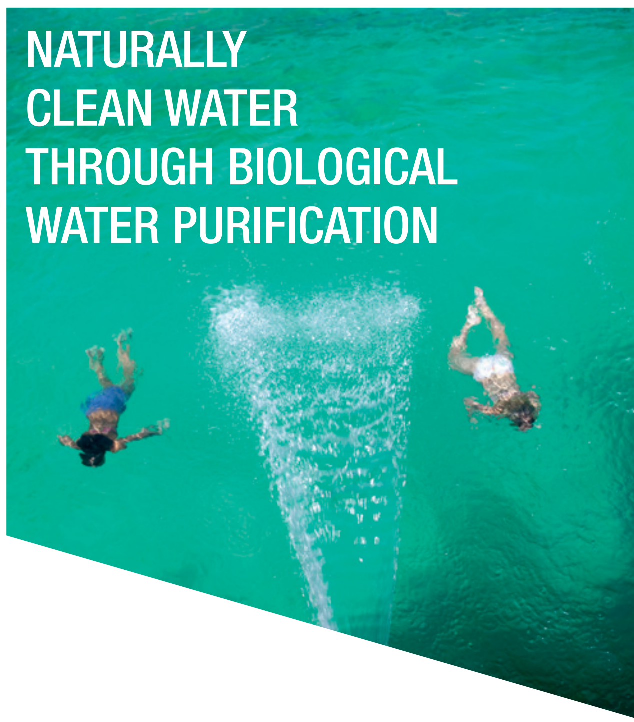
IOB



NATURALLY CLEAN WATER THROUGH BIOLOGICAL WATER PURIFICATION

FOREWORD

Dear readers,

There can be no doubt that swimming and bathing are amongst the most popular of all sporting and leisure activities. In order to ensure that users of private and public swimming ponds and pools experience only good, clean fun, the water must be purified by means of a sophisticated technological process which eliminates the risk of harmful substances and bacteria. The IOB – The International Organization for Natural Bathing Waters – is the body responsible for promoting this technology worldwide. Working alongside active regional associations, we aim to taking a leading role in the planning and construction of swimming ponds with biological water purification on an international level as well as in the further development of the technology. Biological water purification is an extremely viable alternative to conventional chemical disinfection processes for both private and public systems.

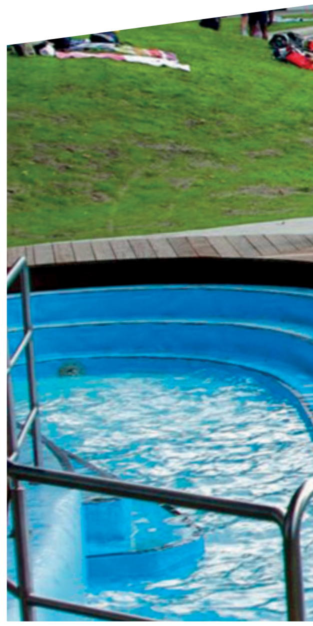
The IOB represents the combined expertise of our members, comprising specialists in the field of planning and construction of pools with biological water purification, active the world over. Indeed, in recent years the international ranks have swelled significantly: today, such systems can be found not just in Germany, Austria and Switzerland, but also in France, Italy, Portugal, Spain, Poland, the USA, Israel, Canada, Chile, Morocco and New Zealand, with countless more systems currently either in the planning or construction phases.

The growing number of pools and swimming ponds has, naturally, served to significantly increase our depth of experience. This success is testament to the fact that both private and public pools with biological water purification really do work. In order to identify just why this is, a number of studies have been carried out all over the world – and a small sample of their findings is included in this very brochure.

We hope that this brochure provides a brief overview of the technological basis for biological purification and the expertise we have gathered. At the same time, we hope to open up the discussion and demonstrate some of the opportunities and potential for optimisation that the technology offers.

We wish you an enjoyable and informative read.

The management board of the IOB, The International Organization for Natural Bathing Waters.



A STRONG ASSOCIATION

Founded in 2009, the goal of our organisation is to distribute information about fully biological water purification. To date, 16 national associations have united under the IOB banner and we are active in 23 states, representing over a hundred companies and individuals in political, research and social matters.

As a registered organisation in Germany headed up by a management board, the IOB is organised in accordance with German law, with our headquarters located in Bremen, Germany. The five-strong, international management board and the committee members report to an assembly made up of members of the national associations.

One of the focal points of our internationally oriented work is the coordination and planning of educational and training events. We are also responsible for sponsoring the biennial International Congress of Natural Bathing Water. In addition to this, the IOB also supports and promotes graduate theses, doctorates and research initiatives relating to this topic.

