Aquatic Pollutants

Reduction and Assessment of Antimicrobial Resistance and Emerging Pollutants in Natural-Based Water Treatment Systems (REWA)

REWA Pioneering Clean Water Materials

Developing Innovative Materials for Modern Water Problems

One Project, Multiple Approaches

Pollutants enter the environment throughout the water cycle. Industrial and agricultural activities contaminate surface water, affecting drinking water. Wastewater treatment plants (WWTPs) may not fully remove contaminants, leading to pollution and limiting wastewater reuse. The REWA project addresses multi-faceted exposure from contaminants of emerging concern (CECs), pathogens, and antimicrobial resistance (AMR) by developing natural **biosorbents, coagulants**, and **photocatalysts** to treat different types of waters (Figure 1).

Biosorbents & Their Benefits

Adsorbents based on biomass, or biosorbents, are a focus of much wastewater treatment research because they are cost-effective, biodegradable and environmentally friendly, making them suitable for implementation in different environments.

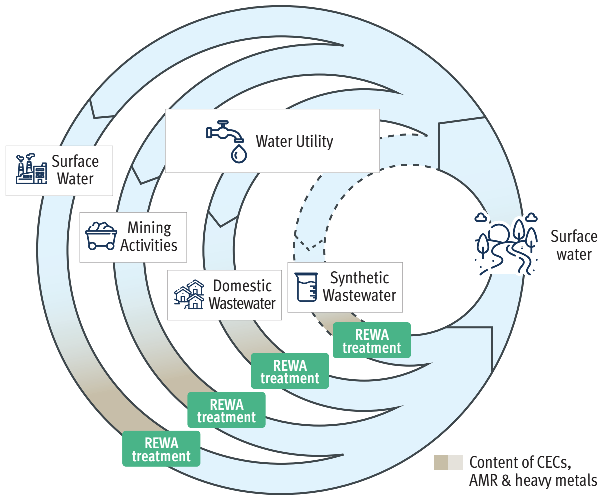


Figure 1. REWA removes CECs, AMR and heavy metals from surface water (including runoff from industrial and agricultural activities), mining wastewater, municipal wastewater effluent and synthetic wastewater, testing multiple materials in four case studies.

REWA for Domestic Wastewater Effluent Polishing

One REWA case study looks at **municipal wastewater effluent** at the Taskila WWTP in Oulu, Finland (University of Oulu). The effluent contained several pharmaceuticals, such as trimethoprim and levofloxacin. We tested the removal of these pharmaceuticals using a filter bed containing **magnetite pine bark (MPB) and biochar biosorbents** (Figure 2). The biosorbents were effective at removing a variety of pharmaceuticals to low concentrations or below the limit of detection (Figure 2, right). The effluent from the adsorption column was tested for biotoxicity, showing that the effluent was not toxic to *Nitrosomonas europaea*.

