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CHEMICAL AND BIOLOGICAL
ENGINEERING CONFERENCE

ChemPor
2018

BOOK OF
EXTENDED ABSTRACTS

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Provisional version



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This volume contains the provisional version of the extended abstracts presented at the 13th International Chemical and Biological Engineering Conference (CHEMPOR 2018), held in Aveiro - Portugal, from the 2nd to the 4th of October, 2018.

University of Aveiro & Ordem dos Engenheiros

**13th International Chemical and Biological
Engineering Conference
(CHEMPOR 2018)**

Book of Extended Abstracts

Edited by:

João Araújo Pereira Coutinho

Carlos Manuel Silva

Inês Portugal

Ana Barros-Timmons

Anabela Aguiar Valente

Dmitry Victorovitch Evtyugin

Mara Guadalupe Freire

Pedro Jorge Carvalho



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Title

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Editors

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SCIENTIFIC PROGRAM

Time		Tuesday, 2/10	Wednesday, 3/10	Thursday, 4/10							
8:00	8:15	Registration									
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8:30	8:45										
8:45	9:00										
9:00	9:15										
9:15	9:30	Welcome Session	Plenary Lecture (PL3) Rajamani Krishna	Plenary Lecture (PL5) Gabriele Centi							
9:30	9:45										
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10:15	10:30		O-BB09	O-EE03	O-IM05	O-RS13	O-EE12	O-BS07			
10:30	10:45		O-BB10	O-EE04	O-IM06	O-RS14	O-EE13	O-BS08			
10:45	11:00		O-BB11	O-EE05	O-IM07	O-RS15	O-EE14	O-BS09			
11:00	11:15	Coffee-break	Coffee-break			Coffee-break					
11:15	11:30										
11:30	11:45	O-RS01	O-BS01	Bondalti							
11:45	12:00	O-RS02	O-BS02	O-MP01	O-BB12	O-EE06	O-ME01	Plenary Lecture (PL6) Nikolaos Hadjichristidis			
12:00	12:15	O-RS03	O-BS03	O-MP02	O-BB13	O-EE07	O-ME02				
12:15	12:30	O-RS04	O-BS04	Prio	O-BB14	O-EE08	O-ME03				
12:30	12:45	O-RS05	O-BB01	O-IM01	O-BB15	O-EE09	O-ME04				
12:45											
		Lunch	Lunch	Lunch							
14:15	14:30	Keynotes (KN1 and KN2) João Rocha Rosa Quinta-Ferreira	Keynotes (KN3 and KN4) Adélio Mendes José António Teixeira	Keynotes (KN5 and KN6) Maria Ascensão Reis Ramesh Gardas							
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14:45	15:00										
15:00	15:15	O-RS06	O-BB02	BB&G	Plenary Lecture (PL4) María José Cocero	O-RS16	O-EE15	O-IM11	Awards and Closing Session		
15:15	15:30	O-RS07	O-BB03	O-MP03		O-RS17	O-EE16	O-IM12			
15:30	15:45	O-RS08	O-BB04	BP		O-RS18	O-EE17	O-IM13			
15:45	16:00	O-RS09	O-BB05	O-MP04		O-MP05	O-IM09	O-IM14			
16:00	16:15	O-IM02	O-BB06	O-RS10		O-IM08	O-IM10	O-IM15			
16:15	16:30	Plenary Lecture (PL2) Paul Christakopoulos	Poster Session and Coffee-break			Multibiorefinery Project Meeting (Coffee-break)					
16:30	16:45		P-BB, P-RS, P-MP, P-ME								
16:45	17:00	Formal Session with Minister of Economy	Bus to Vista Alegre			CHEMPOR participants are welcome					
17:00	17:15		Museum Visit								
17:15	17:30	Poster Session and Coffee-break P-BS, P-IM, P-EE									
17:30	17:45										
17:45	18:00										
18:00	18:15										
18:15	18:30										
18:30	18:45										
18:45	19:00										
19:00	19:15										
19:15	19:30										
19:30					Conference Dinner						

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 [KN] - Keynote Presentation
 [RS] - Reaction and Separation Processes
 [BS]- Biorefinery and Sustainability
 [MP] - Modeling, Synthesis and Integration
 of Chemical Processes

[BB] - Biological Engineering and Biotechnology
 [IM] - Innovative Materials and Applications
 [EE] - Energy and Environment
 [ME] - Multiscale and Multidisciplinary Engineering
 Education

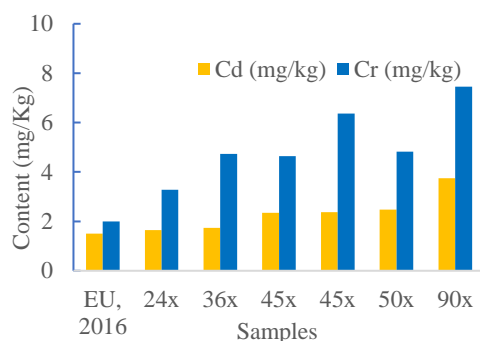
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Investigation of the viability of converting a leachate from a mechanical biological treatment plant for municipal solid waste into fertilizers