In order to ensure sound quality management, we maintain the online database system DANA for outdoor pools featuring biological water purification. Public pools in Switzerland, Poland, Denmark, Sweden, the USA and Canada have signed up to the system of their own volition.

A TRUE SUCCESS STORY

It all began in the 1980s in Austria: a country with a long tradition of swimming in naturally occurring water. And it was in Austria that the first public swimming pool to forego chemical disinfection opened its doors in 1991. Since then, the number of swimming ponds utilising biological water purification across Europe has risen to over 10,000 – of which some 400 are public and hotel pools.

In the many countries in which bathing in natural water does not enjoy the same popularity that it does in Austria, Germany and Switzerland, there continues to be a certain widespread degree of scepticism about biological water purification, which leads to a reliance on chemical methods. Such thinking can be challenged in international discussions with experts, and it is facts and experience that form the strongest basis from which to allay concerns about the technology and hygiene standards.

As the diagram to the right demonstrates, there are a number of different ways to naturally purify the water in a public pool. These can be broadly grouped into two different methodologies: The first method is based on the use of zooplankton and the interaction between micro-organisms and UV light (known as in-situ purification). The second method involves the use of external purification systems, such as hydrobotanical systems, substrate filters and artificial wetlands (known as ex-situ purification).

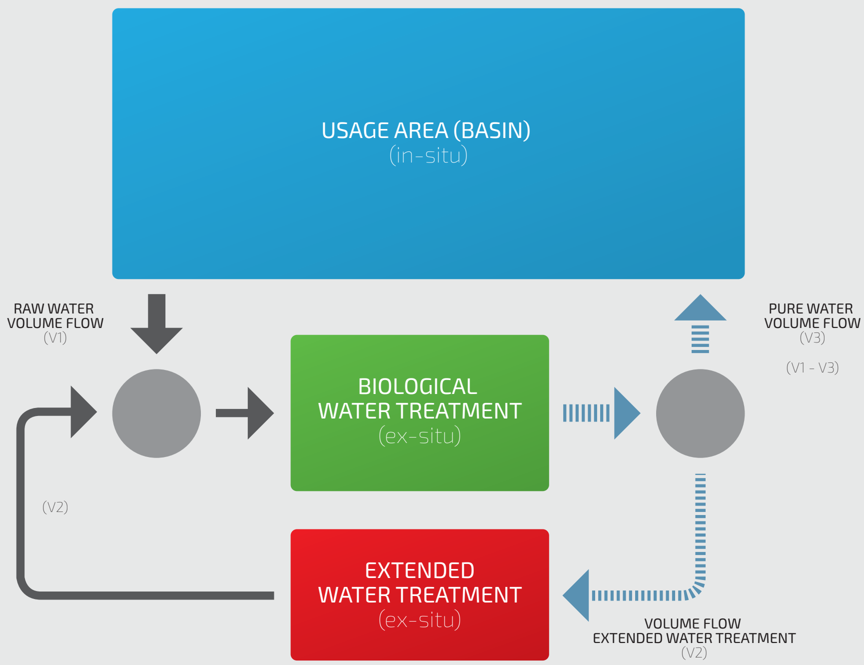


Diagram showing in-situ and ex-situ water purification

A MATTER OF HYGIENE

In the same way as disinfected pools, pools featuring biological water purification consist of a usage area (in-situ) and a treatment area (ex-situ), which is usually external. The repository effect created by introducing disinfectant substances to the pool water in disinfected pools is here created by biological pool degradation mechanisms, such as filtration by zooplankton or competition between microorganisms and natural UV light. The breakdown of harmful germs, viruses and protozones also takes place in the usage area.

When planning and constructing pools with biological water purification, it is vital that the phosphorous content of the filling water, the volume of the pool water and the elimination capacity of the various cleaning elements used, such as substrate filters and aquaculture, are taken into consideration. It must be ensured that the presence of bacteria and germs in the pool water is minimised, in order to guarantee compliance with the legal reference values for the indicator germs E. coli, enterococci and Pseudomonas aeruginosa. As a general rule, during expert planning the filter system should be able to guarantee a germ count reduction of one log step (equal to 90%) of the dominant germ E. coli per cycle.

Every year, millions of people all over the world enjoy carefree swimming in pools with biological water purification – some in naturally purified pools, and some in swimming ponds. That there are so many installations in successful operation worldwide bears testament to the functionality and soundness of this technology.

Natural Pools and Bio-Pools
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ORIGINAL B!OTOP NATURAL POOL

THE EFFICIENCY AND OPERATING PRINCIPLE OF BIOLOGICAL WATER PURIFICATION

Biological water purification can broadly be split into two methods: internal and external. The internal method primarily consists of filtration using zooplankton, while the external method, on the other hand, utilises a connected water treatment area.

