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Changes in Water Consumption in the Educational-Museum Center of Poleski National Park

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ABSTRACT

The aim of the present study was to analyze changes in water consumption which took place in the years 2011–2020 in the Educational-Museum Center of Poleski National Park (Poland), from which wastewater is discharged to a hybrid constructed wetland wastewater treatment plant. Water consumption was shown to be dependent on the number of visitors to the museum. As the number of visitors grew from 11,000 in 2011 to over 55,000 in 2019, the annual water consumption increased from 131 to 430 m^3. Along with an increase in the percentage of individual visitors in the total number of visitors to the museum from over 40% in 2011–2017 to over 80% in 2020, water consumption per person decreased from 12.21 $dm^3 \cdot d^{-1}$ to 7.18 $dm^3 \cdot d^{-1}$. The average daily water consumption per one visitor in 2011–2020 was 10.4 $dm^3 \cdot d^{-1}$, a value that was similar to the water consumption standard for museums (10 $dm^3 \cdot d^{-1}$) set out in the Regulation of the Polish Minister of Infrastructure of 14 January 2002 on defining average water consumption standards. The average daily amount of water used in the museum building in the individual months of the year ranged from 0.12 to 1.28 m^3/d. The highest average daily water consumption was recorded in the high tourist season (May–August), and the lowest in the low tourist season (January–April, September–December).

Keywords: water consumption; water protection; educational-museum center; Poleski National Park.

INTRODUCTION

Rationalization of the use of ground and surface waters, leading to a reduction in water consumption, is currently one of the basic tasks in the field of broadly understood water protection. From the social point of view, the most important objective is to provide the human population with drinking water, and this is closely related to the quantity and quality of water resources. Higher living standards, the development of industry and agriculture, which leads to the pollution of ground and surface waters, and climate change, which increases the risk of flooding and drought, spark off a more and more vivid debate on issues related to the protection of water resources, both at the local and international levels [Burszt-Adamiak 2015].

Proper water and wastewater management is one of the goals of the active water protection policy that has been pursued in Poland for many years now [Jawecki, Ostrowski 2010]. Poland, as an EU member state is obliged to implement the European water policy based on transparent, effective and coherent legislative provisions included in the Water Framework Directive 2000/60/EC (WFD), which establishes guidelines for Community action in the field of water policy, and in Directive 91/271/ EEC of 1991 concerning urban wastewater treatment. The common European water policy commits countries to rationally use and protect water resources in accordance with the principle of sustainable development.

In recent years, much emphasis has been put on water protection measures for protected areas with unique natural and landscape characteristics which are open to visitors and involved in educational and scientific activity. Pursuant to the Act of 16 April 2004 on nature protection, "*in national*

parks and nature reserves, it is prohibited to build or convert structures and technical devices, except for facilities and devices serving the purposes of the national park or nature reserve". This means that facilities such as forester's lodges, museums, educational centers, shelters, and tourist trails with rest stops located in protected areas should be equipped with a water supply system and sanitation infrastructure that does not interfere with the natural environment [Jóźwiakowski et al. 2016; Jóźwiakowski et al. 2017].

Water demand and the selection of measuring devices are regulated by the Regulation of the Polish Minister of Infrastructure of 14 January 2002 on defining average water consumption standards. Water demand is substantially affected by the size and standard of a building as well as the type of sanitary facilities and wastewater treatment system it has [Tuz, Gwoździej-Mazur 2012].

In protected areas, such as national parks, the construction of centralized sewerage systems and treatment plants is usually impossible due to the dispersed development pattern. The only solution is to build local wastewater treatment systems that allow to effectively manage wastewater on site [Micek et al. 2020, Micek et al. 2021]. One example of such a system is a hybrid constructed wetland which has been built to serve Poleski National Park's Educational-Museum Center (PNP EMC) in Stare Załucze [Jóźwiakowski et al. 2016; Obroślak et al. 2017]. Proper operation of this treatment plant depends on the amount of influent wastewater and how uniform the inflow is [Çakir et al. 2015], which means it ultimately depends on water consumption in the building it serves. To date, changes in water consumption on farms and in public utility facilities have been analyzed in the works of Pawełek et al. [2015], Wichowski et al. [2015], Bergel et al. [2017], and Crouch et al. [2017]. Currently, however, the literature provides no data on water consumption in museums, especially those located in national parks. In the present study we wanted to fill this gap by analyzing changes in water consumption in the PNP EMC building, from which wastewater is discharged to a hybrid constructed wetland.

