Water is life.

A Comparative Sustainability Analyses of Natural and Conventional Chlorinated Swimming Pools in Hungary and Sweden.

Ernő Tóth-Pál

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Swedish University of Agricultural Sciences, SLU

Faculty of Landscape Architecture/Department of Landscape Architecture, Planning and Management

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Ernő Tóth-Pál

Supervisor: **György Ängelkott Bocz, Swedish University of Agricultural Sciences, Department of Biosystems and Technology**

Assistant supervisor: Helena Mellqvist, Swedish University of Agricultural Sciences
Examiner: Anders Folkesson

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Swedish University of Agricultural Sciences
Faculty
Department

Abstract

Natural Swimming Pools (NSPs) offer a sustainable alternative to conventional Chlorinated Swimming Pools (CSPs), relying on natural processes for water clarity rather than chemicals. CSPs, while common, do not align with sustainable practices. This study aims to compare NSPs and CSPs in terms of economic, environmental, and social sustainability, specifically in the contexts of Sweden and Hungary. While prior studies have examined these pools, a comparative analysis in this context has yet to be explored. This paper seeks to highlight the differences and compare Swedish and Hungarian perspectives on sustainability regarding swimming pools. Through interviews, site visits, and two questionnaires, qualitative and quantitative data were collected in both countries. The findings reveal that NSPs are significantly more sustainable and healthier than CSPs across economic, social, and environmental dimensions. Despite this, NSPs remain relatively unknown in Sweden and Hungary. However, their popularity is rapidly increasing, suggesting potential future business opportunities. Additionally, the study found that Hungary places greater emphasis on economic and social sustainability factors when choosing swimming pools, underscoring the cultural and economic differences between the two countries.

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1. Introduction

In today's society climate change is a widely debated topic, which sparks diverse opinions and actions. A wider *definition of climate change i*s the one from the Intergovernmental Panel on Climate Change (IPCC) which is: “Any change in climate over time whether due to natural variability or as a result of human activity.” As mentioned before, the previous sentence is a wide definition which hopefully will not cause any confusion among people (Pielke 2004). Indeed, the observed impact of climate change on nearly 100 physical processes emphasises the importance of this issue (Smith et al. 2001). For example, the abundance of water is expected to have significant impacts on the hydrological cycle due to the intensified greenhouse effect (Arnell 1999). This would lead to more extreme weather events, including increased droughts and floods.

Water is a fundamental need for everyday life, and its cycle is indistinguishably linked with climate change (Westall & Brack 2018). Without water, life would not exist on Earth (Kushawaha et al. 2021). As mentioned by Albert Sent-Györgyi, “Water is life's matter and matrix, mother and medium. There is no life without water.” As a result of climate change and its effects, water and water storage areas are going to be essential resources in the future. A good example of a large water storage infrastructure, especially in urban settings, are swimming pools. While they are not initially intended for emergency water storage, their purpose can shift due to significant climate changes.

Sustainability is another crucial concept in today's society which conserves resources and creates well-being for future generations (Brown et al. 1987). Sustainable development can be categorized into economic, social and environmental factors which need to be in balance with each other (Kahn 1995).

(1) Social sustainability is a matter of equity and universality, as it attempts to increase people’s well-being by promoting fair inclusive and integrated communities.

(2) Environmental sustainability ensures the survival of species, protecting natural resources and reducing pollution to avert climate change.

(3) Economic sustainability aims to support long-term economic development without depleting resources or compromising the well-being of current and future generations (Basiago 1998), (Brundtland, G.H., 1987).

In the context of swimming pools, sustainability can be defined as planning, building, and maintaining the pool to minimise negative effects on the environment, preserve natural resources, and encourage long-term viability. Measurable sustainability indicators include water, energy, and chemical management. Additionally, material selection, where eco-friendly materials are chosen, is also a key factor together with sustainability education when teaching pool users and builders.

1. 1. Background

Swimming pools of all types have existed for millennia and people have been using them for their recreational values (Llana Belloch et al. 2011). The usage of pools for relaxation dates back to 3000 BCE to the Indus Valley civilization. However, the Romans and Greeks popularised it and this is what most people refer to when discussing the origin of pools (Gabrielsen 1969). Modern pools can be defined as water bodies constructed for relaxation in an urban-suburban context (*Swimming pool Definition & Meaning | Britannica Dictionary* n.d.). In contrast to a lake or river, a conventional pool lacks both a continuous replenishing of natural freshwater and the natural processes that keep an adequate water quality. Thus, a method of water sanitation becomes essential to ensure safe and enjoyable swimming experiences (Olsen 2007). Swimming pools can be built indoors and outdoors with different methods used for construction. Pools can be above ground where a solid construction keeps the water inside the pools or dug underground where pressure from the earth keeps the water retained.

Typically swimming pools are divided into two different types: conventional Chlorinated Swimming Pools (CSP) and Natural Swimming Pools (NSP).

1. 1. 1. Chlorinated Swimming Pools

The first time chlorine was used for sterilising water was in 1897 by a British scientist Sims Woodhead. However, it was not until the early 1900s that the regular application of this chemical in pool water became common (Olsen 2007). The method of keeping water clean for human purposes such as bathing and swimming in a public context is achieved by putting chlorine and other chemicals like bromine, calcium hypochlorite, and pH regulators in the water which thereby becomes “sterile”. This means all living organisms, bacteria, fungi, amoebas etc. (among which, many can cause diseases such as Escherichia coli, etc.) are killed in the pool and are then removed by filtration.

1. 1. 2. Construction of Chlorinated Swimming Pools

In an urban setting, the first step in constructing any swimming pool is acquiring building permits for the construction needed in the designated country. Pools can be situated both under and above ground. After the design phase, similar to NSPs, excavation and construction follows. The construction process can be divided into the following main phases:

- Site set-up
- Excavation (pool body & pump room)
- Foundation and groundworks
- Construction/installation of the pool body
- Engineering
- Start-up
- Landscaping

There are several ways to construct the pool body.

The traditional method was using natural stone slabs and blocks while during the 20th century, the use of concrete became popular. After the excavation (pool body, pump room, piping, drainage etc.), a base foundation is constructed that includes the piping, electric conduits, drainage and the levelling of surfaces ready to receive the pool body. In the next phase, a pouring form is built and used as temporary walls during the pouring of the concrete (Darling 1933). Steel rebars are used to reinforce the pool structure. Then concrete is poured over the rebar into the retainment walls shaping the pool's outline. After the concrete has cured completely, a membrane is applied on the inside of the pool, usually covered by tiles or PVC plastic liner, which makes the pool watertight and easy to clean in the future (Gabrielsen 1969). Plumbing and other engineering are installed in a separately built engineering chamber (pump room) to circulate water in the pool and connect it to the filtration system. The filtration system typically includes a pump, sand or other types of filter (such as UV) and chlorination dosator equipment to maintain water quality and clarity. Once construction is complete, the pool is filled with water. The water chemistry is balanced by adding chlorine and other chemicals to disinfect the water and maintain proper pH levels (Darling

1933; Gabrielsen 1969). The final phase of the swimming pool construction process is landscaping.

