Water Supply

© 2023 The Authors Water Supply Vol 23 No 2, 948 doi: 10.2166/ws.2023.004

Two years of COVID restrictions: A lesson from water demand data

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ABSTRACT

The long period of great fragility experienced by the lockdown has strained entire countries. In response to COVID-19, Italy performed stay-at-home orders to attenuate disease spread, provoking drastic changes in all aspects of users' behaviour, particularly affecting water demand. A dataset of hourly water demand for 2019, 2020, and 2021, related to five Italian towns permitted to observe water consumption changes. Trends highlight a general decrease in water consumption, linked to the strict restrictions imposed and a morning peak shift. At the end of the strict quarantine regulations, water consumption did not return to pre-pandemic values because COVID-19 has led to a change in lifestyle.

Key words: COVID-19, users' habit, water drinking demand

HIGHLIGHTS

- The study compares the demand for drinking water over three years, two during the pandemic and the previous one, for five population centres in Italy.
- The impact of COVID-19 on water consumption is evident in a change in user habits.
- Reduced commuting and the closure of a huge commercial area impacted the demand for drinking water.

INTRODUCTION

The COVID-19 pandemic, which reached the European continent in the winter of 2020, is one of the most difficult challenges for current generations, representing and tracing what the Spanish flu pandemic had been for previous generations, the last ones dealing with a global pandemic. Even now, at this paper's submission date, we are far from the end of the pandemic, which, although reduced in intensity by vaccines and the high immunisation rate reached in Europe, continues to claim victims.

Although some of the passive containment measures introduced persist today, a large part of the population has now assimilated certain behaviours to counter the virus's spread.

However, the restrictions introduced by the various European governments at the end of the winter of 2020 represented a real shock for millions of people. People were forced to change their lifestyles overnight. Social distancing had a decisive impact on sociality and everyday life as known up to then, opening up entirely new scenarios for which most were almost unprepared. Only a few work activities have not been interrupted (healthcare workers, public service operators, and workers in the distribution of primary commodities), while the remainder have suffered the stop or to reorganise using remote working.

The water sector, since the World Health Organization (WHO) declared the COVID-19 disease a public health emergency, has received little attention, so many of the activities have become more complicated, including monitoring of water networks and withdrawals, a crucial element in curbing wastage of water resources (Antwi *et al.* 2021).

Nevertheless, COVID-19 disease strictly impacted water demand and the urban water cycle (Feizizadeh *et al.* 2021; Girón-Navarro *et al.* 2021; Sowby & Lunstad 2021; Spearing *et al.* 2021). During the lockdown, the pandemic caused different distribution and timing of drinking water demand (Heidari & Grigg 2021). During the lockdown period, the domestic water consumption in various areas increased with a decrease (and a delay) in peak morning and an evident growth on weekdays (Balacco *et al.* 2020; De Oliveira *et al.* 2020; Alvisi *et al.* 2021). People remaining at home increased household water consumption, especially for preventive behaviours and changes in hygiene practices, exasperating the pressure on the water network (Abu-Bakar *et al.* 2021; Campos *et al.* 2021). Restriction measures influenced water demand; examining the instantaneous flow data of five Apulian towns in Italy during the lockdown demonstrated that citizen habits significantly impact water demand (Balacco *et al.* 2020). Also, the social distancing policy implemented to prevent COVID-19 determines a temporal and spatial shift in water demand in the cities investigated, obliging water utilities to change their operational issues in response to the different daily demands (Gatto *et al.* 2020). There is a clear relation between the preventive measures and governmental regulations during the COVID-19 pandemic and the alteration in water consumption patterns. Lüdtke *et al.* (2021) pointed out an increase of about 14.3% in residential water consumption per day, with higher morning and evening demand peaks in Germany. Nemati & Tran (2022) indicated an overall increase of between 3.08 and 13.65% in daily water consumption in US. Cominato *et al.* (2022) highlighted a significant increase in water consumption during the COVID-19 and the peak water consumption times are also changed.

Changes in work and life routines and the closure of many collective activities determine the substantial differences in typical patterns of urban water use (Irwin *et al.* 2021; Li *et al.* 2021; Renukappa *et al.* 2021).

However, these results are strictly affected by the strength of the restriction imposed. In the Czech Republic, lockdown is not as strict as in other countries, so it did not significantly affect water demand. Trends in the household water supply are like those of the pre-pandemic period because the government allowed more freedom to a citizen, which had minor rules to prevent COVID-19 (Ansorge *et al.* 2021). Besides, in rural areas of Africa, where COVID-19 was not very impactful, there were no mobility restrictions.