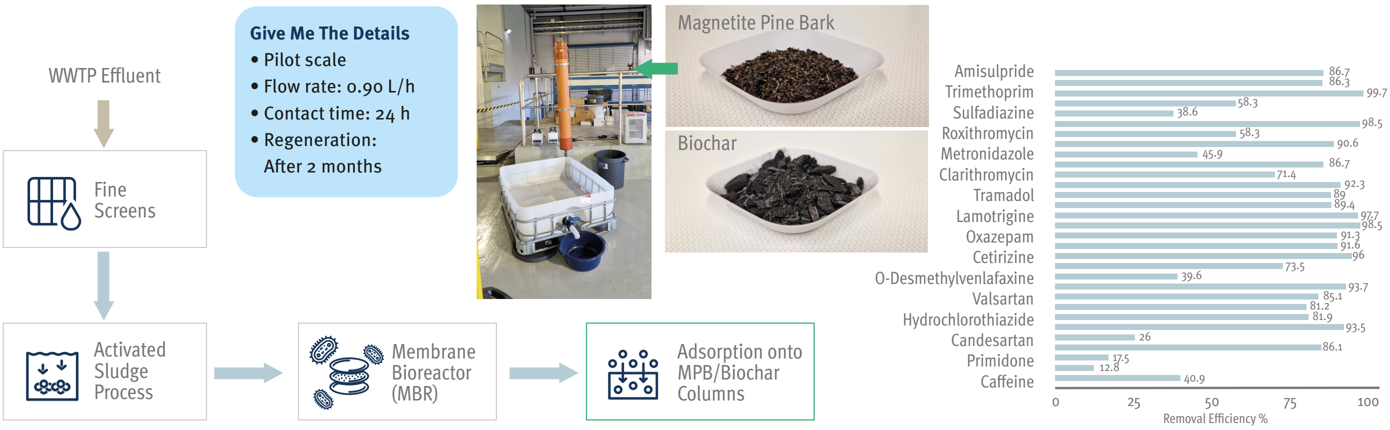


Figure 2: The setup of REWA's pilot plant at the Taskila WWTP. The filter bed containing the biosorbents can be seen in the orange column and treated water flows into the white basin. The overall removal efficiencies for the selected pharmaceuticals are shown in the graph on the right.

Every Challenge Is An Opportunity. Providing safe and sufficient drinking water is a major challenge in many countries. Today's water plants use treatment stages where each stage can be suboptimal. This complexity is challenging due to the system's reliance on various parameters. Moreover, solutions can conflict, such as chlorination creating hazardous contaminants.

Synthetic Wastewater, Real Application

In South Africa, REWA partner University of KwaZulu-Natal is also researching bio-based materials for the future treatment of **domestic wastewater** effluent. Using **synthetic wastewater** at the lab-scale, REWA tested the removal of CECs using 1) a composite composed of **biochar** from waste pine pallets and graphene oxide, 2) a composite derived from biochar from exotic plant material and graphene oxide, 3) tin vanadate-based photocatalysts, and 4) bismuth oxyhalide-based **photocatalysts**. Both classes of photocatalysts show good ability to remove CECs with visible light (degradation of 93%) and the percentage removal of CECs by the composites was greater than 80%.

Cleaning Up Mining Water

A third REWA case study examined the ability of **tannin-based biocoagulants** to remove the metal vanadium from **effluent from an abandoned vanadium mine** in Finland. We tested **quebracho tannin** sourced from Italy and **spruce tannin** from Finland (Figure 3). Tannin-based coagulants are effective over a wide pH range.

Steel's Hidden Cost

Vanadium is often used in steel production and its increasing global consumption poses problems for water pollution in mining regions. REWA is researching the toxicity of vanadium in mining water.

Across all tested pH values, the quebacho tannin coagulant achieved high turbidity and vanadium removals of more than 88%, while the spruce tannin variant showed lower removals of 70%, 46% and 39% at pH levels 4, 7.4 and 9, respectively. Results demonstrate the benefits of quebacho tannin as an alternative for iron sulphate coagulation which requires precise pH control.

Figure 3. Spruce bark (left) and tannin extract (right) developed by University of Oulu for use as biocoagulants.

Clean Water, Healthy Future?

The REWA materials aim to reduce levels of antibiotic resistance and improve water quality. To assess this, we are developing **comprehensive polyphasic microbiome-directed procedures** for testing both the risks and benefits of our treatment technologies already at bench scale (University of Copenhagen). We've conducted preliminary microbial tests for adsorbents, photocatalysts, and biocoagulants and found that the genus *Aeromonas spp.*, relevant for public health, are promising indicator organisms for assessing water quality and evaluating the impact of water treatment on reducing the environmental transfer of antibiotic resistance.

Knowledge Shared is Knowledge Gained

Dissemination of the proposed systems at the local level might considerably improve water quality and reduce exposure to diseases, pollutants and other CECs. We have hosted workshops with local stakeholders in Israel and South Africa and organized an online training course for postgraduate students (Figure 5).

Water, Water, Everywhere

A fourth case study develops a new holistic concept for **surface water treatment**, including 3 modules with different objectives (Figure 4; Galilee Research Institute MIGAL).