Another way of constructing a pool is by using a ready pool form made of fibreglass or plastic such as polypropylene (PP) or PVC. With this method, one builds a foundation in principle the same way as in the case of a concrete pool then places a ready pool body onto the foundation materials (Perkins 2000).

A third way of constructing a pool is to use an outer structural form such as made of metal that is covered on the inside by a liner (PVC, EPDM etc.) (Perkins 2000).

1. 1. 3. Natural Swimming Pools

In the 1970s, the concept of natural swimming pools was developed in Austria by D.I. Werner Gamerith, Professor Roldinger, and Richard Weixler (Dold 2008). In 1985, Austrian ecologist Peter Petrich commercially developed the concept further through his company named Biotop (Littlewood 2005).

NSPs are large ponds with special provisions for people to enjoy the water as well as the various animals that are attracted to it (Littlewood 2005). These kinds of pools don't use chemicals for cleaning but rely on plants, microbes, biofilters, and electric pumps to purify the water in addition to creating a small ecosystem in a confined space (Dold 2008). The main cleaning organisms in NSPs are zooplanktons, like Daphnia, that feed on suspended algae in the water. Plants have multiple roles in Natural Swimming Pools. First, they take up nutrients from the water thereby limiting algae growth. Second, they can absorb pollutants and contaminants floating in the water by natural filtration. Lastly, the roots of these plants provide a habitat for beneficial microorganisms that further contribute to water purification (Littlewood 2008; Daneshgar & Taghizadeh 2017).

From an aesthetic point of view, NSPs can look vastly different (Figure 1). They can be classed into three different categories based on the filter system they use.

1. 1. 4. Traditional Natural Swimming Pools

These kinds of pools use a method where the water is cleaned mainly by a significant amount of aquatic plants. These plants help to oxygenate the water, and absorb nutrients, and specially their root systems provide habitat for beneficial microorganisms, contributing to water clarity (Figure 1 left picture).

1. 1. 5. Living Pools

The living pool utilizes a distinct system known as a Bio-Filter, which employs spongy, surface-increasing material as its media. This material supports the growth of microbial populations on its surface (Dold 2008). The filter is a box filled with an area increasing for example sponge-like material and is usually hidden away underground, somewhere near the swimming area. Pumps need to be used to keep the water circulating to maintain water quality. As seen in the right picture of Figure 1, living pools can look extremely similar to chlorinated pools only without the use of chemicals.

1. 1. 6. Hybrid Natural Swimming Pools

Hybrid NSPs combine elements of both traditional and natural swimming pools, incorporating features.

Figure 1. Differences in how NSPs can vary in looks. Both pools are NSPs but the picture on the left uses a traditional filter system with plants and the picture on the right uses a “Biotope” Bio-filter system hidden underground. *(Pictures obtained from Google’s CC0 picture library)*

1. 1. 7. Construction of Natural Swimming Pools

The first phase, after getting building permits, when constructing NSPs is the planning and design. In the case of a natural swimming pool dimensions and set-up are more crucial than with conventional pools. So the operation's most important phase is deciding the pool's size and depth, which can vary but, there are some recommendations when it comes to NSPs (Littlewood 2008). For an ecosystem to be successful, the pool must be relatively large to ensure greater stability. Small pools can be built, but they are more vulnerable to changes in the environment, thus larger pools are suggested (Pagan 2013). The depth of the pool in the swimming area needs to be at least 2 metres deep to maintain water temperature, which is important for the health of the plants and microbes, especially during the colder, winter months of the year (Pagan 2013). In this phase, the planning includes mapping out both the regeneration and swimming zones, with a requirement that the regeneration zone needs to cover at least 40-50% of the pool's total surface area (Littlewood 2008; Pagan 2013). In addition, the regeneration zone is usually separated by a wall from the swimming zone in order to create two separately controllable environments concerning water flow. After the excavation, Geotextile (f.ex. plyfelt-TS60) is laid down on the ground to protect the PVC, PEHD, EPDM, or Butyl liner. Originally this membrane layer was built with “bentonite” clay however, the synthetic materials replaced traditional ones since they last longer and are easier and cheaper to apply (Pagan 2013). Following this, another layer of protective geotextile is laid down, securing all of these liners with sandbags, washed rocks and boulders. After this, the regeneration zone is covered with a substrate material such as gravel or sand in which pipes are buried to draw water through thereby creating a flow through the substrate bed where the microbes clean the water, e.g. this layer acts as a biological filter (Pagan 2013). Depending on the design and size of the natural pool, other filtration components may be installed, including pumps, bubblers, skimmers, UV filters and biological filters. These components help circulate, aerate and clean the water, maintaining water quality and clarity. The landscaping is finalised parallel to the pool being filled up preferably with rainwater avoiding the least amount of nutrients leaching into the water (Littlewood 2008; Pagan 2013).

1. 2. Objectives

Sustainability has social, economic, and environmental dimensions. Although both pool types have been explored in the past, they haven't been compared in either a sustainability context or concerning their ability to mitigate the effects of climate change. The goal of this study therefore is to compare two types of pools in relation to sustainability and to help mitigating climate change. Furthermore, the paper explores people's perceptions and knowledge of these pools. As the research and data collection took place in both Sweden and Hungary, the paper will briefly explore the distinctions between these two countries as well, thereby how people perceive sustainability in pool-related context in these two countries.

This was accomplished through site visits and interviews, conducted with owners of pool-building companies and pool users in both Sweden and Hungary. Additionally, a questionnaire was sent out on online platforms to facilitate unbiased data collection aimed at comprehending the public's perspectives. This was to accumulate data from all levels of knowledge.
Due to the limitation of time, funding, and lack of research, this study is touching just the surface of the topic.

1. 3. Research questions

The main research question, which this paper was built upon, is the following:

"How do Natural Swimming Pools and Traditional Chlorinated Swimming Pools compare in terms of sustainability; in the context of Sweden and Hungary?"

It is hypothesised that natural swimming pools offer a more sustainable and environmentally friendly alternative compared to chlorinated pools while also providing social, economic, recreational and health benefits.

Another hypothesis of the study is based on the presumption of a lack of knowledge regarding NSPs in both countries, whereas Hungarians may be more

swayed by economic and social factors, while Swedes may prioritise environmental factors when selecting pools.

2. Methods

This study is based on both quantitative and qualitative data which was collected using three different methods: a literary review, site visits with interviews and questionnaire based inquiry during the span of a 3 month period. The project covered two geographic and socio-economical settings, Sweden and Hungary.

2. 1. Data collection

2. 1. 1. Literary review

Access to relevant articles, books, forums, and research papers about natural swimming pools and conventional swimming pools was achieved through using multiple databases such as Google Scholar, SLU Primo, and Web of Science with the use of boolean operators. Additionally, AI research tools were also used like Scispace to further acquire papers for the research. This research involved a comprehensive literature review of 6 books, 2 book sections, 19 scientific articles, 1 thesis, 1 report, and 1 web page. Each source was thoroughly read, with detailed notes and summaries taken. This approach ensured a well-rounded foundation, integrating diverse perspectives on the sustainability of natural and chlorinated swimming pools.