In Italy, the social distancing measure has stopped almost all work activities to avoid contact between people who do not belong to the same family unit, leading to the emptying of factories and offices. The epidemic outbreak in Italy and citizens locked up in their homes for quarantine determined an increase in water demand from 220 L per day to almost 270 L used on average by one person (Motta Zanin *et al.* 2020; Bakchan & Roy 2021). Alvisi *et al.* (2021) demonstrated that, during the lockdown period, the average water consumption in a residential district metered area increased by approximately 18%.

Among the effects of the pandemic and lockdown, national data highlighted a shift in the water demand in the morning a couple of hours forward, thanks to closed schools and remote working. The peak in water demand was recorded in the lockdown period, always around 8:30 am, differing from the pre-pandemic period when it was around 6:30 in the morning (Balacco *et al.* 2020).

MATERIALS AND METHODS

Acquedotto Pugliese (Puglia Aqueduct, AQP in the following lines), the water management authority of the Apulian region, is the largest aqueduct in Europe and consists of a complex of interconnected 'trunks' and aqueduct infrastructure branching off from the main canals and supplying water to around 300 municipalities in Puglia and Campania. AQP manages over 21,000 km, just over 10,000 km of sewerage networks, and 182 wastewater treatment plants.

We made the assessments by comparing the water demand of five municipalities (Figure 1) in Puglia between January 2019 and September 2021. AQP extracted data from the remote-control system of the AQP at a 10-min interval. The considered period also represents the effects of the COVID-19 pandemic restrictions introduced by the Italian government between March and April 2020 and in the winter and spring of 2021.

The five considered towns (Table 1), indicated in the following with Town and a number increasing with the number of inhabitants, are very different from each other, not only for the population but also for the type of users. A high number of commuters in the case of Town 5, about 73,000 inhabitants, and the presence of commercial activity (two large commercial areas with more than 250 shops) in Town 4.

Thanks to remote-control systems, AQP monitored the flow rate data both on an hourly and daily scale to thoroughly analyse if and how the sudden change in lifestyle habits of a large part of the population determined by pandemic conditions influenced the trend of water drinking demand observed up to that point. The analysis was carried out using appropriate modelling capable of underlining water demand trends and their influence on the different water uses (Alvisi *et al.* 2003; Alcocer-Yamanaka *et al.* 2012; Bich-Ngoc & Teller 2020).

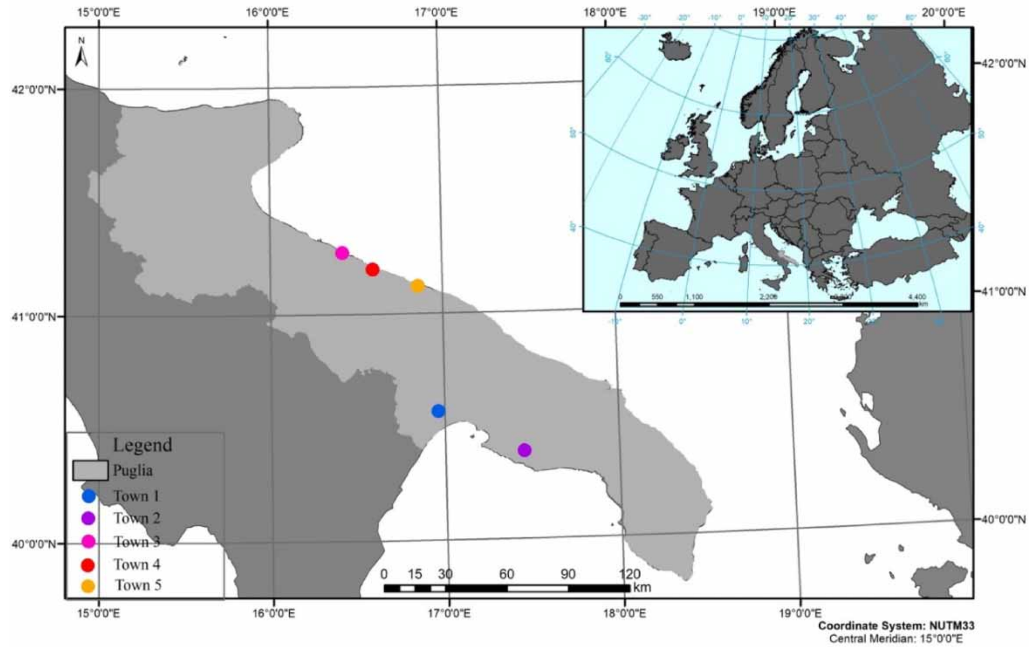

Figure 1 | Different colours represent the five Apulia Towns considered in the studies.

