

CORONASTEP Report 113 (2022 - Week 03) SARS-CoV-2 Sewage Surveillance in Luxembourg

Summary

This report 113 presents the results of SARS-CoV-2 contamination of wastewater at the entrance of the 13 wastewater treatment plants (WWTPs) analysed during the week 03 of 2022. All WWTPs, excepted Hesperange and Boevange were analysed twice this week.

The SARS-CoV-2 RNA flux measured in WWTPs during the week 03 continue to show a very high national prevalence of the virus, with a SARS-CoV-2 flux between 3 and 6 x 10¹² RNA copies per day per 100,000 equivalent-inhabitants. The current SARS-CoV-2 level in WWTPs is now superior to that observed in October 2020, which was so far the highest level measured over the entire period analysed (March 2020 - January 2022). Overall, the general trend over several weeks or even months is clearly upwards.

At the level of the different wastewater treatment plants analysed, a very similar trend is noted, with SARS-CoV-2 levels comparable or even higher than the highest values observed in October 2020, for almost all the WWTPs.

Table 1 – National level of SARS-CoV-2 contamination of wastewaters in Luxembourg.

 Dark green: negative samples for SARS-CoV-2 gene E (-), Green to red: positive samples for SARS-CoV-2 gene E. The intensity of the color is related to the national SARS-CoV-2 flux (RNA copies / day / 100 000 equivalent inhabitants).

2020		
National SARS-CoV-2 Level	Week	
	Week 3	
	Week 7	
	Week 9	
	Week 11	
	Week 14	
	Week 15	
	Week 16	
	Week 17	
	Week 18	
	Week 19	
	Week 20	
	Week 21	
	Week 22	
	Week 23	
	Week 24	
	Week 25	
	Week 26	
	Week 27	
	Week 28	
	Week 29	
	Week 30	
	Week 31	
	Week 32	
	Week 33	
	Week 34	
	Week 35	
	Week 36	
	Week 37	
	Week 38	
	Week 39	
	Week 40	
	Week 41	
	Week 42	
	Week 43	
	Week 44-1	
	Week 44-2	
	Week 45-1	
	Week 45-2	
	Week 45-3	
	Week 46-1	
	Week 46-2	
	Week 46-3	
	Week 47-1	
	Week 47-2	
	Week 48-1	
	Week 48-2	
	Week 48-3	
	Week 49-1	
	Week 49-2	
	Week 50-1	
	Week 50-2	
	Week 51-1	
	Week 51-2	
	Week 52	
	Week 53	

2021		
National SARS-CoV-2 Level	Week	
	Week 01-1	
	Week 01-2	
	Week 02-1	
	Week 02-2	
	Week 03-1	
	Week 03-2	
	Week 04-1	
	Week 04-2	
	Week 05-1	
	Week 06-1	
	Week 06-2	
	Week 07-1	
	Week 07-2	
	Week 08-1	
	Week 08-2	
	Week 09-1	
	Week 09-2	
	Week 10-1	
	Week 10-2	
	Week 11-1	
	Week 11-2	
	Week 12-1	
	Week 12-2	
	Week 13-1	
	Week 13-2	
	Week 14-1	
	Week 14-2	
	Week 15-1	
	Week 15-2	
	Week 16-1	
	Week 16-2	
	Week 17-1	
	Week 17-2	
	Week 18-1	
	Week 18-2	
	Week 19	
	Week 20-1	
	Week 20-2	
	Week 21	
	Week 22-1	
	Week 22-2	
	Week 23-1	
	Week 23-2	
	Week 24-1	
	Week 24-2	
	Week 25	
	Week 26-1	
	Week 26-2	
	Week 27-1	
	Week 27-2	
	Week 28-1	
	Week 29-1	
	Week 29-2	
	Week 30-1	
	Week 30-2	

2021			2022		
National SARS-CoV-2 Level	Week				
	Week 31-1				
	Week 31-2				
	Week 32-1				
	Week 32-2				
	Week 33-1				
	Week 33-2				
	Week 34-1				
	Week 34-2				
	Week 35-1				
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	Week 50-1				
	Week 50-2				
	Week 51-1				
	Week 51-2				
	Week 01				
	Week 02-1				
	Week 02-2				
	Week 03-1				
	Week 03-2				

Figure 1a – RT-qPCR quantification time-course monitoring of SARS-CoV-2 (E gene) in Luxembourgish wastewater samples from December 2019 to January 2022. Grey squares: daily-confirmed cases for Luxembourgish residents (<https://data.public.lu/fr/datasets/donnees-covid19/>), Blue dots: cumulative SARS-CoV-2 flux (RNA copies / day / 100 000 equivalent inhabitants)

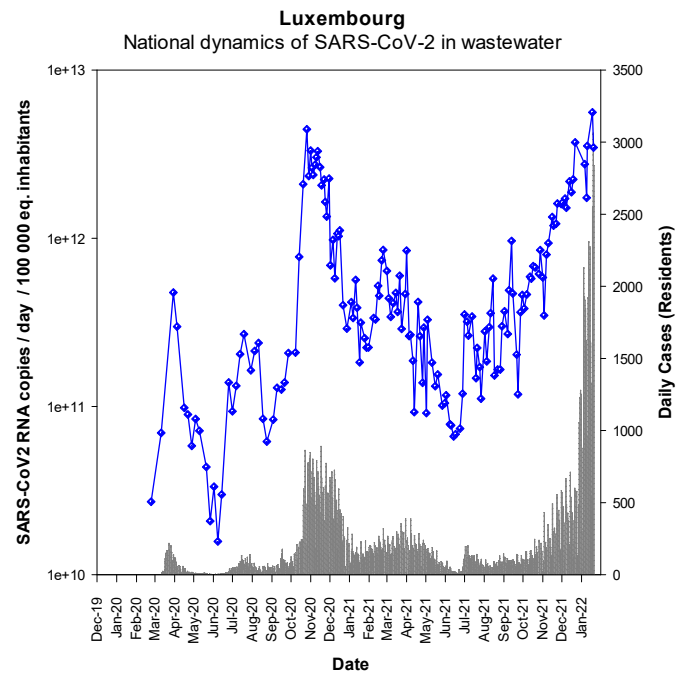


Figure 1b – Close-up of Figure 1a showing results from September 1st, 2020 on.