2. 1. 2. Interviews & Site Visits

Interviews were conducted with both users and builders of NSPs. Participants were chosen with purposive sampling, targeting specific groups that are involved with building or owning natural swimming pools. The same questions were asked both on the interviews and the site visits to ensure comparable data. However, the pool builders and users received slightly different sets of questions that had overlapping questions concerning economic, social, and ecological sustainability. More detailed questions about their knowledge and background in sustainability were posed to the builders, whereas the users were asked more general questions about their perception of the pools (Table 1). Before the face-to-face interview, consent from the interviewee was obtained and captured using a voice recorder. During the 15 to 60-minute interviews, the answers and discussion points were documented with pen and paper.

The interviews took place in Sweden and Hungary in different locations, with English and Hungarian as the chosen languages.
The first interview was with Per-Uno Alm a sustainability expert who lives in a town called Ystad in Skåne (Sweden). The second interview took place on the same day as the first one and involved a couple named Thomas & Britt, who are both pool users and also residents of Ystad. Getting in touch with the company owners and users was done through Google searches and phone calls. The third interview was in the Ekeby settlement, with a company owner called Bo Anders Erling Bosse Andersson. The company is called AQUALYX AB and it specialises in building NSPs in Sweden. The fourth interview was also with a company owner called Károly Görög who owns Görög Vízikertészet Kft. which also specialises in building natural swimming pools in Hungary and Austria. The location of the interview was in Budapest, the capital of Hungary, 11th district. The fifth and final interview conducted was in the 22nd district of Budapest with a pool owner and user named András Tárnok. The questions main questions asked during the interviews can be seen in Table 1.

In addition to the five interviews, in four of them, a site visit has been carried out as well. In the site visits, different NSPs have been inspected and documented with a camera. The building method, maintenance, materials used, and aesthetics have been examined during the site inspection. A Nikon 18-55mm VR lens camera was used to photographically record details of the site visits.

Table 1. Showing the questions asked during the interviews.

Questions asked from the users:	Questions asked from the builders and experts:
Background: Have you ever used a natural pool? If yes, what was your experience? Why did you choose this pool? **Economy:** Which kind of pool is more expensive to build at the beginning? Which kind of pool is more expensive to maintain in the long run? In your opinion what is the life expectancy of these kinds of pools? **Social:** Which type of pool's water quality is better? Why? Which pools promote a healthier lifestyle? (Physical and Mental Health) How do you perceive the aesthetic appeal of natural pools compared to traditional ones? Can pools contribute to educating people about the natural environment? How? **Environmental/Ecological:** Which pool type is better for the environment? **Challenges/Limitations:** Have you observed any drawbacks of owning a natural swimming pool? What?	**Background:** How long have you been involved in building/owning pools? What is your motivation for your business? What are the main reasons customers choose these kind of ponds? Is there a growing demand for these kinds of pools? (Opportunities) **Economy:** What are the initial costs of building a natural pool compared to a traditional one? How do maintenance/running costs compare to the regular chlorinated pools? Will these costs change in the future? **Social:** Is the pool private or business-built? Who uses it? Are natural swimming pools better for human safety and health? Have you observed any social benefits with natural pools compared to chlorinated ones? **Ecological/Environmental:** What environmental benefits do you see in natural pools? (To now and for the future) How do you manage water quality and sustainability in traditional chlorinated pools? **Challenges and limitations:** What challenges do you face when building or maintaining natural pools? Are there any drawbacks to building natural ponds compared to traditional ones you know?

2. 1. 3. Questionnaire

An easy-to-understand questionnaire was put together in Google Forms. Quantitative questions were transformed into measurable value-based questions using the Likert scale. Additionally, two versions of the form were done, one in English and one in Hungarian. However, all the questions were the same in both versions to maintain consistency across the data collection.

The questionnaire included a general section to inform participants about its purpose and who is conducting it. A brief definition of what Natural swimming pools are was placed at the beginning of the form, so people who have never heard of the concept can understand it as well. After that, information about the participant's rights and answers were presented. For example, the questionnaire is completely confidential and all data is anonymised and protected. Furthermore, it was explained that the survey is voluntary, and if any questions or concerns arise while doing the questionnaire from the participant's side, contact information was provided by e-mail and phone number.

All questions were numbered and were collected in a consequent and thematical order in multiple-choice format or rating on a Likert scale from 1 to 5. The

questions presented to the respondents were about their background (gender, age, previous education), knowledge, perceptions, and preferences. The questions asked focused on economic, social, and environmental sustainability. In the form, pictures of different pool types were presented to further explain the question and to keep the participant engaged. Before distributing the form to a wide audience, internal and external validation was done to finalise the questionnaire using a panel of 10 people who gave feedback on the structure and context of the questionnaires. Finally, the form was distributed on online platforms including WhatsApp, Facebook, and Instagram by joining groups where group members help answer each other's forms. The layout how the questionnaire looked like what questions were used can be seen in Figure 2.

