How to Protect Water Distribution Online - Results using Extremely Hazardous Chemicals

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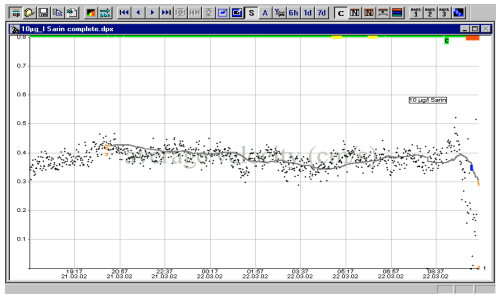
Abstract

The safety of water supplies for civilian and military organisations is an important objective to avoid toxic contamination of civilians and soldiers. Chemical warfare (CW) agents and especially organophosphorous nerve compounds are the most toxic of known chemical agents. A continuously working test system with Daphnia magna as a sensitive organism is used to monitoring drinking water. Both small doses (allowable for short-term water ingestion) and graduated higher concentrations induced toxic reactions leading to alarms in the Daphnia Toximeter System. The system is sensitive to a wide range of CW-agents and their toxic hydrolysis products. Concentrations which are below acute human toxicity could be discovered in a very short time with the actual time depending on the applied concentrations. In every case alarms occur within two hours at concentrations which are considered allowable for drinking water in exceptional conditions.

The Measurement

The graph (to the right) displays an example of Daphnia behavior. The 'median speed' shows strong deviation from former behavior after the addition of the neurotoxin 'Sarin'. Depending on the concentration, a typical effect of neurotoxins is that the movements strongly increase right after the treatment. The effect in this study is reversed after some minutes. Most of the Daphnia will die later. The alarm occurs 25 minutes after the start of the treatment. Other parameters, not on display here, such as height and curviness are involved in the release of the alarm.



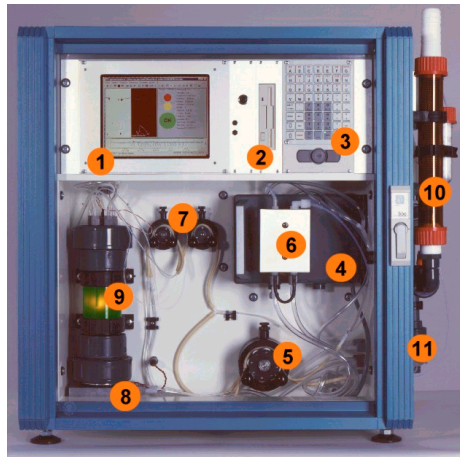
The Organism

The Results

The table (right) shows the tested substances, the concentrations and the reaction times using the bbe Daphnia Toximeter as a sensor. The evaluation of behavioral parameters drastically reduces the time interval between toxification and alarm.

Toxic Effects of CW-Agents in a Daphnia- Toximeter-System

Substance	Dose: µg / l water	Increasing motion indicating a toxic reaction: time interval:	50% inactive time interval:	100% inactive time interval:
Sarin (GB)	100		2min	4min
Allowable:	50		3min	8min
0.02 mg/Individual	25		27min	64min
	10	25min	120min	360min
Soman (GD)	64	22min	38min	47min
Allowable:	32	69min	82min	114min
0.02 mg/Individual	6,4	80min	270min	330min
Tabun (GA)	141	18min	24min	31min
Allowable:	71	45min	66min	85min
0.02 mg/Individual	35,5	55min	65min	99min
Cyclosarin (GF)	240	15min	20min	25min
Allowable:	120	16min	20min	26min
0.02 mg/Individual	60	34min	52min	65min



The Instrument

A CCD camera takes pictures of the measuring chamber (chamber is covered by the door (4)). The behavior of the daphnia gives information about the quality of the water (and above all, a warning if toxic substances are present). For this reason, it is necessary to determine whether the daphnia behave in an unusual way or not. Various parameters are suitable to characterise movements. The following parameters are calculated with the help of the daphnia traces and used to evaluate alarm conditions: median speed, speed distribution, velocity class, height, distance between daphnia, number of moving daphnia and fractional dimension.
The instrument consists of the housing, an industrial PC ((1),(2),(3)), monitoring chamber in a protective door (4), sample pump (5), water conditioning system (6) and automatic food supply ((7), (8), (9)). Not shown is the pre-filtering system and the dechlorination system.

Conclusions

- **Daphnia react very sensitively to the neurotoxins Sarin, Tabun, Soman and Cyclosarin**
- **Daphnia react at concentration levels which are below the 'allowable' concentrations**
- **The bbe Daphnia Toximeter can detect these concentrations**
- **The evaluation of behavioral changes leads to much earlier alarms than the simple distinction between 'active' and 'not active'**