LANDFILL LEACHATE TREATMENT USING HYBRID PROCESS WITH FIXED ZEOLITE BED

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ABSTRACT

Complexity of landfill leachate makes a single treatment method slightly effective for achieving leachate effluent quality. Combination of various treatment methods called "hybrid" is highly suggested. This paper examines treatment of landfilled leachate by hybrid process which contains two steps: chemical precipitation with lime, pH adjustment and air stripping as a first step, followed by treatment with zeolite using column method as a second step. Desorption of harmful substances from saturated zeolite in column has been monitored to test the ability of the zeolite for retention of harmful substances, thereby avoiding secondary pollution during *in situ* application.

Keywords: landfill leachate, hybrid treatment process, zeolite, fixed bed, leaching of saturated zeolite.

INTRODUCTION

Landfills leachates are generated from water percolating through the landfill body and biochemical processes in waste during their decomposition. They contain a large number of harmful inorganic and organic substances, heavy metal salts and soluble gases created by dissolving and decomposition of waste materials on their path. Single treatment method is not efficient for achieving satisfactory leachate effluent quality, thus combination of various treatment methods called "hybrid" is interest of many scientists. This paper examines treatment of landfilled leachate by hybrid process with fixed zeolite bed. In order to avoid secondary pollution during *in situ* application, desorption of harmful substances from saturated zeolite in column has been investigated.

EXPERIMENTAL

The raw leachate has been collected from basin of landfill leachate of the Bikarac landfill which is part of the Centre for Waste Management in Šibenik-Knin County, Croatia, on March 16th and 17th, 2018. 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 (NZ), clinoptilolite, originated from Zlatokop deposit, Vranjska Banja, Serbia, was milled and sieved to granulation of 0.6-0.8 mm and dried at 40 °C.

Hibrid treatment included two steps (Figure 1a). *First step:* filtration, pH adjustment to 12.68 with milk lime with concentration of 60g/l $Ca(OH)_2$, 24 h air stripping. *Second step:* treatment with fixed zeolite bed using column with diameter of 1.2 cm and column height of 50 cm. Column was filled with zeolite up to bed depth of 8 cm. The leachate collected after the 1st step of treatment was passing thought the column using down flow mode. After each step pH, electrical conductivity, turbidity, COD and total Kjeldahl nitrogen have been determined in the liquid phase.

Zeolite retention of harmful substances: Saturated zeolite sample in column have been investigated for retention of harmful substances, by passing ultrapure water with adjusted

pH=6.67, using down flow mode (Figure 1b). The same parameters as mentioned before have been determined.

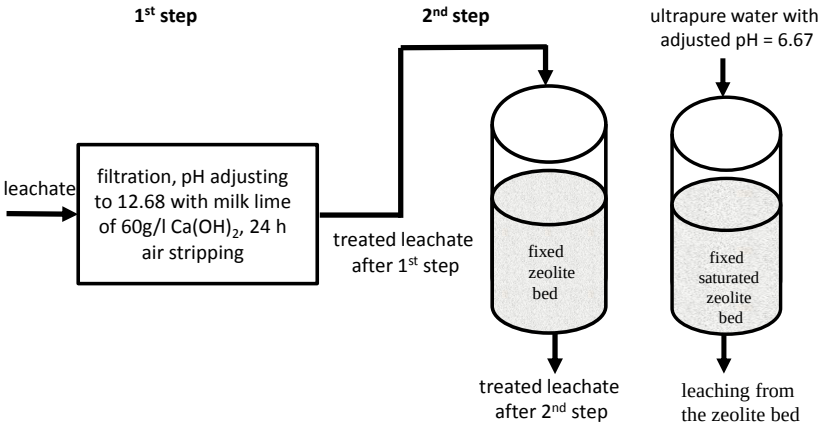

Figure 1. Schematic illustrationof performance for: a) hybrid treatment steps with fixed bed zeolite column; b) zeolite retention of harmful substances.

RESULTS AND DISCUSSION

Table 1 compares efficiency of leachate treatment after 1st and 2nd steps. Results are compared with maximal allowed values according to the Croatian laws [1].

Table 1. Efficiency of leachate treatment after 1st and 2nd step.

