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CH4 abatement in fungal biofilters: exploring the effect of the pH and the packing material.

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In this case has comparatived the effect to pH in the biodegradation the methane with fungus *Fusarium solani,* this investigation has importance for the treatment for low concentrations 5% of methane, the three biofilters operated with packing expanded clay “arlita”, compost, different conditions of pH an 4.6 – 7- 8, the influence of pH is very critical for the fungus colonies and the biofilm, the air flow was 32 mL/min and the concentration for methane was 2%, the biofilter with the pH 4.6 hadn’t remotion but the second biofilter had 40% the set-up was normal and without glycerol, the leached keep to 7, after the removal lowed and added 10 ml/L of glycerol and climbed the remotion the pressure drop maintained to 1 mmH2O . The removal to methane had good results, and would open ways for the investigation, the third biofilter the remotion was 90%, the composition pf compost was analysed with molecular PCR test for identification the microorganism.

* 1. Introduction

The methane is the principal problem in the actuality, it’s considered the second gas more existing in the atmosphere, belongs from of COVs the thermal action affects the ozone layer causing the greenhouse effect. The nature is able to absorb the effects of the contamination under certain conditions but some types of gases are difficult and the nature is unable of assimilate. The production of methane mostly it’s coming from of livestocks industries, the high consume of meat it has generated the increase the breeding of the animals from human consume the consequence it’s increase of manure and generates bad odors , the enteric fermentation produce methane in specific are gases “wind” like result of process of digestion, the amount of methane produced depend of the animal and alimentation organic carbon has the reactions of oxidation and reduction producing methane and carbon dioxide. With the characteristics of methane and the investigations show the limitation between the transference of mass with the biofilm the cause is the low solubility the methane. The news technologies combine to the metabolic potential from the microorganism with the engineering; when it is used biological material always the system is conditioned with operational changes (Josiane y Michèle 2009).

The biofilters have different set-up and each one depend on the type of gas what will remove, the packing is important, the conditions of absorption allow to form an appropriate bed for the formation the biofilm. The moisture for the packing is considerate between 40% or 60% it should maintained the balance between relative moisture and packing. («Tratamiento biológico de compuestos orgánicos volátiles de fuentes fijas - Beatriz Cárdenas González - Google Libros» [sin fecha]), the effect of pH is a parameter that be should control, the abrupt changes could low the efficient of biofilter, the optimal pH is 6.5-7 (-Rodríguez et al. [2017]). Existing some treatment with microorganisms like methanotrophic bacteria, the reactions of oxidation and reduction depending of the enzymes monooxigensas according to (-Rodríguez et al. [2017]) the mount of oxygen and methane should be enough for which existing the reactions of oxido-reducttion, now the investigations bet to use of treatment with fungus (Lebrero et al. 2016) analysed the potential of degradation of methane with mix of the bacterias and fungus *Graphium sp*. The fungus and microorganisms existing into biofilm survive in cooperative mode forming ecological functions (Dwivedi y Dwivedi 2022). The structure of fungus help it to transport of mass when interaction with the bacterias, the fungus *Fusarium solani*  is considered like filamentous fungus therefore (Douterelo et al. 2018) mentioned what the filamentous fungus provide the basic elements or be a biotic support through the hyphae for the colonization the bacterias on the packing.

* 1. Materials and Methods
		1. Inoculum and mineral medium preparation.

The activation of strain *Fusarium solani* was made in specific medium for the fungus Bulion Sabourauda, the strain remained was prepared 0.2 L of inoculum for the first time and has been made active in to petri plates with Bulion sabourauda agar this with the purpose of to see what the strain without contamination, for the second time was prepared 0.2L of the inoculum and grew up in 1800 mL of the medium Sabourauda. For the experimentation was proved two mineral salt medium, the first medium has a few elements this medium is according to (Marycz, Brillowska-D ˛ Abrowska y G˛ Ebicki [sin fecha]): the second medium is complete has much nutrients (Vergara-Fernández et al. 2019): 18 /L NaNO3, 1.3 g/L KH2PO4, 0.38 g/L MgSO4\*7H2O, 0.25g/L CaSO4\*2H2O, 0.055 g/L CaCl2, 0.015 g/L FeSO4\*7H2O, 0.0023 g/L MnSO4\*H2O, 0.013g/L ZnSO4\*7H2O, 0.0023 g/L CuSO4\*7H2O, 0.0015 g/L CoCl2\*6H2O, 0.0015 g/L H3BO3p0, when the set-up of the BFs has changed to BFT.