EXTERNAL DISINFECTION

Disinfection via external water treatment is crucial in ensuring the safety of the system for both users and the environment. A study carried out by the German Federal Environment Agency entitled "Entfernung von Mikroorganismen durch Bodenfilter für Kleinbadeteiche"[1] (Elimination of microorganisms with substrate filters for small bathing ponds) has shown that it is possible to achieve an Escherichia coli elimination rate of two log steps – representing a degradation rate of approximately 99%. The University of Hanover (ISAH) also carried out tests with coliphages and Escherichia coli, using a filter, a water tank and a dosing unit for phosphorus and zooplankton. The test tank was inoculated with coliphages. The elimination rate as a factor of the filter column was 93 to 99%. From this data it can be surmised that an elimination rate for bacteria and viruses in excess of 90% is possible in external biological water purification systems.

References:

1 A. Grunert1 · C. Arndt1 · H. Bartel1 · H. Dizer2 · M. Kock1 · M. Kubs1 · J. M. López-Pila Umweltbundesamt, Berlin, BRD · 2 Helios Klinikum Berlin, Klinik für psychiatrische Medizin und Frührehabilitation, Berlin, BRD, Entfernung von Mikroorganismen durch Bodenfilter für Kleinbadeteiche; Bundesgesundheitsbl - Gesundheitsforsch Gesundheitsschutz 2009 · 52:228-237 DOI 10.1007/s00103-009-0768-x Online publiziert: 10. Februar 2009 © Springer Medizin Verlag 2009.

INTERNAL DISINFECTION

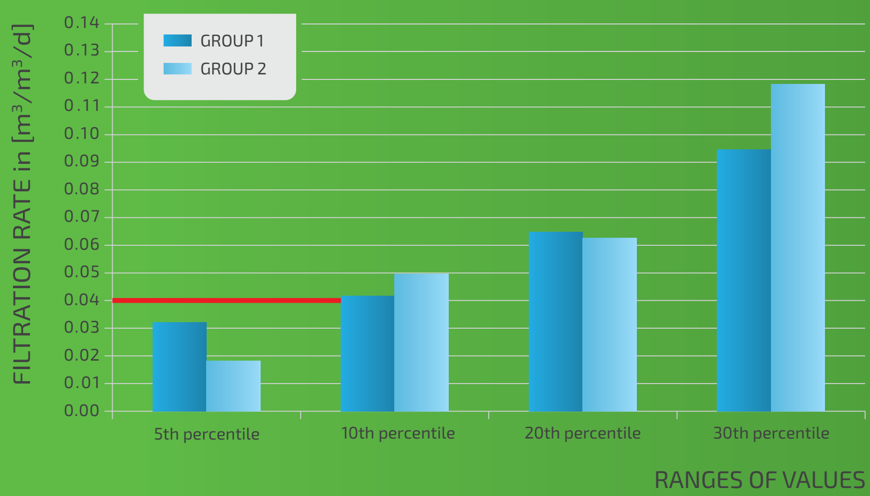
A study of 13 public swimming pools was carried out in Germany[2], with the aim of recording semi-qualitative data on the zooplankton population. The tests detected the presence of the species Flagellata, Ciliata, Rotatoria, Cladocera and Copepoda. A low filtration rate was identified as between 0 and 2.5 times per day, while a comparatively high filtration rate was between 2.6 and 10 times per day.

References:

2 I. Eidler, J. Spieker: Wasserreinigung durch Zooplankton in Schwimm- und Badeteichen Keimelimination durch Zooplankton." Archiv für das Badewesen Mai 2009.
Stefan Bruns, Polyplan Gmbh: Insitu-Entkeimung von Badewasser in Kleinbadeteichen durch Zooplankton und Herleitung eines Badegastgleichwertes. Archiv für das Badewesen Aug 2009.

As a result of the study, the group responsible for the German FLL guidelines defined an in-situ filtration rate of 0.04 $m^3/m^3/d$ or 40 $l/m^3/d$. A thinning out effect had been demonstrated for swimming pond filter systems with a high filtration rate, which leads to increased stress amongst the zooplankton population that could cause severe damage. The effect was also observed following a period of intensive pool usage, which pushes the water treatment system to its maximum limits. In accordance with FLL guidelines, the planner is entitled to set a higher filtration rate; approximately 0.04 $m^3/m^3/d$, for example. In such cases, the operator of the system must regularly carry out additional zooplankton population surveys, as well as the normal hygiene tests. The zooplankton filter the water, grazing on the bacteria, viruses, cryptosporidia, algae and any other edible particles.

