31% for other irregularities.

Table 1 – Inspections in the Velhas River Basin - 2015/2017. Source: the authors, 2018.

YEAR	REGULAR	IRREGULAR	TOTAL	FINE
2015	28	241	269	R$ 225,551.08
2016	12	168	180	R$ 262,351.02
2017	513	412	925	R$ 570,842.82
Total	553	821	1.374	R$ 1,058,744.92

Figure 4 and Table 1 show the number of inspections carried out annually in the Velhas River basin. As indicated, there is a growing trend in the number of inspections in the basin, as per the inspection intensification directive for basins under water shortage conditions. The only exception was in 2016: the reduction is directly linked to the basin's water level situation, as the basin did not undergo Use Restriction Status in that year.

The data presented also show an increase in user regularization (Table 1 and Figure 5), that is, the inspection led basin users to properly formalize their water resources use. In 2015, the percentage of irregular inspected users was 90%, while in 2017 there was a 50% reduction in this percentage, totalling 55% regular users. By increasing user regularization, inspections also directly contribute to water balance adjustments, providing the water resources management agency with a greater capacity to deal with water shortage in the basin.

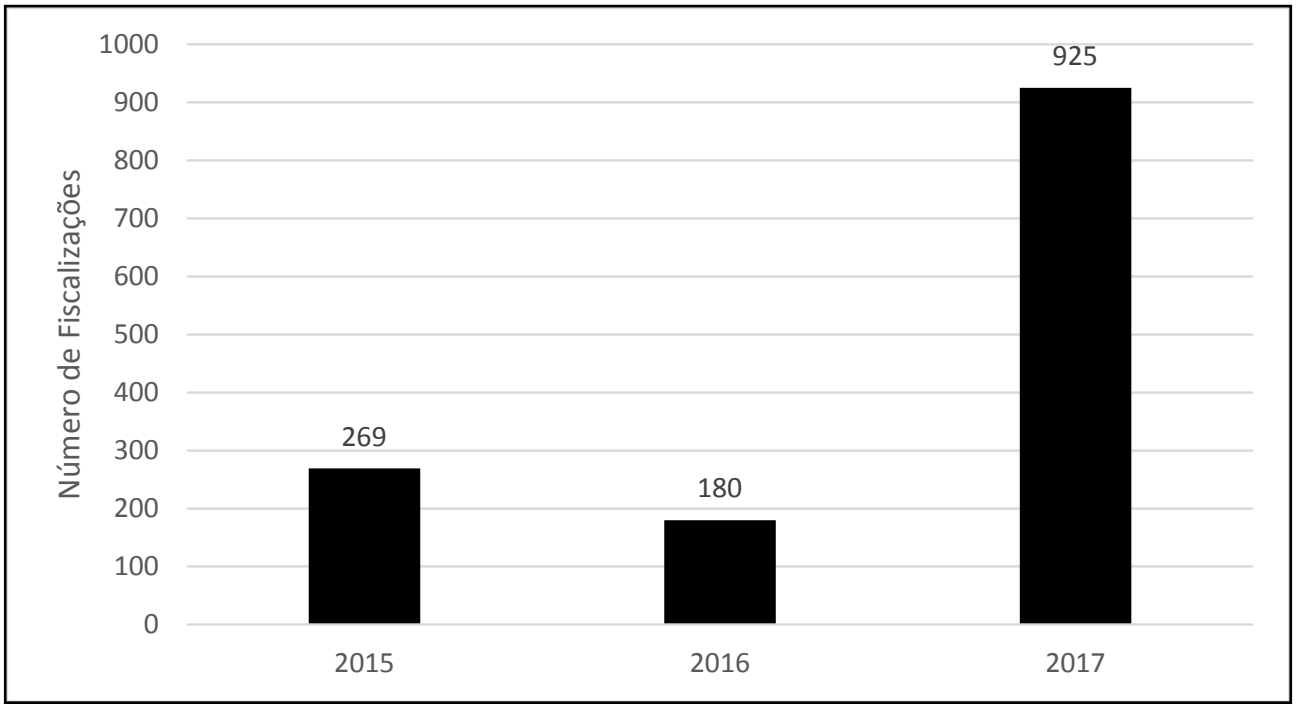

Figure 4 - Inspections in the Velhas River Basin - 2015/2017.
Source: the authors, 2018.

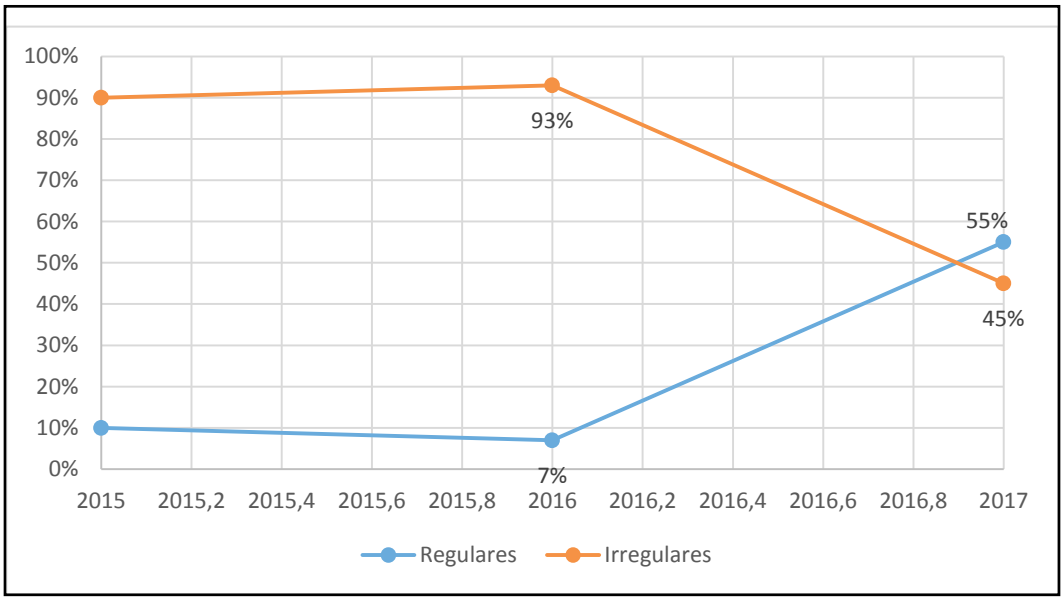

Figure 5 - Situation of the inspected users - 2015/2017.
Source: the authors, 2018.

Figure 6 shows the inspections density in the Velhas River basin between 2015 and 2017. As can be seen, there is a predominance of actions in Alto Rio das Velhas, a region characterized by high population concentration and intense economic activities that require water resources. The area corresponding to the São Hipólito Station, which was under Restriction Use Status in 2015 and 2017, presented the second highest density of users inspected in the period (emphasis on irregular use).

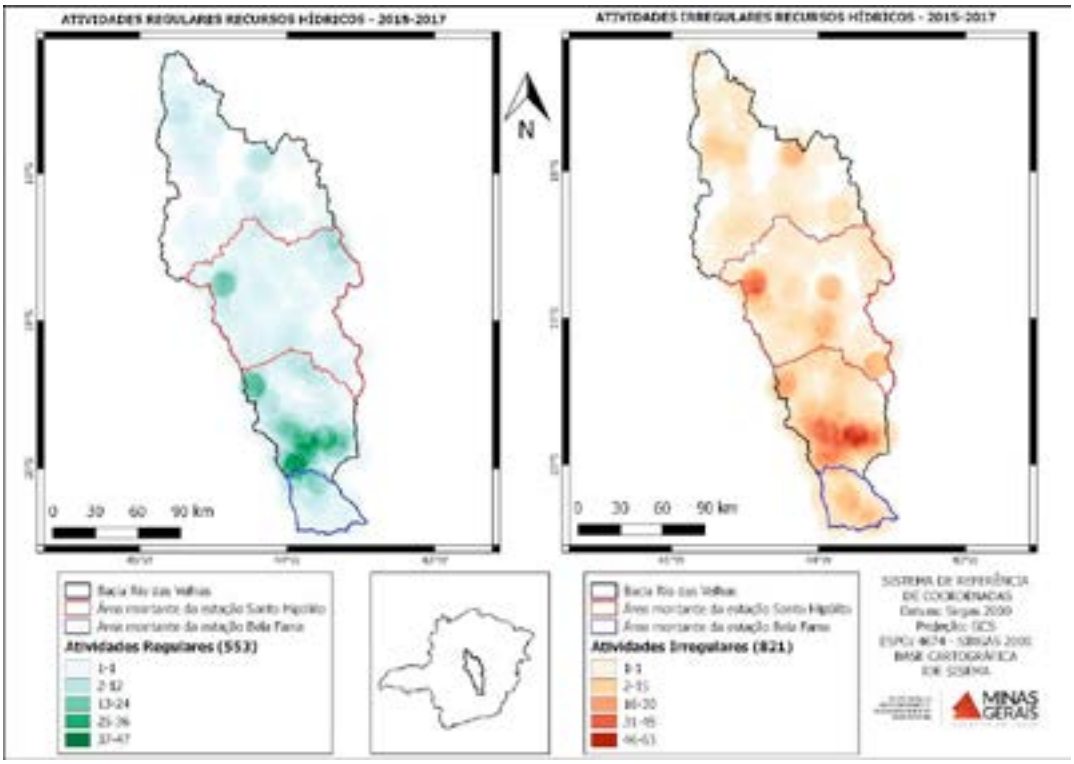

Figure 6 - Inspections in the Velhas River Basin - 2015/2017.
Source: the authors, 2018.

4. CONCLUDING REMARKS

An evaluation of the data presented allows us to conclude that regulatory actions are needed in situations of water scarcity and must be inspection-integrated to ensure effectiveness. In addition to guaranteeing the established water use restriction, they potentialized regularization in the two hydrographic sections investigated, thus reducing the percentage of irregularities detected in each year.

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IMPLEMENTATION OF MANAGEMENT INSTRUMENTS: CHALLENGES FOR IMPROVEMENT

Nádia Antônia Pinheiro Santos[1]
Patrícia Gaspar Costa[2]
Sônia de Souza Ferreira[3]
Allan de Oliveira Mota[4]
Marília Carvalho de Melo[5]

ABSTRACT

The management of water in Minas Gerais, defined by the State Policy for Water Resources, Law n°. 13,199, of January 29th, 1999, has as its cornerstone the implementation of Management instruments and is guided, mainly, by the accomplishment of the state and city master plans; classification, permission, levy and information system. After 19 years as of that State Law, it is of utmost importance to evaluate the situation of these instruments, since it allows us to define new goals and strategies for action in the Minas Gerais Units for Planning and Management of Water Resources (UPGRHs). From the instruments foreseen by law, only the compensation of cities for the exploitation and restriction of use and division of costs of multiple-use works did not come into place. The other instruments were implemented, even if partially, in the State, it being necessary to improve the level of implementation, especially with regards to the integration between them and with those of environmental planning and control. For that end, it is crucial to institutionally strengthen the entities in the State Water Resource Management System (SEGRH) so that they can perform their legal competences and play their role in the policy and management of water resources.

Keywords: Water Resource Management Instruments. Integrated Management. Institutional Strengthening.

1. WATER RESOURCE MANAGEMENT

In the past few years, with water scarcity and the intensifying of conflicts for the use of water, the integrated management of water resources gained relevance as a mechanism that seeks to ensure the multiple use and to mediate conflicts and, as a result, the needs of society.

The set of actions aimed at the regulation, planning and control and that allow for the protection, recovery and preservation of water resources is what is understood as management of water resources. These actions are guided by the implementation of management instruments[6], fundamental tools to ensure the environmental balance, as well as the quantitative and qualitative quality of the waters.

Evaluating the effectiveness of these instruments, 19 years after their implementation, is strategic to reveal the still-existing challenges and establish new goals for commitment with society.

[1]Geographer, master in Environmental Analysis, Environmental Manager at Igam, nadia.santos@meioambiente.mg.gov.br
[2]Agricultural Engineer, master's student, Environmental Analyst at Igam, patricia.costa@meioambiente.mg.gov.br
[3]Specialist geographer, Environmental Analyst at Igam, sonia.ferreira@meioambiente.mg.gov.br
[4]Biologist, master's student Environmental Analyst at Igam, allan.mota@meioambiente.mg.gov.br
[5]Civil Engineer, Ph.D. in Water Resources, Environmental Analyst and Director General at Igam, marília.melo@meioambiente.mg.gov.br
[6] State Law for Water Resources - 13.199/1999, which governs the State Policy for Water Resources and has other provisions

2. IMPLEMENTATION OF MANAGEMENT INSTRUMENTS

The management instruments, defined in art. 9 of Law 13,199/99, have the goal of regulating and sponsoring the rational use of waters. They are the following: State and City Master Plans for Hydrographic Basins; State Information System; Classification of the bodies of water; Permits for usage rights; Charging for the use of water resources; Compensation to cities for the exploitation and restriction of use; Division of the costs of multiple-use works with a common or collective interest and Penalties.

The Water Management Institute of Minas Gerais (IGAM), a state management body, has made efforts throughout the years towards implementing these instruments, along with the Committees for Hydrographic Basins (CBH) and the bodies equivalent to basin agencies. Each instrument has its specific role, be it regulation (permits, master plans, classification), sponsoring the rational use (charging) or support with information that is relevant for the management (information systems) (Brasil, 2015).

In Minas Gerais, the permits, responsible for ensuring the control of use of waters, were the first instrument to come into place, even before Law 13,199 of 1999 was published. A similar situation occurred with the classification of water bodies, which, between 1994 and 1998, was elaborated by the State Foundation for the Environment (FEAM) based on environmental policy. In this period, the water courses of the hydrographic basins of the Piracicaba, Paraopeba, Paraibuna, das Velhas, Pará and Verde rivers were classified by normative deliberation (IGAM, 2013). Throughout the years, the Igam elaborated, through the PDRH, guidelines for the classification of 13 UPGRHs and proposals for classification for 5 hydrographic basins (Figure 1).

Figure 1 - Timeline for the implementation of Management instruments.

In 2004, the IGAM, understanding the importance of planning and defining guidelines and criteria for the management of water resources in hydrographic basins, intensified the elaboration of Master Plans for Hydrographic Basins (PDRH), adding up to, in 2018, 30 plans concluded, four at the contracting stage and two under elaboration by the National Water Agency (ANA).

The level of implementation of these instruments, by Unit for Planning and Management of Water Resources (UPGRH), is shown in Figure 2. The number of instruments made effective per UPGRH was considered in its definition, with the classifications being, high (5), medium (4), low (3) and very low (<2).

Among the 36 UPGRHs in the State, four have all management instruments that were evaluated implemented: those near large urban centers, intensely explored, with a significant environmental commitment. They also have higher popular participation and more active CBHs.

The data presented in Figure 2 represent an outlook by numbers of the implementation. However, the evaluation should not be restricted to quantitative matters; it must also encompass qualitative aspects. Above all, it must be considered that each instrument has its specificities and difficulties for its implementation.

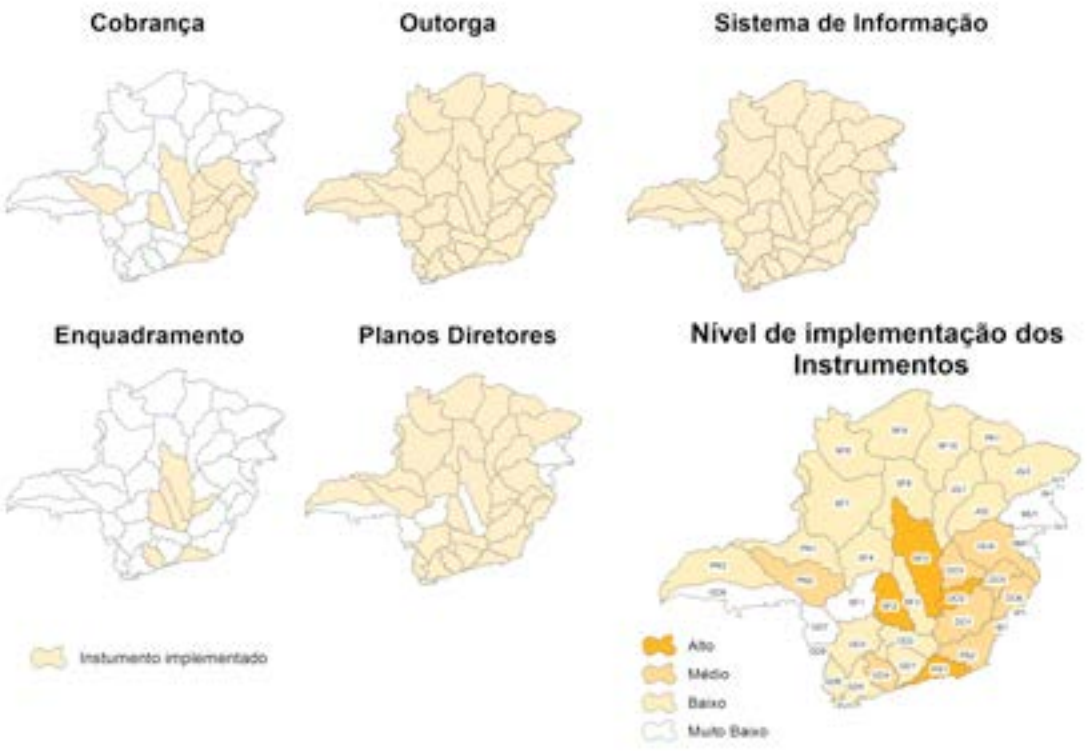

Figure 2 - Level of implementation of Management instruments per UPGRH.

Charging for the use of water, for example, which has as one of its goals to foster the rational use of water through economic mechanisms, has as one of its requirements the potential for tax collection. In some regions in the State, such as northern Minas Gerais, the potential is restricted, due to the low offer of water and dispersion of economic activities. This aspect may create problems for its implementation, as it becomes impossible to pay for the agencies and/or equivalent entities and operationalize the actions foreseen in the master plans. Therefore, in these regions, more support by the state for meeting goals of the management system for water resources is needed.

For the effective execution of the actions in the PDRHs, approved in a large swath of the State, more articulation and coordination with other sector-related public policies that relate to one another within the territory of the hydrographic basin is necessary, as well as more investment of financial resources. Charging for the use of water, for instance, should finance the implementation of the plan. However, the Brazilian social reality and the construction of the credibility of the economic instrument for the water resource management system result in single prices for charging that do not reflect the actual value of water. In addition, the lack of objectivity of programs and actions has made it difficult to apply these resources. Besides, the delays in the execution of the plans have necessitated their updating even before the goals are met.

Evidently, it is not expected to collect with Charging alone the amount necessary to pay for the actions proposed in the plans. But, through time, the volumes obtained have decreased in face of the increase in market costs, whereas the collection[7] is practically fixed. As a solution, other investments of similar sectors, such as sanitation, would complement and allow for programs and actions foreseen in the documents.

In the case of the classification of bodies of water, an instrument that fosters the intercession between water and environmental resource policies, as it defines limits and conditions for emitting polluting loads in the bodies of water for entrepreneurs, the absence of intermediate goals limits its application. Another factor that made it difficult to elaborate new classifications was the absence of a state regulating rule with guidelines to support the administrators. This was solved with the joint action of IGAM and the State Council for Water Resources (CERH) of Minas Gerais that resulted in the approving of CERH Normative Deliberation n° 06, of September 14th, 2017.

The collection permit, as an instrument, is spread and consolidated in the State. In areas with conflicts, collective permits are issued. However, the permit for releasing wastewater is restricted only to the Ribeirão da Mata sub-basin (an affluent of the Das Velhas river). This limits its integration with the classification, since it does not restrict the class standard for receiving bodies of water.

3. INTEGRATED MANAGEMENT: CHALLENGES FOR THE IMPROVEMENT OF MANAGEMENT INSTRUMENTS

The implementation of the instruments did not happen simultaneously in the state, which results in a few difficulties for the integrated management of waters. In this sense, it is fundamental to seek the alignment between them, this ensuring its efficacy (Brasil, 2015). Besides this articulation, it is necessary to improve the application of each of them, increasing the complexity in its execution. For example, the permits, that currently have the surface and underground, collective and wastewater releasing modalities, would improve its action with the issuing of seasonal permits as well.

Speaking more generally, the instruments for the management of water resources should be performed together with those of environmental control and planning[8]. Figure 3 shows the actions for said improvement.

[7]Within the national scope, Resolution No. 192/2017 of the National Council for Water Resources establishes the index for yearly correction of the amounts collected, thus trying to conquer this challenge.

[8]Law No. 6.938/1981, which defines the National Environment Policy.

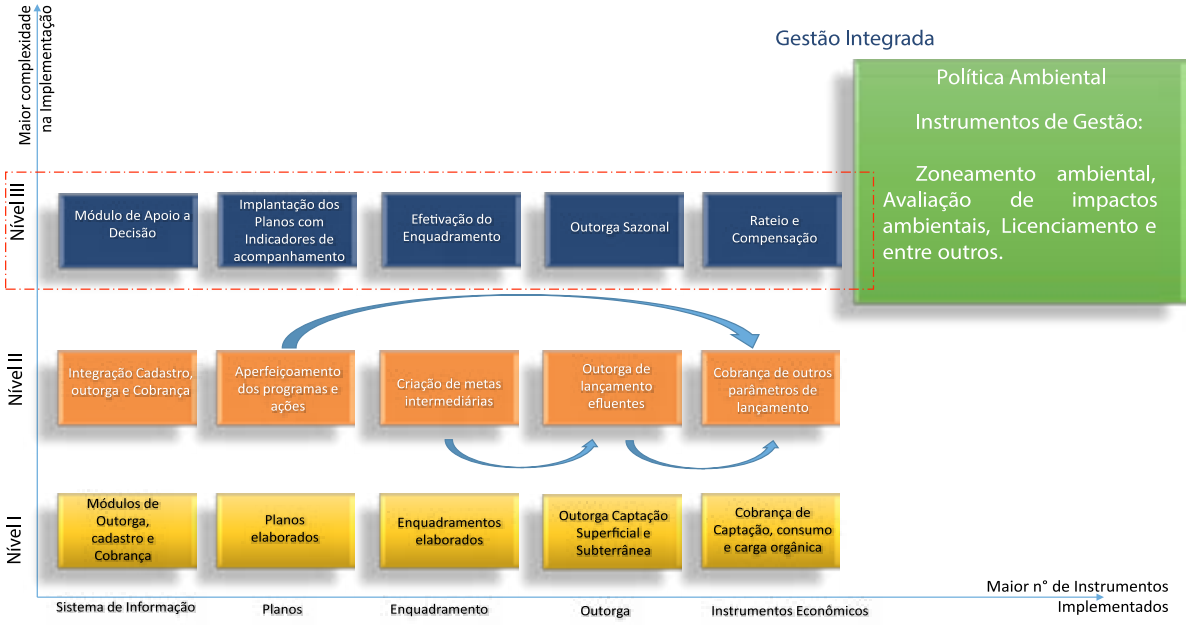

Figure 3- Proposals for the evolution and integration between the management instruments.

Some of these actions are already ongoing, such as the maintenance of modules of the information system, while others are at the planning stages, such as the increase in seasonal permits and permits for releasing wastewater for other regions in the State.

Another evolution would be the improvement in charging for releasing wastewater, encompassing other parameters, besides the DBO, as well as the implementation of other economic instruments such as division and compensation.

In relation to the PDRHs, the methodology for evaluating the implementation of the actions was defined. The analysis uses performance indicators to measure the degree of execution and was already applied to the plans for the hydrographic basins of the das Velhas and Verde Rivers. The analysis of the data was made through implementation and characterization matrixes (MOTA, 2018, in print).

Finally, the current challenge for the integrated, decentralized and participative management of waters in the State is the institutional strengthening of the bodies in the State Water Resource Management System (SEGRH) so that they can perform their legal duties in an effective fashion and fulfill their role in water policy and management. For that end, an agenda of priorities in the short, medium and long terms must be established, considering the management instruments in an integrated fashion within the territory of the hydrographic basin. That is besides the intersection of the water agenda with other sector-based public policies, aimed at improving the availability of water with good quantity and quality.