Parameter	raw leachate	treated leachate after 1st step	treated leachate after 2nd step, at break. point	total removal %	natural surface waters [1]	sewage system [1]
pH	8.31	12.68	9.63	-	6.0-9.0	6.5-9.5
El. cond., μS/cm	8840	9250	5090	42.42	-	-
Turbidity, NTU	40.60	2.34	2.06	94.92	-	-
COD, mgO_2/l	1253.70	394.21	231.15	81.56	100	700
BOD_5, mgO_2/l	76.12	-	-	-	20	250
TN_K, mg N/l	269.63	72.84	51.83	80.77	-	-

The results in Table 1 show that the pH value and conductivity after 1st treatment step is increased, due to added lime. Turbidity is reduced, as added lime caused precipitation of harmful substances. The COD value is reduced from 1254.70 to 394.21 mg O_2/l, indicating that the harmful substances subjected to oxidation were removed. The reduced TK_N after treatment with respect to the initial sample suggests that the organic and ammonium nitrogen can be effectively removed by 1st treatment step. The BOD_5 was not determined, since such a high pH does not favour the survival of microorganisms necessary for the degradation of biodegradable organic matter.

2nd step included treatment of leachate collected after the 1st step with fixed zeolite bed using column methods, and results are given in Figure 2. The results of pH value indicate slowly decrease up to 800 min from 12.68 to 9.63, after which achieve a constant values. There is a noticeable decrease in conductivity from 9850 to 5090 μS/cm for the first 450 min

of column operation, indicating that the zeolite bed has bound a significant amount of conductive ionic species. After that, this value again increases which indicates the saturation of the zeolite bed. The results of turbidity oscillate, and indicate that application of zeolite did not give a significant improvement. The value of COD achieves 231.15 mg O_2/l already in the first sample, which is about 60 % of the initial value. The COD breakthrough curve expressed as effluent and influent COD concentration ratio *vs.* time (Figure 2e) has no characteristic S-shape. The saturation point was reached at 1096 minutes of column operation.

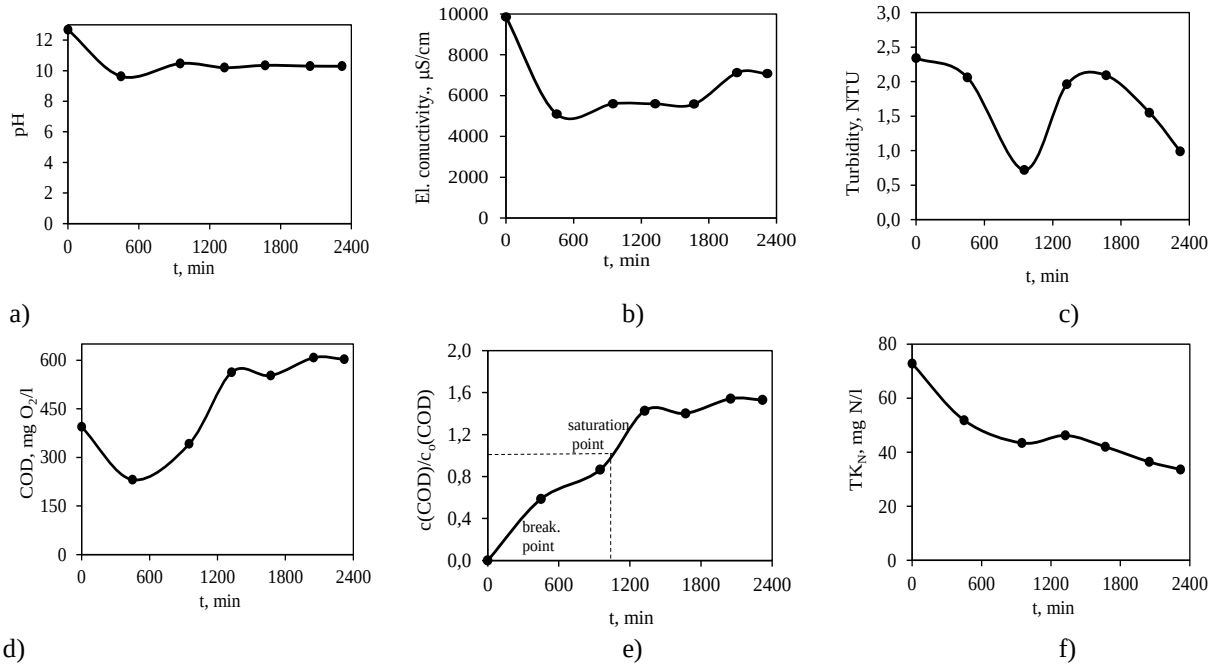

Figure 2. Results of continuously measurement of: a) pH, b) el. conductivity, c) turbidity, d) COD, e) effluent and influentCOD concentration ratio (c/c_o), f) TK_N of leachate during treatment onto fixed zeolite bed.

The results of the TK_N show 29 % of nitrogen removal by the zeolite bed already in first point (correspond to 450 min of operation). Further decreasing trend indicate a further increase in the TK_N binding to zeolite, which is probably consequence of degradation of organic nitrogen compounds during column performance and additionally bounding to the zeolites.

