Natural Swimming Pools (NSPs) – Principles and Trials with Site-Conform Vegetation

Prof. Dr. Wolfram Kircher, Anhalt University, Bernburg, Germany.

Strenzfelder Allee 28, 06406 Bernburg, wolfram.kircher@hs-anhalt.de

Prof. Dr. Andreas Thon, Hochschule Geisenheim University, Germany.

Von-Lade-Str.1, 65366 Geisenheim, andreas.thon@hs-gm.de

1 ABSTRACT

Natural swimming pools (NSPs) offer a new way to swim in fresh water that has not been treated with chemicals or preservation agents. Only biological processes purify the water . (Kircher & Thon, 2016, derived from FLL, 2006 & 2011). NSPs are purified by three different filtering methods which effect either a phosphorus (P-) or a carbon (C-) limitation to guarantee clear water and low string-algae stock. As a side product of the Phosphorus limitation, nitrogen content in the bathing water tends to oligotrophic conditions. Most plants, which are generally used on filter bodies in NSPs, grow weakly and show severe deficiency symptoms.

In trials at Anhalt University plants from oligotrophic bogs and fens were tested on filter bodies of the "Technical Wetland" principal with three different variants of water percolation. Good results were achieved mainly from fen plants, which are recommended for P-limited pools, since these comprise the necessary water hardness and a high pH value. For C-limited systems with low hardness plants from acidic bogs are suitable. Sphagnum mosses however must be selected carefully since capabilities of Sphagnum species depend strongly on the percolation rates.

1.1 Keywords

natural swimming pool, planting design, nutrients, water purification, bog, fen, Sphagnum

2 INTRODUCTION

Natural swimming pools (NSPs) are sealed against the subsoil and comprise a swimming area and a regeneration area. They are designed especially for swimming. Water must not be treated with any chemicals or UV radiation (FLL, 2006; ÖNORM, 2013; Grafinger 2004). NSPs integrate well into the environment, are gentle on eyes and skin. Only biological processes purify the water so there are no harmful side effects of chlorine, chlorine dioxide, mineral salts, organic biocides or ozone, which usually are added to the water of conventional swimming pools. Chemical treatment as well as UV radiators are not acceptable in natural pools because it reduces or disables the desired biological activity (Kircher & Thon, 2016, derived from FLL, 2006 & 2011).

NSPs can play an important role as a part of stormwater management by reducing the discharge speed of rainwater and unburden local sewage systems (Thon, 2009).

In private gardens NSPs promote the biodiversity by increasing the flora and fauna species compared to a conventional garden design which emphases lawn or monoculture plantings (see Thon, 2009, Abromas, Grecevicius, Marcius, 2007).

2.1 Filtration types of NSPs

Depending on water movement, filtration techniques, partitioning and construction type of the swimming area four models of natural swimming pools (NSPs) are distinguished (table 1):

1. Standstill water body: densely planted filter zone (="Hydrobotanical System")
2. NSP with surface flow + Hydrobotanical System (**HBS**)
3. NSP with percolated planted filter bed (=Technical Wetland; **TWL**) + Hydrobotanical System
4. NSP with quickly percolated filter bed (= Biofilm accumulating Substrate Filter; **BSF**). Microorganisms developing on the surfaces of the filter granulate form a biofilm that provides a very effective filtration. In Type 4 plants function as a decoration only (FLL, 2006; ÖNORM, 2013).

Table 1: Different filter models of NSPs

	Hydrobotanical System (1)	Hydrobotanical System (2)	Technical Wetland (3)	Biofilm accumulating Substrate Filter (4)
Limological classification and planting	Standing water body with densely planted filter zone without surface flow or water movement	Slowly perfused with densely planted filter zone with surface flow	NSP with slow and possibly intermittently percolated, planted filter bed; should be combined with a Hydrobotanical System	Intensively, mainly vertically percolated filter beds with high water permeability, planted only for decoration. Permanent fast water movement
Main purification	Plants and plankton	Plants and plankton	Substrate, helophytes and microorganisms adjacent to roots and stems	Microorganisms developing on the surfaces of the filter granulate form a biofilm which provides a very effective filtration
Maintenance requirements	Trimming and harvesting plants	Trimming and harvesting plants	Trimming and harvesting plants	Regularly backwashing the Substrate Filter