Table 1 | The number of inhabitants for each examined town in 2019, 2020, and 2021

Towns analysed	2019 Inhabitants[a]	2020 Inhabitants[a]	2021 Inhabitants[a]
Town 1	7,670	7,630	7,562
Town 2	9,812	9,732	9,698
Town 3	55,610	55,405	55,175
Town 4	58,389	58,145	57,682
Town 5	316,491	315,284	313,003

[a]*Source:* ISTAT (2021).

Data used in this paper were recorded each day with a 10-min interval, from 0:00 to 23:50, starting from 1 January 2019 to 30 September 2021.

Analyses were carried out to exclude the possible dependence of the reduction in water consumption on socio-demographic, socio-economic, and climatic factors to verify that the hypothesis according to which the observed reduction in water demand depended on the restrictive measures imposed by the pandemic was plausible. The assessments were conducted according to the methodology proposed in the study on the effects of the lockdown on water consumption for a town district in Northern Italy (Alvisi *et al.* 2021)

The analyses refer to entire towns and not individual districts, arriving at different considerations, as reported below.

Concerning socio-demographic and socio-economic variables, any changes in the price of drinking water were examined, noting that there were increases of less than 1 euro cent, which were not significant and not such as to determine lower consumption by users. In addition, no awareness campaigns have been aimed at individual towns in the years analysed to influence water consumption practices. Finally, as shown in Table 1, there have been no substantial variations in the number of inhabitants of the single towns beyond the physiological contraction, which we have witnessed for years.

Regarding the possible influence of climatic factors on water consumption, the data on the average monthly temperature and the data of the average monthly rainfall for the years 2019, 2020, and 2021 were analysed, finding that no anomalous values were recorded and that they were not significantly varied over three years under examination.

In addition, statistical tests were performed on the dataset to verify that the variation in pre-pandemic and pandemic water consumption is linked to one or more factors, preliminarily formulating a working hypothesis on the parameter being studied. The hypothesis tests carried out were based on the study of the sample distribution of the test statistic, calculated on the available water consumption data. Data analyses were conducted to determine whether the null hypothesis (the water consumption variation is totally random) is valid for all the investigated towns.

The hypothesis to be tested, called null hypothesis H_0, with which the statistical data analyses were started, shows that the variation in water consumption is random and the values are not significant in terms of support for the thesis of this paper; in other words, the null hypothesis states that there is no relationship between the examined variables. At the same time, with the alternative hypothesis H_1, it is assumed that water consumption has changed due to one or more causes not attributable to the case and that, therefore, the results are significant and support the formulated hypothesis.

The statistical significance level is expressed with a *p*-value between 0 and 1. The smaller the *p*-value, the more substantial the evidence that the null hypothesis should be rejected; conventionally, a significance value of 0.05 is used.

To assess whether the null hypothesis is valid or should be rejected, it is necessary to perform a test, which can be of the parametric or non-parametric type. The Shapiro–Wilk *W* test is used to identify the type of test that best conforms to the given data, which defines whether a sample has a Gaussian distribution (Royston 1992; Hanusz *et al.* 2016):

$$p = \frac{\left(\sum_{i=1}^{n} a_i w_{(i)}\right)^2}{\sum_{i=1}^{n} (w_i - \bar{w})^2} \tag{1}$$

where $w_{(i)}$ (index i included in brackets) is the smallest water consumption value (rank i) of the sample; $\bar{w} = \frac{(w_1 + \ldots + w_n)}{n}$ is the arithmetic mean of the water consumption values of the sample, and the constants a_i are given by:

$$a_i = \frac{m^T V^{-1}}{(m^T V^{-1} V^{-1} m)^{1/2}} \tag{2}$$

where $m = (m_1, \ldots, m_n)$ are the expected values of the ranks of a standardised random number; and V is the covariances matrix of these ranks.

It is also necessary to perform the homogeneity check of the variances of the investigated samples, carried out by the non-parametric test to verify the homogeneity of variances (Levene's test), to check the homogeneity of variances in groups that do not follow a normal distribution (Anderson 2006).

The Wilcoxon test is used for non-normal distributions of the data, which is the non-parametric equivalent of the Student's *t*-test. It involves calculating a statistic that has a known distribution under the null hypothesis (Woolson 2008).

From the complete dataset, one for each town analysed, a sample of 288 data was extracted, the first half for the year 2019 and referring to the day 25 March, and the second half for the year 2020, relating to the day 23 March. The extracted samples are both associated with the same day of the week, that is, Monday. The analyses were performed similarly for each of the five towns investigated and referred to in Table 1.