CHARACTERISTICS OF THE FACILITY

The PNP EMC is located in Stare Załucze in the Urszulin commune in south-eastern Poland (Figure 1).

PNP was established on 1 May 1990 in order to protect water and peat ecosystems. It is situated in the central part of the Łęczyńsko-Włodawskie Lakeland in the Lublin Province. It covers an area of almost ten thousand hectares, and encloses the most valuable parts of Western Polesie when it comes to the natural environment and landscape. Water in PNP is the most important factor responsible for the mosaic structure of the landscape and the biological diversity of the plant and animal world. Living peat bogs, wetland meadows, wetland forests, and lakes together occupy over 65% of the Park's area. The diversity of habitats creates perfect conditions for the growth of numerous species of plants, animals and fungi. Many of them are species that are rare for the region and the whole country.

Nature is undoubtedly the main attraction of PNP. However, in addition to protecting the natural environment, the PPN is involved in intensive educational, tourist and scientific activities. The Park's educational centers and the numerous nature trails with viewing spots provide an excellent setting for educational, scientific and tourist experiences. One such facility is the PNP EMC in Stare Załucze. The Center houses a museum and the Wild Animal Rehabilitation Center, and has an educational trail called Żółwik (Little Turtle), which is equipped with educational boards, a nature-themed playground, and a roofed sitting area with a place for a bonfire.

The PNP EMC in Stare Załucze is an important educational facility, which attracts numerous tourists. Throughout the year, the Centre is open to visitors 7 days a week from April to October. From November to March, it is closed and can only be visited by arrangement with the Centre's staff after prior notification. Over the period from 2011 to 2020, the Centre was visited by over 200,000 people. However, it should be remembered that, due to the COVID-19 pandemic and the associated restrictions, the requirement of social distancing, and other special precautions, including a temporary closure, the number of visitors to the Centre in 2020 was radically different than in the previous years and was almost 50% lower than in 2019. When the year 2020 is disregarded, however, a clear seasonality is observed in tourist visits, with visitors coming to the PNP EMC mainly in the period from April to October.

The PNP EMC building is supplied with water from the communal water supply network