Results of the filtration rates (in-situ) divided into pool groups



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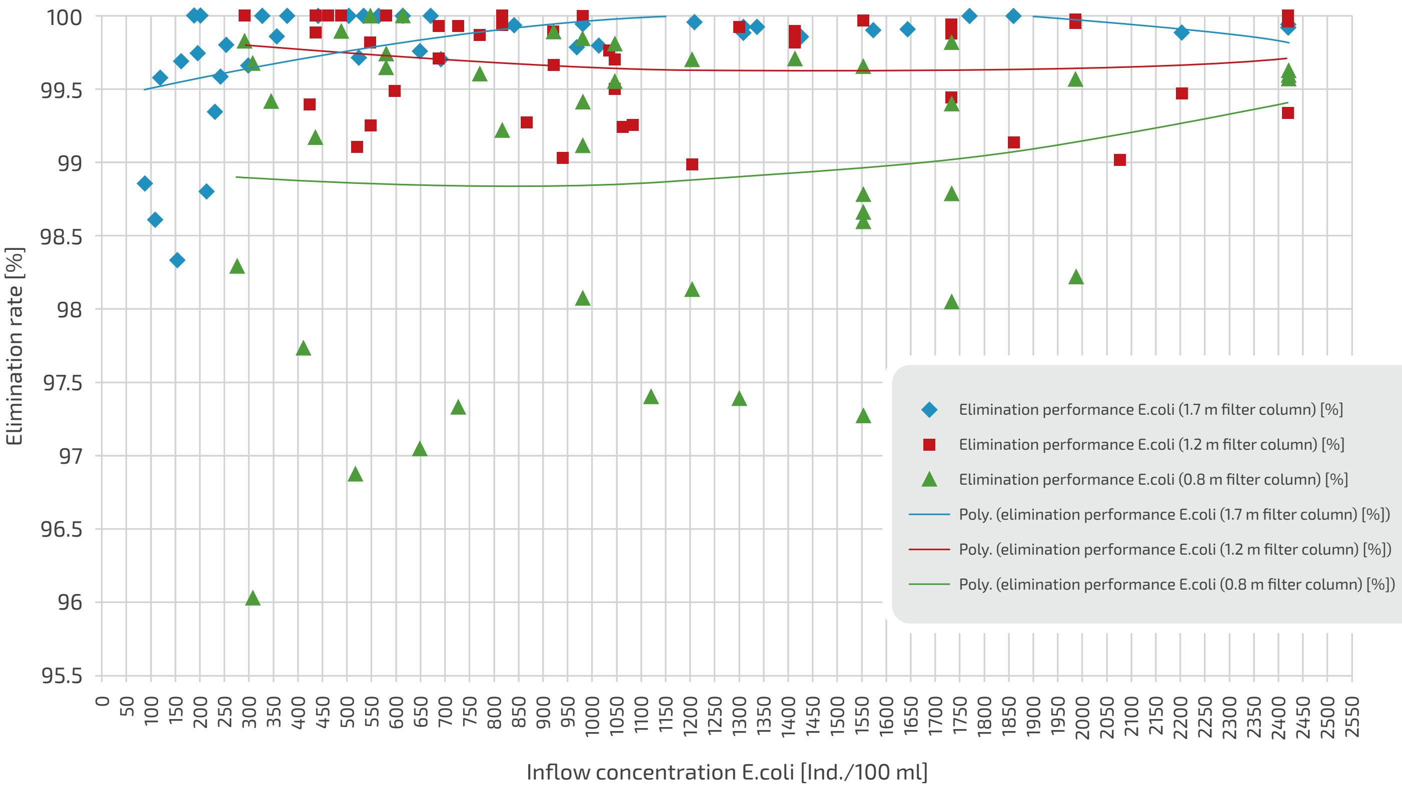
Elimination rate of Escherichia coli in substrate filters as a factor of a filter column with a hydraulic load of 12 m³/m²/d (vertical flow, not flooded).

