Activated Carbon and UV for Pool Water Treatment

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1 Introduction

In the last few years there has been increasing focus on the water quality in public swimming pools, not only in Denmark, but also in may other European countries. An increasing environmental consciousness and knowledge of the influence of water on health and wellbeing have had the consequence that the authorities as well as the users have made demands for better quality of the water with a lower level of inconvenient chemical and microbiological pollution material.

In Denmark the water quality in public swimming pools are subject to various rules and regulations made by the Danish Ministry of the Environment and the Danish Environmental Protection Agency.

The present requirement for the water quality and the turnover period for public pools is shown below:

Water quality:

free chlorine:	0.5 – 2.0mg/l
combined chlorine:	recommended: max 0.5 mg/l (absolute max 1.0 mg/l)
pH:	7.2 – 7.6
THM:	recommended: max 25 *µ*g/l (absolute *max* 50 *µ*g/l)
total germ:	Max 500 per 100ml
coliforms:	0
Pseudomonas:	0

Turnover period:

Swimming pools:	max 5 h
Teaching pools:	max 2 h
Leisure pools:	1-2 h
Hot water pools:	max 0.5 h
SPA-pools:	max 0.1 h

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The Danish environmental authorities are at present investigating the possibilities of a further tightening the requirements for the level of the inconvenient and health damaging materials like combined chlorine (chloramines) and trihalomethanes (THM). The preliminary statements indicates that the marginal values for these materials will be lowered so that over a number of years they are brought down to:

combined chlorine: max 0.20 mg/l
THM: max 20 *µg/l*

In the Danish Association for technology of swimming pools, which is a cooperation of all interest groups within the field of public swimming pools, it was therefore decided in the end of 2001 to carry through an investigation of possibilities of lowering the level of combined chlorine and THM to the issued lower marginal values by means of activated carbon and UV. The Danish Technological Institute (DTI) have participated in the work group that has planned and carried out the experiment and DTI have made the practical tasks of the carrying out of the experiment including control of operations and sampling and analysis of water samples.

Activated cabon and UV

The usage of activated cabon and UV-light as a supplement to the water treatment process for a swimming pool has been known in Denmark for approximately the last 25 years.

The purpose of using activated carbon and UV-light has primarily been to reduce the level of chloramines (combined chlorine) in the water. New knowledge and new environmental regulations has also made it necessary to focus on elimination/reduction of other inconvenient and health damaging compounds in the water, especially trihalomethanes (THM). In addition it would be desirable in general to reduce the level of organic compounds in the water (expressed by the analysis of VNOC = " non volatile organic carbon") and other chemical compounds, like softener (phthalates) and solvents, which is added to the water from e.g. pool coverings, surface treatments, joint pastes, toys and bathing clothes.

1.1 **Experiment plan**

The experiment with activated carbon and UV has been carried out in the public swimming bath at Glostrup leisure centre in the period 3/1 – 17/5 2002 according to an experiment plan prepared by the work group. The experiment has been divided in 3 stages:

Stage 1: (8/1 – 11/2) included operation with A-carbon filters only and the capacity for the carbon filters (the water current through the carbon filters) was altered in the experiment period thus that in the first part of the period (8/1 – 25-1) it was aimed at keeping the combined chlorine at or just below 0.5 mg/l and in the other part of the period (25/1 – 22/2) it was aimed at keeping the combined chlorine at or below 0.2 mg/l

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Stage 2: (25/2 – 12/4) included operations with UV-system only and opposite to the experiment with the activated carbon filters it was aimed at keeping the combined chlorine at or below 0.2 mg/l in the first part of the period (25/2 – 19/3), and in the other part of the period (22/3 – 12/4) it was aimed at keeping the combined chlorine at or just below 0.5 mg/l.

Stage 3: (12/4 – 10/5) included a combined operation with active carbon filters and the UV-system where it was aimed at keeping the combined chlorine at or below 0.2 mg/l and THM at or below 20 *µ*g/l.

In the period 10/5 – 17/5 the systems were adjusted for operation with activated carbon filters only with capacities as under stage 1.

In the total experiment period various registrations and analyses of the water quality was carried out according to the plan made by the work group. All registrations and analysis results has been entered into special operation logs, which have been designed by the work group.

The following measurements and analyses have been made:

By the operational staff of the swimming bath:

free chlorine:	Three times a day
combine chlorine:	Three times a day
pH:	Three times a day
number of visitors:	Daily
consumption of fresh water:	Daily
consumption of electricity (UV)	Daily

By DTI:

THM:	Twice a week
NVOC	Twice a week
free chlorine:	Twice a week
combined chlorine:	Twice a week

(the control laboratory of the swimming bath has also made the normal control analyses of free and combined chlorine and pH and total germ.)

1.2 Analysis results

1.2.1 Activated Carbon Filter System

In the first operation period with activated carbon only the marginal values for combined chlorine and THM are kept within the present guiding marginal values, which are 0.5 mg/l combined chlorine and 25 *µ*g THM both for swimming pool and teaching pool, as the carbon filter capacity was only partly utilised. In the following operation period also with

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activated carbon only, but with utilisation of a larger capacity in the activated carbon filters, the values for the combined chlorine in both pools could be reduced to less than 0.2 mg/l combined chlorine whereas THM in the swimming pool could be reduced to approx. 10 *µg/l and to approx 25 µ*g/l in the teaching pool. It has been proved that with a well dimensioned activated carbon filter it is possible to satisfy the reduced margin values for combine chorine and THM given that the rest of the water treatment system is well dimensioned.

UV-system only

By full utilisation of the UV-system the combined chlorine can be reduced to less than 0.2 mg/l in both pools (the capacity of the partial water stream system for the teaching pool being approx. 50m³/h an din-line system for swimming pool approx. 250m³/h). By 50% utilisation of the capacity of the UV-system the combined chlorine can be kept at approx 0.25 mg/l in the swimming pool and approx. 0.4 mg/l in the teaching pool. However it turns out that the THM is a problem when only the UV-system is used. In the swimming pool THM measurements even at full utilisation show values from 40-80 *µg/l* and in the teaching pool values from 180-350 µg/l appear, i.e. quite unacceptable levels.

1.2.3 UV-system and activated carbon filter system

As a consequence of results in the second operation period, a third operation period has been carried through. Here a combination of UV-system and activated carbon system is used in order to secure reduction of THM. The results from this operation period show that THM can now be reduced to a lower level, however, not as low as by operation only with activated carbon filters. In the swimming pool a level of just below 50 *µ*g/*l* is achieved and in the teaching pool approx. 100 µg/l is achieved in both pools with a flow through the activated carbon filters corresponding to the level in the first part of stage 1.

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