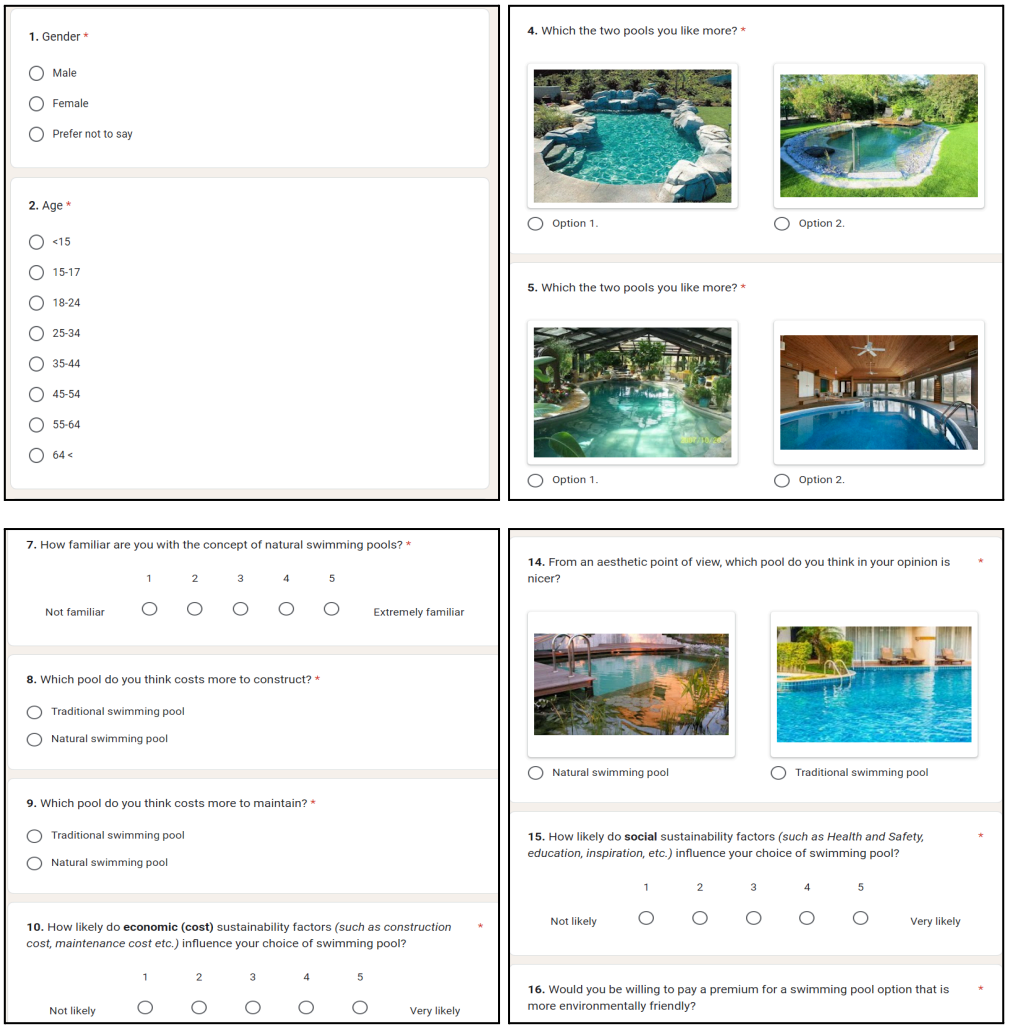

Figure 2. Pictures showing what the questionnaire looked like and what questions were used. *(Pictures obtained from: Ernő Tóth-Pál)*

2. 2. Data analysis

Data gathered in the research from the literature review, interview, site visit, and questionnaire was also analysed. For the thematic and content analysis of the interviews, the responses of the interviewees were organised systemically to identify recurring themes or contradictions. In this way, the analyst was able to see patterns and the consistency or inconsistency of the aspects narrated in the responses. Additionally, the qualitative data that was gathered from Google Forms was also analysed using Excel. The responses were gathered and calculated to percentages to show the tendencies of the responses. Furthermore, the data was transformed into graphs and charts to show how the responses were spread out, making it easier to see any patterns or variations.

A questionnaire was sent to Sweden and Hungary translated into English and Hungarian to collect data from the participants about how they perceive the different parts of sustainability regarding NSPs and CSPs. After the questionnaires had been sent out for 3 weeks, a total of 116 responses (N_{total}=116) were received, with 69 coming from Hungarian and 47 from Swedish respondents. Due to the small sample size, an independent t-test was not conducted however, tendencies can be observed in the results.

3. Findings

This section of the study will provide a detailed analysis and explanation of the findings obtained from the interviews, site visits, and questionnaires to evaluate and compare the sustainability of natural swimming pools and chlorinated swimming pools.

These data-collecting methods were used to try to understand what people think of these kinds of pools and how they perceive them. The diverse backgrounds of the participants - like experts, users, and members of the general public - are intentionally varied to compare their perspectives and explore potential correlations between their countries of origin and expertise. Additionally, the analysis was performed to identify the strengths and weaknesses of these kinds of pools regarding sustainability to discover which pool type is more environmentally friendly and socially beneficial in the long run. That is why both quantitative and qualitative data were collected. Qualitative interviews were conducted to understand people's perspectives, while quantitative data from the questionnaire were used to reinforce and provide support for these insights.

3. 1. Interviews

Table 2. Showing the information regarding the carried out interviews.

Date:	**Interviewee:**	**Background of the Interviewee:**	**Location:**
2024/03/26	Per-Uno Alm	Sustainability expert	Skåne, Ystad
2024/03/26	Thomas & Britt	Pool users in Sweden	Skåne, Ystad
2024/03/27	Bo Anders Erling Bosse Andersson	Pool builder in Sweden	Skåne, Ekeby
2024/04/03	Károly Görög	Pool builder in Hungary	Budapest, 11th district
2024/04/05	András Tárnok	Pool users in Hungary	Budapest, 22nd district

3. 1. 1. Interview 1: **Per-Uno Alm**

The first person interviewed was Per-Uno Alm, a sustainability expert who is well-versed in all the benefits of having a natural pool.

In the interview, it was stated by Per-Uno that the initial cost and maintenance are less compared to a regular chlorinated pool. The main cost difference are not needing to purchase chemicals for NSPs. It was quoted, “The pool is doing its own job and helping itself to maintain.”

Additionally, it was mentioned by Per-Uno that NSPs increase biodiversity and are not harmful to other species nearby. Furthermore, it was noted that the water quality is so good that it can be consumed by both animals and humans.

In case of emergencies, such as extreme drought, the water can be used for drinking and watering, as mentioned by Per-Uno. Per-uno also finds NSPs more aesthetically pleasing than CSPs. It was mentioned by him that visitors are surprised by the fact that having a pool without chemicals can be so clear. The interviewee referred to someone who had previously visited the pool and said: “Water is crystal clear. You can see the pebbles on the bottom as well!”

The main takeaway points from the interview are the following. The regeneration zone doesn't have to cover a minimum of 50% of the swimming area. Instead, spongy materials and meshes can be used to expand the surface area of the regeneration zone where beneficial microbes can grow. Furthermore, without a pump, a NSP can not operate told by, Per-Uno.

3. 1. 2. Interview 2: **Thomas & Britt**

Thomas and Britt are a couple living in the countryside in Ystad, Skåne. The main reason they choose a NSP over a chlorinated one is because they dislike the use of chlorine and other chemicals. Thomas is a professor of chemistry and knows the harm these chemicals can do to the human body. Additionally, these types of pools offer ecological benefits that align with their preferences and priorities.

They did not consider economics since CSPs would have not provided them with the values they wanted from a pool. However, they assume that with the use of chemicals, there would be less maintenance work with the pool.

Since ecological values were one of the priorities when choosing a pool for them they believe it greatly promotes biodiversity. They talked about animals coming to the pond like toads, frogs, salamanders, birds, and snakes which they value a lot and do not consider as any danger. They appreciate the fact that the small pond creates a microclimate in their garden making summers more enjoyable. Britt quoted on regards the pond being healthy for them, “If there is water there is life. Where there's life, it must be good for us as well!”

Regarding questions of social sustainability, the couple talked about NSPs promoting a healthier lifestyle which is more aesthetically pleasing and will last longer in the future. In addition, they highlighted that NSPs can be a brilliant teaching method for learning about sustainability, especially for future generations.

The main takeaway points from them were that the thinking of sustainability in today’s society is kind of lost. This needs to be needs to be thought again for the people and NSPs are a great way of doing so.

3. 1. 3. Interview 3: **Bo Anders Erling Bosse Andersson**

Bo Anders Erling Bosse Andersson is the owner of AQUALYX AB a company that specialises in building NSPs in Sweden. He is a polymath regarding his occupation since he learned about NSPs in Austria where the concept originates and was close friends with Peter Petrich the founder of the company Biotop. He has been in the business for 6 years and his goal is to get more people to use NSPs free from chemicals.

He mentioned that in terms of the initial construction cost, it tends to be more expensive compared to CSPs; nevertheless, he mentioned that it could be built cheaper but not recommended. However, maintenance is easier and cheaper at a NSP compared to a CSP. Furthermore, the longevity of the pool is three times more than that of a chlorinated swimming pool making it more sustainable. Additionally, it was mentioned that the demand for NSPs is growing exponentially.

