Regulations concerning natural swimming ponds in Europe: considerations on public health issues

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ABSTRACT

Natural swimming ponds (NSPs) are a new type of recreational water facility characterized by the substitution of traditional disinfection with biodepuration. While this feature meets esthetic desires of users, specific concerns on public health issues have been raised by the scientific community and local authorities. The absence of a European directive applicable to these environments leaves each country without specific and harmonized indications. The present work describes the local/national policy situation, describing adopted parameters and monitoring activities. All documents underline the need for appropriate microbiological analysis and correct water management.

Key words | guidelines, natural swimming ponds, policies, public health, safety, surveillance

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INTRODUCTION

The use of water in pools dedicated to recreational activities, leisure and sport, is a characteristic of human society. The opportunity to build swimming facilities was largely appreciated also in ancient times. The first described swimming pool is the Siloam pool narrated in the Bible, fed by the waters of the Gihon Spring, through Hezekiah's Tunnel, built in the 8th century BC (Elitzur 2008). In this facility, as in the 'Thermae Romanae', a continuous supply of spring water ensured good hygienic conditions through the principle of dilution. During the 20th century, the dilution system was replaced by filtration and disinfection. The modern treatment of swimming pools was rapidly introduced all over the world, in parallel with the understanding of chloramine formation and breakpoint chlorination (Palin 1945). These new procedures allowed the maintenance of good hygienic conditions without the need for a huge water supply. Unfortunately, chlorine has some disadvantages, such as bad smell and certain irritating effects, and it leads to the formation of disinfection by-products that could increase the risk of allergy and respiratory diseases (Florentin *et al.* 2011). While the lack of data in the literature does not allow clear definition of this risk, specific concerns have been raised in the population (Kogevinas *et al.* 2010; Downing 2011). Actually there is a cultural trend that supports the discovery of alternative 'natural' disinfection methods in substitution of chlorine. A recent proposal

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concerned the adoption of 'sphagnum moss', that exhibits mild antibacterial properties, to purify pool water, but at the moment there are no published scientific data supporting a true sanitation action (Mellegård *et al.* 2009). Less than 30 years ago, in some European regions a new concept of artificial water recreational environments emerged, taking the name of natural swimming ponds ('Kleinbadeteich' in German, 'biopiscine' in Italian, 'piscina naturalizada' in Spanish, 'piscines naturelles' in French). These facilities look like small ponds found in nature but actually they are artificial basins where the water is contained by an isolating membrane and processed by a circulating system (with skimmers and pumps) between the regeneration zone and the swimming area. The regeneration part of the pool is usually an ecosystem of water plants and microorganisms where biological processes should clean organic compounds, and pathogens from the water.

NATURAL SWIMMING POND STRUCTURE

Several different design and construction methods have been described for natural swimming ponds (NSPs), but few fundamental characteristics are common for all facilities (Littlewood 2008). In particular, a pond liner of synthetic material will waterproof the bed, ensuring the retention of water and reducing contamination from the soil. The liner can be of vinyl chloride or other flexible impermeable materials; layers of sand are commonly used to protect it from sharp objects.

The second key feature for a NSP is the presence of a regeneration zone (RZ). This part of the pond is dedicated to the ecosystem that will depurate the water, and its size may be calculated considering the total volume of the pond, the number of swimmers and other environmental aspects. In order to guarantee a good ecological equilibrium, the RZ should be at least of 150 m^2 and close to 50% of the total surface of the pond. In this situation, the selection of plants specific for phosphorus and nitrogen uptake will counteract possible hypertrophication processes, reducing algae and microorganism proliferation (Wu *et al.* 2011). A balanced mix of plants can include marsh plants (helophytes, like *Typha* and *Iris*), floating-leaved plants (hydrophytes, like *Nymphaea*) and free-floating plants (pleustophytes, like *Salvinia*). At the same time the presence of detritivores and filtrator invertebrates will help bacteriological and particulate control. As in every ecosystem, the biodiversity and the size of the biological population strongly affect the buffer capacity, the characteristic that allows the system to absorb perturbation without loss of the functional equilibrium (Pasari *et al.* 2013).

