

# The Rio dos Sinos watershed: an economic and social space and its interface with environmental status

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(With 2 figures)

## Abstract

The Rio dos Sinos watershed is located in the eastern region of the state of Rio Grande do Sul and includes 32 municipalities. These municipalities develop several different economic activities such as farming and livestock along the 190 km length of the Rio dos Sinos, one of the rivers with the worst quality of water in Brazil. The region is also characterised by growing urbanisation and heavy industrialisation. The main economic activity is the leather and footwear industry. This diversified land use puts the Rio dos Sinos watershed at risk of a wide range of potential environmental impacts. The aim of the present article is to discuss the socioeconomic process currently implemented in the Rio dos Sinos watershed and the effect of these human actions on the environmental quality described throughout this special issue of the Brazilian Journal of Biology.

*Keywords:* Rio dos Sinos watershed, environmental impact, socioeconomic characterization.

## A bacia hidrográfica do Rio dos Sinos: um espaço econômico e social e sua interferência na situação ambiental

### Resumo

A bacia hidrográfica do rio dos Sinos está localizada na região leste do Estado do Rio Grande do Sul e inclui 32 municípios. Esses municípios desenvolvem diferentes atividades econômicas diversas, como a agricultura e a pecuária ao longo dos 190 km de extensão do rio dos Sinos, um dos rios com qualidade de água mais baixa no Brasil. A região também é caracterizada pela crescente urbanização e intensa industrialização. A principal atividade econômica é a indústria do couro e do calçado. Esta ocupação diversificada coloca a bacia do rio dos Sinos em risco de uma vasta gama de potenciais impactos ambientais. O objetivo do presente artigo é discutir o processo socioeconômico implementado atualmente na bacia hidrográfica do rio dos Sinos e os efeitos dessas ações humanas sobre a qualidade ambiental descrita ao longo desta edição especial da Revista Brasileira de Biologia.

*Palavras-chave:* bacia hidrográfica do Rio dos Sinos, impacto ambiental, caracterização socioeconômica.

### 1. Contextualisation of the Rio dos Sinos Watershed

The Rio dos Sinos watershed is located in the eastern region of the state of Rio Grande do Sul and it is part of the Guaíba hydrographic region. The Rio dos Sinos watershed extends over approximately 3,800 km<sup>2</sup>, including 32 municipalities. The Rio dos Sinos is the main river of the watershed and one of the most important rivers in the state of Rio Grande do Sul, being 190-km long. Its source is located in the municipality of Caraá, approximately 900 metres above sea level. The Rio dos Sinos comes to an end when it reaches another river (Jacuíf), 12 metres above sea level.

The Rio dos Sinos watershed is divided into three sections according to the steepness of the ground: the upper section is 25-km long, the river flow is very fast and there

are many waterfalls in this area because the altitude ranges between 600 and 60 m; the middle section stretches over 125 km between 60 and 5 m above sea level with the river flowing without significant irregularities; and the lower section is 50-km long and runs on a quite flat terrain with a very slow flow. From the headwaters to the mouth, the main tributaries with sources located at the upper section of the watershed are: the Rolante, the Rio da Ilha, and the Paranhama; in the lower section, the tributaries include the following streams: Sapiranga, Pampa, Luis Rau, Portão, João Corrêa, Sapucaia, among others.

The Rio dos Sinos watershed used to be inhabited by the Guarani Indians before European colonisation and these native people still have a small reserve in the upper section

of the watershed. The systematic population settlement started in the 19<sup>th</sup> century, when farmers who immigrated from Germany settled in the region receiving support from the Portuguese Colonial Empire. This population was distributed in small allotments and started to grow food. As a consequence, within a short period of time, they created small trading centres and used the rivers for transportation. The intense trading relationships with Porto Alegre established by means of river transportation stimulated the economy of the Rio dos Sinos watershed. The region also developed as a result of the installation of a factory of leather products that manufactured harness and shoes. This plant was located in the area between the municipalities of São Leopoldo and Novo Hamburgo. This was the first factory of the so-called “footwear industrial hub”, which, since the 1960s, has been the main footwear exporting centre in the country. Such industrial development has brought many resources to the Vale do Rio dos Sinos region, attracting a huge amount of migrants who were expelled from the countryside by the agricultural revolution, leading to a fast and unplanned growth of urban areas and negatively affecting the watershed. A long period of governmental subsidies to industrialisation was also important to build a business community able to invest and expand its activity in the footwear industry.