After asking questions about environmental sustainability it was clear that Anders is well aware of all the benefits of having a NSP and all the disadvantages of CSPs. It was mentioned how harmful the chemicals are to the environment and the way the water is treated after using the pool is not sustainable. During the interview, an interesting concept that had not been heard before was raised. He mentioned that developed and healthy NSPs have a so-called “immune system”. This means a NSP which had time to develop the ecosystem of the water can fight off harmful viruses and bacteria like e. coli, polio, or cholera. In addition, it was mentioned that in CSPs the chemicals that serialise the water from harmful diseases kill the beneficial bacteria on the surface of the human skin, which in turn can cause problems.

He also mentioned working together with athlete swimmers in the past and they’ve requested a pool without chlorine because the chemicals were affecting the athletes. Similar to Per-Uno, Anders brought up the argument that the pool can be used as an emergency water reservoir for drinking and watering in the event of droughts caused by climate change. During the interview, mental health was mentioned as well. According to Anders and other studies, swimming in nature can decrease stress and improve people’s mood and well-being (Overbury et al. 2023). A complaint about having too many mosquitoes with NSP was also brought up. A governmental issue concerning NSPs was also raised that these kinds of pools can’t be used in social settings since health and hygienic

regulations would not allow the gathering of too many people in a non-sterile environment.

3. 1. 4. Interview 4: **Károly Görög**

Károly Görög is the company owner of Görög Vízikertészet Kft. With 40 years of experience in the industry specializing in constructing NSPs in Austria and Hungary. However, his clients are mostly from Austria, making him operate abroad most of his time. This trend may come from a better understanding of sustainability and higher affordability for such luxury items among the Austrian population compared to that of Hungary. A statement made by one of Görög's Austrian clients exemplifies the community's sustainable mindset: "What falls into the pond belongs there." He also talked about how there is a lack of knowledge about these ponds however the demand in the industry is exponentially growing. Most of his customers choose these kinds of pools because they don't want to have chemicals and want to enjoy the pool for longer times.

Economically, initial investments for NSPs can cost more but this can vary a lot depending on circumstances. On the other hand, the running and maintenance costs of NSPs are significantly lower. Due to not needing to buy chemicals, significantly less refilling of the pool, and no electricity is needed for heating the water.

Görög was well-educated on the topic regarding the environmental impact of NSPs. It was mentioned that the addition of such habitat even in the most urban setting can significantly increase biodiversity in a short amount of time. It was said that within hours of a client's pool being made animals started appearing.

From the social sustainability point of view, NSPs are healthier mentally and physically, as stated by Görög. People swimming in chlorinated water for a long period of time can develop different lung problems he mentioned. Moreover, NSPs offer a valuable educational experience for individuals, particularly children, to learn about sustainability.

Furthermore, Görög mentioned that in the future the swimming area of the pools can change over time. Due to climate change, the summers are getting hotter so a deeper swimming area needs to be accounted for in regards to building. This is due to the necessity of maintaining water quality, which requires that the water temperature not exceed a certain threshold. It was further mentioned regarding governmental permits that in Hungary, private owners do not need a permit to build such pools in their gardens for private use. According to Görög, this makes the beginning phase of planning pools for people less stressful, quicker and,

more efficient. This could certainly be incorporated in other counties as well, as Görög stated.

3. 1. 5. Interview 5: **András Tárnok**

Tárnok is a student at the Hungarian University of Agriculture in Gödöllö. Tárnok has previous experience with NSPs in addition to him being educated in the topic as well.

Questions regarding the economy, Tárnok thinks both the initial costs and maintenance are lower compared to CSPs. However, the maintenance is significantly different between the two pools.

Since Tárnok studies horticulture engineering, he knows all about the environmental benefits of having a NSP. He shared that upon the pool's construction, wildlife from various locations began appearing in his garden, including rare species. A particular anecdote was mentioned about a heron, an exceptionally uncommon sight in his urban neighbourhood, flying into his garden. Furthermore, Tárnok and his family use the nutrient-rich water from the pool for watering the garden.

After asking the question regarding which pool has better water quality, his response was: “The traditional pond is cleaner but people won't get hurt by these natural pools.” Aestatich vice, Tárnok prefers the NSP a lot more compared to the CSP. Additionally, he finds great satisfaction in the interaction between himself and his pool.

He mentioned drawbacks of the pool. When frogs are in mating season the sound they make in their garden is annoying them. Since the family owns a CSP as well, cleaning the NSP is found to be more tedious.

Tárnok can only recommend people to build NSPs in their gardens but understands that these kinds of pools are not for everyone.

His overall summary regarding these pools was: “People who don't get bothered by nature but praise it; will understand that natural swimming pools are better.”

3. 2. Site visits

3. 2. 1. Site visit 1: **Per-Uno Alm**

The NSP inside his home is owned by Per-Uno Alm, operating on a hybrid filtration based on an Alnarp Clearwater water cleaning system, connected to his rainwater harvesting system (Figure 3). The filter system has one plant species only and mostly relies on microbial activity to clean the water. As for aesthetics, the way the pool was built it does not look like a NSP but more like a CSP. The pool was drained when the site visit happened however, a picture was received from Per-Uno showing the pool when it has water (Figure 4).

Figure 3. Hybrid filter system (left of the picture) which is connected to rainwater. *(The picture was taken by: Ernő Tóth-Pál)*

Figure 4. Per-Uno's pool when it is filled up with water. *(Picture retrieved from: Per-Uno Alm)*

3. 2. 2. Site visit 2: **Thomas & Britt**

The construction of the pool is done in a traditional way of having a larger regeneration area where plants clean the water (Figure 5). The pool is built in a way that resembles a river coastline with a shallow entrance for the swimming area. It also incorporates water design elements like bubblers and a waterfall. The bubbler and waterfall are not only there for aesthetic reasons but also to promote microbial activities by oxygenating and circulating the water (Figure 6). The pool was relatively small but wildlife was observed during the site visit.

Figure 5. Different zones of the pool and how it uses a traditional filter system with plants. *(The picture was taken by: Ernő Tóth-Pál)*

Figure 6. Water design elements like a waterfall and bubblers. *(The picture was taken by: Ernő Tóth-Pál)*

3. 2. 3. Site visit 3: **Bo Anders Erling Bosse Andersson**

Anders constructed the pool himself, implementing a Biotope system to maintain water quality and easy maintenance. As the design of the pool, it is considered as a traditional Natural Swimming Pool (Figure 7). Roughly 70% of the pool is the planted regeneration area where plants and microabs clean the water additionally (Figure 8).

It uses a two-water circuit design for filtration and water circulation, that uses two pumps. The first pump is responsible for cleaning surface debris like fallen leaves, bugs, and twigs. This pulls the surface water with the floating particles into a filter, removing them from the pool throughout the day (Figure 9). The second pump uses a submersible pump which allows water to flow by the force of gravity saving on energy. This is responsible for removing organic compounds dispersed in the water. In addition, this runs on a lower capacity compared to the other first pump only operates during the swimming seasons (Figure 10).