Source: Polyplan GmbH



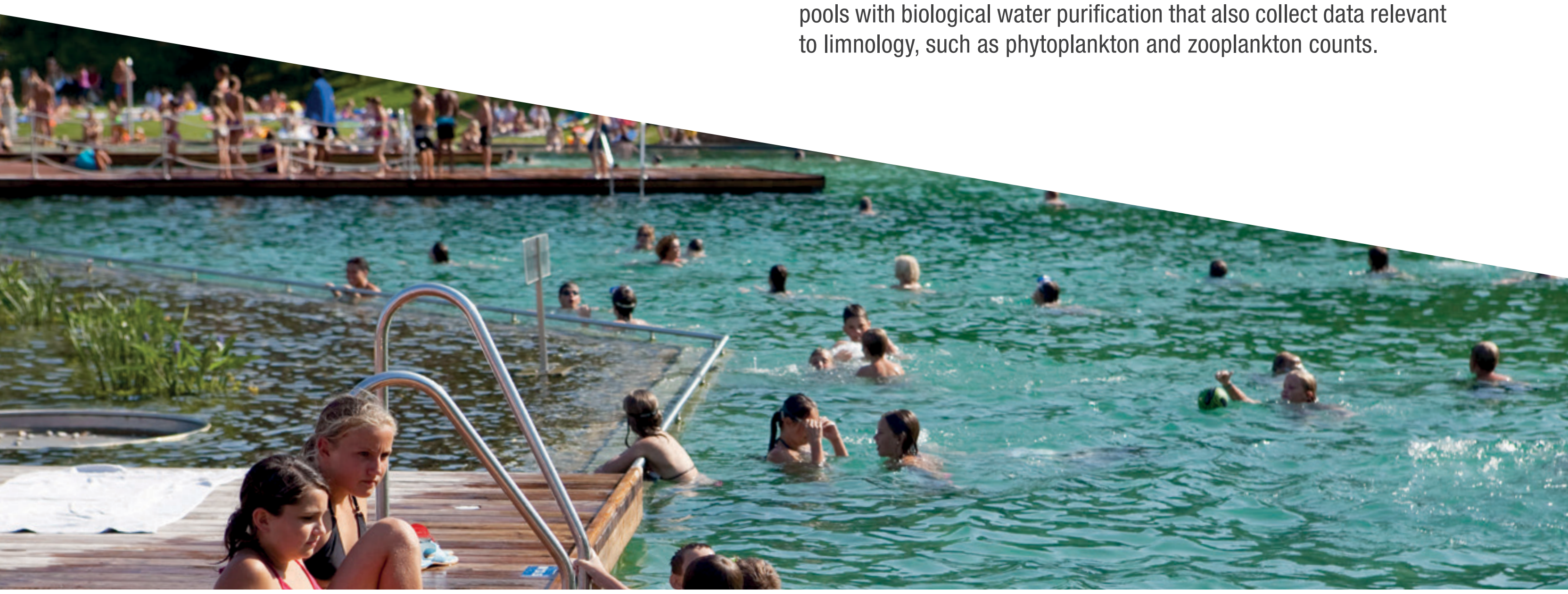
A study was carried out in various systems with high and low filtration rates in order to observe the plankton populations of swimming ponds and their influence over the elimination rate caused by the 'grazing effect'. To ensure that the recorded values were comparable, phytoplankton from the first trophic level and zooplankton from the second trophic level were surveyed. 102 surveys were carried out to determine the frequency, 49 for the calculation of biomass and 65 to determine the zooplankton count. The results showed that the zooplankton frequency in swimming ponds with high filtration rates was not lower than in swimming ponds with low filtration rates, however the values fluctuated substantially from system to system. The highest filtration rate using zooplankton recorded in this field experiment was 15 [m³ filtration rate/m³ pool volumes/d], meaning that the same water is filtered 15 times per day. The minimum value identified was around the 0 mark [m³ filtration rate/m³ pool volumes/d]. This suggests that the zooplankton primarily filter areas which are rich in food. The FLL guidelines used a standard filtration value of 0.04 [m³ filtration rate/m³ pool volumes/d] which represents a value of 10%. In the event of a value of 0.04 [m³ filtration rate/m³ pool volumes/d], the planner does not need to undertake any additional zooplankton population studies. Should they wish to set a higher filtration rate, however, then regular additional zooplankton population surveys (for rotatorea, copepods, calrocera) should be carried out.

