COMPARISON OF COAGULATION AND ELECTROCOAGULATION WITH ADDITION OF NATURAL ZEOLITE FOR TREATMENT OF BIOWASTE COMPOST LEACHATE

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ABSTRACT

Even composting is recognized as an effective way of managing organic waste, it creates significant amounts of leachate which contains a variety of hazardous substances that can have potential adverse effects on the environment. This paper examines the treatment of leachate from biowaste composting by a hybrid process which integrates coagulation and electrocoagulation with addition of natural zeolite. Efficiency of each process was monitored by pH value, electrical conductivity, turbidity, chemical oxygen demand and total Kjeldahl nitrogen.

Keywords: natural zeolite, electrocoagulation, coagulation, biowaste compost leachate.

INTRODUCTION

Composting technologies are recognized as an effective way of managing organic waste because they reduce the volume and mass of the initial waste by approximately 50%. However, composting on an industrial scale creates significant amounts of leachate and contains a variety of hazardous substances that can have potential adverse effects on the environment. Therefore, they need to be treated before discharge into the sewer or natural recipient. Recently, integration of various treatment methods is highly investigated as single treatment methods are not efficient for achieving satisfactory leachate effluent quality. This paper compares coagulation and electrocoagulation with addition of natural zeolite as an integrated process for efficient treatment of biowaste compost leachate.

EXPERIMENTAL

***Two biowaste compost leachate** solutions* were used for treatment. The first leachate (mark as A_o) was obtained from composting mass in an open container and the second from the rotary composter (mark as B_o). The pH, electrical conductivity, turbidity, chemical oxygen demand (COD), biological oxygen demand (BOD_5) and total Kjeldahl nitrogen (TN_K) were determined in the initial leachate.

Natural zeolite, clinoptilolite, originated from Zlatokop deposit, Vranjska Banja, Serbia, of granulation of 0.1-0.5 mm was used.

Electrocoagulation was performed in an electrochemical cell filled with 250 ml of simulated leachate solution and immersed aluminium electrodes (height: width: thickness = 5.9: 1.9: 0.6), with a distance between the electrodes of 3 cm. Electrochemical treatment was performed under the conditions of I = 0.1 A, U = 29.9 V, contact time t = 60 min, with gentle stirring with a magnetic stirrer, without addition of electrolyte. In the electrocoagulation experiments with addition of zeolite (marked as A_Z and B_Z), the mass of added zeolite was 5 g per 250 mL of effluent (solid to liquid ratio 20 g/L). Between each experiment, the electrodes were cleaned with distilled water and immersed into 0.1 mol/L HCl solution to remove impurities.

Coagulation is performed by addition of leachate solution and appropriate amount of coagulant $Al_2(SO_4)_3$, calculated by Faraday's law, in a glass beaker. In experiment with zeolite, 5 g of natural zeolite is added at the beginning of the process (marked as A_Z and B_Z). Coagulation was performed using the JAR test.

During electrocoagulation and coagulation with and without addition of zeolite, the pH value and electrical conductivity were monitored, and after the experiment, the pH value, electrical conductivity, turbidity, chemical oxygen demand (COD) and total Kjeldahl nitrogen (TN_K) were determined.

RESULTS AND DISCUSSION

Table 1 gives a physical-chemical analysis of leachate compared with maximal allowed values according to the Croatian Regulation [1].

Table 1. Biowaste compost leachate characterization.

Parameter	leachate A_o	leachate B_o	Natural surface waters [1]	Public sewage system [1]
pH	8.66	8.58	6.5-9.5	6.5 – 9.5
El. cond., μS/cm	838	759	-	-
Turbidity, NTU	87.5	48.5	-	-
COD, mgO_2/l	557.20	606.95	125	700
BOD_5, mgO_2/l	279.80	115.18	25	250
BOD_5/COD	0.502	0.190	-	-
TN_K, mg N/l	47.62	44.82	15*	50*

Note* - values for total nitrogen are compared since values for Kjeldahl nitrogen are not specified by Croatian Regulation [1]

The results showed that both leachates are characterized with medium organic load, ammonia concentration, conductivity and turbidity, while the pH values are within the limit values prescribed by the Croatian Regulation [1]. The value of the BOD_5/COD ratio indicates the biodegradability of leachate. This value in sample B_o is significantly lower and indicates the presence of less biodegradable organic components in leachate.

Comparison of pH and el. conductivity during leachate treatment

Both leachates were treated by coagulation and electrocoagulation, without and with the addition of zeolite. Results of monitoring of pH and el. conductivity during the process are compared in Fig. 1. and 2.