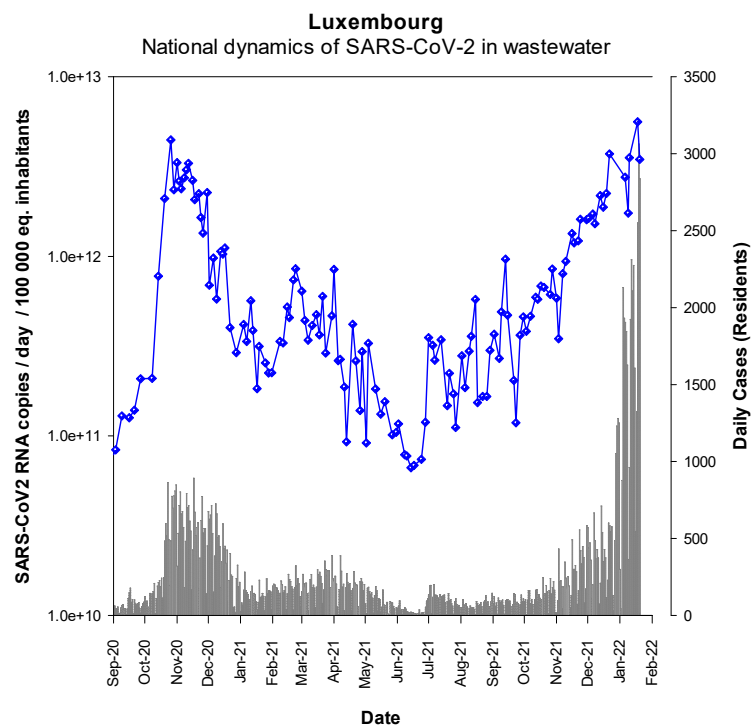


Table 2 - Level of SARS-CoV-2 contamination of each analyzed wastewater treatment plant in Luxembourg in 2021. BEG: Beggen, BET: Bettembourg, SCH: Schifflange, BLE: Blesbruck, MER: Mersch, PET: Pétange, HES: Hesperange, ECG: Echternach, UEB: Uebersyren, GRE: Grevenmacher, TRO: Troisvierges, BOE: Boevange sur Attert, WIL: Wiltz



Dark green: negative samples for SARS-CoV-2 gene E (-), Green to red: positive samples for SARS-CoV-2 gene E. The intensity of the color is related to the RT-qPCR signal (Ct values) Grey boxes: no data

WWTP	2021																																	2022										
	Week 25	Week 26-1	Week 26-2	Week 27-1	Week 27-2	Week 28-1	Week 29-1	Week 29-2	Week 30-1	Week 30-2	Week 31-1	Week 31-2	Week 32-1	Week 32-2	Week 33-1	Week 33-2	Week 34-1	Week 34-2	Week 35-1	Week 35-2	Week 43-2	Week 44-1	Week 44-2	Week 45-1	Week 45-2	Week 46-1	Week 46-2	Week 47-1	Week 47-2	Week 48-1	Week 48-2	Week 49-1	Week 49-2	Week 50-1	Week 50-2	Week 51-1	Week 51-2	Week 01	Week 02-1	Week 02-2	Week 03-1	Week 03-2		
BEG																																												
BET																																												
SCH																																												
BLE																																												
MER																																												
PET																																												
HES																																												
ECH																																												
UEB																																												
GRE																																												
TRO																																												
BOE																																												
WIL																																												

Figure 2a – RT-qPCR quantification time-course monitoring of SARS-CoV-2 (E gene) in the four most impacted wastewater treatment plants from March 2020 to January 2022. Grey squares: daily-confirmed cases for the contributory area of each wastewater treatment plant, dots: SARS-CoV-2 flux (RNA copies / day / 10 000 equivalent inhabitants).

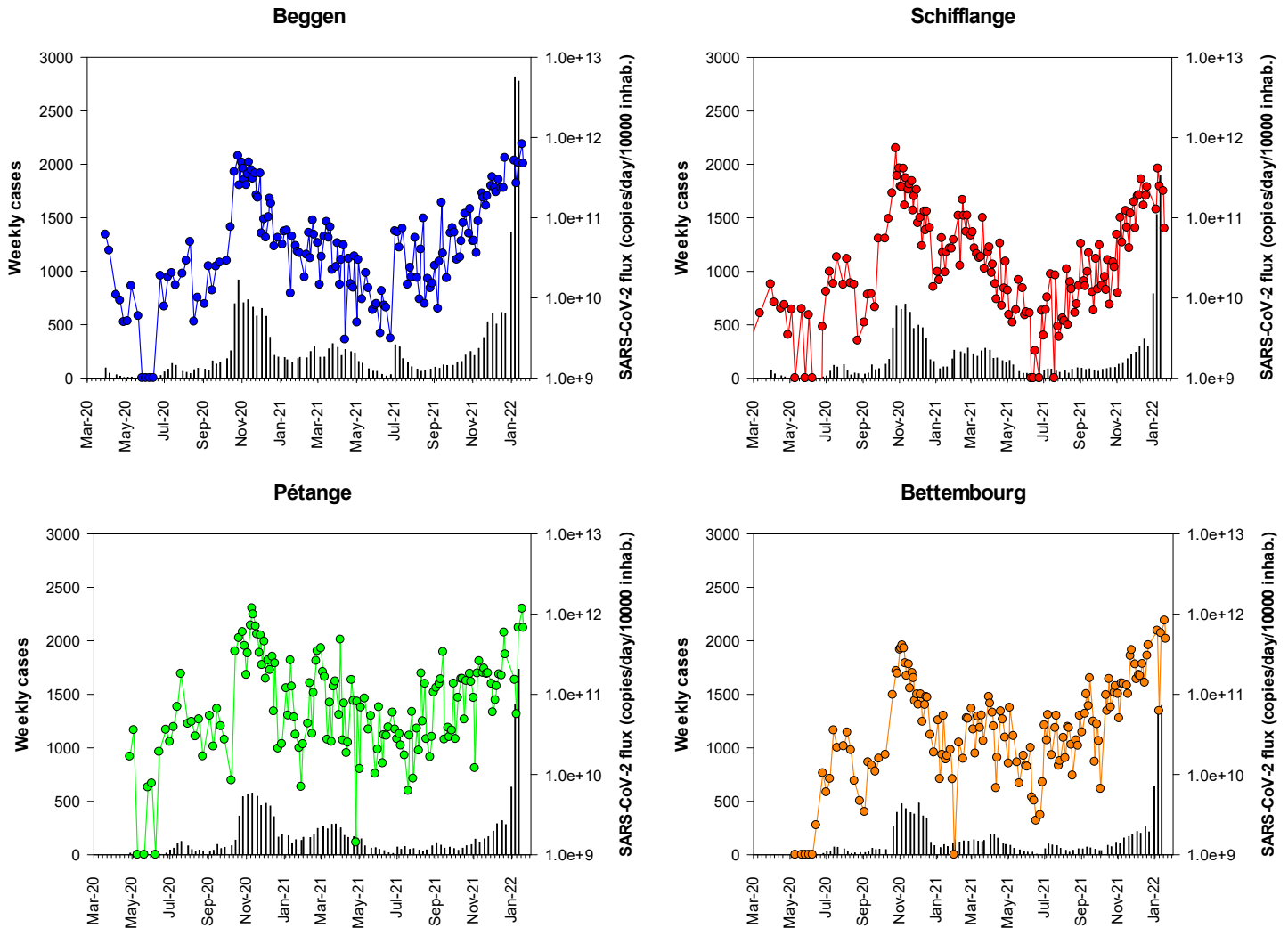


Figure 2b – Close-up of Figure 2a showing results from September 1st, 2020 on.