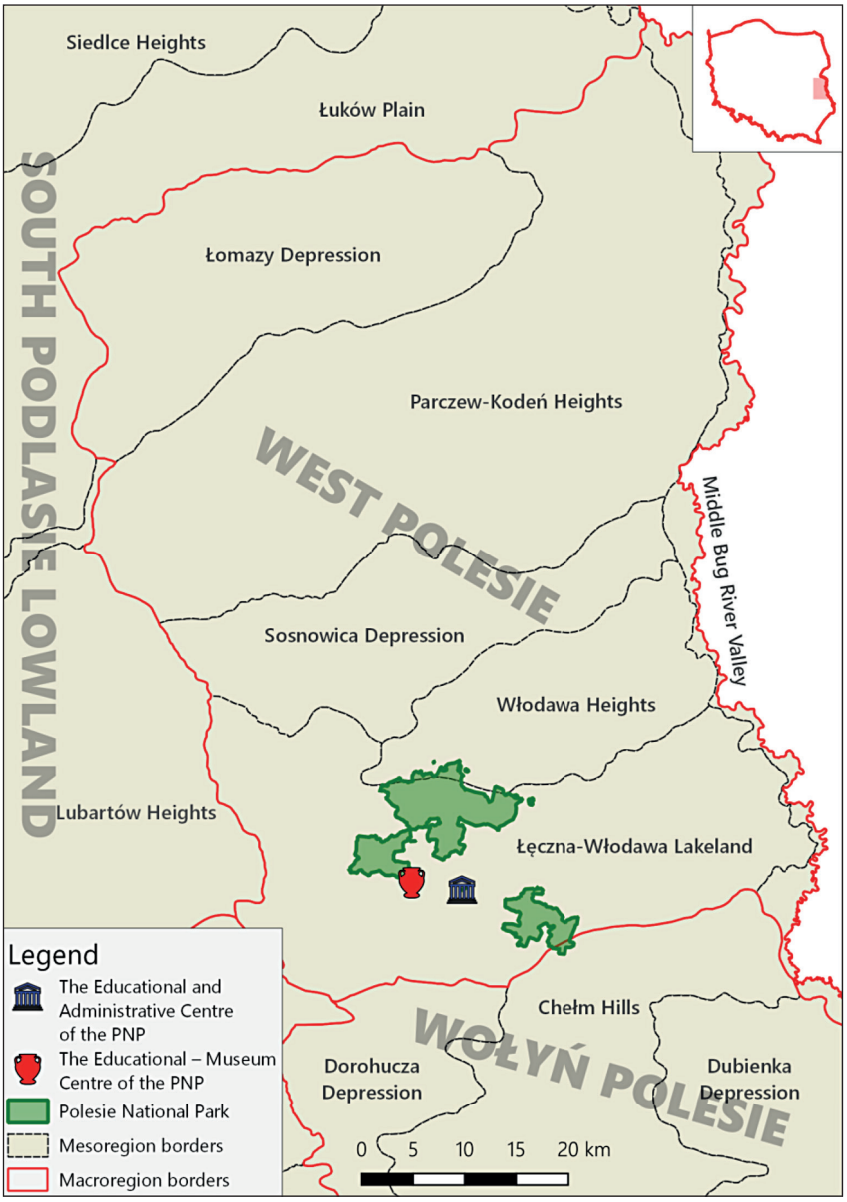

Figure 1. Location of the Educational-Museum Center of Poleski National Park in Stare Załucze, in south-eastern Poland (map drawn by Łukasz Omelczuk, PNP)

of the Urszulin Commune. Water is used by the Centre's three employees and the numerous visitors to the facility. The village of Stare Załucze does not have a mains sewerage network. Since 2015, wastewater from the EMC building has been discharged to a turtle-shaped hybrid constructed wetland. This treatment plant uses a system of vertical- and horizontal-flow soil-plant beds, a P-filter for chemical removal of phosphorus, and an infiltration hydrophyte pond to which treated wastewater is discharged. The beds are planted with water-loving plants typical of the bogland ecosystems occurring in the PPN [Jóźwiakowski et al. 2016; Obroślak et al. 2017].

METHODS

The goal of the study was to determine changes in water use by the employees of and visitors to the PNP ECM building in Stare Załucze in the period 2011–2020. Data for the analysis of the changes in water consumption was obtained from the district utility company (DUC) Gminny Zakład Usług Komunalnych Sp. z o.o. in Urszulin and the PNP office in Urszulin. The data provided by the DUC included sold water volume readings from a SENSUS 2006 JS 1.5 m^3/h water meter No. 1661395-06 installed in the ECM building. The data provided by the PPN, which came from the Register of Tourist Visits to Poleski National

Park in 2011–2020, were used to analyze the actual water consumption in the ECM building over the investigated period. On the basis of these data, we determined the number of tourists visiting the ECM and calculated monthly and annual water consumption levels for the years 2011–2020 as well as the correlation between the variation in water consumption and the number of visitors. The standard deviation and the coefficient of variation were calculated for average daily water consumption for each month. Variation in water consumption and the water consumption variation group according to Mucha's classification [1994] were established. All the data in the figures were analyzed using Microsoft Excel 2010.

The results concerning average daily water consumption per one visitor to the PPN in Stare Załucze were compared with the average water consumption standards for museums set out in the Regulation of the Polish Minister of Infrastructure of 14 January 2002 on defining average water consumption standards.

RESULTS AND DISCUSSION

Table 1 presents the number of visitors to the PNP ECM and annual water consumption in m^3 in the years 2011–2020.