When the size of the NSP is not sufficient to reach a stable ecological equilibrium, a filtration zone may be added to the RZ in order to improve biological cleaning of the pond. Elements of the filtration zone are modules of biological fine filters, overflow skimmers, substrate filters and a pumping system that guarantees several total water filtration cycles per day. The adoption of this kind of filtration zone at least partially reduces the natural characteristic of the pond, it can consistently increase management costs, but allows the building of domestic ponds, on reduced surfaces, maintaining the typical look of a swimming pond (Casanovas-Massana & Blanch 2013).

PUBLIC HEALTH ISSUES

Bathers are an external element that can strongly alter the ecological equilibrium of the swimming ponds. Swimmers are a source of organic matter and microorganisms (commensals or pathogens) that require a biodepuration activity by the RZ. The sustainable contamination load is strictly dependent on the size and functionality of the RZ and the filtration zone. The absence of any chemical disinfectant (e.g. free chlorine) in the water, and the small volume of many ponds can highly enhance the risk of communicable diseases between bathers frequenting the facilities in the same time period. In this situation, a specific program for hygiene surveillance, mainly based on regular microbiological quality checks, is critical in order to prevent waterborne diseases (Giampaoli *et al.* 2011).

An outbreak of viral meningitis was reported in Kassel (Germany) from July to October 2001, affecting more than 200 people (Hauri *et al.* 2005). Data obtained from a case-control study, together with clinical and environmental molecular identification of a specific echovirus as the etiological agent of the meningitis, allowed public health institutions to associate bathing in a public, nature-like pond as the most probable cause of the outbreak. In particular, the wide spread of the infection was fostered by a condition of overcrowding of the swimming facility (1,500 bathers per day, in 3,680 m^3 of water). The relatively new presence of NSPs in many European countries and the absence of dedicated epidemiological observatories allow speculation that the problem of waterborne diseases related to NSPs can be underestimated. These considerations enhanced the need to promote with care NSPs and the requirement for dedicated maintenance procedures.

Currently in Europe there are no directives dedicated to public health issues that can be applied to NSPs. The Directive 2006/7/CE (EC 2006) concerning the management of bathing water quality and repealing Directive 76/160/EEC states in art.1 that it 'shall not apply to: swimming pools and spa pools, confined waters subject to treatment or used for therapeutic purposes, artificially created confined waters separated from surface water and groundwater'. At the same time, a European directive has not been released for swimming pool safety and hygiene issues, and individual countries produce specific laws, where the different environments are depicted and procedures to monitor the quality of the water of swimming pools open to the public are defined (Botzenhart & Pfeilsticker 1999). In this scenario few local or national laws and guidelines dedicated, or extended, to NSPs have been released, which have the intent to describe correct monitoring and management procedures, water quality assessment, specific risks, and surveillance parameters.

THE AUSTRIAN SITUATION

In Austria NSPs are widely diffused with more than 50 public facilities. Around 70 specialized natural pool builders are present in the country and many of them are organized in a national association (Verbandes Österreichischer Schwimmteich- and Naturpoolbau, VÖSN). In 1998 a regulation dedicated to different categories of bathing facilities, including also NSPs, was prepared (BHygV 1998). The document described requirements for water quality for different categories of pool and it defined also monitoring and control procedures. The regulation was made in application of the federal law on the hygiene of bathing facilities, last updated in 2012, that describes authorization rules, regulatory control measures, and penal provisions (BHygG 1976). The specific limits of microbiological, chemical and physical parameters for NSPs are described in the technical norm released by the Austrian standard institute in 2010 (ÖNORM 2010): microbiological limits are summarized in Table 1 and compared to those present in other countries. All these regulations impose special attention on the number of users in relation to biodepuration ability and with respect to frequent checks of parameters.

Table 1 | Comparison of microbiological requirements for NSPs in Germany, Austria, Switzerland, Italy and France

	Germany	Austria	FOPH & Aargau (CH)	SVBP (CH)	Bozen (I)	France
Document	FLL (2011)	ÖNORM (2010)	BäV (2001); FOPH (2004a, b)	SVBP (2012)	BZ (2011)	AFSSET (2009a, b); ANSES (2010)
Enterococci (cfu/100 ml)	max 50	max 20[a]–50	max 40	< 20[a] max 50	max 50	max 40
E. coli (cfu/100 ml)	max 100	max 30[a]–100	max 100	< 30[a] max 100	max 100	max 100
P. aeruginosa (cfu/100 ml)	max 10		max 10	max 10	max 10	max 10
S. aureus (cfu/100 ml)			nd	nd	nd	max 20
Salmonella		nd/100 ml	nd/100 ml	nd/100 ml	nd	
Cryptosporidium (oocysts)			nd/1,000 ml			
Legionella		nd/100 ml				
Staphylococci (cfu/100 ml)		max 100		max 100		

[a]Reference value.
nd = not detectable.