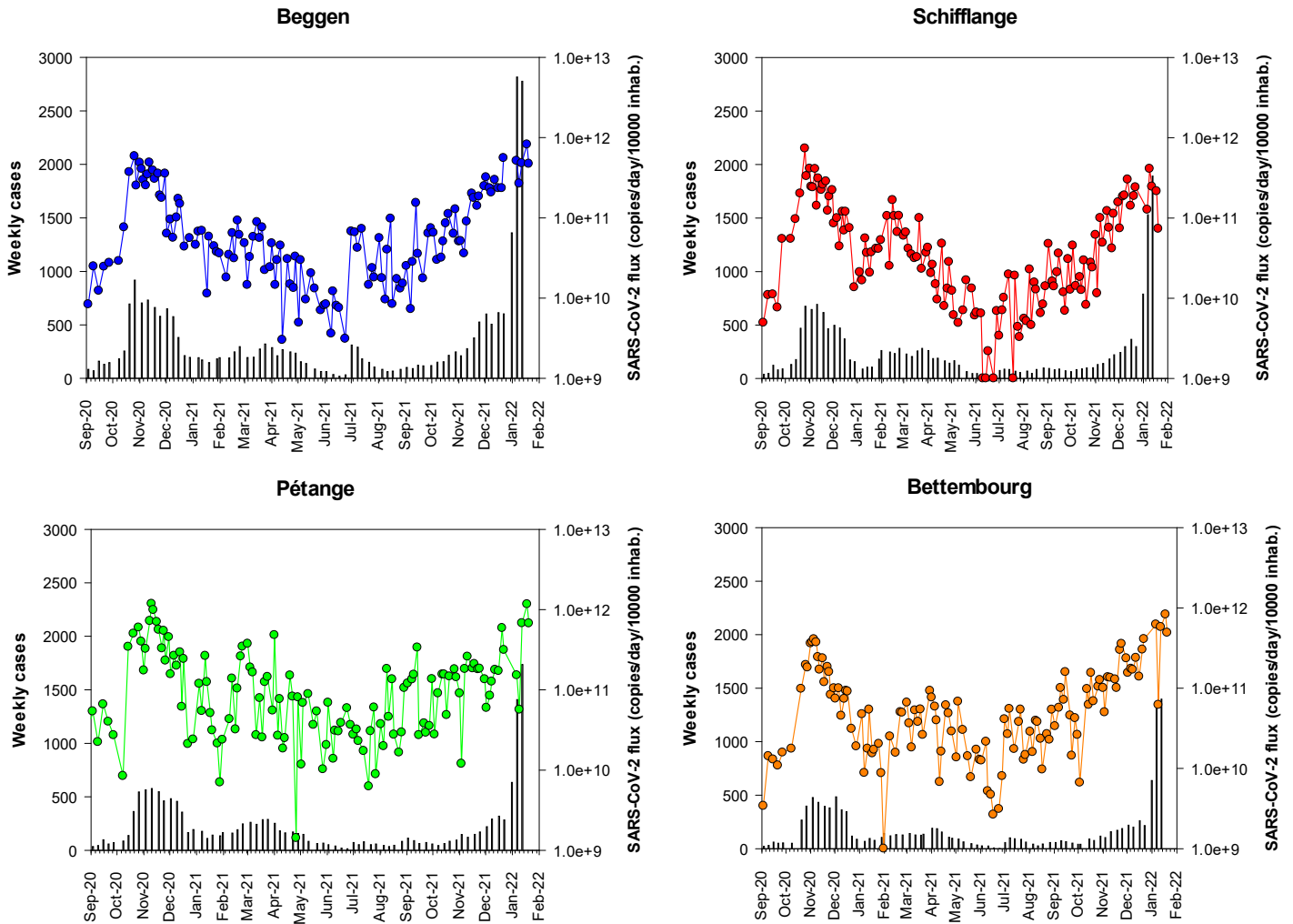


Figure 3a – RT-qPCR quantification time-course monitoring of SARS-CoV-2 (E gene) in Hesperange, Mersch and Boevange-sur-Attert wastewater treatment plants from March 2020 to January 2022. Grey squares: daily-confirmed cases for the contributory area of each wastewater treatment plant, dots: SARS-CoV-2 flux (RNA copies / day / 10 000 equivalent inhabitants).

