

## **The filter – A source of (re)contamination**

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### **Synopsis**

In many cases when pool waters failed to show satisfactory aesthetic or hygienic quality the source of contamination was found to be the filter. The reasons for contamination were often found in the design of the filter tank, the operation of the filter plant and/or servicing of the filter media. Research-work undertaken and tests performed over the past 30 years have shown that filters can easily become a major source of recontamination of swimming pool water, even when the recommendations, standards and regulations in place are followed.

When looking at filtration plants around the world, some fundamental differences in design criteria and operation have been found which can enable and even support the proliferation of micro-organisms.

As well as the design of a filtration system, good maintenance plays a vital role in controlling contamination. Further hygiene procedures within the facility including pre-swim showering and adequate deck cleaning can help to reduce the risks.

Experience of cleaning-up pathogen contaminated systems (incl. *Pseudomonas aeruginosa*, *Cryptosporidium parvum*) will help the audience to find practicable and tested water hygiene solutions to overcome the deficiencies found and provide examples of how to avoid common pitfalls in hydraulic system design and maintenance.

### **Background**

For over 35 years the companies of the WAPOTEC® Group have supported operators around the world in their effort to improve water quality in swimming pools and spas.

When checking installations for causes of outbreaks or poor water quality, a number of issues regularly showed up including inadequate filter design, poor filter operation, ineffective treatment systems and/or the lack of servicing the filter tanks and/or the filter media.

Top of the list is inadequate filtration capacity. Many facilities are overloaded with patrons. The recommendation of 2 cubic meters per patron per hour is a usually adequate in providing good water quality (see also DIN standard 19643-2ff/calculated according to part 1) although for pools with extreme changes in bather loads even this figure may not be sufficient. Excellent coagulation/flocculation can help to compensate for such deficiencies. However, very often filtration speeds, contact times for flocculation agents in free board and poor backwash rates can increase the risk of contamination not being effectively removed during backwash.

Filters with nozzle plate bottoms, which are mandatory in Austria and standardized in the German DIN and Swiss SIA standards, appear to be less often contaminated than filters using laterals embedded in the filter media as collectors.

To many pool operators, daily backwashing of the filters may appear to be a convenient way of preventing contamination build-up, but this method can be costly for pool operation, seriously affect filter efficiency, and in most cases will not improve the situation.

Contaminated filters were found containing all kinds of filter media including silica sand/gravel, carbon based filter media including GACs, diatomaceous earth, perlite, glas, shamotte and zeolite.

The Hygieneinstitut Gelsenkirchen demonstrated disadvantages of DE filtration over sand/multilayer in a 2-year field study of 225 pools in the NRW area.

### **Development of TCDO Treatment**

In response to the problems identified, the WAPOTEC<sup>®</sup> Group developed a method for the in-situ cleansing and regeneration of filter and carbon media using the TCDO (tetrachlorodecaoxide) method. The TCDO liquid agent produces a safe and controlled release of chlorine dioxide on contact with organic contaminants. A prepared solution of TCDO can be injected into a contaminated filter where its unique properties allow it to activate and chemically 'drill down' through organically loaded filter media. Correctly applied and allowing 8-24 hours of contact time (dependant on temperature and degree of contamination), the TCDO treatment breaks down organic pollution and thoroughly disinfects the filter media, often restoring it to a hygienic standard superior to its original condition. This method has been successfully used in the clean-up of several high profile Cryptosporidium P. and Pseudomonas A. incidents in European public and commercial pools. At the same time, and in only small quantities, TCDO solution can also be used to treat the whole of the pool volume and plant circuit to afford safe but potent additional oxidation power, particularly useful for the treatment and/or prevention of biofilm formation.

While chlorine hydrolyses in pool water forming hypochlorous acid/hypochlorite ion (depending on pH levels), chlorine dioxide remains as a soluble gas which is why TCDO/halogen solutions are able to be more effective in the treatment of biofilm contaminated systems. The processes developed are covered by a number of international patents including a technology for the flushing of filters<sup>1</sup>. The benefits in controlling certain parasites were also documented by Ross Gregory of the Water Research Centre.

In comparison to other methods TCDO also provides a safe and simple application. The product has been classified non-hazardous and non-toxic. It is fully decomposable in oxygen and chloride and does not leave any organic residues that could effect the treatment if not entirely removed before putting the filter back in service.