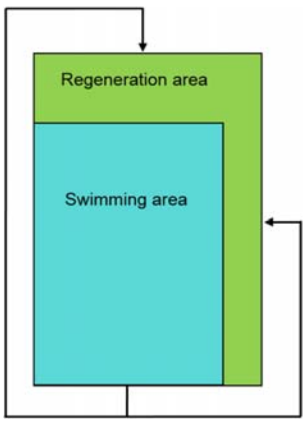
In addition to the three filter types listed in table 1 mechanical filters (sieves and mats) and chemical filters (phosphorus-reduction with iron hydroxide) can be added. Physical treatment, such as UV radiation, subsonic devices, copper salts and any items, which effect a non-selective impact on the water biology do not meet the requirements of guidelines for NSPs (FLL, 2011, ÖNORM, 2013).

To guarantee clear water and a low string-algae stock, either phosphorus (P-) or carbon (C-) limitation should be envisaged (see Jaksch, Wesner & Fuchs, 2013).

Standing waters tend to be meso- to eutrophic. Their inundate zones accommodate a diverse range of plant species. In NSPs with percolated filter systems, such as Technical Wetlands, the nitrogen level constantly declines to a very low level due to nitrification and denitrification processes (Baumhauer & Schmidt, 2008). The low nitrogen content will even effect oligotrophic conditions. Thus, most plants, which are generally used on filter bodies, grow weakly, mainly in NSPs of type 3 and 4 (Kircher & Thon, 2016).

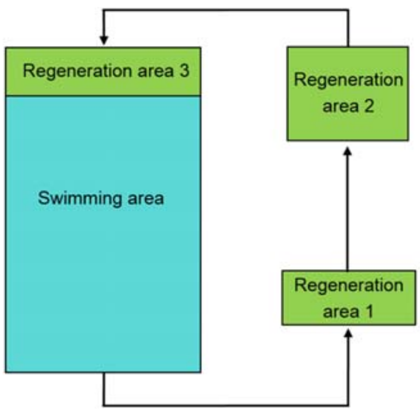
2.2 Partitioning types of NSPs

Natural swimming pools can be designed as a single unit or as a series of two or more water bodies. The regeneration area comprises the filter as Hydrobotanical System, Technical Wetland or rather Biofilm accumulating Substrate Filter.



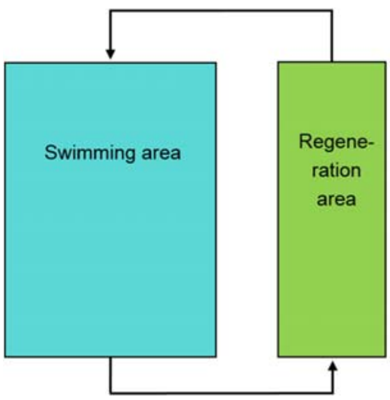
Partitioning type A

In situ: Regeneration area completely within the swimming area
(single-chamber system)



Partitioning type B

In situ + ex situ:
Regeneration area partly outsourced
(here: multiple-chamber system)



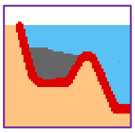
Partitioning type C

Ex situ: Regeneration area completely outsourced
(here: double-chamber system; the regeneration area could also comprise several bodies)

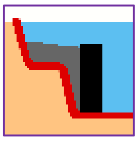
Figure 1. Schematic Partitioning Types for NSPs (Kircher & Thon, 2016)

2.3 Construction types of NSPs

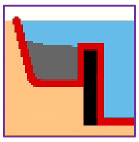
The following principle-sketches show simplified sections of four possibilities how to frame the swimming zone:



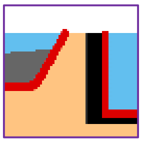
No wall: The edges of the swimming area are only modelled into the underground with a more or less steep slope and covered by the sealing. A covering of stones may be set on the slope to embellish its appearance.



