The application of electrocoagulation process as a method for pretreatment of wastewaters from gasification processes before their phytoremediation

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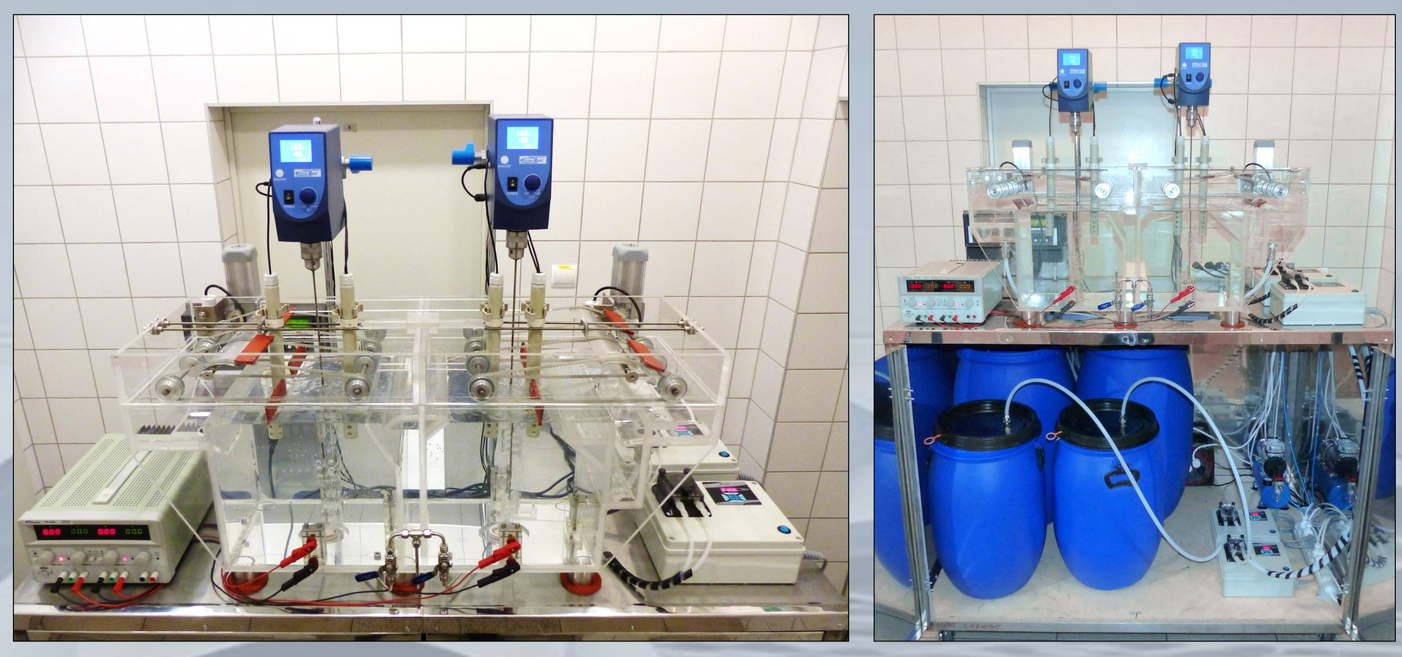

Figure 1: Pilot scale reactor for continuous electrocoagulation process

Abstract:

UCGWater+ is dedicated to the remediation of waters contaminated with a diverse range of organic and inorganic pollutants. Our research primarily targets wastewaters stemming from underground coal gasification (UCG), chosen as an effluent that has high levels of pollutants and is intrinsically complex to treat. Aligned with the Circular Economy paradigm of repurposing waste to resource, the project strives to develop methodologies transferable across various sectors and applications, particularly thermochemical processes using biomass as a primary feedstock.

This study aims to assess the efficacy of electrocoagulation as a pretreatment strategy for wastewater, preceding purification through phytoremediation in constructed wetlands.