THE ITALIAN SITUATION

The Italian situation is peculiar due to the fact that these ponds are mainly located in the Bozen region (North Italy) where the first public pond was built in 1996. At the moment there are seven public ponds in Bozen and one in Trento. In the rest of the country some resorts recently started building NSPs of reduced size, in order to offer this new kind of pool to tourists.

The Italian law for swimming pools, the Agreement between the Ministry of Health and Regions and autonomous towns of 16th January 2003, is not applicable to NSPs due to the fact that they require specific free chlorine levels for water (ASR 2003). In this context the town of Bozen adopted a local resolution in 2011, with specific guidelines for this kind of environment. The document defines water supply and in-pool microbiological, chemical and physical requirements, but also building procedures, structures involved in official external safety controls, self-monitoring and general characteristics of the facility (BZ 2011). The above mentioned document is a response to the need for surveillance of NSPs and in part meets the points suggested by the international organization for natural bathing waters (Internationale Organisation für naturnahe Badegewässer, IOB), a society of individuals and companies that deal primarily with planning and construction of natural swimming pools.

THE FRENCH SITUATION

In France, in recent years, the interest for NSPs has been increasing for private and collective uses. From 2001 to now, more than 10 natural-like swimming ponds for collectivities have been installed in France by companies specialized in outdoor architecture. At the moment, a simple statement must be realized in city hall and these installations are opened under the responsibility of only the building owner and the administrator. No preliminary authorization from the health authority is needed before opening.

Nevertheless, the assessment of the health risks potentially associated with these installations is a major concern for the Directorate General for Health and the French Agency for Food, Environmental and Occupational Health and Safety (ANSES). This Agency was created on 1st July 2010 through the merger of two French health agencies: AFSSA (the French Food Safety Agency) and AFSSET (the French Agency for Environmental and Occupational Health Safety).

AFSSET was instructed on 22nd December 2006, by the Ministries of Health and of Ecology and Sustainable Development, to estimate the sanitary risks linked to categories of bathing that are not covered by regulations. It was asked to pay particular attention in the case of the public installations of bathing marketed as 'biological or ecological swimming pools'. The agency edited the following documents about natural swimming pools: an expertise report in July 2009 (AFSSET 2009a), a note on the 17th July 2009 (AFSSET 2009b), and a note in September 2010 (ANSES 2010).

For regulated bathing sites (3,000 natural sites in freshwater and seawater) and conventional swimming pools (16,000 swimming pools for sporting or leisure use) the quality of water is monitored by the Ministry of Health and, at regional level, by the Regional Health Agencies. Each year, the Ministry of Health (Directorate General for Health) edits guidelines for Regional Health Agencies, in application of the European directive 2006/7/CE concerning the quality management of bathing waters and on the basis of the AFSSET reports for natural-like swimming ponds. These guidelines specify the methods to use for health control, categorizing bathing water and assessing the health risk to bathers for a given season (from 15th June to 15th September in general).

Monitoring of the microbiological quality of bathing water in open waters is based on detection and enumeration of fecal contamination indicators (FCI, enterococci and *E. coli*). The aim of the monitoring of the microbiological quality of swimming pools is (i) to verify the effectiveness of disinfection, (ii) to verify the absence of fecal contamination, and (iii) to monitor the microbiological parameters directly correlated to the density of bathers and indicators of risk of human disease transmission.

According to AFSSET, neither the parameters for monitoring the microbiological quality of bathing water, nor the parameters for monitoring the microbiological quality of water pools are sufficient to characterize microbial contamination and other health hazards of artificial bathing waters. As a result, the agency recommends following FCI and additional parameters. Thus, *P. aeruginosa* is retained as an indicator of survival of pathogens adapted to aquatic environments. *S. aureus* is retained as an indicator of risk of human transmission. AFSSET also recommends following the development of micro-algae and cyanobacteria and consideration of phosphorus. For NSPs the parameters to monitor are presented in Table 2.