These extracted samples, divided into two vectors of 144 data each, were then subjected to statistical analysis, preliminarily using the Shapiro–Wilk and Levene's tests, the first to verify the possible normal distribution of the extracted data and the second to evaluate whether the variances were homogeneous. These analyses made it possible to identify the type of test, parametric or non-parametric, which best described the considered dataset and allowed us to evaluate the validity of the null hypothesis.

Since the analyses carried out with the Shapiro–Wilk *W* test have shown a non-normal distribution of the data, Levene's test was used to verify the homogeneity of the variances, obtaining non-homogeneous sample variances.

Statistical evaluations made using the Shapiro–Wilk *W* test, Levene's test, and the Wilcoxon test show that data distributions are not normal, and variances are not homogeneous, so it became necessary to use the Wilcoxon non-parametric test (Royston 1992; Anderson 2006; Woolson 2008; Hanusz *et al.* 2016).

Since *p*-values from the Wilcoxon test for all analysed towns were smaller than 0.05, it is possible to affirm that the null hypothesis must be rejected in all cases. This means that the alternative hypothesis is true, i.e. the water consumption variation was not random but linked to one or more causes. Table 2 reports the results of the statistical analysis.

Table 2 | Shapiro–Wilk, Levene, and Wilcoxon test results

		Town 1	Town 2	Town 3	Town 4	Town 5
Shapiro–Wilk test	*p*-value 2019	$1{,}703 \times 10^{-6}$	$3{,}562 \times 10^{-6}$	$5{,}107 \times 10^{-10}$	$1{,}964 \times 10^{-7}$	$4{,}618 \times 10^{-6}$
	p-value 2020	$3{,}676 \times 10^{-6}$	$2{,}066 \times 10^{-6}$	$6{,}908 \times 10^{-9}$	$9{,}056 \times 10^{-7}$	$2{,}674 \times 10^{-6}$
Levene's test	*p*-value 2019	$3{,}313 \times 10^{-3}$	$1{,}057 \times 10^{-3}$	$1{,}519 \times 10^{-4}$	$1{,}376 \times 10^{-15}$	$2{,}578 \times 10^{-9}$
	2019 significance	**	**	***	***	***
	p-value 2020	$6{,}777 \times 10^{-3}$	$5{,}083 \times 10^{-5}$	$2{,}794 \times 10^{-6}$	$7{,}350 \times 10^{-8}$	$8{,}452 \times 10^{-5}$
	2020 significance	**	***	***	***	***
Wilcoxon test	*p*-value	$9{,}345 \times 10^{-4}$	$1{,}922 \times 10^{-2}$	$2{,}200 \times 10^{-16}$	$1{,}109 \times 10^{-7}$	$2{,}200 \times 10^{-16}$

Legend: ***$0 < p\text{-value} < 0.001$; **$0.001 < p\text{-value} < 0.01$; *$0.01 < p\text{-value} < 0.05$.

Data analyses

After performing statistical analyses, it was decided to investigate different periods, according to the aim to analyse differences between the pre-pandemic period (2019), the pandemic lockdown (2020), and the 'Italian coexistence period' with the virus (2021). Furthermore, the present study analyses the impact of water demand produced by different restrictions imposed by the Italian government in 2021 (coloured zone), when selective closures of activities were carried out as the number of infections changed.

The collected data were aggregated on a daily temporal scale to identify the average daily volume and, therefore, evaluate the water consumption even on a daily scale over a more extended time series. This allows for investigating whether the changes recorded were systematic or related to the level of restrictions imposed by the government. The average daily volume of water consumption V_d for each town investigated was calculated:

$$V_d = \frac{\sum_{i=1}^{24} \sum_{j=1}^{6} v_{i,j}}{n} \quad (3)$$

where $v_{i,j}$ is the instant volume obtained from AQP remote-control system, i is the number of hours in a day ($i = 1, \ldots, 24$), j represents the number of observations in 1 h ($j = 1, \ldots, 6$), and n is the number of data available for 1 day with 10-min interval ($n = 144$).

The variables analysed are the hourly water demand and the daily-cumulated volume. Data were displayed through line plots, correlating the abovementioned variables to time.

