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Compost Leachate Pretreatment by Coagulation/Flocculation Followed by Filter Press

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Abstract

Compost leachate was treated with coagulation/flocculation followed by filtration in order to obtain effluent suitable for further purification by reverse osmosis process. The poly aluminium chloride coagulant and the poly acryl amide flocculant were applied for coagulation/flocculation process. Filtration tests were performed to choose the proper fabric for filtration of compost leachate. There were huge differences between compost leachate samples' properties taken at the plant; therefore, it was difficult to determine the optimum coagulant/flocculant dosage. It was found that, among the fabrics available, only one was appropriate, and was made of polypropylene. With other filter fabrics the pressure during the filtration increased above 6 bar, which means above the highest specified allowed pressure for the device used. The filtration was carried out with several differently pretreated samples of compost leachate. The turbidity was reduced by as much as 89.8 %. The particle-size distribution analyses showed that most colloids and suspended solids were removed after the treatment. The results indicate that combination of coagulation/flocculation followed by filtration is not adequate for proper treatment of compost leachate, and some other technique, such as electrocoagulation, ultrafiltration, and nanofiltration need to be investigated.

Keywords

Filter press, filter fabric, compost leachate, coagulation, turbidity

1 Introduction

Compost leachate is a side product of decomposition of organic waste.[1] Composting involves growth, thermophilic, and maturation phases, lasting several weeks to produce compost leachate.[2] Insufficient aeration could lead to anaerobic conditions and the strange smell of rotten eggs or cabbage. The composition of compost leachate may vary in the content of organic compounds, nitrogen, metals, and other inorganic compounds.[1] The range of chemical oxygen demand (COD) in compost leachate could vary from 1500 to 42 000 $mg\,l^{-1}$ O_2, while the content of total nitrogen is approximately half of the COD value. Zn and Cu are the most represented among heavy metals. If compost leachate is composed due to leaf degradation, it contains phenolic compounds. Among toxic compounds, also present are pesticides, polycyclic aromatic hydrocarbons (PAH), and polychlorinated biphenyls.[3]

Compost leachate is thus heavily polluted and must be treated before being released into environment. Among conventional treatment processes, coagulation, flocculation, filtration, and adsorption are applied. The combination of more than one method is commonly applied.[4] Membrane bioreactor (MBR) has been successfully applied for compost leachate treatment with COD removal of 99 %.[5] Since compost leachate contained huge amounts of ammonia also its removal achieved 99.9 %. The MBR process was monitored for one month. Anaerobic treatment of compost leachate was efficient by reducing ~~the~~ sludge production.[6] Anaerobic digestion reduced the level of odour and stabilised the residue of treated compost leachate.[7] The study showed that compost leachate may also be considered a source of nutrients and water, and used as fertiliser.

The compost leachate has also been efficiently treated with coagulation and membrane separation.[8] Results indicate that coagulation by poly ferric sulphate is very effective in the reduction of turbidity, reaching 75 %. However, additional nanofiltration treatment was required to achieve leachate quality required by the pollution control standard (GB16889-2008). Our previous study showed that the organic matter could be removed below the legislative value of 120 $mg\,l^{-1}$ with the combination of coagulation and nanofiltration.[9]

The purpose of this research was to filter the compost leachate to the extent that it would be suitable for further purification by the reverse osmosis process. Compost leachate was treated with coagulation/flocculation followed by filtration in order to obtain effluent suitable for further purification by reverse osmosis process. The performance of an innovative hybrid airlift bioreactor (HALBR) for removing high organic matter content and ammonia from composting leachate has recently been investigated.[10] To the best our knowledge, the combination of coagulation and filter press filtration has not yet been studied. The poly-aluminium chloride coagulant and the polyacrylamide flocculant were applied for the study. Different types of filtration fabrics were chosen. Filtration tests were performed to choose the proper fabric for filtration of compost leachate.

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2 Experimental

2.1 Chemical analyses

All chemical analyses were performed in the laboratory following ISO standard methods. Parameters measured were turbidity (expressed in nephelometric turbidity units, NTU) with HACP 2100P turbidimeter, electrical conductivity (κ) with WTW LF 537 conductivity meter, dry mass (dm) was determined gravimetrically, particle size (d), and zeta potential of the particles (ζ). The particle size distribution and zeta potential of the particles were measured using a Zeta sizer Nano ZS instrument (Malvern Instruments, UK). The removal percentage (E(%)) for turbidity was calculated according to Eq. (1):

$$E(\%) = \frac{c - c_f}{c} \cdot 100 \qquad (1)$$

where c is initial value for turbidity and c_f turbidity value after treatment.

2.2 Coagulation and filtration of compost leachate

The samples of compost leachate were taken at Kogal Composting Plant, Slovenia. Annual generation of biological waste is 65 kt of green and biodegradable waste. An amount of 24 m^3 of compost leachate is produced daily or around 130 $l\,t^{-1}$. The main concentration ranges of monitored parameters over the last three years are shown in Table 1.

