MULTISOURCE

USA – MSU – High Strength Wastewater

DESCRIPTION

The US pilot is specifically tailored for the treatment of high-strength domestic wastewater in a sub-freezing winter climate and is housed at the Bridger Bowl Ski Area, at 45.040 degrees N and an elevation of 1,960 meters. The ski area receives approximately 5 m of annual snowfall. The pilot receives clarified wastewater during the ski season, from December to April, with water temperatures of 2–4 °C. The pilot is a two-stage sub-surface vertical flow system with two parallel cells at each stage. The effluent of the second stage is recycled and independently applied to the first stage to facilitate complete nitrogen removal. Both stages were planted with two wetland plant species native to the northwestern United States, *Carex utriculata* (beaked sedge) and *Schoenoplectus acutus* (hardstem bulrush). The primary purpose of the partially saturated first stage is the removal of influent COD and the denitrification of nitrate recycled from the second stage effluent. The unsaturated second stage facilitates aerobic nitrification of influent ammonia to nitrate in the presence of low COD.

DESIGN AND TECHNICAL DETAILS

Type of influent

High-strength domestic wastewater from ski lodges including lavatories and kitchens

Design criteria

- Two-stage subsurface vertical flow system, 95 m^2 total
- First stage partially saturated to facilitate removal of NO_3^-
- The effluent of the second stage is recycled to the first stage to facilitate complete nitrogen removal
- Influent COD is between 600–900 mg COD L^{-1} and influent total nitrogen is between 150–200 mg N L^{-1}

Climatic conditions

The system operates during the winter ski season from December through April, when it is necessarily covered with snow and plants are dormant. The water temperature ranges from 2.5 – 5 °C

Operational constraints

- Winter conditions with snowpack on surface
- Freezing temperatures
- Seasonal operation

www.multisource.eu pilot2@multisource.eu

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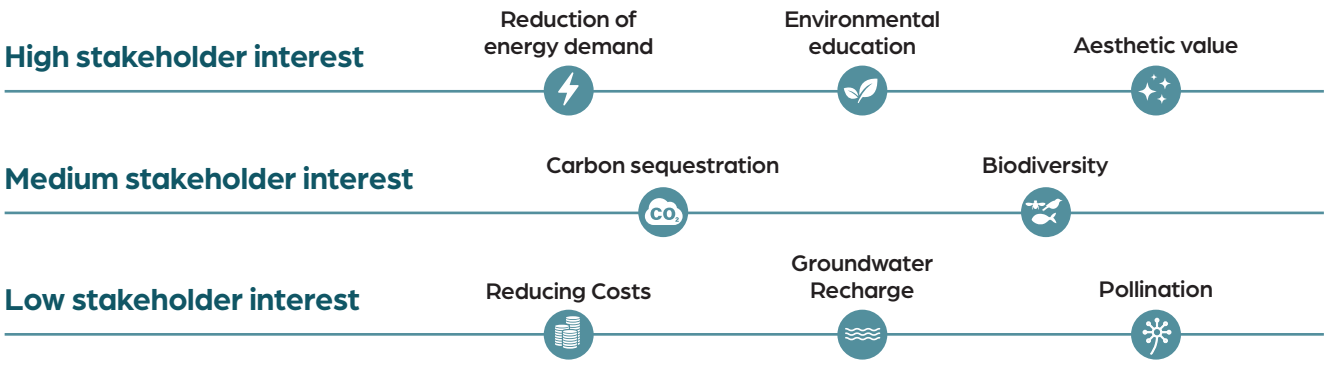
TREATMENT PERFORMANCES

- **Conventional Pollutants:** Overall COD removal was >95%, TN removal was >70%, and ammonia removal was >97%.
- **Organic Micropollutants:** Thiry-eight CECs were detected in the influent wastewater over the 2022-23 operational season. Caffeine and gabapentin had the highest average influent concentrations. Lamiotrigine, amoxicillan, and iopamidol also had relatively high concentrations in the raw influent.

  Six compounds detected in the influent were removed in the TW to levels below their detection limit: azithromycin, citalopram, clarithromycin, codeine T14, THC-COOH and trimethoprim.
- **Greenhouse Gases:** N2O, CH4 and CO2 emissions showed variable trends and emissions increased generally during dosing of wastewater onto the pilot. Emission factors were on the low end of measured GHG emissions for wastewater treatment processes.

CO-BENEFITS



RISK ASSESSMENT

Several chemicals exceeded their predicted no effect concentration in influent, mid-process and effluent (i.e. risk quotient>1). The risk drivers were solely **organic chemicals** (i.e. pharmaceuticals and caffeine).

The treatment efficiency was generally high with risk reduction from influent to effluent of **78.6%** (median).

However, the exceedance of risk threshold was still 2-3 orders of magnitude in the effluent, likely due to the high-strength nature of the wastewater.

CHALLENGES

The primary challenges with operating a TW for ski resort wastewater treatment are:

Seasonal operation – the system operates four months of the year and is thus limited with respect to opportunities for data collection

Cold weather and freezing impacts on equipment and operators – air temperatures can drop to -40 °C. While the snow provides insulation from freezing, equipment can still be impacted by the cold and operators cannot always safely monitor and collect samples.

LITERATURE

S.H. Ayotte, C.R. Allen, A. Parker, O.R. Stein, E.G. Lauchnor, Greenhouse gas production from an intermittently dosed cold-climate wastewater treatment wetland, Science of The Total Environment, Volume 924, 2024, 171484, https://doi.org/10.1016/j.scitotenv.2024.171484.

Stephanie H. Ayotte, Sarah J. Wallace, Christopher R. Allen, Kela P. Weber, Otto R. Stein, Ellen G. Lauchnor, Microbial community dynamics in a two-stage treatment wetland: Insights from treating seasonal ski resort wastewater, Bioresource Technology Reports, Volume 27, 2024, 101885, https://doi.org/10.1016/j.biteb.2024.101885.

Ayotte, S. H., Allen, C. R., Stein O. R., Lauchnor, E. G. Greenhouse emissions from a subalpine zone treatment wetland: Implications of mass transfer effects and sampling frequency. Submitted to Ecological Engineering.

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