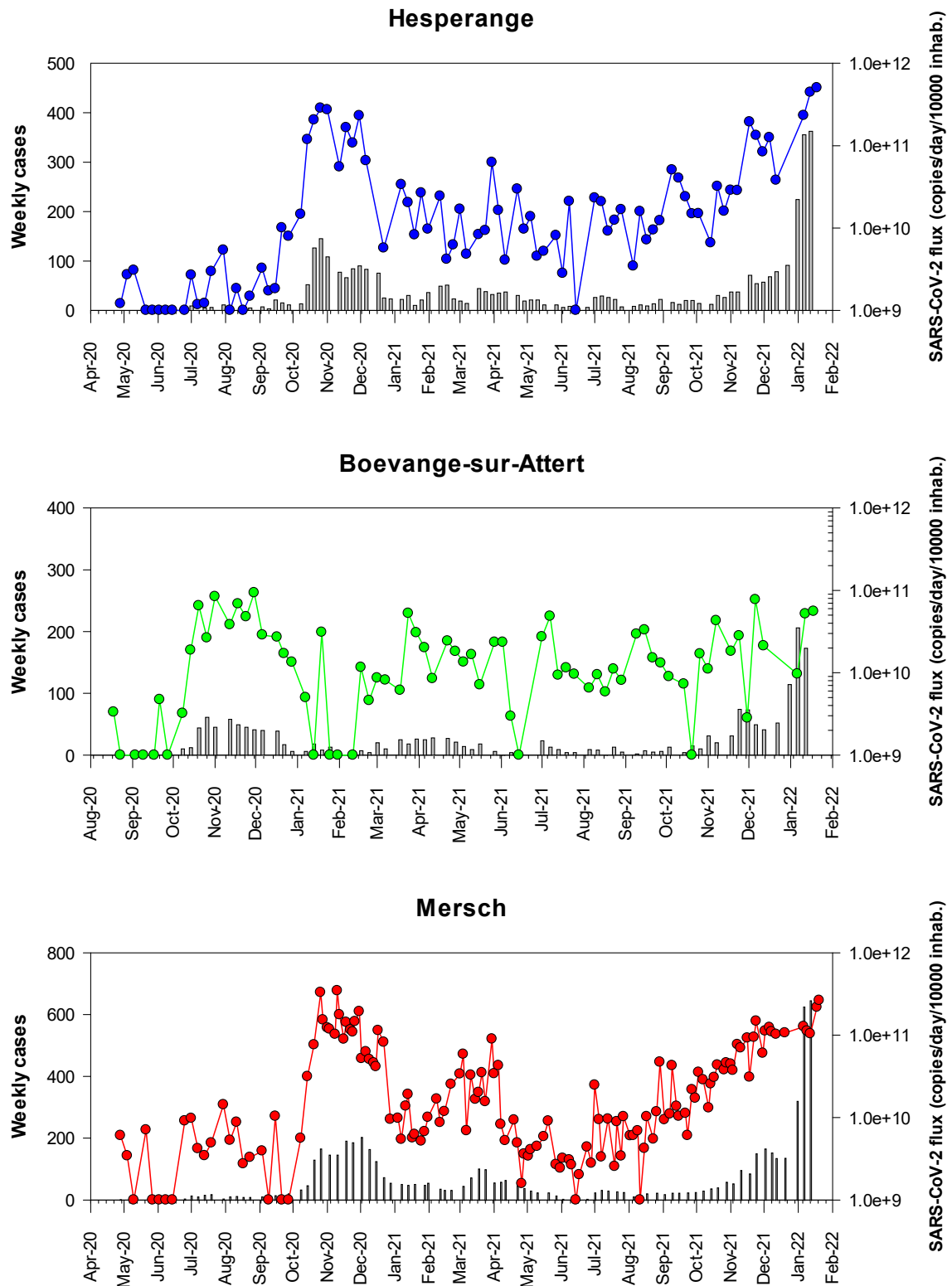


Figure 3b – Close-up of Figure 3a showing results from September 1st, 2020 on.

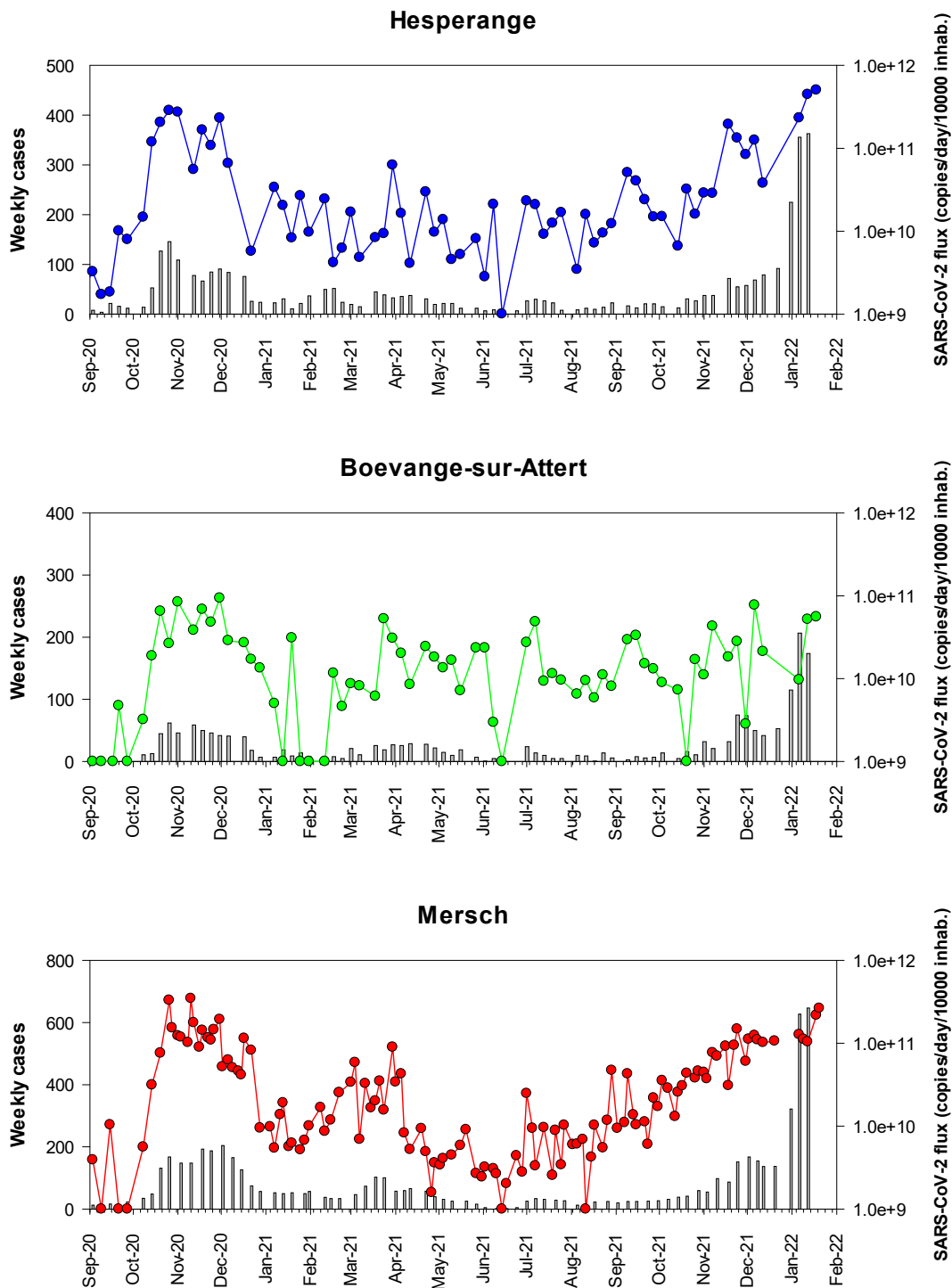


Figure 4a – RT-qPCR quantification time-course monitoring of SARS-CoV-2 (E gene) in SIDESt wastewater treatment plants from March 2020 to January 2022. Grey squares: daily-confirmed cases for the contributory area of each wastewater treatment plant, dots: SARS-CoV-2 flux (RNA copies / day / 10 000 equivalent inhabitants).