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The main environmental issue associated with the compost production is the production of a liquid leachate. However, the leachate may also be considered as a source of nutrients and used as fertilizer. The main concern is loading the soil with metals that can result in increased metal content of crops. This work intends to determine the physical and chemical properties of a raw leachate from a mechanical biological treatment plant for municipal solid waste, to assess the possibility of converting it into as commercial fertilizer which meets to the specifications required in the proposal of regulation of the European Parliament of 2016, for fertilizers. In a preliminary study, it is concluded that the leachate qualitatively meets the requirements established for the composition of commercial fertilizers and the production cost of leachate as raw material is low.

Introduction

Disposal of municipal waste is a major environmental problem. Increased urbanization and industrialization, especially in developing countries, requires municipal authorities to handle larger amount of municipal waste than in the past. [1] Considerable attention has been paid to the land application of municipal solid waste composts and sewage sludge worldwide in recent years. [2]

Chemical properties were determined for a raw leachate from a mechanical biological treatment plant for municipal solid waste, to check if it meets the adequate requirements for using as commercial fertilizer according to the proposal of regulation of the European Parliament of 2016, for fertilizers. [3]

Methods

pH and conductivity were determined using a pH-electrode SenTix 41 from WTW and a conductivity cell TetraCon 325 from WTW. TOC analysis was performed with 1:1000 dilution, in a Shimadzu TOC-L equipment. Density assessment was done using 5 and 10 mL pycnometers dried for 24 hours. Heavy metals quantification was performed by digesting the samples with HNO₃/HCl, filtration using a 0,2 µm syringe filter in a 50 mL volumetric flask, completed with a 5% HNO₃ solution, with subsequent analysis by atomic absorption spectroscopy. Ammoniacal Nitrogen was characterized through distillation of the initial sample. The distillate was collected using boric acid solution at 4% and then titrated using hydrochloric acid 0,0978M previously standardized. Total Kjeldhal Nitrogen (TKN) analysis was performed following the same procedure used in Ammoniacal Nitrogen but with digestion using H₂SO₄ before the distillation. Organic Nitrogen was calculated through the difference between Total and Ammoniacal Nitrogen. Phosphorous analysis was performed by digesting the sample with HNO₃ for 45 minutes and then with HClO₄ for 1 hour. Then, it was transferred to a 250 mL volumetric flask, which is filled. Afterwards, it was filtered and 85 mL of the filtered solution is mixed with 15 mL of vanadate molybdate solution. The solution is left to rest for 10 minutes. The 500 ppm standard solution was prepared using 0,9640g of 40% purity KH₂PO₄, dried for 2h at 105°C, in 1000 mL volumetric flask. The standards solutions used for calibration were prepared from the 500 ppm solution and contain 20, 25, 30, 40 and 50 ppm of P₂O₅, respectively containing 20mL of distilled water and 15mL of vanadate molybdate solution in 50 ml volumetric flasks. The

standards must stand for 10 minutes to complete color development and determination of the absorbance of the solutions is carried out at 400 nm using as a blank the solution containing 20 ppm of P₂O₅.

Results

Chemical properties of the leachate samples are presented in Table 1. The original leachate used as initial sample is too diluted and must be concentrated to fulfill the requirements of the EU fertilizers legislation. Some samples are processed to reach 3% of TOC. The density, pH and conductivity were measured, showing high variations between the original e the concentrated samples as presented in Table 1. The concentration process, due to water removal, promotes the concentration of the inorganic carbon content, like carbonates, that must be corrected to a neutral pH before a possible use as fertilizer.

Table 1. Chemical properties of the leachates samples

Samples	% TOC	Density (mg/L)	pH	Conductivity (mS/cm)
EU, 2016	3	-	-	-
Original	0,14	1,01	8,7	12,5
24x	3,48	1,15		
36x	3,53	1,13		
45x	4,69	1,22		
45x	4,30	1,20	11,0	124,8
50x	3,54	1,02		
90x	7,01	1,34		

The heavy metals concentration was determined only in the concentrated samples because the original sample did not reach the analysis detection limit. As shown in Figure 1 (top), the content of Pb and Ni fulfill the requirements of the EU legislation while in Figure 1 (bottom), Cd and Cr must be removed to achieve the fertilizer requirements. However, the concentrate leachate still displays viability to produce a commercial fertilizer.

It is observed that the organic carbon content has a strong influence on the final density of the concentrated samples obtained. Therefore, some statistical resources were used to test the correlation, represented in Figure 2, between bulk density of the concentrated samples and TOC.