The results of the settlement and colonisation methods used in the Rio dos Sinos watershed are expressed by its population density, which has increased significantly in recent decades. Currently, the population of the watershed amounts to approximately 1.2 million inhabitants, with a density of around 300 inhabitants per square kilometre. According to the 2008 data provided by the Brazilian Institute of Geography and Statistics (IBGE), 5.98% of the population live in rural areas and 94.02% live in urban areas. This population represents approximately 12% of the inhabitants of the state of Rio Grande do Sul and is concentrated in only 1.5% of the area of the state; therefore, the population density of the watershed is ten times higher than that of Rio Grande do Sul. The urban areas with higher population density (Novo Hamburgo, Canoas, São Leopoldo, Sapucaia do Sul, and Esteio) are located in the lower section of the watershed.

The economic activities are related to the relief of the watershed: in general, from the headwaters to mid-altitude regions, the agribusiness predominates along the deforested areas in the banks and sources of the water courses, where only a few patches of native forest still survive. The low-altitude regions are more urbanized and have more industries. However, in the lower section of the watershed, there are some wetlands that are home to an important biodiversity in terms of flora and fauna in the marshy areas of the Rio dos Sinos.

The productive activities of the region are distributed among several industries as follows: lumber and furniture, tourism, lodging and shopping in the upper and middle section (Gramado, Canela, and San Francisco de Paula); leather and footwear industry in the middle and lower sections (Igrejinha, Parobé, Sapiranga, Campo Bom, Estancia

Velha, and New Hamburgo); and the industrial sector, which comprises the metal mechanical, food, and petrochemical industries in the lower section (São Leopoldo, Sapucaia do Sul, Esteio, and Canoas). It is important to highlight that the lower section of the Rio dos Sinos watershed is exposed to the strongest anthropogenic pressure and has the largest industrial base in the state.

Historically, the lower section of the Rio dos Sinos watershed is highly important for the economy and labour market of Rio Grande do Sul. In terms of the economy, this region, which is represented by the Regional Development Council (COREDE), was responsible for 15.7% of the gross domestic product (GDP) of Rio Grande do Sul in 2005, standing out because of its significant participation in industrial activities, which accounted for 39.5% of the GDP of Rio Grande do Sul during that period. With regard to the labour market, the Vale do Rio dos Sinos region concentrated 36.2% of the economically active population (EAP) in the metropolitan region of Porto Alegre (RMPA) in 2006 and one third of the total state population in that year.

The settlement model of the Rio dos Sinos watershed, based on unplanned methods and aggressive technologies in terms of water and land use, has led to increasing contamination of its water resources and degradation of the native flora and fauna. The watershed supplies water for approximately 1.2 million inhabitants. The industry activity and agribusiness, mainly that devoted to rice cultivation, have used the watershed as a source of water supply, and civil construction has removed sand from the bed of its rivers to expand the cities.

The rivers of the watershed receive the waste produced by the population and the household liquid waste from urban and rural areas, as well as industrial effluents and leachate from poorly-implemented waste dumps or landfills. In addition, the environmental risks to health include lack of access to drinking water, poor basic sanitation, food contamination with pathogenic organisms, air pollution, and proliferation of disease vectors.

Therefore, the main environmental impacts within the Rio dos Sinos watershed are related to water overuse, pollution of soil, air and water resources caused by the use of pesticides and fertilisers, with consequent infiltration of animal slurry into water sources, elimination and/or reduction of the native fauna and flora, with the latter covering less than 10% of the original area because of deforestation for cultivation and pastures, contamination of farmers as a consequence of improper use of pesticides, contamination of the urban population caused by gas and liquid waste emissions from industries, and heavy traffic in the cities.