### **Contamination Detection Procedures**

The easiest way for an operator to verify filter contamination is by sampling water pre filtration and post filtration for free and total chlorine. If the water after the traditional sand/gravel filter is significantly depleted of free chlorine and/or the residual of combined chlorine is notably increased, further investigation by an expert should be arranged.

A more thorough method of detection is provided by the DIN standard 19643 in its parts 2ff. This standard offers a bench-mark for filter effluent water testing (or "Filterfunktionsprüfung"). When comparing limit values set for pool water and treated water, there are a number of interesting parameters to consider. Table 1 compares these parameters

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<sup>1</sup> Int. Patent: Method for flushing particle-bearing filter beds, to sterilize and decontaminate the same/Patent (WO/2001/064310), WIPO, Polak W., Geneva 2001

from different parts of DIN standard 19643. Some of the data have been simplified for better readability. This test procedure allows to test the effluent water but does not measure the contamination on the media in particular. Instant and valuable results can be achieved from turbidity tests as suggested by the standard.

Tests undertaken by accredited laboratories suggested to focus as well on the filter media. Samples were taken from various sites and a method was established to make results comparable. A 10g sample of the filter media was taken and mixed into 100ml of distilled water for 6 hours.

Unless specific tests were required, samples were routinely tested for the following parameters:

- Ammonium
- Yeast
- Fungi
- Colonies
- Pseudomonas
- Legionellae
- Entero bacteria
- Coliforms

This procedure can be used to test filter media before and after cleaning allowing to verify the efficiency of a cleaning/disinfection procedure.

Table 1: Benchmarking of key water quality parameters for pool water, treated water and filter effluent water (filter performance testing) according to DIN 19643 part 1<sup>2</sup>/part 2<sup>3</sup>/part 3<sup>4</sup>/part 4<sup>5</sup>/part 5<sup>6</sup>:

Parameter	DIN 19643-1				DIN 19643-2ff*
	Treated water		Pool water		Filter testing
	min.	max.	min.	max.	max.
Pseudomonas aeruginosa at 36±1 °C (per 100ml)	-	n.d.	-	n.d.	n.d.
Escherichia coli at 36±1 °C (per 100ml)	-	n.d.	-	n.d.	n.d.
Legionella pneumophila at 36±1 °C (per 100ml)	-	n.d.	-	n.d.	n.d.
Colonies (CFU) at 36±1 °C (per 1ml)	-	20	-	100	100
Turbidity (as NTU/FTU)	-	0,2	-	0,5	0,1
KMnO <sub>4</sub> -consumption (as KMnO <sub>4</sub> in mg/l - above filling water)	-	0	-	3	0

