

Solar disinfection of drinking water (SODIS): Chemical risk assessment

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BACKGROUND

What is SODIS?

SODIS (solar water disinfection) [1] is a simple water treatment method relying on solar UV-A radiation and temperature to inactivate pathogens that cause diarrhea. SODIS is gaining worldwide significance in areas where people do not have access to safe drinking water.

Water to be treated is filled into used transparent PET (polyethylene terephthalate) bottles and exposed to full sunlight for six hours.

Two synergistic mechanisms are involved in the treatment of water by sunlight: UV-A radiation (wavelength 320 - 400 nm) and elevated water temperature.

SODIS is more efficient in water containing high levels of oxygen. Saturation of the water with oxygen can be achieved by filling the bottles to three quarters and shaking them for about 20 seconds before they are filled completely.



Contamination of water by migration of plasticizers?

Recent publicity on a possible cancer risk from plasticizers migrating from PET into the water [2] was the trigger for the present investigation.

OBJECTIVE

Risk assessment of organic components migrating from PET into water

Characterization of organic components leaching from PET into water upon SODIS treatment.

Quantification of plasticizers di(2-ethylhexyl) adipate (DEHA) and di(2-ethylhexyl) phthalate (DEHP).

Risk assessment of DEHA, DEHP, and other critical organic components possibly present.

METHODS

Samples

PET bottles used for SODIS treatment during 6 months in Honduras, Nepal and Switzerland, as well as new PET bottles were rinsed and filled with analytical-grade water. A total of 15 bottles was investigated:

- 6 bottles were exposed to sunlight at 60 °C.
- 6 bottles were exposed to sunlight at ambient temperature (corresponding maximum water temperature 34 °C).
- 3 bottles were kept in the shade at room temperature (25 °C) for two consecutive days.

Total time of exposure to sunlight was 17 hours. Controls consisted of analytical-grade water stored in glass flasks.

Analysis

After addition of the internal standard (0.5 µg ¹³C₆-DEHA and 2.5 µg ²H₄-DEHP), 100 mL aliquots were extracted with 1 mL *n*-hexane.

The extracts were analyzed by GC/high resolution MS SIM analysis (mass resolution 10'000) in positive ion mode. For full-scan GC/MS analysis (mass resolution 1'000), an aliquot of 500 µL was reduced in volume to 20 µL.

RESULTS

Qualitative analysis

Qualitative analysis of the water samples revealed traces of several organic compounds (e.g. limonene) possibly due to flavor components of the originally bottled beverages. Above a detection limit of 1 µg/L, no further organic components could be detected.

Concentrations of DEHA and DEHP

	DEHA [µg/L]	DEHP [µg/L]
Exposure:		
sun (water temperature 60 °C)	0.027 ± 0.014	0.36 ± 0.21
sun (ambient temperature)	0.019 ± 0.0054	0.26 ± 0.10
shade (room temperature)	0.020 ± 0.0045	0.19 ± 0.053
Age:		
new bottles	0.021 ± 0.012	0.34 ± 0.22
used bottles	0.023 ± 0.0092	0.25 ± 0.10
Country of origin:		
Honduras	0.032 ± 0.011	0.29 ± 0.062
Nepal	0.016 ± 0.0036	0.39 ± 0.21
Switzerland	0.018 ± 0.0046	0.17 ± 0.074
Control (glass bottles):	0.018 ± 0.0032	0.11 ± 0.031

Correlations

Exposure: Average levels of DEHA and DEHP in water from bottles exposed to sunlight and heated to 60 °C are slightly elevated compared to bottles exposed to sunlight without additional heating and to bottles kept in the shade. No significant difference is seen between bottles exposed to sunlight at ambient temperature and bottles kept in the shade.

Age: No significant difference between new and used bottles.

Country of Origin: DEHA levels in water from Honduras bottles are slightly higher than the levels in the remaining samples. No differences were found for the respective DEHP levels.

RISK ASSESSMENT

Assumptions and procedure

Except for DEHA and DEHP, no other critical organic components could be detected.

In the toxicological risk assessment, a worst case situation is assumed:

- It is based on the highest detected levels of DEHA and DEHP.
- Permanent use of drinking water containing these levels is assumed.

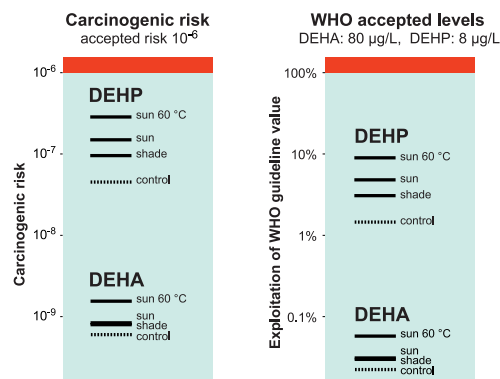
The risk assessment is based on toxicological data for chronic exposure to DEHA and DEHP [3, 4]. These data are based on a daily *per capita* consumption of 2 litres of drinking water by a person weighing 60 kg.

Health risk of DEHA and DEHP

Toxicological risk based on maximum concentrations (water from bottles exposed to sunlight, water temperature 60 °C):

	DEHA	DEHP
Maximum concentration [µg/L]	0.046	0.71
Drinking water unit risk per µg/L	3.4 · 10 ⁻⁸	4.0 · 10 ⁻⁷
Carcinogenic risk	1.6 · 10 ⁻⁹	2.8 · 10 ⁻⁷
WHO Guideline value [µg/L]	80	8
Exploitation of WHO Guideline value	0.0058%	8.9%

Toxicological risk posed by exposure to concentrations determined at various experimental conditions:



Summary

The traces of the plasticizers DEHA and DEHP leaching from PET bottles upon SODIS (solar water disinfection) treatment do not pose a significant cancer risk and are below the respective limits for drinking water fixed by the WHO.

REFERENCES, LINKS

- <http://www.sodis.ch>
- Re-using water bottles may be a health risk. Source Weekly no. 5-6, 10 February 2003 (<http://www.irc.nl/source/issue.php/165>).
- EPA Integrated Risk Information System, U.S. Environmental Protection Agency, 1994.
- WHO Guidelines for drinking water quality, World Health Organization, Geneva, 1993.