

AC MWW — the fourth treatment stage

Advanced polishing of municipal wastewater:
pharmaceutical residues, pesticides and other micropollutants.

Installed behind an existing plant — without rebuilding the line.

DANIEL-LM s.r.o. | AquaTech NorthBohemia Division

What passes through the plant

- Medicines people take are excreted and end up in the sewer. The plant does not break them down.
- The biological stage was designed for organic load, nitrogen and phosphorus — not for substances present at billionths of a gram per litre.
- Hormones, pesticides and residues from households and industry travel the same route.
- Water that meets current limits is not the same as water free of trace substances.

The risk is passed to the receiving water and further into the ecosystem — and where water is reused, it comes back to people.



Why this matters now

1. Where fresh water is limited, the plant outflow is the most reliable local source available. Its quality decides whether it can go to irrigation, industry or aquifer recharge.
2. Spent activated carbon normally has to be shipped to a reactivation furnace, often abroad. On-site regeneration removes that dependency.
3. The European Union has made this stage mandatory under Directive 2024/3019, phased by plant size. Other regions increasingly benchmark against the same criteria.
4. The investment is decided once. The cost per cubic metre is paid for the lifetime of the plant.

This is not a technical detail. It is a capital decision with a fixed horizon.

Where it fits in the line

Pre-treatment → activated sludge → tertiary stage → AC MWW module → controlled discharge or reuse

- The module is installed after the existing tertiary stage. The line is not rebuilt.
- Modular configuration by flow rate (m^3/h , l/s).
- During service the module runs in bypass and the plant keeps operating.
- Individual process units can be omitted where they are not needed.

Three layers. The middle one is optional.

A — Intensified biology:

selected probiotic cultures dosed directly into the aeration tank.

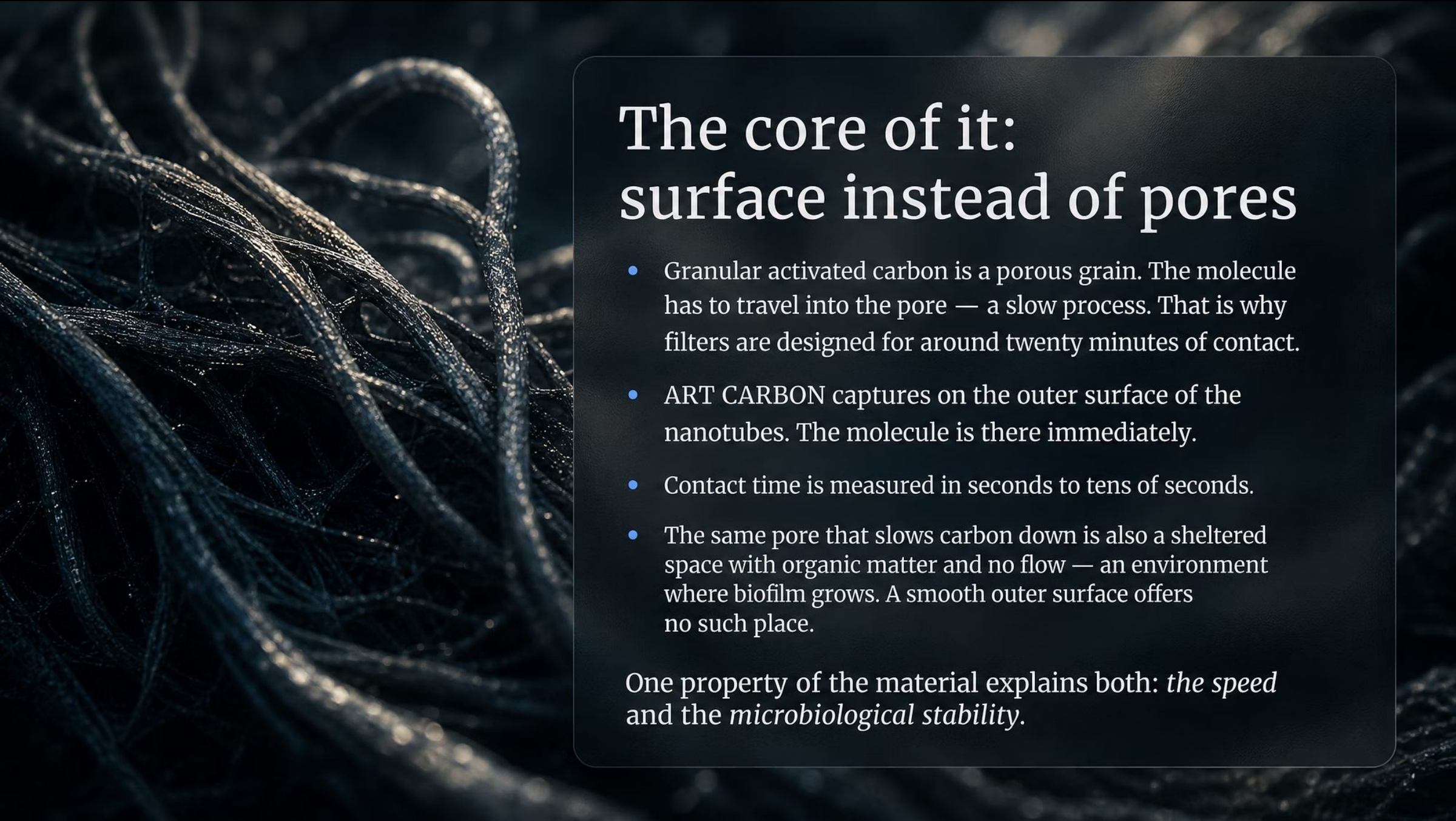
B — Ceramic ultrafiltration:

a barrier for undissolved solids. Optional stage.

C — ART CARBON®:

capture of micropollutants and on-site regeneration.

The technology adapts to the plant, not the other way round. Layer B can be left out where the biological effluent is clean enough, or where a membrane system is already installed — which lowers the capital cost.



The core of it: surface instead of pores

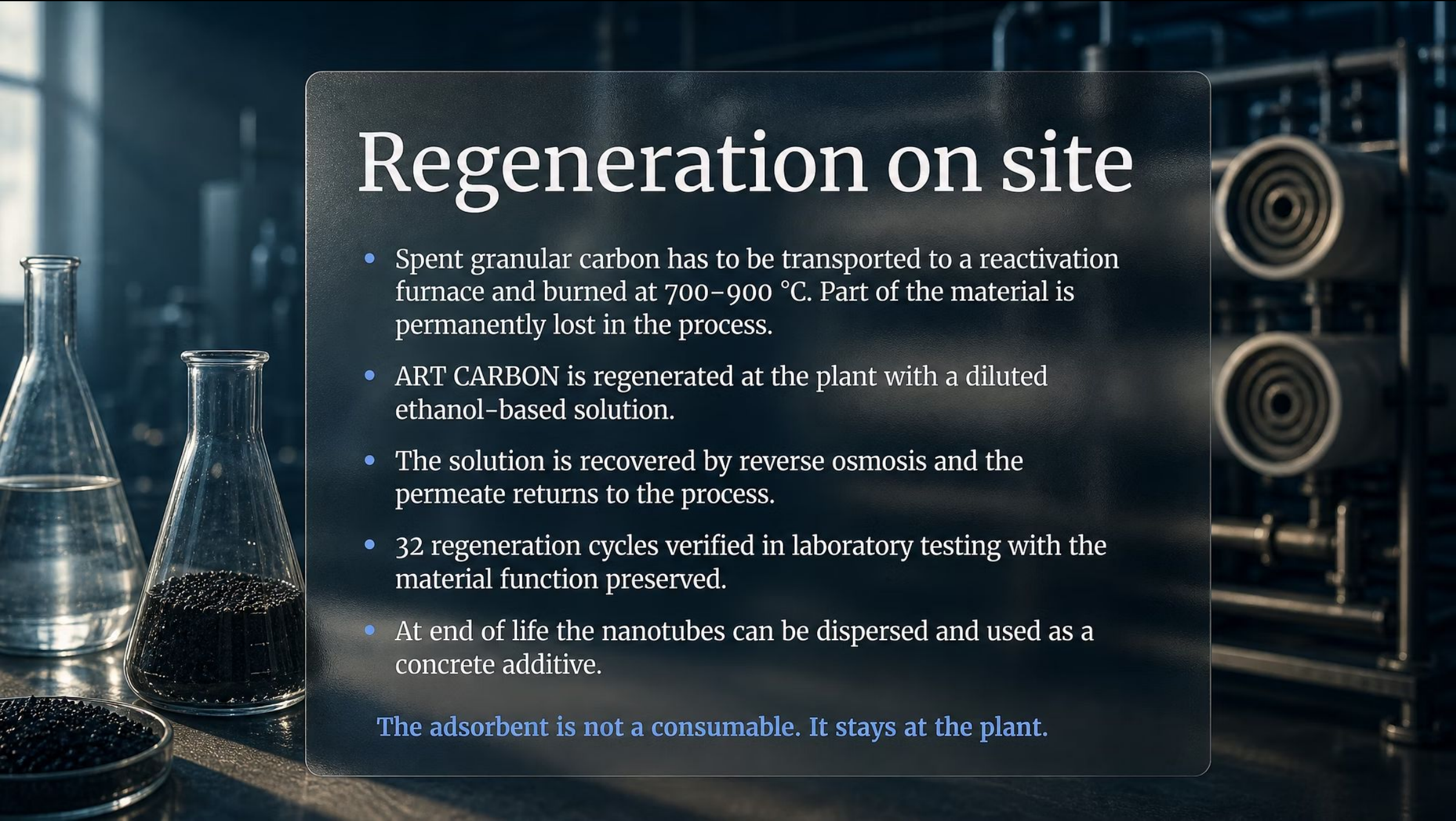
- Granular activated carbon is a porous grain. The molecule has to travel into the pore — a slow process. That is why filters are designed for around twenty minutes of contact.
- ART CARBON captures on the outer surface of the nanotubes. The molecule is there immediately.
- Contact time is measured in seconds to tens of seconds.
- The same pore that slows carbon down is also a sheltered space with organic matter and no flow — an environment where biofilm grows. A smooth outer surface offers no such place.

