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SUBSTRATE ADDITIVE FOR BIOLOGICAL DEPURATION

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Abstract. *The following study presents the results of testing of a substrate liquid added to a pre-existing system of biological filtration process air of a composting plant. The substrate under test is a mixture of micro and macro nutrients useful to improve the efficiency of degradation in the cases of degradable pollutants from microbial metabolism in the presence of a ratio C : N : P equal to 200 : 10 : 1. The tests were conducted in the field by applying the substrate in liquid form to a biofilter present in a plant for composting. The biofilter involved in the trial receives the effluent gases captured from the section of accelerated bio-oxidation system. The distribution of the substrate was carried out manually above the filter surface and the quantity of substrate used has been established in relation to the pollutant load input to the garrison to environmental and chemical-physical characteristics of the filter material. The effect of the use of the substrate was evaluated in terms of concentration of microorganisms in a cm^3 of filter material and the method used for this measurement was that established by Standard EN ISO 6222 of 1999.*

Key words: *degradable pollutants, biological filtration, biofilter, composting plant, microbial metabolism*

1. INTRODUCTION

The biological purification of flue gases is important in case of biodegradable substances. The decomposition of the pollutants is carried out by microorganisms that colonize a solid substrate support [7]. Support materials most commonly used are: wood chips, bark, peat, heather, and other similar materials, whether or not mixed together [11].

To ensure optimum operation of the biofilter [1] it is necessary to be the best conditions to promote the activity of microorganisms:

• humidity;
• pH;
• temperature;
• organic substance in the substrate;
• adequate time of contact between the effluent and the, material [5, 12].

For air that passes through the biofilter must be guaranteed a minimum contact time equal to about 60 seconds, equivalent to a maximum volumetric loading of 60 m^3 of air per hour per cubic meter of biomass filter [2]. The biofilter is constituted by biologically active material, resistant to compaction, with a good water retention capacity [9]. The moisture content should be maintained between 50% and 70%, it is good practice to irrigate the surface of the biofilter, humidify the incoming air and remove any drainage.

Fig. 1: Particular composition of the biofilter used.

The pH must be between 5 and 8.5 and should be compensated for any phenomena of acidification related to products that are formed during the biological oxidation. The temperature of the air introduced should preferably be between 10° and 45° C to remain in the optimal range of microbial growth without phenomena of excessive drying [6].

The tests were conducted for a period of 2 months with the preparation of an initial test used as proof "time zero" without the use of substrate.

The results obtained from extractions and microbial counts have shown that the use of the substrate has influenced the performance of the microbial population within the filtering mass according to the steps shown below:

1. the initial average concentration (test t_0) resulted into a value of $400 \bullet 10^2$ CFU;
2. the average concentration after 15 days (test t_1) by the application of the substrate resulted into a value equal to $2800 \bullet 10^3$ CFU;
3. after 30 days (test t_2) the value was equal to $7500 \bullet 10^3$ CFU;
4. after 45 days (test t_3) the value was equal to $1800 \bullet 10^3$ CFU;
5. after 60 days (test t_4) the value was equal to $100 \bullet 10^3$ CFU.

2. MATERIAL AND METHODS

The tested product allows a rapid rise in the concentration of microorganisms in the unit volume of treated matrix, adding a substrate composed of micro and macro elements of water wetting and is dosed in order to obtain a CNP ratio equal to 200:10:1 [3].

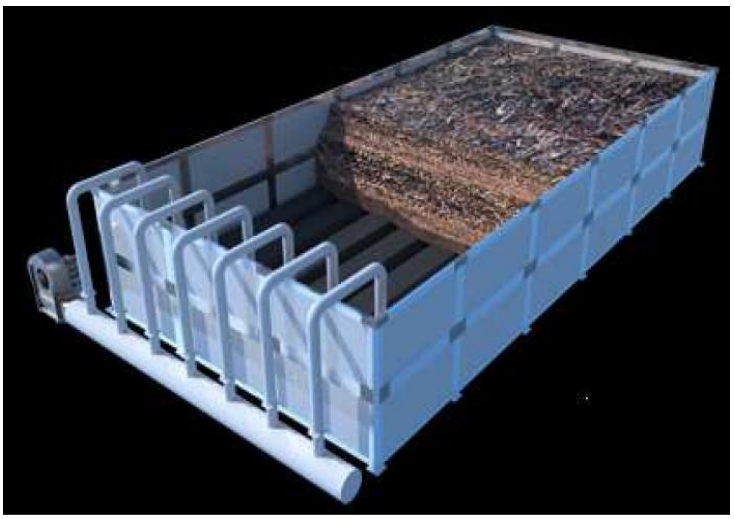

Fig. 2: Schematization of purification process by the use of the biofilter.