The problem of water scarcity is combined with the problem of poor water quality. According to the legal standards (CONAMA Resolution 357/05 - National Environment Council), the Rio dos Sinos and its tributaries have better conditions of dissolved oxygen in the less industrialised and less populated section of the watershed, which stretches out from the source (municipality of Caraá)

to the town of Santa Cristina. Another piece of information provided by COMUSA (Municipal Sanitation Company of Novo Hamburgo) helps to understand the situation of the river: the concentrations of fecal waste start to increase near Arroyo Pampa, where there is more industrialisation and urbanisation. A remarkable change is observed in the Rio dos Sinos from its source (Figure 1) to the municipality of Novo Hamburgo, where the problem of pollution of streams caused by the presence of cities gets worse.

Lack of industrial waste treatment (private), lack of household waste treatment (public administration), and the irresponsibility of the civil society (public-civil) is a combination that causes poor water quality in the Rio dos Sinos. The consequences of this environmental aggression, for which the watershed serves as a catalyst, were confirmed with the death of more than 90 tons of fish in the Rio dos Sinos in 2006 (Figure 2). This event tragically showed the neglect in relation to this vital source provided by water resources. In short, all these facts have negative impacts on the environment and pose risks to human health, reducing the quality of life of the population living in the Rio dos Sinos watershed.



**Figure 1.** Rio dos Sinos source, next to the municipality of Carará.



**Figure 2.** Rio dos Sinos disaster, in 2006 (picture taken by the biologist Jackson Muller).

## 2. The Socioeconomic Impacts and Detection of Risks for the Rio dos Sinos Watershed

In several studies on environmental issues, Somlyódy and Varis (2006) reported that the water has been a common topic of concern in the development strategies of States and Nations in recent decades. Its social and economic importance, multiplicity of uses, and the fact that it is a vital and irreplaceable resource for survival call the world's attention to water.

Therefore, it is necessary to design active public policies to address the main problems of the region. According to Beck (1997), a new way of doing politics is emerging in this context, an autonomous politics of subsistence based on a synergy between economic, social, and environmental goals.<sup>1</sup> However, the most important problem is that the population living in the Rio dos Sinos watershed believes in and/or needs industrial development as the only way of visualising progress. Also, the acceptance of potentially hazardous industries is seen as a social and cultural product that is part of the stigma built throughout the history of a large portion of the Rio dos Sinos watershed, and mainly in the Vale do Rio dos Sinos region, whose economy depends on the leather and footwear industry.

Goffman (1993) helps us to understand this situation by stating that society provides the means to characterise people and the additional attributes that are perceived as natural and common in the members of each category. It defines the categories to which people should belong, i.e., society determines an external standard for individuals, and such a predefined standard makes it possible to predict the individuals' category, social identity, and relation to the environment. A social model of individuals is created and during their life experiences this image may not show the reality, but it may represent what Goffman calls a *virtual social identity*.

Considering this bias, the topic of perception of environmental risks and the analysis of "culture and politics" is crucial so that societies can define the future. Douglas (1996) points out that awareness of dangers and eligibility of people in face of dangers are directly related to the ideals of morality and justice, and this suggests an institutional crisis of industrial society (Beck, 1998).

To understand this crisis, it is necessary to describe social relations and environmental risks. Thus, it is evident that the community of the Rio dos Sinos watershed classifies risks according to its relative convenience, i.e., people prioritise industrial development as a basic and immediate need. Therefore, the population ignores the dangers because they are part of its daily routine and are accepted as part of normality. A good example of this phenomenon is the tanning industry (the first industry to be installed in the Vale do Rio dos Sinos region): when people started to arrive (the process of migration from the countryside to the city) to live in municipalities of the

<sup>1</sup> According to Giddens (1996) this is the way that will lead us to think of and look for alternatives different from the left or the right wing: a Third Way.

valley, they felt sick because of the smell produced by the tanneries; however, as time went by, they started to take it as something normal that was part of their lives. Douglas (1992) calls this a process of *unconscious incorporation* that takes place during the individuals' socialisation. That is, there are social groups that encourage and codify the risks; Goffman (2006), Giddens (2000) and Douglas (1996) called this social interaction.

