

HEALTH RISK ASSESSMENT AND PERCEPTION OF RISK BY END-USERS OF REUSED WATER: A CASE STUDY FROM TOULOUSE

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CONTEXT

Toulouse-Ginestous-Garonne wastewater treatment plant, with a total capacity of 950,000 population equivalent, is equipped with a 60 m³/h membrane and disinfection treatment unit. This tertiary treatment enables to use the treated wastewater for the irrigation of the green areas of the plant and of a golf course located nearby. An opportunity study conducted in 2021-2022 highlighted a possible extension of wastewater reuse to about twenty potential projects within a radius of 3 km around the plant. Among these projects, those with the greatest technical and economic feasibility were selected. They include the irrigation of young plants by the municipality, the hydro-cleaning of the sewerage network, the supply of the toilets and the irrigation of sport fields of a large stadium, and the washing of metro trains. These new applications require prior studies to assess the specific health risks related with these uses and identify the ways to control them.

For this purpose, qualitative and quantitative risk assessment approaches were applied. The originality of this project was to combine this assessment of health risks with a sociological approach to take into account the perception of risks by future users.

Taking into account the expectations of users of recycled wastewater in the risk control measures allows both to prevent the barriers to this use and to ensure the proper application of preventive measures during use.

METHODS

For the risk assessment, two complementary approaches were applied:

- 1) A qualitative assessment of health risks according to ISO 20426 (2018). This approach, based on the HACCP principles, makes it possible to identify possible modes of exposure to the hazards potentially carried by the recycled wastewater, and to identify prevention means.
- 2) A quantitative microbial risk assessment, as recommended by the WHO for the re-use of wastewater for drinking water (WHO, 2017). This approach makes it possible, on the basis of an objective of maximum tolerable concentration of pathogenic microorganisms in the water, to verify the reduction capacity of the treatment, to identify the critical steps of the treatment, and to set alert thresholds and critical limits on the critical sensors and analysers present in the system.

For the sociological approach, we first identified the key players in the project, then exchanged with them individually by phone and finally met them during a workshop. This workshop was led by a group with interdisciplinary skills: an environmental engineer specialized in the regulatory and technical aspects of water

reuse, a medical doctor, a sociologist, and the Project Manager from Toulouse Métropole. An educational material had been prepared to present i) the functioning of the water cycle, ii) the positioning of wastewater reuse within this cycle, iii) a comparison on the main parameters, between the drinking water distributed in Toulouse Métropole, the reused water from Ginestous and the water from the Garonne Lateral Canal (currently used for watering the sport fields of the stadium), iv) the "service station" provided for in the project where gardeners and other professionals (hydro cleaners) will be able to come and fill their tanks, v) the results of the above-mentioned health risk studies.

RESULTS

Qualitative risk assessment

The HACCP approach applied to the Ginestous treatment process enabled a detailed analysis of possible water pollution accidents and possible failures of each of the treatment steps, as well as the identification of control measures to prevent these failures. This analysis did not reveal any gaps in the process control means, each identified hazard having at least one associated control measure.

The hazards related with the future uses of the recycled water, as well as the associated means of prevention, were defined by a group of experts in the fields of health, occupational medicine, and water treatment. The relevance of the prevention and control measures resulting from this analysis, and the possible difficulties of application, were verified during the interviews conducted with the future users. No major risk situation was identified. The control measures already in place or envisaged make it possible a priori to ensure the safety of future users and the environment, without additional constraints for these persons, compared to their current practices.

Quantitative Microbiological Risk Assessment (QMRA) and HACCP Plan

The application of QRMA in the field of water has been codified by the WHO (2016), in order to make it easy to use for operators. According to this simplified approach, it is broken down into three steps:

- 1) A characterization of the concentrations of pathogens in the raw water,
- 2) An estimate of the reduction of these pathogens by the treatment,
- 3) A comparison of the reduction by the treatment in place to the reduction that would be necessary to meet an acceptable level of risk for the end-user.

On this basis, a HACCP plan was developed, defining the critical points of the treatment as well as the sensors and physico-chemical parameters to monitor their proper functioning. For each parameter, two types of limits were defined:

- 1) An operational limit, corresponding to a threshold for triggering an alarm for maintenance intervention,
- 2) A critical limit, beyond which water must be considered as potentially outside the expected health criteria. Reaching this limit results in the shutdown of the tertiary treatment line.

