

Reviewer 1

A brief summary

Water stress resulting from population growth, high water demand, and climate change currently represents an environmentally derived social and economic problem at global, regional, and local scales. The use of rainwater is a feasible option for reducing shortages of potable and nonportable water.

The subject of the manuscript is fitting well in the scope of the Sustainability Journal. The importance of this issue becomes obvious from their advantages use rainwaters for swimming pool purposes in Poland for its simplicity and low-cost efficiency.

Thank you for your positive feedback.

Broad comments

However, I suggest specifying more in detail the limits and standards for the swimming waters.

The limits and standards for swimming waters have been discussed in details, also taking into account other reviewers' questions and comments in this matter, it has been implemented into both the Introduction chapter and it is also elaborated below.

A wide range of Standards are applied across Europe to the pool and spa industry. The overview of European norms for the main standards applicable to the swimming pool and spa industry includes among others EN 15288 Swimming pools for public use - Part 1: Safety requirements for design and Part 2: Safety requirements for operation. These documents do not specify the limit values for the concentrations of pollutants with respect to swimming pools. Unfortunately, the legislation on the quality of swimming pool water is not consistent across Europe; it varies from country to country. There are no clearly defined limit values for the pollutant concentrations, which could specify whether the water is safe for swimming and bathing purposes or not. For example, only in Poland are a swimming pool, a bathing area and a spa pool considered to be three completely different types of facility in accordance with Polish law and its definitions of them, so they are subject to quite distinct sets of regulations. It should also be emphasized that these standards and regulations do not apply to pools used for domestic purposes (and in some cases in Poland the pools in hotels are not considered, surprisingly, to be public swimming pools!). This article, by virtue of both its title and its purpose is concerned with public swimming pools, which are „artificial” by definition.

The Act of August 18, 2011 on the safety of persons staying in water areas (Polish Journal of Laws of 2020, item 350, as amended), defines a swimming pool as an indoor or outdoor facility with circulating water that is intended for swimming or bathing. It should be equipped with at least one artificial swimming pool basin (an artificial tank of water intended for swimming or bathing) with a durable edge and bottom and it should be accompanied by sanitary facilities, changing rooms and showers (Article 2 point 8).

The Regulation of the Minister of Health of 9 November 2015 on the requirements to be met by water in swimming pools (Polish Journal of Laws of 2015, item 2016, as amended) specifies the requirements that should be met by water in swimming pools; the frequency of water sampling at swimming pools; the reference methodologies for its analysis and the method of assessing whether the water in swimming pools meets the required conditions; and the way of informing the population about the quality of water in swimming pools.

The above mentioned requirements for public artificial swimming pool water in Poland are divided into microbiological requirements (Annex No. 1) and physical and chemical requirements (Annex No. 2). Annex No. 1 defines the highest permissible number of microorganisms [CFU or NPL] of *Escherichia coli*, *Pseudomonas aeruginosa*, and the total number of microorganisms present at $36\pm 2^{\circ}\text{C}$ after 48 h, which may include Coagulase-positive staphylococci and *Legionella* sp depending on the water stream type in the swimming pool facility (The possible types are: water introduced into the swimming pool basin from the circulation system; water in the swimming pool basin; water in swimming pool basins equipped with devices that generate a water-air aerosol; water in swimming pool basins that are made available for swimming lessons for infants and small children under 3 years of age; or water in showers)

Annex No. 2 is divided into part A (Physical and chemical requirements) and part B (Additional physical and chemical requirements). Part A defines the minimum and maximum values of redox potential at the Ag/AgCl electrode 3.5 M KCl, pH values and chlorine concentration depending on the water stream type in the swimming pool facility (as listed above, the possible types are: water introduced into the swimming pool basin from the circulation system; water in the swimming pool basin; water in swimming pool basins equipped with devices that generate a water-air aerosol; water in swimming pool basins that are made available for swimming lessons for infants and small children under 3 years of age; or water in showers)

Additional physical and chemical requirements relate to turbidity, nitrates, combined chlorine, chloroform, Σ THM and other parameters determined for certain specific situations. For example, in the case of water ozonation, after sorption filtration, this part defines the permissible concentration of ozone in water introduced into the swimming pool basin from the circulation system. In the case of di- and trichloroisocyanurate usage, the maximum isocyanuric acid concentration is defined for water in the swimming pool basin and water in the swimming pool basins equipped with devices generating a water-air aerosol.