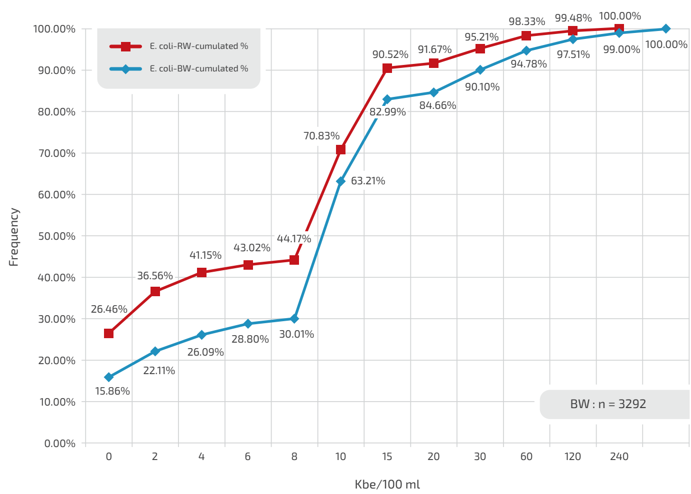
DANA DATA PLATFORM

DANA – the database of natural swimming ponds – was developed in the course of a research project sponsored by the German Federal Environmental Foundation (DBU). The project was set up with the goal of establishing a secure data repository featuring query analysis functionality, which could be used to demonstrate the correlation between the hygiene indicators E. coli, enterococci and Pseudomonas aeruginosa and other, system-specific factors. As well as the individual construction and hydraulic parameters of each system, operational data such as visitor numbers, temperature variations and filling water supply were taken into account. The master data module was set up using a Java servlet with a web-based SQL database as its basis. The data for each outdoor pool is fed into the master data module, including all of the essential reference data relating to the pool, the water purification systems and the untreated water and pure water flow rates in detail. The database defines and illustrates all routine monitoring programs, including the required parameters, measuring procedures, units and sampling or measuring points. Documents pertaining to the systems can also be fed into the database, including diagrams and operation and field manuals.

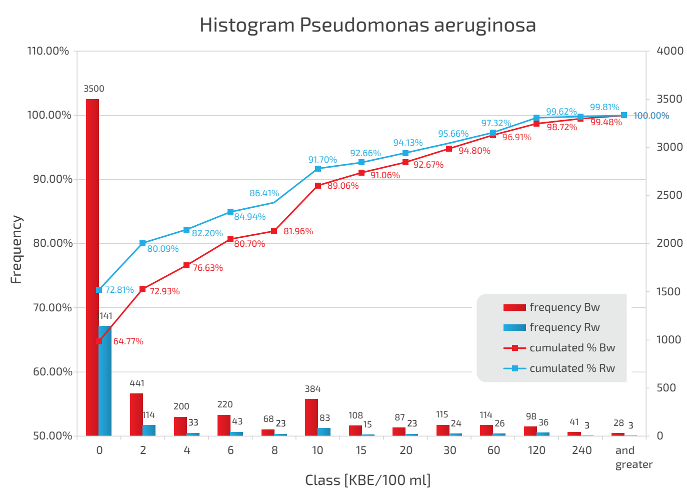
Pool operators can record specific data about their own pool via an internet browser on their PC or smartphone. During such manual inputs, plausibility queries are carried out to mitigate erroneous submissions. The platform also allows data to be imported digitally: lab data, for example, can be imported directly in xml format via the 'TEIS 3.0' interface. This means that all contributors are able to call up the current operational status of the pool in real time. There are currently over 70 public pools with biological water purification in the database system, which – other than a few exceptions – are all designed in accordance with FLL 2003.

Open air swimming pools with biological water purification are regularly tested by health authorities and accredited laboratories. As standard, these tests are for the hygiene indicator parameters Escherichia coli, intestinal enterococci and Pseudomonas aeruginosa. The chemical inspection parameters phosphorus as Ptotal and nitrate, as well as the physical parameters depth of transparency and pH-value, are also measured. Approx. 3000 data sets per pool are fed in online daily, including flow rate measurements, water and air temperatures, pump runtimes and error messages. There are 15 pools with biological water purification that also collect data relevant to limnology, such as phytoplankton and zooplankton counts.





Frequency distribution of E. coli populations in pure water (Rw) and pool water (Bw) 2009–2012. Source: DANA