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WATER RESOURCES AND GEOINFORMATION: SPATIAL DATA INFRASTRUCTURE IN THE TERRITORIAL MANAGEMENT OF RIVER BASINS

Fabrício Lisboa Vieira Machado[1]
Marília Carvalho de Melo[2]
Germano Luiz Gomes Vieira[3]

ABSTRACT

The efficient management of official data and information produced by government agencies is one of the major challenges facing public managers, especially when the nature of the work involved implies the use of geographical variables, such as river basin management. In this sense, this paper aimed to evaluate the improvements resulting from the adoption of a geospatial data governance model within the scope of the State System of Environment and Water Resources. Through the construction of a Spatial Data Infrastructure (SDI), the dissemination of an online platform to access data and the accomplishment of cross-checks of geographical information with satellite images, the initial results pointed to an evolution in the speed and quality of service of the state environmental agencies to citizens, as well as the improvement of territorial management.

Keywords: Spatial Data Infrastructure. Water resources. Territorial management.

1. INTRODUCTION

A common historical challenge to public managers in Brazilian states and municipalities has undoubtedly been the ability to govern and disseminate the data and information produced and/or managed by government agencies, especially in view of the increasing advancement of new technologies and data generation capacity in increasingly shorter time intervals.

In the case of state environmental agencies, where products and services are fundamentally based on geographic variables, that is, those whose represented phenomena are located in the territory, the capacity to manage data and information will have direct repercussions on the efficiency of environmental management policies and instruments.

A particular example is the management of water resources, whose own Water Law (Law No. 9.433/1997) acknowledges the need to adopt the river basin as a territorial unit for the development of master plans, in view of the integration of the morphological aspects and processes of the geographical space with the use and occupation of the land, natural and anthropic characteristics that, when interacting, reflect the dynamics of the quality and quantity of resources, and are translated in computational environment by using data and information endowed with geographic value.

[1]Master in Geography and Environmental Analysis and Director of Environmental Territorial Management of the State Department of Environment and Sustainable Development.
[2]PhD in Civil Engineering and Director General of the Minas Gerais Water Management Institute (IGAM).
[3]Master in Law and Secretary for Environmental and. Sustainable Development.

In this sense, geoprocessing – a discipline that resorts to mathematical and computational techniques to treat geographic information (CÂMARA & DAVIS, 2001) – is an important tool for the management of water resources in the State of Minas Gerais, as it allows the intersection of several layers of spatial information, the modeling of scenarios and the transformation of such results into policies and instruments capable of guaranteeing access to the resource by citizens, with quality and quantity.

However, the absence of established norms and standards for data generation, treatment, storage and sharing by the State System of Environment and Water Resources (SISEMA), besides culminating in the culture of duplication of actions and waste of resources for obtaining official geographic information, has also impacted on the speed and quality of public administration services as for the issues concerning the environmental portfolio.

In view of the problems created, the need to remodel SISEMA, and the incorporation of locational criteria and geographical variables into state management instruments – such as environmental licensing – we have sought to adopt a corporate and shared governance model for data, standards and geospatial technologies, technically backed by government and academia: a Spatial Data Infrastructure (SDI).

Therefore, this paper aims to demonstrate the experiences and improvements of the state management of water resources, as well as the access to SISEMA's geographic data, enabled by the adoption of an SDI.

2. TERRITORIAL MANAGEMENT IN ENVIRONMENTAL LICENSING

The environmental legislation in the state of Minas Gerais has been modernized over the last three years. Initially though the promulgation of Law No. 21.972 of January 21, 2016, which reorganized the Environmental Policy Council, reestablishing the specialized technical chambers as decision-making bodies in the scope of Environmental Licensing. Regarding the instrument of environmental regulation of enterprises, the Law has standardized the three-phase, concomitant, and simplified licensing model. The latter represents an advance in the environmental performance control of activities that, until then, had been exempted from licensing and were regularized by means of an Environmental Operating Permit (EOP; in Portuguese, "Autorização Ambiental de Funcionamento, AAF). In spite of the contemporary conception of the EOP, which was solely based on the responsibility of the presenting party and the subsequent inspection, the practice has proved the low effectiveness of the instrument.

In 2017, COPAM 217 approved a Normative Resolution (in Portuguese, ND), which regulates environmental licensing in Minas Gerais. The main normative innovation is the inclusion of the locational variable in the framework of potentially polluting enterprises. From its application, an enterprise that intends to install in places with environmental or water resources vulnerabilities will have greater requirements of studies and environmental controls, if compared to those whose location does not coincide with locational factors chosen as validators of this norm. The new ND effectively manages the territory as the basis for licensing in the state.

As for the water issue, the new Minas Gerais standardization, which is based on a vision of licensing as an integrator of the environmental, forestry and water resources agendas in the territory, includes water resources variables within the enterprise classification framework. The following are locational water framework criteria:

1. Expected location in drainage area upstream of a watercourse in special class; and

2. Capture of surface water in areas of conflict motivated by the use of water resources.

Thefollowing are factors for the restriction or sealing of installation projects:

1. Restriction and control of groundwater use area (Approved through Joint Normative Resolution by COPAM-CERH, in a meeting held on 09/14/2017) – Restricted to the implementation of projects that depend on the use of groundwater, according to specific acts;

2. Special Class Water Bodies (Conama Resolution No. 430, dated May 13, 2011, and Joint Normative Resolution COPAM/CERH-MG, No. 01, of May 05, 2008) – Prohibits the release or disposal in the specified terms , including effluent and treated waste. In Special Class waters, the natural conditions of the body of water must be maintained;

3. Permanent Preservation River (State Law No. 15.082, of April 27, 2004) – Prohibits the modification of the river beds and banks and the sediment turnover for the mining of mineral resources in the specified terms, except in legally permitted cases.

The use of water criteria for the framing of the enterprise and installation restrictions shows an effective integration of environmental and water resources policies, which will lead to the improvement of the environmental quality of the territory. In this context, the IDE-SISEMA Platform is the tool that allows operating the territorial management introduced by the ND 217/2017 in the technical analysis.

3. THE IDE-SISEMA PLATFORM AND THE USER INTERFACE

With the main purpose of offering access services to geographic information through data collection catalogs on internet platforms, as Davis & Alves (2006) point out, IDEs (in English, Spatial Data Infrastructure, SDI) have gained national support and proportion through the publication of Decree No. 6.666/2008, which implemented the National Spatial Data Infrastructure (in Portuguese, INDE)

Substantiated by a robust Implementation Plan, conducted by the National Cartography Commission of the Brazilian Ministry of Planning, Budget and Management (CONCAR, 2010), the INDE is considered a landmark in the Brazilian geoinformational governance, given the set of organizational, technical and human dimensions which culminated, from the technological point of view, in the INDE Viewer – an important repository of free national geographic data on the web.

In Minas Gerais, by means of Decree No. 45.394/2010, the State Spatial Data Infrastructure (IEDE) was created in an effort conducted by the former Institute of Applied Geosciences, which, in a standardized way and in accordance with the national model, compiled the geospatial data from government departments on an online distribution portal.

However, given the specificity of the work of the environmental portfolio and, above all, the management of water resources, which requires complex technological tools to enable, for example, the development of surface and underground water availability studies for the regularization of users, portals and existing platforms, were not in line with the agencies' goals.

In addition, with the new environmental licensing model, which consolidates the premises brought by Copam Directive No. 02/2009, with the incorporation of locational criteria that add differentiated weights to projects located in areas of high natural vulnerability, the development of a thematic repository of geospatial data collected by state environmental agencies with technological features and resources adequate to the nature of the work has become essential.

In view of this, Joint Resolution No. 2.466/2017 established the Spatial Data Infrastructure of the State System of Environment and Water Resources (IDE-SISEMA), which is managed by a Steering Committee consisting of specialized technical sectors of the State Department of Environment and Sustainable Development, the Minas Gerais State Institute of Water Management, the State Institute of Forestry and the State Foundation for the Environment.

Among the actions developed by the Committee, more than 200 SISEMA professionals were trained in geoprocessing, aiming to improve the technical qualification of the professionals involved in the production of the agency's geospatial data, in light of the norms and rules provided for by IDE-SISEMA.

In addition, a continuous data inventory effort is being carried out, where all the layers of SISEMA information are mapped and placed in a unique and official geographical database, whose governance and updating is shared by the members of the Steering Committee.

Finally, a Geographic Information System on the web has been developed, in an internal way and based exclusively on free technologies, which will be the official georeferenced information repository for SISEMA. As shown in Figure 1, the "IDE-SISEMA Platform" has the features of updated satellite images and consultation of the information catalog of the organ, subdivided in thematic folders that include data concerning hydrography, relief, vegetation, soils, etc., beyond the state legally protected areas. It should be noted that the locational criteria of the new Copam ND 217/2017 have been mapped in the Platform, among which are the conflict areas for water use, the framing of the watercourses and the permanent preservation rivers.

By enabling the layers, a user can cross the available information through an integrated and spatial view of the territory, observing the physical and anthropic aspects of the state river basins. In addition, entrepreneurs and rural producers will be able to foresee possible environmental restrictions in the territories and basins of their interest, as well as to envisage locational alternatives for the installation of new enterprises, given the range of information already mapped by the agency.

Along these lines, the knowledge of the most diverse environmental variables can be anticipated by the interested party, so that, on the one hand, there are gains in quality of analysis and, on the other, in speed, rationality, adjustment of expectations and planning – issues that have been demanded by society for a long time.

Figure 1 - Active layers in the IDE-SISEMA Platform, which allow the visualization of the areas of conflict by use of water resources, central pivots and the basins drainage network._
Source: Test version of the IDE-SISEMA Platform.

In turn, the Public Prosecutor's Office can consult where environmental monitoring operations are being carried out, and all attributes related to that feature are available in the Digital Platform, such as the audited agenda, the dynamics of the assessments, the municipality and the river basin where it has occurred, as well as water quality indicators and anthropogenic pressures imposed over the water resources.

Furthermore, the IDE-SISEMA Platform can also be used during the analysis of the processes of water resources regularization by legal bodies, adding safety and technical quality to the identification of impacts resulting from the activities modifying the environment.

4. FINAL REMARKS

The IDE-SISEMA Platform is currently in the final stages of testing, and its Steering Committee is attentive to the support and feedback channels. It is hoped that with its launch and with the effective contribution of state environmental servants, scholars, State Councils on Water Resources Councils and Environmental Policy, among other participants, the Platform can consolidate itself as a tool for territorial management, providing excellent river basin management and government/citizen relationship, in the scope of the environmental agenda in general as well as for access to information.

In addition, the first results already reveal the consequent improvement in the safety and speed of the processes of environmental management and regulation and water resources in the State, subsidized not only by the technological tool but also by the cyclical and continuous effort of geoinformation governance.

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PROJECT ON MUNICIPAL ENVIRONMENTAL MANAGEMENT: A COOPERATIVE EXPERIENCE IN THE RIO DOCE BASIN

Andrea Lopes Pereira[1]
Leonardo Castro Maia[2]
Luciana Hiromi Yoshino Kamino[3]
Luciane Teixeira Martins[4]

ABSTRACT

Project to foster joint actions of the District Attorney's Offices (Execution Entities) of the State of Minas Gerais Public Prosecutor's Office on environmental problems in the Hydrographic Basin, especially the ones related to access to water and basic sanitation in partnership with Instituto Prístino, the Rio Doce River Basin Committee (CBH-DOCE, acronym in Brazilian Portuguese), and Instituto BioAtlântica. Primary and secondary data on municipalities in Minas Gerais were collected by means of formulaires filled out by municipal managers, and expert reports, and legal measures under the responsibility of the Public Prosecutor's Office were adopted. Whilst, the municipalities along the basin have received funds from CBH-DOCE in order to implement their Sanitation Plans.

Key-words: Water and basic sanitation rights. Public Prosecutor's Office. Doce River basin. River Basin Committee. Project.

1. INTRODUCTION

Based on the ideas of Antônio Herman Benjamin (BENJAMIN, 1998) and seeking to foster joint efforts of its execution entities accountable for environmental actions, considering hydrographic basins as work units, especially as regards the importance of administrative efficiency, the State of Minas Gerais Public Prosecutor's Office (MPMG, acronym in Brazilian Portuguese) established the first Regional Offices per Hydrographical Basin in 2001 (SOARES JÚNIOR, 2003); and, in 2011, the Rio Doce Basin Regional Office (CRRD, acronym in Brazilian Portuguese).

The Project on Municipal Environmental Management in the CRRD has been developed in light of such ideas.

2. THE PROJECT

The Project started in 2014, having two sets of facts as starting points:

[1]Specialist in Environmental and Urbanistic Law at UNIDERP. Analyst on the State of Minas Gerais Public Prosecutor's Office Law. E-mail: andrealopes@mpmg.mp.br
[2]Doctorate Candidate in Humanities at UFSC. MA in Integrated Territory Management at UNIVALE. Specialist on Environmental and Urbanistic Law at UNIDERP. Coordinator of the Environmental Public District Attorney's Office at Rio Doce Basin. Public Prosecutor in the state of Minas Gerais. leonardomaia@mpmg.mp.br
[3]PhD and MA in Vegetal Biology at UFMG. Biologist and Coordinator of the Instituto Prístino. luciana@institutopristino.org.br
[4]Biologist, holds a postgraduate degree in Normative Management of Water Resources. President of the Doce River Hydrographic Basin/CBH-DOCE. luteix2005@hotmail.com

1) A substantial part of the environmental problems in Rio Doce Basin, especially the ones related to access to water and basic sanitation, are related to actions (or neglect) by the municipalities as regards managing their territories.

2) The CRRD, since its inauguration, had already collected knowledge and precedents regarding several environmental problems, due to its supporting activities as well as the initiative of its District's Attorney Offices. Such activities demand compilation and sharing of data throughout the basin eventually leading to increased chances to effective compliance with proper legislation.

Thus, the following problems were chosen for the MPMG to deal with in coordinated actions: (a) Lack of Basic Sanitation Plan; (b) Lack of drinking water supply; (c) Lack of sewage collection and treatment; (d) Issues on solid waste management; (e) Violation of the State Law 12.503/1997, which determines investment in the basins for water conservation by the water concessionaires; (f) Issues in the Municipal System for Environmental Licensing; (g) Lack of a Municipal System on Environmental Data; (h) MPMG is no notified of environmental violations identified by the environmental agencies; (i) Issues on setting up and regularizing Municipal Conservation Units (UCs, acronym in Brazilian Portuguese)[5].

It has been set that the aim of the Project would be to: (a) Collect data on the situation of the municipalities along the basin, by using information provided by municipal managers[6], as well as, other databases, and through procedures performed in loco by the CRRD, in an effort not to burden Execution Entities with the cost of services; (b) Compare and interpret collected data, and make it available to Execution Entities and the public at large; (c) Prepare supporting material, such as Conduct Adjustment Terms (TAC, acronym in Brazilian Portuguese), lawsuits (ACPs, acronym in Brazilian Portuguese), due diligence investigations, etc.; (d) Introduce and inform support procedures to each municipality, by sending supporting material to Execution Entities, notwithstanding the institutional independence of each Entity, but with coordinated cooperation, rationalization, optimization and standardization, in order to maximize the efficiency of institutional actions; (e) Working proactively in negotiated solutions, and, as a last resort, through fostering mandatory proper actions.

Partnerships with Instituto Pristino were established to overcome technical (not legal) difficulties, especially as regards drafting technical. Moreover, other partnerships were established with the CBH-DOCE and its respective Water Agency, Agência de Águas (IBIO AGB DOCE), to review the obligations listed in the job aid. Also, evidence showed that the CBH-DOCE could take action and had the resources to pay for drafting Sanitation Plans, which was a convergence point to the work being conducted by MPMG in the municipalities along the basin.

Considering such scenario, the Project has complied with the 2010-2023 MPMG Strategic Map, as regards the search for: (a) Results for society in defending the environment and health; (b) In external relationships: (b.1) Fostering and monitoring implementation of public policies to improve indicators and bring about social change; (b.2) Improve communication between CBHs and municipalities; (c) In internal processes: (c.1) Deliver effective work; (c.2) Rationalize, optimize, and standardize procedures to maximize efficiency of institutional actions; (c.3) Increasingly uniform practices between agencies while protecting institutional independence; (d) As regards resources: (d.1) Optimize management of human, physical, and financial resources, reduce concentration of

[5]It is important to highlight that fostering regularization, expansion, and connectivity of territories protected for special reasons was one of the objectives of the State of Minas Gerais Public Prosecutor's Office Overall Action Plan in 2014.

[6]Electronic form based on the print form developed in the scope of the STATE OF BAHIA PUBLIC PROSECUTOR'S OFFICE, made available by Public Prosecutor Luciana Espinheira da Costa Khoury.

demands on Execution Entities; (d.2) Have specialized technical support to perform target activity; (e) Foster knowledge management in order to make it easier to share and multiply knowledge.

3. CONCLUDING REMARKS

The total amount of actions and other criteria were set by the MPMG as project indicators. Such MPMG measures were managed because of the support developed on the scope of the CRRD as relates to target activities performed by Execution Entities, as well as work assessment conducted by such entities.

Achieved results can be summarized as follows:

a) Total amount of measures implemented until February, 8th 2018: 163 Support procedures implemented, one in each municipality; 215 files from Execution Entities (Civil Inquiries, Preparatory Procedures, and Actual News), 205 of those files were returned with ACP minutes, TAC, closure, or diligences; 309 Actual News were introduced, informed, and sent to Execution Entities; 272 ACPs, 48 on solid waste; 30 on Waste Management Plan; 84 on sewage; 26 on water supply; 30 on regularization of UCs; 1 on regularization of the Municipal Environment Council; 27 on the violation of the State Law 12.503/1997; 26 on Basic Sanitation Plan; 29 on TACs agreed upon: 13 on Basic Sanitation Plan, 7 on regularization of UCs; 4 on drinking water supply; 2 on sewage, and 3 on solid waste; 20 Civil Inquiries were closed: 4 on solid waste; 1 on Waste Management Plan; 2 on sewage systems; 7 on water supply; 1 on regularization of UCs; 2 on Municipal Environmental Council; 3 on Basic Sanitation Plan.

b) On the (optional) assessment conducted by Execution Entities, the results were as follows: 100% on the usefulness of the job aid material sent by the CRRD; 91,7% maximum approval rate of the quality of the job aid material (grade 10, gap from 1 to 10), the lowest grade was 6; 79,4% maximum approval rate on service period (grade 10, gap between 1 to 10), the lowest grade was 6.

c) Expert investigations performed by Instituto Prístino: 200 (two hundred).

In 2016, the Project was awarded first place in the category Management Professionalization by the Public Prosecutor's Office National Council (CNMP, acronym in Brazilian Portuguese).

During the same period, 165 municipalities in the state of Minas Gerais received funds from CBH_DOCE for their Sanitation Plans.

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THE NEW APPROACH FOR PRESERVING AND RECOVERING THE WATER SUPPLY WELLSPRINGS USED BY COPASA-MG

João Bosco Senra[1]
Maíra Fares Leite[2]
Nelson Cunha Guimarães[3]
Glaycon de Brito Cordeiro[4]

ABSTRACT

The Pro-Wellspring Program was conceived by Copasa in 2016 and its inclusion in the tariff makeup was approved during the 2017 revision performed by the ARSAE - Regulatory Agency for Water Supply and Sanitation Sewage Services of the State of Minas Gerais, aiming to recover and preserve the water basins and recovery areas for surface and underground wellsprings, where Copasa captures the water for the public supply, thus improving the quantity and quality of this natural resource. The Program is based on the award-winner Cultivando Água Boa Program, implemented by Itaipu Binacional, applying principles such as shared responsibility, subsidiarity and participative methodologies. The participation of the cities' authorities and the creation of a local collective made up by several entities, in charge of the stages of diagnosis, planning and monitoring of the actions implemented by Copasa and partners, is indispensable for the development of the program. The Program is being initially developed in 149 cities and is continuous, with new cities being yearly inserted.

Keywords: Wellspring protection. Social participation. Water supply.

1. INTRODUCTION

The climate changes highlighted by the UN Intergovernmental Panel on Climate Change worsen the critical effects - intense droughts, major storms, more frequent floods, impacting the conditions of human life, biodiversity and water, with repercussions on economic activities (INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE - IPCC, 2014), above all those that directly depend on water resources, as is the case of Copasa – Minas Gerais Sanitation Company.

We have seen in the past few years an uncommon drought period that generated a situation of water scarcity in several regions of the State of Minas Gerais, never seen before, requiring preventative and urgent measures to ensure the preservation of the supply sources of water for the population's consumption.

Copasa has been developing, since the 1980s, continuously, environmental protection programs. These programs were reformulated, culminating in the Pro-Wellspring Program, aimed at protecting and recovering the water micro-basins and the recovery areas for aquifers with wellsprings that provide the capture of public water supply systems operated by Copasa. The Pro-Wellspring program seeks the fostering and implementation of actions integrated with partners and the community, aiming at the improvement of the quality and quantity of water, supporting environmental, economic and social sustainability.

[1]Graduated in Civil Engineering at Faculdades Kennedy, Master and Doctoral Student in Sanitation, Environment and Water Resources at UFMG, Chief Technical Advisor of the COPASA-MG Presidency, joao.senra@copasa.com.br
[2]Bachelor in Geography at UFMG, master in Water and Society at Université Montpellier2/AgroParisTech, sanitation analyst at COPASA-MG, maira.fares@copasa.com.br
[3]Graduated in Civil Engineering at the UFMG, Master in Sanitation and Environmental Engineering at UFMG, Environmental Superintendent at COPASA-MG, nelson.guimaraes@copasa.com.br
[4]Graduated in Civil Engineering at UFMG, manager of the Environmental Action Division at COPASA-MG, glaycon.cordeiro@copasa.com.br

Copasa, as per ARSAE Resolution 96/2017, will invest the equivalent to 0.5% (half percent) of the previous year's operational revenue in developing the Program. For applying the Resources, three hydrographic regions were defined, encompassing the 36 Units for Planning the Management of Water Resources in Minas Gerais - UPGRH - defined by the State System for Managing Water Resources, as per the map below.

Figure 1 - Map of the Hydrographic regions for the Investment of Resources of the Pro-Wellspring Program

The yearly choice of wellsprings to receive resources of the Program is made through a prioritization matrix that evaluates the following criteria: water scarcity undergone by the wellspring in previous years (past two years); population supplied by the wellspring; initiatives for recovery/protection in place in the city; quality of the water captured; environmental situation of the wellspring basin and type of capture.

An important cornerstone of the Program is the work with the participation of communities and with the establishment of partnerships, ensuring the sustainability of the actions and of their results and generating more security with regards to the water distributed by Copasa to the population. The Program fosters proactivity, social responsibility, creativity and protagonism from the training of transformative local agents, whose work integrated with the local public policies enhances the results of the Program.

2. THE DEVELOPMENT OF THE PROGRAM

In the first year of the Program, 149 cities were selected by Copasa in the State of Minas Gerais, as per Figure 3. Its development is made up by well-defined, sequential stages in a participative fashion, as described in Figure 4, based on the coordination of Local Environmental Collectives – COLMEIA with components of Copasa, the city halls and public or private entities.

