

Évaluation des pressions sur une rivière anthropisée, le cas de la Sorgue

Assessing pressures on an anthropized river: the case of the Sorgue

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RÉSUMÉ

La pollution des ressources en eau et sa raréfaction sont devenues un enjeu majeur au cours des vingt dernières années, posant à la fois un problème de santé publique et d'altération des écosystèmes (*IFPEN | Gestion du cycle de l'eau et changement climatique*, 2024). L'eau, est une précieuse ressource reliant les écosystèmes (biotopes et biocénoses) et les socio systèmes (humains), et elle est nécessaire à tous au regard de fonctions et services écosystémiques : vie biologique, alimentation, hydratation, cultures agricoles, lieux de détente, loisirs, zones de rafraîchissement...). Face aux enjeux climatiques et à la nécessité de préserver cette ressource, il semble important d'identifier, de quantifier et de suivre les différentes pressions qu'elle subit, notamment les rivières, en interaction avec leur environnement proche. C'est le cas de la rivière de la Sorgue, qui va être étudiée selon différents aspects que sont l'hydrologie, l'éco toxicologie, la géographie-sociale et le droit de l'eau, afin de les mettre en relation et d'identifier les leviers importants pouvant changer son exploitation et favoriser sa protection en passant par l'élaboration d'une problématique interdisciplinaire dans le cadre de ce cluster.

ABSTRACT

Water pollution and scarcity have become a major issue over the last twenty years, posing both a public health problem and a threat to ecosystems (*IFPEN | Gestion du cycle de l'eau et changement climatique*, 2024). Water is a precious resource linking ecosystems (biotopes and biocenoses) and socio-systems (humans), and it is necessary for everyone in terms of ecosystem functions and services: biological life, food, hydration, agricultural crops, places for relaxation, leisure, cooling zones...). Faced with the challenges of climate change and the need to preserve this resource, it seems important to identify, quantify and monitor the various pressures it is subject to, particularly in rivers, in interaction with their immediate environment. This is the case for the Sorgue river, which will be studied from different angles - hydrology, eco-toxicology, social geography and water law - in order to link them up and identify the key levers that can change its use and encourage its protection, by developing an interdisciplinary problem within the framework of this cluster.