The weakness of this study is that only short period of the year 2023 were compared. Is there any reason for that? What about the other years, are the results comparable?

Please note that here we are presenting a study of the roof runoff only, which is much more stable in its quality and will depend mostly on the pollutants coming from the air. Historically, in the transitional period from winter to spring, starting from April, it is the worst month in terms of air pollution, which was why we captured the data from that month. On the other hand, April is still a month with high temperature fluctuations in Poland: during the day time, the ambient temperature could be as high as $20 - 25^{\circ}\text{C}$ but during the night time it could drop to $3 - 4^{\circ}\text{C}$. These fluctuations could cause some microelements to be released from metals which would be washed off from roofs during a rainfall event.

We are referring to a statistical document which clearly shows that the peak rainfall events over the last 10 years have fallen within the month of June. This implies that the heaviest rains may be expected to occur during the first summer months.

Snowy months in Upper Silesia are expected to last from the middle of November to the middle of March and during these months we were not collecting any samples due to the fact that no technical opportunities for rain collection occurred. On another note, even if we had had the possibility to collect these samples, the initial signature of micropollutants could have been lost during the snow's thawing.

In the autumn time, the typical rains in Silesia consist of drizzle and cloudy rains which might not even produce any appropriate runoff and rain water samples would be difficult to collect.

All the above-mentioned reasons underlie the main limitation which we had to take into consideration. Micropollutant analysis is an extremely expensive and laborious process, which requires both the availability and the appropriate training of staff in terms of their accuracy in relation to instrument calibration. With this in mind, three critical months have been chosen for sampling in order to define micropollutants. We believe that the other months July-October, although useful for the whole picture, are highly unlikely to contribute radically to the whole picture of roof runoff from the view point of the presence of micropollutants.

As you can see, it has been taken time to provide a proper explanation here. However, the point you are making is vitally important, so we have included a paragraph in the methodology section about it.

What are the differences between water quality requirements for swimming: 1.) in natural and 2.) artificial swimming pools? This should be incorporated in the intense literature review of this type too, especially if you compare the different studies. In addition, the possibilities, of using different waters treatment methods (different than a conventional system, e.g. constructed wetlands) with their advantages and disadvantages are not mentioned too.

The differences between water quality requirements for swimming in natural and artificial water have been discussed in details, also taking into account the possibilities, of using different waters treatment methods (different than a conventional system) with their advantages and disadvantages and other reviewers' questions and comments in this matter, it has been implemented into both the Introduction chapter and is also elaborated below.

First of all, It should be emphasized that a swimming pool, a bathing area and a spa pool are three completely different types of facility in accordance with Polish law and their definitions, so they are subjected to completely different regulations. It should also be emphasized that these standards and regulations do not apply to pools used for domestic purposes (and in some cases in Poland the pools in hotels are not considered, surprisingly, to be public swimming pools!). This article, by virtue of both its title and its purpose is concerned with public swimming pools, which are „artificial” by definition.

Both the title and the purpose of this article concern public swimming pools, which are „artificial” by definition. The Act of August 18, 2011 on the safety of persons staying in water areas (Polish Journal of Laws of 2020, item 350, as amended), defines a swimming pool as an indoor or outdoor facility with circulating water that is intended for swimming or bathing. It should be equipped with at least one artificial swimming pool basin (an artificial tank of water intended for swimming or bathing) with a durable edge and bottom and it should be accompanied by sanitary facilities, changing rooms and showers (Article 2 point 8).

