DISINFECTION BY SMALL WASTEWATER TREATMENT PLANTS FOR REUSE AND OTHER APPLICATIONS

Sophie Besnault[1], Yann Pastel[1], Stéphanie Prost-Boucle[1], Gaël Mertz[1], Jean-Marc Choubert[1] and Rémi Lombard-Latune[1]

[1]UR REVERSAAL INRAE - France

ABSTRACT

Introduction

According to the 2021 French urban wastewater database (Portail Assainissement, https://assainissement.developpement-durable.gouv.fr/pages/data/actu.php), 221 wastewater treatment plants (WWTPs) with a capacity of less than or equal to 10,000 population equivalent (PE) are equipped with a disinfection system (ie UV, ozone, chlorine or other chemicals, membranes or ponds). The aim of this disinfection process is to provide a water quality compatible with treated wastewater reuse (REUSE), protection of bathing or water-based recreational areas, drinking water catchment points, or fishing or shellfish farming.

Epnac national working group (https://www.epnac.fr/), which brings together all of French public sanitation organizations (Departmental councils - SATESE, water police services - DDT and DEAL, water agencies, INRAE, Ministries, OFB, OiEau), focuses on integrated urban water management in small and medium-sized municipalities, with particular emphasis on wastewater treatment processes. Surveys carried out by Epnac as part of the REUSE panorama in France in 2022 (Lombard-Latune et al., 2023) indicate difficulties in operation and performance of disinfection systems. In this context, a specific study on disinfection was initiated in 2023.

A national survey was carried out to identify small WWTPs equipped with a disinfection stage, to determine the treatments in place, to assess their efficiency in relation to the plant's treatment objective, and to study the particular challenges they face. Indeed, many problems have been identified in terms of system management complexity or failure to achieve required performance levels. Significant flow variations in small communities can also be an unfavorable factor. Nevertheless, the need is likely to increase in the coming years, particularly with the development of REUSE practices. The respondents to the survey were departmental councils (SATESE), water police services or plant operators.

Results and discussion

The national survey provided more detailed information on 247 WWTPs with a nominal capacity of less than or equal to 10,000 PE in mainland France and its overseas territories. Some plants not listed in the Portail Assainissement but equipped with disinfection were identified thanks to this survey, which explains why the number of plants included in this survey is higher than 221, the number of plants equipped with disinfection according to the Portail Assainissement. 48% of the facilities surveyed are equipped with ultraviolet (UVC), 28% with ponds, 9% with chemical post-treatments (chlorine, performic acid) and 6% with membranes (membrane bio-reactors, ultrafiltration). As regards the seasonality of the disinfection, 60% of the disinfection systems are in operation all year round, while 27% are only in operation for part of the year and 9% are absent or have been shut down. Some WWTPs are required to disinfect, according to their operating regulations, but were not equipped with a disinfection system when the plant was built, mainly due to a lack of budget (4% of the treatment facilities of this survey).

As shown in Figure 1, the main reason for the set-up of a disinfection stage in the surveyed WWTPs was bathing and water-based recreation (59%), followed by shellfish farming or fishing (30%). REUSE was the third most important reason for installing a disinfection system (16%). For many plants, the disinfection objectives are plural: for example, bathing and shellfish farming. In this case, each purpose was counted once, which explains why the total percentage is over 100%.

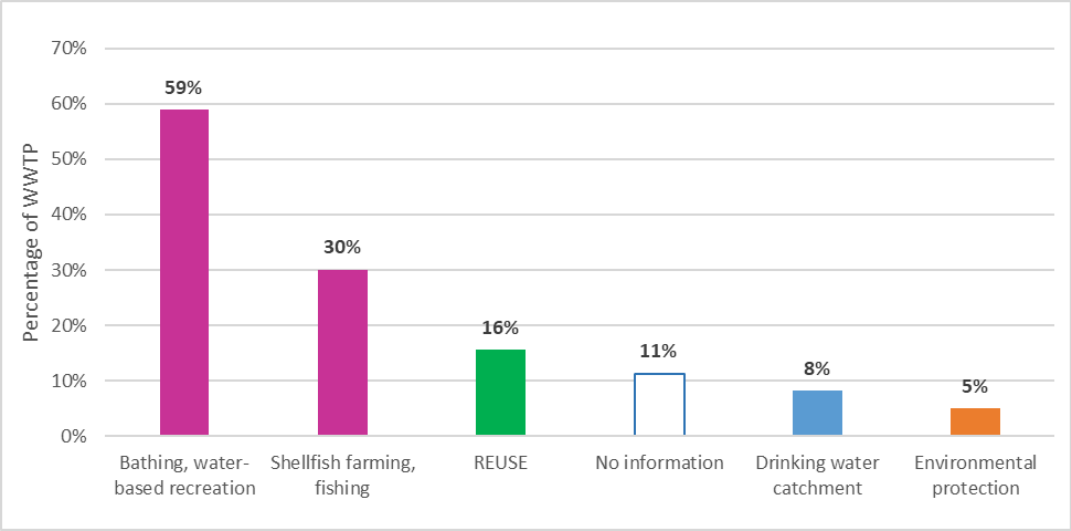

Figure 1: Purpose of the set-up of a disinfection system (n=331)