Wall on sealing: A vertical wall framing the swimming area is constructed on the sealing. Natural stone walls or timber constructions are commonly used. Outside a special substrate is filled between sealing and wall, implementing the filter systems or planting zones.



Wall under sealing: The vertical wall defining the swimming area is built with concrete, masonry or special plastic elements. Outside sand is filled up to the intended depth of the regeneration area and compressed. Finally the sealing is placed on top.



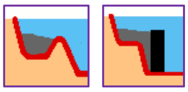
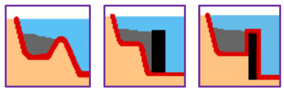
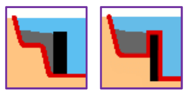
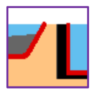
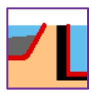
Separate pool (analogous to partitioning type C): A pool without any regeneration area is built separately (regeneration area completely outsourced). A rectangular pool without any marginal plantings offers the possibility of covering the surface with a protection roller when not in use. This is the easiest variant for converting existing traditional pools into naturally purified ones: from the integrated skimmer the water will no longer be conventionally treated, but bypass through a filtration pool or chamber.

A detailed description of these characters as well as of the following models is given in Kircher & Thon,2016.

2.4 Principle models of NSPs

The 4 basic models of natural swimming pools are defined according to their filtration equipment. Table 2 shows possible or rather recommended pool constellations.

Table 2: Four hydraulic and filtration types combined with three partitioning types result in nine models of NSPs

Partitioning type → + recommended construction types Hydraulic & filtration type + recommended size of filtering area (with reference to total surface area)	**A** **In situ: Regeneration area entirely within the swimming area (single-chamber system)**	**B** **In situ + ex situ: Regeneration area partly outsourced (double- or multiple-chamber system)**	**C** **Ex situ: Regeneration area completely outsourced (double- or multiple-chamber system)**
1 **Standing bodies of water** without technical installations only natural circulation **HBS ≥ 65 % densely planted area**	**1A** 	---	---
2 **Bodies of water with surface flow** water slowly flows through planting zone **HBS ≥ 50 % densely planted area**	**2A**	**2B**	Not recommended
			
3 **Bodies of running water with Technical Wetland filtration** Percolation at moderate speed (<300 l/m²/hr) through planted filter bed **TWL + HBS ≥ 30-40 % densely planted area on percolated substrate**	**3A**	**3B**	**3C**
			
4 **Bodies of running water with Biofilm-accumulating Substrate Filter** Controlled fast percolation (>> 500 l/m²/hr) through substrate filter **BSF ≥ 25 % filter area** **(≥ 5 - 20 % for professional systems);** can be combined with TWL and HBS	**4A**	**4B**	**4C**
			

HBS = Hydrobotanical System; **TWL** = Technical Wetland; **BSF** = Biofilm accumulating Substrate Filter

2.5 The limiting factor as main approach to combat algae

According to the rule of the limiting factor from Sprengel and v. Liebig the main strategy of natural pools is to bring either carbon (C) or phosphorus (P) into minimum to combat algal emergence. These strategies demand contradictory measures to work successfully: C-limitation works best in soft water and at low pH, whilst phosphorus is eliminated through sedimentation as insoluble compounds, such as apatite, in hard water with a pH around 8,3 (Jaksch, Wesner & Fuchs, 2013). Pools of model 1 to 3 will work successfully with both, C- or P-limitation. Model 4-pools should operate with P-limitation only. The biofilm in the BSF grows best with high pH and hard water. To promote this, the filter substrate should contain carbonates, so often dolomite gravel is added. In a NSP it is not only P or C which decreases to very low levels, but also nitrogen. Mainly in facilities of model 3 and 4 (table 2) severe nutrient deficiency symptoms and a very weak and unsatisfactory growth occur at the conventionally used plants (Kircher, 2007). Percolated filter bodies are mostly completely submerged. The range of plant-species, which accept both, oligotrophic conditions as well as a water level of more than 20 cm, is very restricted.