**2.2. Biofilters**

The biofilters consisted of a jacketed PVC column with 0.8 m height and 0.08 m of inter diameter, the total volume of the packing was 2L and the flow air 0.032 L/min, the irrigation with the medium was each 12 hours 100 mL in the morning and 100 mL in the night. The concentration of pure methane was 2% v/v. the volume recirculation was 2 m/h.

**2.2. Experimental and analytical procedure.**

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| **Inóculo** | **Relleno** | **MSM** | **pH** | **EBRT** | **Set-up** |
| *Fusarium solani* | Arlita | Complete | 4.6 | 45 | Normal/biotrickling |
| *Fusarium solani* | Arlita | Incomplete/ Complete | 7 | 45 | Normal/biotrickling |
| *Fusarium solani* | Compost | Incomplete/Complete | 8 | 45-18 min | Normal. |

The experiment had some changes like pH, configuration, and packing, the removal and efficient depending of the biofilm and the metabolic activities the fungus and microorganism. The first set up for the biofilters were without recirculation, the mineral salt medium incomplete had 6.7 and the mineral salt medium complete had pH 4.6. The first biofilters worked with only medium complete with a pH 4.6.

The day...... It was changed the set up to biotrickling. For the second biofilter worked with medium incomplete to pH 7 and de second medium to adjusted 7 with a solution of NaCl, 0.2 M. For the second biofilter with *Fusarium solani* and the packing arlita operated for 129 da permanecer ys, pH to 7 and used both the MSM since the star until the day 40 it was usted MSMI after it was used to MSMC this change allowed to get better the remove of methane, the first 43 days it was set up with EBRT 42 minutes and air flow with 48 mL/min, the day 45 changed the EBRT to 45 minutes, the day 93 it was changed the EBRT for 63 minutes and the air flow out 32 mL/min from of the day 102 it was changed to set up of biofilter normal to biotrickling biofilter this condition remained until finish the experimentation. The day 111 it was added in the MSMC 10 mL/L of glycerol where take out 100 ml the MSMC and exchange for 100 mL of new MSMC with gycerol. The day 123 changed the MSMC for new MSMC without glycerol and it wass added 10 mL of glycerol for every 100 mL of the MSMC that was changed.

The first biofilters were set up for the leached of MSM added fall into the cone and can remove for the other analisis. Every day it had the control about the results,especially the flows out of the biofilters and the leached was analyzed carbon organic total (TOC-IC).

This biofilter worked 94 days with the normal configuration, after it changed the set up to biotrickling. The third biofilter maintained to pH 8 the set up during all experiment. .

The third biofilter was inoculated with *Fusarium Solani* between compost and little rings of polypropilene operated for 129 days, since 0 day until 38 day operated with a EBRT 42 minutes and with air flow out 48 mL/min, the day 39 it was changed to the EBRT 45 minutes and air flow 44 mL/min this condition remained until to 61 day, the day 62 changed the EBRT 30 minutes with the air flow out 60 mL/min, the day 93 it was changed to the EBRT 24 minutes with the air flow out 82 mL/min, /the day 111 it was changed to EBRT 18 minutes with air flow of 110 mL/min, during the experimentation existed a period of acidification the leached for counter the effect was added the NaOH- 1M the final ajusted MSM pH to 8; the day 40 was changed the MSMI for MSMC.

The last biofilter was inoculated with *Fusarium Solani* and MSMC to pH 4,6, the experimentation finished after 70 days, it was started with EBRT 45 minutes and with an air flow 44 mL/min after the day 34 was changed the EBRT for 63 minutes and with an air flow out 32 mL/min the day 43 it was changed the set up of normal biofilter to biotrickilng biofilter, the day 52 it was added in the MSMC 10 mL/L of glycerol where take out 100 ml the MSMC and exchange for 100 mL of new MSMC with gycerol. The day 64 changed the MSMC for new MSMC without glycerol and it wass added 10 mL of glycerol for every 100 mL of the MSMC that was changed.