RESULTS

The analysis of the collected data compared the 2019 drinking water consumption data with those from the first lockdown in 2020 (4 March–30 April 2020) and the subsequent one in 2021. The Italian government set the first lockdown from 4 March to 3 May 2020, with the progressive closure of schools and universities (4 March 2020), all commercial shops except groceries and pharmacies (10 March 2020), and non-essential productive industries (23 March 2020). In 2021, the Italian government enacted a law dividing the country into three different coloured zones (*Red*, *Orange*, and *Yellow*) depending on the contagion trend. Differences among the three zones regarded unlike levels of mobility restrictions and the closure of some activities, almost all in the *Red* zone, while in the *Yellow* zone, more mobility was allowed. The Apulia region was identified as the *Red* Zone between 15 March and 25 April, the *Orange* zone from 26 April to 9 May, and the *Yellow* zone between 10 May and 13 June.

AQP data collected, expressed in terms of instantaneous flow data, were processed to obtain the average daily volumes using Equation (3). Such data are essential to analyse a determined town's water demand trend differences between January and September 2019, 2020, and 2021 (Figure 2). In addition, average daily volume data were processed with an appropriate calculation code to extract peak values, divided between weekdays and weekends, for the periods January–May 2019, 2020, and 2021.

The availability of measures made it possible to compare the data collected in the period 23–29 March 2020 with the relative data in an equivalent week of the previous year, 25–31 March 2019, and a comparable week of the following year, 22–28 March 2021.

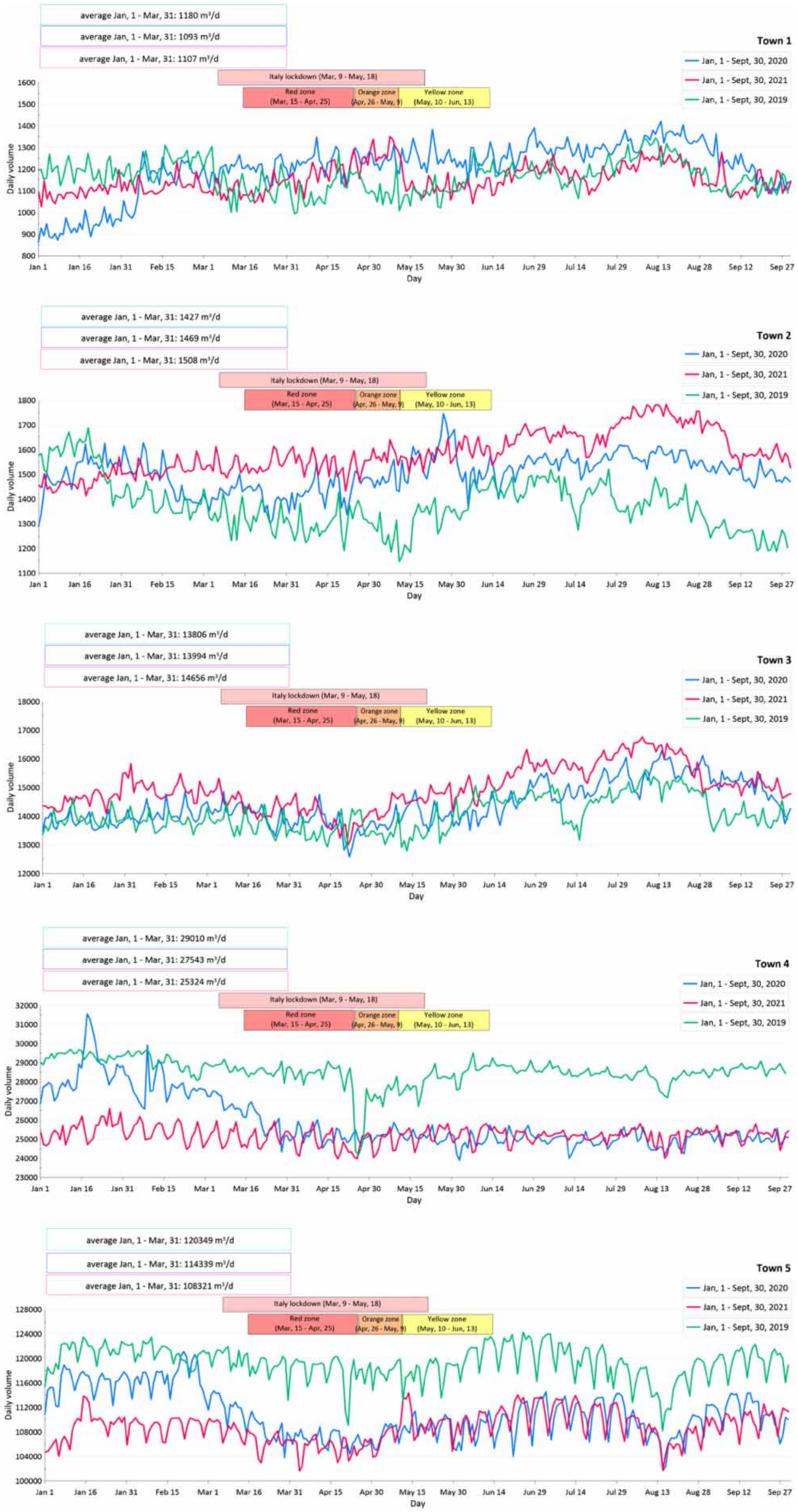

Figure 2 | Daily volume trends from January to September for, respectively, 2019, 2020, and 2021 for the analysed towns.