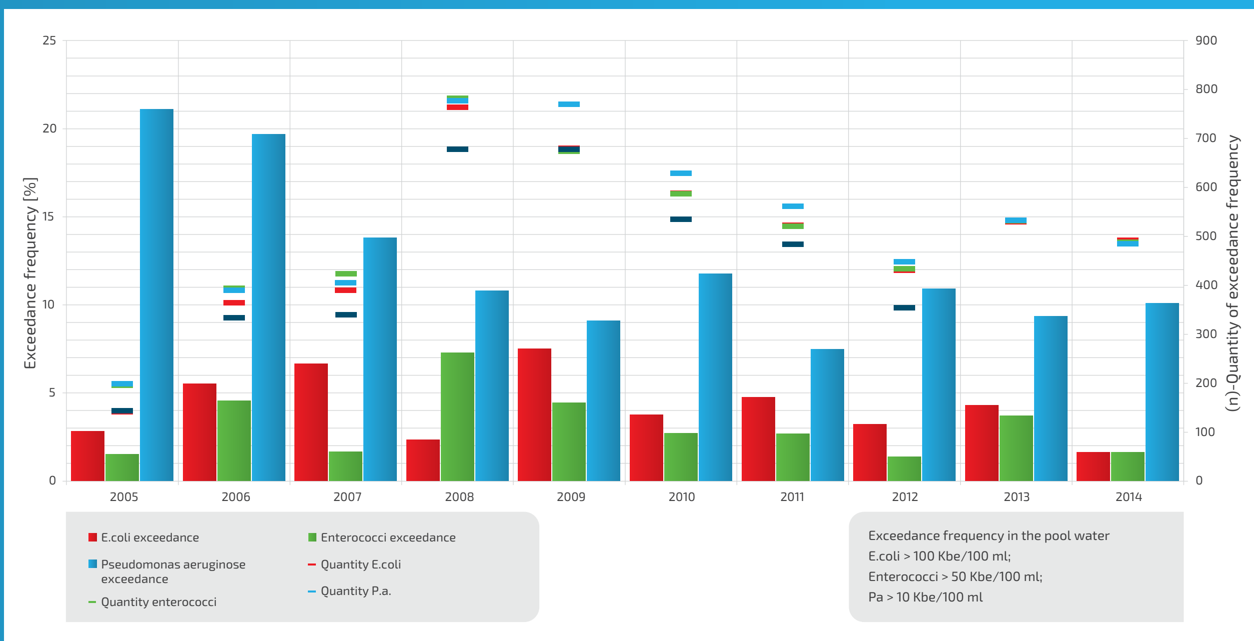
Frequency distribution of E. coli populations in pure water (Rw) and pool water (Bw) 2007–2015. Source: DANA

THE HYGIENE SITUATION

In the past, studies into the frequency with which Escherichia coli (red) exceeded the limit revealed an average value of approximately 3.5%. In most of these cases, the cause was identified as being the presence of animals in the pool, such as aquatic birds, martens and raccoons. Contamination as a result of the introduction of human faecal matter (caused for example by accidents involving nappies) were significantly less frequent. Both causes can lead to limits being massively exceeded, sometimes at multiple measuring points throughout the pool.

In the past, determining the cause of excessive levels of Pseudomonas aeruginosa has proved difficult. Studies do suggest that approximately 50% of violations are due to stagnation in pipelines, with the remaining 50% being attributed to permanently wet areas around the edge of the pool. A specific cause cannot be identified in the majority of cases in which limits are exceeded only minimally, i.e. under 100 cfu/100 ml. It is generally accepted that the standard methods for examining colony-forming units of Pseudomonas aeruginosa are highly susceptible to error due to high levels of other flora. For this reason, such studies often return false positives.

As part of the “Untersuchung und Evaluation der Hygienestabilität in Naturfreibädern” (“Assessing and evaluating hygiene stability in natural open-air pools”) research initiative, the degradation capacity of not flooded substrate filters was determined. The study took place in a specially developed testing environment which allowed specific inflow and outflow conditions to be simulated. Multiple series of tests were carried out in order to ascertain the influence of various hygienic and hydraulic conditions over the total bacteria and virus elimination capacity of the filter system. Filter columns with 0.8, 1.2 and 1.7 m filter layers were used in the tests. With a view to determining whether the substrate filter actually eliminated the inflow concentration of coliphages and E. coli, rather than just delaying their outflow, each experiment was carried out over time periods in excess of 6 hours. Regardless of varying hydraulic loads and filter sizes, a consistent elimination capacity of 97.7–100% was achieved. Overall, the elimination capacity of the trial filters fell as the effective substrate filter thickness dwindled. The elimination capacity tends to fall with filter layers of 0.8 m, particularly in the event of high inflow concentrations.



Frequency with which hygienic parameters exceed limits; Source: DANA, Polyplan Gmbh, Bremen, Germany, 2015