The average monthly water consumption was at a similar level of about 15 m^3 across the study period (Figure 2). The only exception was 2019, when both the maximum and the average water consumption levels were almost twice as high as in the remaining years, which was related to the highest recorded number of tourists visiting the Centre in that year. In 2020, the number of tourists decreased to the level registered in 2018. Minimum water consumption was recorded in the months in which the Center was closed (November till March). The highest water consumption was observed in May and June. During these months, the Centre was visited by a very large number or the largest number of tourists. At the same time, these were the months when the Centre was the most willingly visited by organized groups (Figure 2 and 3).

Our study shows that during the 10-year observation period, as the number of visitors to the PNP EMC increased from nearly 11,000 in 2011 to over 55,000 in 2019, the amount of water used also grew from 131 m^3 to 430 m^3 in 2019. In 2020, the COVID-19 restrictions led to a decrease in the number of tourists to around 27,000 and a drop in water consumption to 195 m^3. There was also an increase in the percentage of individual tourists in the total number of tourists visiting the Museum (from over 40% in 2011–2017 to almost 70% in 2018–2019 and to over 80% in 2020). This was accompanied by a falling trend in water consumption per person from 12.21 $dm^3 \cdot d^{-1}$ in 2011 to 7.18 $dm^3 \cdot d^{-1}$ in 2020 (Figure 4). Organized groups use more water (higher daily consumption) because they

Table 1. Number of visitors to PNP ECM in Stare Załucze and annual water consumption in m^3 in the years 2011–2020

Parameter		Year									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Month	January	33	4	0	9	0	0	0	0	0	328
	February	0	27	53	0	6	0	0	0	18	428
	March	123	60	0	63	0	0	0	0	362	36
	April	292	350	153	484	620	1025	1058	1823	2866	0
	May	2952	2607	2286	2804	3486	5306	4380	5754	8989	2096
	June	2247	2885	3121	3051	3036	3425	3626	3622	7119	3678
	July	1030	1567	1776	1636	3287	3448	3867	3430	10286	6938
	August	1210	1780	1996	2022	2228	3767	4723	4126	12142	8976
	September	1448	1140	858	1135	1543	1058	1367	2087	5257	3073
	October	1289	1772	1483	1405	3001	1226	1308	2166	6259	1595
	November	94	65	12	122	0	50	0	0	1354	0
	December	15	35	0	25	0	0	24	0	385	0
Annual number of visitors		10733	12292	11738	12756	17207	19305	20353	23008	55037	27148
Annual water consumption in m^3		131	145	114	139	200	230	241	210	430	195

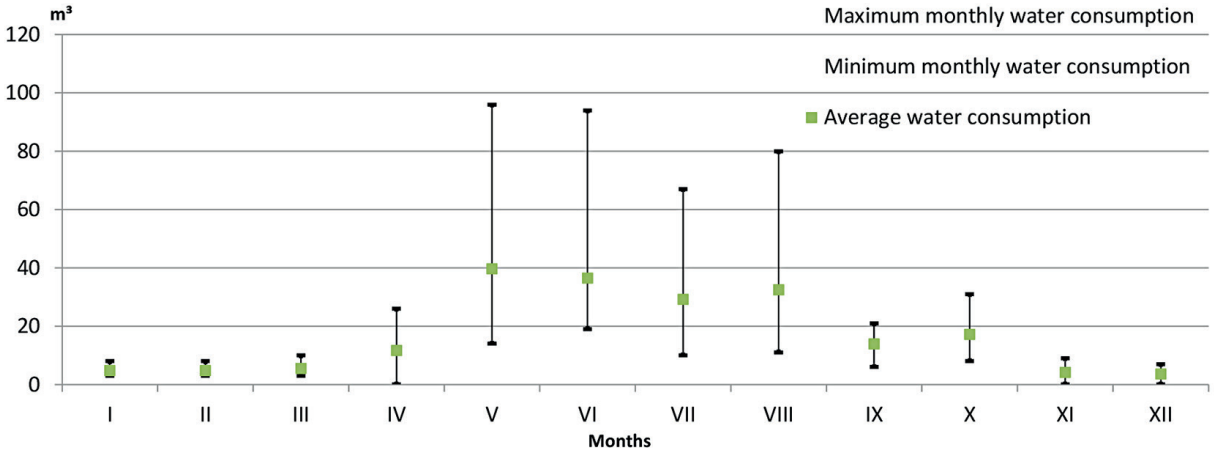

Figure 2. Variation in water consumption at the PNP EMC in Stare Załucze in 2011–2020 by month