According to Douglas and Wildavsky (1982), shared values lead to shared fears, thus there is an implicit agreement about what not to fear. Therefore, the Rio dos Sinos watershed is compatible with what to fear (what is feared) or with the preference of the risk that determines the social and cultural development of this region. Furthermore, people are determining their values and behaviours based on individuality, which is favourable for the market and will guide their private life mainly towards profit achievement. This explains the lack of concern with environmental issues, since the current basic priority of the region can be defined by and divided in profit, for some, and employment opportunities, for others.

To further clarify this issue, consider that to think about environmental *risk acceptability*<sup>2</sup> means to relate to the quality of life and the principle of morality of a given society, i.e., its values, institutions, and culture. Hence, in face of truths imposed by politics and internationalisation of the economy, civil society is concerned with immediate problems (starvation, violence, unemployment, etc.) and it relies on development and "safety" currently represented by industrial society. This has an impact on most municipalities that make up the Rio dos Sinos watershed: the industries are supported by the population; on the other hand, the government is blamed for all problems, even if sometimes such problems are ambiguous. For instance: in the economic scope, governments are made accountable for the fact that companies do not invest in and do not improve their facilities; on the other hand, the environmental problems of the region are attributed to lack of governmental control, thus minimising the companies' commitment to environmental preservation and civil society's responsibility for this issue.

In short, for all the problems observed in the Rio dos Sinos watershed, it is clear that employment opportunities are the basic need of this society and environmental risks are a profitable business. What really matters is that everyone is satisfied: those who exploit the environment using rural or urban methods are not punished because they offer job opportunities, covering the basic needs of a large portion of the population.

It is clear that there is a need to assess the environmental problems of the watershed in order to analyse the shortage and diversification of jobs, mainly highlighting the centralisation of the leather and footwear industry. A socioeconomic analysis is crucial to realise that the private capital in the Rio dos Sinos watershed is using a public asset (the environment), maximising profits and benefits as much as possible, and

<sup>2</sup> In "Risk Acceptability according to the Social Sciences" by Mary Douglas (1985).

socialising environmental losses. In order to describe any scenario, it is crucial to perceive the indifference of a society that centralises and monopolises the rural and urban market in some sectors, considering the unplanned development without any social and environmental responsibilities the only way to progress.

The leather and footwear industry of the Vale do Rio dos Sinos makes up a cluster of national and international relevance. It includes 7,830 companies, a production of 808 million pairs of shoes and 302,892 direct jobs, translating into 4.3% of total persons employed in the manufacturing industry in the country. Within the national context, Rio Grande do Sul is responsible for 37% of direct jobs according to official numbers provided by the State Department of Planning.

The companies installed in the Rio dos Sinos watershed have different levels of development. Because each company has its own unique characteristics (size, market, financial resources, etc.) and each one sets the level of environmental influence in its guidelines, Pereira (1997), Santos and Porto (2008) defined the following stages to classify the companies' attitude: Stage 1 (Beginners), Stage 2 (Fire Fighters), Stage 3 (Aware) and Stage 4 (Pragmatists). The identification of patterns of stages or approaches shows that the companies usually achieve maturity in terms of "environmental issues" when they have a systemic view and deal with the operations in a systemic manner, which, in general, is not observed in the watershed. Cultri (2005) suggested that in order to achieve the efficiency of a systemic operation in an industry that seeks to expand its commitment to preservation and sustainable growth, it is important to engage all stakeholders in its economic and social development, emphasising that the systemic approach puts in the spotlight the actors and elements directly or indirectly related to the company and who are committed to environmental preservation. The strict behaviour in each stage seems to make the company to move according to progressive steps. The description of change in progressive stages is necessary, but it actually happens in movements that gradually intertwine, influence and interfere. In general, companies that are part of the cluster are very concerned about developing technologies focused on products; however, they lack maturity because they do not view themselves in a systemic way. In addition to increasing costs, this lack of vision significantly contributes to generate waste.

