

## Research Paper

# Effect of television broadcasts of global sporting events on short-term changes in the use of water from the water supply network

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### ABSTRACT

The article discusses the influence of television broadcasts of global sporting events on water usage in the city of Toruń during the final match of the FIFA 2014 World Cup in Brazil. The analyses covered accurate data of water usage (recorded every 1 minute) in the city on the day of the final match. The obtained results were compared with the data for the same days of the week (Sundays) but with no such important events. A completely different trend in water usage was documented during the television broadcast, including: exponential and short-term increases and decreases in water demand immediately after the end of the successive parts of the football match. The deviations in water usage from the normal trend for the same day of the week and the same hours ranged from  $-318$  to more than  $550 \text{ m}^3 \cdot \text{h}^{-1}$  (calculated on an hourly basis). Therefore, water usage can be a good indicator of the interest of audiences in television programmes, particularly in those gathering millions of viewers, such as broadcasts of global sporting events.

**Key words** | FIFA 2014 World Cup, flush analysis, toilet facilities, water supply

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### INTRODUCTION

Global sporting events have been among the most popular television programmes for years. They collect the highest number of viewers. Football matches, and especially the World Cup, are particularly important. One of the latest events of this type was the FIFA 2014 World Cup in Brazil, held from 12 June to 13 July 2014. According to the [Kantar Media \(2014\)](#), the in-home television broadcast reached a projected total audience of 94.8 million people around the world based on viewers watching 1 full minute of the coverage, and the average live in-home global audience was 22.6 million. The highest average audience was recorded in Brazil (11.6 million people). The average audiences of over 1 million were generated in five other territories: Colombia, Germany, Poland, South Africa, and Turkey. Notice that countries with the highest numbers of viewers also include those that did not qualify for FIFA

2014 World Cup Brazil, namely Poland, South Africa, and Turkey ([KantarSport 2014](#)).

Various mega-events are known to cause a number of economic, social, and political effects ([Dodouras & James 2004](#)). During the events, short-term changes in the lifestyle of television viewers, and particularly sports fans, are observed ([Horne & Wolfram 2006](#)). Such changes involve a temporary cessation of house work when watching television at home and outside (in pubs or specially organised sports fan zones). This change in behaviour results in disturbances in water usage in comparison to the average daily cycle ([Focus Online 2006](#); [Oldiges 2015](#)).

The objective of this paper is to assess the evidence of the effect of television broadcasts from global sporting events on short-term changes in the use of water from the water supply network in the city of Toruń (Poland). The

data for the analysis were collected during the final match of the FIFA 2014 World Cup in Brazil, watched by approximately 30% of 210,000 residents of Toruń. The water supply network in Toruń has a long history dating back to the 14th century. It was then that a gravitational system of water supply was built using wooden pipes. The pipes began to be gradually replaced with cast iron ones only in the early 19th century. The length of the water supply network currently amounts to 576.9 km. It is used by 97.8% of the city's residents. Mean water consumption in households is  $33.6 \text{ m}^3 \cdot \text{year}^{-1}$  (for comparison, in all larger cities of Poland the value amounts to  $34.3 \text{ m}^3 \cdot \text{year}^{-1}$ , according to data from the Central Statistical Office of Poland).

The remainder of this paper is composed of four parts. The following section presents the research methodology. The next section presents the results, which is followed by a discussion section that explores the implications of short-term disturbances in water consumption. The concluding section emphasises the wide significance of the problem and its lack of consideration in international studies.

## METHODS

The analysis of the effect of television broadcasts of global sporting events on short-term changes in water usage in the city concerned the final match of the FIFA 2014 World Cup in Brazil between Germany and Argentina, held on 13 July 2014. The city is provided with water from two water intakes. Both of the intakes feature devices recording the amount of water introduced to the water supply network every 1 minute. The system measuring water flow uses electromagnetic flow meters and has been functioning since 2008. Flow meter MAGFLO by SIEMENS was installed on one of the intakes, and FM 300 by ENKO Gliwice on the other. The aforementioned devices ensure the highest precision of measurement, because they contain no internal mechanical elements. These devices ensure the undisturbed flow of the measured water. Flow measurement is independent from water pressure, its density, viscosity, or temperature. From the moment of introduction of the automatic measurement system, the water supply company has been collecting data and results of analyses of rapid changes in water demand. This permits forecasting of such changes during