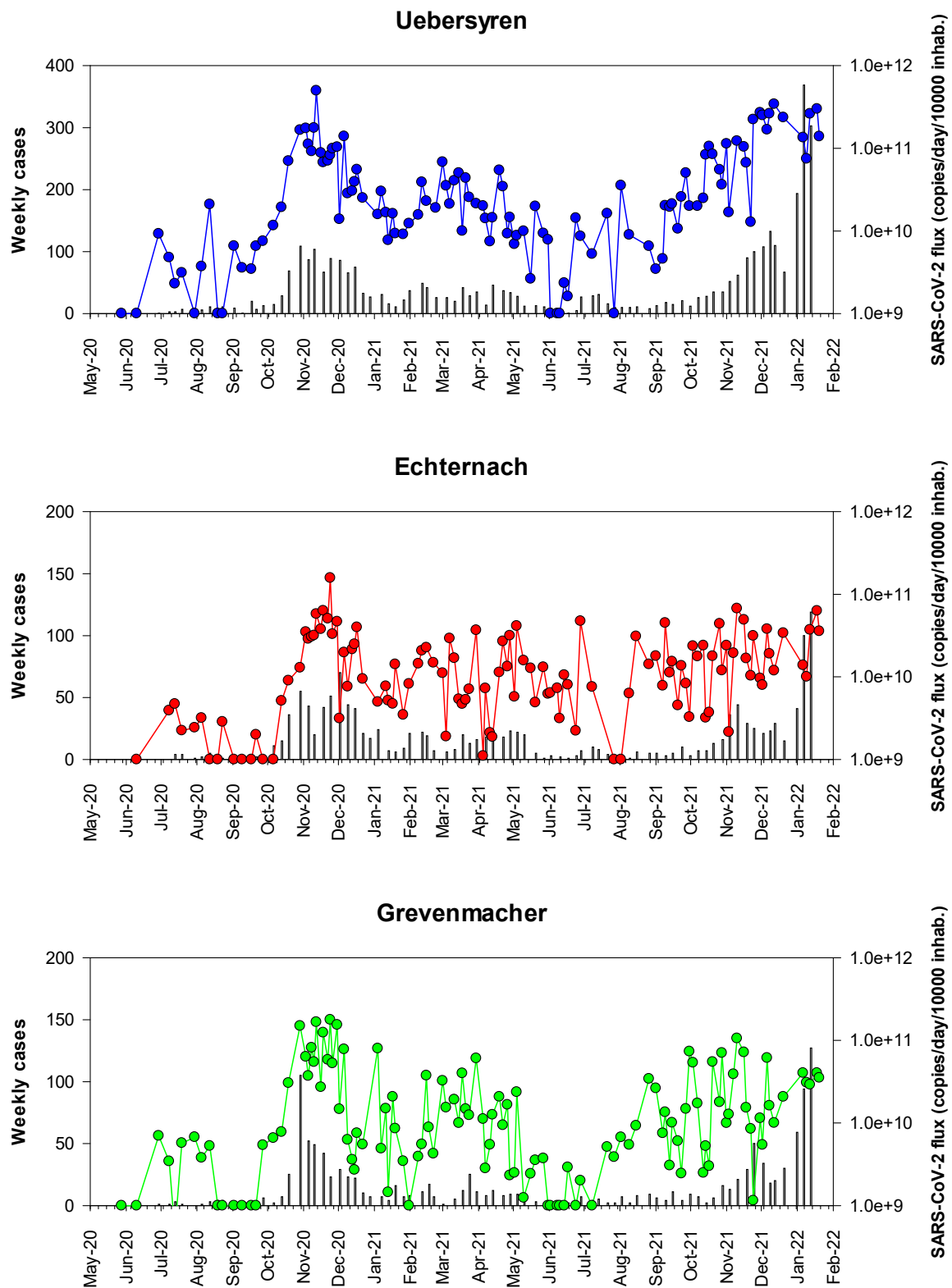


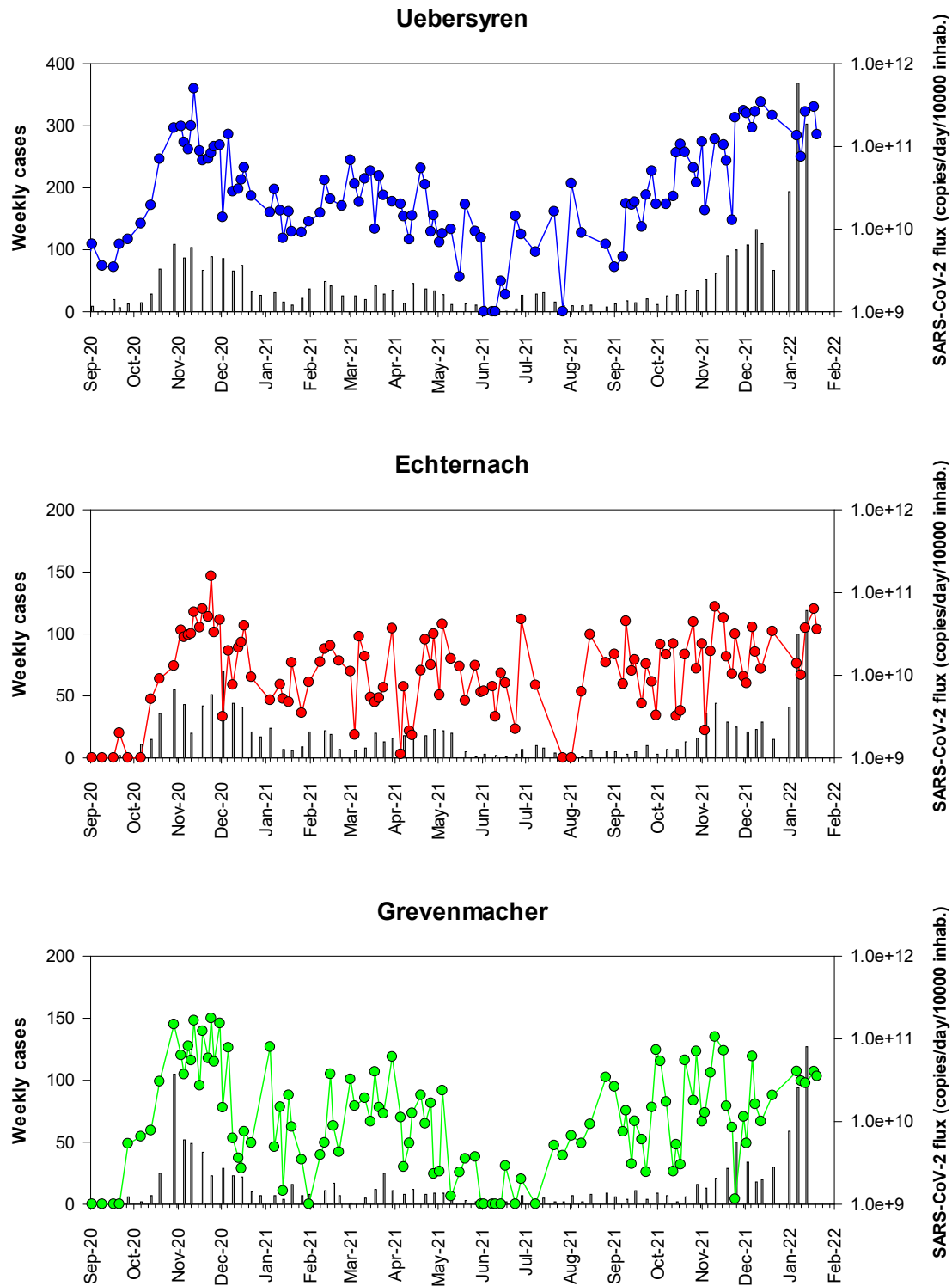
Figure 4b – Close-up of Figure 4a showing results from September 1st, 2020 on

