*Proceedings of the 10th International Conference on Environmental Pollution, Treatment and Protection (ICEPTP 2025)*
*Barcelona, Spain - April, 2025*
*Paper No. ICEPTP 157*
*DOI: 10.11159/iceptp25.157*

# Characterizing VOC Emissions and Retention in Recovered Water during Solar Drying of Wastewater Sludge under Variable Conditions

**Lidia Nuño [1], Virginia Pérez [1], Luis Saúl Esteban [1], Nuria Ortuño[2], Adoración Carratalá[2]**
[1]Biomass unit, Ceder-Ciemat
E-42290 Lubia, Soria, Spain
Lidia.nuno@ciemat.es; Virginia.perez@ciemat.es; Luis.esteban@ciemat.es
[2]University Institute of Chemical Process Engineering, University of Alicante
E-03080 Alicante, Spain,
Nuria.Ortuno@ua.es; A.Carratala@ua.es

## Extended Abstract

Photochemical processes are a significant source of secondary organic aerosols (SOAs), many of which are water-soluble and remain in the condensed phase [1], [2], [3]. Water recovery from wastewater sludge is feasible, as previously discussed in this congress ("*Greenhouse Gas Emissions and Water Recovery in Solar Drying of Wastewater Sludge: Insights from LIFE-DRY4GASr*"). However, the characterization of VOC emissions during solar drying of wastewater sludge (WWS) under varying light intensities has not been explored. This study provides the first identification of VOCs emitted into the air and retained in water during laboratory-scale solar drying of WWS.

A laboratory-scale solar dryer with controllable heat sources was designed for this purpose. Experiments were conducted using two independent heat sources: artificial solar light and heated plates. Light intensities of 625 W, 400 W and 200 W corresponded to dryer temperatures of 50 ºC, 45 ºC and 35 ºC, respectively, while heated plates were set to 60 ºC, 50 ºC, 40 ºC, yielding internal dryer temperatures of 45 ºC, 37.8 ºC, and 28 ºC. To simulate the dryness levels achieved in the LIFE-DRY4GAS prototype [4], each experiment continued until the WWS weight decreased from 100 to 15 %.

VOC emissions during drying were measured in both the air and the recovered water. Airflow was directed sequentially through the sludge, water recovery system, and air emissions sampling setup. Hydrophobic VOCs were collected using two Tenax sorbent tubes in series. Recovered water was stored at varying pH levels to evaluate its influence on VOC retention. In one set of experiments, samples were preserved at their original pH (8-10) or acidified to pH 2. In another setup, the impingers were acidified with $H_2SO_4$ before condensation to maintain a pH of 2 throughout condensation. Recovered water was analysed by ion chromatography for $F^-$, $CH_3OO^-$, $HCOO^-$, $ClO_2^-$, $NO_2^-$, $NO_3^-$, $PO_4^{3-}$, $SO_4^{2-}$, and $C_2O_4^{2-}$. VOCs in water were further analysed using headspace solid-phase micro extraction (HS-SPME), while VOCs retained in Tenax tubes were identified using a thermal desorption system coupled to gas chromatography-mass spectrometry (TDS-GC-MS).

The results revealed that VOC emissions were higher when temperature increases were driven by artificial solar light compared to heated plates. The dominant chemical families included alkanes, non-oxygenated terpenes, and aromatic hydrocarbons. Recovered water showed acetate concentrations around 300 ppm, while other analytes remained below 1 ppm, consistent with results from the LIFE-DRY4GAS prototype. VOC analysis of recovered water indicated two predominant chemical families: carboxylic acids and aromatic hydrocarbons. Carboxylic acids were more concentrated at acidic pH, whereas aromatic hydrocarbons dominated at the original pH (8-9). Acidification of water after recovery increased the concentration of carboxylic acids, while pre-acidification of impingersresulted in greater VOC diversity, particularly esters. Aromatic compounds in water were primarily toluene and phenols, whereas the carboxylic acids identified included butanoic acid, propanoic acid, and pentatonic acid.

These findings demonstrate the interplay between temperature, light intensity, and pH in determining VOC emissions and their retention in recovered water, providing valuable insights for optimizing sustainable WWS drying processes.

## References

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