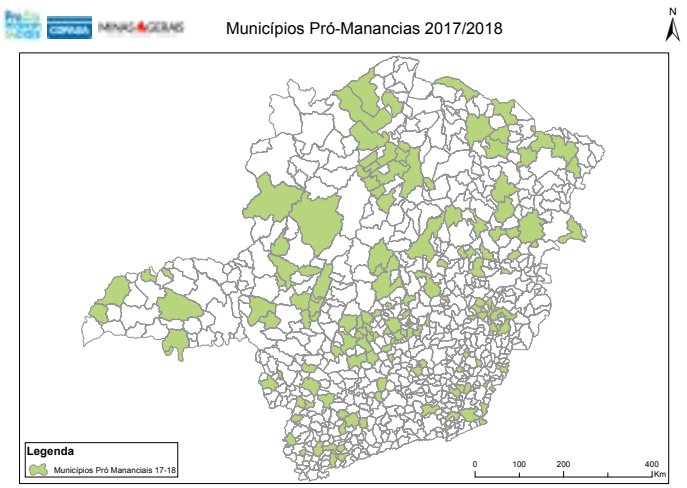

Figure 2 - 2018 Pro-Wellspring city map

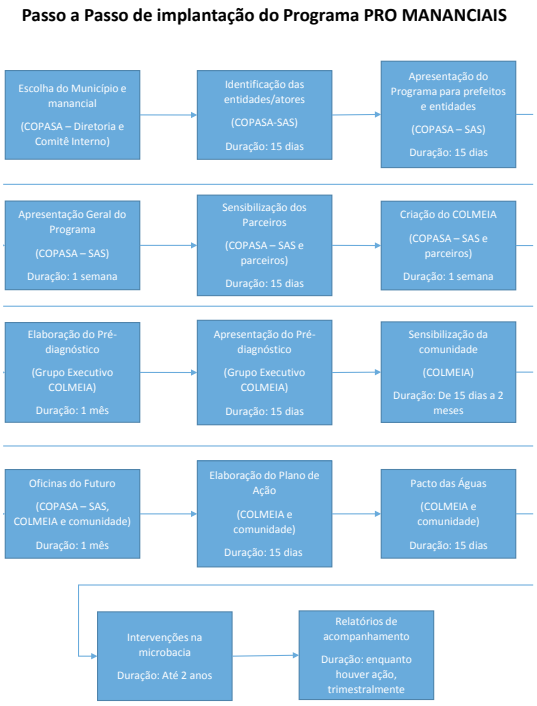

Figure 3 - Step-by-step implementation of the Pro-Wellsprings Program

So far, the Program has achieved over 38 Km of spring enclosures and permanent preservation areas, 816 machine hours used in the construction of firebreaks and containment basins for rainwater, besides actions for environmental education in 33 schools in the city and state systems.

Figure 4 - Enclosure in Montes Claros

Figure 5 - Containment basin in Curvelo

2.1. The COLMEIAs

Copasa, after the approval by the city authorities, the identification of entities present in the territory chosen and the divulging/mobilization with the community, proposes the creation of the Local Environmental Collective - COLMEIA, which participates on the stages of diagnostic, planning, building and follow-up of the action plans to be developed in the microbasin chosen, in a participative and collaborative fashion. For that end, the methodology of the Oficina do Futuro, created by the Ecoar Citizenship Institute and used by the Cultivando Água Boa Program is applied, in three stages: Muro das Lamentações ("Wailing Wall", a moment for discussing the challenges and differences, for expressing the group's issues), Árvore dos Sonhos ("Dream Tree", stimulating the dreams of the participants for the territory worked) and Caminho Adiante ("Path Ahead", planning of the actions and responsibilities for reaching the goals that were defined) (CAB, 2018).

In the Action Plan of the basin, each member of the COLMEIA takes charge for certain actions, be it material, financial and/or human resources, besides the possible contributions by the community that resides in the micro-basin. Copasa has a "menu of actions" that can be performed by the company as per the needs and specificities of the area, among them planting, enclosure of permanent preservation areas, installation of biodigesters, infiltration dams, cisterns for rainwater, recovery of roads and training and workshops for fostering sustainable practices at the basin, such as agroecological practices.

So far, 65 COLMEIAs were formed in the State, with the participation of local partners, such as city departments of environment, health and education, EMATER, associations of producers and residents, NGOs, organized civil society and others.

Figure 6 - COLMEIA Meeting - Campos Gerais, 08/17

Figure 7- Oficina do Futuro - São Tiago, 10/17

2.2. The partnership with the Regulating Agency

The Pro-Wellspring Program was validated by Copasa with ARSAE, through ARSAE Resolution 96/2017, which established as a yearly expenditure goal and considered in the tariffs the integral earmarking of resources corresponding to 0.5% of the Operational Revenue obtained in the previous year to the Wellspring Protection Program. Rules were also established to ensure the transparency and the social control of the Program, besides mechanisms for following up on and for surveying the projects and resources applied, also foreseeing tariff compensations for complying with usage goals.

Follow-up reports for the Program will be made quarterly, with the actions performed in the period and those foreseen in the action plan of each microbasin chosen, as well as an evaluation of the development of the Program in the city. The report is jointly elaborated by the COLMEIA in the city and sent to ARSAE, thus maintaining the Social Control of the Program and of the resources applied by Copasa.

At present, COPASA issues an annual performance report with its findings to inform ARSAE.

3. CONCLUDING REMARKS

The Pro-Wellspring Program is an efficient instrument to ensure the improvement in the quality and quantity of water in wellsprings operated by Copasa so as to ensure more water safety to the water supply systems. The accumulation of actions by the company and actions of partners with the effective participation of the local community in the diagnosis, planning and monitoring of the

program fosters the feeling of belonging and commitment of all involved in preserving the water resource and in generating a sustainability culture. ARSAE's understanding of the importance of the Program and the inclusion of specific resources for its development in the water tariff is an innovative arrangement that allows for advancing the application of the principle of shared responsibility between different parties. This principle is fundamental for the process of change in the territories, for the preservation of the resources needed for our survival and living standards and for the construction of socially beneficial and productive environments.

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PROCESSES FOR WATER MANAGEMENT OPTIMIZATION

Fernando Falco Pruski[1]

ABSTRACT

In addition to being a fundamental component of the environment and natural landscapes, water is necessary for nearly all human activities. When water is abundant, it can be treated as a freely available resource with no economic value. Water scarcity is associated with situations in which water availability is insufficient to meet the demands and maintain the necessary environmental conditions for sustainable development. Defining water shortage risk requires proper knowledge of water availability and demand, because scarcity can also arise from qualitative aspects. This paper presents alternatives that can allow the increase of water availability and the more rational use of water resources while mitigating existing or potential conflicts.

Keywords: Erosion control. Availability quantification. Seasonality.

1. A PRACTICAL VIEW OF WATER RESOURCES MANAGEMENT

Water management is the main method of addressing scarcity-related issues. Natural availability is understood in terms of the minimum flow rate levels, which reflects water availability in so-called run-of-the-river conditions. The average water flow rate determines potential water availability and is the largest regulated flow rate today. Proper water management requires knowing the (natural and potential) availability of water in order to meet demands.

In this process, the hydrographic basin should be the basic planning unit: hydrography is the basin's circulatory system and the water body is the basin. Whatever is done in the basin is reflected in its hydrography. Intervening in the hydrography means working at the "consequence" level: if the goal is to address the cause, then the right course of action is to intervene in the basin. Changing this approach is essential in order to migrate from management to actually planning. In this sense, areas with agro-silvo-pastoral occupation play a key role, since it is in non-waterproofed areas that water production can be maximized on a regular basis and at quality levels. While in urban areas interest lies in rapid drainage, in rural areas it rests in ensuring long-lasting water infiltration and maintenance in the hydrological system.

2. IMPLEMENTING ACTIONS FOR EROSION CONTROL

Erosion is the process through which soil particles are detached and dislodged. In addition to suspended soil particles, surface runoff also carries chemical nutrients, organic matter, seeds, and agricultural pesticides, which promote river and reservoir pollution. Erosion also causes water availability problems, resulting in floods in the wet season and increasing scarcity in the dry season.

Adopting measures to contain water runoffs means "transforming problems into solution". Conservation planning should be based on increasing the duration the water remains in the basin: the higher

[1]The Federal University of Viçosa, ffpruski@ufv.br.

the site where water infiltration is promoted, the more efficient this action will be, thus reducing sediment release and transport, which in turn increases the length of time the water can remain in the basin. From such a perspective, it is possible to bypass the long-awaited, emblematic revitalization of water springs, as this would grant the "down the slope" springs a return to their place of origin.

3. QUANTIFYING WATER RESOURCES AVAILABILITY

Water availability knowledge can be helpful when making political and administrative decisions associated to water usage. Therefore, it is essential to develop actions aimed at promoting better knowledge about the availability and best use of water resources. By means of regionalization studies in which the real complexity of this process is considered, the adequate quantification of water availability can lead to better water allocation. Such studies need to take into account variables that help to describe the behavior of the natural system and should also employ a solution that allows for the extrapolation of the regionalization equations in headwater sections.

Sponsored and monitored by the Water Management Institute of Minas Gerais (Igam), a study developed by the Water Resources Research Group (GPRH) at the Federal University of Viçosa (UFV) conducted the regionalization of the minimum ($Q_{7,10}$, Q_{95}, Q_{90}) and average (Qmld) water flow rates, allowing them to be obtained in any hydrographic section (1:100,000 or 1:50,000 scale) under Igam's control.

It is worth mentioning that groundwater resources are not an inexhaustible source and that the availability of surface water resources is directly linked to groundwater. The intensive use of these resources leads to reductions in minimum flows, since the subsurface flow is the main source of water flow in dry periods.

4. MANAGEMENT BODIES' CRITERIA COMPATIBILITY TO ESTABLISH MAXIMUM PERMISSIBLE FLOW RATES FOR WATER ALLOCATION

In addition to contradicting the National Policy of Water Resources, which establishes river basins as a basic planning unit, the adoption of different permit granting criteria also creates serious problems in basins that share different management bodies.

A study about the Rio Paracatu basin, which has 96% of its area in the state of Minas Gerais, 2% in the state of Goiás and the remaining 2% in the Federal District, examined the permits in force in January 2010. The run-of-the-river permits had two distinct minimum flow rates: Q_{95}, as used by the National Water Agency (ANA) for the Preto River basin, and $Q_{7,10}$ adopted by IGAM for the remainder of the Paracatu River basin. At the time the study was carried out, the criterion in force in Minas Gerais was to grant up to 30% of the $Q_{7,10}$ minimum flow rate. The study showed that if IGAM's criterion (30% of $Q_{7,10}$) had been used in the whole basin, only 51.8% of the granted passages would be in compliance, while 95.3% would be compliant if the criterion used by ANA (70% of Q_{95}) had been adopted.

The management agencies' quest for compatibility between granting criteria for maximum flow permits will result in fairer distribution of water resources, thus representing a significant advance in the process of sharing water.

5. THE USE OF MINIMUM MONTHLY FLOW RATES FOR PERMIT GRANTING

The adoption of minimum monthly flow rates for permit granting allows the rational use of water, reducing the risk of environmental damage in the remaining flows. In addition to comprising a single restriction for the entire year, annual minimum flow rates are beneficial due to the fact that in general high demand periods for water resources do not coincide with periods of minimum water availability.

Bof (2010) evaluated the impact of using several criteria for permit granting considering the conditions in the sub-basin of the Rio Paracatu upstream of the confluence with the Entre Ribeiros stream. The maximum permissible flows for granting permits were compared based on the criteria used by IGAM and ANA on an annual and monthly basis. At the time, the criterion used by IGAM was to grant up to 30% of $Q_{7,10}$. In the study, data from six stations located in the basin were used. Figure 1 presents the results for the Fazenda Limoeiro station - the behavior evidenced in the other stations is similar to that station.

The annual Q_{95} is 47% higher than the annual $Q_{7,10}$, which, based on the 70% granting criteria of Q_{95}, makes the permit value is 3.4 times greater than the 30% criteria of $Q_{7,10}$. This last criterion is quite restrictive, since it limits the permissive value for water use to a restriction observed in one period of the year only. The use of the criterion corresponding to 70% of the annual Q_{95} also limits the use of water to a restriction arising from specific periods in which water availability is reduced. In this case, the criterion, in addition to being restrictive in the months of greater water availability, is excessively permissive in the months of less availability, which increases the likelihood of the river eventually drying out (in September and October). In these months, 70% of the annual Q_{95} rate reaches the $Q_{7,10}$ monthly values, which implies that there is a high risk of the river drying out. However, with the use of the 70% criterion of the monthly Q_{95} rate, this risk decreases.

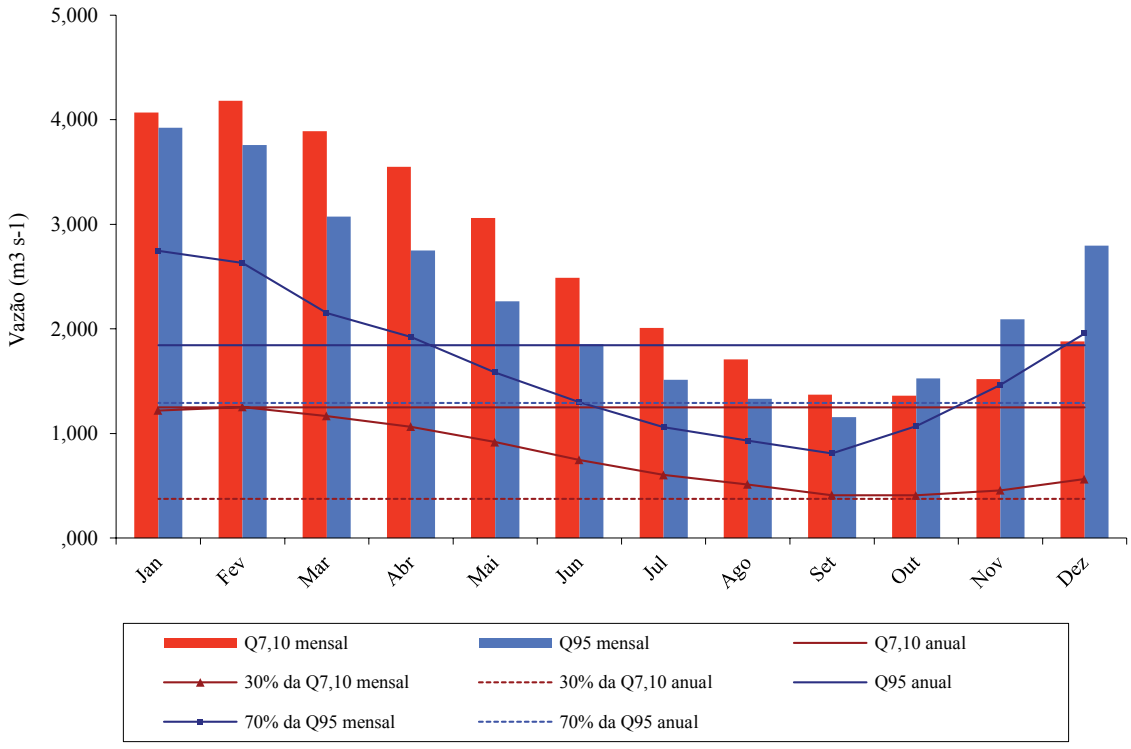

Figure 1 - Monthly and annual $Q_{7,10}$ e Q_{95} and maximum flow rates available for permit granting in the Fazenda Limoeiro station. Source: Bof (2010).

The use of monthly flow rates offers significant advantages for irrigation, as shown in Figure 2, in which the average of the relative difference values (DH%) between monthly and annual $Q_{7,10}$ flows can be observed and was obtained in sections corresponding to eight fluviometric stations. From December to June, the mean DH% values indicate DH values greater than 100%, which signals a potential replacement of the annual reference flow by the monthly flow, thus allowing an increase in the use of water resources under run-of-the-river conditions.

Additionally, a gap can be noticed in the beginning of the wet season in comparison to the period in which minimum flow rates begin to grow. Thus, in months when there is a great demand for irrigation water (May to August), due to the high water deficit resulting from reduced rainfall, the increase in water availability based on the monthly criterion is quite significant. Given the significant rainfall levels in the months of October and November, in which the increase in water availability is lower, as based on the monthly criterion, there is an expressive supply of water for the crops.

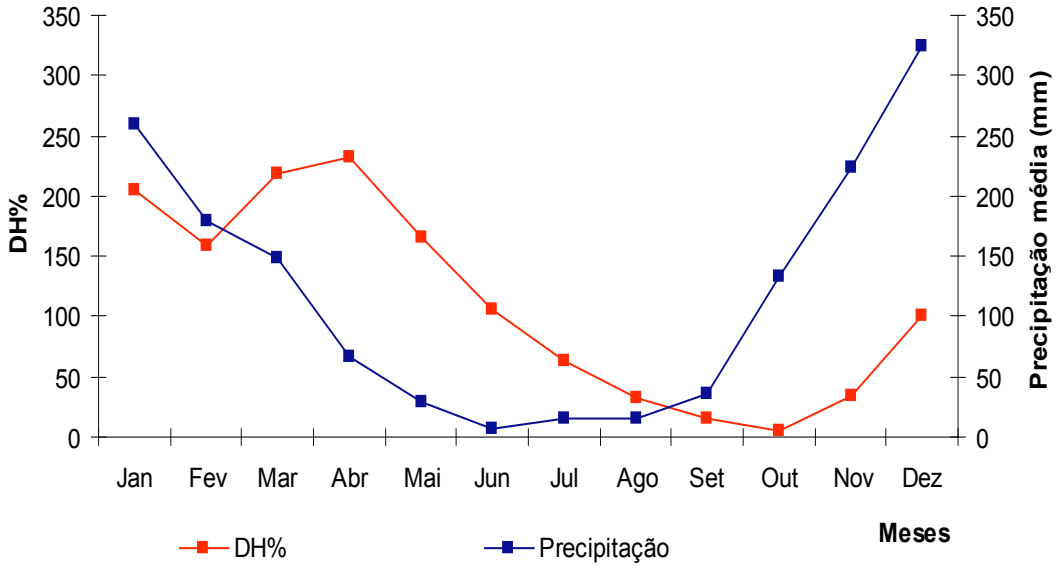

Figure 2 - Mean of the relative difference values (DH%) between the annual and monthly $Q_{7,10}$ flow rates obtained in the sections corresponding to eight fluviometric stations. Graph of the normal climatological parameters of the Paracatu station.

6. NORMALIZING FLOW RATES THROUGH RESERVOIR CONSTRUCTION

As long as natural water availability is associated with minimum flow rates, potential availability will always be related to the long-term average flow. Flow normalization can represent a significant increase in the availability of water resources - and substantial conflict reduction. For the Entre Ribeiros basin, correlations between Qmld and $Q_{7,10}$ rates ranging from 8.3 and 9 times have been identified. Nevertheless, this type of practice, like any other, should not be regarded as a generalization, since it requires specific studies that can evaluate the real complexity of the situation under analysis.

7. CONCLUDING REMARKS

The management of water resources involves analyzing and aligning demands and availability. For proper management, actions are needed to better understand the availability of water resources and to optimize consumption by different sectors of water use.

Scientific knowledge is essential to better comprehend and describe water availability and to improve its utilization across various sectors, thus maximizing the basin's productive and economic potential without posing a greater risk to the environment. In addition, it helps to mitigate conflicts between water users.

In regards to adjusting demands to water availability, these are some practices that allow the water management optimization: implementing actions for soil and water conservation of soil and water; quantifying the availability of water resources; aligning the maximum permissible flows criteria for granting permits between the water resources management bodies; using monthly minimum flows as a reference index for defining criteria for permit granting; and regularizing flows and optimizing water use by means of irrigation.

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COOPERATIVE RESEARCH, DEVELOPMENT, AND INNOVATION TO FACE WATER-RELATED CHALLENGES

Francisco Antônio R. Barbosa[1]

ABSTRACT

The ideas discussed in this text were partially presented at the "Water JPI Conference" in Rome in May 2016 and at the "Water International Cooperation/CONFAP/CNPq" workshop in Brasilia, DF, in August 2017. The article discusses the main water-related challenges on a global scale and in Brazil, through the following topics: i) the increasing demand for water, particularly by the agricultural sector; ii) necessary improvements in basic sanitation practices, universalizing sewage treatment at the tertiary level; iii) investments in water education at all levels and in inter-multi-transdisciplinary and systemic workforce training and development; (iv) investments in the assessment of aquatic biodiversity and its sustainable use; and (v) investments in water database collection and cataloging and ensure free access. To address these challenges, the article stresses the need to invest in research, development, and innovation.

Keywords: Water-related challenges. Cooperation in research. Development and innovation. Water education. Conservation. Aquatic biodiversity. Databases.

1. INTRODUCTION

In order to address the main water issues at the global and domestic levels, it is necessary to point out some of the challenges modern society faces in today's globalized world, among which the following should be highlighted: i) accelerated population growth and the fact that approximately 85% of the world's population lives on the dry half of the planet; ii) increasing urbanization indicates that in 2050 around 75% of the world's population will be living in cities; iii) the general degradation of water quality; iv) increasing demands for water, mainly to meet the needs of the agricultural and industrial sectors; v) strong climate changes, whose severe impact is reflected in droughts and floods; and (vi) the threat of waterborne diseases, particularly in developing countries. In summary, these are the greatest threats related to the availability of good quality water and to the improvement of health conditions in developing countries (Jimenez-Cisneros, 2014).

In addition, other challenges stressed by Miletto (2014) at the World Water Assessment Programme also deserve attention:

- By 2050, global consumption should reach 55% of existing water resources;
- More than 40% of the world's population will be under water supply stress;
- 20% of currently known aquifers are already overexploited;
- there will be a reduction in the ecosystems' capacity to purify water; and
- there will be a 30% increase in energy demand.

To conclude these points, but certainly no less relevant, it is worth noting that the general water supply level will remain basically the same, in around 200,000 km3 (UN Water Statistics).

[1]LIMNEA/ICB & INCT-Acqua – UFMG. Avenida Antônio Carlos, 6627 – Pampulha – 31270-901 Belo Horizonte, Minas Gerais, Brazil.

With regard to water, Brazil has impressive data: the country has the largest hydrographic system on the planet, with no less than 12% of the Earth's freshwater located in its territory, in addition to ranking first among the so-called megadiverse countries. Equally striking is the fact that Brazil only treats 37.4% of its sewage (PNAD 2014), which results in a high proportion of hospital admissions due to waterborne diseases, among other consequences.

2. WATER-RELATED CHALLENGES: COOPERATION IN RESEARCH, DEVELOPMENT, AND INNOVATION

This paper aims to demonstrate that cooperative actions in research, development, and innovation can significantly contribute to address some of the water challenges exemplified below.

The increasing demand for water

Modern agriculture alone uses approximately 40% of the water supply in irrigation. Some impacts of this irrigation should be singled out, particularly soil salinization: there certainly already exists genetically modified organisms that show high resistance to salinity. However, this can not be understood as the solution for this major environmental challenge. In this sense, Igor Shiklomanov's statement that "irrigation is the primary consumer of water on Earth" remains current.

Considering the cooperation between different civil society sectors, some necessary actions have been listed below:

i) Increase water use efficiency in agriculture by, for example, reducing water consumption through investments in drip irrigation or subirrigation, as opposed to the widespread use of center-pivot irrigation, which could save up to 25% water (USGS Water-Science-School, January 14, 2018). By 2013, Brazil had 18,000 central pivots irrigating 1.2 million hectares. The total irrigated area in Brazil is 6 million hectares compared to 25 million in the United States and 60 million hectares in China and India (Embrapa Milho e Sorgo, March 3rd, 2015).

ii) The virtual water exportation should be incorporated into the price of end-products. For example, the United States is the number one country in virtual water exports, reaching 164 million m3/year. Brazil is the 10th largest exporter of water. Mainstream economy does not take into account ecosystem services and the price of exported products may not offset the costs of recovering water sources and local ecosystems. In addition, virtual water trading has geopolitical implications and promotes interdependence among countries, which could stimulate both collaboration and peace, as well as become a reason for potential conflicts.

iii) Adopt the Water Governance approach rather than using traditional water management practices, as indicated by the 2015 United Nations "Water for a Sustainable World" report. According to this report, maintaining current consumption patterns creates a 40% deficit in water availability, mainly due to intense urbanization, inadequate agricultural practices, and pollution. In addition to these predictions, it should be remembered that today approximately 20% of the world's aquifers are overexploited and that no less than 43% of the irrigation water comes from these aquifers. The Angela Ortigara's maxim deserves attention: "Water Governance shall be a must" (Unesco-World Water Evaluation Program, 2015). One should also keep in mind the recommendations for changes in public administration and investments in infrastructure and education (Mariana Tokarnia/Agência Brasil-EBC March 20th, 2015).

Necessary improvements in basic sanitation practices (tertiary treatment)

i) Adopt new approaches and methodologies for the treatment of special pollutants such as persistent organic pollutants (POPs), antibiotics, hormones, and viruses.
ii) Around R$ 10 billion/year in investments, over 20 consecutive years, are necessary to universalize basic health practices in Brazil. This amount corresponds to approximately 0.6-0.7% of the Brazilian Gross Domestic Product (GDP). According to a report by the United Nations Development Program (UNDP), maintaining the current water and sanitation deficit costs 9 times more than resolving it. The developing countries' health systems alone would save US$ 1.6 billion a year. The cost of the current deficit amounts to US$ 170 billion, which is greater than Argentina's GDP, or 2.6% of all the developing countries' GDP together.