Using the test of significance for Spearman's correlation coefficient, it is concluded that there is a significant correlation for significance tests with $\alpha = 0.05$ and $\alpha = 0.01$.

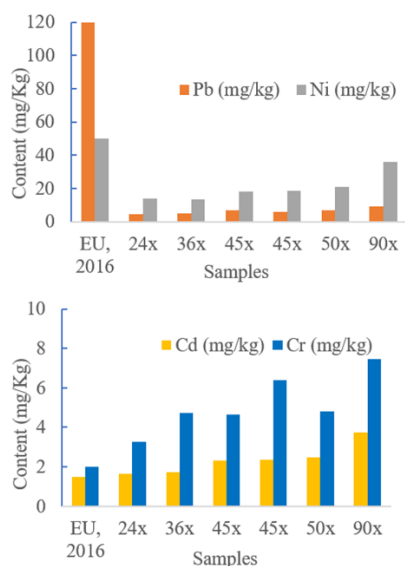


Figure 1. Content of Pb and Ni in the leachates samples (top); Content of Cd and Cr in the leachates samples (bottom).

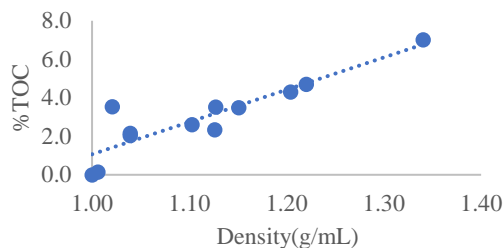


Figure 2. Correlation between Density and TOC.

The procedure for the characterization of organic nitrogen was carried out to obtain parameters for the leachate in the legislation are shown in Table 2. The analysis was proceeded only using the original leachate because with the distillation process, the volatile fraction of nitrogen is lost due to heating.

Table 2. Concentration of nitrogen.

Sample	TKN N (%w/w)	Ammoniacal N (%w/w)	Organic N (%w/w)
1	0,0286	0,0227	0,0059
2	0,0245	0,0231	0,0014
3	0,0272	0,0227	0,0045

According to European Union legislation, in order to be considered as a liquid organo mineral fertilizer, the product must contain at least one of the following declared nutrients in the

Acknowledgments

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References

[1] M. Farrell, D.L. Jones, *Bioresource Technology*, 100 (2009) 4301–4310.
 [2] A.H. Khoshgoftarmansh, M. Kalbasi, *Commun. Soil Sci. Plant Anal.*, 33(2002), 2011–2020.
 [3] *Circular Economy Package*, 2016/0084, Brussels (2016).

minimum quantities: 2% by weight of total nitrogen of which 0,5% by mass of the fertilizer product must be organic nitrogen or 2% by weight of total phosphorus pentoxide (P₂O₅) or 2% by mass of total potassium oxide (K₂O). Therefore, it is necessary to carry out the phosphorus and potassium analyzes, using the concentrated leachates, to verify the possible content in one of the required nutrients.

For the characterization of total phosphorus, the standard solutions were analyzed to attain the regression curve in order to obtain phosphorus concentration in the samples. The samples were analyzed in sequence, following the same conditions applied to the standards. In Table 3, data referring to absorbances and concentration %w/w of each sample is presented, in addition to the minimum concentrations required by the legislation.

Table 3. Concentration %w/w of P₂O₅

Sample	Absorbance	Concentration (% m/m)
EU, 2016	-	2
24x	0,144	0,036
50x	0,345	0,039

The values obtained are below the minimum required by the legislation, even in more concentrated samples such as that was concentrated 50 times in relation to the original residue. These values represent a low concentration of P₂O₅ in the sample collected from the supernatant waste, stored in the resting tank.

Conclusion

The concentrated leachate shows potential to be used as fertilizer after simple processing. It displays high values of pH and concentration of total organic carbon (TOC) and low levels of heavy metals. Therefore, a few adjustments must be made, especially in pH and heavy metals concentration. Nitrogen and phosphorus presented low concentrations, mainly due to the composition of the sample used, since more than 99% was composed of water. Samples richer in organic content should be analyzed, as well as the samples taken directly at the exit of the plant, instead of the storage open tank where the effluent is collected, before it is sent to the treatment process. These samples may show higher levels of organic carbon and nutrients without requiring an initial concentration process. Seasonal factors also introduce complications for the characterization of the residues, because they induce large variations of composition of the material, which is exposed to external contaminants and weather conditions. This problem could be overcome through the introduction of a mixing previous step for homogenization of the residue, minimizing the need for further correction processes of composition to adapt the liquid waste to fertilizer legislation composition requirements. Though, the potential use of these wastes as fertilizers is still worthy of further studying because it represents the production of a high value-added material and, in addition, the recycling of wastes that are currently only regarded as pollutants which need to be treated.