DISCUSSION

The analysis comparing daily volumes of the three considered years from January to September (Figure 2) demonstrated that the daily water volume for the first three cases (Towns 1, 2, and 3) is almost unchanged in quantitative terms during the years of the COVID-19 pandemic. In small towns (Towns 1 and 2) with a predominantly agricultural vocation, a situation in contrast with the large urban cities is observed, with slight increases in water demand instead of the pre-pandemic period, probably related to the reduction in commuting to larger centres in the proximities of a part of the population that works or attends school in a town other than that of residence which, being less populous, has fewer services and productive activities. In fact, agricultural activity has not suffered any limitations to its development, and at the same time, many students and workers, who went to neighbouring cities, mainly stayed in their homes due to the government-imposed lockdown that restricted all urban and suburban mobility. Town 3, even if more considerable than the other two, has suffered from the presence of commuters who daily travel away from the city for both work and study and stay-at-home during the pandemic.

The data for Towns 4 and 5 show an overall reduction in water demand. Daily volume data for Town 4, characterised by the presence of two large shopping centres (the largest in the Apulia region), highlights a reduction in the total water demand between 2019, 2020, and 2021, probably due to the prolonged closure of the commercial areas during the lockdown periods. A sharp drop was detected in Town 5, where the absence of about 72,000 commuters (students and workers) linked to the simultaneous closure of, e.g. schools, offices, universities, shops, business centres, and companies, affected the total daily water demand considerably. However, 2021 values show a similar water demand to 2020, despite the gradual reopening of work activities, offices, and institutional activities, but fewer consumptions than in 2019.

Altogether, data indicate a reduction of about 9% for 2020 and 12% for 2021 for Town 4 and 41% for 2020 and 9% for 2021 for Town 5. Moreover, it emerges that, for Towns 4 and 5, the passage from an ordinary condition (pre-COVID-19) to the pandemic condition determines a significant decrease in water consumption because of the closure of collective activities. Water consumption from March 2020 to September 2021 has not significantly changed due to restrictive measures imposed on commercial activities and socio-psychological conditions resulting from the fear of the pandemic.

Plots show that the water demand for 3 weeks in 2021, in which Puglia was respectively 'red', 'orange', and 'yellow' zone, has not changed. The data show that collective activities, which were never allowed in the three periods, probably affected water demand the most.

In general, in the months with the highest number of infections, the 2021 trend follows the 2020 one because all principal restrictive measures remain. However, the restrictions in 2021, especially in the orange rather than red zone, were not as stringent as those in 2020. We can justify a similar behaviour by considering the psychological and social effects on the population due to the Covid-19 pandemic (Saladino *et al.* 2020).

The maximum daily flow rate for the weeks and the weekends and the corresponding time related to March–May in 2019, 2020, and 2021 have been isolated and reported for Town 2, Town 4, and Town 5 (Figure 3). Data provided evidence of how and how much population habits have changed due to the lockdown imposed to prevent the virus's spread.

We can attribute the main differences between the three datasets to the time lag of the morning peak observed during the week. It was delayed by about 2 h in 2020 and 2021 compared to 2019, as in the pre-pandemic period, it was from 6.00 to 8.00 am, while in the post-pandemic period, it was between 8.00 and 10.00 am. The trends in 2020 and 2021 are similar in peak values and spatial data distribution, showing a significant difference in total water demand compared to 2019. This lag is probably related to a delayed morning wake-up time resulting from distance learning and remote working, which no longer requires travel to study and work locations, thus saving time.

During the weekend, the situation seems not to change regarding the maximum daily flow rate time.

In addition, times indicated a substantial uniformity between weekdays and weekends during both the lockdowns, indicating that forced stay-at-home has led to standardising user habits during the days of the week.

We can observe a situation different for the maximum daily flow rate entity. Town 2 does not show an increase in the week or the weekend. On the other hand, Towns 4 and 5 show that the maximum daily flow rate changed in quantity since the beginning of the blockade and continued COVID-19 restrictions in 2020.

The maximum daily flow rates underwent a gradual reduction, with minimum peaks reached in March and April 2020, characterised by the most severe restrictions, no longer returning to pre-pandemic values during the same months of 2021.