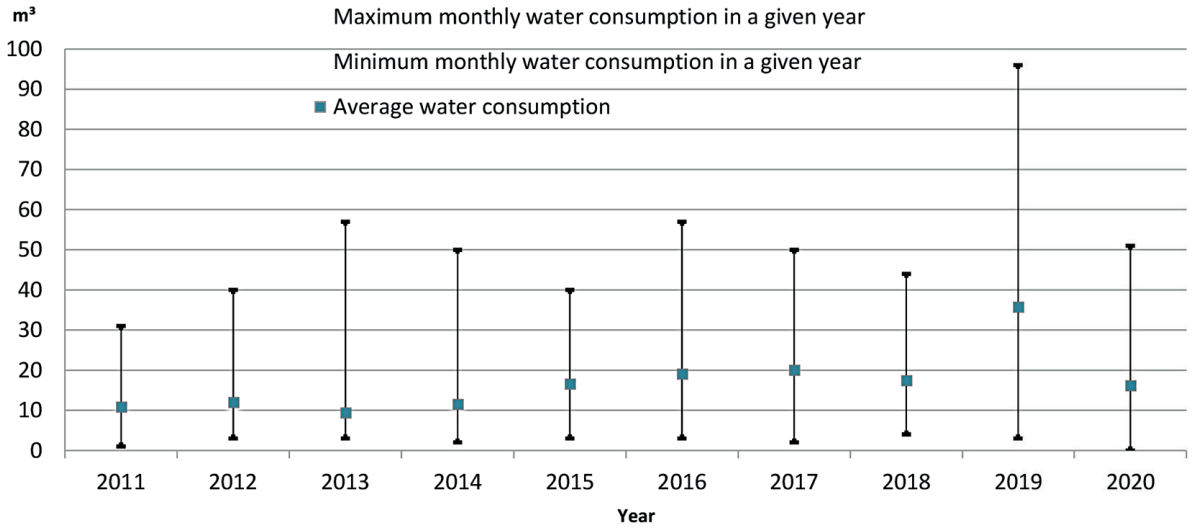

Figure 3. Variation in monthly water consumption at the PNP EMC in Stare Załucze in the years 2011–2020

mostly consist of schoolchildren, who use water in restrooms less economically than individual tourists.

The average daily water consumption per visitor to the PNP EMC in Stare Załucze in 2011–2020 was 10.4 $dm^3 \cdot d^{-1}$, a value that was similar to the water consumption standard for museums (10 $dm^3 \cdot d^{-1}$) set out in the Regulation of the Polish Minister of Infrastructure of 14 January 2002 on defining the average water consumption standards. The literature provides no information on water consumption in museums located in national parks, which is why our results cannot be compared to literature data. There are data on the volume of and variation in water consumption for households, residential building complexes, hotels, and academic institutions [Pawełek et al. 2015; Wichowski et al. 2015; Bergel et al. 2017; Crouch et al. 2017], but these types of buildings cannot be accurately compared to the PNP Museum as they differ considerably from it in the water consumption pattern – while visitors spend about one to two hours in the museum, users in households and public utility buildings use water throughout the day.