<sup>2</sup> Standard DIN 19643-1, Beuth Verlag, Berlin 1997

<sup>3</sup> Standard DIN 19643-2, Beuth Verlag, Berlin 1997

<sup>4</sup> Standard DIN 19643-3, Beuth Verlag, Berlin 1997

<sup>5</sup> Standard DIN 19643-4, Beuth Verlag, Berlin 1999

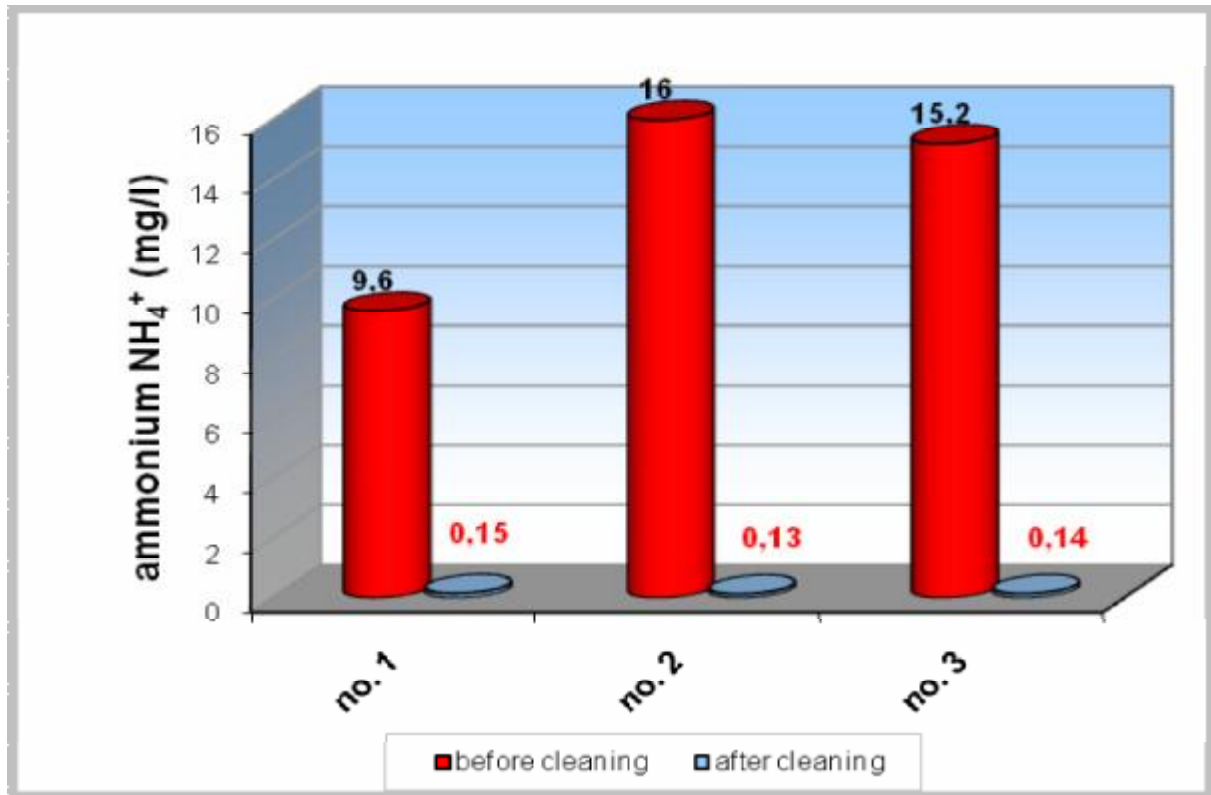
<sup>6</sup> Standard DIN 19643-5, Beuth Verlag, Berlin 2000

Combined chlorine (as mg/l Cl)	-	0,2	-	0,2	0,1
Trihalomethanes (as chloroforme in mg/l)	-	-	-	0,02	0,02
ortho-Phosphate (as P in mg/l)	-	-	-	-	0,005
Iron (in mg/l)	-	-	-	-	0,02
Aluminium (in mg/l)	-	-	-	-	0,05
Ozone (in mg/l)	-	-	-	-	0,05
Adsorbable organically combined halogens (as AOX in mg/l)	-	-	-	-	0,1
pH value (in fresh water)	6,5	7,6	6,5	7,6	-
Redox potential (ORP in mV)					
a) $6,5 \leq \text{pH-value} \leq 7,3$			750		
b) $7,3 \leq \text{pH-value} \leq 7,6$			770		
Free chlorine (in mg/l Cl)					
a) pools in general	0,3	As	0,3	0,6	-
b) whirl pools	0,7	required	0,7	1,0	-

\* Note: Parameters may not show all variations of the various parts of DIN standard 19643.

### Examples

The following table shows test results from 3 different GAC media taken from deozoneation filter tanks sampled before and after cleaning.



Graph 1: Comparison of Ammonium before and after cleaning of GAC filter media

Sample	Total plate count (CFU/ml)		Enterobacteria (CFU/ml)		Yeast, (CFU/ml)		Fungi (CFU/ml)	
	before	after	before	after	before	after	before	after
1	$5 \times 10^3$	< 10	$10^3$	n.d.	30	n.d.	20	n.d.
2	$8 \times 10^2$	< 10	$10^2$	n.d.	<10	n.d.	400	n.d.
3	$9,8 \times 10^5$	< 10	$5 \times 10^4$	n.d.	<10	n.d.	500	n.d.
Comparison with unused, new GAC								
new	$3 \times 10^2$		n.d.		---		---	

Table 2: Examples of contaminated GAC from pools before and after cleaning

All 3 filters were cleaned by adding an aqueous TCDO/halogen solution over night. Both the chemical as well as microbiological results demonstrate the efficient elimination of contaminants. In all cases the results prove that the applied method was effective, in fact it was demonstrated that in terms of Total plate count results all media cleaned had lower CFUs than unused carbon from the factory.

After cleaning all samples showed almost the same results as unused filter media (with a residual of 0,13 mg/l NH<sub>4</sub><sup>+</sup>).

## **Control and Application of TCDO**

A number of solutions have been researched and patented to ensure control of organic and micro-biological contamination.