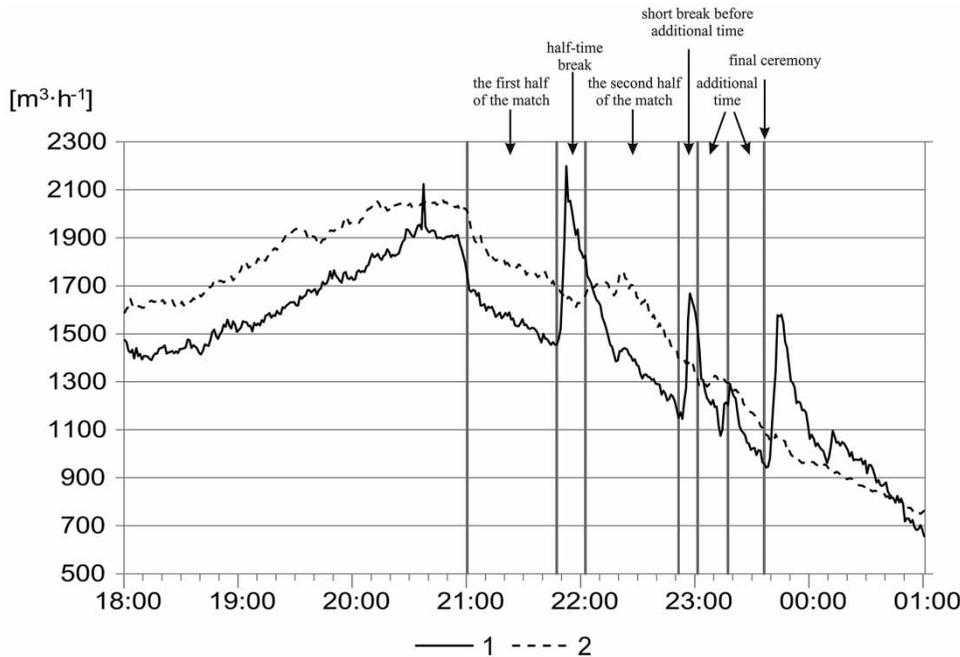
other important events (including popular TV shows), and an increase in water pressure in the network in advance.

The water supply company in Toruń does not benefit from a commercial program such as DemandWatch. The operation of the network and access to data is ensured by an in-house computer program dedicated to devices used in the company. The program does not allow for advanced analyses such as those in the case of DemandWatch. However, it permits obtaining detailed data on water use in each minute. It cannot be qualified to typically intelligent programs discussed by Boyle *et al.* (2013).

A database was developed with values of water usage every 1 minute on the day of the final match. Particular attention was paid to water usage during the hours directly preceding the final match, during the match, and after it. A separate database was established for all Sundays in June and July 2014 without matches. This permitted a comparison of the course of water usage in the city on Sundays with no football matches with the Sunday of the final World Cup match. The indices of deviation of water usage during the match from the mean value at the same time on days with no matches were calculated.

## RESULTS

The course of water usage on Sundays in Toruń is characterised by mild changes. A systematic increase in water intake is observed from 6 a.m. to 10 a.m. (on average from  $790$  to  $1,930 \text{ m}^3 \cdot \text{h}^{-1}$ ). Then it is maintained at a level of approximately  $1,900 \text{ m}^3 \cdot \text{h}^{-1}$  until 1 p.m. In the second part of the day, an insignificant decrease in water usage is recorded (from  $1,900$  to  $1,650 \text{ m}^3 \cdot \text{h}^{-1}$  from 1 p.m. to 6 p.m.), followed by an increase to approximately  $2,000 \text{ m}^3 \cdot \text{h}^{-1}$  by 9 p.m. Late in the evening and by night, water usage systematically decreases (the detailed course of water usage is presented in Figure A1, available with the online version of this paper). The water usage in the city by households is comparable to that of similar sized cities in Europe (see Ren *et al.* 2016; Soto-Córdoba *et al.* 2016). The water usage reflects the daily biological rhythm of the vast majority of residents of cities. In this context, the course of water usage during the television broadcast of the final match on 13 July 2014 was completely different (Figure 1). The final match (Germany vs. Argentina)



**Figure 1** | Course of water supply in Toruń on Sunday evenings: 1 – on 13 July 2014; 2 – on average in summer 2014 with no football matches.

began at 9:00 p.m. UTC + 1. Several phases of demand for water considerably deviated from the norm during the match:

- a fast decrease in demand from 1,912 down to 1,455  $\text{m}^3\cdot\text{h}^{-1}$  beginning several minutes before the start of the broadcast and persisting over the first half of the match (20:55–21:47);
- a soaring increase in water demand from 1,455 to 2,199  $\text{m}^3\cdot\text{h}^{-1}$  in the first minutes after the first half of the match (21:47–21:52);
- a fast decrease in water demand from 2,199 down to 1,146  $\text{m}^3\cdot\text{h}^{-1}$  beginning at the end of the break and persisting over the second half of the match (21:47–22:53);
- another increase in water demand from 1,146 to 1,668  $\text{m}^3\cdot\text{h}^{-1}$  during the second break before the overtime (22:53–22:57);
- another decrease in water demand from 1,668 down to 947  $\text{m}^3\cdot\text{h}^{-1}$  during the overtime with a momentary increase during a short break (22:57–23:38);
- another increase in water demand from 947 to 1,579  $\text{m}^3\cdot\text{h}^{-1}$  after the end of the overtime (23:38–23:45); and
- a decrease in water demand from 1,579 down to 955  $\text{m}^3\cdot\text{h}^{-1}$  during the closing ceremony (23:45–00:08).

The fastest increase in water demand was recorded in the first 5–6 minutes of the two breaks (after the first half of the match and after the second half, and before the overtime), and after the end of the overtime. At the beginning of the first half-time break, the rate of the increase in water demand amounted to 124  $\text{m}^3\cdot\text{h}^{-1}$  on average, and 105.1  $\text{m}^3\cdot\text{h}^{-1}$  after the overtime. The total increase in water demand equalled 51.1% at the beginning of the first break, and reached 66.7% after the end of the overtime (Table 1). Considering regular water demand in the evening hours, all these values prove considerable divergence from other Sundays. Before the match kick-off water demand was lower (by approximately 8%) than the average. During the subsequent parts of the television broadcast, the differences between regular water use and the use during the match ranged from several to several dozen percentage points. The highest water demand was recorded during the first break. It averaged 1,872.7  $\text{m}^3\cdot\text{h}^{-1}$ , i.e. it was nearly 14% higher (Table 2). The greatest differences (above 22%) were recorded during the closing ceremony. It was held at midnight when water usage is already at a low level.

The strong variability in water demand during the period directly preceding the match, during the match, and after its end is not observed in the analysed time intervals

**Table 1** | Increase in water demand during the first 5–6 minutes of the breaks and after the end of the additional time

Half-time break/the end of the game	Time	Increase		Average increase $\text{m}^3\cdot\text{h}^{-1}$
		$\text{m}^3\cdot\text{h}^{-1}$	%	
After the first half	21:47–21:52	From 1,455.1 to 2,199.1	51.1	124.0
After the second half	22:53–22:57	From 1,145.6 to 1,668.3	45.6	104.5
After the additional time	23:38–23:43	From 946.2 to 1,577	66.7	105.1

**Table 2** | Mean water demand in the analysed time intervals on Sunday 13 July 2014 (with the final match coverage) set against other Sundays (without the coverage of football matches)

Time interval	Sunday 13 July [ $\text{m}^3\cdot\text{h}^{-1}$ ]	Sundays without football matches [ $\text{m}^3\cdot\text{h}^{-1}$ ]	Difference [%]
1 hour before the game 20:00–20:59	1,868.3	2,028.5	–7.9
First half of the match 21:00–21:47	1,596.1	1,838.2	–13.2
Half-time break 21:48–22:01	1,872.7	1,645.5	13.8
Second half of the match 22:02–22:51	1,413	1,629	–13.3
Half-time break 22:52–23:00	1,431	1,375.4	4
Additional time 23:01–23:36	1,158.2	1,245.3	–7
Final ceremony 23:37–00:08	1,223.1	998.8	22.4
1 hour after the game 00:09–01:09	862.7	837	3.1

for other Sundays. It presents interchangeably positive and negative values, corresponding to particular parts of the match (see Table 2).

## DISCUSSION

Documenting high variability of demand for water in short time intervals is only possible in the case of meeting several conditions. The first one is the availability of data on the amount of water introduced to the water supply network each minute. Such availability only exists in enterprises equipped with modern devices for continuous monitoring of the amount of water pumped into the water supply network. The second is related to scheduled breaks. Viewers withhold the use of various facilities (particularly sanitary) until a break in the sporting mega-event. A further condition

is related to water recipients. In the case of the city of Toruń, the main recipients of water are residents, using almost 80% of water introduced to the municipal water supply network (the majority of industrial plants have their own water intakes). Therefore, the presented study results accurately characterise demand for water of the city's population during television broadcasts of important events, particularly those with global significance. The analysis also benefited from the circumstance of the broadcast happening in late evening hours. As was mentioned before, on Sunday night, when no mega-events are held, a gradual decrease in water usage is recorded (compare Figure 1). All the above points suggest that the analyses were performed in the optimum place and time.