One property of the material explains both: *the speed and the microbiological stability.*

What this means for footprint and civil works

- Shorter contact time means smaller tank volume.
- The adsorption stage is an order of magnitude smaller than a conventional filter bed.
- It fits onto an existing site as equipment, not as construction.
- Smaller volume means lower capital cost and a shorter build.



The background of the slide features a dark, moody photograph. On the left, there are two Erlenmeyer flasks on a reflective surface. The flask in the foreground is partially filled with a black granular substance, while the one behind it contains a clear liquid. In the bottom left corner, a petri dish also holds some of the black granules. On the right side, the background shows out-of-focus industrial machinery, including what appears to be a large cylindrical tank or reactor with concentric circles on its front, and various pipes and structural elements.

Regeneration on site

- Spent granular carbon has to be transported to a reactivation furnace and burned at 700–900 °C. Part of the material is permanently lost in the process.
- ART CARBON is regenerated at the plant with a diluted ethanol-based solution.
- The solution is recovered by reverse osmosis and the permeate returns to the process.
- 32 regeneration cycles verified in laboratory testing with the material function preserved.
- At end of life the nanotubes can be dispersed and used as a concrete additive.

The adsorbent is not a consumable. It stays at the plant.

Pharmaceutical residues: 35 of 37

Thirty-seven active pharmaceutical substances were identified in the sample. Thirty-five of them were completely removed after filtration.

Column testing on a wastewater sample from the central treatment plant in Prague.

This is a single test. The result does not transfer automatically to other water types; performance for a given plant is confirmed by pilot testing.

Source: Internal laboratory report, May 2024



Microbiology and viruses

- E. coli: 100 → 0 MPN/100 ml
- Coliform bacteria: 20,050 → 12 MPN/100 ml
- Colony counts: $>10^6$ → 2,200 CFU/ml at 36 °C and 2,000 CFU/ml at 22 °C
- Rotavirus A: 8×10^6 particles/ml at the inlet, 0 at the outlet

Microbiological protocol: University of Chemistry and Technology, Prague, 2022.