Figure 7. Traditional natural swimming pool design of Ander's pool. *(The picture was taken by: Ernő Tóth-Pál)*

Figure 8. Regeneration zone of the pool and the plants planted for aesthetic and water purification purposes. *(The picture was taken by: Ernő Tóth-Pál)*

Figure 9. Skimmer pump system removing the floating debris from the pool. *(The picture was taken by: Ernő Tóth-Pál)*

Figure 10. Submersible pump chamber *(The picture was taken by: Ernő Tóth-Pál)*

3. 2. 4. Site visit 4: **András Tárnok**

Around 2020, during the COVID-19 pandemic, Tárnok and his family owned a large Chlorinated Swimming Pool and they decided to convert half of it into a NSP with goldfish. The original pool was emptied and a retention wall from concrete was built to support the pressure from the water. In Figure 11. the traditionally constructed NSP can be seen in addition, on the left side of the picture the original swimming pool, which they have cut in half. On the other side of the retention wall, the NSP was built with a hybrid filtration system including bio-filtration and a UV filter. The regeneration area of the pool is roughly 70% (Figure 12). The pool also includes a waterfall for aesthetic reasons and oxygenating the water (Figure 13).

Figure 11. Design of the NSP. On the left side of the picture, the concrete retention wall can be seen, separating the CSP and NSP from each other. *(The picture was taken by: Ernő Tóth-Pál)*

Figure 12. Regeneration area of the pool with planted and existing plants. *(The picture was taken by: Ernő Tóth-Pál)*

Figure 13. Waterfall design element. *(The picture was taken by: Ernő Tóth-Pál)*

3. 3. Questionnaires

Questions 1-3 uncovered the respondent's background.

In Sweden, the majority of respondents were female with 57% around the age of 18 to 24 with a previous education of either high school or university. In Hungary, 76% of respondents were female mostly between the ages of 18 and 24 with a similar education background to Sweden with an even distribution of high school and university. Meaning, that the two groups of participants have relatively similar backgrounds.

In questions 4 and 5, two pools were shown, an NSP and a CSP, both with a similar style and the participants needed to choose which they preferred. In question 4, both pools were rounded shapes located outside and in number 5 both pools were inside with similar design elements. In question 4, participants chose the Chlorinated Swimming Pool with a minority and in question 5, participants chose the Natural Swimming Pools with a majority as shown in Figure 14. This can be due to the picture selection.

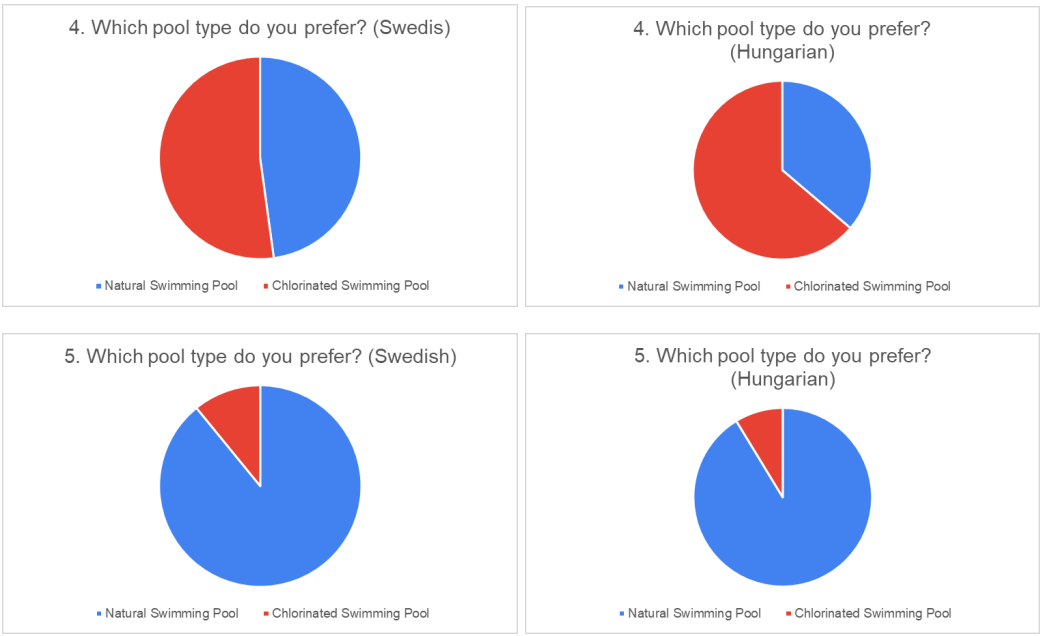

Figure 14. Graphs showing which pool type people prefer by pictures presented.

In question 6 it was asked if the participants had ever used a NSP before. In both cases, the majority of participants have not used these kinds of pools before.

In question 7, the participants were asked about their familiarity with the concept of Natural Swimming Pools and were instructed to rate their level of familiarity on

a scale of 1 to 5. A rating of 1 indicated not familiar at all, while a rating of 5 indicated extreme familiarity. The results show a slight tendency for the Hungarians to be slightly less familiar in total compared to Swedish participants regarding the subject as shown in Figure 15.

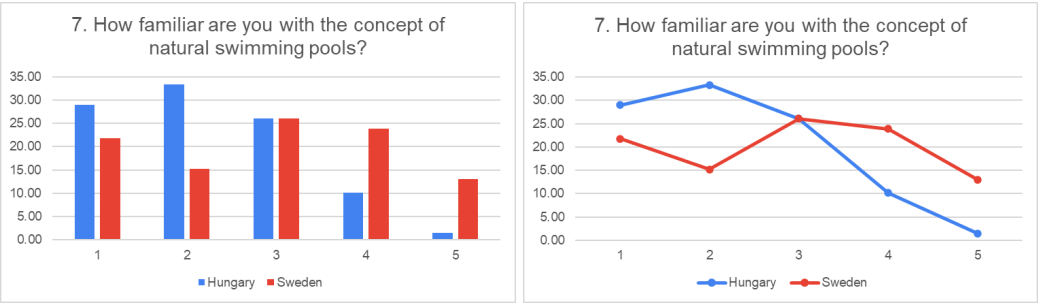

Figure 15. Graph showing a slight tendency of Hungarians being not as familiar with the topic of Natural Swimming Pools compared to Swedish participants.

In question 8 the question was asked which pool type costs more to construct and the difference between the two answers was equal to insignificant difference. *Question 9* asked the participants which pool type they think costs more to maintain and the results show a slight deviation towards CSPs costing more.
In question 10 it was asked how much economic sustainability factors influence the choice of swimming pools. Participants were asked to rate this on a 1 to 5 scale where 1 indicated not likely, while a rating of 5 was extremely likely. In this question, a deviation can be seen where the Hungarians are more dependent on economic sustainability factors than the Swedish when choosing a pool (Figure 16).