Figure 3 | Time and peak values related to the period January–May of 2019 (green), 2020 (red), and 2021 (blue) on (a) weekdays and (b) weekends for Town 2, on (c) weekdays and (d) weekends for Town 4, and on (e) weekdays and (f) weekends for Town 5.

In addition, it is essential to underline how, in the cited towns, the secondary peak, close to lunchtime between 2 and 4 pm, which was particularly noticeable for town 2 in 2019, disappears entirely in the first lockdown in 2020 and the second in 2021 (Figure 4). The users are all at home, which leads to a redistribution of water consumption over a completely different time interval,

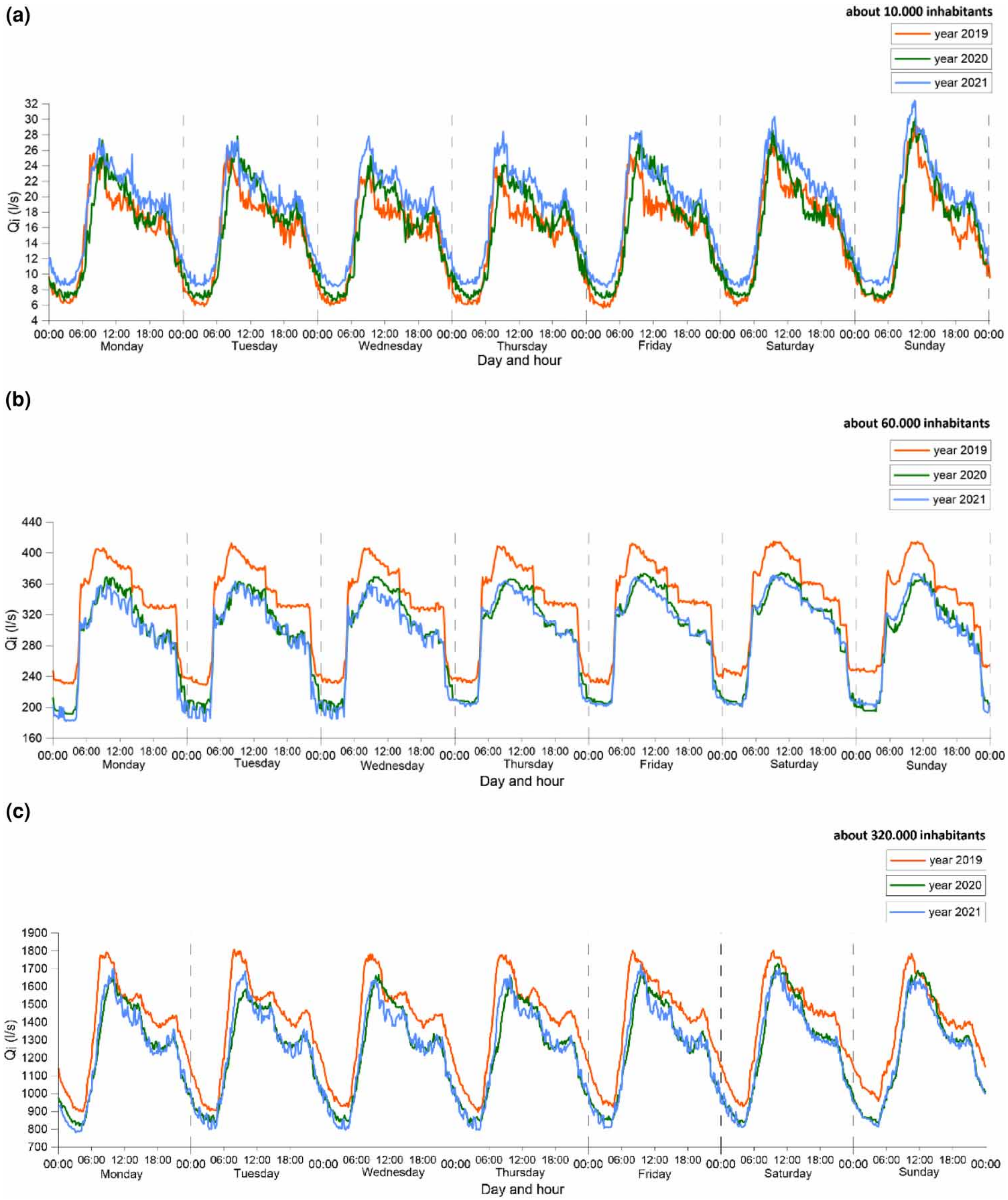

Figure 4 | Hourly water drinking daily demand trends for Town 2 (a), Town 4 (b), and Town 5 (c) during the COVID-19 lockdown (22–28 March 2021, 23–29 March 2020, and 25–31 March 2019).