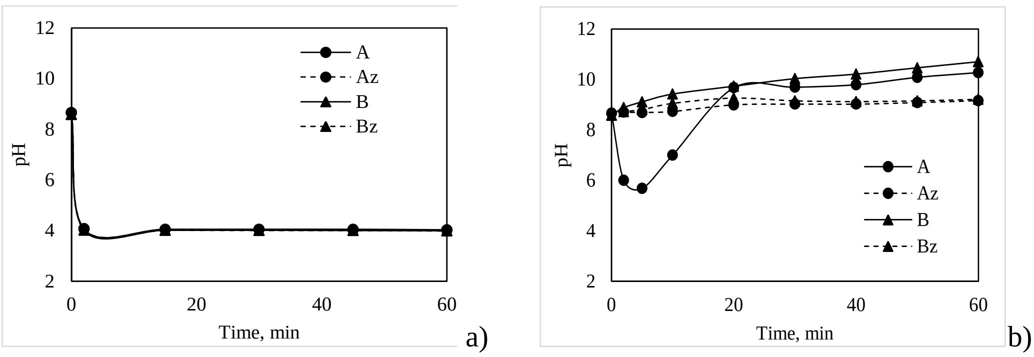
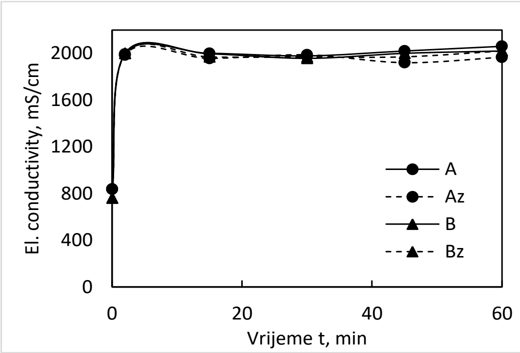
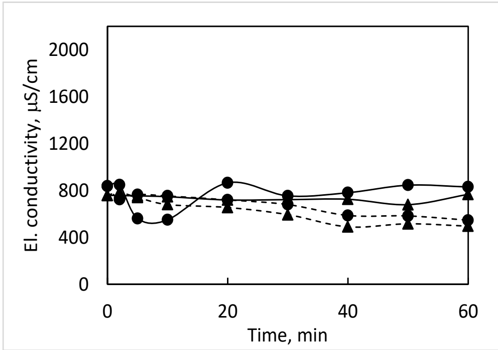


Figure 1. Comparison of pH values during leachates treatment without and with addition of zeolite by coagulation (a) and electrocoagulation (b).



a)



b)

Figure 2. Comparison of el. conductivity during leachates treatment without and with addition of zeolite by coagulation (a) and electrocoagulation (b).

During coagulation, the sharp decrease in pH to values around pH~4 (Fig 1.a) and increase in el. conductivity (Fig 2.a.) are observed. This is due to addition of coagulant $Al_2(SO_4)_3$, the hydrolysis of Al^{3+} and formation of mononuclear and polynuclear hydroxo complexes according to the general reaction:

$$Me^{3+}(\mathrm{aq}) + \mathrm{n}H_2O \leftrightarrow Me(OH)_{\mathrm{n}}^{3-\mathrm{n}} + \mathrm{n}H^{+}(\mathrm{aq}) \quad (1)$$

During electrocoagulation, the pH curves show a slight increase (Fig 1b.) and slight decrease in el. conductivity (Fig 2b). This behaviour is due to the process of hydrolysis of water at the cathode, which produces OH^- ions and hydrogen gas [2]:

Cathode: $$3H_2(l) + 3e^- \rightarrow 3/2\ H_2(g) + 3OH^- \quad (2)$$

However, the increase in pH and decrease of el. conductivity is less pronounced for samples with added zeolite (A_Z and B_Z). This is attributed to the ability of zeolite to neutralize solutions and capturing of the contaminants that contribute to el. conductivity [3]. Also, addition of zeolite particles acted abrasively on the electrodes and contributed to cleaning the electrode surface from oxides, corrosion products and organic mucous layer formed on anode.

Comparison of efficiency of process

Results of turbidity, COD and Kjeldahl nitrogen before and after leachate treatment by coagulation (C) and electrocoagulation (EC) process without and with the addition of zeolite (addition of zeolite marked as C/Z, EC/Z), are compared in Fig. 3-5. In Table 2, comparison of the removal efficiency α (%) by coagulation and electrocoagulation with and without addition of zeolite is given.

Table 2. Comparison of removal efficiency α (%) using coagulation and electrocoagulation without and with addition of zeolite.