Understanding and involvement of users prior to implementation

The interviews conducted with the stakeholders and especially the workshop held with the team of gardeners (and their managers) of Toulouse Municipality made it possible to collect information on the current practices and uses of these professionals, on their relationship to water resources in the territory and their knowledge on this subject and finally on their perceptions of the project and its ambitions. Their perception of risks and their relationship to the precautionary principle were questioned and compared with the results of the qualitative risk analysis carried out.

The gardeners present an increasing sensitivity to the water resource, a "raw material" that is essential to their professional activity. Those with the longest seniority in the team note significant changes that they associate with more frequent and intense periods of drought. For example, they mention changes in the plants planted (much fewer annuals and more perennials for the beds, tree species from Lebanon, Syria or the Maghreb), excess

mortality of trees, even aged 10-15 years, the systematic use of ground covers to limit soil dryness or changes in the organisation of work (working hours) linked to the restrictions in force during the drought decrees.

These new practices have led to a 60% reduction in the consumption of drinking water used to irrigate municipal green spaces in 7 years, even though the number of trees planted is increasing, following the proven effectiveness of green lungs in the fight against urban heat islands (project conducted in the framework of Toulouse Métropole's "100,000 trees" plan, of which 50,000 have already been planted).

Having the possibility of replacing this drinking water with "recycled" water was very positively received by the professionals interviewed, particularly to cope with the periods of restrictions imposed by the drought decrees. Indeed, on the one hand, these restrictions disrupt the organization of work in a period of summer understaffing and on the other hand, they lead to losses among the plants planted, reducing to nothing the work carried out for months by the professionals.

Constructive, pragmatic exchanges and a very positive projection of the use of treated wastewater

The workshop was facilitated in such a way as to allow the participants to express themselves as much as possible on their current professional practices and to raise questions about the prospect of using recycled water.

First of all, the questions raised concerned the agronomic impact of this "new water" on the watered plants, in the short term and especially in the long term ("what is the quantity of nitrates, nitrogen and sodium in the recycled water?"). The gardeners mentioned an adjustment of the fertiliser inputs and the interest of a test on a few young trees.

Then came questions about logistics and the changes in practices that this use will entail: will there be a need for a dedicated tank? Will rinsing be necessary and how often? How will they be warned in the event of shutdown of the production of recycled water?

The health issues for the workers did not emerge on their own, it was the team of facilitators who brought them up. The subject of wearing Personal Protective Equipment (PPE) was raised. The results of the QMRA study and the HACCP Plan were presented in an educational manner and allowed the professionals to be reassured, although they did not specifically mention any fears about their health.

The only subject ultimately related to the question of the acceptability of the use of recycled wastewater concerned the general public and in particular local residents, who may witness the watering of green spaces during periods of restriction, during time slots when individuals are not allowed to water. The discussion led to an interesting idea on the creation of a synthetic and didactic document, which would be present in the trucks, to be given to local residents who would ask questions on this subject. This information would be likely to remove any objections but above all to reassure professionals who would have support at their disposal.

CONCLUSIONS

The originality of this project was based on the combination of objective health risk assessment approaches with a sociological approach allowing users to express their interests, fears and needs with regard to the use of recycled wastewater.

The application of HACCP principles made it possible to carry out a comprehensive analysis of all possible failure scenarios of the treatment system and to verify the existence of appropriate control means. The QMRA approach made it possible to identify the critical points of the treatment, and to guarantee their control through a HACCP Plan defining the critical sensors and their critical limits. This control guarantees the end user that he will always have a water quality that meets the expected quality criteria.

The HACCP approach, also applied to future use scenarios for reused water, and validated during discussions with professionals, made it possible to identify all the prevention means necessary to protect future users. The interviews and the workshop carried out with the future users (gardeners and hydro cleaners) made it possible to confirm the acceptability of these prevention methods and to adapt them according to their remarks. During the discussions, the future users supported the use of treated wastewater, and were serene about the health aspects. The main obstacle cited to the realization and sustainability of this new use would be logistical, if this change in resource leads to significant impacts (tank rinsing, dedicated tank, waiting time at the service station). This

consideration of the perception of future users seems essential to maximise the chances of sustainable success of future projects, i.e. water use and implementation of preventive measures over time.

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