leading to a smoothing process of the consumption itself. Furthermore, for Town 2, which is smaller than Town 4 and Town 5, a substantial decrease in the number of peaks can be observed; the morning peak, linked to the hygienic and sanitary habits of the townspeople, continues to be observed, but consumption in the central hours (lunch) and in the evening (dinner) tends to expand over time. This is probably by virtue of changed habits linked to staying at home, which no longer imposed almost equal times on the population for lunch and dinner, during which water consumption was concentrated, linked to work time, but allowed them to choose the most opportune time for each, thus lowering peaks and diluting consumption over a wider time span.

On the contrary, in the larger centres, with a greater number of educational and personal services and work activities, the peaks in consumption, concentrated mainly in the morning and evening, were only shifted in time.

On the other hand, the evening and night situation does not change in terms of weather. Habits related to the evening and the time when water demand is drastically reduced seem not to have changed much.

At the end of the analysis shown in this paragraph, it emerges how government restriction measures produced substantial changes in water demand due to the stop imposed on industrial and commercial activities that have changed styles of life, work, and education known until then. Furthermore, the data collected by AQP and the trend shown by them about the comparison between the pre-pandemic periods and the months of lockdown highlights how the social dynamics and lifestyle habits of the population greatly influence water drinking demand and are determining factors for the critical evaluation of consumption (Balacco *et al.* 2020).

Finally, from the analysis of all the plots shown in the previous paragraph, it emerges that in Apulian tourist towns, such as Town 2 and Town 3, there was an increase of about 10% in consumption during the summer period of 2021 during the same period of 2020, under identical conditions, due to the rise in tourist presences (Puglia Promozione 2019, 2020, 2021; Bich-Ngoc & Teller 2020). In addition, it is essential to underline, in the cited towns, the secondary peak of daily water consumption, around 7 pm, and the one allocated in the morning. Both these two situations need to be adequately investigated through the evaluation of water consumption trends for towns with the same tourist vocation and the comparison with what emerged in this study, as this result is not the objective of this article.

There will probably be a reversal of water consumption trends in post-COVID-19. Therefore, the health crisis will lead to a lasting reduction in water consumption, with the perspective of a more environmentally sustainable world (Zambrano-Monserrate *et al.* 2020).

CONCLUSIONS

The COVID-19 pandemic is undoubtedly one of the most critical global challenges that actual generations face, affecting all life sectors.

As illustrated in the previous paragraphs, starting from flow data extracted from the remote-control system, this analysis aimed to describe how the restricted measures introduced during the pandemic by national and regional governments determine changes in water demand.

Plots indicate a general reduction in water consumption, starting from the beginning of the pandemic, for large cities, where there are more collective activities, unlike what happened in smaller towns, where the impact on water consumption of the COVID-19 restrictions and the socio-psychological condition created was less significant.

Restrictive measures determine a shift in the morning peak, in all investigated towns, of about 2–2.5 h; if in the pre-pandemic period the peak was until 8 am, during the pandemic, due to a delayed morning wake-up call coming from schools and activity closures and the implementation of distance learning and remote working, which no longer required travel to places of education and work.

The analysis of water consumption for three different weeks in which Apulia was ‘red zone’, ‘orange zone’, and ‘yellow zone’ highlighted that the restricted measures provided determined a change in water demand in larger towns (Town 4 and Town 5) due to the stop of collective activities, showing that the latter, which were not always allowed during the three periods, influence the most water demand values.

However, in 2021, when the pandemic is less relevant thanks to high levels of vaccination and a reduced fear in the population due to the waning of the virus, plots denote a slight recovery in water consumption, of about 10%, regarding tourist towns and to the summer period.

This study demonstrates that implementing changes in daily habits, such as the working lifestyle and users' lifestyle habits, significantly impact daily water consumption trends, and those collective activities produce a significant increase in drinking water consumption.

It emerges how government restriction measures produced substantial changes in water demand due to the stop imposed on industrial and commercial activities that have changed styles of life, work, and education known until then. Consequently, this demonstrates that the performance of a water network can be affected by the phenomenon of commuting and by the possible presence of large commercial areas, which must be duly taken into account when designing the distribution network.

ACKNOWLEDGEMENTS

The authors thank AQP for providing technical support and data. Moreover, they thank Dr Vincenzo Totaro for the helpful suggestions.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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First received 15 November 2022; accepted in revised form 23 December 2022. Available online 17 January 2023