Table 1 – Compost leachate characteristics
Tablica 1 – Karakteristike kompostne procjedne vode

Parameter Parametar	Compost leachate Kompostna procjedna voda
pH	4.9–5.5
κ / mS cm^{-1}	19.0–24.0
dm / g dm^{-3}	10.0–23.1
COD / g dm^{-3}	15.0–65.1
BOD / g dm^{-3}	7.0–33.1
TN / g dm^{-3}	1.0–3.1
Cu / mg dm^{-3}	0.2–11.0
Zn / mg dm^{-3}	6.1–20.0
Ni / mg dm^{-3}	0.0–2.0
d / nm	901–1500
ζ / mV	−15.8–2.0

The values of chemical and biochemical oxygen demand (COD, BOD) are quite high, as is total nitrogen (TN), as seen from Table 1. The values are in accordance with the literature.[8] Firstly, coagulation/flocculation process was performed using a laboratory JAR test system, which was then followed by filtration. Kemiclar 100 (Kemira KTM, Slovenia) solution was applied as poly aluminium chloride (PAC) coagulation media with 17 to 18 V% of Al_2O_3 and one drop of Magnafloc polyacrylamide flocculant (Applied Chemicals Anwendungstechnik, Lörrach, Germany). The coagulant amount was varied in the range 10–30 ml l^{-1} of compost leachate.

Four different filter fabrics were chosen for filtration. Table 2 presents the comparison between the different fabrics' properties. The material was either made of polypropylene mono- or multiple filaments. The specific masses were in the range 360 to 490 g m^{-2}, and air permeability 10–100 dm^3 dm^{-2} min^{-1}.

Table 2 – Specifications of filter fabrics
Tablica 2 – Specifikacije filtarskih tkanina

Fabric mark Oznaka materijala	Specific mass Specifična masa / g m^{-2}	Air permeability Propusnost zraka / dm^3 dm^{-2} min^{-1}	Material Materijal
FF1	360	10	Polypropylene multifilament
FF2	490	10	Polypropylene monofilament
FF3	360	15	Polypropylene monofilament
FF4	370	90–100	Polypropylene monofilament

Fig. 1 shows the filter press filtration on site. The filter press (left in Fig. 1) consisted of eight parallel filter plates. The dimensions of filter plates were 10 × 10 cm. The filter fabric was placed between the filter plates. The compost leachate was pumped from the storage tank into the filter press. The applied pressure was up to 6 bar. The solids formed a filter cake on the plates, while the filtrate exited through the corner ports into the distributor, yielding clean filtered compost leachate water, which was chemically analysed.

Fig. 1 – Filtration on-site
Slika 1 – "On-site" filtracija

3 Results and discussion

The chemical analyses of the compost leachate sample taken from Kogal Composting Plant were performed. Compost leachate samples varied in composition: turbidity in the range 2500–4300 NTU, electrical conductivity in the range 19–22 mS cm^{-1}, dry residue in the range 22–24 g dm^{-3}, particle-size distribution in the range 900 -1300 nm, and zeta potential of the particles in the range −15–2 mV.

The results of the compost leachate sample 1 are presented in second column of Table 2. The concentrations 10, 15, 20, and 25 ml l^{-1} of Kemiclar, as well as two drops of Magnafloc were added into each of four jars. The JAR test was performed, but a black foam had formed, probably due to the microbiological degradation of organic compounds and gas production at the same time, as seen in Fig. 2. Despite the foam formation, the chemical analyses of the treated compost leachate samples were performed, and the results, after adding 15 ml l^{-1} of Kemiclar, are presented in the last column of Table 3. This sample was chosen because it had the lowest amount of foam.

Table 3 – Result of chemical analyses of sample 1
Tablica 3 – Rezultati kemijske analize za uzorak 1

Parameter Parametar	Compost leachate 1 Kompostna procjedna voda 1	Treated compost leachate 1 Obrađena kompostna procjedna voda 1
turbidity / NTU	4250	3250
κ / mS cm^{-1}	21.3	21.3
dm / g dm^{-3}	22085	22780
d / nm	901	1600
ζ / mV	−15.8	−3.8

Fig. 2 – Foam formation after coagulation of sample 1
Slika 2 – Nastanak pjene nakon koagulacije u uzorku 1

As seen from Table 3, the zeta potential measurement suggests the unstable dispersion and larger agglomerates formation; therefore, coagulation failed to provide expected results. Further, the foam generation was disturbing. However, the JAR test was repeated with another aliquot of the same compost leachate sample with increased addition of Kemiclar, but the results were very similar to those presented in Table 3, also with the formation of foam. The concentrations of Kemiclar and Magnafloc were optimised to reduce the turbidity of the sample; however, none of the attempts to treat compost leachate gave satisfactory results. Since the properties of compost leachate samples were very different, another sample was taken. Already the appearance of the compost leachate was much different compared to the first sample. Less oils and greases were observed in the leachate sample. The coagulation was performed by adding 10, 15, 20, and 25 ml l^{-1} of Kemiclar.

