



**The Performance of a Water Treatment  
Apparatus on the Elimination of Chemicals and  
Micro-Organisms related to Drinking Water**

## **The Performance of a Water Treatment Apparatus on the Elimination of Chemicals and Micro-Organisms related to Drinking Water**

Four apparatuses intended for water treatment were received in June 2004. The devices represented a new product with the model designation Purity modell 230.01.00.

The analytical programme comprised (i) 26 different organic compounds of different volatility and polarity, (ii) three compounds known to cause taste and odour problems in drinking water world-wide, (iii) BTX, i.e. benzene, toluene and xylene, (iv) trihalomethanes and 2,4,6-trichlorophenol, common by-products formed upon chlorination, (v) 19 different pesticides, (vi) active chlorine, (vii) hydrogen sulphide, (viii) radon and (ix) micro-organisms known to constitute potential problems in drinking water and (x) the colour of a humic water. In addition, for comparison, the decrease in the amount of water during a treatment cycle was measured.

All analyses were performed by addition of the hazardous chemicals to ordinary tap water. The water was analysed before and after treatment with two apparatuses. The results are shown in Tables I - X.

### **Water**

One of the more volatile compounds present during the analytical programme was the water itself. If elimination of the chemicals was dependant strictly on volatility, water would have been one of the compounds most efficiently eliminated. The results are shown in Table I.

**Table I. The elimination of water during treatment.**

Compound	Device A elimination/%	Device B elimination/%
water	2.3	3.1

### Experiment with 26 organic compounds

In order to investigate the dependence of volatility and hydrophobicity on the elimination of organics, 26 compounds were added to ordinary tap water. The compounds had boiling points between 125 and 350 °C. They represented several classes of organic functionalities from the polar alcohols to the non-polar hydrocarbons. The results can be seen in Table II.

**Table II. Elimination of 26 organic compounds during water treatment.**

Compound	b.p. °C	Device A elimination/%	Device B elimination/%
1. butyl acetate	127	78	73
2. chlorobenzene	132	>99	>99
3. 1-hexanol	158	75	74
4. amyl acetate	149	>99	>99
5. anisole	155	89	91
6. 1,3-dichlorobenzene	173	98	99
7. decane	174	98	98
8. acetophenone	182	76	75
9. 1-chlorooctane	203	>99	>99
10. 1-octanol	194	87	83
11. benzyl acetate	215	65	69
12. naphthalene	218	44	39
13. 2-decanone	211	96	96
14. dodecane	216	98	97
15. 1-decanol	229	86	89
16. 4-tert-butyl phenol	240	>99	>99
17. tetrachlorobenzene	224	95	99
18. methyl decanoate	246	>99	>99
19. diphenyl ether	258	94	97
20. 1-chlorododecane	260	99	99
21. pentachlorobenzene	262	88	98
22. 1-hexadecene	306	94	93
23. 1-chlorotetradecane	292	92	96
24. octadecane	340	52	69
25. 1-chlorohexadecane	322	56	76
26. 1-chlorooctadecane	348	66	62

### **Odour-causing compounds**

There are a few compounds usually responsible for taste and odour problems in drinking water based on surface water. These compounds are extremely potent and may cause complaints from consumers in concentrations down to 1 ng/l.

During testing 5 ng/l of each compound was added to ordinary tap water. The results are shown in Table III.

**Table III. Elimination of odorous compounds during water treatment.**

Compound	Device A elimination/%	Device B elimination/%
Geosmin	86	88
2-Methylisoborneol	85	86
2,4,6-Trichloroanisole	89	94

### **BTX**

Benzene, toluene and the xylenes are low-molecular-weight aromatic compounds. All of them have been found in drinking water. In particular, benzene is hazardous and should not be present in drinking water. The efficiency of the apparatuses to eliminate BTX is shown in Table IV.

**Table IV. Elimination of BTX during water treatment.**

Compound	Device A elimination/%	Device B elimination/%
Benzene	92	86
Toluene	79	81
Xylene	92	91

### Chlorination by-products

Haloforms are formed upon disinfection of water with active chlorine species. The most frequent haloform is usually chloroform. When water with high concentration of bromide ions is chlorinated, active bromine is formed. The result is an increase in brominated organic compounds. The results are shown in Table V.

Another very common chlorination by-product is 2,4,6-trichlorophenol. It is also a precursor of the odour-causing compound 2,4,6-trichloroanisole. In Table V the elimination of the trichlorophenol is shown.