Investments in water education at all levels and in inter-multi-transdisciplinary workforce training and development

i) Given that water: a) is a finite resource; b) is absolutely necessary for all forms of life; c) is unevenly distributed; d) has been consistently degraded on a global scale; and e) is increasingly consumed to meet unsustainable agriculture demands, it is necessary to: a) educate people so that they can understand the different features of the water cycle, particularly in how to use this vital resource in a sustainable way. Water schools should be created to provide this type of training at all levels; b) create advanced research and development centers linked to postgraduate programs to facilitate the introduction of new concepts for research and management, such as ecohydrology and ecotechnology (Jorgensen et al., 2005; Tundisi 2007; Zalewski, 2007); c) urgently train and develop workforce for land monitoring and planning and water management, a consequence of the increase in groundwater use (Rogers, Llamas & Martinez-Santos, 2006; Hirata, 2010).

Investments in cataloguing and preserving aquatic biodiversity and in its sustainable use

It is worth mentioning the aspects detailed by Mittermeier et al. (2010), which stress the importance of conserving water resources and using their associated biodiversity in a sustainable way: "Freshwater is the final link between mountain tops and coral reefs and should be managed and used differently from terrestrial and marine systems, in part because the diversity of species in freshwater systems is quite different. In addition, freshwater accounts for only 2.5% of the total amount of water on Earth, of which 68.7% is retained in glaciers and perennial snowfields, 30.1% is deep groundwater, 0.86% is frozen in "permafrost". Less than 0.3% freshwater (0.0075%) cover around 0.8% of the Earth's total surface area (4 million km2), representing just under 3% of the Earth's surface."

Investments in research to ensure free access to databases

These actions will result in a precise assessment of water availability and quality in different territories.

3. CONCLUDING REMARKS

The data presented here can lead to the conclusion that, in order to face water-related challenges in the world and particularly in Brazil, it is fundamental to create partnerships in the areas of research, development, and innovation, without which it will be impossible to reduce the "big gap" between developed and developing worlds. Water issues are central to reducing inequalities

between these spheres, ensuring, the achievement of the millennium development goals, among other advances.

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UFLA'S INSTITUTIONAL ACTIONS FOR THE CONSERVATION OF WATER RESOURCES IN THE CAMPUS

Leandro Coelho Naves[1]
Dyego Maradona Ataide de Freitas[2]

ABSTRACT

UFLA is standing out as a sustainable institution. The proper management of water resources generates economic and environmental gains and proves that it is possible to reconcile economy and environmental preservation, and to ensure the quality of the services provided, to develop teaching, research and continuing education in harmony with the environment. UFLA's water resources management encompasses the safe and rational production, treatment, and distribution of water, including rainwater reutilization and waste treatment for reuse. The institution is internationally recognized for its commitment to sustainability, with a water management that has proven to be efficient and resulted in the institution's certification as a Blue University by The Council of Canadians.

Keywords: Water management. Sustainable campus. Environmental policies.

1. INTRODUCTION

Water is a vital resource for life (PEDRO-MONZONIS et al., 2015), which is why the United Nations (UN) has acknowledged the access to clean and safe drinking water and sanitation as a basic human right.

The availability of water for human consumption entials not only quantity, but also quality. Water has become increasingly scarce as a consequence of factors such as increased demand, poor environmental conditions, and poor water resources management by public and private entities that also contribute to water pollution (SOUSA et al., 2015; RAMOS et al., 2017; GOMES; BITTAR; FERNANDES, 2016).

As an education and professional development institution, the Federal University of Lavras (UFLA) has planned and implemented its own policy to contribute to the environment and show that it is possible to be a sustainable institution in the current context of globalization and increasing consumption. This mentality should be part of any professional development program.

UFLA's water resources management begins with the academic community's awareness about its responsibility in the rational consumption of this public and finite natural resource. Some examples of the university's management practices are: the preservation of springs, replenishment areas and the supply of good quality water, adequate waste treatment for release in watercourses, reuse of rainwater and reuse of treated waste.

The management of natural resources in the campus has been positive and beneficial and has brought significant savings, which allows for resources to be redirected to the students' education and training at the institution.

[1] Master in Forestry Sciences; Agricultural Engineer; UFLA; leandro.naves@dma.ufla.br.
[2] Environmental Engineer; UFLA; dyegofreitas@dma.ufla.br.

2. WATER TREATMENT SYSTEM

UFLA's water treatment system aims at meeting the university's water needs in a rational way and at distributing high quality water on campus. As a consequence, economic and environmental gains are created.

2.1. Preservation of springs and riparian forests

UFLA has nine springs in the campus, of which two are responsible for supplying the three dams with total storage capacity close to 173,000 m³. These dams are used to capture and store untreated water volumes intended for treatment and distribution on campus.

In the springs and riparian forest areas of water replenishment and in other environmental preservation areas, vegetation management and maintenance is undertaken, with its continuous restoration and enhancement. Since the beginning of the project, in 2009, approximately 96,000 seedlings of native species have been planted in areas deemed strategic for the management of water resources.

In addition, the campus has adopted a minimum waterproofing policy, thus ensuring rainwater infiltration. Stormwater drainage volumes flow into the dams, increasing the availability of water resources. The goal is to preserve water, guaranteeing the quantity and quality required to meet demands in a sustainable way.

2.2. Water treatment plant

In September 1991, UFLA implemented the Water Treatment Plant. Since then, the institution has been responsible for treating and distributing good quality water to meet internal consumption needs. The treatment is of the conventional type, with an estimated daily production of 600 m³, which results in R$ 3.0 million in annual savings for the institution.

3. WASTEWATER TREATMENT SYSTEM

UFLA has an advanced biological-type wastewater treatment system associated with a chlorination and ultraviolet radiation disinfection system. The system is fully automated, thus increasing operational efficiency. Concomitantly, the system monitors the treated wastewater, which guarantees high efficiency rates and allows for proper wastewater disposal for practical, non-human reuse, particularly in the irrigation of plant nurseries and in landscaping.

3.1. Release Control of Chemical Waste

The institution has a program to control the release of chemicals into the sewer system. Waste from laboratory analyses is stored and redirected to the Chemical Waste Management Laboratory (LGRQ), where it is recycled and whenever possible sent back to the laboratories that generated it. Ongoing awareness and effective collection, treatment, and redistribution of treated waste brings environmental and economic benefits, optimizing the waste treatment system and reducing the procurement cost of these materials.

4. TEACHING AND RESEARCH

At UFLA, continuous effort is employed to promote the involvement of the entire academic community in the management of the institution's water resources. Together, teachers, students,

and administrative technicians work to apply several areas of knowledge in the advancement of water and wastewater treatment techniques and in the improvement of environmental conditions in replenishment areas. The Water Treatment Plant (ETA/UFLA) and the Wastewater Treatment Plant (ETE/UFLA) are open spaces for research development aimed at contributing to the improvement of these processes. Reduced consumption, rational use of water and the optimization of processes that use this natural resource are part of the academic community's daily life.

As a result, UFLA is an institution that has been developing techniques and improving its water resources management policy over the years. Process optimization, reduced consumption, and the development of new technologies for water resources management are also consequences of the healthy and productive engagement of the academic community towards a common understanding: the management of water resources is only possible when everyone does their part.

5. CONCLUDING REMARKS

In addition to financial and environmental gains, improvements in UFLA's water resources management policy in the past years have ensured good quality water and treated wastewater on campus as well as the dissemination of environmental awareness across the academic community consequently reaching the local population. UFLA has stood out as a sustainable institution, whose prominent position in international sustainability rankings, such as the UI GreenMetric, is a sign of the university's assertiveness in environmental actions. The successful work carried out at UFLA reflect the institution's commitment to environmental management, particularly water management: in recognition of its adequate management of water resources, UFLA has been certified by The Council of Canadians as a Blue University.

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ECOSYSTEMS

SPECIAL MONITORING OF THE DOCE RIVER WATERS FOLLOWING THE FUNDÃO DAM COLLAPSE - A CASE STUDY IN MINAS GERAIS

Regina Márcia Pimenta de Mello[1]
Matheus Duarte Santos[2]
Carolina Cristiane Pinto[3]
Katiane Cristina de Brito Almeida[4]
Vanessa Kelly Saraiva[5]
Sérgio Pimenta Costa[6]

ABSTRACT

This paper aims to present the evolution of water quality in the Doce River and in the Gualaxo do Norte and Carmo rivers, after two years of monitoring and following the Fundão Dam collapse in the district of Bento Rodrigues, Mariana. From the evaluations carried out, it was possible to verify the general behavior of the affected area in relation to selected pollutants. The means in the second period (05/11/2016 to 10/08/2017) were reduced for the eight parameters evaluated, indicating a trend towards the historic values observed in the IGAM monitoring program, but still with several violations of the limits established in the COPAM/CERH-MG Normative Deliberation No. 01/2008. It should be emphasized that IGAM will continue monitoring the affected region to evaluate the impacts caused in water bodies for as long as technically necessary.

Keywords: the Fundão Dam. Water Quality. Monitoring. The Doce River.

1. INTRODUCTION

Located in the Bento Rodrigues district of Mariana, the Fundão Dam owed by Samarco Mineração S.A collapsed on November 05, 2015. As a Class III dam, Fundão presented high environmental damage potential and was destined to receive and store the waste generated by the iron ore beneficiation activity. The rupture of the Fundão Dam caused several socioeconomic and environmental impacts in the Doce River basin, with numerous implications for water quality in the Doce River basin, impacting the entire Doce, Gualaxo do Norte, and Carmo rivers.

As the agency responsible for monitoring surface and groundwater quality in Minas Gerais, in place since 1997, IGAM intensified its program through the elaboration and implementation of a special

[1]Biologist, Environmental Analyst at the Water Management Institute of Minas Gerais. regina.mello@meioambiente.mg.gov.br
[2]Geographer, Environmental Analyst at the Water Management Institute of Minas Gerais. matheus.santos@meioambiente.mg.gov.br
[3]Chemical Engineer, Master in Sanitation, Environment and Water Resources (UFMG). Environmental Analyst at the Water Management Institute of Minas Gerais. carolina.cristiane@meioambiente.mg.gov.br
[4]Biologist, Master in Sanitation, Environment and Water Resources (UFMG). Environmental Analyst at the Water Management Institute of Minas Gerais. katiane.brito@meioambiente.mg.gov.br
[5]Química, Mestre em Aplicação de Tecnologias Nucleares em Meio Ambiente pela CDTN. Environmental Analyst at the Water Management Institute of Minas Gerais. vanessa.saraiva@meioambiente.mg.gov.br
[6]Biologist, Environmental Analyst at the Water Management Institute of Minas Gerais. sergio.costa@meioambiente.mg.gov.br

monitoring plan. As of November 7, 2015, IGAM began collections at 12 stations along the Doce River channel, which were already part of the institution's monitoring program. In addition, monitoring was also carried out in the Carmo and in the Gualaxo do Norte rivers located downstream of the Fundão Dam, thus totaling 14 special monitoring stations of the Doce River (Figure 1).

Eight parameters were selected: in situ electrical conductivity, dissolved oxygen, total suspended solids, turbidity, total arsenic levels, as well as metal levels: dissolved aluminum, dissolved iron, and total manganese levels, which may be directly related to the impacts arising from the Fundão Dam collapse.

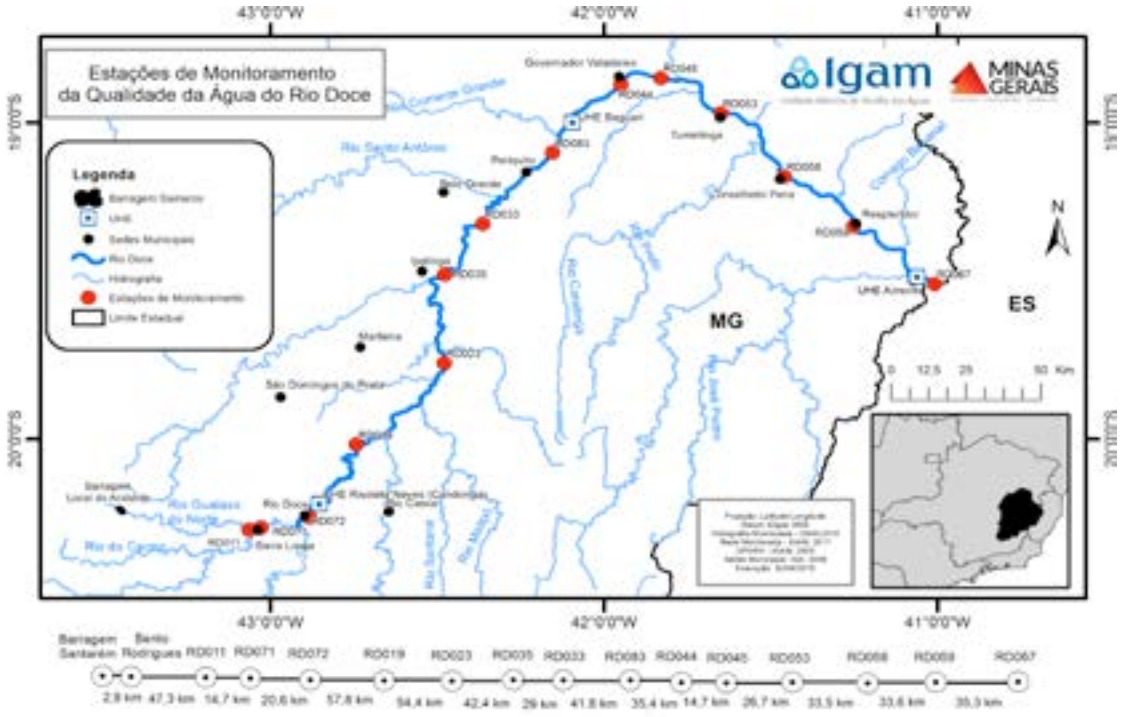

Figure 1 - Geographic location of the Doce river special monitoring stations.

The article aims to present the water quality evolution in the Doce River and the Gualaxo do Norte and Carmo Rivers, after two years of monitoring and following the Fundão Dam collapse in the district of Bento Rodrigues, municipality of Mariana.

[7]Daily collections were made from 6/11/2015 to 12/3/2015, weekly until 12/21/2015, and biweekly from January to August 2016. From October 2016 the collections were made on a monthly basis, then intensified to a weekly basis in the wet season of 2016/2017 (November to March). For administrative reasons, no collections were made in the months of September 2016, April, May and June 2017.

2. METHODOLOGY

In order to summarize the large amount of data obtained during the monitoring process, with post-collapse analysis frequency[7] varying from daily to monthly, the arithmetic means of the results were calculated according to the following periods:

- 1st post-collapse period: November 05, 2015 to November 04, 2016
- 2nd post-collapse period: November 05, 2016 to November 09, 2017

Data from these periods were compared with IGAM's pre-collapse historic series data (January 2000 to October 2015).

3. RESULTS

Two years after the rupture of the Fundão Dam in Mariana, it was possible to verify the affected area general behavior, in relation to the selected pollutants. The first period assessed (11/5/2015 to 04/11/2016) shows a large increase of the means for seven of the eight parameters[8] evaluated in this study, when compared to the historical means recorded prior to the collapse. In the second period (05/11/2016 to 09/11/2017) there was a significant reduction in these means, indicating a tendency towards the historic values observed in IGAM's monitoring, but still with a large proportion of violations pertaining Normative Resolution COPAM/CERH-MG No. 01/2008.

For the total arsenic and dissolved oxygen levels, all means remained within their respective class limits throughout the assessed period, albeit still divergent from the historic series. However, it is worth mentioning that the presence of violations in these limits in samples measured in the first

[8]With the exception of the dissolved oxygen parameter, which had an initial decrease in values, then experienced mean increase in the second period, thus also reaching the historic means.

days of monitoring, soon after the dam rupture, fully were regularized in less than a month. In the second period evaluated, no sample presented violations of these parameters.

Despite not having a quality standard defined in the environmental normalization, the electrical conductivity parameter showed means equivalent to that of the other parameters, with a decrease in the values in the comparison between the two post-collapse periods. This parameter's means also remained above the historic series in both periods.

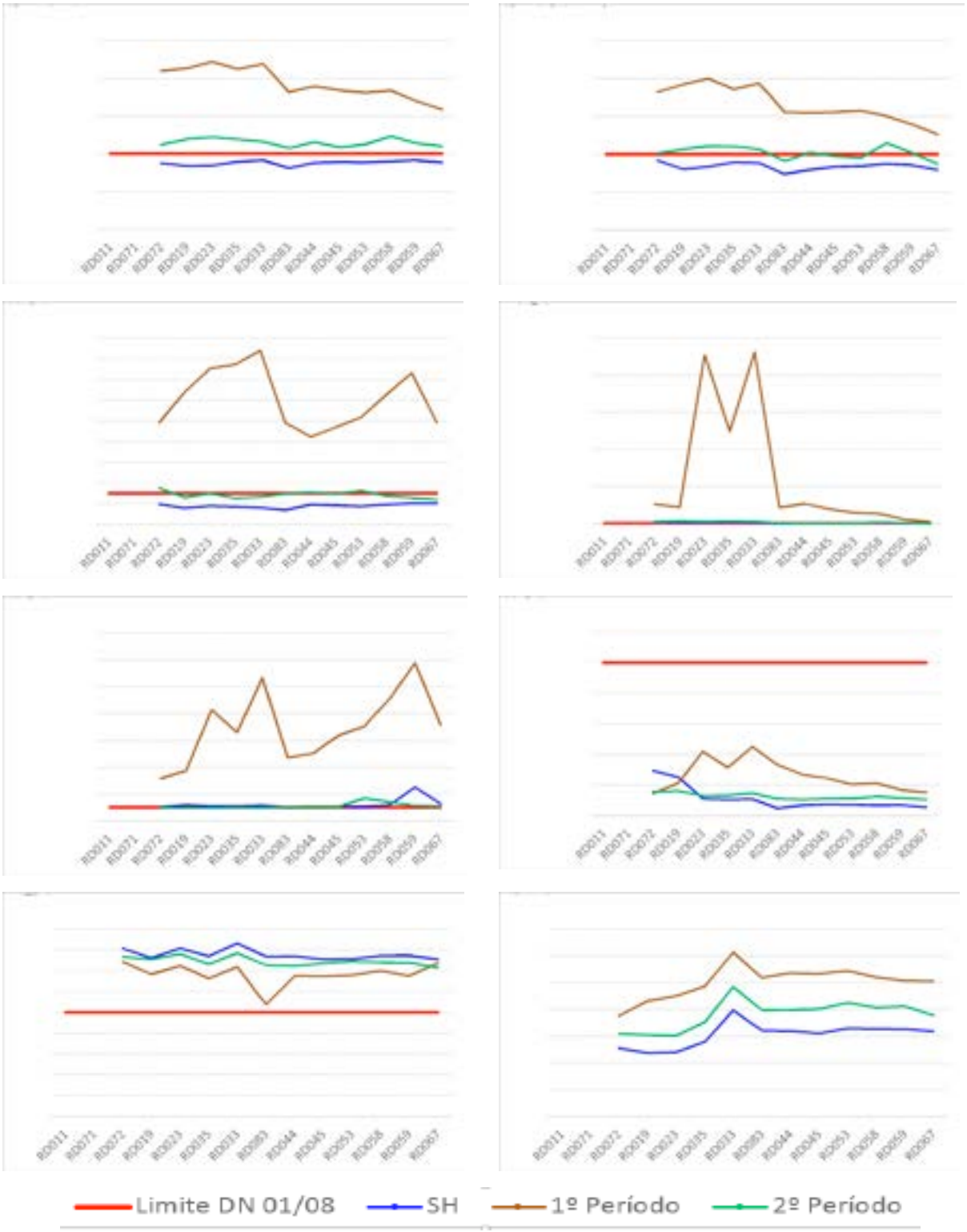

Figure 2 - Arithmetic mean results for turbidity and total suspended solids, in logarithmic scale, and dissolved iron, total manganese levels, dissolved aluminum, total arsenic levels, dissolved oxygen, and in situ electrical conductivity in the Doce river special monitoring stations

4. CONCLUDING REMARKS

The study indicated that all parameter results behaved similarly in all regions analyzed, first presenting very high values, due to tailings plume discharges, pending towards reduction over time. Two years after the Fundão Dam collapse in Mariana, the most worrying aspect to consider is the maintenance of most means analyzed here, which are still above their respective legal limits and historic means. Mostly due to tailing accumulation in river deposits and riverbanks, these results are still being dealt with, either naturally or artificially. On the other hand, a gradual normalization of the results is experienced. With no new occurrences, these means should keep decreasing, albeit in an increasingly slower manner.

Emergency-based in its first year, this monitoring aimed to gain insight into the basin's water quality situation and the evolution of this quality over time, in order to subsidize measures to be taken by the other agencies and entities involved in the event.

IGAM will keep monitoring the region to evaluate the impacts caused in the water bodies, for as long as technically necessary. It will also continue widely communicating the results of water quality analyses conducted in the affected region of the Doce River basin, through its website[9] and at Portal Infohidro.

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MODELING THE SPATIAL PATTERN OF EXTREME WEATHER EVENTS LINKED TO PRECIPITATION IN MINAS GERAIS, BRAZIL

Alessandro Ribeiro Campos[1]
Felipe Santos de Miranda Nunes[2]

ABSTRACT

One of the greatest environmental challenges for fostering resilience is dealing with the occurrence of extreme events – such as droughts, storms and floods – within a climate change context. Particularly, the extremes connected to precipitation exert strong pressure on water safety and the exposure to natural disasters. This work presents the preliminary results of the modeling of the spatial pattern of extreme weather events in the state of Minas Gerais, Brazil, in order to aid in the decision-making process. Historical data for precipitation were treated and spatialized so as to estimate the average consecutive days without precipitation (<1mm) (CDD) and the maximum precipitation accumulated in five consecutive days (Rx5day). From a geostatistical approach, continuous surfaces were generated indicating the variation of these two indexes using the Kriging method. The spatial pattern of the CDD index varied from 31 to 143 days with big regional differences. The average Rx5day index varied from 134 to 186 mm. The validation process also indicated a good capacity for prediction by the model based on error statistics and uncertainty maps. Preliminary results show the potential of the computational evaluation platform for environmental data, under development, as a tool for generating knowledge for governmental planning with regards to weather risks.

Keywords: Weather extremes. Public Policies. Spatial modeling.

1. INTRODUCTION

Like many environmental issues, climate changes became visible and politically understandable due to the advance and assimilation of scientific knowledge (HOPPE, 2010). The main scientific findings related to the global phenomenon are nowadays addressed by international treaties and several public policies – national and subnational – in spite of political and cultural differences (HOPPE AND WESSELINK, 2014; NUNES et al., 2016). In particular, the changes in precipitation patterns and the expected increase in the number of extreme events are pointed out as serious pressure factors for water safety and for human exposure to natural disasters in several regions (IPCC, 2012).

In the state of Minas Gerais, Brazil, these factors already integrate the government plans and some climate impacts are also measured. It is estimated that, since 2008, severe events, such as intense rain and prolonged drought, have cost 17.4 billion reais (FEAM, 2015). And, confirming the correlation between the increase in the average temperature and the occurrence of extreme weather (FISCHER and KNUTTI, 2015) on a regional scale, the expected increases of 2°C to 5°C indicate even more challenging scenarios (FEAM, 2011).
In face of the magnitude of the impacts, the state government has prioritized, as a strategy, the implementation of the Minas Gerais Energy and Climate Change Plan - PEMC. The Plan is configured as a public policy in the medium term (2015-2030), aimed at fostering the transition into

[1]Geographer, Master in Analysis and Modeling of Environmental Systems, State Foundation for the Environment – Feam, alessandro.campo@meioambiente.mg.gov.br
[2]Biologist, Ph.D. in Applied Meteorology, State Foundation for the Environment – Feam, felipe.nunes@meioambiente.mg.gov.br

a low-carbon economy, reducing climate vulnerability and articulating coherently the ongoing initiatives (FEAM, 2015).

However, one of the most important issues for the science and policy of climate changes in the short term is to verify if the occurrence of extreme events is increasing or decreasing in time and space, that is, if there is a trend and where the effects are being felt the most in the territory. For that end, it is necessary to collect, integrate and analyze a vast set of climate data from hundreds of meteorological monitoring stations.