KEYWORDS

Droit, Eco-toxicologie, Hydrologie, Social, Sorgue

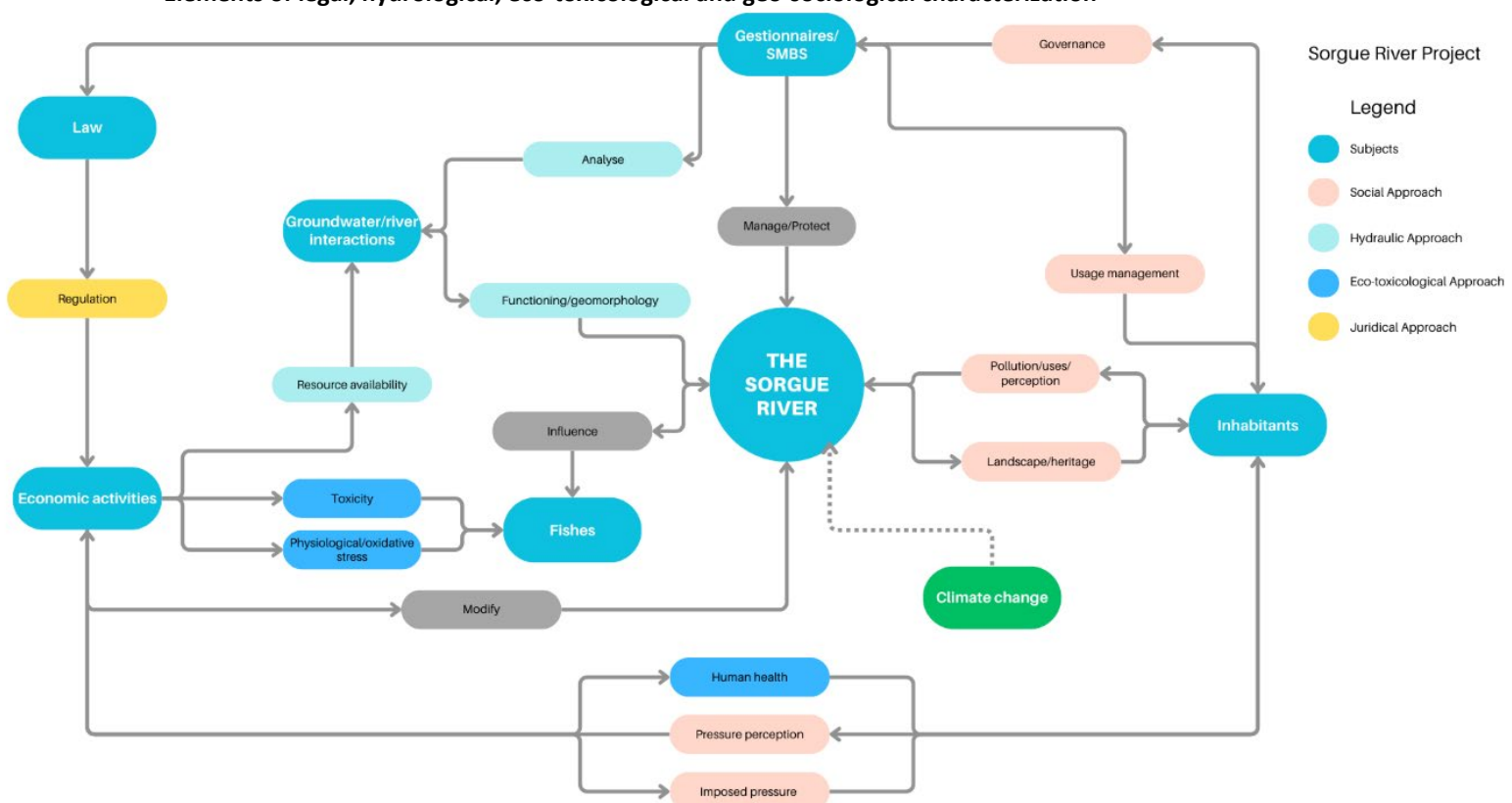
Ecotoxicology, Hydrology, Law, Social, Sorgue

Climate change is profoundly altering hydrological cycles, with significant consequences for river basins. According to the (IPCC — Intergovernmental Panel on Climate Change, 2024) , global temperatures could rise by up to 4°C by 2100, intensifying precipitation fluctuations and increasing the risks of both water scarcity and excess (Aslam et al., 2024; Chai et al., 2024). These effects, compounded by population growth and human pressures, are exacerbating stresses on water resources already strained by urbanization and ecosystem degradation. Studies highlight that “freshwater withdrawals have far outpaced global population growth,” further heightening water stress (Chai et al., 2024). Urbanization, ecosystem decline, and natural disasters amplify these vulnerabilities, compromising hydrological stability (Aslam et al., 2024). On a legal front, the European Union’s 2000 Water Framework Directive establishes a framework for the management and protection of water resources at the river basin level, setting an ambitious goal of achieving “good status” for water bodies by 2015, extendable to 2027 as a final deadline. However, the latest report from France to the European Commission reveals that 67% of surface water bodies are at risk of failing to meet environmental objectives by 2027. This widespread degradation of ecosystems also undermines water quality, impacting fish populations through pollution bioaccumulation and threatening aquatic flora and fauna more broadly. Furthermore, it leads to a decline in ecological functions and the ecosystem services they provide, with far-reaching implications for both biodiversity and human well-being.