Facilities called „public swimming pounds” are an artificial ecosystems for swimming or bathing in which the conditions of natural waters are imitted. They are distinct from official bathing areas in surface water and from conventional public swimming pools. In that case the guiding principle is that the water has been treated biologically by planting certain species which have special properties that are conducive to the treatment of the water and applying plant filters, occasionally supported by other treatment processes such as phosphate/nitrate treatment. In this particular case, water will be disinfected by UV or ozone instead of chlorine as the latter could kill all the bacteria and plants responsible for the biological treatment. The whole idea of swimming pounds is to mimic constructed wetlands or lagoons which are part of SuDS and consequently part of the rural and urban landscape and they play a crucial role

Natural water courses like rivers, lakes and the sea are called bathing areas, what is defined according to European Bathing Water Directive in Polish Art. 16 Act of 20 July 2017 Water Law (Polish Journal of Laws of 2021, item 1641) as a separated and marked fragment of surface waters, designated by the commune council, which may be used by a large number of bathers, provided that no permanent bathing ban has been issued in relation to this bathing area. The Regulation of the Ministry of Health of 17 January 2019 on the supervision of water quality in bathing areas and places occasionally used for bathing (Journal of Laws, item 255) specifies the requirements that water in bathing areas and places occasionally used for bathing should meet. Water quality assessment in bathing areas includes microbiological requirements (*Enterococcus* ≤ 400 CFU/100 ml measured in accordance with PN-EN ISO 7899-1 or PN-EN ISO 7899-2 and *Escherichia coli* ≤ 1000 CFU/100 measured in accordance with PN-EN ISO 9308-3 or PN-EN ISO 9308-1), as well as other stated requirements including the following: there should be no cyanobacterial bloom (streaks, scum, foam); no evidence of macroalgae or marine phytoplankton proliferation; and no presence of contaminants in the water such as tarry materials from refining, distillation or any pyrolytic treatment, in particular distillation residues, glass, plastics, rubber or other waste (in quantities that cannot be deleted immediately). The Act of March 14, 1985 on the State Sanitary Inspection (Journal of Laws of 2021, item 195) stipulates that the supervision of the quality of bathing areas and places occasionally used for bathing must be carried out by the bodies of the State Sanitary Inspection under the terms set out in the regulations of the State Sanitary Inspection.

Regarding the main advantages and disadvantages:

Swimming or bathing in natural water (understood as not being disinfected by means of chlorine) may pose health risks to users when the water quality is microbiologically poor. Microbiological contamination of surface water in bathing areas or water in swimming ponds may occur, for example, through direct fecal input from man or animal, sewage overflow, discharge from wastewater treatment plants, and surface runoff. The water quality may also deteriorate because of the growth of microorganisms that are part of the natural aquatic flora. Since the water in artificial public swimming pools must be disinfected by the use of chlorine, the risk of microbial contamination is relatively lower there.. However, in cases where both organic and inorganic micropollutants occur in the water, these might react with free chlorine, and this reaction will lead to the production of disinfection by-products that are dangerous for human health, including e.g., trihalomethanes (THMs).

Abstract

In this part there is an absence of the key information, which has to be included to make the abstract useful to someone who may to reference your work. It should summarize the major aspects of the entire manuscript. However, there are missing the important information about the overall purpose of this study and basic design of this study. It should be incorporated mainly major findings or trends found as a result of this analysis, and a brief summary of your interpretations and conclusions. It means it must be presented and explained all the main arguments, the important results and evidence of this manuscript. Because it is too general, I suggest rewriting it to be more compact.

Thank you for your feedback. The abstract has been rewritten according to Reviewer 1's comments and suggestions.

Introduction

This part is too general too. However, you should not only describe briefly and clearly why you are writing the paper, but you also should provide a rationale for the study.

Thank you for your valuable help in improving the Introduction of our manuscript. It has been rewritten, also taking into account other reviewers' questions and comments on this matter. The answers to Reviewer 1's questions are listed below:

Could you, please Indicate, why this field is so important, and what has already been done (with proper citations)?

As Reviewer 1 effectively pointed out in the brief summary of this revision, the importance of the subject of the research presented in this paper becomes obvious when one sees how it takes account of the advantages to be gained by using rainwaters for public swimming pool purposes in Poland, thanks to the simplicity and low-cost efficiency of that procedure. Water stress resulting from various causes (including population growth, high water demand, and climate change) currently represents a problem on a different scale at global, regional and local levels from environmental, social and economic points of view.

Outline the purpose and announce the present research,

The purpose of this study is to investigate rainwater with reference to various types of physico-chemical pollution that may affect it in order to comment on its suitability for usage in public artificial swimming pools as a resource for filling the pool basins, particularly in the context of water quality and the formation of disinfection by-products.

clearly indicating what is novel and why it is significant.

