

Factsheet:

Adsorption with sludge-based renewable adsorbents

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Adsorption with sludge-based renewable adsorbents



Unique selling points:

- ✓ Reuse of by-products
- ✓ Low-cost carbonaceous adsorbent
- ✓ Monitoring system with online measure of COD (UV and Fluorescence), pH and conductivity
- ✓ Test for emerging contaminants

Description of the technology

Hydrochars are carbon-rich porous material obtained by hydrothermal carbonization (HTC) of feedstock materials. HTC is a thermochemical process that converts wet biomass into a value-added product (Kazak & Tor 2020). HTC has been applied to treat numerous typologies of biomass, such as green waste (Puccini et al. 2017), sunflower stem, walnut shell, olive stone, vinasse, red mud, rattan stalks, rice straw, argan nut, (Román et al. 2013, Kazak & Tor 2020, Zbair et al. 2020, Mohamed et al. 2017 and Islam et al. 2017) and waste and sludge produced in wastewater treatment plants (Kirschhöfer et al. 2016, Benstoem et al. 2018 and Tasca et al. 2020). It is underlined that in 2022, Italian national guidelines have been published (UNI 11853:2022) regarding the specifications of the material obtained from the hydrothermal carbonization (HTC) treatment of the residues of urban wastewater treatment plants or industrial sludge with an organic matrix.

One of the most promising applications for the reuse of hydrochars is the adsorption process. However, this recovered material to be performant in contaminant removal needs to be activated to increase pore size and surface area. In fact, the hydrocarbons usually suffer from a low specific area with BET surface area $< 10 \text{ m}^2 \text{ g}^{-1}$ (Chen et al. 2017). The activation of hydrochars can be achieved by two different methods, namely physical and chemical activation. During the physical activation, an activating agent (steam, carbon dioxide, air or a combination thereof) gasifies at elevated temperatures part of the carbon structure and creates porosities. In the chemical activation process, the feedstock is first impregnated with a reagent (KOH, ZnCl_2 , H_3PO_4 , K_2CO_3 , etc.) and then heated in an inert atmosphere (Miliotti et al. 2020). Hydrochar has been reported to have high adsorption capacities for heavy metals and polar/non-polar organic pollutants in aqueous solutions (Kazak & Tor 2020, Puccini et al. 2017, Zbair et al. 2020, Benstoem et al. 2018).

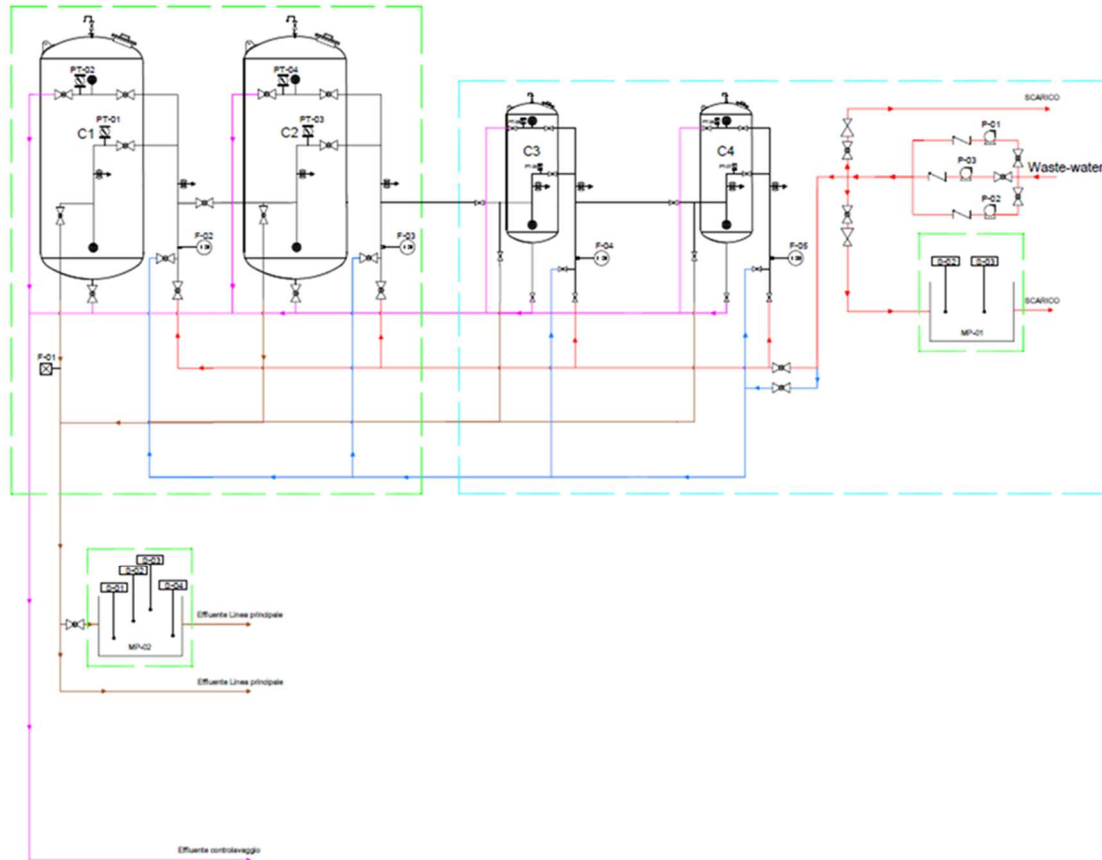
In ULTIMATE project, Hydrochar produced by hydrothermal carbonization of sewage sludge of municipal wastewater treatment plants (WWTP) will be utilized to remove COD and emerging contaminants. The pilot will be instrumented with online meters for the monitoring of pH, conductivity and COD (in this case fluorescence and UV absorbance at 254 nm will be used as surrogate parameters). The pilot will be composed of four adsorption columns of





different dimensions. The Hydrochar has been activated through a slow pyrolysis process at a temperature of 450°C with a residence time of 90 min.

Flow scheme of the technology



Pictures of the technology and product



Synergetic effects and motivation for the implementation of the technology

- ✓ Recovery of by-products





In the scientific literature, hydrochar has been proposed as a low-cost carbonaceous adsorbent for pollutants removal from water (Kazak & Tor 2020). The reutilization of hydrochar produced from sewage sludge will increase the circularity of the wastewater treatment process reducing costs and produced wastes.

✓ Monitoring system

In the design of the pilot specific attention was given to the monitoring system. Different sensors will be installed along with a control unit in order to allow a real-time monitoring of the adsorption process.

Requirements of the technology and operating conditions

The adsorption columns have been designed in order to have an Empty Bed Contact Time in the range of 5-30 minutes and a hydraulic loading rate of 5-15 m/h.

Tab. 1 Typical ranges for operating parameters

Parameter	Units	Min	Max	Reference
EBCT	min	5	30	Metcalf & Eddy 2014
Hydraulic loading rate	m/h	10	6	Metcalf & Eddy 2014

Key performance indicators

Tab. 3 Key performance indicators

Parameter	Units	Value	References
Adsorption capacity compared to commercially available materials	%	TBD	
Reduced waste production	kg/ton	TBD	

Links to related topics and similar reference projects

Process/technologies	Reference

References

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Outlook

Case study specific information will be provided, when the results of the other work packages are available:

- Lessons learned from the case study
- Outcome of the assessments
- Legal and regulatory information concerning the whole value chain concerning the technology
- Business opportunities

