# Industrial Water Detoxification with the Sunlight Enhanced Fenton Reaction


**Figure 1: Solar water treatment plant at DLR's Lampoldshausen site, Germany. (1: fluid system with recirculation tank, photocatalyst recycling system and storage tanks; 2: tubular receiver reactor )**

## Water Treatment with Fenton conditions

In contrast to semiconductor photocatalysis, solar water treatment with photo-Fenton conditions offers several advantages like enhanced degradation by photolysis of iron complexes, utilization of solar radiation up to 580 nm, beneficial effect of higher temperatures, no need for energy demanding turbulent flow as well as simple and energy effective photocatalyst separation and recovery. Due to this issues, a modular receiver reactor technology and an automatically operating treatment system were designed by DLR and its partners to realize solar water treatment applications at a relevant scale.

## Plant Design

In order to provide simple scalability, tubular receiver reactor modules were designed and several plants ranging from prototype to pilot and demonstration scale were established. The degradation kinetics were referred to collected solar energy (global or UVA insulation) per volume wastewater at defined hydrogen peroxide dosage and iron concentrations. The automatically operating fluid handling system of the demonstration plant comprises a detoxification loop for recirculating batch operation and an independently operating photocatalyst recycling loop.

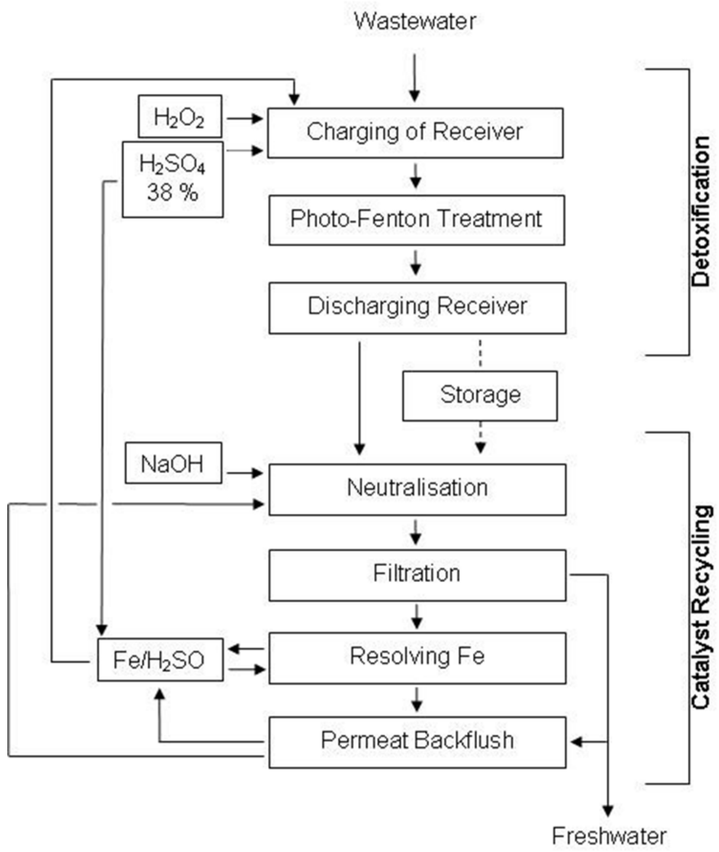


**Figure 2: Process design of the solar demonstration plant at Lampoldshausen.**

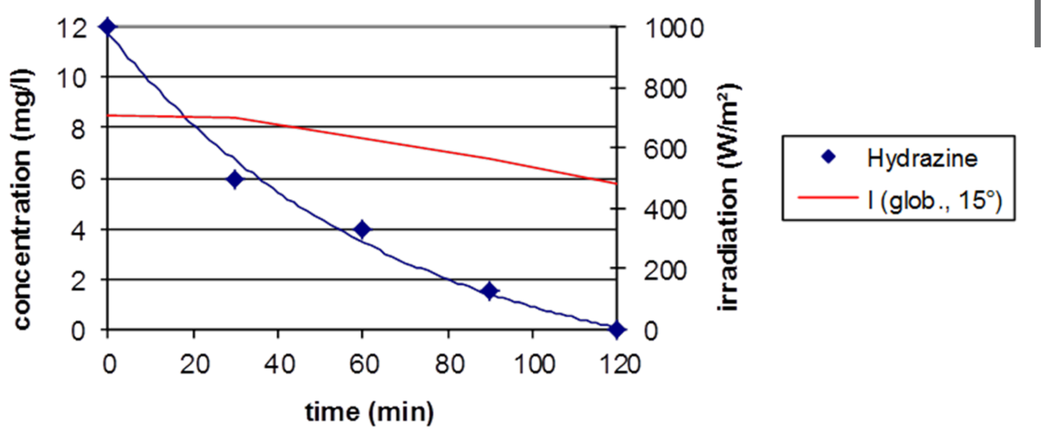


**Figure 3: Degradation of hydrazine with the Lampoldshausen plant.**

## Application at Real Scale Level

As a first full scale application, an automatically operating demonstration plant was established in 2010 at DLRs Lampoldshausen site for detoxification of cooling water from space propulsion tests. Hydrazine derivatives and nitrite are the main contaminants. Typical concentrations (< 3 mg/l) are degraded within 1-2 hours allowing for up to 5 batches of 4.5 m³ per day.

## Transfer and Outlook

The demonstration plant was mainly tested for the contaminants of the Lampoldshausen site. Additionally, the degradations of sulfamethoxazole and iopromide were also successfully tested with this system.
In order to estimate the capacity and application scope of the Lampoldshausen design at several sites and for different applications, solar degradation tests with a prototype plant at 150 L were performed at DLRs Cologne site. With these data and weather data from different locations, throughput estimations were performed.

**Table 1: Expected wastewater treatment capacities from solar prototype and demonstration tests with a Lampoldshausen plant size at different locations.**

| | MTBE (TOC, mg/L) | PCE mg/L | OECD sewage model (COD, mg/L) | Iopromide mg/L | Sulfamethoxazole mg/L | Caprolactam mg/L | (TOC, mg/L) |
|---|---|---|---|---|---|---|---|
| **initial** | 68 | 10 | 800 | 5 | 1.5 | 115 | 73 |
| **end** | 17 | 0.1 | 400 | 0.3 | 0.01 | 0.1 | 4 |
| **$Q_{glob}$ (Wh/l)** | 90 - 100 | 20 - 30 | 55 - 75 | 12 | 16 | 12 | 60 |
| **max. Capacity (m³/a)** | | | | | | | |
| **LA** | 1,200 – 1,300 | 3,900 – 5,800 | 1,500 – 2,100 | 9,700 | 7,300 | 9,700 | 1,900 |
| **Kourou** | 2,000 – 2,300 | 6,800 – 10,200 | 2,700 – 3,700 | 17,000 | 12,800 | 17,000 | 3,400 |
| **Las Cruces** | 2,400 – 2,600 | 7,900 – 11,900 | 3,200 – 4,300 | 19,800 | 14,800 | 19,800 | 4,000 |

As a result, plant sizes in the range of 250 m² receiver area seem to be suitable for small to medium wastewater quantities. Currently, commercial applications are expected in industrial processes or groundwater remediation tasks.

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