The variety of materials such as leather, chemicals, galvanised parts, foam, soles, insoles, laminate, counter, fabric, paper and cardboard, thread, fabric impregnated with toxic products, cans of glue, etc. used to manufacture the end product is a reason for concern in terms of environmental preservation. All raw materials and inputs used in the manufacturing process generate some waste. The amount and volume of such waste vary from one company to another, and a large portion of it is considered to be dangerous.

In the history of the leather industry, even with the emergence of new technologies related to equipment, processes, and chemical inputs, significant changes in

the process of waste generation and recycling have not been observed, making this industry responsible for the largest generation of hazardous solid waste in the state of Rio Grande do Sul according to the reports made public available by the regulatory agencies (report on the generation of industrial solid waste in the state of Rio Grande do Sul. MMA. FEPAM. May 2003). For Donaire (1995), when companies become aware of the fact that instead of creating only more expenses, environmental issues can be an opportunity to reduce costs, the importance of environmental issues reaches levels hitherto unimaginable. This can be possible through the sale of waste, reuse, development of recycling opportunities, discovery of new components and raw materials that are transformed into more reliable and cleaner products.

In the Rio dos Sinos watershed there are excellent waste storage centres; however, it is still very common to find leather residues along the highways. It is the simplest method of waste disposal without any treatment and criteria. Solid waste of all kinds, with all degrees of danger and contamination potential, are discarded in the outdoors, in vacant lots, or on the outskirts of cities. The harm caused to the physical environment (geology, soil, groundwater, geomorphology, and climate) is huge.

### 3. Solid Waste, Wastewater and Environmental Impact in the Rio dos Sinos Watershed

In general, the great concern over solid waste is to avoid that the production of lixivia and leachate and waste physical deterioration contaminate the soil and water of aquifers and groundwater, as well as the air, eventually affecting people. Few municipal governments treat leachate and even fewer comply with disposal guidelines. Direct disposal of untreated leachate into the streams of the Rio dos Sinos watershed is very common.

Soil pollution is the most direct form of contamination because it changes its physical, chemical and biological characteristics, stimulating the development and production of bacteria, viruses, and a rich microbiological environment. Air pollution is caused by uncontrolled waste disposal and inappropriate burning, which generate gases and odours.

Water contamination is another reason for concern in the Rio dos Sinos watershed. Considering the fact that an average of 0.9 m<sup>3</sup> of water per tanned leather piece is used, it is possible to assume that, considering only the tanning industry, 38.79 million m<sup>3</sup> of water, i.e., almost 39 billion litres are consumed every year in the country. If these 39 billion litres of water were divided by the number of Brazilian inhabitants (according to the IBGE, the country has approximately 180 million inhabitants), it would amount to 217 litres per person per year. Comparing this number with the small amount of 20 litres per person/day recommended by the World Health Organization (totalling 7,300 litres/person/year), we found that only the consumption of the tanning industry in Brazil represents about 3.0% of the minimum amount of water suggested

for the basic human needs. That being said, it is possible to understand the true scale of water consumption by the tanning industry in general and the consequent generation of wastewater with high pollution potential. The companies of the cluster located in the Rio dos Sinos watershed produce wastewater with high pollution load and high organic pollution load. In addition, because of the intensive use of chemicals in their processes, they also generate a very significant inorganic load characterised mainly by the presence of chrome, sulfides, and organic pigments, cyanide and inorganic chemicals used in the dyes.

In recent years, with the consolidation of legislation and regulatory control,<sup>3</sup> companies have begun to treat the water used in their manufacturing process. In general, in the watershed, the treatment basically consists of two stages: primary or physical-chemical treatment and secondary or biological treatment. During primary treatment there is great reduction in the wastewater toxicity, allowing for the secondary treatment to promote the development of microorganisms that break down the remaining organic matter. It is also worth mentioning that the wastewater treatment plants are old and their size is determined based on end-of-pipe technologies. There is lack of technical staff in the companies specialising in effluent treatment. Some companies have environmental consultants who merely send reports to the environmental agencies. Therefore, the conventional treatment used by most companies, even those that comply with the guidelines for wastewater discharge, is not sufficient to restore the initial characteristics of the water used in the manufacturing process and, thus, in addition to discouraging its reuse by the company, the treatment also contributes to the waste and degradation of a natural resource that is no longer so abundant. This is made evident by the high level of contamination of the receiving bodies in the region. It is also important to highlight that, from the economic point of view, the possibility of reusing the water used in the manufacturing process will become an important factor for industrial sustainability and competitiveness in the near future.

