Section 2

Effectiveness of the Chemical Disinfection Process at Full Scale (Seine Valenton WWTP)

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Chapter 1

Technical description of the industrial trials conducted at Seine Valenton WWTP

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1.1 INTRODUCTION

In order to verify the industrial-scale effectiveness of PFA disinfection and its impact on Seine River water, industrial-scale trials were performed in 2018

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within the Paris Metropolitan Area. The identified recreation spots were located in the center of Paris, near the Ile de la Cité and Tour Eiffel. The SIAAP wastewater treatment plant (WWTP) discharges located upstream impacting these sites are Seine Valenton (SEV) WWTP and Marne Aval (MAV) WWTP. SEV treats far more wastewater than MAV (by a factor of 10), and MAV already had a UV disinfection unit, so the PFA industrial-scale trials were conducted at SEV.

Few industrial-scale trials were found in the literature, especially on WWTP treated water discharged into a river. Among them, Venice (Italy) in 2005–2011 (Ragazzo *et al.*, 2013), Biarritz (France) in 2015–2017 (Pigot *et al.*, 2019) and Berlin in 2012 (internal report, unpublished) can be cited for purposes of comparison, but they concern wastewater discharged into the sea, a lagoon or lakes. The Venice, Biarritz and Berlin cases will be technically described in Part 4 of this book. In addition, PFA disinfection units have been industrially implemented to disinfect combined sewer overflows in Denmark (Chhetri *et al.*, 2015).

Considering that SEV WWTP treats around 550,000 m^3/day under normal conditions, as explained in this chapter, such industrial-scale PFA disinfection trials are, to the best of the authors' knowledge, the most extensive performed thus far in the world. Moreover, the Paris Metropolitan Area case is very interesting since during summer (recreational period), the SEV WWTP discharge accounts for around 6 m^3/s, while the Seine River in summer normally flows at around 80–100 m^3/s. The anthropic pressure exerted by Parisians on the Seine River is thus extremely strong during the summer season, which makes achieving adequate bathing quality a real technical challenge.

This chapter will present in detail a technical description of the industrial trials performed at SEV WWTP in 2018. The process layout of the plant will be described first, followed by the tested Kemira Desinfix technology. Lastly, the trial design will be explained, including the PFA disinfection conditions applied, the sampling methodology and the analytical parameters monitored.

1.2 PRESENTATION OF THE SEINE VALENTON WWTP

The Seine Valenton (SEV) WWTP is located 15 km southeast of Paris and has a treatment capacity of 600,000 m^3/day (2,600,000 population equivalent) under normal conditions and between 600,000 and 1,500,000 m^3/day under degraded conditions, including wet weather. This WWTP is capable of receiving a maximum peak flow rate of 21 m^3/s; it treats wastewater originating mainly from the eastern part of Paris before discharging the treated water into the Seine River, upstream of the city of Paris. The WWTP layout is composed of two parallel treatment lines, named Valenton 1 and Valenton 2. Figure 26 summarizes the SEV WWTP treatment layout.

Raw wastewater is first pretreated by screening and grit and oil removal. Next, the pretreated wastewater is split between Valenton 1 and Valenton 2. Under

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normal operating conditions (SEV flow rate below 550,000 m^3/day), Valenton 1 treats the pretreated wastewater by primary settling before a biological treatment using low-charge activated sludge with a succession of anoxic and anaerobic tanks, aimed at treating carbon and nitrogen, along with a tertiary physicochemical treatment adding $FeCl_3$, anionic polymer and micro-sand. Under degraded conditions, the tertiary treatment is partially bypassed; moreover, under normal operating conditions, Valenton 2 treats the pretreated wastewater by primary settling before a biological treatment by means of low-charge activated sludge with a succession of endogenous, anoxic, anaerobic and aerobic tanks for treating carbon and nitrogen. Under degraded conditions, primary settling is partially bypassed. In wet weather, when the raw wastewater flow exceeds 11.4 m^3/s, a fraction of the pretreated wastewater is treated only by the tertiary physicochemical lamellar settling units. Above 17.6 m^3/s, all tertiary units are treating pretreated wastewater, and above 21 m^3/s or 550,000 m^3/d, the tertiary units are bypassed and pretreated water is discharged directly into the Seine River.