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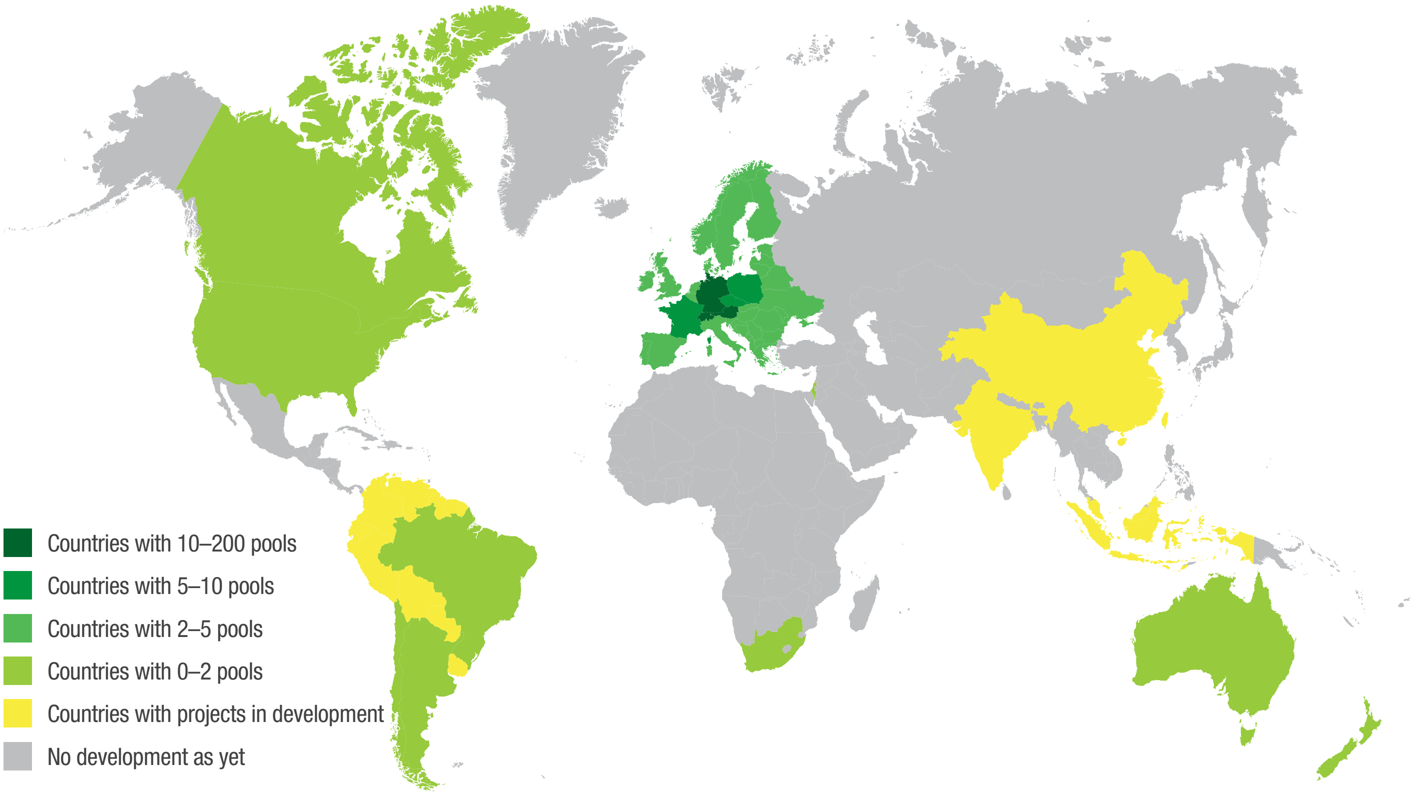
EXPERTISE AND GUIDELINES FOR USAGE IN PUBLIC POOLS

The operation of swimming ponds and pools with biological water purification boasts a long, rich tradition. The first public installation was opened in Austria in 1991, with Germany later following suit, unveiling its first system at the Expo 2000 World's Fair. The health and safety performance of these public installations was at the very heart of the debate from the beginning of their planing and construction. Following shortly after the Expo event, Germany's first public pool of its kind opened in the Lower Saxony region, whose state government had defined rules and standards for its construction and operation. In 2003, it was acknowledged within a document entitled "Empfehlungen für die Planung, den Bau, die Wartung und den Betrieb von öffentlichen Schwimm- und Badepools" ("Recommendations for the planning, construction, maintenance and operation of public swimming and bathing pools") that the use of chlorine in a pool or pond with biological water purification was entirely unnecessary and could lead to undesirable side effects. As a result, the use of chlorine in such pools was prohibited. The use of algae-fighting agents was also forbidden, as these increase the concentration of toxins in the water, leading to health risks. It was also decided that phosphorus concentrations must be below 10 µg/l. This official recommendation represented the first time that a document had set out clear rules for the construction and operation of swimming ponds with biological water purification. It states that:

- the use of chlorine is forbidden
- the biological process works to prevent toxic germs in the water
- biological water purification is effective against pathogens and efficiently purifies water
- the phosphorus content of the water must remain under 0.01 mg/l.

In 2011, the previous draft of the recommendations was published in a revised form. The new guidelines for the planning, construction, maintenance and operation of swimming and bathing pools are now based on experience, data and facts garnered from some 180 public swimming pools in Germany, stored in the DANA project described in this brochure. The sound scientific basis of the German guidelines have been recognised all over the world, as can be evidenced by the similar regulations currently in place in other countries such as Denmark, Sweden, Belgium and the United Kingdom. In Austria, too, a clear framework and set of guidelines was put in place at the time of the first pool's opening in 1991, with a focus on builders and planners.

MAP OF INTERNATIONAL ACTIVITIES



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