Only 41% of the disinfection systems are considered to be in good working order by the respondents. The main problems observed were clogging or high maintenance requirements (27%), operational problems (11%) (such as high load variations or insufficient disinfection), absence or shutdown of the disinfection system (11%). As shown in Figure 2, some disinfection systems are more prone to problems according to the respondents: ponds and chemical post-treatment, that require less operation and maintenance actions, are considered to be in good working order for 68% and 61% of the systems respectively, whereas UV, that require more maintenance and operation, are considered to be in good working order for 43% of the systems. Filtration systems (mostly sand filters) are not considered to be in good working order, although it is a process that requires few operation actions. Membranes are a complex process to operate but appear to be in good working order for 67% of the small number of plants included in this survey.

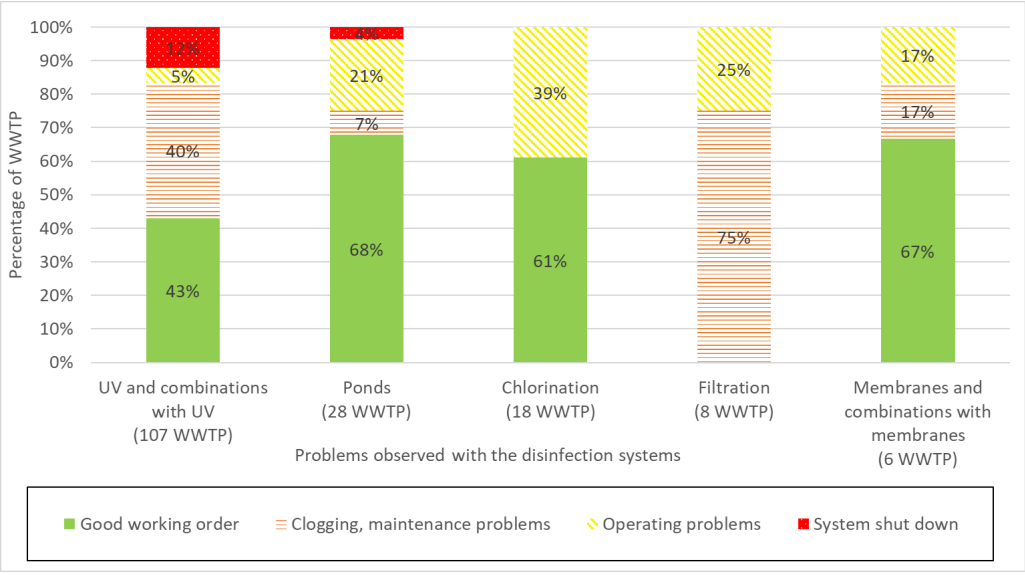

Figure 2: Main reported problems observed for each disinfection systems

Local operating decrees (containing the plant's treatment requirements) were collected for 109 WWTPs. The parameters monitored are very different from one plant to another: *Escherichia coli* is the most frequently monitored parameter, followed by *Enterococci*, fecal coliforms, total coliforms and in rare cases helminth eggs. Except for helminth eggs, only bacterial parameters are monitored. Discharge limits are not homogeneous at national level and vary, for example, from 100 to 100 000 CFU/100 ml for *Escherichia coli*.

Data were gathered from 799 regulatory monitoring (24-hour flow composite samples) in 66 WWTPs equipped with a disinfection stage or with an operating regulation requiring disinfection. 83% of the 24-hour flow composite samples were below the required pathogen levels. The compliance rates vary according to the disinfection process installed, as shown in Figure 3. The percentage of compliance rates is over 79% for UV, ponds, chlorination and membranes and around 50% for filtration and WWTPs without disinfection. Even when operators report that their disinfection systems were not in good working order (Figure 2), their efficiency was sufficient to reach concentrations of pathogens below the discharged limits.