3 PROBLEM STATEMENT AND AIMS AND OBJECTIVES

NSPs are defined by purification of water free from chemicals. Due to nitrifcation and denitrification processes the N-level is often low. Therefore NSP designers and building companies recommend a N fertigation to increase the vitality of plants, microorganisms and biofilms. This is not consistent in terms of natural purification.

NSPs with Technical Wetland or Biofilm accumulating Substrate Filters comprise limonologically a running water system with a low trophic level. The range of suitable plants for oligotrophic running waters is low (Kircher & Thon, 2016).

A research project at Anhalt University, Bernburg, aimed in testing alternative plantings on filters, which provide an inundated substrate body with a shallow water level (Thon, 2014). The tested plant ranges derive from experiences made with pilot projects of model 2- and 3-pools (Kircher, 2007). Peat mosses (*Sphagnum* species) are the typical vegetation of acidic bogs. They even decrease the pH by their ability to exchange cations with H+. Besides testing plant species for their suitability the trial should proof, if *Sphagnum* mosses were able to thrive in NSPs and their impact on string-algae growth. In P-limited NSPs it is crucial to minimize the influx of phosphorus with the refilling water, so the plants' transpiration should be as low as possible, which also was assessed in the trial.

<u>Trial objectives at a glance:</u>

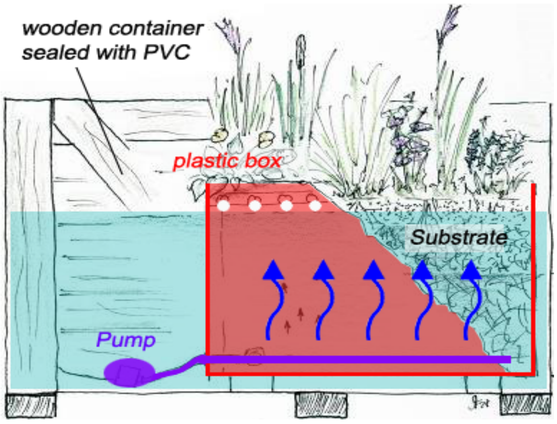
- Finding recommendable plant ranges to use on filter zones of NSPs with hard water (P-limitation, models 1-4) or soft water (C-limitation; models 1-3)
- Testing the possibility to reduce string algae development by *Sphagnum* mosses
- Reducing water losses by using plants with a low transpiration rate

4 METHODS

Plants from oligotrophic bogs and fens were tested on filter bodies of the "Technical Wetland" principal. Technical Wetlands and Biofilm accumulating Substrate Filters are the most common water purification methods for running water. Purification is guaranteed by microorganisms, developing adjacent to roots and stems of the plants (TWL) or on surfaces of the filter granulate (BSF). Due to energy consumption and to increase ecological benefit trials were organized on Technical Wetlands, not on BSFs.

Wooden containers, sealed with a PVC liner (l x w x h = 1,15m x 0,9m x 0,80m) represented smaller sized NSPs of model 3A (see table 2). As filter area (TWL) plastic boxes (l x w x h = 0,80 m x 0,60 m x 0,60 m) were inserted and filled with a substrate: mixture of 50% rhyolite-gravel and 50% lime-gravel (grain sizes in stratification according to the section drawing below). As substrate for the "acidic bog" planting variant (see below) only pure rhyolite (siliceous magmatite) was used.

By investigating plant ranges in oligotrophic natural wetland habitats a significantly higher amount of species occur on emerged sites (bogs and fens), not on inundated sites. For that reason the surface test-filterbodies adequately located about 5 cm above the water level.



Substrate stratification:
Layer height → grain size

- Cover layer according to planting
- 4 cm → 2/ 5 mm
- 10 cm → 2/16 mm
- 20 cm → 16/32 mm

Figure 2: Section sketch of a trial container with bottom-up percolation (not to scale)

Figure 3: Trial setup which represents NSPs with plastic boxes as filter beds

Factor vegetation:

1. **Without planting**
   cover layer = gravel 2/8
2. **Conventional planting**
   cover layer = Sand + standard substrate
   ("Patzer-Einheitserde") 1:1
   Plants per replicate:
   1 *Acorus calamus*
   1 *Carex elata*
   1 *Myosotis palustris*
   1 *Mentha cervina*
   1 *Typha shuttleworthii*
   1 *Lythrum salicaria*
   1 *Iris pseudacorus*
   3 *Caltha palustris*
3. **Lime fen**
   cover layer =Sand + bog peat 1:1
   Plants per replicate:
   6 *Allium suaveolens*
   3 *Eriophorum latifolium*
   3 *Carex viridula*
   3 *Carex davalliana*
   3 *Parnassia palustris*
   1 *Epipactis palustris*
   1 *Dactylorhiza* Hybr.
4. **Acidic bog**
   Cover layer = bog peat
   Plants per replicate:
   2 *Eriophorum vaginatum*
   2 *Sarracenia purpurea*
   2 *Erica tetralix*
   2 *Pogonia ophioglöossoides*
   2 *Narthecium ossifragum*
   2 *Vaccinium oxycoccos*
   Covered with *Sphagnum palustre*

Factor percolation:

1. Not actively percolated:
wall of the plastic box perforated:
122 holes with 13 mm Ø

2. Percolated top - down:

1500 l/m²/day;
On/off in 30 minute intervals

3. Percolated bottom - up:

1500 l/m²/day;
On/off in 30 minute intervals

Three variants of plantings (factor vegetation) and three variants of percolation through the filter (factor percolation) were tested with four replicates (two per container). “Conventional planting” means helophyte species which are mostly used on filter zones of NSPs. Most of these species do naturally occur in meso- to eutrophic wetlands. “Lime fen” represents a mixture of species from oligo- to mesotrophic fens with a distinct lime content, effecting an accordingly high pH. “Acidic bog” consists in species from meso- to oligotrophic bogs with very low carbonate content. The pH of the latter is usually below 6. The trials were installed in 2007, assessments 2008, 2009, 2010; further observations until 2014. Total phosphorus (P_{tot}), nitrate (NO_3^- and carbonate hardness (KH) were analyzed. Besides the water quality, water loss due to transpiration, algae growth (dry weight of string algae) and plant vitality were assessed.

Increasing the replicates was not possible for monetary reasons. A further research project on a larger scale of NSP with standardized methods of influencing factors is in progress.

5 RESULTS:

Table 3 shows the enormous fluctuations of dissolved phosphorus (P_{tot}). The ammonium content was low enough to keep it unmentioned. The very low nitrate values refer to oligotrophic conditions.

Table 3: Measured values in the pool water 31st calender week 2009 (ranges of individual measurements)

Variant	P_{tot} / µg/L	NO_3 / mg/L	KH / mmol/L
Without planting	4,7 – 215,2	< 1	0,4 – 0,8
Conventional planting	4,7 – 359,5	< 1	1,3 – 1,4
Lime fen planting	2,4 – 42,6	< 1	1,0 – 1,6 (3,6)
Acidic bog	23,6 – 288,5	<1 - 4	0,3 – 1,0

It were mainly the fen plants, which brought good results. Fen vegetation is recommended for P-limited pools, which comprise the necessary water hardness and a high pH value. For C-limited systems with low hardness, plants from acidic bogs have been proven suitable.

NSPs without fertigation and therefore reduced vitality of microorganisms and biofilm can reproduce good water quality with low algae growth. The comparison of the string algae’s dry weight showed significantly differences between the four planting variants. Figure 4 shows the results from the measurements in 2009. The significantly lowest string algae production occurred in the acidic bog variants, but also the top-down percolated lime fen plots were rated similarly low. *Sphagnum* mosses formed attractive cushions and could reduce the emergence of string algae in the pool water, though they effected a great fluctuation of the pH. *Sphagnum palustre* thrived in standstill water, whilst on percolated filters only *Sphagnum squarrosum* worked well. From these results as well as from practical experiences with case studies of NSPs (Kircher, 2007) the authors derived recommendations for plant combinations in P- and C-limited pools (Kircher & Thon, 2016).