Figure 5a – RT-qPCR quantification time-course monitoring of SARS-CoV-2 (E gene) in SIDEN wastewater treatment plants from March 2020 to January 2022. Grey squares: daily-confirmed cases for the contributory area of each wastewater treatment plant, dots: SARS-CoV-2 flux (RNA copies / day / 10 000 equivalent inhabitants)

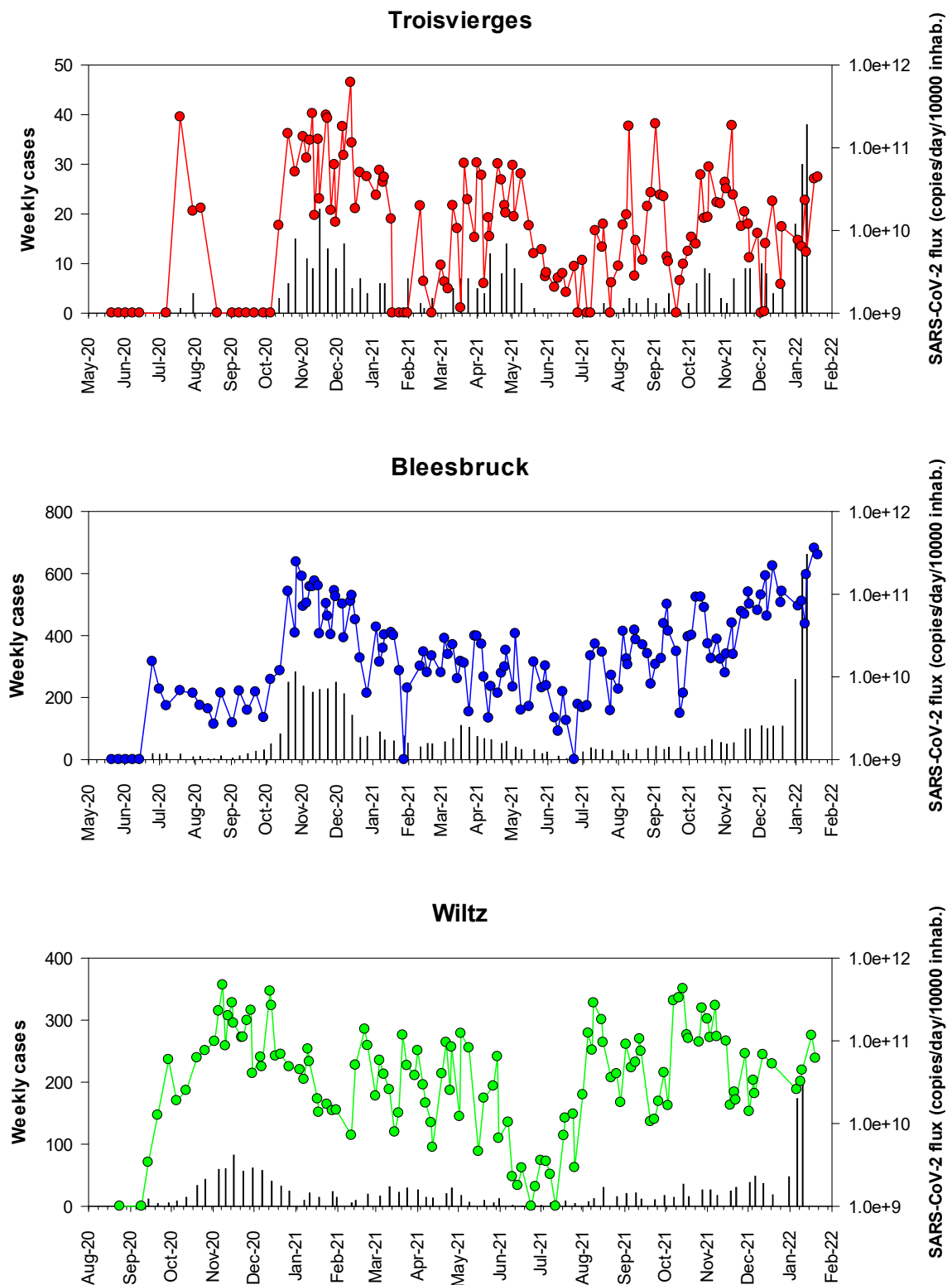


Figure 5b – Close-up of Figure 5a showing results from September 1st, 2020 on.