To avoid sanitary risk, AFSSET defines limits for the load of bathers by mean of the FMI (maximal instantaneous attendance) and the FMJ (maximal daily attendance) as:

$$\mathbf{FMI} = V_{\text{total}}/10$$

V_{total}: total volume (m^3) of the bathing.

Denominator: estimation of the minimal volume needed per bather (10 m^3)

$$\mathbf{FMJ} = \text{FMI} \times (V_{\text{total}} + V_{\text{recirculated}} + V_{\text{renewed}})/(V_{\text{total}}) = (V_{\text{total}} + V_{\text{recirculated}} + V_{\text{renewed}})/10$$

V_{total}: total volume (m^3) of the bathing, $V_{\text{recirculated}}$: circulated and treated volume of water during the daily open period of the bathing, V_{renewed}: volume added to the bathing during the daily open period of the bathing.

AFSSET also recommends: (i) to avoid dead zone for the entire bathing volume, (ii) to provide a water supply in many parts of the basin, (iii) to have drains at the bottom and at the surface of the bathing area, (iv) to remove at least 50% of the film surface, and (v) to physically separate the bathing area from the RZ in order to monitor the proper operation of the hydraulic system and the effectiveness of the particular input-output balance. The NSP should also be equipped with a recirculation system in the swimming area coupled to the biological treatment filtration system for a renewal of the entire volume of swimming water in less than 12 hours. Mechanical and regular removal of biofilm growing on the edge and bottom of the pond and removal of the algae throughout the bathing area is required. In addition children under 6 years old should not bathe in the pond. The following should be avoided: ornamental jets that generate aerosol, the usage of toxic plant varieties (*Cicuta virosa* and *Solanum dulcamara*), the addition of nitrogenous nutrients to promote the growth of plants, or of bacterial inoculum for the maintenance of pool biological treatment.

Table 2 | Frequency of controls and limits for the quality of supply water (A) and for pool water (B) in NSPs in France

A Supply water[a] Parameters	Frequency	Closed system	Open system Fresh water	Open system Sea water
Intestinal enterococci (cfu/100 ml)	Weekly	40	200	100
Escherichia coli (cfu/100 ml)	Weekly	100	500	250
Phosphorus (μg/l)	Weekly	30[b] 10[c]	–	
Microalgae and cyanobacteria	Weekly	Absence	Absence	

[a]Parameters applicable for non-drinking water.
[b]Imperative value.
[c]Guideline value.

B Parameters	Frequency	Open system (closed) Fresh water	Open system (closed) Sea water
Intestinal enterococci[a]	Weekly[b]	200 (40)	100 (40)
Escherichia coli[a]	Weekly[c]	500 (100)	250 (100)
P. aeruginosa[a]	Weekly	10 (10)	
S. aureus[a]	Weekly	20 (20)	
Cryptosporidium spp.[a]	According to vulnerability		
Giardia[a]	According to vulnerability		
Water transparency	Weekly[d]	< 1 m	
Biofilm	Weekly[e]	Absence	
Cyanobacteria	Monthly[f]	–	
temperature	Weekly		
pH	Weekly		

[a]cfu/100 ml.
[b]NF EN 7899-1.
[c]NF EN 9308-3.
[d]Secchi index.
[e]Visual control.
[f]Enumeration & genus identification.

The Regional Health Agencies perform analyses of the natural-like swimming ponds and inform the administrator of the results. If a sanitary risk is proved, the health agencies inform the mayor of the city who can then close the bathing facility.

THE GERMAN SITUATION

The German Infection Protection Act (IfSG 2000) provides basic and general regulations in order to prevent and control infectious diseases in humans. These regulations are valid for pool water in commercial establishments, public pools and others, not only privately used facilities for swimming and bathing (like artificial bathing ponds). It only stipulates that no harm to health, especially by pathogens, must result from use of the water. Furthermore, another paragraph indicates that details need to be regulated by the ministry in charge. However, due to political reasons, these detailed regulations had never been enacted.