Parameter	Removal efficiency α (%) using coagulation			
	A	B	A_z	B_z
Turbidity	92.39	97.94	92.95	93.36
COD	87.14	84.26	87.86	85.90
TK_N	85.29	34.38	97.06	53.13
	Removal efficiency α (%) during electrocoagulation			
Turbidity	78.51	73.13	99.74	99.36
COD	76.07	77.38	84.64	88.52
TK_N	41.18	31.25	82.35	81.25

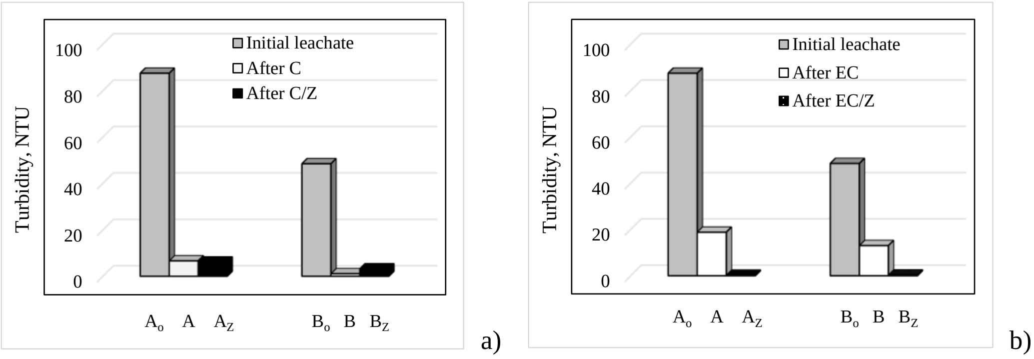


Figure 3. Turbidity values before and after leachate treatment without and with the addition of zeolite by coagulation (a) and electrocoagulation (b).

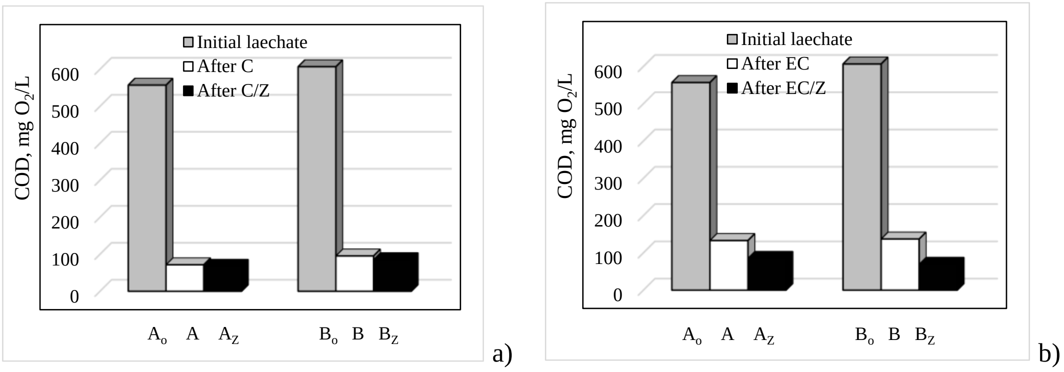


Figure 4. The COD values before and after leachate treatment without and with the addition of zeolite by coagulation (a) and electrocoagulation (b).

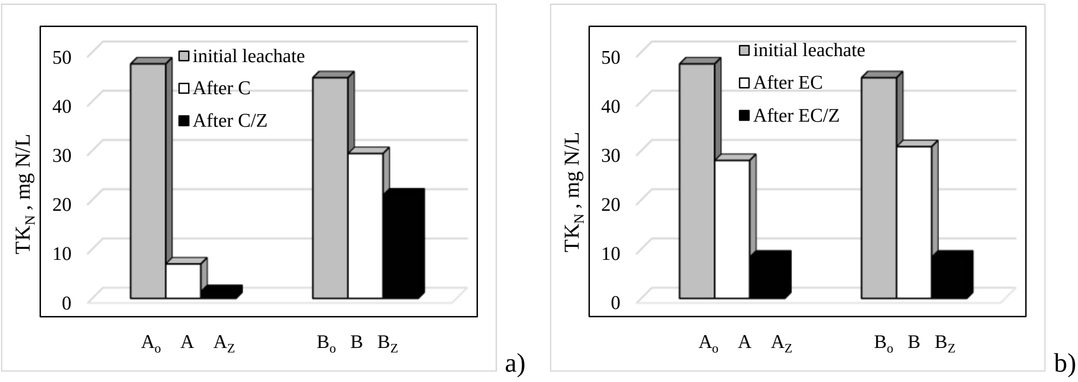


Figure 5. Kjeldahl nitrogen before and after leachate treatment without and with the addition of zeolite by coagulation (a) and electrocoagulation (b).

CONCLUSION

Significant reduction in the turbidity, COD and Kjeldahl nitrogen by coagulation and electrocoagulation process are observed. However, significantly better results are obtained with addition of zeolite. Obtained turbidity is decreased for > 99%, COD for >84 % and total Kjeldahl nitrogen for >81%, for both samples.

REFERENCES

[1] Regulation on emission limits values in wastewater, NN 26/2020 *(in Croatian).*
[2] V. Oreščanin, R. Kollar and K. Nađ, *Hrvatske vode,* 2016, **24**, 129-142 *(in Croatian).*
[3] N. Vukojević Medvidović, Doctoral thesis, Faculty of Chemistry and Technology in Split, Split, 2007. *(in Croatian).*