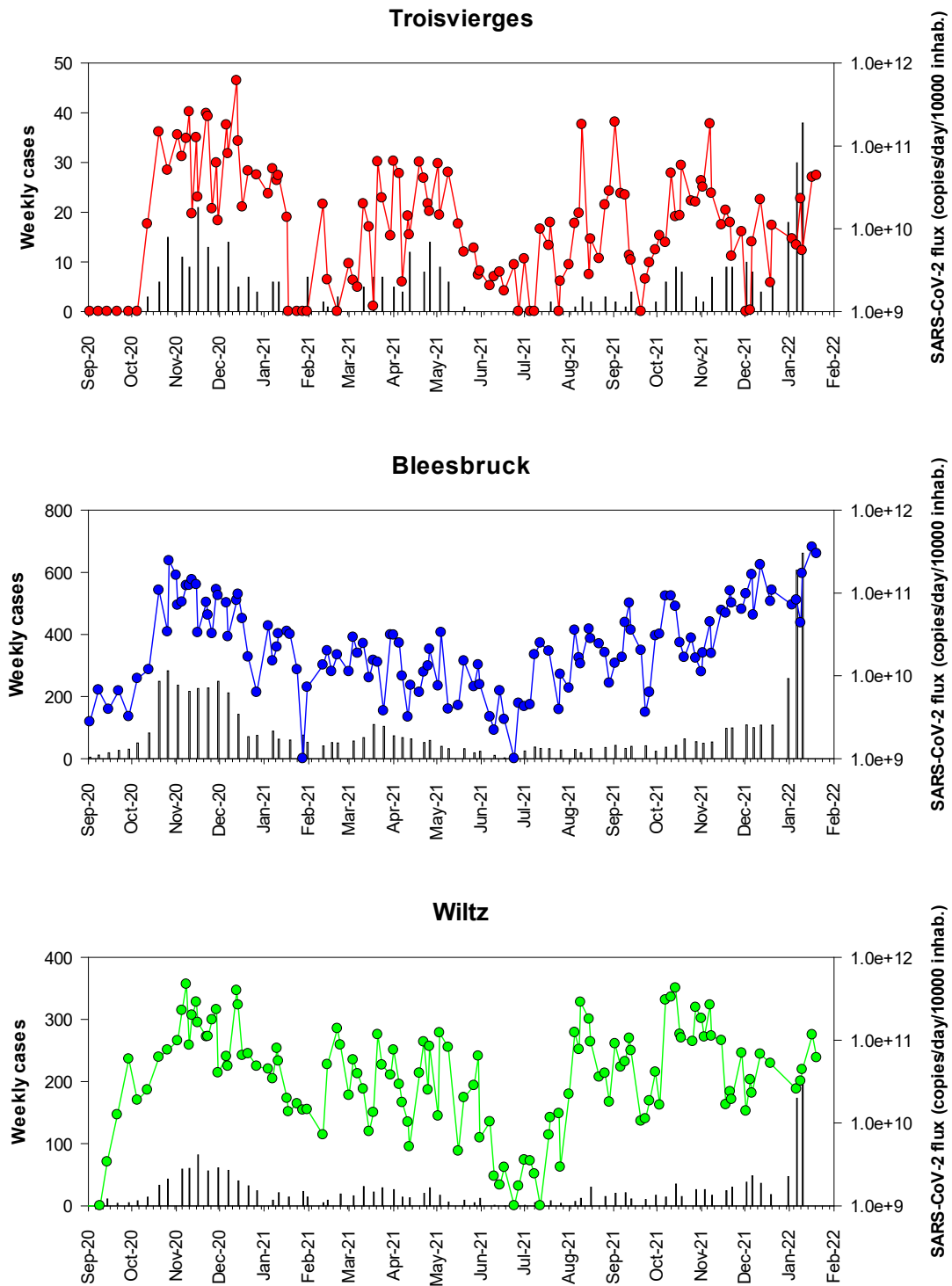


Table 3- Timing of sewage sampling since the beginning of the CORONASTEP study

[illegible][illegible]

	Week 01	Week 02	Week 03	Total samples
WWTP				
Beggen	2	2	2	150
Bettembourg	2	2	2	142
Schiffflange	1	2	2	161
Bleesbrück	2	2	2	142
Mersch	2	2	2	144
Pétange	2	2	2	157
Hesperange	1	1	1	86
Echternach	2	2	2	121
Uebersyren	2	2	2	122
Grevenmacher	2	2	2	125
Troisvierges	2	2	2	136
Boevange sur Attert	1	1	1	71
Wiltz	2	2	2	126
Total	23	24	24	1683
Pop Lux (2019)				

Materials and Methods

Sewage samples

From March 2020 to January 2022, up to thirteen wastewater treatment plants (WWTPs) were sampled at their inlet according to the planning presented in Table 3. The operators of the WWTPs collected a 24-h composite sample according to their routine sampling procedure. Composite sample was stored at 4°C until sample processing.

Sample processing

The samples were transported to the laboratory at 4°C and viral RNA was isolated on the day of sampling. Larger particles (debris, bacteria) were removed from the samples by centrifugation at 2,400 x g for 20 min at 4°C. A volume of 120 mL of supernatant was filtered through Amicon® Plus-15 centrifugal ultrafilter with a cut-off of 10 kDa (Millipore) by centrifugation at 3,220 x g for 25 min at 4°C. The resulting concentrate was collected and 140 µL of each concentrate was then processed to extract viral RNA using the QIAamp Viral RNA mini kit (Qiagen) according to the manufacturer's protocol. Elution of RNA was done in 60 µL of elution buffer.

Real-time One-Step RT-PCR

Samples were screened for the presence of *Sarbecovirus* (*Coronaviridae*, *Betacoronaviruses*) and/or SARS-CoV-2 virus RNA by two distinct real-time one-step RT-PCR assays, targeting the E gene (Envelope small membrane protein) and the N gene (nucleoprotein). The E gene real-time RT-PCR can detect *Sarbecoviruses*, i.e. SARS-CoV, SARS-CoV-2 and closely related bat viruses. In the context of the COVID19 pandemic, it can be assumed that only SARS-CoV-2 strains will be detected by this assay given that SARS-CoV virus has been eradicated and other bat viruses do not commonly circulate in the human population. The E gene assay is adapted from Corman et al. [17]. The N gene real-time RT-PCR assay (N1 assay) specifically detects SARS-CoV-2 virus. It is adapted from the CDC protocol¹. The two primers/probe sets are presented in Table 3. The RT-qPCR protocols and reagents were all provided by the LIH.