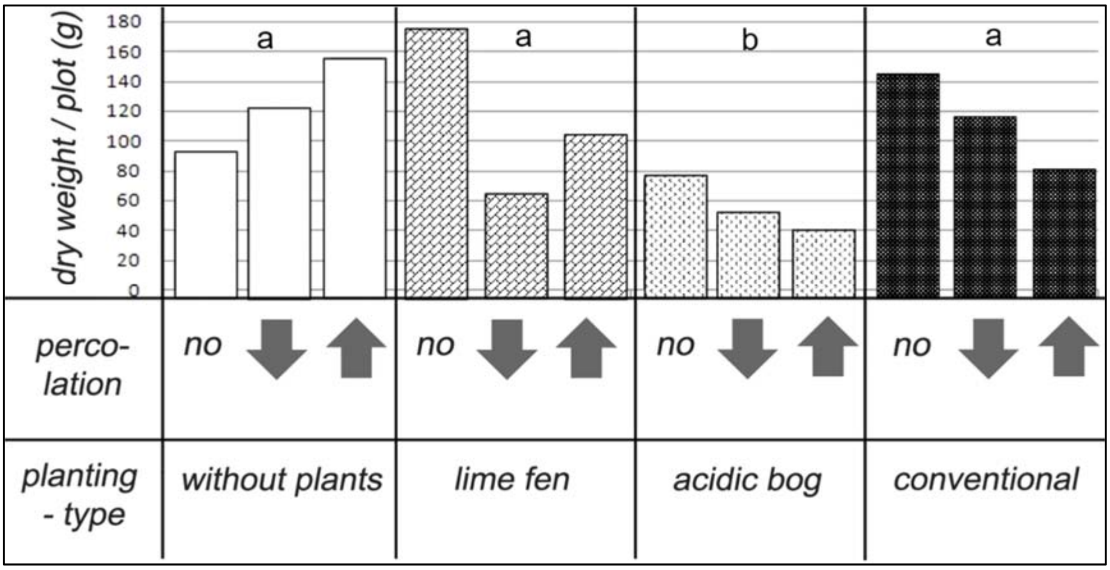


Figure 4: dry weight of string algae in the pool water 2009. Different letters above show significantly different results (T-Test; α= 0,5) (figure by the author)

Even in 2009, in which the conventional vegetation still showed good growth, the acidic bog plots transpired more water than all other variants. Though *Sphagnum*-mosses form dense cushions, their transpiration rate must not be underestimated! The water loss effected by lime fen plots was not significantly higher than the loss of non-planted filters. The influence of the percolation direction was low, but bottom-up percolation effected significantly more transpiration than non-percolated plots.

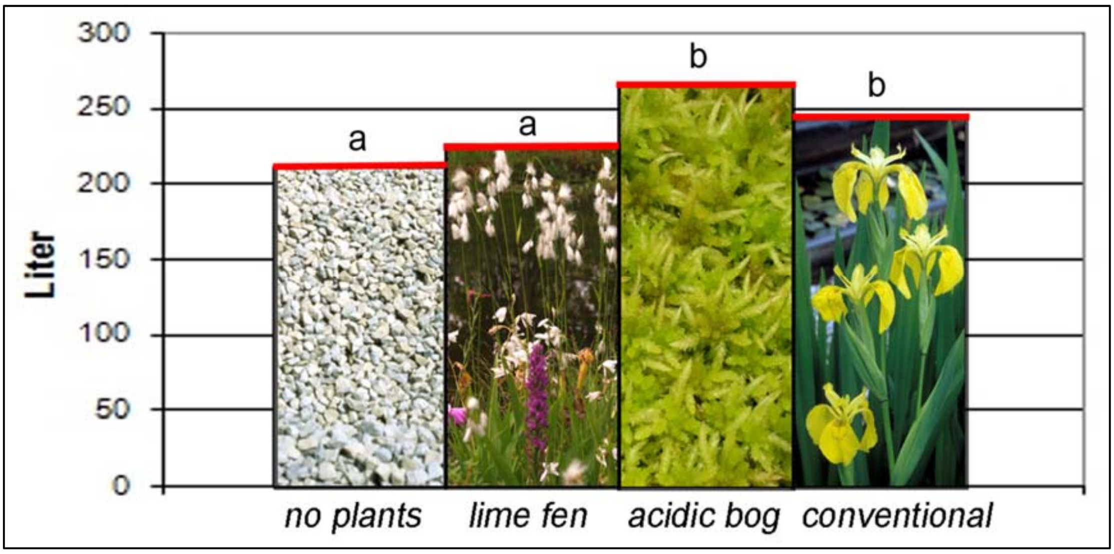


Figure 5: Refilled water in 2009. Different letters above show significantly different results (T-Test; α= 0,5)