**Table V. The elimination of 2,4,6-trichlorophenol and haloforms**

Compound	Device A elimination/%	Device B elimination/%
2,4,6-trichlorophenol	49	50
1,1,1-trichloroethane	99	>99,9
Chloroform	97	98
Trichloroethene	98	99
Bromodichloromethane	99	99
Dibromochloromethane	98	99
Tribromomethane	96	97
Carbon tetrachloride	99	99
Perchloroethylene	99	99

### Colour

Colour is one of the main consumer complaints regarding drinking water. It could be expected that the colour of a humic water would increase in intensity upon heating due to condensation reactions of the humic compounds. When measured with absorption spectroscopy the colour did not increase in intensity upon treatment.

### Pesticides

Pesticides have been reported in drinking water occasionally. In Table VI the effect of the elimination of pesticides is shown. The pesticides chosen in the test consist of a package of 29 different compounds, recommended by the National Food Administration for the analysis in drinking water. These compounds have relatively high water solubility.

**Table VI. Elimination of pesticides during water treatment.**

Compound	Device C elimination/%	Device D elimination/%
Atrazin	5	10
BAM (2,6-diklorbensamid)	0	0
Bentazon	11	11
Bitertanol	0	0
Cyanazin	0	0
Desetylatrazin	0	0
Desisopropylatrazin	28	17
2,4-Diklorfenoxisyra	0	0
Diklorprop	0	0
Dimetoat	65	64
Diuron	21	16
Etofumesat	0	0
Fenoxaprop	0	0
Hexazinon	0	0
Iprodion	46	0
Isoproturon	0	0
Kloridazon	0	0
Klorsulfuron	18	27
Kvinmerak	67	60
MCPA	0	0
Mecoprop	0	0
Metamitron	14	14
Metazaklor	0	0
Metribuzin	0	5
Metsulfuronmetyl	55	61
Simazin	0	0
Terbutylazin	11	28
Thifensulfuronmetyl	70	82
2,4,5-Triklorfenoxisyra	0	0

**Active chlorine**

Chlorine in active i.e. oxidised form is used during disinfection of drinking water. It is added at the water works in concentrations high enough to give a residual concentration for disinfection of the distribution system. It is, however, undesirable with high concentrations of active chlorine in drinking water.

**Table VII. Elimination of active chlorine during water treatment.**

Compound	Device C elimination/%	Device D elimination/%
Total active chlorine	>90	>90

*Comment: The numeral >90% is due to the high detection limit of the method (0,1 mg/l). Probably, the reduction of active chlorine is very close to 100%.*

### Hydrogen sulphide

Hydrogen sulphide may cause taste and odour problems with ground-water based drinking water. The effect of treatment is shown in Table VIII.

**Table VIII. Elimination of hydrogen sulphide during water treatment.**

Compound	Device C elimination/%	Device D elimination/%
Hydrogen sulphide	96	93

### Radon

Radon is a threat to human health in many areas with radon in the ground-water. The effect of treatment is shown in Table IX.

**Table IX. Elimination of radon during water treatment.**

Compound	Device C elimination/%	Device D elimination/%
Radon	>99,5	>99,5

### Micro-organisms

When consumers are subjected to acute illness due to drinking water quality it is most often caused by micro-organisms. The effect upon treatment is shown in Table X.

**Table X. Elimination of active micro-organisms during water treatment.**

Compound	Device C elimination/%	Device D elimination/%
Heterotrophic bacteria	>99	>99
Coliformic bacteria	>99	>99
E. Coli	>95	>95

*Comment: The numeral >95% is due to a low starting concentration of E.coli bacteria. Probably, the reduction of E.coli is very close to 100%.*

### Conclusions

Upon treatment a large number of undesirable compounds present in the water were eliminated. Although the amount of water decreased only marginally, the concentrations of a number of organic compounds, with much higher boiling points, decreased substantially. The characteristics responsible for the elimination of chemicals seemed to be (i) volatility and (ii) hydrophobicity. As can be seen from Table III, the hydrophobic compound 1-chlorooctane

(b.p. 203 °C), was eliminated to more than 99 %. The less volatile 1-hexanol (b.p. 158 °C) was eliminated to 75 % and water was reduced by less than 5 %.

The effect on odorous compounds was between 85 and 95 %. Similar results were obtained for the more volatile BTX-compounds.

The gaseous compounds chlorine, hydrogen sulphide and radon were almost completely removed and the effect on micro-organisms was also quantitative.

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