Table 4 – RT-qPCR primer-probe sets

Target	Primer name	Primer sequence (5' to 3')	References
E gene	E_Sarbeco_F1	5-ACAGGTACGTTAATAGTTAATAGCGT-3	Corman et al., 2020
	E_Sarbeco_R2	5-ATATTGCAGCAGTACGCACACA-3	
	E_Sarbeco_P1	5'-FAM-ACACTAGCCATCCTTACTGCGCTTCG-BHQ1	
N gene	2019-nCoV_N1_Fw	5'-GAC CCC AAA ATC AGC GAA AT-3'	CDC, 2019
	2019-nCoV_N1_Rv	5'-TCT GGT TAC TGC CAG TTG AAT CTG-3'	
	2019-nCoV_N1 Probe	5'-FAM-ACC CCG CAT TAC GTT TGG TGG ACC-BHQ1-3'	

Each reaction contained 5 µL of RNA template, 5 µL of TaqPath 1-step RT-qPCR MasterMix (A15299, Life Technologies), 0.5 µL of each primer (20 µM) and probe (5 µM) and the reaction volume was adjusted to a final volume of 20 µL with molecular biology grade water. Thermal cycling reactions were carried out at 50 °C for 15 min, followed by 95 °C for 2 min and 45 cycles of 95 °C for 3 sec and 58°C (E gene) or 55°C (N gene) for 30 sec using a Viia7 Real-Time PCR Detection System (Life Technologies). Reactions were considered positive (limit of detection – LOD) if the cycle threshold (Ct value) was below 40 cycles.

¹ <https://www.cdc.gov/coronavirus/2019-ncov/downloads/rt-pcr-panel-primer-probes.pdf>

Controls

A non-target RNA fragment commercially available (VetMAX™ Xeno™ IPC and VetMAX™ Xeno™ IPC Assay, ThermoFischer Scientific) was added to the viral RNA extract from sewage concentrates as an internal positive control (IPC). This IPC-RNA is used to control the performance of the RT-qPCR (E gene) and to detect the presence of RT-qPCR inhibitors.

Viral RNA copies quantification of both targeting genes in wastewater samples was performed using RT-qPCR standard curves generated using EDX SARS-CoV-2 Standard (Biorad). This standard is manufactured with synthetic RNA transcripts containing 5 targets (E, N, S, ORF1a, and RdRP genes of SARS-CoV-2, 200,000 copies/mL each). Using such a standard, the limits of quantification (LOQ) of both RT-qPCR assays were estimated to 1 RNA copy per reaction (Figure 6).

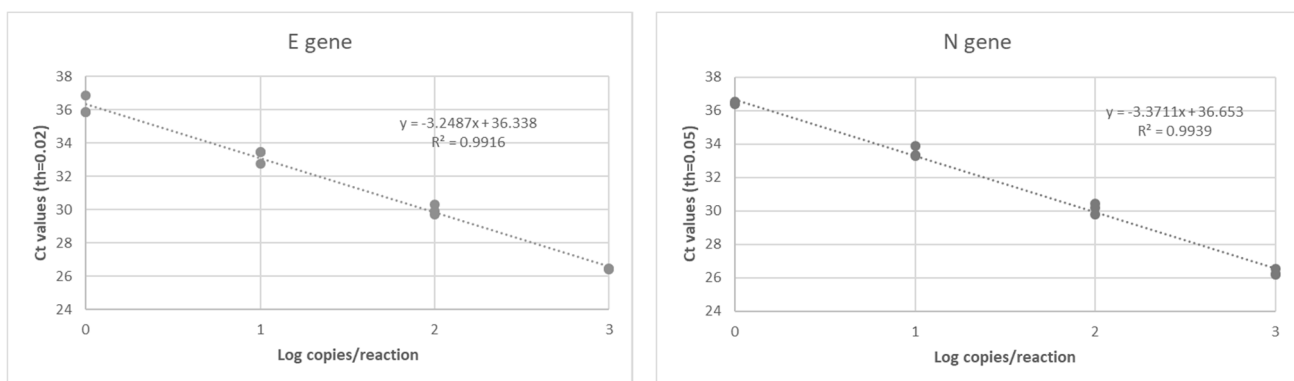


Figure 6 – RT-qPCR standard curves established for both target genes (E gene and N gene) of SARS-CoV-2 using a commercially available standard (Biorad).

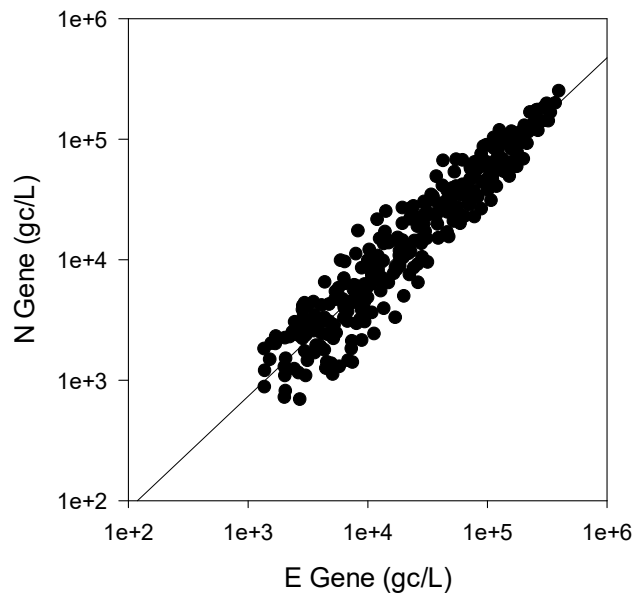
Data interpretation

A sample is declared positive for the presence of SARS-CoV-2 if both targets (E and N gene) are detected with Ct values less than or equal to the LOQ. If only one target is detected or if target genes are detected with Ct values between the LOD and the LOQ, samples are reported as presumptive positive (+/-). A sample is declared negative when no target genes are detected (Ct values superior to the LOD).

In case of presumptive positive, sample is tested again using another RT-qPCR detection assay (Allplex 2019-nCoV Assay, Seegene). This commercially available detection kit is a multiplex real-time RT-PCR assay for simultaneous detection of three target genes of SARS-CoV-2 in a single tube. The assay is designed to detect RdRP and N genes specific for SARS-CoV-2, and E gene specific for all *Sarbecovirus* including SARS-CoV-2.

As shown in Figure 7, a highly significant correlation (Pearson Correlation, $R^2=0.964$, $p = 5.979 \cdot 10^{-24}$) was obtained between the SARS-CoV-2 RNA concentrations estimated using the E gene and the N gene, respectively. Therefore, only the E gene results were presented in this report.

Figure 7 - Relationship between the SARS-CoV-2 RNA concentration (RNA copies / L of wastewater) estimated by the both distinct RT-qPCR systems targeting the E and N gene, respectively (n=415),



Acknowledgments

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