To protect this fragile ecosystem while addressing human needs, an interdisciplinary internship project has been launched, involving hydrology, ecology, law, and social geography. The aim is to assess the impacts of various uses, identify legal levers, and guide the decisions of the Sorgues Basin Mixed Union (SMBS) to balance river exploitation with preservation.

2 GENERAL PROBLEMATIC

« To what extent do uses have an impact on the natural environment of the Sorgue valley? »
Elements of legal, hydrological, eco-toxicological and geo-sociological characterization



The approach used to link these different aspects involves the development of individual topics, which are pooled and studied together from their inception as well as during their evolution, in order to create an adaptive method in response to the results of each discipline. The diagram below gives an overall view of the cluster, showing how the individual topics are linked together, and how the results can be used to achieve a common goal.

3 CLUSTER INTERSHIPS

3.1 Hydrological aspect

Supervised by Frédéric Paran – Mines Saint-Etienne – UMR 5600 EVS

The hydrology internship is divided into several parts guided by the following question: **“How can we characterize (or even quantify) groundwater-surface water relationships (and even wetlands) in the alluvial environment of the Sorgues plain, taking into account the complexity of this hydro system? And how can we monitor these relationships over time? And how can these relationships be monitored over time?”**

Through this study, the “Syndicat Mixte du Bassin des Sorgues” hopes to obtain the answer to the problem indicated. The results could contribute to the development of a decision-making tool adapted to the study of these interactions and the quantification of water flows in space and time.

Water flow relationships in this hydrosystem will be interpreted from the perspective of characterizing interactions between groundwater and surface water. Such characterization could, for example, highlight the influence of these flows on the quality and physico-chemical characteristics of the water, and thus provide a better understanding of the relationships between water pollution and exchanges with the water table. Maintaining good water quality is of vital importance for fish habitats (see ecotoxicology course). In order to carry out this project, the field will be approached from two angles of observation: large scale (linear sections of course extended to the Sorgues watershed), and reduced scale (river sections). These will be linked to obtain a fine temporal vision over an extended period.

The first line of work will be to carry out an initial characterization of the terrain, based on bibliographical elements interacting with the 3 other approaches (ecotoxicology, social geography, legal), in order to understand possible groundwater/river exchanges and their location, with the aim of selecting relevant study sections. In addition, a field reconnaissance campaign will be carried out to refine this initial diagnosis. As hydrological dynamics are of prime importance, the topography of the watercourse will be identified.

The second focus will be on characterizing interactions between groundwater and surface water, i.e. identifying the direction of water flow (groundwater to river or river to groundwater), and quantifying this flow. Ultimately, the aim is to gain a better understanding of the issues linked to the use of neighboring farmland, or the impact of water abstraction and land treatment on groundwater preservation (Lalot, 2014). To this end, geomatic analyses of water levels (underground and surface) will be carried out. These analyses require measurements of clogging (hydraulic conductivity of the bed bottom), piezometry and water level in the river. A better understanding of these exchanges could be used to set up an indicator to make the link with the ecotoxicology project and fish habitats.

3.2 Geo-sociological aspect

Supervised by Anne Honegger - ENS Lyon - UMR 5600 EVS

In the context of this project, social geography aims to explore three main axes that integrate environmental, social, and participatory issues surrounding the sustainable management of the Sorgues. These axes will help address the following question: **“What are the main pressures affecting the Sorgues, and how are they perceived by the residents? To what extent does citizen participation contribute to fostering a collaborative and sustainable management of the river in a context marked by climate change?”**

The first axis focuses on analyzing these pressures. This involves studying the uses and dynamics of the stakeholders involved to better understand the socio-economic and environmental challenges facing the Sorgues

basin. Historically, rivers were often considered through the lens of the hydrological cycle, which tended to isolate them from human influence. However, recent research, particularly on the concept of the hydrosocial cycle, challenges this perspective. It demonstrates that rivers are co-constructed entities where water flows are closely tied to infrastructure, cultural practices, and power relations (Linton & Budds, 2014). A diachronic analysis of land use will be conducted to map the evolution of these pressures. A typology of stakeholders will also be developed to understand the logic connecting them and the issues they carry. This contextual analysis is essential for selecting measurement stations for hydrology and ecotoxicology internships.