With that in mind, this work presents the preliminary results for monitoring and modeling for climate data on a state scale. The estimates, generated through a computational platform that is spatially explicit for environmental evaluation, are inserted in the context of the implementation of the PEMC, coordinated by the State Foundation for the Environment (Feam). Two indicators of the occurrence of extreme events that are widely recognized in the scientific literature (IPCC, 2012) were modeled, namely, the number of consecutive days without precipitation (< 1mm) (CDD) and the maximum precipitation accumulated in five consecutive days (Rx5day). The resulting maps representing the average variation of indexes, obtained through spatial interpolation, present the distribution pattern for these events, a key piece of information to subsidize the design of measures for adapting and reducing the risk of disasters.

2. DATABASE AND METHODS

2.1. Collection, treatment of the data and calculation of the extreme weather indicators

Figure 1 - Pluviometric stations used for extreme weather spatial modelling

The historical series for daily precipitation of 232 pluviometric stations were obtained at the web portal for the National Water Agency[3]. The following statistic criteria were used for selecting the valid years: i) a minimum of 95% valid daily data for the dry period (M-J-J-A-S-O-N) (CDD) and ii) a minimum of 95% valid daily data for the rainy period (D-J-F-M-A) (Rx5day). Both indicators were calculated in yearly and average terms for the period of 1996-2016. Afterwards, the stations with an average that demonstrated a variation coefficient over 0.4 were discarded, resulting in a sampling subset of 138 stations, distributed as per Figure 1.

[3]http://www.snirh.gov.br/hidroweb

2.2. Spatial modeling of the extreme climate indicators

Generally speaking, the precipitation pattern is associated to a spatial dependency structure that determines its distribution as a function of the analysis scale. Thus, the spatialization of the CDD and Rx5day indicators was obtained from the development of a geostatistical model (SMITH et al., 2015). The following stages were developed: 1) spatialization and exploratory analysis of the data; 2) modeling of the semivariograms (calibration and validation); 3) spatial interpolation (Krigging); 4) quantification of the uncertainty of the interpolation; and, finally, 5) general prediction variation.

A strategy for systematic interaction between the calibration of the semivariograms, interpolation and validation of the prediction was adopted, using the cross validation method. For the spatial interpolation, the choice was made for Ordinary Krigging (YAMAMOTO and LANDIM, 2013). For the evaluation of the errors, descriptive statistics were used, such as error mean (EM), error mean standard deviation (EMS), root mean square error (RMSE) and root mean square standardized error (RMSSE). The distribution of the uncertainty in the space through the Prediction Standard Error Map was also verified. The final stage of validation involved the compatibility of the standard produced by the interpolation in relation to the reference climatology in the report.

3. RESULTS

The modeling for the CDD index indicated a minimum value of 31 days and a maximum value of 143 consecutive days without precipitation (FIGURE 2-A). The evaluation of errors indicates a predominant stretch between 6 and 8 and a maximum standard error of 13 days for locations further away from stations, highlighting the good capacity of the model. The spatial distribution indicates a concentration of the highest values (110 – 143 days) in the northern region of the state. By their turn, the lower values (31 – 43 days) are located in the far south and in the southeast/east region.

For the Rx5day indicator, a minimum value of 134 mm and a maximum value of 186 mm were estimated (FIGURE 2-B). The results suggest a variability of approximately 12.5 mm, with a predominance of the standard error interval of 13 to 15 mm in the territory. The spatial distribution indicates a predominance of higher values (174 – 186 mm) in the central region and in the region of the Alto Rio São Francisco. The values for the lower stretch (134 – 145 mm) are concentrated in two different regions, the far south and the far north of the state.

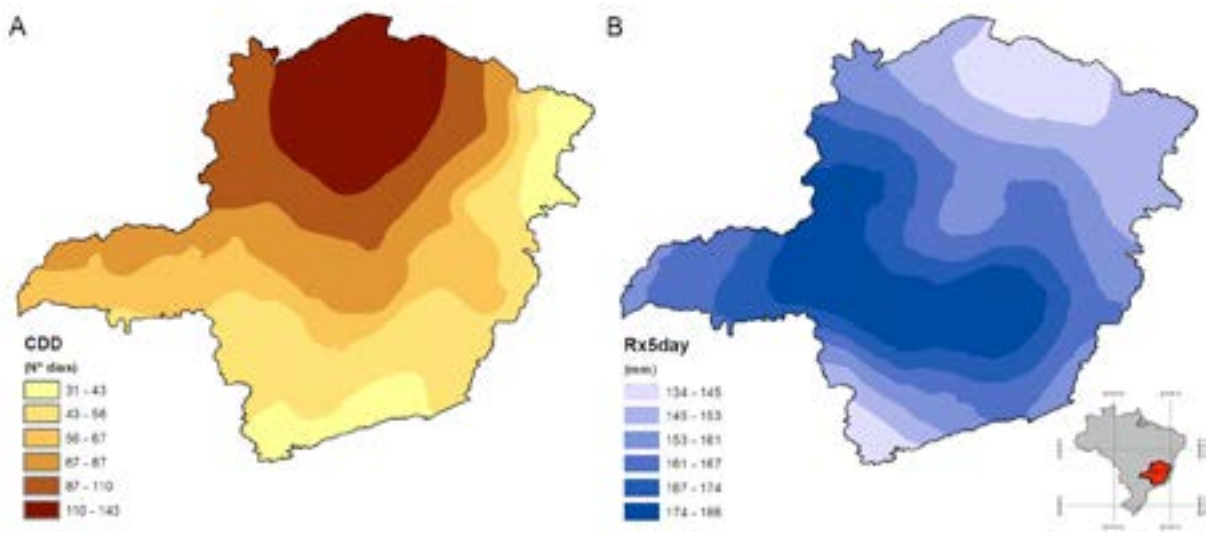

Figure 2 -A) Average CDD for 1996-2016; B) Average Rx5day for 1996-2016

4. CONCLUDING REMARKS

The preliminary results presented here have several applications for research and for policies for adapting to climate changes. The indexes estimated reflect the historical patterns of duration of the periods of drought and the occurrence of large accumulated precipitation in a short period, both responsible for substantial loss and damages in the state of Minas Gerais in the period from 1991 to 2012 (CEPED, 2013). In this sense, increasing the knowledge about the occurrence of these extreme events becomes essential for reducing the risk of disasters in the territory.

In the future, the identification of trends and the spatialization of the other extreme event indicators available in literature (IPCC, 2012), as well as their correlation with the impacts registered, should be better investigated so as to support government planning. As other benefits, the systematic monitoring and modeling of the spatial pattern intended may contribute for the sustainable development through the availability of climate information for key sectors of the economy, such as agriculture, infrastructure and others.

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THE BOLSA VERDE PROGRAM: GENERATING INCOME THROUGH ENVIRONMENTAL CONSERVATION

Leonardo Diniz Reis Silva[1]
Manuela Cardoso Stein[2]
Lissandra Helena Pereira de Paiva Fiorine[3]
Jonathan Paulo dos Santos[4]
Maykon Douglas de Moraes Ângelo Viegas[5]

ABSTRACT

Managed by the State Institute of Forestry of Minas Gerais, the Bolsa Verde Program aims to support native vegetation coverage conservation in Minas Gerais by financially rewarding rural landowners and squatters who preserve their property native vegetation. The benefit is only directed at mid-stage or advanced regeneration coverage. In 2010 and 2011, two calls were opened, resulting in 2,696 benefits registered and a covered area of 91,563,5874 hectares. The three biomes present in the state of Minas Gerais, namely Mata Atlântica, Cerrado and Caatinga, have some of their areas preserved through the program. Bolsa Verde also has an important social aspect, since it contemplates socially and economically vulnerable landowners and squatters, such as indigenous peoples, family farmers, and those located in agrarian reform settlements. The registered native vegetation areas include riparian forests, hilltop, and slopes, among other permanent preservation areas that play an important role in maintaining the quality and quantity of water in Minas Gerais. The program is an effective instrument to ensure sustainable development in the state, and is an income alternative for rural farmers or landowner to preserve native vegetation.

Keywords: Payment for environmental services. Bolsa Verde. Sustainable development.

1. INTRODUCTION

Native vegetation contributes to the environment in a variety of ways, such as in the supply of water resources and in the regulation of the hydrobiological, the chemical composition of drainage water, the transport of organic matter and sediments to rivers, lakes, and dams, erosion control, the intensity of surface runoff, and the replenishment of aquifers (GUEDES & SEEHUSEN, 2011; TUNDISI & MATSUMURA-TUNDISI, 2010).

What the native vegetation provides in terms of quality and quantity is a key economic component for water production, as it creates positive impact through reductions in water treatment costs for public supply and electricity generation (TUNDISI & MATSUMURA-TUNDISI, 2010).

At present, financial compensation to rural landowners and/or squatters may be the best way to encourage the preservation and recovery of natural environments, and the environmental benefits they provide.

[1]Public Administrator and Social Communicator, BA in Journalism, Master in Environmental Socioeconomic Sustainability, IEF, leonardo.diniz@meioambiente.mg.gov.br.
[2]Biologist, IEF, manuela.stein@meioambiente.mg.gov.br.
[3]Forestry Engineer, Diploma in Environmental Project Management, IEF, lissandra.fiorine@meioambiente.mg.gov.br.
[4]Production Engineering student, IEF, jonathan.santos@meioambiente.mg.gov.br.
[5]BA in Geography, IEF, maykon.viegas@meioambiente.mg.gov.br.

According to Wunder (2005), Payment for Environmental Services (PES) is:

1. a voluntary transaction where
2. a well-defined ES (or a land-use likely to secure that service)
3. is being 'bought' by a (minimum one) ES buyer
4. from a (minimum one) ES provider
5. if and only if the ES provider secures ES provision (conditionality). (WUNDER, 2005)

In this sense, PES is an alternative source of income that can motivate rural landowners to consider providing environmental services, when making decisions on land use. This would ensure sustainable development and availability of quality water, among other benefits.

At the state level, the payment for environmental services in Minas Gerais is carried out by the Bolsa Verde Program. The financial incentive is granted to rural landowners and squatters who preserve vegetation of native origin and is proportional to the size of the territory conserved in the areas in the Atlantic Forest, specifically those in mid or advanced stage of regeneration.

2. DISCUSSION

The Bolsa Verde Program was instituted by Law 17.727 on August 13, 2008, and is regulated by Decree 45.113 of June 5, 2009. The State Institute of Forestry (IEF) is in charge of managing the program.

In 2010 and 2011, two public notices were released and 2,696 benefits were registered, totalling an area of 91,563.5874 hectares. The biomes found in Minas Gerais, namely the Atlantic Forest, Cerrado, and Caatinga, have some of their sections preserved through the Program.

These are some priority beneficiaries: family farmers, rural producers whose land ownership or possession consists of up to 4 fiscal modules in area, and rural producers whose properties are located inside Conservation Units subject to expropriation and pending settlement land ownership.

In establishing these priorities, the program also sought to address social issues by prioritizing beneficiaries in vulnerable economic and social situation. This benefit reached those beneficiaries located in indigenous peoples' and agrarian reform settlements.

The Applied Economic Research Institute (IPEA) and The Nature Conservancy (TNC) carried out a study to survey the costs involved in restoration projects, according to the different techniques used in Brazilian biomes (BENINI & ADEODATO, 2017). An average of the techniques most used in the 3 biomes where the Bolsa Verde Program operates shows a cost of approximately R$ 12,370.00/ha to perform the restoration of native vegetation (BENINI & ADEODATO, 2017). An analysis of these expenses in the Conservative Water Program for the Posses micro-basin, as surveyed by Kfouri and Favero (2011), indicates a total cost of of R$ 88.74/ha.year, which added the Bolsa Verde Program benefit of R$ 200.00/ha.year (paid in five annual installments, as defined in 2010, when the 1st public notice was issued), it can be concluded that granting rural landowners and/or squatters the financial incentive to preserve native vegetation is still cheaper than restoring the area. At the moment, the resources passed on to beneficiaries under the Program amounts to R$ 30,899,195.55
In terms of direct and indirect gains from preservation, a PSA program shows even greater advantages, since the registered native vegetation areas include riparian, hilltop, and hillside forests,

among other permanent preservation areas, which play an important part in maintaining the quality and quantity of water.

The expressive number of benefits and registered area resulted in a wide range of situations to be dealt with, thus posing some difficulties during the management of the Bolsa Verde Program.

The absence of a data management system led to data inconsistencies and a greater use of time and manpower, reducing the Program's promptness and transparency and complicating decision-making and decision effectiveness analysis. As this was the State Government' first experience with a state-wide Payment for Environmental Services initiative, intercurrences arose in the management phase, for which there were no defined procedures, thus delaying the resolution of certain issues. Another point worth mentioning is that benefit payment funds were temporarily suspended during the implementation of the Program.

3. CONCLUDING REMARKS

In the management phrase of the Bolsa Verde Program, through communication with benefit holders (in visits or in telephone conversations), it noticeable that several rural landowners and squatters not only found it more interesting to obtain income from the standing forest, but also to use the resources obtained with the benefit to expand the protection of the area registered in the program, following the recommendations discussed in the IEF technical visits, that is, by setting up fences and through firebreak maintenance.

Despite the three-year suspension in the beneficiaries' payment for environmental services provided, there was a low drop-out and intervention rate in the areas registered in the Bolsa Verde program (approximately 4% of the total area), probably because some beneficiaries realized that it is indeed possible to gain financial returns with environmental conservation.

The last installment of the Program's 2nd public notice (2011) will be finalized in 2018, with no provision for new notices thus far, which has led to frequent complaints mainly on the part of the beneficiaries - a sign of Bolsa Verde's social and environmental importance.

On the occasion of new public notices, the lessons learned from the management of the 2010 and 2011 editions will enable actions in priority areas and a more efficient monitoring of the areas under preservation, as well as faster communication with beneficiaries.

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THE SUSTAINABLE TERRITORY OF RIBEIRÃO DO BOI

Narliane Martins[1]
Amanda de Andrade[2]

ABSTRACT

The project "Sustainable Territory of Ribeirão do Boi" innovates by seeking sustainable rural development in the Doce River basin. It was planned based on the Environmental and Productive Zoning (ZAP). Based on robust data and technical-scientific analyses, the project focuses on the synergy between forest cover recovery, pasture and crop productivity, and territorial governance by empowering local actors. Through a new development model for the basin, it will be possible to guarantee the availability of water in quantity and quality in the medium and long terms.

Keywords: Doce River. Governance. Development. ZAP. CAR. URT.

1. INTRODUCTION

The Sustainable Territory of Ribeirão do Boi is a project aimed at catalyzing and integrating social, environmental, and economic actions for the sustainable development of a micro-basin in the Doce River Basin. The project innovates by seeking sustainable rural development through the promotion of the best practices for environmental and productive suitability of the territory, with shared management and the engagement of local communities.

Territory information systematization, the training and empowerment of the participants, and the development of a network of partners were necessary steps for the design and execution of structural projects and programs. This articulation was later oriented towards territorial governance. In the current context of the Doce River basin, and after the collapse of the Fundão tailings dam, this model of sustainable and community development has become even more relevant, since it empowers the people who live in the basin, promotes territorial planning, and results in greater environmental and productive resilience. This summary presents the main stages of territorial and landscape planning focused on the environmental and productive adequacy of the Ribeirão do Boi micro-basin.

2. ENVIRONMENTAL AND PRODUCTIVE ADEQUACY PLAN FOR THE BASIN

The environmental and productive adequacy plan for the Ribeirão do Boi sub-basin was prepared by the IBIO team in partnership with several public (e.g. EMBRAPA, EMATER, IEF, city halls) and private institutions (e.g. FIEMG, SEBRAE, CENIBRA, Doctum Network) in addition to the direct contributions from the basin farmers. The project was sponsored by Usiminas between 2011 and 2015 and supported by the Caratinga River Basin Committee.

2.1. Environmental and Productive Zoning

The planning's first stage was the delimitation of a total area of 35,000 ha, comprising part of four Minas Gerais municipalities, namely: Vargem Alegre, Entre Folhas, Caratinga, and Bom Jesus do Galho.

[1]Biologist, Instituto BioAtlântica, narliane@ibio.org.br
[2]Master in Ecology and Natural Resources, Instituto BioAtlântica, amanda@ibio.org.br

Subsequently, the Environmental and Productive Zoning (in Portuguese, ZAP) was continued, in line with the State Decree No. 46.650 (2014) guidelines, which instituted the ZAP as a planning tool for the sustainable development of river basins. The ZAP analysis is carried out by overlaying geographic information layers, namely: Land Use and Occupation (UOS), water availability, and landscape units.

The territory use classification was mapped based on high-resolution images and field work (Figure 1). It revealed that 35% of the basin is used for pasture, 12% for forestry, 9% is covered by flooded areas, and 25% by fragments of semi-deciduous Atlantic Forest in intermediate and advanced stages of regeneration.

The water availability analysis was performed with official data provided by IGAM. It indicated 347 stretches of watercourse in the basin, nine with a demand for consumptive use, two of which are located in the Entre Folhas Stream sub-basin and presented a water deficit, that is, the demand for water use was greater than its supply. Both stretches showed potential for flow regulation.

The Landscape Units mapping was carried out in partnership with EMATER and revealed six landscape units in the basin, of which terraces, convex slopes, and floodplains are the most significant, area-wise.

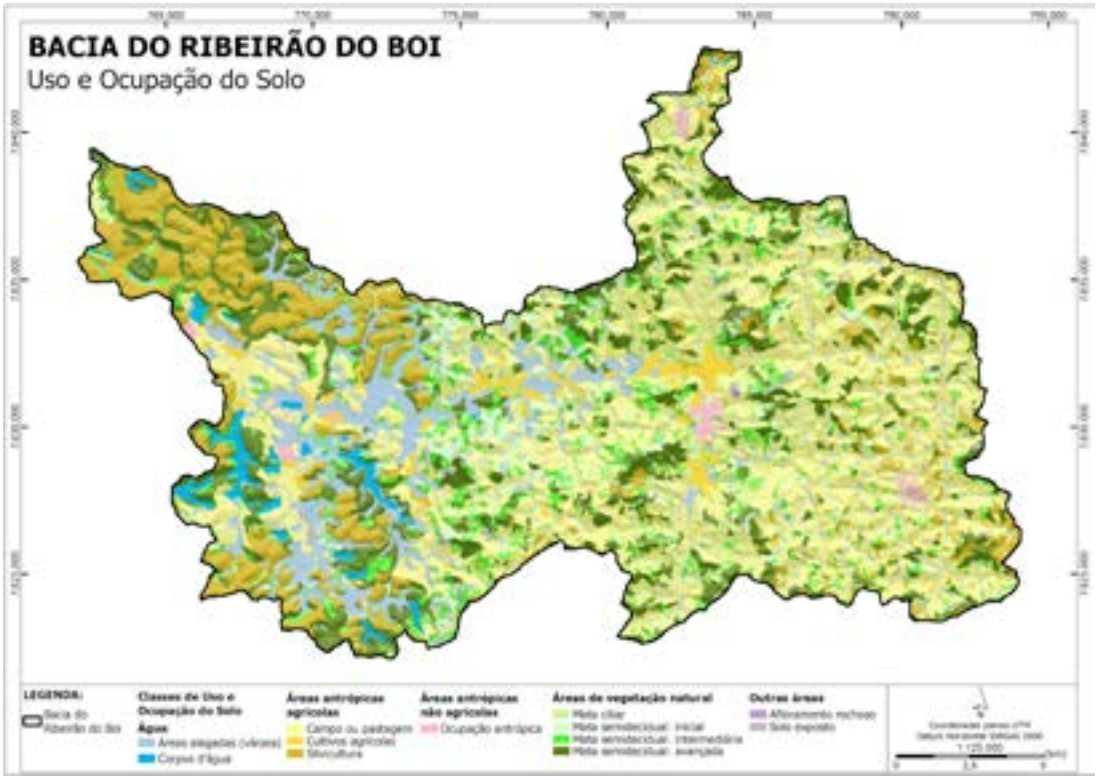

Figure 1 - Classification of Land Use and Occupation of the Ribeirão do Boi sub-basin.

2.2. Shared Strategic Planning

The combined and overlapping analysis of the data collected by the ZAP signaled the potential for territory environmental and productive suitability. The micro-basin had 1,268 ha of permanent water preservation area to be recovered, about 3,000 ha with potential for irrigated agriculture and 4,500 ha viable for crop expansion and diversification. The Entre Folhas Stream sub-basin was identified as a priority area for adaptation due to the water deficit found by this research. The ZAP also recommended investments in water reservation infrastructure to regulate the flow, Payments

for Environmental Services (PES) for forest conservation and restoration, degraded pastures recovery, aquaculture, and agro-ecotourism.

Alongside the clear synergy between the environmental and productive agendas in the basin, the governance process was enriched by the participation of local farmers, who were mobilized and consulted by two actions called Prosa do Produtor and Porteiras do Boi.

During the Prosa do Produtor, meetings were held to discuss the rural landowners' demands and points of view. A SWOT analysis was performed, building a collective view of the current scenario, desired future scenario, and likely future scenario for agribusiness in Ribeirão do Boi by 2020. Inspired by the participatory rural diagnosis developed by MDA and widely disseminated to develop the rural communities self-determination, six social maps and two productive chain maps were made, in addition to a profile survey of the territory's rural properties (on social, economic, environmental, and cultural grounds) through the sampling of 106 properties and by holding six geographically distributed meetings.

This sampling was then expanded through Porteiras do Boi – da cabeceira ao Doce, in which local public school students trained by the IBIO team visited rural properties to collect primary information. 222 properties were sampled. About 360 rural farmers were mobilized and 165 secondary school students were trained in rural context perception and primary information collection.

2.3. CAR and Technological Reference Units

The promotion of a development model aimed at environmental and productive adequacy in the Ribeirão do Boi territory began with property regularization in face of the new forest code and the mandatory rural property registration in the Rural Environmental Registry (CAR), in partnership with the State Institute of Forestry (IEF) and the City of Entre Folhas. In total, 116 rural properties were registered in 31 days, totaling 9,441 ha officially mapped and classified.

A Technological Reference Unit in a Crop-livestock-forest Integration System (URT-iLPF) was installed in partnership with EMBRAPA, IEF, and EMATER, with the goal of transferring said technology to territorial suitability. The iLPF system consists of a more sustainable livestock alternative by enabling soil protection, water reservation, and sustainability of the production chain, thus increasing the profitability and productivity of rural properties. As a demonstration unit of a sustainable rural development model, several training and Technical Assistance and Rural Extension (ATER) activities were conducted in the form of workshops, field trips, and thematic meetings. The unit monitoring is done through Agroecosystems Sustainability Indicators (ISA).

3. CONCLUDING REMARKS

Due to the its profile and culture, environmental and productive adaptations in the Ribeirão do Boi basin are synergistic and interdependent. To guarantee water availability in the quality and quantity needed to meet demands the model of rural development adopted in the region has to be changed. To this end, landscape planning is essential, as is the involvement of rural landowners in regional governance.

In the search for concrete solutions, this study stresses the vulnerability of some micro-basin areas to unfavorable climatic events, especially droughts; while recommending nature-based solutions to mitigate associated risks, such as the development of agricultural chains that promote sustainable practices and the protection and recovery of riparian areas, in addition to pointing out priorities identified in the region. As a counterpoint, water reservation is indicated as a complementary solution to the water deficit identified in this study.

The study demonstrates the local farmers' clear commitment to environmental and productive recovery, especially given their strong acceptance of the Ribeirão do Boi program. The path for building a sustainable micro-basin includes instruments that aggregate value and satisfy the local population, such as the Payment for Environmental Services system and the diversification of nature-related activities, such as Ecotourism. In this sense, this paper can be seen as technical reference in the elaboration of actions plans for the micro-basin in question.