Virological analysis: Institute of Virology, Faculty of Medicine, Masaryk University Brno.

The material does not feed bacteria and does not form biofilm — so the stage does not become a secondary source of contamination.

COD across the full line

Biological effluent —	45.0 mg/l
After intensified biology —	15.0 mg/l
After ceramic ultrafiltration —	10.0 mg/l
After adsorption —	1.0 mg/l

These figures come from a model balance of one specific tested configuration. For a given plant the values are confirmed by pilot testing.

Operating cost

In the order of € 0.12 per cubic metre of treated water.

- Electricity: 0.10 kWh/m^3 for ultrafiltration + 0.50 kWh/m^3 for pumping
- Chemicals and regeneration, regenerate recycling, concentrate handling and nanotube replacement: roughly € $0.04/\text{m}^3$ combined
- The energy share depends on the local electricity tariff
- No transport of spent adsorbent, no reactivation furnace, no import logistics

Indicative calculation of direct production costs. Service, maintenance and operating labour are not included — they are added according to the specific configuration and operating conditions.



Comparison of available routes



Ozonation

Contact time: approx. 10 minutes

Post-treatment: yes, biological

Regeneration: —

By-products: bromate, transformation products



Granular carbon

Contact time: approx. 20 minutes

Post-treatment: no

Regeneration: off site, 700–900 °C, with material loss

By-products: no



AC MWW

Contact time: seconds to tens of seconds

Post-treatment: no

Regeneration: on site, wash + reverse osmosis

By-products: no

Swiss full-scale plants, where the quaternary stage has been mandatory since 2016, achieve annual removal of 75–90 % against a legal requirement of 80 % for twelve indicator substances.

How a project runs

1. Technical and operational audit: water analysis, hydraulics, targets
2. Configuration options and integration into the existing line
3. Outline CAPEX and OPEX, schedule
4. Pilot verification and laboratory monitoring
5. Installation, trial operation, handover

The first two steps are offered as a non-binding assessment with no contractual commitment.





What we need from you

1. Analysis of the plant effluent
2. Capacity in population equivalents and flow rates
3. Description of the existing treatment line
4. Discharge requirements or the intended use of the treated water
5. Available space and hydraulic conditions

On that basis we prepare a configuration proposal and outline economics.

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This document is a public presentation of the technology. It is not design documentation and not a guarantee of performance for every type of water. A specific design requires a water analysis and a project assessment.

Annex 1 — Mass balance

Waste streams per 1 m³ of treated water:

- Nanotube dose: 0.3 kg — circulates, is not consumed
- Regenerating agent: < 0.2 l — recycled
- Concentrate with regenerate recycling: 0.2 dl
- Concentrate without regenerate recycling: 2 dl

The concentrate volume depends on whether reverse-osmosis regenerate recycling is included. We state both variants deliberately.

Annex 2 — Adsorption layer configurations

Parallel columns: A pair of columns with valve switching. One is always in operation while the other is regenerated — the line never stops. Suited to stable flow and available plant room.

Slurry adsorption on a ceramic filter: Nanotubes are dosed into an adsorption channel with a static mixer and separated on the membrane unit. Suited to higher and fluctuating flows.

Ceramic ultrafiltration: silicon carbide, pore size approx. 0.1 µm, energy demand 40–80 W/m³, service life up to two decades depending on configuration. Operation monitored via TMP / ΔP; captured sludge returns to the aerobic part of the plant.

Annex 3 — Test conditions and protocols

- **Column testing:** wastewater sample from the central treatment plant in Prague. A single test, not generalizable to other water types.
- **Microbiological protocol:** University of Chemistry and Technology, Prague, 2022.
- **Virological analysis:** Institute of Virology, Faculty of Medicine, Masaryk University Brno.
- **COD balance:** model balance of one tested configuration.
- **Performance against PFAS and TFA** is determined substance by substance for the specific water; we state no general percentage.

Detailed analytical protocols, test conditions and supporting documentation are provided during technical project assessment.