A potential way for rainwater to be used is to fill public swimming pools with it and, to the best of the authors' knowledge, this is a novel and innovative topic which requires further investigation and research. Apart from the possibility of using rainwater in swimming pool facilities, it may also be recycled for watering greenery or used to flush toilets as has already been done, for example, on a single-family housing estate in Rzeszów, Poland [4] and for a dormitory located in the city of Košice, Slovakia [5]. The first attempts are being made to use rainwater from roofs for the purpose of back-washing swimming pool filter beds [6]. A hitherto completely unexplored approach, however, is the use of rainwater as a source for filling the pool basins of public artificial swimming pools.

Our discussion of this issue touches on some legal inconsistencies in regard to it that have been additionally discussed in the Introduction chapter, taking also into account other Reviewers' comments and questions.

[4] Słyś, D.; Stec, A. Centralized or Decentralized Rainwater Harvesting Systems: A Case Study. *Resources* 2020, 9, 5. <https://doi.org/10.3390/resources9010005>

[5] Stec, A.; Zelenáková, M. An Analysis of the Effectiveness of Two Rainwater Harvesting Systems Located in Central Eastern Europe. *Water* 2019, 11, 458. <https://doi.org/10.3390/w11030458>

[6] Lempart-Rapacewicz A., Wyczarska-Kokot J., Kudlek E., Dudziak M., Copik J., Mika-Shalyha A., Rapacewicz R., Lempart Ł., i Waławek S., Examples of technological solutions used in Poland in the field of reducing the operating costs of swimming pool facilities, „10th International Conference on Swimming Pool & Spa. Sustainability of Swimming Pools and Spa in a One Health Perspective, Bologna, February 15-17, 2023. Abstract book”, 2023, s. 56.

What is the hypothesis of this study?

The literature review described above helped us to test our key hypothesis, namely that rainwater would be an appropriate source of water for public artificial swimming pools for swimming or bathing purposes.

Would you be so kind to avoid repeating the abstract; providing unnecessary background information; exaggerating the importance of the work claiming novelty without a proper literature search.

Both the abstract and the introduction have been rewritten, also taking into account other reviewers' questions and comments on this matter. Thank you for your comments, which have allowed us to improve these two chapters of our paper.

Line 33-34: Some information are repeated in this part, e.g.:

For example, in Poland the total volume of rainwater stored in existing harvesting systems is only 6.5% of the volume of the average annual river discharge,...

Line 73-75:

Meanwhile, the total volume of water stored in existing retention basins in Poland is only about 4 billion m³, which is only 6.5% of the volume of the average annual river discharge.

Thank you for noticing our error; the repeated information has been removed.

Line 78: Could you provide the description where the Figure 1 comes from?

The Polish National Central Statistical Office report, Available online: <https://raportsdg.stat.gov.pl/> (accessed on 06 July 2023) does not contain Figure 1. Renewable freshwater resources per capita (annual multi-year averages) in Europe [3].

Thank you for noticing our mistake. The description had been corrected. Figure 1 comes from The Polish National Central Statistical Office report, for which the full link is https://raportsdg.stat.gov.pl/Stany_srodowiska.html#Zasoby_naturalne

Materials and Methods

Could you provide the definition about the rainfall intensity? What are the precipitation amounts *for intensive and moderate rainfall*, see:

Line 115-118:

Samples were collected during selected rain episodes according to rainfall intensity and after rejecting the first flush. The first flush time was established for intensive and moderate rainfall...

The definition of the rainfall intensity has been provided into the Materials and Methods chapter, an intersection 2.1. 'Subject of study' and is also elaborated below. Thank you for your attention and pointing out the lack of this definition in our article.

The rainfall intensity is a parameter which measures the amount of precipitation over a period of time and, it will normally be measured in mm/min. It is a very changeable parameter. It can vary over a wide range within one rainfall event, regardless of its duration. For example, with the maximum intensity maintained for 20 minutes, under a heavy rainfall, almost half of the monthly amount of precipitation can fall.