1.3 PRESENTATION OF PFA DISINFECTION BY APPLICATION OF THE KEMIRA KEMCONNECT DEX TECHNOLOGY

The disinfection technology tested in the SEV WWTP is the Kemira Desinfix process, based on *in situ* performic acid (PFA, DEX-135) production and injection. PFA is obtained by mixing hydrogen peroxide (DEX-550) and catalyzed formic acid (DEX-A375); it is highly unstable, thus making its production necessary on-site just before injection. Consequently, this technology basically consists of a mixing unit and two storage tanks (Figure 27). The PFA output contains approximately 13.5% PFA by mass, 20% H_2O_2 and 30.9% residual formic acid.

1.4 DESIGN OF THE INDUSTRIAL-SCALE TRIALS

1.4.1 Applicable PFA disinfection conditions

The trials were performed between late August and late October 2018, with a total of 10 sampling weeks. Five weeks were dedicated to evaluating PFA disinfection effectiveness and the other five weeks were spent monitoring as a control without PFA injection. The PFA dose injected during the trials is given in Table 9.

1.4.2 Sampling methodology

Throughout the 10-week period, the same sampling methodology was applied, including treated, disinfected and Seine River samples. Figure 28 provides the exact location of the sampling points as red crosses plus a photo of each point.

The samples were collected upstream (1) and downstream (2) of the PFA injection in order to evaluate the removal effectiveness of the treatment.

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The downstream samples were collected at the end of the WWTP discharge channel (3.65 km from the PFA injection point), corresponding to a hydraulic retention time (and PFA contact time) before discharge to the Seine River of about 10–30 min, depending on hydraulic conditions. Point-specific samples were collected three times a day and 3 days a week (Tuesdays, Wednesdays and Thursdays), with a telescopic rod for the upstream point and a pump for the downstream point; a gap of 30 min was introduced between upstream and downstream samples.

Other samples were collected from the Seine River both upstream and downstream of the WWTP discharge point to evaluate the impact of WWTP discharge on the river with and without PFA injection. These samples were collected at two spots of the MeSeine Platform, which is responsible for Seine River quality monitoring in the SIAAP Authority: Choisy-le-Roi (PK 622.440) (3) and Port à l'Anglais (PK 626.152) (4). The Choisy-le-Roi sampling point is located approximately 1500 m upstream of the WWTP discharge point, on the first bridge accessible to pedestrians. The Port à l'Anglais sampling point is located in Alfortville about 2500 m downstream of the discharge point, also on the first bridge accessible to pedestrians. At both sampling points, one-time samples were collected on the right bank of the Seine River, the left bank and the middle using a bucket and a rope thrown from the bridge; the samples were then mixed together with equal volumes. Sampling was performed once a week (Wednesdays). It is important to keep in mind that depending on weather conditions, rainfall sewer overflows can occur on occasion between these two Seine River sampling points, significantly lowering water quality in the process.

1.5 ANALYTICAL PARAMETERS MONITORED

Several parameters were analyzed within the collected samples; they are given in Table 10 along with the frequency and type of water in which their determinations took place.

Regarding pathogens, *E. coli* and intestinal enterococci were analyzed in all samples, while spores of anaerobic sulfite reduction bacteria (SSR) and F-specific RNA bacteriophages were analyzed solely in the WWTP discharge and disinfected water once a week (Tuesdays). Conventional wastewater quality parameters were also assessed in all samples, including total suspended solids (TSS), carbon (dissolved organic carbon, chemical and biochemical oxygen demands), nitrogen (Kjeldahl nitrogen, ammonium, nitrite and nitrate) and phosphorus (total phosphorus and orthophosphates) parameters, as well as pH, conductivity and turbidity. Specific analyses were performed in SEV discharge and disinfected water once a week (Tuesdays) to determine the halogenated organic hydrocarbons (AOX), bromide and bromate. Similarly, color, chloride and sulfate were measured only in the Seine River samples.

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All analyses were conducted by the central SIAAP Laboratory or the CARSO Laboratory, in accordance with the reference methods. The analytical methods, limits of quantification and estimated analytical uncertainties are listed in Table 11.

Lastly, several operations-related datasets from SAV WWTP or the Seine River were collected to process the results. For SEV WWTP, this dataset included the flow of SEV WWTP discharge at the time of sampling, the water level and geometry of the discharge channel, and information regarding the internal process bypass within the WWTP capable of impacting discharge quality. For the Seine River, this dataset included the daily flow of this section of river collected from the online HYDRO databank (http://hydro.eaufrance.fr), precipitation collected from the SAV WWTP monthly operations report, and Seine River temperature collected from the MeSeine databank at the Alfortville monitoring point.

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