### 4. Environmental Impacts and Human Health in the Context of the Rio dos Sinos Watershed

The 21<sup>st</sup> century started focused on broad economic development in the developing countries. In Brazil and in the area of the Rio dos Sinos watershed, such development is undoubtedly associated with an intense process of urbanisation, increased industrial activity, wrongly planned changes in terms of land use and consequent environmental problems, affecting the quality of water, air, and soil. Besides the direct and local effects of human action, this region might be affected in the next few years by global climate changes that are already taking place. The processes

<sup>3</sup> Ministry of Environment, National Council of Environment – CONAMA. Resolution no. 20 of March 17, 1986. RIO GRANDE DO SUL. Technical Norm-SSMA no. 01/89. Official Gazette of Rio Grande do Sul, March 29, 1989. Pertaining to the criteria for wastewater emission.

of increased urbanisation and expansion of economic activities, which are leading to the creation of a larger metropolis stretching out from Porto Alegre to the mid-size municipalities of the Rio dos Sinos watershed, cause the side effect of a series of environmental impacts: there is an increased generation of sewers within this geographic scope, higher emission of pollutants in the air, strong impact of rainfall (great intensification), causing floods and surface runoff of pollutants from cities to rivers, recirculation, and concentration of priority pollutants in the water and soil. These impacts not only damage the environment per se and require better monitoring and ecological, geophysical and geographical intervention, but also present new challenges to the sciences related to the diagnosis of diseases.

Both local and global changes in the environmental system will eventually produce a new epidemiological picture for human populations, particularly in rapidly expanding metropolitan areas, such as the Rio dos Sinos watershed. The following findings are currently evident and clear predictions for the geographical environment analysed: relative decrease in the quality and availability of water for the next decades, evident changes in the quality of air caused by deficits in the treatment of industrial gases and a transportation system greatly based on the use of motor vehicles, and unplanned soil use, which exposes the population to intense contact with environmental contaminants. In the context of the Rio dos Sinos watershed, there is lack of current and future training of individuals able to diagnose and intervene in the human health problems closely related to the impacts described above.

The impairment of the quality of water and the possible shortage of water described in the catchment sources of the Rio dos Sinos watershed, despite some initiatives related to wastewater and sewage treatment using very outdated technology, are and will be even more intense in the future. According to preliminary data on the watershed, there will be a significant spread of microorganisms responsible for causing waterborne diseases, especially fecal-orally transmitted viruses and bacteria causing diarrhea and hepatitis. Also on the topic of water quality, the presence of environmental toxicants may be associated with induction of cytological, biochemical and genotoxic changes in the individuals exposed. There are also preliminary data about this.

The quality of the air, mainly when there is presence of toxicants and particles, may have a strong influence on the cause or aggravation of acute and chronic respiratory diseases. There is a set of preliminary data about this suggesting a serious situation in the municipalities of the region. Non-compliance with occupational safety, mainly in industrial plants, and inadequate disposal of solid waste containing classic environmental dangerous chemicals like lead and other emergent toxicants such as those related to electronic waste associated with a poor or even inexistent planning of land use are also potential causes of damage to human health in the Rio dos Sinos watershed.

In conclusion, based on the analysis of this watershed, it is evident that science alone is not sufficient to reverse the effects produced by industrialisation. It is necessary to develop joint strategies based on the social reality and responsibility of the governments and the civil society (public and private). The issue of risk distribution is far from replacing the problem of wealth distribution; therefore, the efforts made by “expert systems” to broaden the scientific and technological knowledge should be one of the priorities in the Rio dos Sinos watershed. Thus, due to the relevance of the *Brazilian Journal of Biology*, the decision of publishing this special issue is quite reasonable and legitimate. This issue will portray the environmental problem and present results and initiatives. This will culminate with a significantly enhanced perception of the environmental risk in this region, at the macro and micro level, based on the scientific character of this journal.

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