EPC-EqTech- An innovative turnkey solution to process spent caustic in the Oil&Gas industry
PROJECT: EPC-EqTech

TITLE: EPC-EqTech – an innovative turnkey solution to process spent caustic created in the Oil&Gas industry at low-cost and that meets wastewater regulations

PROJECT LOCATION: Kirikkale (Turkey)

FINANCING: H2020 – FTI- 2018 (79 % subsidized)

BUDGET: 3,296,650 € (2,604,317.5 € subsidized)

DURATION: 2 years (July 2021 – June 2023)

COORDINATING BENEFICIARY

ASSOCIATED BENEFICIARY(IES)
In the petrochemical industry, alkaline washing processes for oil product desulphurisation purposes result in spent alkaline solutions, known as *spent caustic*.

**Characteristics**
- High chemical oxygen demand (COD) → range of 20 g/L–300 g/L
- High hydrogen sulphide concentration → 3-5 g/L
- pH >11
- Hazardous odours
- Corrosive components
- Toxic volatile organic compounds

**Challenges**
- High environmental impact
- High processing cost
- Few approved local spent caustic disposal facilities
- Difficult to treat using conventional processes

**Disposal Options**
- Deep well injection
- Biological Treatment
- Incineration
- Wet air oxidation
- Disposal off-site

i) Difficult operation  
ii) Significantly cost prohibitive  
iii) Damaging to the environment  
iv) Inability to treat extremely hazardous materials
EPC-EqTech is an innovative electrochemical solution based on electro-peroxicoagulation (EPC) technique.

**MAIN ADVANTAGES**
- Environmentally compatible
- Hard COD removal (>80 %)
- Low CAPEX and OPEX
- Known regularity standards
- In-situ production of coagulant and floculant
- Scalable capability
- No secondary pollutants are generated

**MAIN DISADVANTAGE**
- Periodic replacement of (low-cost) sacrificial anodes
- **Pre-peroxidation**: With certain amount of $\text{H}_2\text{O}_2$ sulphides are oxidized to sulphates, and COD easily biodegradable is greatly reduced (50 %)
- **EPC**: In presence iron soluble species and hydroxyls radicals the hard COD and toxic pollutants are removed.
- **pH adjustment**: Reduce >85 % of toxicity
- **Flocculation/clarification**: Optional stage to remove iron as settleable matter and precipitable organic matter

**KPIs:**
- >80 % of COD Removal
- >85 % of sulphides Removal
- Plant life time >12-15 years
- End-user waste reduction 20 %

$\text{Fe}^{2+} + \text{H}_2\text{O}_2 \rightarrow \text{Fe}^{3+} + \text{OH}^-$

Organic matter + OH\(^-\) $\rightarrow$ CO\(_2\) + H\(_2\)O
Treated volume: 12 m$^3$/h (batch mode)

In each reactor there are 20 steel plates of 25x250x500 mm.
PHASE 1
WP1-Project co-ordination and management
WP2-System specification and materials selection
WP3- Pilot Plant construction

PHASE 2
WP4-Building and commissioning

PHASE 3
WP5- Field trials and certification
WP6- Exploitation and communication
For the plant design optimisation, the following aspects are evaluated:

- Operating conditions (bench scale)
- Gas treatment and venting optimization
- Reactor temperature optimization
**Operating conditions**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Raw spent caustic</th>
<th>Treated spent caustic</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>11.5</td>
<td>12</td>
</tr>
<tr>
<td>Conductivity (mS/cm)</td>
<td>223</td>
<td>230</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>67,000 ± 960</td>
<td>8,180 ± 750</td>
</tr>
<tr>
<td>Sulphides (mg/L)</td>
<td>3,340 ± 440</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>382 ± 35</td>
<td>23 ± 7</td>
</tr>
</tbody>
</table>

- >85% of COD removal
- >99% of sulphides removal

**BENCH SCALE CONDITIONS**

- **Pr-PX- 180 min**
  - 0.8 L, COD 67,000 ppm

- **EPC- 180 min** (ratio COD: H2O2: Fe = 1:1.5:0.15)
  - 0.8 L, COD 30,000 ppm

**Impact of biomass in WWTPi**

The treated spent caustic will be discharged upstream of the biological treatment. For this purpose, the impact on the biomass of the Biological Reactor was assessed by carrying out **Respirometry Tests**.

By adjusting the pH to 10.5-11.0 of the treated spent caustic and discharging the flow to 1 m³/h (FD 1:200) the biomass is not affected and does not lose activity.
Gas Treatment and Ventilation system

- $\text{H}_2$ is generated during the operation and is directly proportional to the amount of dissolved iron
- $\text{H}_2\text{S}$ only could be generated in the worst-case scenario where there is a pH mismatch and decrease below 7.

**Anodic reaction:** $\text{Fe} \rightarrow \text{Fe}^{2+} + 2e^-$

**Catodic reaction:** $2\text{H}_2\text{O} + 2e^- \rightarrow \text{H}_2 + 2\text{OH}^-$

During operation, $\text{H}_2$ and $\text{H}_2\text{S}$ shall be operated below the flammable limit (< 25 % LEL).

Therefore, the main reaction tank will be equipped with a chimney and a fan for the introduction of forced air to ventilate the pilot area. In addition, the pilot will be equipped with explosion sensors that if they detect gas, will trigger an alarm and shut down the system.

Reactor temperature optimisation

The reaction that occurs when oxidizing and breaking the organic matter chains is exothermic. To prevent the temperature from rising to dangerous limits and decreasing the efficiency of the process it is necessary to have a cooling system.

The cooling system must be able to dissipate all the heat generated during the process. Theoretical calculations and laboratory scale experiments determined that 2 heat exchangers were necessary.

The cooling system will allow to dissipate the energy generated during the reaction and maintain the temperature of the spent caustic stream at about 30-35 °C.
Actions foreseen

PHASE 1
WP1-Project co-ordination and management
WP2-System specification and materials selection
WP3- Pilot Plant construction

PHASE 2
September 2022
WP4-Building and commissioning

PHASE 3
WP5- Field trials and certification

WP6- Exploitation and communication
• EPC-EqTech solution has demonstrated technical viability to process spent caustic.
• The solution is environmentally compatible application suitable for all Oil&Gas downstream spent caustic wastes.
• EPC-EqTech solution has a lower CAPEX and OPEX compared with the actual disposal management.
• TRL 6 to TRL 8.
Research.
Collaboration.
Thinking forward.

Thanks to the organization for the opportunity to present the EPC-EqTech project in the 9th Conference on Sustainable Solid Waste Management

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