Therefore, local health authorities have no clearly defined tools to enforce at least basic health standards. While technical rules for the construction and operation of in- and outdoor pools are defined by DIN19643 (DIN 2012), no generally accepted regulations or rules for bathing ponds are currently available. Facing this dilemma, the German Environmental Protection Agency (Umweltbundesamt, UBA), in cooperation with the authorities of the Ministry for Health and a committee of swimming pool water experts edited recommendations for basic standards of hygiene in bathing ponds (UBA 2003), indicating maximum contamination levels for *E. coli* (100/100 ml), enterococci (50/100 ml), and *P. aeruginosa* (10/100 ml). Depth of visibility should be not less than 2 m. Next to other reasons, the purpose of this parameter is limitation of growth of algae, especially of Cyanobacteriaceae. To meet this parameter, total phosphorus in the water should be below 10 μg/l. Water temperature should not exceed 23 °C to limit growth of microorganisms. Short time exceedance for natural reasons may be accepted; however, no artificial or on-going heating of the water is allowed. In bathing ponds, no biocides or artificial ultraviolet (UV) irradiation may be employed because of the formation of by-products and mainly because measures of artificial disinfection could impair organisms necessary for nature-like water preparation. Pathogens should be eliminated by natural processes only; however, there is a clear statement that up to now, there is no scientific basis for the design of an acceptable biological water preparation system. Therefore, at least for babies and children, a separated basin with conventional water preparation and disinfection should be present. Finally, all bathers should be informed that due to the missing disinfection of the water there is an elevated risk of infection increasing with the number of bathers.

It is important to underline that these recommendations are not able to substitute legal regulations or technical rules. Construction of bathing ponds is mainly done by landscape gardeners using technical rules of the FLL (Forschungsgemeinschaft Landschaftsentwicklung Landschaftsbau e.V.). FLL is the research organization of German landscape gardeners trying to establish a scientific background and technical recommendations and rules in a wide variety of fields, including bathing ponds. Another professional association (Deutsche Gesellschaft für das Badewesen; German Society for Bathing issues) released guidelines for the control of the hydraulic function of outdoor pools with biological water treatment (DGfdB 2011). FLL guidelines claim that outdoor pools with biological water preparation are artificial ecosystems imitating and being very close to natural systems. In comparison to UBA recommendations, FLL guidelines allow higher temperatures and artificial heating of the water (FLL 2006, 2011). However, maximum contamination levels as indicated in the UBA recommendations are adopted, but not the conclusions regarding bathing of babies and children and warning of increased risk of infection.

Public meeting protocols of UBA's pool water committee indicate its concern about the new FLL guidelines (FLL 2011). Obviously, instead of 'ponds' the new guidelines address the transformation of traditional swimming pools into swimming pools with biological water treatment only. Although the extension of bathing ponds in Germany is steadily increasing, there is vivid and controversial discussion on the safety and health compatibility of small artificial bathing facilities without technical water preparation and chemical disinfection. Whilst large systems may be adequate to imitate nature and to dilute incoming pathogens to acceptable concentrations, there is no dilution effect in small systems and biological water preparation is possibly too slow to remove incoming pathogens in time. At the moment a reduced quantity of epidemiological data are available and for this reason it is difficult to make a comparison of risks between conventional swimming pools and NSP. Research so far has concentrated on the elimination of phosphate and indicator organisms like *E. coli*, although other microorganisms like *P. aeruginosa*, *Legionella* or even viruses behaving very differently during biological water preparation might be a bigger problem.

THE SWISS SITUATION

There are no federal laws on swimming pools or bathing water in Switzerland. The Swiss law on the prevention of transmitted diseases (Loi sur les épidémies 1970) gives the basic regulations in order to prevent and control infectious diseases in humans. This law stipulates that the regional states (cantons) should provide a frame regulation to control epidemics, and allows the cantons to close pools or to restrict the access to any bathing water sites in case the water quality is not suitable. Most cantons, but not all, have edited rules or ordinances on public swimming pools. As the main goal of these regional texts is to reduce the risks of infection, they focus on the monitoring of water microbiology in disinfected swimming pools; some cantons include also physical-chemical parameters, such as concentration of free and combined chlorine, transparency of pool water, and pH. A single canton, Aargau, has included rules for the water quality of NSPs (BäV 2001).