Analysis of zeolite retention of harmful substances

Retention of harmful substances onto saturated zeolite in column was investigated by passing ultrapure water with adjusted pH_o=6.67. Continuous monitoring of pH, el. conductivity, turbidity, COD and TK_N in effluent is given in Figure 3. Even the results of pH show a sudden rise followed by a continuous decrease, the range of pH values are within the range of limit values for wastewater discharge (pH = 6.0-9.5) determined by Croatian low. The values of el. conductivity, turbidity, COD and TK_N are showing the highest values at the first point, which comes from the residual leachate solution in the zeolite bed. However, further leaching with ultrapure water with adjusted pH_o=6.67 did not result in releasing of harmful substances from the bed, which would affect the increase in values of examined parameters.

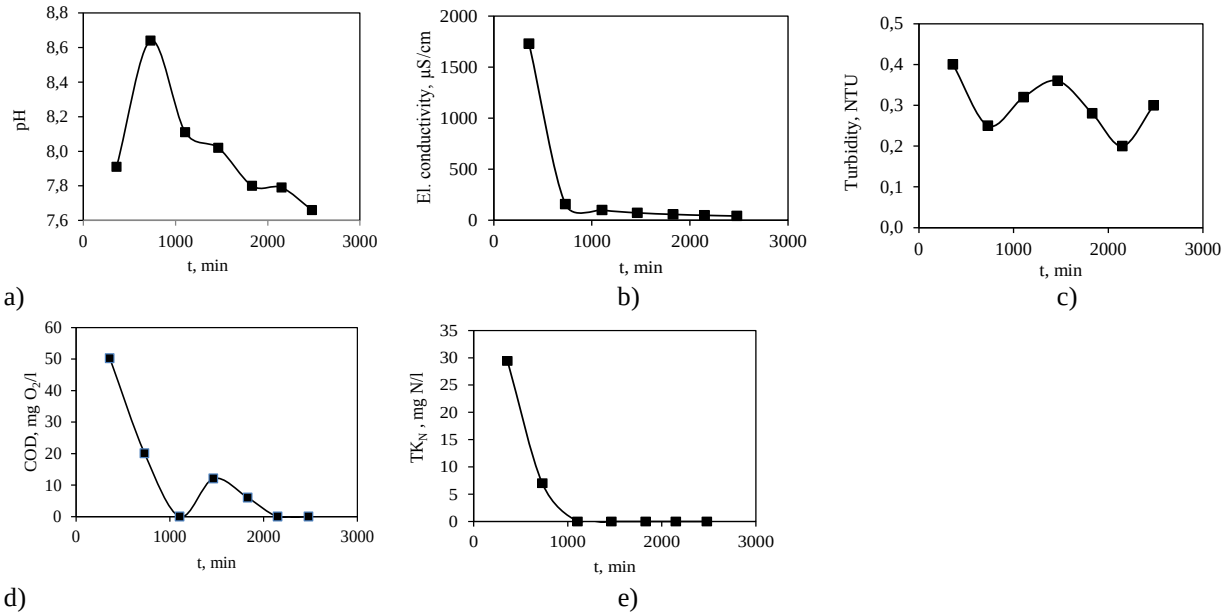

Figure 3. Results of continuous measurement of: a) pH, b) el. conductivity, c) turbidity d) COD, and e) TK_N during leaching of saturated zeolite with ultrapure water of adjusted pH_o=6.67.

CONCLUSION

Landfill leachate can be effectively treated by a hybrid process which involve filtration, pH adjusting to 12.68 with milk lime and 24 h air stripping as a 1st step, followed by treatment with zeolite fixed bed in column as a 2nd step. After 450 min of column operation, the following results of physico-chemical indicators are obtained: reduction of el. conductivity by 42.42 %, turbidity by 94.92 %, COD by 81.56 % and TK_N by 80.77 %. The final pH of the effluent was 9.63. Although the results of treatment the hybrid process with the zeolite showed a satisfactory reduction of the examined parameters, the obtained values are still above the limit values determined by the Croatian low for the discharge form nonhazardous waste landfills. The results of leaching of the saturated zeolite with ultrapure water with adjusted pH_o=6.67 showed the following characteristics of the effluent: pH value in range 7.91-8.64, turbidity in range 0.25 to 0.40 NTU, el. conductivity in range 159.1 to 1730.0 µS/cm, COD<50.25 mgO_2/l and TK_N<29.42 mg N/l, indicating that natural zeolite bed has the ability to retain harmful substances and that "*in situ*" application will not cause any further secondary pollution.

ACKNOWLEDGMENT

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REFERENCES

[1] Regulation on emission limit values in wastewater, NN 80/2013 (in Croatian).