USING AN ECOLOGICAL INTEGRITY INDEX TO CLASSIFY THE QUALITY OF THE AQUATIC ENVIRONMENTS OF MINAS GERAIS

Helena Lúcia Menezes Ferreira[1]
Márcia Couto de Melo[2]
Mariana d'Ávila Fonseca Paiva de Paula Freitas[3]
Sylvia Therese Meyer Ribeiro[4]
Mônica de Cássia Souza Campos[5]
Glaysimara Aparecida Felipe[6]
Karina Cristiane Alves[7]
Aylton Carlos Soares[8]
Pedro Fialho Cordeiro[9]
Marcela David de Carvalho[10]
Enio Marcus Brandão Fonseca[11]

ABSTRACT

This study assessed the ecological quality of reservoirs and their drainage basins in Minas Gerais, based on the development and adjustment of an ecological integrity index. The methodology was based on an integrative vision of the lotic and dammed lotic environments, in different scales, considering the aquatic ecoregions and the typification of the aquatic environments of Minas Gerais, as well as the validation of this typification through further studies in the Cajuru, Peti, and Rio de Pedras reservoirs and river segments of their contributoty basins. To this end, the concept of ecological integrity was grounded in three elements: ecohidromorphological habitat conditions, physical and chemical conditions of waters and sediments, and aquatic communities (biological indicators), to establish and spatially represent the ecological quality levels of these aquatic environments. This work can be seen a contribution to the improvement of methodologies applicable to manage continental aquatic environments and advances in compliance with the provisions of the COPAM/CERH-MG Joint Deliberation No. 001/2008.

Keywords: Ecological integrity. Aquatic environment quality. Cajuru, Peti, and Rio de Pedras reservoirs. Aquatic ecoregions.

1. INTRODUCTION

Since the beginning of this century, several countries have adopted new guidelines for the management of water resources, based on a more comprehensive outlook that goes far beyond water quality by focusing on the ecological quality classification of the aquatic environment, in an

[1]Biologist, CIT - ISTMA, hlmenezes@fiemg.com.br
[2]Geographer, CIT - ISTMA, marcouto50@gmail.com
[3]Environmental Engineer, CIT - ISTMA, mdfreitas@fiemg.com.br
[4]Biologist, CIT - ISTMA, smeyer@fiemg.com.br
[5]Biologist, CIT - ISTMA, mosouza@fiemg.com.br
[6]Biologist, CIT - ISTMA, mara.felipe@fiemg.com.br
[7]Biologist, CIT - ISTMA, kcristiane@fiemg.com.br
[8]Biologist, CIT - ISTMA, aysoares@fiemg.com.br
[9]Environmental Engineer, CIT - ISTMA, pcordeiro@fiemg.com.br
[10]Biologist, CEMIG, marcela.david@cemig.com.br
[11]Forestry Engineer, enio@cemig.com.br

interplay between quality-related geomorphic, sedimentological, physical-chemical and biological processes and the sediments that complement and reinforce each other. The goal is to provide more comprehensive data and information to better understand the aquatic environment ability to support anthropogenic impacts, as well as to propose and implement management and recovery actions in these environments.

In this scenario, the COPAM/CERH-MG Joint Deliberation No. 001/2008 stands out, since it broadens the processes adopted in the evaluation and monitoring of water bodies, innovating them with technologies to support water resources management and extending the approach for dealing with associated problems. More than an anthropocentric view of water use, the new guideline seeks a holistic understanding of the aquatic environment.

The SENAI FIEMG Technology and Innovation Center (CIT), as part of the Institute of Technology for the Environment (ISTMA), conducted a FAPEMIG, CEMIG GT and ANEEL sponsored project called "Using an Ecological Integrity Index to Classify the Quality of the Aquatic Environments of Minas Gerais" (FERREIRA et al., 2017) to assess the ecological quality of electric energy production reservoirs and their drainage basins in Minas Gerais through the development and adjustment of an ecological integrity index.

The studies covered three interconnected levels of scale (broad, meso, and fine), allowing the integration of data from various sources and resolutions.

The broad-scale study included the river segment classification of the aquatic ecoregions of Minas Gerais, based on integrating information about rocky substratum with the altimetry of the land. To typify the reservoirs, 19 environments indicated by CEMIG were assessed by means of multivariate statistics (cluster) methods of morphometric variables: involvement factor, water level variation, residence time, altitude, age, air temperature, area, depth, volume, and perimeter development.

For the meso-scale and thematic in situ studies, three pilot areas were considered: the reservoirs of Cajuru, Peti, and Rio de Pedras, as well as the lotic waters of their contributory basins, which together correspond to 3,630.47 km² or 0.62 % of the state's area.

The abiotic and biotic components that form the concept of ecological integrity of aquatic environments (Figure 1) were described and assessed in fine-scale. The studies were conducted in the dry season of 2013 and 2014 in 42 river sites representing different types of watercourse, and in the dry and wet season of 2014, in 25 coastal sites and 20 sites in the limnetic and benthic regions of the three aforementioned reservoirs.

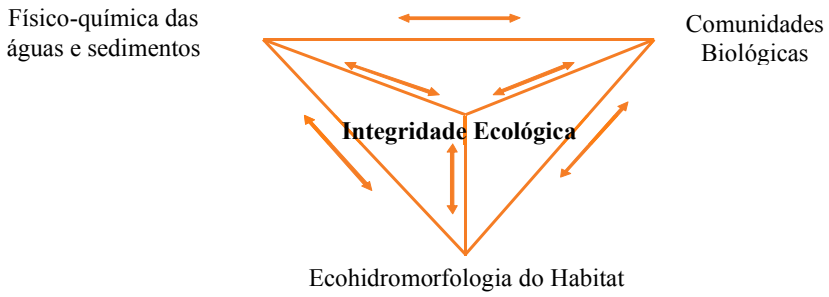

Figure 1 – Fine-scale verification of the aquatic environments' ecological integrity

The Ecological Integrity Assessment (EIA) was based on the multimetric method proposed by Karr and Chu (1999), Barbour et al. (1999) and AQEM (2002), and included the identification and characterization of the reference conditions from the selection and calibration of vegetation, phytoplankton, phytoperitone, zooplankton, zooperiphyton, and aquatic macroinvertebrates metrics, by evaluating the responses of these biological communities (Biocenose Integrity Index – BII) to the disturbance gradient.

In relation to the reference conditions, response deviations of these bioindicators as well as of abiotic indicators (Trophic State Index – TSI, metal toxicity presence or absence in water and sediment, Habitat Quality Index – HQI and Water Quality Index – WQI, only for river sites) guided the assessment and classification of the aquatic environments ecological quality at distinct levels of modification.

2. WATER MASS TYPIFICATION

The typification process clustered river segments with relatively homogeneous hydromorphological characteristics. Among the 19 evaluated, 21 types of lotic water masses (Figure 2a) and 7 groups of reservoirs (Figure 2b) were identified: 1) large reservoirs in volume and area; 2) medium reservoirs; 3) small reservoirs, at higher altitudes and with lower level variation; 4, 5, and 6): only one reservoir each; 7) smaller reservoirs in area and volume, shorter water residence time – run-of-the-river.

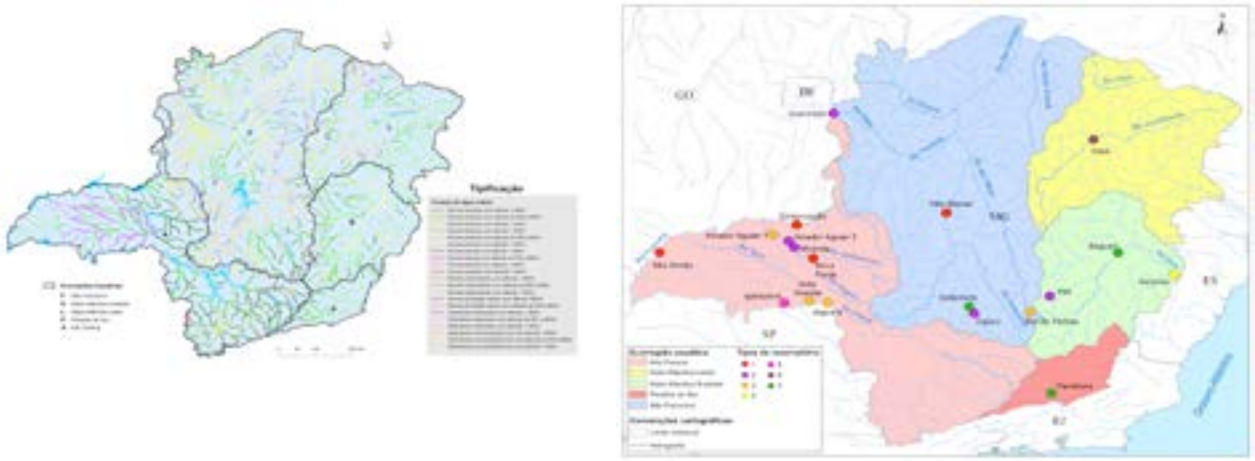

Figure 2 – Typification of aquatic environments in Minas Gerais: (a) lotic environments and (b) dammed lotic environments.

Out of the 21 river types, those that drain over siliceous rocks and at altitudes greater than 800 meters predominate. By clustering the meso-scale features, 24 river types were identified in the three pilot areas. Of this total, there is a predominance of siliceous rocks above 800m in low gradient, sinuous channel and open valley, followed by the lotic type on uncontaminated sediments between 500 and 800m altitude, also in in low gradient, sinuous channel and open valley.

3. ECOLOGICAL INTEGRITY OF AQUATIC ENVIRONMENTS

In the São Francisco ecoregion, the Cajuru reservoir (Figure 3) showed the worst ecological integrity condition, with predominantly regular sites, as opposed to Rio de Pedras, whose quality was identified as excellent in some sites, but declined in other areas when trophic conditions and the presence of trace elements were analyzed.

Figure 3 – Ecological integrity of the Cajuru reservoir and in river segments of its contributory basin, Minas Gerais, 2017.

With greater variability in ecological status (from excellent to poor), the Peti reservoir (Southeast Atlantic Forest Ecoregion) experienced decline in the water trophic levels (regular in most coastal sites) and showed trace elements above legal limits, in water or sediments (less frequent), particularly in the upstream part of the area, which is closer and more likely to be influenced by urban and industrial water waste.

4. CONCLUDING REMARKS

Differences between the reference sites were expressed by biota for some of the criteria proposed for lotic environments typification . The small number of reference sites, coming from a small geographic area, makes the validation of the proposed typification still incomplete. Advances in the project show that synergistic technology can be used to innovate the management of aquatic environments in collaboration with the environmental responsibility held by CEMIG, by the energy sector, and by the civil society, thus focusing on the continuity of studies in this line of research to expand the database and reinforce the validation of aquatic environment classification in Minas Gerais.

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USING STATISTICAL TECHNIQUES FOR SURFACE WATER QUALITY ASSESSMENT: A CASE STUDY OF THE SÃO FRANCISCO RIVER BASIN

Sílvia Corrêa Oliveira[1]
Carolina Cristiane Pinto[2]
Ana Luiza Cunha Soares[3]

ABSTRACT

Several statistical methods are typically employed to assess and interpret water quality data in order to extract as much information as possible from the large and complex data matrix generated by monitoring programs. In this study, data from the Water Resources Management Institute of Minas Gerais (IGAM) monitoring program were assessed in relation to the Minas Gerais section of the São Francisco River basin. From the numerous statistical analyses carried out, it was possible to confirm greater degradation in sub-basins SF5 (the Velhas River), SF3 (the Paraopeba River), and SF2 (the Pará River), located in the Metropolitan Area of Belo Horizonte, as based on 36 water quality parameters.

Keywords: Statistical techniques, Water quality, São Francisco River basin.

1. INTRODUCTION

Natural ecosystems are heavily dependent on water in adequate quantity and quality, which makes surface water quality monitoring and assessment extremely important for an efficient management of water resources (ANA, 2017). Systematic and periodic monitoring of the condition of water resources allows planning improvement interventions, identifying clandestine releases, subsidizing inspection, environmental licensing and environmental policy making (FINOTTI et al., 2009). However, the long term monitoring of water bodies at several sampling stations creates a complex and extensive database, making it difficult to analyze and interpret the information.

Statistical techniques are an excellent exploratory tool for interpreting these complex sets of information and are commonly used to assess water quality. Several studies have employed some of these techniques (non-parametric tests, trend analysis, and multivariate techniques) to achieve different objectives. The results provide a more direct interpretation of the data and indicate high priority actions for water quality improvement, in order to control surface water pollution (MOHAMED et al., 2015).

Thus, this study aims to present the statistical techniques usually employed in water quality assessment, as well as the types of results that can be obtained. A case study is presented based on the analysis of the water quality data obtained from IGAM's water monitoring program in the Minas Gerais section of the São Francisco River basin.

[1]Electrical Engineer, MSc., PhD em Saneamento, Meio Ambiente e Recursos Hídricos pela UFMG. Associate Professor of the Department of Sanitation and Environmental Engineering (DESA) – UFMG. silvia@desa.ufmg.br
[2]Chemical Engineer (UFSJ). MSc. em Saneamento, Meio Ambiente e Recursos Hídricos pela Universidade Federal de Minas Gerais – UFMG. Analista Ambiental do Instituto Mineiro de Gestão das Águas (Igam). carol-cp@ufmg.br
[3]Environmental Engineer (FUMEC). MSc., Phd candidate in Sanitation, Environment and Water Resources (UFMG). analulucunha@ufmg.br

2. METHODOLOGY

Water quality monitoring databases should be carefully prepared to minimize errors in the results of statistical data processing (OLIVEIRA et al., 2017), as they may present inconsistencies, outliers, censored and missing data. Table 1 presents some statistical techniques usually applied in water quality assessments.

Table 1 - Statistical techniques and applications in water quality assessments.

Technique	Application in water quality assessment
Kruskal-Wallis (KW) non parametric test	Identify significant differences in the water quality concentration parameters between river basins and/or monitoring stations.
Cluster Analysis (CA)	Evaluate the similarity of hydrographic basins and/or monitoring stations as per the water quality concentration parameters measured.
Principal Component Analysis (PCA) and Factor Analysis (FA)	Identify the main parameters responsible for explaining the greater variability in water quality and the different sources of pollution in each group formed by the CA.
Discriminant Function Analysis (DFA)	Group samples that share common properties.
Mann-Kendall Trend Analysis/Mann-Kendall	Check elevation or reduction trends or lack thereof in terms of water quality parameters.

Source: Gilbert (1987); Helsel & Hirsch (1992); Hair et al., (2009).

3. A CASE STUDY OF THE SÃO FRANCISCO RIVER BASIN

The São Francisco Hydrographic Region (RH) has approximately 638,466 km2 (7.5% of the national territory), covering seven Federal Units: Bahia, Minas Gerais, Pernambuco, Alagoas, Sergipe, Goiás, and the Federal District (ANA, 2015). Due to its extension and coverage in the national territory, several state networks carry out the systematic monitoring of the region's water quality, in a varying number of monitoring stations, the larger of which is located in the state of Minas Gerais (316 sampling points). The Minas Gerais section of the basin is divided into ten Water Resources Planning and Management Units (UPGRHs), as presented in Table 1, which also shows the key features of each UPGRH, including the number of water quality monitoring stations, population, and area. Figure 1 illustrates the UPGRH locations in the basin.

After organizing and standardizing the database, techniques for comparing the water quality of the sub-basins and identifying the most affected ones were applied. Figure 2 shows the Cluster Analysis (CA) results, fully linked, in which it is possible to visualize the most similar UPGRHs clusters, as based on the medians of 36 parameters.

Table 1 - Key features of each UPGRH of the São Francisco River basin

UPGRH	No. of monitoring stations	Population (hab.)	Area (km²)
SF1 – Alto São Francisco Tributaries	7	227,893	14,155.09
SF2 – Rio Pará River	29	766,756	12,233.06
SF3 – Rio Paraopeba River	33	1,123,881	12,054.25
SF4 – Entorno da represa de Três Marias	18	171,763	18,654.66
SF5 – Velhas River	118	4,569,544	27,857.05
SF6 – Jequitaí and Pacuí Rivers	9	273,517	25,045.45
SF7 – Paracatu River	30	281,803	41,371.71
SF8 – Urucuia River	13	89,575	25,032.53
SF9 – Pandeiros and Calindó Rivers	23	272,592	31,150,94
SF10 – Verde Grande River	22	731,754	27,003.52

UPGRH SF5, a sub-basin of the Velhas River, has been very impacted and presents distinct characteristics, such as high population density and high industrialization (IGAM, 2010; POMPEU et al., 2005; TRINDADE et al., 2017) completely isolating itself from the other sub-basis, as is SF10 (the Verde Grande River sub-basin), the most preserved. Groupings 4 (SF1, SF2, SF3, and SF4) and 3 (SF6, SF7, SF8 and SF9) are consistent with the sub-basins location, a sign of their geographical proximity.

Figure 1 - Location of the São Francisco River Basin UPGRHs in the state of Minas Gerais. Source: TRINDADE, 2013

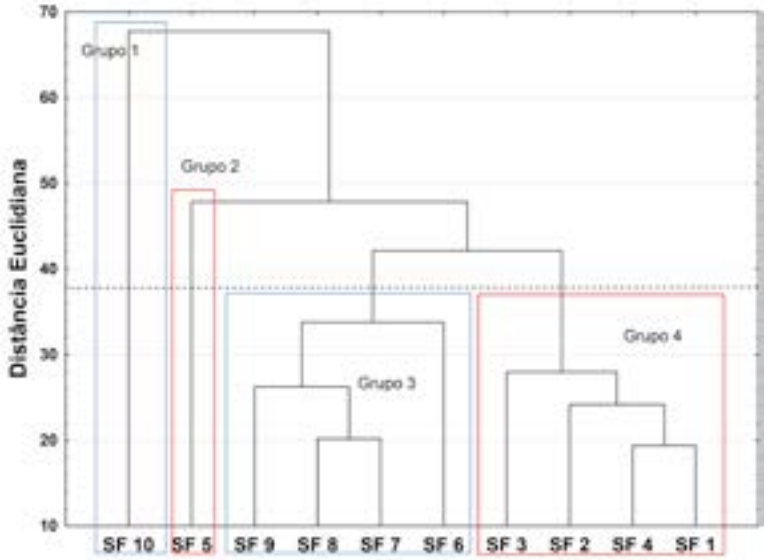

Figure 2 - Cluster Analysis dendrogram for the database of medians from 2008 to 2017: 188 stations, 10 years of historic series, and 36 parameters

The Kruskal-Wallis test was used to individually compare 36 quality parameters in each of the ten sub-basins using the raw data. When the results were significantly different, at the 5% level of (⍰) significance, multiple comparison tests were employed. Figure 3 shows, by way of example, the comparison of UPGRHs in relation to the data of the fecal contamination microbiological indicator.

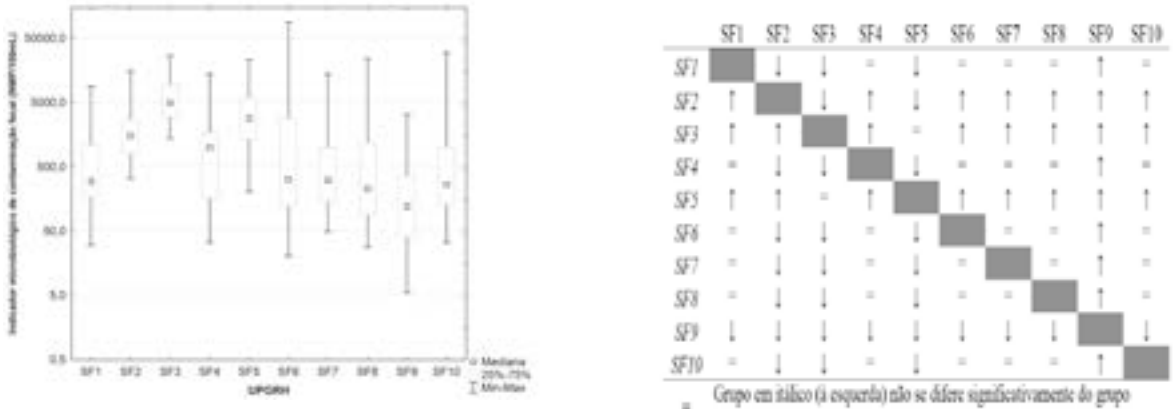

Figure 3 - Box-plot of microbiological indicator concentrations for fecal contamination and multiple comparison test results, considering the 10 UPGRHs of the São Francisco River basin.

SF3 (UPGRH - the Paraopeba River), SF5 (UPGRH - the Velhas River) and SF2 (UPGRH - the Pará river) are the most impacted sub-basins in relation to this parameter, presenting higher concentrations than all other sub-basins. These three most impacted by faecal contamination UPGRHs cover the municipalities of the RMBH and are the densest of the entire Minas Gerais section of the São Francisco River basin. A major problem detected in the region is contamination by domestic sewage, due to untreated or insufficiently treated wastewater disposal. In addition, high phosphorus values and high total solids concentrations are observed, indicating a high risk of eutrophication and silting. Fish mortality, difficulties in reservoir navigation and operation, and the impairment of water quality for human use are some of the resulting damages (ANA, 2015).

4. CONCLUDING REMARKS

Monitoring the quality of surface water is an important tool for water resources management, since it can identify polluting sources and spatial and temporal variations in water quality. Statistical tools are useful to assist in data management and interpretation, generating accessible and usable results from large historical database series, as is usual in environmental data.

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"GUARDIÃO DOS IGARAPÉS": A PRODUCTION AND CONSERVATION PROGRAM FOR THE WATERS OF IGARAPÉ, MINAS GERAIS - BRAZIL

Isaías de Barros Abreu[1]
Lina Deise de Morais dos Santos[2]
Franciane Fátima Queiroz[3]
Eliane Assunção Nunes[4]
Larissa Cristina Gomes Ribeiro[5]
Colaboradores[6]

ABSTRACT

The "Guardião dos Igarapés" Program aims at promoting water production and conservation through an annual-basis Payment for Environmental Services (PES) made to water-producing rural landowners in Igarapé. The program was institutionalized with Law No. 1.672/2014 and regulated by Decree 1.849/2015. The Rural Landowners' Accreditation Notice No. 01/2015 started the Pilot Project in the Batatal Stream micro-basin, conducted with technical and financial support from the National Water Agency. Property Improvement Plans (PIP) were implemented with actions to allow water infiltration and erosion abatement: expansion and conservation of the native forest coverage; mechanical actions of soil conservation (small dams, terracing, and adaptation of rural roads). The PSA also pays for sustainable agriculture and rural sanitation practices. The Pilot Project covered 23 properties, totaling 206.92 hectares, with an average PES of of R$ 1,929.06 per property in 2017. 55 hectares of native forest are now under conservation, 7 of which were recovered by the Program. 4,500 meters of fencing were installed around springs and watercourses, 60 small dams were built, with 19,700 m² (5 km) of rural roads adjusted, and septic tanks allocated in each property. Environmental education was extended to the entire municipality, totaling 4,000 students and including theater plays, 3 trainings for 148 teachers and supervisors of the City's school district, and 7 trainings for 12 firefighters. The Pilot Project conclusion led to the expansion of the Program for the entire sub-basin of the Serra Azul System, which comprises the Metropolitan Area of Belo Horizonte water supply and has an approximate area of 7,100 ha.

Keywords: Payment for Environmental Services. Water Production. River Basin Management.

1. INTRODUCTION

The municipality of Igarapé, in the Metropolitan Area of Belo Horizonte (RMBH), was one of the largest vegetables suppliers for CeasaMinas in the 1980's. More recently, the municipality started developing floriculture-related actions. For these reasons, the city's water demand is high, resulting in the interruption of perennial watercourses' flow rate at certain times of the day and even at some periods of the year in some locations.

[1]Production Engineer, e Sanitarista Especialista em Meio Ambiente, Secretário Municipal de Meio Ambiente na Prefeitura Municipal de Igarapé-PMI, sema@meioambiente.igarape.mg.gov.br
[2]Biologist, Specialist in Environmental Risk Analysis, PMI, rhid@meioambiente.igarape.mg.gov.br
[3]Environmental Engineer, PMI
[4]BA in Silviculture, PMI
[5]Environmental Technician, PMI
[6]Other collaborators at PMI and in partner organizations.

Supplied by watercourses that cover 64% of Igarapé, the Serra Azul System reached 5% of its storage capacity in November 2014 (COPASA, 2018). The degradation of riparian forests and the sedimentation of water bodies are other contributing factors (IGARAPÉ, 2014). In this scenario, Igarapé is strategic for the RMBH's development, due to water or food production, two intrinsically interconnected and interdependent elements.

Acknowledging the importance and historical degradation of these systems, the municipality has sought initiatives to turn the environmental degradation culture into a culture of awareness, with sustainability and financial support to rural landowners.