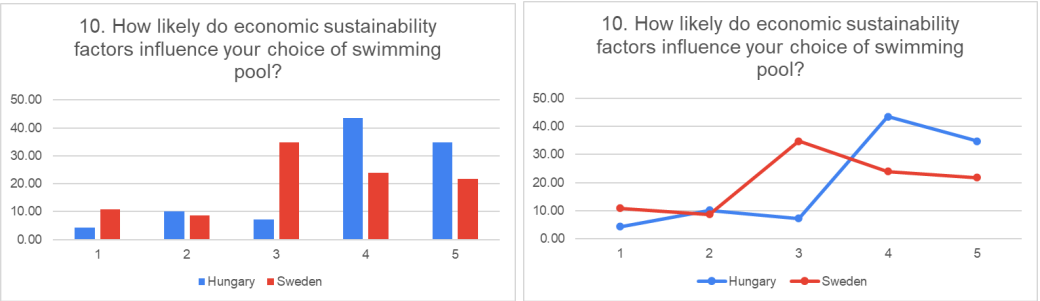

Figure 16. Graph showing a deviation that Hungarians are more dependent on economic sustainability factors when choosing a pool.

In question 11 participants were asked which pool contributes more to educating the people about the natural environment. The participants chose NSPs over CSPs with more than 90% majority in both questionnaires.

Question 12 question pool water quality was compared in terms of how they perceive the word “better” and the results show that around 80% chose to think the water quality is better in NSPs in both questionnaires.

Question 13 examined how likely participants would consider the health risks of chlorine and other chemicals when deciding on which type of pool to choose. The question used a 1 to 5 rating scale, with 1 representing not likely and 5 indicating very likely. In the Swedish questionnaire, the results lean towards the higher number whereas in the Hungarian the opinion is more split (Figure 17).

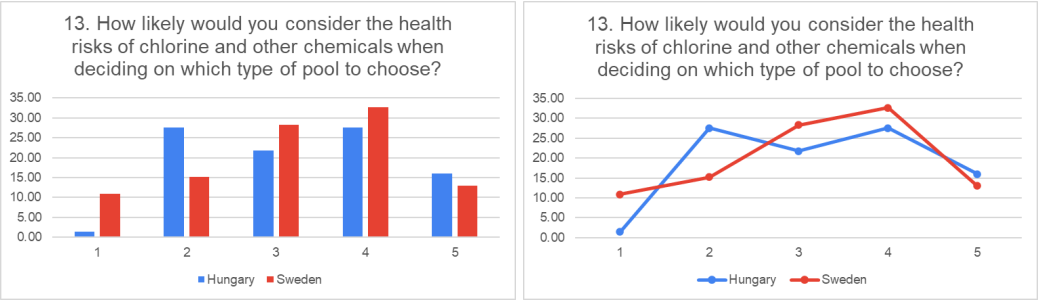

Figure 17. Swedish questionnaire leans towards more health considerations whereas the other is more slit opinions.

Question 14 examined how participants perceived each pool's aesthetic appearance. Over 80% of respondents chose NSPs over conventional ones with negligible difference between questionnaires.

Question 15 (constructed similarly to question 10) was concerned with social sustainability factors. A clear difference can be seen in the tendencies of answers, namely that Hungarians are more influenced by social sustainability factors than their Swedish counterparts as shown in Figure 18.

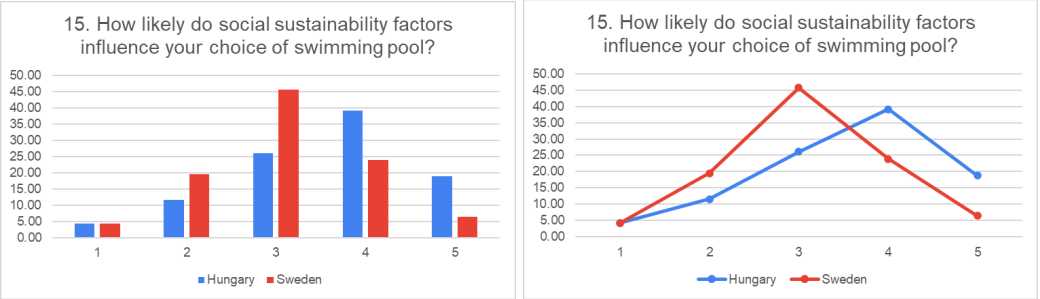

Figure 18. Graph showing that Hungarians are more influenced by social sustainability factors than Swedish when choosing a pool.

Question 16 asked the question of whether participants would be willing to pay a premium for a swimming pool option that is more environmentally friendly. Findings show that in both countries people would pay more for a more environmentally friendly pool. 66% of people answered yes in the English questionnaire and 76.8% of people did the same in the Hungarian one.

In Question 17 the environmental sustainability factors were asked similarly to questions 10 and 15. Both of the answers from the questionnaire lean towards higher numbers however a slightly higher peak can be observed in the Hungarian one towards 4 (Figure 19).

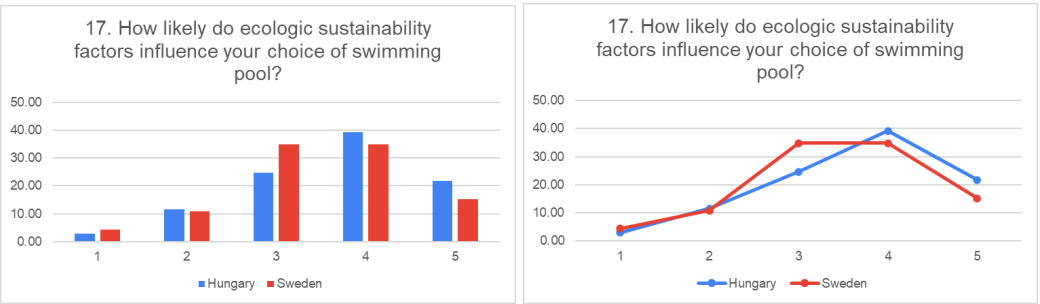

Figure 19. Graphs show that the answers are similar with a slight peak observed at the Hungarian one.

Question 18 asked participants about the biggest drawbacks of conventional pools and requested participants to provide keywords related to these. The words given by participants from the Hungarian questionnaire were first translated into English, and then these keywords were put into a word-map shown in Figure 20. The most frequent keywords were: chemicals, chlorine, smell, and irritation from 75 responses.

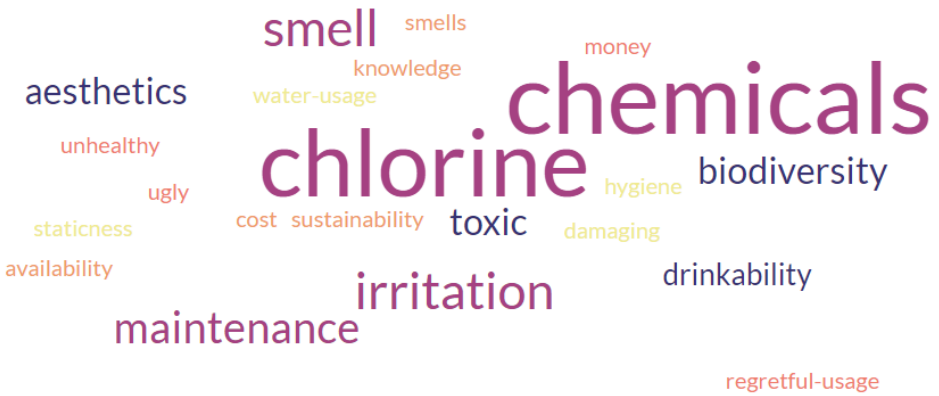

Figure 20. Word-map showing the participant's answers from the English questionnaire about the drawbacks of Chlorinated Swimming Pools.