The primary task of the municipal water supply network is to provide continuous water supply. The task is not easy in the case of uneven demand for water or in the case of

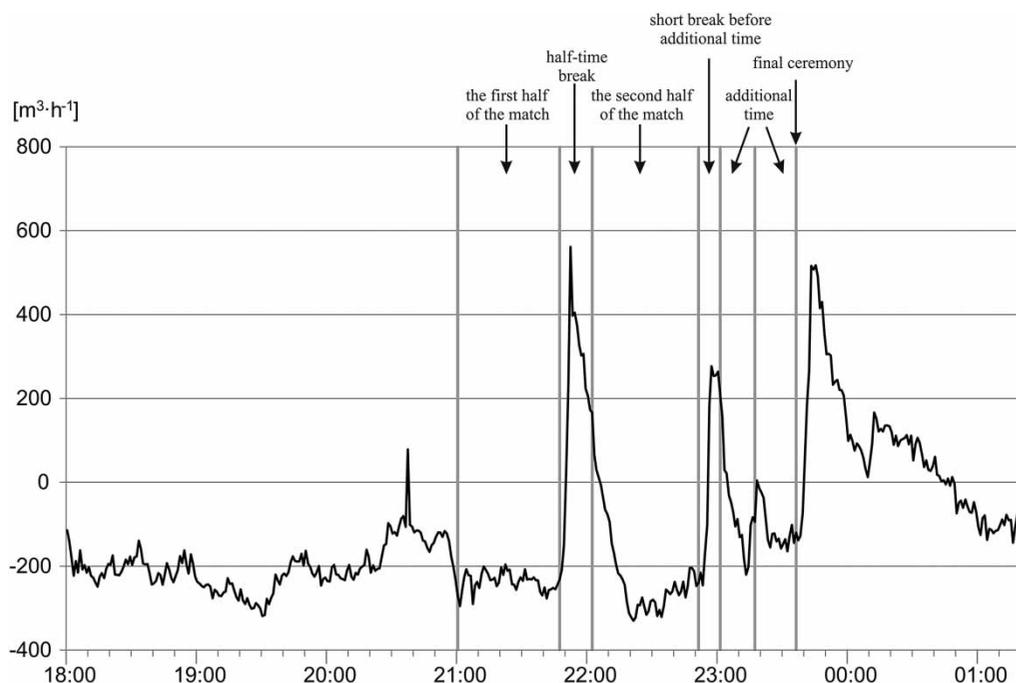
emergencies. A sudden increase in demand for water generates a rapid increase in pressure in the water supply network, and therefore a short-term instability of water pressure. This in turn can be a cause of a failure or temporary deterioration of water quality. During failures, even temporary water shortage can be observed, particularly in the peripheral part of the water supply network. The deterioration of water quality occurs in the case of uncontrolled pulling-off of sediments deposited in the pipes as a result of a rapid increase in the rate or change in direction of water flow (Prince *et al.* 2003). Over the past several years, this type of malfunction has occurred in the Old Town area of Toruń. Limiting this type of negative incident requires constant monitoring of water pressure in the water supply network. To do this, water pressure meters should be installed in places potentially prone to failures. Measurement results are submitted to the management centre. In the case of a failure, the technical services regulate water flow in the vulnerable sections of the water supply network in real time. In spite of good monitoring and a well-developed system of technical services, micro failures accompanying sudden changes in water usage by the city's residents cannot be avoided. Therefore, detailed knowledge on the values of rapid changes in water usage seems to be necessary for proper management of the water supply network, and can be helpful in its modernisation.

Proper functioning of the water supply network also depends on its age. In the case of the city of Toruń, more than half of its length (i.e. 306 km) was constructed after 2000, owing to the subsidy obtained under the framework of EU programmes 'Instrument for Structural Policies for Pre-Accession' (ISPA) and Infrastructure and Environment (I&E). The new sections of the water supply network were built in peripheral residential districts. Older facilities dominate the historical centre of the city (Old Town). More than 100 pubs and restaurants can be found in the city centre, attracting residents (particularly sports fans) who want to experience important media events together. During such events, beverages are traditionally consumed, particularly beer, which is very popular in Poland. Its consumption averages 98 litres per capita per year (Europe Economics 2016). In the case of broadcasts of sporting events, numerous TV commercials provide an additional incentive to consume beer. It is worth emphasising that beer is characterised by a

multi-directional effect on the human organism (Kolota *et al.* 2014). In reference to the analysed event, the important fact is that it causes frequent urination, and as a consequence – an increase in water usage.