The 1st module serves as preliminary treatment. **Clay-polymer nano-composites**, created from various combinations of minerals and polymers, were used to remove particulate matter from **surface water**, clarify **laundry effluent** for reuse and **industrial effluent**. Tests showed that nanocomposites were able to effectively remove total suspended solids (TSS) and turbidity, as well as remove ›95% of pathogens.

Ready for Take-Off

The nanocomposites tested in this case study can be found in 3 Israeli patents and are commercially available (TRL 9).

The 2nd module investigates photodegradation using ultraviolet (UV) light and **TiO_2-clay photocatalysts**, which matched the performance of commercial TiO_2 in some cases and were effective in mineralizing organic pollutants like bisphenol S, ofloxacin, and carbamazepine.

A 3rd module uses **adsorption matrices of clays, organoclays and nanocomposites.** Modified organoclays exhibited enhanced adsorption properties of bisphenol A, bisphenol S and carbamazepine.

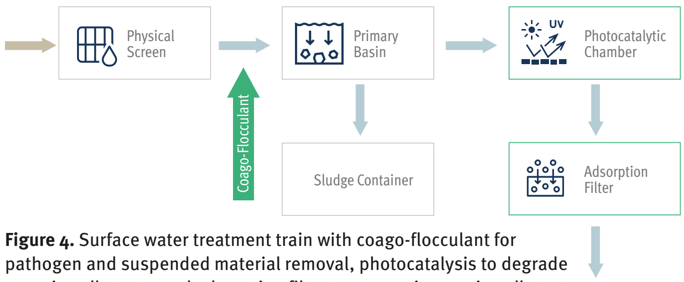
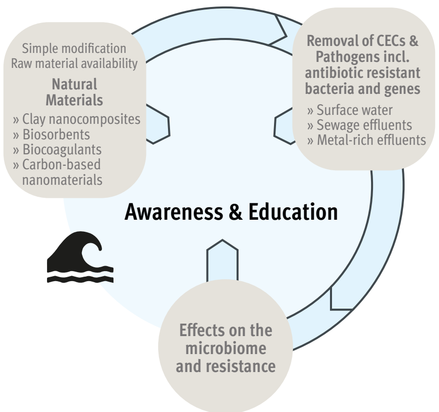


Figure 4. Surface water treatment train with coago-flocculant for pathogen and suspended material removal, photocatalysis to degrade organic pollutants, and adsorption filter to remove inorganic pollutants and remaining bacteria/viruses, organic residues and possible degradation by-products.



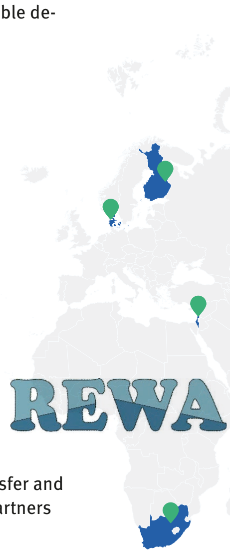


Figure 5. Left: REWA places a large focus on knowledge transfer and outreach to support uptake of our solutions. Right: REWA partners are located in Finland, Denmark, Israel and South Africa.

Collaboration

This factsheet was developed by AquaticPollutantsTransNet in collaboration with the REWA project as part of the Aquatic-Pollutants Cross-Cutting Issue #3 on "Mitigation Technologies for CECs and AMR".

aquatic-pollutants.eu

REWA

REWA Partners

1. University of Oulu, Finland (coordinator)
2. University of Copenhagen, Denmark
3. Galilee Research Institute - MIGAL, Israel
4. University of KwaZulu-Natal, South Africa

Funding

Water JPI · JPI Oceans · jpiamr Joint Programming Initiative on Antimicrobial Resistance

The AquaticPollutantsTransNet partners have received funding from the BMBF, the ANR and the SRC as part of the 2020 Transfer Project Call, which will be implemented as part of the ERA-NET Cofund AquaticPollutants of the Joint Programming Initiatives (JPIs) on Water, Oceans and Antimicrobial Resistance (AMR)