The "Guardião dos Igarapés" Program aims to increase water production and improve water quality in the above mentioned municipality through restoration and preservation of water systems, environmental management of rural properties, and Payment for Environmental Services (PES).

Municipal Law No. 1.672 of October 14, 2014 and Municipal Decree No. 1.849 of July 13, 2015 grants the City's executive authority the power to award financial support to rural landowners who provide environmental services within the "Guardião dos Igarapés" Program scope. After the Program was institutionalized, the Batatal Stream micro-basin was chosen to host the pilot project. Door-to-door mobilization was then initiated and the Rural Landowners' Accreditation Notice No. 01/2015 was issued, along with the methodology for calculating the PES
.
Interested landowners were visited by the "Guardião dos Igarapés" technical team for an environmental assessment of their property. A Property Improvement Plan (PIP) was presented with recommended actions. The final PIP was then prepared with the actions that each owner agreed to carry out, emphasizing the Program's voluntary nature. Terms of Commitment were signed between the owners and the City of Igarapé.

The actions proposed by the Environment Department of Igarapé-SEMA focused on forest restoration through planting native species and fencing permanent preservation areas (PPA); on soil conservation by building small dams for rain catchment, terracing, and rural road adaptations; on environmental sanitation by implementing an individual treatment system of domestic wastewater with a grid tank, a grease trap, a septic tank, an anaerobic filter, and a septic drain field.

The PES calculation methodology first considers the size of each property to set reference values per hectare. Based on the property size, Notice 01/2015 considers the property's relative area of forest coverage, the technical team's proposal acceptance, the number of sustainable agricultural and sanitation practices for the valuation of the environmental services rendered
.
Concomitant to the actions on the properties, awareness and environmental education actions were carried out with rural landowners and an environmental conservation course was offered to the City school teachers so that they could address the Program's principles in the classroom. The educational institutions hosted three theater plays addressing themes related to the water cycle: capture, treatment, water supply, and rational use of water at home and at school.

The owners were also invited to form a voluntary wildforest fire brigade with theoretical and practical training offered by the Program. Water monitoring was also performed with the analysis of twenty water samples (ten of springs and ten of watercourses), in four different moments. Hence, it is possible to monitor the results of the Guardião dos Igarapés Program in terms of quantity and quality of water produced in the mid and long term.

The "Guardião dos Igarapés" Program is run in partnership with organizations that provide financial resources, or goods and services. They are: the National Water Agency (ANA), the Minas Ge-

rais Company for Technical Assistance and Rural Development (EMATER), the Minas Gerais Public Prosecutor's Office (MPMG), The Nature Conservancy (TNC), the City Council for Environmental Defense and Conservation (CODEMA), and the Advisory Council Igarapé.

2. RESULTS

The results obtained in the Batatal Stream micro-basin are shown in Table 1:

Table 1 – Results for the "Guardião dos Igarapés" pilot project

GOALS	RESULTS
Conservation of remnant forests	Conservation of 48 hectares of native forest.
Planting	Restoration of 07 hectares through planting of native species in PPA.
Fencing	4.500 metros de cerca em APP de nascentes e cursos d'água.
Rainwater catchment sheds – small dams	Installation of 60 small dams for rainwater catchment.
Road infrastructure adjustments	Infrastructure adjustments in 5km of rural roads.
Environmental education – students – theater plays	03 theater plays for 4,000 students in municipal schools.
Environmental education – teachers – training	03 training courses for 148 teachers of the city school district.
Environmental education – rural farmers – training	03 training courses for 100 rural farmers.
Wildland Fire Department	07 training and development courses for 12 volunteer fire departments.
Septic tanks	Allocation of 50 septic tanks in the micro-basin's rural properties.
Management of water quantity and quality	04 monitoring cycles with 10 spring samples and 10 watercourses in the Batatal Stream micro-basin and in the Estiva Creek sub-basin.
Payment for Environmental Services	23 properties (206.92 hectares) received an average of R$ 1,929.06 for providing water production environmental services in 2016 and 2017.

Source: the City of Igarapé, 2018.

In addition to direct PES benefit holders, the Program indirectly helps 100,000 inhabitants in the metropolitan area of Belo Horizonte, with the potential to reach 1,200,000 indirect beneficiaries, as based on the maximum water flow rate granted, on COPASA's funding system, and on the fact that the Serra Azul System is part of the Integrated System of Paraopeba.

This experience has been shared at the Federal University of Minas Gerais' 1st Workshop on Metropolitan Spring Management and Modeling, in which countries such as the United States, France, and Russia also took part.

3. CONCLUDING REMARKS

Once the pilot project was concluded, the Project Management Unit (UGP) issued the Rural Farmers' Accreditation Notice No. 01/2018, expanding the reach of "Guardião dos Igarapés" to the other basins that supply the Serra Azul System, where mobilization has already begun.

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FROM RESEARCH TO PRACTICE: UFMG/ COPASA'S SANITATION RESEARCH AND TRAINING CENTER (CEPTS) - SHARING EXPERIENCES IN FAVOR OF THE WATERS OF MINAS GERAIS

Cláudio Leite de Souza[1]
Marcos von Sperling[1]
Carlos Augusto de Lemos Chenicharo[1]

ABSTRACT

Formerly named ETE Experimental UFMG/COPASA, its research units were implemented in 2002 with resources from PROSAB/FINEP/CNPq, FAPEMIG, and FUNASA. Now called CePTS (the Sanitation Research and Training Center) is a result of the expansion of the sanitation areas that it serves and also of the activities it enables, notably in the area of operation training. Located next to the Arrudas Stream WWTP in Belo Horizonte, CePTS is one of the most important sanitation research and training centers in Latin America, housing several research units supplied with the Arrudas WWTP sewage post preliminary treatment. The research conducted at CePTS seeks the development of new and/or simplified alternatives and types of sewage treatment systems and by-product recovery systems (sludge and biogas), as well as the optimization of sizing and operating parameters. In addition to its use for research purposes, teaching activities (practical and demonstration classes) and training sanitation technicians are also developed at CePTS, which consists of several experimental sewage treatment units and support and control units.

Keywords: Research, Training, Sanitation, Sewage Treatment, WWTP.

1. INTRODUCTION

For 16 years, the Sanitation Research and Training Center (CePTS) has been run by UFMG and COPASA at the Arrudas Stream wastewater treatment plant (WWTP) in Belo Horizonte, where different types of treatment systems are handled as ready-for-use prototypes. Faculty, researchers, and students from UFMG's School of Engineering have been surveying suitable systems to serve small communities (+100 inhabitants, at R$ 200.00 to 400.00 per inhabitant), as such small-scale systems neither demand large amounts of resources and energy nor require qualified workforce.

In an area of around 10,000 m^2, the Center accommodates compact, easy-to-manufacture, space-saving systems, as well as natural systems – all non-mechanized or simplified. Regarded as one of the most important structures of its kind in Latin America, CePTS houses research units that are supplied with a portion of the Arrudas WWPT sewage after its pre-treatment (coarse solids and sand). The main goal is to create and offer new alternatives and types of sewage treatment units and by-product recovery – sludge and biogas, in addition to optimize sizing and operating parameters. Combinations between processes are also investigated, some of which already exist in isolation. The investigations help to set and improve criteria and parameters to be employed by the sanitation service providers.

[1]Professors of the Department of Sanitary and Environmental Engineering at UFMG.

The facilities jointly managed by UFMG and COPASA process about 3 liters of sewage per second – white the Arrudas WWTP treats an average of 2,000 liters per second. Figure 1 shows the schematic diagram of the CePTS experimental system.

Figure 1 – The Sanitation Research and Training Center (CePTS).

The so-called compact systems remove nearly the same amount of organic material as the natural ones (which use ponds or plants). Removal of organic material is important to prevent fish death. On the other hand, natural systems are able to eliminate pathogens more efficiently. Compact systems take less space and can be supplemented with disinfection units. In both cases, processes are fully biological, with no use of chemicals (Von SPERLING, 2015).

The investigations conducted at CePTS are documented in academic productions in the form of master's theses and doctoral dissertations (estimated amount in Table 1) and in books such as the "Principles of Wastewater Biological Treatment" series – a collection of seven textbooks written in Portuguese, English, and Spanish, some of which are best sellers in this segment in Brazil and abroad. Published by Editora UFMG, the series is a benchmark publication in several courses and in projects carried out in several hot climate countries, notably in Latin America, Africa and Asia.

Table 1 – Number of thesis and dissertations produced by the CePTS at UFMG

TYPE OF ACADEMIC PRODUCTION	NO. OF PRODUCTIONS
Master thesis	53
PhD dissertations	23

The Center's foundation and continuous expansion has relied on the important support of several entities, namely the National Council for Scientific and Technological Development (CNPq), the Coordination for the Improvement of Higher Education Personnel (CAPES), the Minas Gerais Foundation for Research Support (FAPEMIG), the Brazilian Funding Authority for Studies and Projects (FINEP), and the National Health Foundation of Brazil (FUNASA), in addition to privately-held companies (Von SPERLING, 2015).

2. FROM RESEARCH TO PRACTICE

One of the most widely studied reactors at CePTS is of the UASB kind (Upflow Anaerobic Sludge Blanket), in which the sewage travels to the bottom of the tank, from where it flows into the

naturally-formed and accumulated mass of microorganisms. The conversion of organic material generates biogas (which may be energy efficient), excess sludge (resulting from microbial mass growth, which can be transformed into agricultural input), and sewage. In addition, CePTS also delves into research on the UASB wastewater post-treatment to further increase efficiency and to incorporate the removal of other pollutants (mainly nutrients and pathogens).

Due to its advantages and applications in Brazil and in Minas Gerais, but mostly as a result of the intensive research conducted at CePTS, the UASB reactor has been increasingly employed state and country-wide and is one of the primary technologies used in the sewage treatment of most cities in Brazil and Minas Gerais. An example is the Onça WWTP (Figure 2A), which serves about 1 million people in Belo Horizonte and is run with UASB reactors for primary treatment and with Percolating Biological Filters (PBF) for post-treatment.

Waste stabilization or polishing ponds are another option for post-treatment of UASB reactor effluents – very applicable to the Brazilian reality. Such ponds are heavily researched in CePTS, with different associations and innovations. This accumulated experience has traveled beyond the halls of research to land in realms of practice, that is, materializing in the Lagoa da Prata WWTP. By adopting a system investigated in CePTS, consisting of a UASB reactor, Polishing Ponds (PP), and Coarse Screen (CS), the WWTP serves the Minas Gerais municipality, reaching about 60,000 inhabitants while providing greater environmental quality (Figure 2B).

(A) (B)

Figure 2 – The Onça WWTP: UASB+PBF (A)and the Lagoa da Prata WWTP: UASB+PP+CS (B)

3. CONCLUDING REMARKS

The Sanitation Research and Training Center (CePTS) has created ongoing dialogue between research and practice for UFMG, COPASA, and several other research and development agencies and government bodies, for the benefit of the sanitation services in Brazil and Minas Gerais. In addition, in more than 15 years of its existence, the CePTS has provided learning and practical experience for numerous students and professionals in all levels of education, from situations very close to their reality.

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TREATING SUPERFICIAL WATERS WITH RECYCLED MEMBRANES IN MINAS GERAIS

Eduardo Coutinho de Paula[1]
Poliana Vicente Martins[2]
Míriam Cristina Santos Amaral[3]

ABSTRACT

In the context of improving water access to poorer populations, this paper explores the technical feasibility of using low-cost recycled membranes for the successful water treatment of the rivers of Minas Gerais, Brazil. In the first stage, the objective was to recycle, through oxidative treatment, polymer membranes discarded after reverse osmosis and nanofiltration processes, which would be disposed of in landfills. Subsequently, the research evaluated the use of recycled membranes in surface water treatment. Membrane performance before and after recycling was investigated by measuring the water flow in tangential-axial flow, at bench and pilot scales. Experimental results indicated that recycled membranes can be used in processes analogous to ultrafiltration, with satisfactory flow performance and scale resistance behavior. Tests have shown that recycled membranes operated steadily in water treatments under 0.5 to 1 bar pressure. Low pressure is regarded as favorable for the purpose of minimizing energy costs. The scale of the recycled membrane was removed through conventional cleaning. The quality of the treated water is similar to that reported in previous works evaluating new spiral modules of commercial ultrafiltration membranes. The permeate produced from the raw water treatment samples from the Doce, Paraopeba, and Velhas rivers using the recycled membranes obeyed the Brazilian potability standards for the following analyzed parameters: apparent color, turbidity, Escherichia coli, and heterotrophic bacteria.

Keywords: Access to water. Water treatment. Recycled membranes.

1. INTRODUCTION

The recycling of composite polymer membranes, which at the end of their useful life would be disposed of in landfills, gained increasing interest in academic and industrial environments (Lawler et al., 2015; Landaburu-Aguirre et al., 2016). The recycling technique used in this experiment consisted of immersing the membranes in a commercial solution of sodium hypochlorite pH 11 (NaClO) for 2.7 hours (~ 300,000 ppm·h) (Coutinho de Paula et al., 2017). In terms of water permeability, based on the new reverse osmosis (RO) membrane, which is 3.0 L · h-1 · m-2 · bar-1, the membranes oxidized with NaClO showed an increase from 27 to 39 times, while salt rejection decreased from ~ 96% to 15.5% (Coutinho de Paula et al., 2017). Thus, this work explores the feasibility of using recycled reverse osmosis and nanofiltration membranes to successfully treat the waters from the Minas Gerais rivers. The results indicate the low-cost recycled membranes potential to favor the population's access to water, especially in rural areas or in emergency situations.

[1]Chemical Engineer, PhD in Sanitation, Environment and Water Resources, School of Engineering, Federal University of Minas Gerais, ecoutinho@desa.ufmg.br
[2]Graduate student in Chemical Technology at the Federal Technological Education Center of Minas Gerais, polianavicente@outlook.com
[3]Chemical Engineer, PhD in Sanitation, Environment and Water Resources, School of Engineering, Federal University of Minas Gerais, miriam@desa.ufmg.br

2. MATERIAL AND METHODS

The performances of discarded membranes and recycled membranes were investigated in bench and pilot scale tests, through cross-flow water permeation measurement. The procedures for the chemical cleaning of the membranes were evaluated according to Coutinho de Paula et al., 2017. The operation of water treatment by recycled membranes was repeated for three different sources of raw water from Minas Gerais rivers, namely: Rio Doce, Paraopeba, and das Velhas. No pretreatment was used for the river waters. The cleaning of the recycled membranes was performed at room temperature under immersion involving 0.1% (m/m) NaOH plus 0.2% (m/m) HCl for 2 hours at each stage. The physical-chemical parameters were analyzed according to APHA (2017).

3. RESULTS AND DISCUSSION

The performance of the pilot test using a recycled spiral-wound membrane in relation to the normalized permeate flux decline at 25° C at a flow rate of 3.2 L · min-1, at 1 bar pressure, over 24 continuous hours of permeation, is shown in Figure 1. A non-accentuated permeate flow decline occurred in the first hours of operation, due to concentration polarization and/or scaling (pie-crusting), as expected in this type of operation. It was observed that after about three hours of operation, the flow became stable (~ 16 L·h-1·m-2).

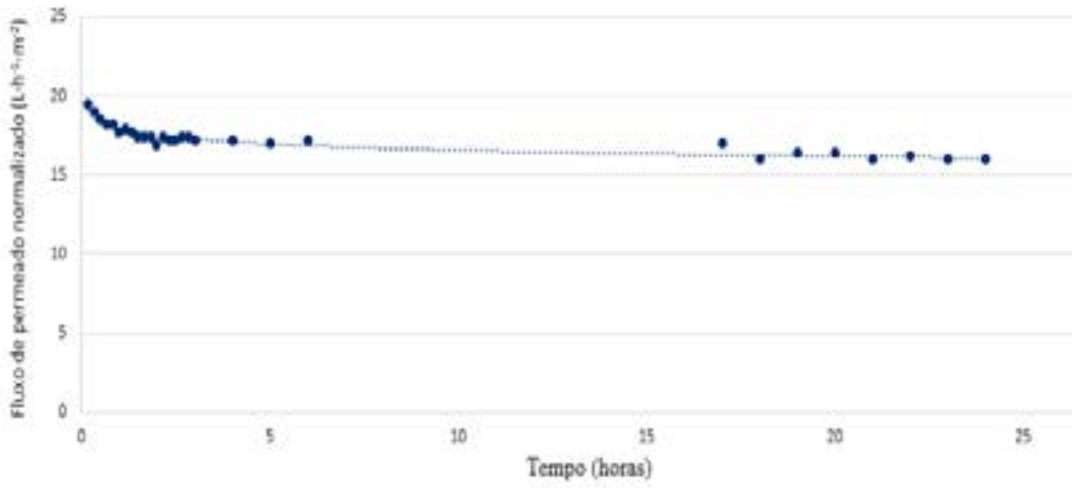

Figure 1 - Experimental results of normalized permeate flow at 25° C (L · h-1 · m-2) in function of time (24h of continuous permeation) of the Doce River water, pH ~ 7 in pilot test (membrane recycled with NaClO, flow rate 3.2 L · min-1, pressure of 1 bar).

Table 1 shows the results of the physical-chemical analyses of the analyzed parameters for the Doce River raw and treated water samples, according to APHA (2017).

Table 1 - Comparison between the results of the analyzed parameters for the Doce River raw water and water treated with recycled polymer membranes.

PARAMETER	UNIT	RAW WATER	TREATED WATER	REMOVAL (%)
pH	-	7.48	7.42	-
Electrical Conductivity	S·cm-1	196.9	192.5	-
Apparent Color	uH	113	1.9	98.3
Turbidity	NTU	10.5	0.11	99.0
TOC	$mg \cdot L^{-1}$	10.8	6.78	37.2
COD	$mg \cdot L^{-1}$	26.4	15.3	42.0
Total Nitrogen	$mg \cdot L^{-1}$	9.985	< 1	90.0
Alkalinity	mg $CaCO_3 \cdot L^{-1}$	26.97	15.93	40.9
Total Coliform	MPN·100 mL^{-1}	> 2.419,2	< 1	100
Escherichia coli	MPN·100 mL^{-1}	> 2.419,2	< 1	100
Heterotrophic Bacteria	CFU·mL-1	> 5.700	< 1	100

MPN = Most probable number
CFU = Colony-forming unit
Source: authors.

The evaluation of the efficiency of the recycled membrane indicates significant reductions in the apparent color and turbidity of the treated water compared to raw water, as well as the complete removal of microbiological parameters, which shows the added value of using recycled membranes. The monitored parameters for the permeate were kept at approximately constant values during the operation time. The physical-chemical analyses of the raw water samples from the Paraopeba and Velhas rivers, as well as their treated waters, showed similar results.

4. CONCLUDING REMARKS

The recycled polymer membranes showed similar performance and characteristics to the processes with low-pressure membranes. The result proved that recycled membranes can be applied to surface water treatments under a pressure of 0.5 to 1.0 bar. Low pressure is regarded as favorable for the purpose of minimizing energy costs. The chemical cleaning adopted proved to be effective for removal of scale and consequent recovery of the recycled membrane permeability. The quality of treated water is similar to that reported by several authors who have evaluated brand new commercial ultrafiltration (UF) spiral-wound modules. The permeate produced from the treatment of different raw waters of the rivers using the recycled membranes obeyed the Brazilian standards of potability for the following analyzed parameters: apparent color, turbidity, Escherichia coli and heterotrophic bacteria.

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PROTECTING THE PARACATU RIVER BASIN'S SPRINGS AND PALM SWAMPS

Gabriel Vargas Mendonça[1]
Osmar Alves Ferreira[2]
Alessandro Lucioli Nepomuceno[3]
Marcos do Amaral Morais[4]
Antonio Eustáquio Vieira[5]

ABSTRACT

The Paracatu River Basin Project is designed to promote fencing of these areas in the municipality of Paracatu, Minas Gerais. Such action prevents livestock from invading the land, consequently reducing soil trampling and compaction, guaranteeing the conservation of these important ecosystems, and contributing to water retention in water tables. The project generates information about soil conservation practices, correct use of natural resources, and environmental legislation, To verify the effectiveness of this initiative, flow monitoring equipment were installed. Since 2010, the Project has already reached over 100 rural properties and protected more than 200 springs, ensuring the maintenance of water availability for the region. There are more than 1,000 hectares of fenced areas, which corresponds to 120 km of fences built. Rural farmers of the municipality are directly benefited, as water supply is guaranteed in quantity and quality compatible with the natural conditions observed prior to land occupation. In addition, the entire community that uses the basin's water resources is indirectly benefited, since the springs and palm swamps in the area supply the whole municipality.

Keywords: Cerrado. Water. Biodiversity.

1. INTRODUCTION

The Paracatu Spring Protection Project, conducted by MOVER – the Green Movement of Paracatu NGO and financed by KINROSS Paracatu, is aimed at promoting fencing installation of the springs and palm swamps that integrate properties located in the interior of the municipality, in order to protect the vegetation surrounding the springs and palm swamps, thus preventing soil trampling and soil compaction, The Project's institutional partners are: the State Institute of Forestry (MG), the São Francisco River Basin Committee, the Paracatu River Basin Committee, Ecológico magazine, Agência Peixe Vivo, Refloreste, and rural farmers of the Paracatu municipality (MG).

The Project's guiding principles are directed at the way the surrounding areas of the basin headwaters are used and occupied, as this is the drainage system that supplies the region's main watercourses. In general terms, land use and occupation (appropriated by third parties) is held in disorderly fashion or with the adoption of inadequate soil management practices, turning these lands into high impact and degradation areas.

In addition to changing the quantity and quality of their waters, this situation puts the springs and palm swamps that supply the drainage system at risk. Therefore, measures and actions that gua-

[1]Forestry Engineer, Kinross Paracatu: +55 (38) 999831329, Gabriel.Mendonca@kinross.com
[2]Biologist, Kinross Paracatu: +55 (38) 36791165, Osmar.Ferreira@Kinross.com
[3]Sustainability and Licensing Director, Kinross Paracatu: +55 (38) 36791055. Alessandro.Nepomuceno@kinross.com
[4]Environment and Licensing Manager, Kinross Paracatu: +55 (38) 36791020, Marcos.Morais@Kinross.com
[5]CEO at Mover – The Green Movement of Paracatu: + 55 (38) 99964-8152, movimentoverdeptu@yahoo.com.br

rantee the preservation of the aquifers' allocation and replenishment areas have become urgently necessary (TOKARNIA, 2015).

2. JUSTIFICATION

The current water crisis demands much reflection and debate so that progress in the search for perennial solutions can be made. Just as households have been affected by the shortage in water supply, so has the production sector, whether in retail, farming, service or industry, including the mining segment, which is a source of wealth and currency at the municipal, state, and federal levels (MOTTA; GONÇALVES, 2016).

Therefore, priority should be given to the discussion on how to ensure access to water for all segments, from the housekeeper to those who use water for farming or in industry. Without this understanding, the municipalities', the states' and, consequently, of the entire country's expectations of development will be not be met. Contrary to what certain groups and individuals believe, this is the moment for unison and for sharing ideas and attitudes that can benefit all sectors, as opposed to trying to demonize some in order to favor others, through unsubstantiated allegations
.
Consolidation of the water resources management system is paramount, to be carried out by the management agencies' active operations and by implementing both the Policy and the National System of Water Resources Management technical, economic, strategic, and institutional instruments (LIMA; SILVA, 2002). In this sense, this project was majorly aimed at the hydrological maintenance of the Paracatu River basin.

3. METHODOLOGY

For each of the areas within the scope of the Project, the following have been considered: the type of monitoring (qualitative or quantitative) of the fenced areas, the type of instrument to be employed in each section (in the case of quantitative monitoring), the specifications and procedures for equipment installation, as well as descriptions of the system maintenance and the general criteria to be observed during operation.

Environmental education projects are carried out with the rural farmers in order to identify the water courses and springs that will be fenced and revitalized, providing them with information on soil conservation practices, spring maintenance, and environmental legislation. The mapped area is fenced with resources provided by Kinross Paracatu, after which structures and equipment for water flow monitoring are set up, thus allowing the initiative to be checked for effectiveness (Figure 1)

(a) (b)

Figure 1 – Fencing installation along the springs and palm swamps (a) and gutters for water flow measuring and monitoring (b). Source: the authors

4. RESULTS

The Project has favored rural farmers who, in addition to learning to preserve the source of this natural resource, are rewarded with greater water volume: the rehabilitation of water sources supported farming activities all year long, the result of which is income growth for the families involved in this process. What is special about the Paracatu Project is that tasks are developed in collaboration with rural landowners and the communities, aiming at changing their culture of water use. Rural landowners have come to understand the importance of preserving springs and of making conscious and careful use of water resources.