Question 19 was similar to question 18. Participants were asked to give keywords related to the drawbacks of natural swimming pools (Figure 21). The most answered words were maintenance, cleaning, knowledge, and cost from total of 75 responses.

Figure 21. Word-map showing the participant's answers from the English questionnaire about the drawbacks of Natural Swimming Pools.

4. Discussion

Economically, NSPs seem to be more sustainable also being in line with Sustainable Development Goals (SDGs) 8 and 9 (United Nations 2024). Initial costs differ greatly depending on materials, techniques, availability and other variables. According to builders, initial costs are higher compared to CSPs however, according to most users and some literature it can also be less depending on individual circumstances such as material reutilization and procurement practices. However, maintenance was found to be cheaper for NSPs in the long run since chemicals and water changes are unnecessary (Pagan 2013). According to the interviews and literature, there are different expenses for maintenance in NSPs however it adds up less compared. For example, maintenance equipment such as pumps and water heaters use less electricity because NSPs don't require heating or high-performance pumps. (Pagan 2013; Çanakkale Onsekiz Mart University et al. 2022). In addition, building NSPs seems like an exponentially growing business across countries. According to the interviews, legal rights and building permits are not consistent across countries and in some cases acquiring these can be more difficult than for CSPs.

The questionnaire shows that, Hungarians are more influenced by economic sustainability than in Sweden and the biggest drawback of people choosing NSPs over CSPs is maintenance and cost. However, this perspective can change over time in case they become better informed about the economic benefits of using a NSPs over a long period of time.

Socially, NSPs were found to be significantly more sustainable concerning health and well-being as described by the UN in the global sustainability goal no. 3 (United Nations 2024). This finding is in line with both the literature review and interviews eg. being in nature and swimming in natural water reduces stress levels and improves well-being (Littlewood 2005; Overbury et al. 2023). However, some studies suggest that there are mental health benefits associated with interactions with water, doesn't matter if the water is chlorinated or not (Wutich et al. 2020). Being close to nature in a swimming setting may be more beneficial to mental health than being in chlorinated swimming pools, but this needs to be

explored in future studies. In addition, it was found that people who are frequently exposed to chlorinated pools, such as swimming instructors, pool staff, and competitive swimmers, may be at higher risk for respiratory and skin health issues (Couto et al. 2021). According to interviews, NSPs can be used as a teaching tool; offering hands-on learning opportunities and promoting environmental awareness. This would be in line with SDG no. 4 ensuring quality education which promotes lifelong learning (United Nations 2024). Further generations can learn about biology, sustainability and community engagement through the use of NSPs as educational tools (Hassall 2014). It was found through the questionnaire that NSPs are not known to the general public, especially in Hungary. Furthermore, while natural swimming pools (NSPs) can be more aesthetically pleasing due to their integration with plants and nature, people's perception of beauty is more closely linked with the water's clarity and colour, making it difficult to draw a clear distinction (Smith et al. 1995). According to the questionnaire, Hungarians are more influenced by social sustainability than people in Sweden. People recognise the immediate irritative effects of chlorinated water, but because NSPs are less widely known and here is limited public knowledge about the long-term health risks associated with chronic exposure of chlorine, they believe they have no other option but to choose NSPs over CSPs (Couto et al. 2021). This could be changed with the advertisement of these kinds of pools over multiple media; creating awareness.

Environmentally, NSPs provide much greater benefits compared to CSPs which is in line with SDG no. 13, 14, and 15 (United Nations 2024). According to the literature review and the data collected from interviews, biodiversity and resource management are rapidly and greatly improved with the use of NSPs. Biodiversity is enhanced surprisingly rapidly after the installation of a pool. In NSPs, resources like electricity and water are managed more efficiently. These pools usually do not use water heaters or high-performance pumps that require high voltage and water does not need to be changed yearly. According to the comparison of the construction of these types of pools and relevant literature, NSPs seem to have a smaller carbon footprint than CSPs. NSPs use consensus less energy for running than CSPs which is considered the main source of carbon footprint (Hu et al. 2015). However, this is only relevant while the pools are in operation. CSPs are not in use 75% of the time of the year while NSP

equipments are mostly in operation throughout the year. The carbon footprint should be investigated more in-depth in future studies. In addition, waste and chemical management is more sustainable in NSPs compared to CSPs. NSPs create microclimates in people's gardens regulating temperature across the year (Hassall 2014). As highlighted from the interviews, the land of the swimming pool can be used by animals, plants, and humans for longer in NSPs resulting in more efficient usage. According to the questionnaire research, people are aware of the benefits of NSPs and would be willing to opt for a more environmentally friendly alternative. Due to the lack of awareness about NSPs, people are unaware that there is a more environmentally friendly alternative.

5. Conclusion

This project explored the sustainability of Natural Swimming Pools (NSPs) versus traditional Chlorinated Swimming Pools (CSPs) in Hungary and Sweden.

Research Question: How do Natural Swimming Pools and Traditional Chlorinated Swimming Pools compare in terms of sustainability; in the context of Sweden and Hungary?

Natural Swimming Pools are a more environmentally friendly and sustainable option to choose over Chlorinated Swimming Pools in people's back gardens or even in community areas. All pillars of sustainability - economics, social, and environmental - benefit from using NSPs over CSPs. NSPs are experiencing rapid growth, indicating that they will likely become economically viable for businesses in the near future, potentially leading to future job opportunities. NSPs are not well understood by the general public at the moment. To overcome this, increased advertising and promotion are necessary which will create awareness of the advantages of these pools. By creating habitats, micro-climates, and resources for organisms all year round natural pools increase great biodiversity and improve the environment. In addition, NSPs offer a rapid pace of improvement in creating biodiversity, making them a favourable choice for environmental restoration. Compared to CSPs, NSPs could have a greater positive impact on mental and physical health. Furthermore, people are aware of the health consequences of chlorine in swimming pools but due to a lack of knowledge about NSPs and governmental regulation, it is difficult to change or see other opinions. In the context of Hungary and Sweden, Hungary seems to be more dependent on economic and social factors of sustainability when deciding on swimming pools. Environmentally, both countries are influenced equally. However, due to a lack of information and data, these conclusions can’t be fully descriptive when it comes to describing the general population. Further studies need to be done regarding this topic to explore and expand the knowledge of how people in different countries are dependent on sustainability factors.

In conclusion, due to global warming and climate change, it's crucial to enhance the care and preservation of water as a natural resource. Water is life and we as humans need to take care of this essential resource. This is especially important

in the expanding urban areas when considering the design and maintenance of swimming pools is crucial for a sustainable future. Therefore, NSPs are recommended to be used more frequently in urban areas.

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