The results of the second sample are presented in Table 4, second column. In the last column, the optimum sample, after adding 15 ml l^{-1} Kemiclar, was analysed because of its lowest turbidity. This time, the results were more promising. Turbidity reduced by 90.0 %. Stable dispersion formed with high negative zeta potential −50.9 mV.

Table 4 – Result of chemical analyses of sample 2
Tablica 4 – Rezultati kemijske analize za uzorak 2

Parameter Parametar	Compost leachate 2 Kompostna procjedna voda 2	Treated compost leachate 2 Obrađena kompostna procjedna voda 2
turbidity / NTU	2498	250
κ / mS cm^{-1}	19	18
dm / g dm^{-3}	24710	19430
d / nm	1272	245
ζ / mV	1.97	−50.9

Firstly, only tap water was filtered through chosen polymeric material (listed in Table 2). The best flux was achieved with the material FF4; therefore, it was selected for further trials.

With other filter fabrics, the pressure during filtration increased above 6 bar, which means above the highest specified allowed pressure for the device used. Coagulation of the second compost leachate sample was followed by filtration. The results of raw compost leachate sample 2, and the same compost leachate sample treated by coagulation, followed by FF4 material are presented in Table 5. The results showed negligible changes between the properties of compost leachate after coagulation and those after both coagulation and filtration. Turbidity and zeta potential values were only slightly worse, suggesting that filtration showed no effect on the quality of the treated compost leachate.

Table 5 – Results of chemical analyses of sample 2 treated with coagulation and filtration
Tablica 5 – Rezultati kemijske analize za uzorak 2 obrađen koagulacijom i filtracijom

Parameter Parametar	Compost leachate 2 Kompostna procjedna voda 2	Treated compost leachate 2 Obrađena kompostna procjedna voda 2
turbidity / NTU	2498	255
κ / mS cm^{-1}	19	18
dm / g dm^{-3}	24710	17430
d / nm	1272	148
ζ / mV	1.97	−45.9

Other attempts with other samples to improve the quality of compost leachate gave similar or worse results. Thus, it could be concluded that a filter press is not a good solution for the removal of colloids from compost leachate. Coagulation using other coagulants followed by other kinds of filtrations, such as nanofiltration is more suitable.[9]

4 Conclusion

The aim was to pretreat the compost leachate in such a manner that it would not foul the reverse osmosis membrane. In order to remove colloid from leachate as much as possible, the combination of coagulation/flocculation and filter press filtration was chosen. Due to large differences in properties of compost leachate samples, it is very hard to determine the optimal conditions for each treatment step. Pretreatment of individual samples was not always successful. Among major obstacles, the foam formation was demanding. Further research is required to explain and eliminate problems by optimising the pretreatment process. The most successful was turbidity removal of 90 %. However, the final values were still huge and additional treatment steps, such as ultrafiltration, electrocoagulation, nanofiltration, *etc.,* are required.

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List of abbreviations and symbols
Popis kratica i simbola

NTU – nephelometric turbidity unit, NTU
κ – specific conductivity, mS cm^{-1}
dm – dry mass, g dm^{-3}
d – particle diameter, nm
ζ – zeta potential, mV

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SAŽETAK

Predobrada kompostne procjedne vode procesom koagulacije/flokulacije praćene filtarskom prešom

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Kompostne procjedne vode primarno su obrađene koagulacijom/flokulacijom nakon čega je slijedila filtracija da bi se dobio efluent pogodan za daljnje pročišćavanje postupkom reverzne osmoze. Aluminijev klorid je u procesima koagulacije/flokulacije upotrijebljen kao koagulant, a poliakrilamid kao flokulant. Provedena su ispitivanja filtracije kompostne procjedne vode da bi se odabrala odgovarajuća tkanina za filtraciju. S obzirom na veliku fluktuaciju u sastavu procjedne kompostne vode izuzete na postrojenju, bilo je teško odrediti optimalnu dozu koagulanta/flokulanta. Utvrđeno je da je od dostupnih tkanina samo jedna odgovarajuća, a bila je izrađena od polipropilena. Kod drugih filtarskih tkanina tlak je tijekom filtracije porastao iznad najvišeg dopuštenog tlaka za upotrijebljeni uređaj koji je iznosio 6 bar. Filtracija je provedena na nekoliko različitih prethodno obrađenih uzoraka kompostne procjedne vode. Zamućenje se smanjilo za čak 89,8 %. Analiza raspodjele veličine čestica pokazala je da je većina koloida i suspendiranih tvari uklonjena nakon obrade. Rezultati pokazuju da kombinacija koagulacije/flokulacije i filtracije nije primjerena za pravilnu obradu kompostne procjedne vode te je potrebno istražiti neke druge tehnike poput elektrokoagulacije, ultrafiltracije i nanofiltracije.

Ključne riječi

Filtarska preša, filtarska tkanina, kompostna procjedna voda, koagulacija, zamućenje

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