The rural farmers who took part in the Project have realized that protecting the springs is indeed important. But this goes beyond raising awareness - it is about convincing people. Protection brings advantages for crop production and improvement in water quality. There have been cases in which rural properties experienced water shortage in the dry season and now the water volume is high enough to supply families and irrigate agricultural production.

Since its inception in 2010, the Project has already covered 142 rural properties. A total of 203 springs have been preserved and protected, thus guaranteeing the increase of water flow in the region. With 1,375 hectares of protected areas and 120 km of fencing installed, for 2018 and 2019, the installation of more than 30 km of fencing is expected.

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SHARING

WATER RESOURCES MANAGEMENT IMPROVEMENTS: IMPLEMENTING A SYSTEM TO RECORD INSIGNIFICANT USE OF WATER RESOURCES

Marconi Rocha da Silveira[1]
Thiago Figueiredo Santana[2]
Alexandre Jose Combat Barbosa[3]
Bruno Meira Tenorio D'Albuquerque[4]
Nádia Antônia Pinheiro Santos[5]

ABSTRACT

The System for Recording Insignificant Use of Water Resources[6] has the goal of fostering the regulation of minor uses. This System was developed by the The Water Management Institute of Minas Gerais (IGAM) with the support of The State Department of Environment and Sustainable Development (SEMAD) and in a partnership with the Minas Gerais State Department of Economy (SEF). With an investment around R$ 500 thousand, besides providing for the improvement of management through the identification of a larger number of users, it benefits, yearly, 30 thousand rural producers, who become able to access the record and to become compliant with the rules, speeding up the process for obtaining rural loans and credit funding. The information in the Record, along with the data for water use permits, is essential for water planning and security, considering that it allows us to understand the universe of the user, allowing for the State to work on reducing the risks associated to critical events (droughts and floods), as well as the protection of water ecosystems.

Keywords: State System of Water Resources Information. System for Recording Insignificant Use of Water Resources Management of Water Resources:

1. INTRODUCTION

In the past five years, Minas Gerais has been facing the challenge of minimizing critical events (droughts and floods), especially those related to water scarcity. This scenario has led IGAM to propose new actions that ensure water availability, thus providing the State with more security.

In this context, and as foreseen in Law No. 13.199 of 1999, implementing instruments is strategic, in particular the State System for Water Resources Information, aimed at collecting, treating, storing, recovering, and disclosing information on water resources and water management factors,

[1]Historian, Specialist in Public Policy, Environmental Analyst at the Water Management Institute of Minas Gerais, marconi.rocha@meioambiente.mg.gov.br
[2]Agricultural Engineer, Specialist in Management and Elaboration of Water Resource Projects, Environmental Manager at the Water Management Institute of Minas Gerais thiago.santana@meioambiente.mg.gov.br
[3]Systems Analyst, Specialist in System Engineering, Capgemini Brasil S.A., alexandre.combat@capgemini.com
[4]Administrator with Training in Foreign Commerce, BA in Law, MBA in Business Management, Fiscal Auditor of the State Revenue Service, bruno.meira@fazenda.mg.gov.br
[5]Geographer, Master in Environmental Analysis, Environmental Manager at the Water Management Institute of Minas Gerais. nadia.santos@meioambiente.mg.gov.br

in addition to subsidizing the implementation of other instruments, which allows for safe decision--making.

A System for Information is a structure built around the organization of data, information (space, charts, and documents), and methods of components (substructures) that interact with the external environment and among themselves (ASFORA et al., 2001). The greatest challenge of its implementation is to balance the different existing databases by articulating the data system with the generating areas and treating the information in such a way that it adequately tends to the needs of the internal and external public (SISEMA, 2012).

The System for Recording Insignificant Use is an ke element part of the State System of Environment and Water Resources, along with the modules System for the Calculation of Water Quality (SCQA), System for Registering Water Use and Users (SISCAD), the System for Water Use Charges Calculation (SISCOB) and the System for Presenting Projects for the Fund of Water Basin Recovery, Protection, and Sustainable Development of Minas Gerais (FHIDRO) (Figure 1).

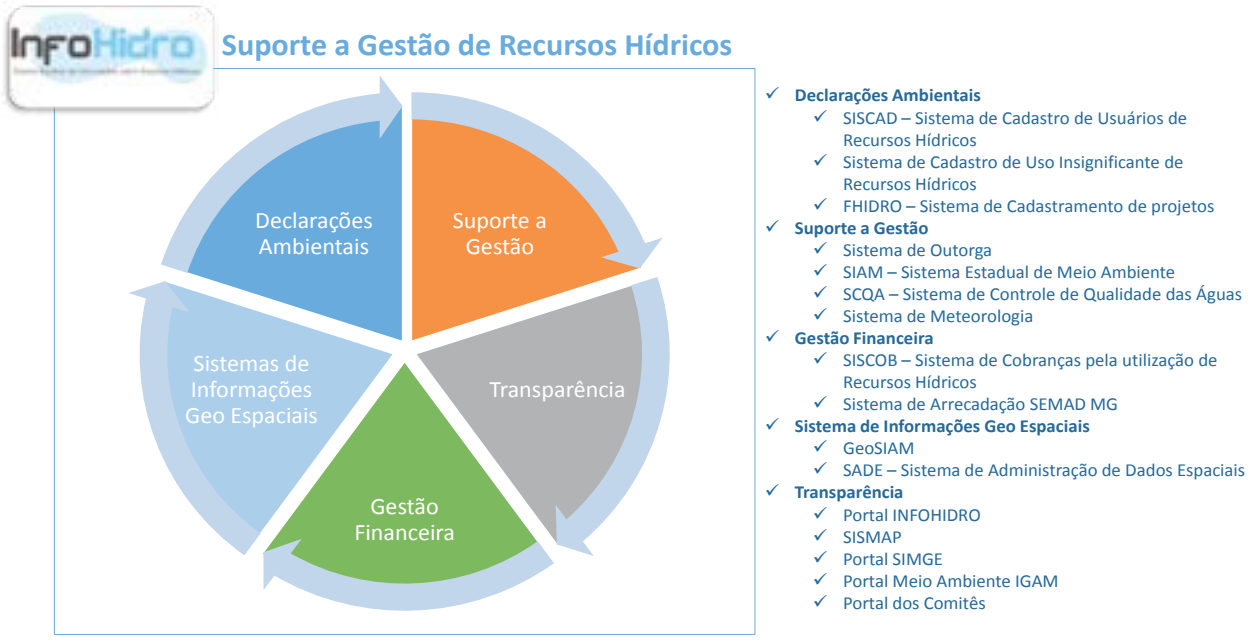

Figure 1 - Structure of the State System of Water Resources Information

Developed by IGAM in partnership with SEMAD and SEF, the System cost approximately R$ 500,000 and is aimed at increasing, fostering, and facilitating insignificant use compliance.

2. RECORDING OF INSIGNIFICANT USE OF WATER RESOURCES

The concept of insignificant use is related to the total water flow rate and the daily water capture rate by user. The criteria for defining insignificant uses are established in the Normative Decisions of the State Council for Water Resources CERH /MG n°. 09/2004[7] and n° 34/2010[8] (Table 1). The parameters depend on the water basins and on the Units for Planning the Management of Water Resources (UPGRHs) in which the user is inserted (Picture2).

[7]It establishes the insignificant uses for the water circumscriptions in the State of Minas Gerais.
[8]It defines the insignificant use of tubular wells located in the Water Resources Planning the Management Units.

Type	Usage Modes	Encompassing Area	Water Flow Rate (l/s)	Vol. Acumulação (m³)	Accu-mulation Vol. (m³)	Max. Depth (m)	Diameters (mm)
Surface	Capture in water bodies (rivers, natural lakes, etc.); Capture in water course dams, without water flow rate regulation; Capture in water course dams, with water flow rate regulation (Maximum area flooded equal to or smaller than 5.00 HA); Water course dam, without capture, for the purpose of water flow rate regulation.	Rivers Doce, Grande, Paranaíba, Paraíba do Sul, Piracicaba e Jaquari, São Mateus, Buranhém, Itabapoana, Itapemirim, Itaúnas, Peruípe and part of the São Francisco (SF1 to SF5)	≤ 1,0	≤ 5000	-	-	-
		Jequitinhonha, Pardo, Mucuri, Jucuruçu, Itanhém and part of the São Francisco (SF6 to SF10)	≤ 0,5	≤ 3000	-	-	-
Underground	Collection of underground water through a manual well (cistern)	Entire State	-	-	≤ 10	≤ 20	≥ 150 e ≤ 3500 *
	Water collection at the source (headwaters)					-	-
	Collection of underground water through an existing tubular well	Jequitinhonha, Pardo, Mucuri, Jucuruçu, Itanhém and part of the São Francisco (SF6 to SF10)	-	-	≤ 14	-	-

* IGAM Ordinance No. 62, of December 7th, 2017

When evaluated in isolation, these minor uses of water, whose inexpressive allocation lies in watering livestock, human consumption, small area irrigation, among others, present a moderate impact in water availability. However, the sum of these uses is significant and their accounting in water availability calculation is vital for a basin's water resources manageme

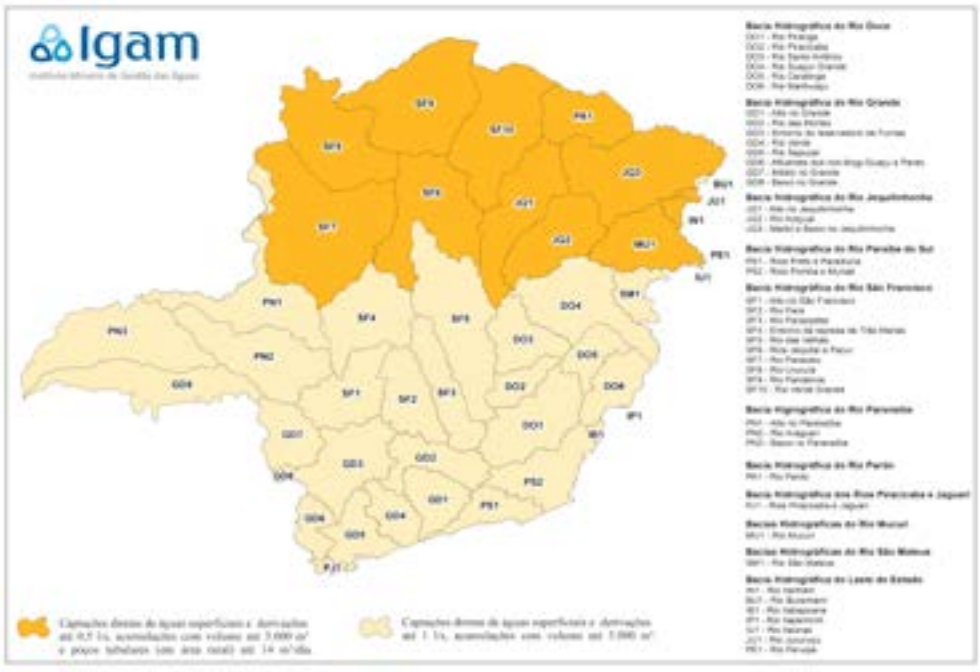

Figure 2 - Limit and volume of capture for the definition of insignificant use by the UPGRH.

2.1. Workings of the System

The System for Recording Insignificant Use is run online. Users supply information about their water resources usage (date of the user/entrepreneur and of the business, geographical coordinates, water flow rate, purpose, usage data, among others) and issues the Certificate for Registration of Insignificant Water Resource Use (Figure 3).

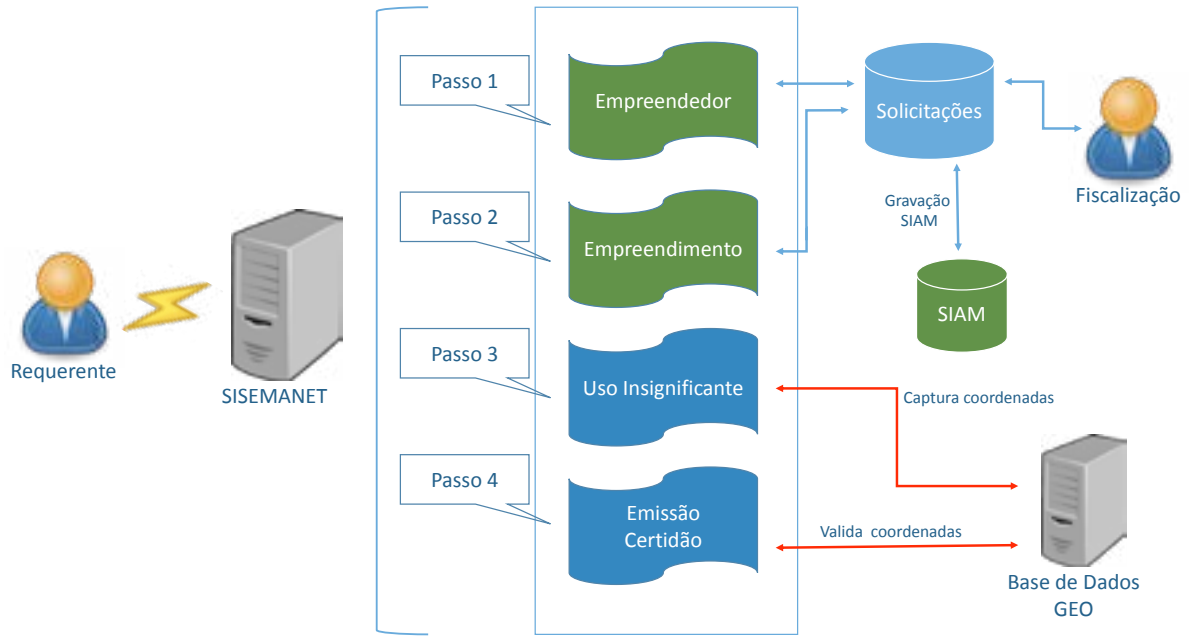

Figure 3 - Conception of the System for Insignificant Use.

3. CONCLUDING REMARK

Before the System was launched, the average monthly registrations issued by the Regional Environment Superintendencies (SUPRAM) was 2,144 processes. Between May, 2017 and January, 2018, 46,212 requests for insignificant usage (Table 1) were issued, a monthly increase of 124%.

Amount	Status
38.444	Certificates deferred
403	Certificates refused (refused meaning that the insignificant use was not qualified)
2200	Certificates canceled
5.165	Unfinished registrations

Table 1 - Quantitative measurement of requests for the registration of Insignificant Use
Source: System for Recording Insignificant Water Resources Use, 2018.

In this sense, the speed at which Certificates are issued does not exempt users from being inspected, specifically in order to fact check the truthfulness of the information provided. In addition, as of data gathering, water resources inspection is already in place for regular uses (permitted and registered) and irregular uses (unauthorized allocation) in water basins. The actions are intensified

at times of water scarcity aimed at providing for priority uses as established by law, such as those that occurred at the basins of the Santa Isabel River and the Juramento Reservoir (São Francisco) and of the São Bartolomeu River (Doce River).
This information also fostered management improvement by means of recommendations for modifications to the legislation in force, such as the changing criteria proposal for insignificant uses in the State of Minas Gerais. A new methodology has been proposed: insignificant use is limited by property or by water resource used.

Understanding the universe of water resource users in Minas Gerais allows the Management Agency to work towards the reduction of risks associated to critical events (droughts and floods), as well as in the protection of water ecosystems. It also allows for new actions to be proposed, so as to improve water management policies in the state.

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METHODOLOGY FOR AREA SELECTION AND ENVIRONMENTAL RESTORATION IN THE WATER TERRITORIES OF THE DOCE, SÃO FRANCISCO, AND JEQUITINHONHA RIVER BASINS

Rafael Deslandes Ribas[1]
Luiz Cláudio Ferreira de Oliveira[2]
Mariana Morales Leite Costa[3]
Felipe Augusto Fernandes Oliveira[4]

ABSTRACT

The present article aims to point out the innovation brought by the organization of parameters and procedures performed for the selection of areas that are being restored through no-till farming of native forest seedlings, within the scope of the project "Semeando Florestas, Colhendo Águas na Serra do Espinhaço" (in English: "Planting forests and harvesting waters in Serra do Espinhaço"). This project aims to restore permanent preservation areas (PPA) in the Doce, São Francisco, and Jequitinhonha river basins, supporting the implementation of ecological corridors according to the logic of the post-CAR (Environmental Regularization Program, in Portuguese, PRA), incorporating the dynamics of water territories and Integrated Territory Management. The article presents the techniques that are being used to select 2,145 hectares of the areas that are currently undergoing restoration, with the planting of 3 million seedlings through an in loco survey of the physical, biotic and abiotic characteristics, generating maps and georeferenced data. The parameters established for the selection of areas include PRA implementation based on CAR information; areas indicated by basin committees as priorities for environmental recovery; priority areas for environmental recovery within the context of public supply; priority degraded areas for forest restoration. This innovative methodology developed by Instituto Espinhaço will create a new model for the forest restoration processes in the scope of river basins.

Keywords: River basins. Georeferencing. CAR. Innovation. Scientific paper. Standardization. Research.

1. INTRODUCTION

This paper presents the methodology developed by Instituto Espinhaço for the Selection and Restoration of impacted areas in the 61 municipalities covered by the project "Planting the Future: Sowing Forests, Harvesting Waters in Serra do Espinhaço", which aims to plant 3 million tree seedlings native of the Cerrado and Atlantic Forest biomes in the Doce, São Francisco, and Jequitinhonha river basins, in the territory recognized as the Serra do Espinhaço Biosphere Reserve.

[1]Rafael Deslandes Ribas – Geographer, Graduate Student in Recovery of Degraded Areas – Instituto Espinhaço. E-mail: rafael.ribas@institutoespinhaco.org.br
[2]Luiz Cláudio Ferreira de Oliveira – Philosopher – Instituto Espinhaço. institutoespinhaco@institutoespinhaco.org.br
[3]Mariana Morales Leite Costa – Ecologist – Instituto Espinhaço. E-mail: mariana.morales@institutoespinhaco.org.br
[4]Felipe Augusto Fernandes de Oliveira – Biologist – Instituto Espinhaço. felipe.augusto@institutoespinhaco.org.br

For the selection of areas, a multidisciplinary team composed of technical coordinators and socio-environmental analysts with higher education was assembled. The work of the team of selection of areas is performed in synergy with the teams of seed collection, production of seedlings, social mobilization, planting and monitoring of planted seedlings; in addition, the integration of all departments of the project is paramount.

The area selection planning begins with the study of secondary data and the identification of the main Permanent Preservation Areas such as springs, riparian forests, and hilltops while observing the type of vegetation present and the possible areas for restoration in each municipal territory. For the selection of areas, a data overlay is performed with information collected from the Rural Environmental Registry (CAR) and the River Basin Committees (CBH), aiming to create an innovative process of unification of efforts and actions in the territories. To this end, Instituto Espinhaço has signed more than a dozen cooperation agreements with municipalities (through the town halls) and universities at local, regional, national and international levels. In order to access the most reliable data from the CAR and also the priority areas and sources for environmental restoration processes, according to the view of the river basin committees, Instituto Espinhaço has created a system to identify and select areas, crossing essential information so as to avoid overlapping efforts and inadequate use of financial resources (Figures 1 and 2).

In possession of these data, the area selection team travels the territory in the company of the previously mobilized rural landowners to continue mobilization and dialog. The purpose is to understand the specific recovery objectives, the land use and occupation history, the possible existence of an economic source generated through the exploitation of the property, the difficulties and facilities of cultivation, the availability of potable and non-potable water, as well as other information that owners may have about their property and region.

The area selection team is also responsible for performing the geoprocessing of the qualitative and quantitative data described in this methodology, such as: soil type, present or absent vegetation, size of the area that will receive the seedlings for restoration, recommended spacing according to the level of regeneration, the estimated amount of seedlings, photographs of the area, among other activities and uses verified in the property, which are paramount sources for the effective process of environmental restoration.

In rural property territory, the team uses a GPS to demarcate the farmhouse geographical coordinates. When traveling to the area to be restored, attention must be paid to the access conditions for the planting team and the restoration process displacement in that particular property. If the planting area can be reached by conventional vehicles, it must be georeferenced through GPS and identified as an access route. If the area cannot be reached like that, it should be identified as a selection topographic profiling. We consider as profiling every displacement carried out by means of alternative transport, such as horses, on foot, motorcycles, tractors, boats, and the like. This information is very important for the planting logistics, which should always be integrated with the selection of areas and the other departments of the project.

Once the team reaches the area to be restored or recovered, they should observe the entire local landscape, taking into account the characteristics of the property visited and also of its neighboring properties. It is also necessary to perform the georeferencing of the area, giving priority to going around its perimeter, making punctual incursions in its interior, to carefully analyze the type of soil found, while taking into account mainly its depth, humidity, stoniness, and shaliness; to check for the presence of rocky outcrops, springs, sinkholes, ants, termites and insects; to check the stage of regeneration of the present vegetation, the existence of erosion and gullies, the presence of high voltage lines, the intensity of natural light, the presence or absence of animals such as buffalo, cattle and equines, as well as other characteristics present in the areas. All these data

should be recorded in photographs, to illustrate the information explained in the Area Selection Report (RESA), which is delivered together with the georeferencing of all areas.

After data compilation, the completion of the RESA and the georeferencing of the area, the spacing suggestion and the number of seedlings estimated for no-tillage is presented. In addition to agroforestry techniques that are applied according to the reality and necessity of each property, we use as basis the quincunx method to estimate the spacing, always taking into consideration the biome to be worked and the physical and biological characteristics of the site, while seeking to act in the dynamics of the water territories.

In possession of the geospatial data, we work with the need to create ecological corridors to form or integrate Conservation Units (UC) mosaics. This action aims to strengthen the environmental restoration actions while integrating it to larger and convergent efforts, which favor ecosystem services.

According to the guidelines of the Ministry of the Environment (MMA), ecological corridors "play an effective role in protecting nature, reducing or preventing the fragmentation of existing forests, through the connection between different modalities of protected areas and other spaces with different land uses" (http://www.mma.gov.br).

Along the lines of this proposal, Instituto Espinhaço aims to unify the planting areas and sensitize the communities on the importance of communication between plant extracts in order to reduce the fragmentation, while maintaining or restoring the connectivity of the landscape and facilitating the genetic flow among the populations. Therefore, the team prioritizes the visit to the rural owners upstream to downstream, to the main supply areas of the Doce, São Francisco, and Jequitinhonha river basins, focusing on the formation and intensification of ecological corridors.

Besides the creation of corridors, we also work with the communication between mosaics so that by planning the landscape we can integrate the conservation units in order to promote the construction of the environmental mosaics

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Figure 1 – Territorial map
Source: Espinhaço Institute Databank.

Figure 2 – Map of selected areas
Source: Espinhaço Institute Databank.

CONCLUDING REMARKS

We emphasize that this methodology of selection of areas can be reapplied in all Brazilian biomes, in processes of restoration of forest landscapes, to promote effective actions of environmental awareness, restoration and recovery of degraded areas through no-till farming of native forest seedlings, in synergy with the development of a geospatial information system and with effective processes of mobilization and social engagement. Furthermore, this set of actions and stages should be organized and articulated among themselves, fulfilling the great advantages of this

project, providing training and support to ecological corridors and mosaics, following the logic of post-CAR, together with the interests of preservation and restoration of the basins covered by the project.

The generation of geospatial information, the methodology used and the connection between actions of social mobilization, selection of areas, seed collection, seedling production, planting, and monitoring, constitutes a differential achieved by Instituto Espinhaço in the restoration of forest landscapes in Brazil.

To this date, more than 1,000 properties have been selected, totaling more than 2,145 hectares of areas for restoration and environmental restoration, with an estimated 1.8 million seedlings. The final result to be achieved in this project will be the planting of 3 million native seedlings with restoration and recovery of approximately 3,000 hectares of the Cerrado and Atlantic Forest biomes in Minas Gerais.

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