6 DISCUSSION AND CONCLUSIONS:

Mainly on Biofilm accumulating Substrate Filters (BSF), as used in NSPs of model 4, a planting with vegetation from oligotrophic lime fens is site conform, since this technology aims in lime containing hard water with a pH up to 8,4 to support P-limitation (ÖNORM, 2013). Typical lime fen species thrive on planting zones connected to water, but with substrate surface slightly above water level.

Kircher & Thon (2016) show planting lists for NSPs with lime fen plants in wetland and swamp area plus appropriate species in the neighbored areas. The distribution pattern follows the strategy of randomly mixed plantings according to Kircher et al. (2011). The fen vegetation reduces water loss through transpiration, so there is less need for refilling.

NSPs, which aim C-limitation, provide soft water and can look very attractive if surrounded with *Sphagnum* moss carpets in the wetland and swamp zone. Within the *Sphagnum* layer, attractive specialists of acidic bogs can thrive. In addition, the emergence of string algae can be low in a pool with *Sphagnum* vegetation. C-limitation is an option only for NSPs of model 1, 2 and 3. It works best in a moist climate with cool summers and low evapotranspiration rates. Under such conditions, the high transpiration rate of *Sphagnum* mosses will be acceptable. *Sphagnum palustre* is suitable for areas with standstill water, whilst on percolated filters or adjacent to any water movement *Sphagnum squarrosum* must be preferred. We recommend testing more *Sphagnum* species for their suitability.

Table 4 lists recommendable species for plantings on filter zones, which provide a wetland habitat slightly above water level for P- as well as for C- limited NSPs. The listed species proofed to be successful in the described trials or rather in several case studies (Kircher, 2007).

Table 4: recommended plant species for C- and P-limited NSPs, hardy in Central Europe, to be used on TWL filters if the substrate protrudes 0 – 5 cm above water level.

Plants for **P**-limitation (species from oligo- to mesotrophic fens and close related sites)	Plants for **C**-limitation (species from oligo- to mesotrophic bogs and close related sites)
Allium angulosum, A. suaveolens, Caltha palustris, Cardamine pratensis, Carex viridula, Dactylorhiza Hybr*., Epipactis palustris, Eriophorum latifolium, Iris setosa* subsp*. Canadensis, Gentiana asclepiadea, Liatris spicata* (low growing forms), *Parnassia palustris, Schoenus ferrugineus, S. nigricans, Tofieldia calyculata, Zigadenus elegans*	*Aster nemoralis, Erica tetralix, Eriophorum russeolum, E. vaginatum, Kalmia polifolia, Ledum groenlandicum, Lobelia sessilifolia, Pogonia ophioglöossoides, Sarracenia purpurea, Sphagnum palustre, S. squarrosum, Trichophorum alpinum, Vaccinium corymbosum* cultivars*, V. macrocarpon, V. oxycoccos*

7 SUMMARY:

Depending on water movement, filtration techniques, partitioning and construction type of the swimming area four models of natural swimming pools (NSPs) are distinguished. To guarantee clear water and a low string-algae stock, either a phosphorus (P-) or a carbon (C-) limitation should be achieved. Parallel to this the nitrogen content in the water will tend to oligotrophic conditions. Most plants, which are generally used on filter bodies in NSPs, grow weakly. In trials at Anhalt University plants from oligotrophic bogs and fens were tested on filter bodies of the “Technical Wetland” principal with three different variants of water percolation. Good results were achieved mainly from fen plants, which are recommended for P-limited pools, since these comprise the necessary water hardness and a high pH value. For C-limited systems with low hardness plants from acidic bogs are suitable.