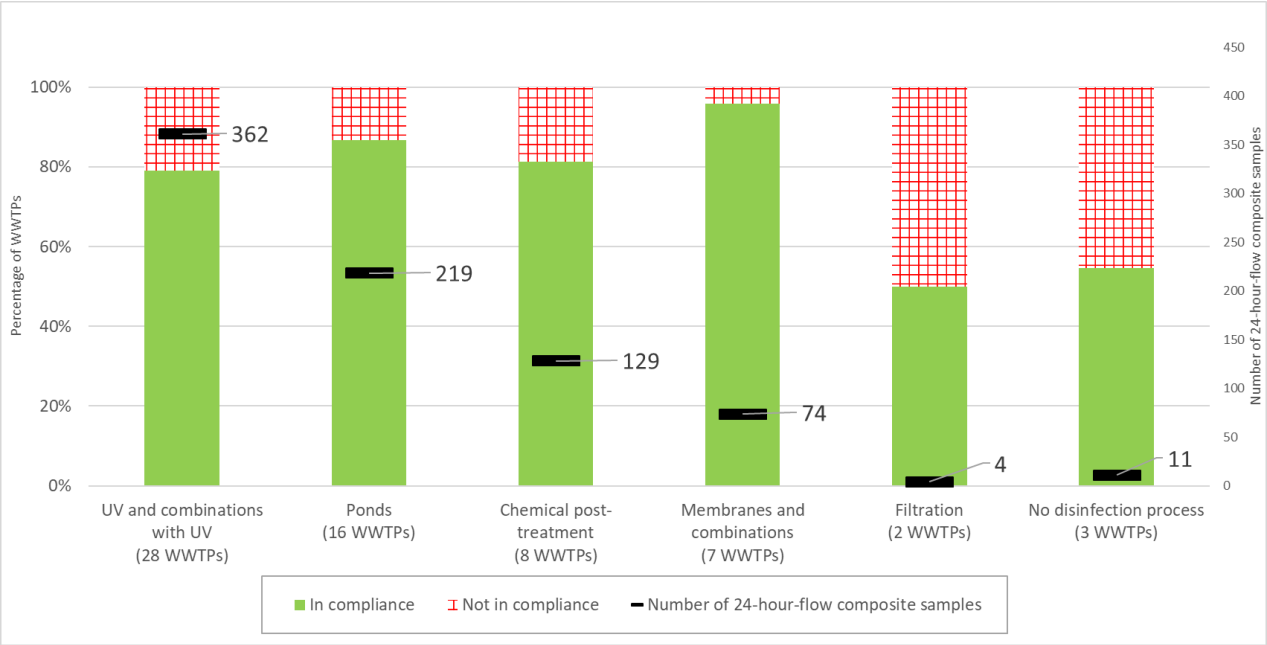

Figure 3: Compliance rate by installed disinfection process

For 227 of the 799 24-hour flow composite samples, pathogens levels were also measured at the inlet of the treatment plant to determine the removal rate. Figure 4 shows the removal efficiency for the parameter *E. coli.* A large dispersion of the removal yields can be observed, except for membranes which have the best performance for *E. coli* removal around 6 log thanks to their high cut-off threshold (Bodzek, 2019). As expected, WWTPs without a specific disinfection process are already able to remove around 2 log of *E. coli* thanks to biological and physical mechanisms (Kamizoulis, 2008). UV and ponds can remove up to 5 log thanks to irradiation (Collivignarelli et al., 2017).

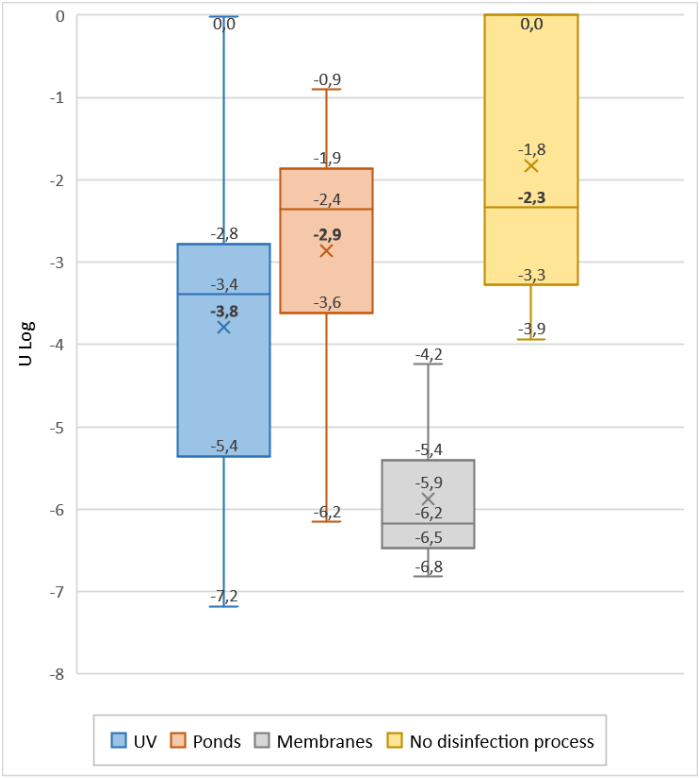

Figure 4: Statistical distribution of microbiological load reduction values for WWTPs (≤10,000 PE) according to disinfection process for *Escherichia coli* (n=228)

Prospects

In order to obtain information on the removal of other types of microorganisms, such as viruses and protozoa, which are now included in the REUSE regulations, REVERSAAL and partner SATESEs are carrying out sampling campaigns to determine the performance of disinfection processes on several microbiological indicators (*Escherichia coli*, spores of sulfite-reducing anaerobic bacteria and specific RNA bacteriophages). The analysis of the results is currently in progress. The study will provide information on the capacity of WWTPs in small and medium-sized municipalities to meet the quality objective required for the implementation of a REUSE project. Indeed, the addition of a disinfection stage to small and medium-capacity treatment plants represents an additional constraint that increases the technical nature and cost of operation. Future work will investigate the constraints of installing a disinfection system in relation to the expected benefits for the local area.

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