The second axis examines residents' perceptions of the ecological quality and health of the river's ecosystems. Considering these perceptions is crucial for enriching the understanding of ecosystem status, improving their condition, and enhancing their management. These perceptions will be studied through qualitative and quantitative surveys. The project will specifically cross-reference these perceptions with ecological indicators, such as the health of fish populations or groundwater/river exchanges, to better understand the links between water quality and residents' perceptions.

The third axis highlights citizen participation as a driver of engagement and social transformation. Reconnecting residents with their river is a central objective, exemplified by the project "Aux Sorgues, citoyens!" led by the Sorgues Basin Mixed Union (SMBS). This initiative aims to create a dialogue platform to raise public awareness, promote behavioral changes, and integrate citizens into decision-making processes. Particular attention will be given to Phase 2b of the project, which includes idea debates and initiatives such as Forum Theater. This objective also serves as a contextual framework to identify potential levers, in connection with the law internship, to mitigate the pressures on the river identified by the hydrology and ecotoxicology internships.

3.3 Eco-toxicological aspect

Supervised by Raphaël Santos - IAPHY-ENTPE - UMR 5023 LEHNA

As part of the study project on the Sorgues watershed, the ecotoxicological approach aims to address the following question: **"How can the ecotoxicological state of the Sorgues be assessed using common fish species as bioindicators while developing innovative and effective biomarkers applicable to fish models present on a national scale?"**

The objective is to better understand the impacts of pollutants on the aquatic ecosystems of the Sorgues watershed by relying on reliable biological indicators. This approach is aligned with the preservation of fish habitats and is interconnected with the other aspects of the project (hydrology, social geography, and legal studies).

The first axis involves conducting a preliminary site study by combining bibliographic data with insights from the three other disciplines. This analysis will help locate fish-rich areas to determine sampling sites. These sites must capture the ecotoxicological context of the watershed, highlighting the pressures exerted by pollutants on the ecosystem and human health.

The second axis will focus on interpreting the ecotoxicology results. After sampling and analyzing the collected data, an initial assessment will be conducted, considering statistical requirements to compile a list of pollutants present in the river and their consequences on the environment. These results will need to be contextualized within the watershed to identify potential sources of these pollutants. This axis will connect, on the one hand, with the pressures and uses identified through the project's socio-geographical approach and, on the other hand, with the hydrological aspect to understand how hydrological functions influence the presence of pollutants in the river.

Finally, the last part of this work will evaluate the relevance of the biomarkers used in the analysis and the species selected. If results for the chub and trout prove to be similar, conducting ecotoxicological studies on chub could allow for more generalized results due to its wide distribution in French waters (Santos et al., 2016).

4 CONCLUSION

So, in order to respond to the urgency of these global challenges locally present on the Sorgue, this cluster internship will enable us to assess the impact of uses, identify legal levers and guide the decisions of the Sorgue Basin Joint Syndicate in reconciling river use and preservation, by linking these different aspects in a transdisciplinary approach. In order to link our internships, two interdisciplinary supports will be produced to represent the nature and evolution of the joint work: a localized map of the pressures exerted on soils and fish, as well as groundwater-river exchanges and fish-related issues. This map will also include the distribution of

different land uses by populations, so that these aspects can be linked. To complete the picture, a table of uses will be drawn up, in order to better anticipate the combination of uses/pressures on the basin, associated with external constraints (climate change...) and local perceptions. In the long term, this cluster will enable us to better estimate the pressures of the various uses and their impacts, and to identify the appropriate legal levers for reconciling uses and preservation of the environment.

5 ACKNOWLEDGEMENTS

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