* 1. Results

**3.1. Equipment calibration**

The equipaments calibration was made for parts, the first equipment was peristaltic pums to 4 measure of water flow at 200,300,400,500 ml/min, in the calibration curve was adjusted the measure to 100 ml/min. for the second equipment was rotameters for air flow and the last rotamer for the methane in this got the 2% v/v. the abiotic test was important, it was check that there are not leaks, the test keep for 2 days, the results were input equals output.

3.2. Efficient the biofilters

The efficient of biofilters depending the some factor like transfer of mass, biofilm, nutrients, and condition of operation, for the three biofilters the initial conditions of concentration was 2%, the first biofilter operated for 70 days with only medium MSM complete the set-up is normal it hadn’t some change, for the first 33 days the flow out air was 44 ml/min, in the packing was observed grown of the biomass near of the arlita, the production of CO2 the first day was 9.71 $g/m^{3}h$ then it decreases until get 0,436 this showed that it didn’t exist metabolic activities and % RE got 5.05%, the removal for this process was is not efficient, the medium to adjusted to pH4.6 nevertheless the day 43 the set up changed to biotrickling assuming that would improve the transfer of mass this it was not possible, the day 54 day had added 10 ml/L of Glycerol, the grown of biomass was evident in the packing and it had a jump in the effect the removal to 25.02%, the removal percentages began to decrease and remained in a range of 11%, the removal by microorganisms was affirmed by the existence of a high CO2 production.

The second biofilter was operating 128 days in the first configuration was normal having a leachate at the end of the cone on the day 33 it began to degrade methane without the presence of methane the percentage of degradation became close to 40% as an indicator of metabolic activity was the production of CO2 during the 58 days of operation the biofilter worked with an MSM at an acidic pH starting on day 59 the pH was regulated to 7 in wich the percentage of removal reached 37%, this percentage remained stable for 5 days and later began to decrase in order to copare the biofilters it was decided to change the configuration to biotrickling in this instance 10 ml/L of methanol was inserted to show if there is any cometabolism route. The methane removal did not improve with each decreasing day however biomass production was evident in the packing and CO2 production increased.

The BF3 was inoculated with Fusarium Solani in a compost medium, the operation was carried out from day 15 to day 92 with several changes in the both the EBRT and the chemical composition of the medium. The MSM %RE curve shows an increasing trend but in particular a rise is shown from day 40 which coincides with the change in the mineral medium, the increase is significantly high, going from 33.77% to 76, 51% and after that the ascent of the curve reaches its maximum point of 95% removal of methane gas. One of the comparison parameters is the change in pH this was kept at a pH of 7 and bacteria from dying with the process aod acidification and alkalination. This mixture of bacteria and fungi has allowed it to have a very high effectiveness however there are values that oscillate around 70% the microbial community works alongside the fungal community there is reseach that mencions the effectiveness of a consortium of bacteria and fungi.

* 1. Conclusions

The biofilters were inoculated with *Fusarium solani*  in a complete and incompleted mineral medium of mineral salts at an acidic pH with an EBRT residence time of 45 minutes with the normal configuration of the BF there was no removal of methane however the configuration of the biofilter was changed to continued as biotrickling despite the changes that were made there was no degradation of methane when adding glycerol in the mineral medium there was a jump in methane degradation of 25% the elimination capacity was 3.13 the following days the percentage of low removal because excess biomass growth.

The pH of the mineral medium is fundamental for the feeding of the microorganisms this is evidenced in the BF2 which was inoculated at pH 7 maintainig this pH the growth of the biomass and the compaction in the fill was successful, methane degradation existed only in the normal configuration biofilter without the addition of methanol with an EBRT of 45 minutes, when changing the configuration to biotrickling there was no degradation however methanol was added to help cometabolism between fungi and bacteria, the biofilm having degradation and production of CO2 in percentages that allow the study of future metabolic pathways of fungi.

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