Experimental set-up

Lab scale:

batch CSTR; V=2 dm^3; $A_{el.}$=20 cm^2; i_{max}=350 mA; V_{max}=15V

Pilot scale:

continuous CSTR; $\dot{V}$=2 dm^3; $A_{el.}$=790-2915 cm^2; i_{max}=6,5 A; V_{max}=15V

Electrode material:

Armco steel plate (<99.5% Fe grade 04 J according to PN 89/H-84023/02

Power supply:

Twintex TP-2305 (30V DC, 2x5A) or Elektro-Automaik GmbH & Co. KG PS8080-60 T 1500W (80V DC, 60A).

Method

Laboratory scale – screening of process conditions:

Determination of the influence of **iron dissolution rate** (current vs time) and **pH**. Optimization of the process regarding the efficiency of removal of phenols (phenolic index, PI), sulphides, cyanides, heavy metals, and BTX.

Pilot scale - validation and optimization of reactor design:

Three reactor set-ups were tested to optimize the performance of a continuous electrocoagulation process.

Analytical methods:

COD, PI, CN^-_{free}, S^{2-} – **spectrophotometry**; Al, As, Cd, Co, Cu, Cr, Fe, Mn, Mo, Ni, Pb, Sb, Ti and Zn – **ICP-OES** + microwave mineralization; BTX – **GC-FID**.

Conclusions and remarks

In **UCGWater+**, electrocoagulation was applied to remove from the effluents from underground coal gasification processes potentially toxic substances that could hinder the subsequent phytoremediation process. However, this method can be utilised for treatment of a wide array of contaminants such as fats, waxes, tars, and solids, thus can be applied to clean wastewaters produced in bio-, hydro-, and thermo-chemical conversion processes.

- This study demonstrated that electrocoagulation can effectively treat effluents from gasification installations.
- The significance of the design of an electrocoagulation reactor was underscored as the decisive factor that can either enhance or hinder the technological efficiency of the treatment.
- In this investigation, the continuous reactor setup achieved or surpassed the removal efficiencies observed during batch experiments; hence, indicating not only the better applicability of the obtained results but also a higher potential for further upscaling of the process.

Results:

1) Electrocoagulation (EC) has proven its efficiency in removal of cyanides, sulphides, heavy metals and BTX from UCG wastewater
2) Efficiency of EC in removal of phenols and COD remains limited.
3) Positive effect of dose, time and their interaction were determined for the removal of cyanide.
4) >94% and >98% removal efficiency for CN^- and S^{2-} resp., BTX removal of 51-55%; however, for very low initial concentration of 0.110 mg/dm^3
5) EC enables pretreatment of the UCG effluent for its subsequent use in eg. phytoremediation process.

Table 1: Electrocoagulation parameters tested in the pilot scale

Reactor setup	A	B	C
Area of the elec., [cm^2]	790	2915	
Current, [A]	4.6	5.0	6.5
Voltage min ÷ max, [V]	14.99 ÷ 15.12	3.28 ÷ 3.34	4.18 ÷ 4.23
Flow rate, [l/h]	20 ±0.5		
Dose of Fe, [mg/L]	204	254	316

Table 2: Results of continuous electrocoagulation of UCG effluent

Reactor setup	A		B		C	
Stream	Feed	Treated	Feed	Treated	Feed	Treated
pH [-]	8.65	8.98	8.64	8.98	8.76	9.03
Conductivity [mS/cm]	2.00	1.86	1.80	1.58	1.81	1.59
Redox [mV]	-135	-153	-136	-156	-132	-148
CN^- [mg/l]	14.60	0.72	13.50	1.32	13.40	0.684
S^{2-} [mg/l]	39.20	6.18	29.85	<DL	32.85	0.65
COD [mg/l]	355.70	243.2	329.20	196.2	259.20	178.2
PI [mg/l]	23.10	19.4	6.37	5.09	9.31	5.7
Sum of metals*, [mg/kg]	3.638	0.821	3.638	0.498	3.638	0.458
Sum of BTX, [mg/dm^3]	0.110	0.112	0.110	0.050	0.110	0.054

* without Fe;