TCDO/halogen combinations have demonstrated great effectiveness over other methods. The quickest way to apply treatment is to thoroughly backwash the filter and to completely drain the filter tank. The filter tank is filled up with an aqueous solution containing a TCDO/halogen combination. The media is soaked (inside the tank) usually overnight. It is beneficial to aerate the filter media several times during the soaking period. In the morning the tank is finally aerated and backwashed. The concentration of the TCDO/halogen combination depends on the filter media composition and typically ranges from 1,5%-10% of the solution added. This is easily achieved by proportional dosing equipment.

A more sophisticated method is to recirculate the TCDO/halogen solution within the filter tank through a temporary by-pass which should include all of the critical sections of the filtration train and the treatment system. The heat exchanger is not directly included but separately treated if necessary. A small circulation pump ensures a controlled flow during the treatment and contaminants are taken out by a small additional filter. This set-up has been published in an international patent granted to the WAPOTEC<sup>®</sup> Group. This method allows reduced chemical usage but requires some additional installation as described above in order to create the system to recirculate the solution. If the cleaning is done regularly as suggested, this method is more economic and equally efficient.

Another method is the use of TCDO encapsulated in pearls of specific sizes. These pearls release a small dose of TCDO constantly for an extended period of time. The TCDO reacts with the chlorine in the water. The pearls are topped up at intervals of 6 to 12 months. This method is particularly interesting for preventative maintenance of carbon based filter media (including GAC) in deozonation plants.

The effectiveness of each of the cleaning procedures can be proven by testing the filter media contamination using the above mentioned method.

## **Prevention**

Experience has shown that filter and filter media should be regularly cleaned and disinfected. Filters in outdoor facilities should be serviced at least once-a-year before opening the pool to the public for the season.

This practice is enforced by many tour operators in order to accept booking for the hotels concerned.

Preventative maintenance should include the cleaning of the filters and filter media in regular intervals, e.g. every 6 months (in indoor pools) or at the beginning and the end of the season (in outdoor pools) but at least whenever the installation is stagnant for a longer period of time (service shut down) or according to recommendation/requirements set by health and safety executives, particularly in spa systems. In our experience vertical filters tend to require less chemical treatment than horizontal filters due to poorer hydraulics of horizontal filters. We also recognized that filters with lower bed depths require shorter intervals than deep bed filters (>120cm).

Dosing rates depend on filter media composition and the cleaning process applied. The simplified DesoPur<sup>®</sup> Process requires little equipment. After draining the filter tank, the tank is refilled with a DesoPur solution using the following concentrations:

Filter media composition	Recommended dose rate
Sand/Gravel/Glass filter media only	2% of solution
above in combination with carbon based filter media	7% of solution
above in combination with GAC based media	10% of solution

The solution should sit in the tank for at least 8-12 hours. In order to accelerate the reaction, activation by chlorine could be chosen. The chlorine concentration should be considered for each project and adequate pH levels maintained.

The above-mentioned concentrations are proven to be adequate to clean the media and to regenerate Granulated Activated Carbon (GAC) media..

## Conclusion

Filters are an integral part of every treatment system and their optimal function must be assured at any time. In many cases insufficient effort is made in order to ensure that the best possible filter design based on bather load and contamination is selected. But even the best filter design or filter media cannot avoid contamination issues unless adequate operation and maintenance procedures are in place. This includes intervals between backwashes to be based upon differential pressure and not time. If the filter design allows, aeration should be applied as part of the backwashing procedure. It is critical to verify that filters are backwashed at the correct speed in order to ensure a proper expansion of the filter bed.

In their vital role filters also represent substantial risks for (re)contamination of the pool water and must therefore be well operated and maintained.

Benchmarking through regular tests of the pool water as well as the quality pre and post filtration (e.g. against DIN standard) is necessary to detect potential growth of biofilm on filter media.

When filter and/or filter media are found to be contaminated, servicing of the filters should not be delayed. Several TCDO treatment processes were developed to perform effective cleaning of media and have been proven by independent research-work. They have been successfully used to clean-up outbreaks in a number of cases including *Pseudomonas* and *Cryptosporidium* effected facilities. After all cleaning procedures the successful treatment should be verified and retested a few days later.

Based on all findings it can be concluded that filter media cleaning and regeneration should be a fundamental part of the preventative maintenance program in swimming pool and spa facilities.

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