Sphagnum mosses formed attractive cushions and could reduce the emergence of string algae in the pool water, though they effected a great fluctuation of the pH. *Sphagnum palustre* thrived in standstill water, whilst on percolated filters only *Sphagnum squarrosum* worked well. Recommendations for plant combinations in P- or C-limited pools are given.

8 REFERENCES:

1. Abromas, J., Grecevicius, P., Marcius R. (2007): The impact of Water Ponds and Installations to the Quality of Urban Landscapes; International Congress Formation of Urban Green Areas 2007, Lithuania.

2. Baumhauer J., Schmidt, C. (2008): Schwimmteichbau, Handbuch für Planung Technik und Betrieb, Patzer Verlag, Berlin-Hannover, ISBN 983-3-87617-113-5, 392 pp.

3. FLL (ed. 2006): Recommendations for the planning, construction and maintenance of private swimming and natural pools. Bonn, 2006; 64 pp.

4. Grafinger, R. (2004): Schwimmteiche – Gratwanderung zwischen Algen und Technik. Der Schwimmteich (3), p. 4 – 5

5. Jaksch, H., Wesner, W. & Fuchs, A. (2013): ASC Formblätter Z0013 – Z0020 - 10 Gebote Schwimmteichbau: www.asceuropa.org

6. Kircher, W., Thon, A. (2016): How to Build a Natural Swimming Pool. London: Filbert Press; 328pp

7. Kircher, W.; Messer, U.; Fenzl, J.; Heins, M. & Dunnett, N. (2011): Optimizing the Visual Quality and Cost Effectiveness of Perennial Plantings by Randomly Mixed Combinations - Application Approaches for Planting Design. In: Buhmann, E, S.Ervin, D.Tomlin, M.Pietsch (Eds.): Proceedings Teaching Landscape Architecture. Digital Landscape Architecture 2011 & Notre Summer School 2011 at Anhalt University of Applied Sciences. Bernburg & Dessau; p. 320 – 330

8. Kircher, W., Thon, A. (2007): Marginal Wetland Planting for Oligotrophic Swimming Ponds. Formation of Urban Green Areas', Klaipeda Business and Technical College, Lithuania; pp. 65-69

9. ÖNORM L 1128 (2013): Schwimmteiche und Naturpools - Anforderungen an Planung, Bau, Betrieb und Sanierung. Wien: Österreichisches Normungsinstitut (ON)

10. Thon, A (2009).: Shallow Constructed Roof Wetlands für Greywater Treatment. Master Thesis at Anhalt University, Bernburg, Germany; 58pp

11. Thon, A. (2014): Untersuchung von Bepflanzungsvarianten und Durchströmung der Filterzone von Kleinbadeteiche. Dissertation at Vechta University, Germany; 262 pp.

CELA MEDIA STATEMENT (Optional)

Title of Paper or Research:

Natural Swimming Pools (NSPs) – Principles and Trials with Site-Conform Vegetation

Authors:

Prof. Dr. Wolfram Kircher, Anhalt University, Bernburg, Germany.
Wolfram Kircher teaches and researches in planting design and vegetation techniques. His main interest is in NSPs, perennial plantings, maintenance techniques, greening of buildings.

Prof. Dr. Andreas Thon, Hochschule Geisenheim University, Geisenheim, Germany.
Andreas Thon teaches and researches in landscape construction. He is interested in NSPs, irrigation and water filtration techniques.

Authors please select one of the following: I DO want to prepare a media statement for general release from the 2017 CELA Conference. (If you choose DO NOT, you do not need to prepare a media statement).

Media Statement (100 words max.):

Natural swimming pools (NSPs) offer a new way to swim in fresh water that has not been treated with chemicals. Only biological processes purify the water by different filtering methods. As a side effect of the filtering, the nitrogen concentration declines, which causes weak growth of most traditionally used plants. In trials at Anhalt University, Bernburg, plants from nutrient-poor bogs and fens were successfully tested on "Technical Wetland" filters. The authors give application recommendations in their presentation and in their book "How to Build a Natural Swimming Pool" (2016, Filbert Press, UK).