Figure 5 shows the average daily water consumption in the PNP Museum in Stare Załucze in the years 2011–2020 by month. Tourist visits, which took place mainly in the period from April to October, were clearly seasonal. The highest average daily water consumption was observed in the high tourist season (May–August). It was 1.25 $m^3 \cdot d^{-1}$ for the entire period 2011–2020. In the low season (January–April, September–December), the average daily water

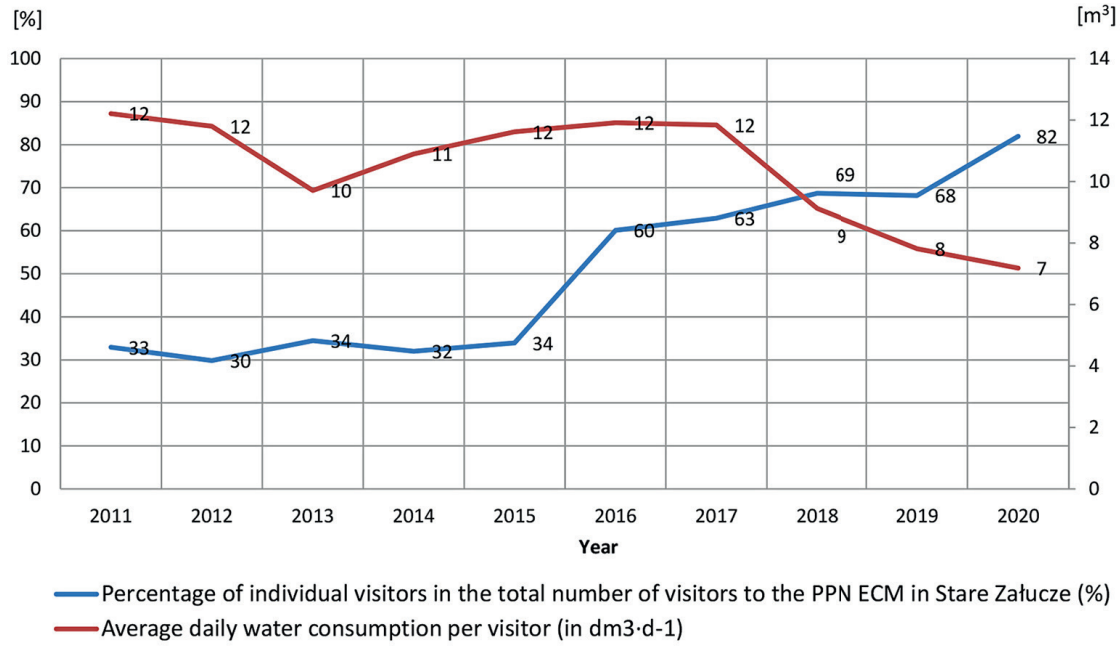

Figure 4. Average daily water consumption per person ($dm^3 \cdot d^{-1}$) and the percentage of individual tourists in the total number of visitors to the PNP EMC in Stare Załucze in 2011–2020

