The Effect of Solar Irradiation on the Removal of Humic Substances from Water

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Introduction

Humic substances (HS) are a mixture of organic compounds that occur ubiquitously in fresh water. They affect potable water quality as they:

- cause color, taste and odour problems.
- react with chlorine to form carcinogenic disinfection by-products (DBPs).
- lower the efficiency of treatment processes.

Recent data have shown that the biggest proportional increase of HS has occurred in UK. Conventional water treatment processes can not efficiently remove HS. The advanced oxidation processes may produce unexpected by-products and are normally high-cost. Therefore, there is a need for cost-effective technologies to support conventional processes to breakdown HS so as to further cut the forming potential of DBPs.

The aims of the experiment are:

- to investigate the effect of solar irradiation on the reduction of HS from water in winter.

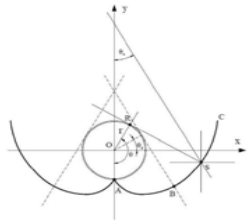
- to assess three solar concentrators (compound parabolic and parabolic ones) performance on the HS removal.

Methods

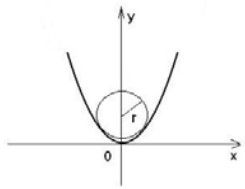
A B C D

Container: 1L PET bottle
Location: Roof of the Chadwick Building, UCL
Duration: 4 weeks (average daily solar Intensity: 26-330 W/m^2)
A – bigger parabolic solar collector (W:40cm, H:32cm)
B – compound parabolic solar collector (W: 25cm, H:10cm)
C – parabolic solar collector (W:25cm, H:10cm)
D – CS300 pyranometer

Solar Concentrators



Compound parabolic concentrator - in the special case $\theta_a=90^\circ$, and AC is an ordinary involute, concentrator can collect both direct and diffuse sunlight. Aperture a=2 π r.



Parabolic concentrator – the parallel sunlight is concentrated on the bottle center (the focal point of parabola). Equation: $x^2=4yr$

Results

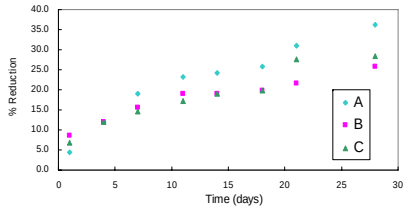


Fig. 1 Reduction in UV_{254} absorbance of humic samples (initial UV_{254}=0.116). Highest UV reduction was achieved with A. The reason is larger area can collect and concentrate more sunlight on the samples, leading to more humic substances removal.

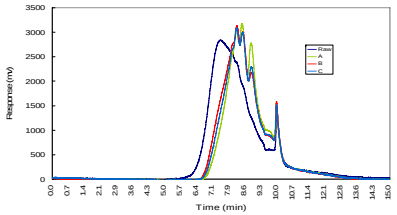


Fig. 2 High performance size exclusion chromatography (HPSEC) results for humic water before and after irradiation show that the high molecular fractions shifted to longer elution time, indicating a decrease in the molecular size after irradiation.

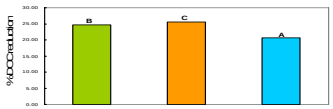


Fig. 3 Reduction in dissolved organic carbon (DOC) of humic samples after 4 weeks irradiation.

Conclusions

Even though these results were obtained in winter with low solar irradiation, it is obvious so far that
(i) solar irradiation can result in the molecular weight change and UV_{254} reduction of humic substances;
(ii) using low-cost solar collectors is feasible in humic removal and more removal can be achieved with larger reflecting surface.
More tests need to be done with varying humic water qualities and under stronger sunlight to understand the feasibility of this new method. Adsorption behaviour of humic substances after solar irradiation is also being investigated.

References
[1] Singer, P.C. (1999) Humic substances as precursors for potentially harmful disinfection by-products. Wat. Sci. Tech. 40, 25-30. [2] Zularisam, A.W., Ismail, A.F., Slaim, R. (2006) Behaviours of natural organic matter in membrane filtration for surface water treatment- a review. Desalination. 194, 211-231.
[3] Goslan, E.H., Gurses, F., Banks, J. and Parsons, S.A. (2006) An investigation into reservoir NOM reduction by UV photolysis and advanced oxidation processes. Chem. 65, 1113-1119. [4] Malato, S. (2004) Photocatalytic reactors for the treatment of liquid wastewater in the presence of solar irradiation.