The Swiss Society for Architects has published a norm for the planning, building, maintenance and monitoring of disinfected pools (SIA 2011). This norm, that also defines the water quality with microbiological and physical-chemical parameters, has become a reference and is cited in some of the cantonal ordinances. This norm excludes the NSP from its field of application.

As nothing was available for the monitoring of NSPs, the Federal Office of Public Health (FOPH), in collaboration with a multidisciplinary working group, published dedicated recommendations in 2004 (FOPH 2004a, b). They define microbiological (Table 1) and some physical-chemical parameters that should be monitored and respected. The pH should be between 6 and 9, and the depth of visibility over 2 m, in order to limit the growth of algae, especially of cyanobacteria. To meet this parameter, the total phosphorus in the water should be below 10 μg/l. Recently, the Swiss Society for Nature-like Swimming Water and Plant Sewage works in collaboration with Swiss Garden have published general recommendations for the planning, building and maintenance of NSPs (SVBP 2012). The text recognizes five categories of NSPs that simulate different stagnant and flowing natural water surfaces. Among the five categories the steps of clearance increase and may include the removal of surface water, different types of filter materials, aqua cultures, secondary ponds and the use of pumps. It is not as detailed as the FLL norm from Germany, but refers to available norms and in addition gives details of specific features for NSPs. The maintenance works and the water controls are described. In addition to microbiology (Table 1) the recommendation provides an ambitious program for the monitoring of the physical-chemical water quality. This includes the above limits set by FOPH as well as others such as DOC (dissolved organic carbon), ammonium, nitrate, oxygen, etc. Heating over 23 °C or cooling with fresh water are not permitted.

Public NSPs are not very common in Switzerland with an estimated number of 10, while there are approximately 50 hotel and camping NSPs. Public NSPs have not been the subject of strong controversy. Nevertheless, the control authorities are sometimes confronted with exceeding values or with old-fashioned NSPs and are worried about the possible consequences on swimmer health. As no data are available on outbreaks caused by NSPs or by conventional swimming pools the comparison is not possible.

CONCLUSIONS

Since the building of the first NSP in the early 1980s in Austria, the phenomenon has diffused to different European regions. The potential expansion of this sub-group on the general market of swimming recreational environments has been clearly understood by gardening companies and pool builders. This rapid evolution of new artificial aquatic facilities, characterized by the absence of disinfectant reagents, has underlined the presence of possible health risks for bathers raising some concerns in local authorities.

While specific epidemiological data are still scarce, the strict similarity to other recreational environments, and in particular natural small ponds, allows public health officials to implement specific surveillance protocols. In fact, the strict association with bathing in ponds of outbreaks attributed to *Shigella*, *E. coli* O157:H7, and *Naegleria* is well known (Craun *et al*. 2005).

For this reason, in a more general prevention framework, some countries have adopted guidelines or regulations dedicated to NSPs. At least for some parameters (see for example the microbiological ones summarized in Table 1) the specific documents are largely homogeneous. At the same time, due to the low number of scientific and epidemiological data linked to these specific environments, the suggested technical limits look mainly derived from the experience in coastal, fresh waters and conventional pools. Nevertheless, all documents presented in this paper maintain an important meaning in Public Health, and can be a milestone for defining specific strategies. The importance of frequent checks of microbiological parameters is clearly underlined in several regulation documents. This requirement is strictly correlated with the adoption of fast analytical methods for microbiological indicators. The substitution of the cultural approach, with more specific and less time consuming enzymatic and/or molecular protocols can lead to a more prompt monitoring of the environment, strongly reducing the risk of large outbreaks in the population (Valente *et al*. 2010; Valeriani *et al*. 2012; Lawson *et al*. 2013).

The presence of some national guidelines underline the need for regulation documents in this field, and it is also an impulse for the European Commission. At the moment, it is still missing a common directive on conventional swimming pools, leaving the Union without a definitive harmonizing document. Starting from this gap, it could be possible to develop of a single law dedicated to all artificial recreational environments, enabling at least a standardization in monitoring and surveillance. Such a document could be useful also in solving the open questions related to those recreational facilities supplied with thermal spring water that, due to their peculiar chemical compositions, can present some technical problems with standard sanitation procedures (Giampaoli *et al*. 2013).

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