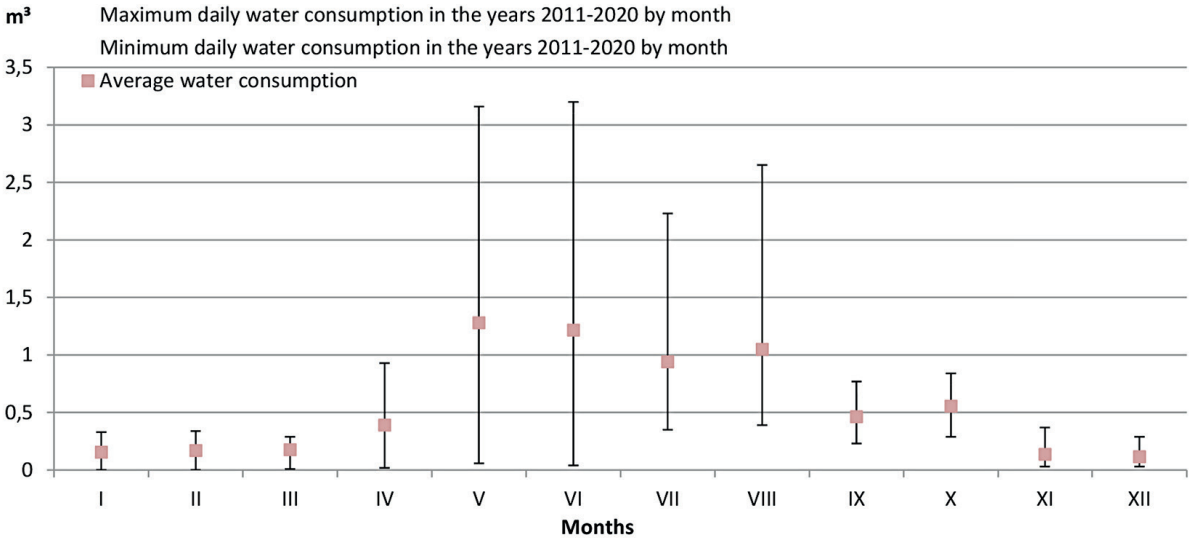

Figure 5. Variation in daily water consumption in the building of the PNP Museum in Stare Załucze in 2011–2020 by month

consumption for the years 2011–2020 was 0.30 $m^3 \cdot d^{-1}$. The highest daily water consumption in the high tourist season was recorded in June 2019 at 3.10 $m^3 \cdot d^{-1}$ and the lowest in July 2014 at 0.35 $m^3 \cdot d^{-1}$ (Figure 5).

Based on the data shown in Table 2, it can be concluded that variation in water consumption in the EMC building in the years 2011–2020 differed across the year. In the months of May to August, i.e. in the high tourist season, as well as in the months of November and December, there was a high variation in water consumption according to Mucha's classification [1994]. In the remaining months of the year, the variation in water consumption was usually moderate (Table 2).

The results show that the average daily water consumption in the building of the PNP Museum in the individual months of the year ranged from 0.12 to 1.28 m^3/d, and was slightly higher than that quoted by Jóźwiakowski et al. [2014] (0.15–1.01 m^3/d) in their conception of a hybrid constructed wetland for the PNP EMC in Stare Załucze.

Table 2. Variation in average daily water consumption in the PNP EMC building in Stare Załucze in 2011–2020 by month

Month	S – average daily water consumption [m^3/d]	X – standard deviation	Coefficient of variation V = (S/X)·100%	Variation group according to Mucha [1994]*
January	0.15	0.04	25.6	II
February	0.17	0.04	23.6	II
March	0.18	0.05	26.1	II
April	0.39	0.23	59.5	III
May	1.28	0.75	58.5	III
June	1.22	0.69	56.5	III
July	0.94	0.55	58.0	III
August	1.05	0.70	66.5	III
September	0.46	0.14	29.7	II
October	0.55	0.20	36.4	II
November	0.14	0.07	49.9	III
December	0.12	0.05	41.8	III

Variation group: I – low variation (0–20%), II – moderate variation (20–40%), III – high variation (40–100%)

CONCLUSIONS

Water usage in a public facility such as Poleski National Park's Educational-Museum Centre in Stare Załucze depends on the facility's specific activity, and in this particular case on the number of tourists passing through the museum. As the number of visitors to the PNP Museum grew from 11,000 in 2011 to over 55,000 in 2019, the annual water consumption increased from 131 m^3 to 430 m^3. Along with an increase in the percentage of individual visitors in the total number of visitors to the museum from over 40% in 2011–2017 to over 80% in 2020, water consumption per person decreased from 12.21 $dm^3 \cdot d^{-1}$ to 7.18 $dm^3 \cdot d^{-1}$. The average daily water consumption per one visitor to the museum in 2011–2020 was 10.4 $dm^3 \cdot d^{-1}$, a value that was similar to the water consumption standard for museums (10 $dm^3 \cdot d^{-1}$) set out in the Regulation of the Polish Minister of Infrastructure of 14 January 2002 on defining average water consumption standards. The average daily water consumption in the PNP EMC building in the individual months of the year ranged from 0.12 to 1.28 m^3/d. The highest average daily water consumption in the study period was recorded in the high tourist season (May–August), and the lowest in the low tourist season (January–April, September–December). A large variation in water use was observed in the high tourist season (May – August) and in the months of November and December. In the remaining months of the year, the variation in water consumption was moderate.

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