In accordance with the morphological features, i.e. with the set of external signs, rainfall types can be classified as drizzle, cloudy rainfalls and storm rainfalls. Drizzle refers to rains with an intensity of 0.1 mm/min; rains with an intensity from 0.01 to 0.02 can be categorised as cloudy rainfalls. Rains with an intensity of more than 0.5 mm/min (30 mm/hr) can be classified as storm rainfalls. Thus, in the case of our study, moderate and intense rains have been chosen with the intensity exceeding 0.02 mm/min.

Could you provide the description of the climate characteristics was the area, where the study fields are situated?

The description of the climate characteristics of the the Upper Silesia area, where the study fields are situated have been provided. It has been implemented into the Materials and Methods chapter, an intersection 2.1. 'Subject of study' and is also elaborated below. Thank you for your pointing out the lack of this description in our article.

Upper Silesia has a Central European climate that is influenced by oceanic and continental air masses. The climate of this area is characterized by its high variability and irregularity of cycles, with a predominance of oceanic influences, which determines small temperature fluctuations. The climatic conditions are transient and are affected by both oceanic air masses from the west and continental air masses from the east. The average annual rainfall is high (700-800 mm), due to the prevailing upland nature of the area, and the average annual temperature ranges from 7 oC to 8oC. Westerly winds of low speed predominate. The annual number of days with frost can reach 40, and there may be up to about 50 snowy days. The greatest frosts rarely exceed -30°C, while the maximum temperature is 38°C. The thickness of the snow cover varies from 50 cm in the Silesian Lowland to 150 cm in the Beskids.

Natural processes are also overlapped by anthropogenic factors, which results in the creation of separate local climatic conditions within urbanized areas, which are distinct from those in the surrounding areas. In the areas of economic agglomeration, a local climate has developed which is characterized by an increased number of foggy and rainy days. In GOP (the Upper Silesian industrial district), the air pollution indicators are higher than in other industrial agglomerations.

Could you justify, why did you choose these specific locations in the study fields?

These specific locations have been chosen in order to determine the impact of roofing material on water quality. We have taken into account different areas, such as urban, rural and industrial ones, to check whether the type of area might contribute to the rainwater quality.

The justification of the specific locations in the study fields have been provided into the Materials and Methods chapter, an intersection 2.1. 'Subject of study'. Thank you for your right suggestion and comment which pointed out the lack of this justification in our article.

Why you study period April to June 2023? Is there a special reason for that?

Please note that we have already answered this question (please see above) in the 'Broad Comments' part of this review. In addition to that we have summarised our detailed explanation into a single paragraph which we have included in the Materials and Methods chapter, an

intersection 2.1. 'Subject of Study'. Thank you again for your attention, appropriate comment and for pointing out the lack of this explanation in our article initially.

Results and Discussion

Could you provide of mark limit values for each of the testing parameters according to applicable standards in Poland? Otherwise, Table 3 is a very difficult to interpret.

Mark limit values for each of the testing parameters, according to standards applicable in Poland, have been provided in Table 4. which is entitled 'Some water quality standards for swimming pools according to Polish requirements'

Would you be so kind to provide also limit values concentration of total Zn and other investigated substances for the swimming waters, assessed according to the criteria of the European Union?

A wide range of Standards are applied across Europe to the pool and spa industry. The overview of European norms for the main standards applicable to the swimming pool and spa industry includes among others EN 15288 Swimming pools for public use - Part 1: Safety requirements for design and Part 2: Safety requirements for operation. These documents do not specify the limit values for the concentrations of total Zn and other substances investigated in this study with respect to swimming pools. Unfortunately, the legislation on the quality of swimming pool water is not consistent across Europe; it varies from country to country. There are no clearly defined limit values for the pollutant concentrations, which the authors of this paper also regret. The discussion of this issue have been provided in the Introduction chapter, also taking into account other reviewers' comments.

Conclusions

The conclusion is rather vague and general. This part is not presenting what is the scientific view in this research, and the innovation is not clear here. It is not clear which water samples were suitable for swimming purposes and which compounds were appropriate according to regulations in Poland and European Union. Was there any time variability between the individual samples taken from the same surfaces?

Thank you for your feedback. The conclusions chapter has been rewritten according to Reviewer 1's comments and suggestions.