Complete readiness of facilities for the production and transport of water constitutes a considerable cost for all water supply companies. Because of this, water supply companies rely on detailed results of calculations of demand for water. Such calculations consider among others the uses of water supply, the demand for water by recipients, as well as the variability of such demand in different cycles (daily, weekly, annual, and other). In the case of the assessment of the demand for water of city residents, average norms of water usage are determined with consideration of many factors (e.g. type of building development, facilities in apartments, presence of gardens). The factors, however, still do not include a consideration of the effects of television broadcasts of important global events on the uneven character of water demand. As the viewing interest in global events continues to increase, water utilities should plan for significant variations in water consumption during the broadcast of these events. Short-term forecasts (hourly, daily) should be used particularly for the purpose of providing efficient current functioning of the water supply system. This particularly refers to minimising the time that water is stored in containers to ensure its good quality (Babel & Shinde 2011).

Television broadcasts substantially contribute to an increase in the unevenness of water usage. During sporting competitions (in this case a football match), water usage is lower than average, and in breaks and after the end of the games, its usage rapidly increases. This is primarily caused by the simultaneous use of toilets, bathrooms, and kitchens by TV viewers (sports fans). Such a phenomenon is particularly evident in sports stadiums. In breaks of football matches, a sevenfold rapid but short duration increase in water usage in toilets has been recorded (Schwacke *et al.* 2012). Strong fluctuations of water usage during breaks in sporting events cause substantial deviations from the average value. In the analysed case of the city of Toruń, it varied from  $-318$  to more than  $550 \text{ m}^3 \cdot \text{h}^{-1}$ , as presented in Figure 2. A rapid increase in water use is observed not only during sporting mega-events. Other examples include the most popular TV shows (including TV series) after



**Figure 2** | Deviations from average water usage in Toruń on Sunday 13 July 2014.

which an evident increase in water use occurs. The increase, however, does not have such a rapid course, because it is not related to a break in the programme, but its end. A high increase in water use but with a gentler course is observed during evening hours on hot days. It is related to increased use of water in house gardens. A similar high increase in water use is recorded in morning hours on working days. The increase, however, occurs over a longer period of time, and is not so sudden.

Changes in the manner of water use during broadcasts of global sporting events have not been analysed in detail so far. Information on the subject is scarce on the internet. Based on data provided by Berliner Wasserbetriebe, during a break in a football match between Brazil and Germany (8 July 2014), water usage in the capital of Germany increased over several minutes from approximately 11,000 to almost 30,000  $\text{m}^3 \cdot \text{h}^{-1}$  (Edwards 2014). The recorded rapid and momentary increase in demand for water in Berlin is fully justified, because the German national team participated in the football match. A case documented from a Polish city confirms a similar response of residents during a sporting event with no participation of their national team.

In earlier years, information on an increase in demand for water during breaks in sporting events (finals of Super Bowl and NHL) or other important media events was published for example in American and British press. The findings were not backed by scientific analyses and therefore they cannot be included in sources of scientific information. It seems, however, that this type of information is critical for water utilities so they can plan for future, time sensitive, high demand events.

## CONCLUSIONS

Modern technologies permit the precise documentation of phenomena and processes, including those related to water management and water supply. This suggests that water usage in a city can be a good indicator of the interest of residents in television programmes, particularly those attracting millions of viewers. Such programmes include broadcasts of sporting events with global importance. Documenting such a correlation, however, is only possible in a city with good monitoring of water supply. A sudden

increase in water demand during the break of a football match (or another event) can have dramatic impacts on the effective functioning of the water network. Therefore, the data provided by this analysis provide useful insight into the scale of the changes in demand that could be expected during the broadcast of a global event.

The study of World Health Organization water safety plans does not directly indicate mega-events as a source of threat for the water supply network (Davison *et al.* 2004). However, the plans mention other factors such as pressure fluctuation and water supply disturbance which can be caused by mega-events. For this reason, it seems necessary to consider these types of events in water safety plans.

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