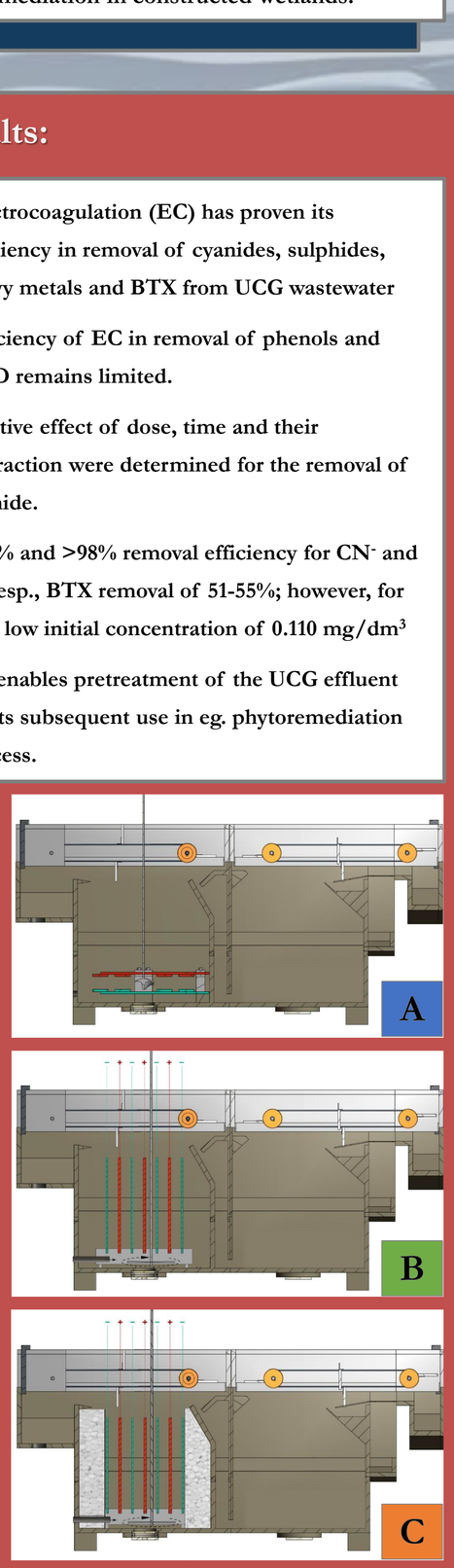

Figure 2: Modifications of the continuous reactor set-up

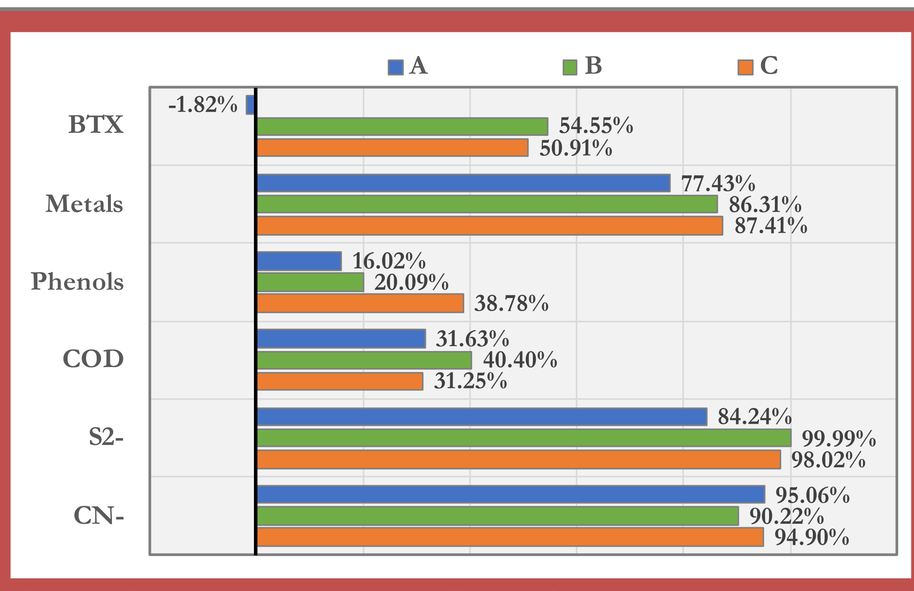

Figure 3: Electrocoagulation removal efficiency for selected contaminants

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