2.1 Tests performed

The checks carried out to the substrate have been completed in 2 times. Were initially drawn to scale within a laboratory operating conditions of a biofilter and then it turned to field trials of a bio-active in a plant for compost quality.

2.2 Tests in laboratory

Each of laboratory models has been realized by means of a bath in plexiglass with the double bottom, for the forced passage of air and the collection of the drain system. For the wetting of each of the systems has been used a volume of 3 liters of the drain of a biofilter after a characterization of the parameters COD, BOD, N and total sulfur compounds.

The 3 models have been filled with a volume of 0.125 m^3 and wood chips were used to obtain respectively:

- the model 1 for the reference test, known as "white";
- the model 2 for test n. 1, called "test concentration to 1% by volume";
- the model 3 for test n. 2, called "test a concentration of 5% by volume".

To evaluate the efficiency of the system was measured in each of 3 models the concentration of CFU per cm^3 of wood chips and the parameters COD, BOD, total N and sulfur compounds to the drainage system.

The measurements on each of the 3 models were conducted in n. 5 periods:
- at time zero, before the application of the substrate, "time 0";
- at 15 days from the application of the substrate, "time 1";
- at 30 days from the application of the substrate, "time 2";
- at 45 days from the application of the substrate, "time 3";
- at 60 days after the application of the substrate, "time 4".

2.3 Field testing

For field testing was added to the product, at concentrations equal to 1% by volume, of the biofilter irrigation water present in a plant for compost quality [8, 10].

To evaluate the efficiency of the system was measured before and after the addition of the substrate the concentration of CFU per cm^3 of wood chips and the parameters COD, BOD, total N and sulfur compounds to the drainage system.

Measurements were conducted in 5 periods:
- at time zero before the application of the substrate, "time 0";
- at 15 days from the application of the substrate, "time 1";
- at 30 days from the application of the substrate, "time 2";
- at 45 days from the application of the substrate, "time 3";
- at 60 days after the application of the substrate, "time 4".

2.4 Determination of total viable count in water and wastewater

This test method is based on a procedure EN ISO 6222:1999.

Water of all kinds invariably contain a variety of microorganism [4] derived from various sources such as soil and vegetation and estimation of the overall numbers provide useful information for the assessment and surveillance of water quality. Most bacteria capable of growth in potable water and natural surface waters in temperature climates will grow better in culture media at 22°C than at higher temperatures. Organism that grow best at 37°C usually grow less readily in potable water and are likely to have gained access from external sources particularly of human or animal origin.

These two groups of organism are counted separately of ground water sources and the efficency of water treatment process such as coagulation filtration and disinfection and provide an indication of the cleanliness and integrity of the distribution system.

In pool waters, the colony count at 37°C is used as these organism are most likely to have been derived from the bathers and are a better measur of the disinfection of the pool water.

The main value of colony counts lies in the detection of changes from those expected, based on frequent long temr monitoring. Any sudden increase in the count can be an early warning of serious pollution and calls for immediate investigation. It is therefore important that the same tecnique and media should always be used to examine a given water sample. For the purpose of this method the following definition applies: colony count (culturable micro-organism), various synonyms are frequently used instead of "colony count", these include heterotrophic colony count, viable count, plate count and culturable micro-organism. Measured volumes of the sample or dilutions of the sample are mixed with molten yeast extract aqar in sterile Petri dishes and incubated under the conditions specified. Calculate the number of colony forming units (CFU) per millilitre (ml) of the sample from the number of colonies.

2.5 Procedure with reagents and apparatus

Reagent that occured in these tests are:
- milli-Q water, pour plate agar, ringer solution.
- waterbath, 45°C +/- 1°C;
- boiling waterbath;
- incubator, 22°C +/- 1°C, 37°C +/- 1°C;
- petri dishes;
- autoclave;
- colony counter.

Aseptically measure a 1 ml volume of sample or dilution into a Petri dish using a automaic pipettor and sterile tips. Aseptically pour approximately 15-20 ml of melted extract (PCA) which has been cooled to 45°C, into the Petri dish. The time elapsing from when the prepared dilution or neat sample in inoculated into the Petri dish and the moment when the mediun is added shall not exceed 15 minutes.

Immediately mix the sample and agar carefully for at least 10 seconds, by rotating to the Petri dish clockwise three times, anti-clockwise three times and clockwise a further three times. It is essential to keep the Petri dish flat on the bench throughout the procedure.

Allow the agar to set. Invert the Petri dishes and incubate.

3. RESULTS AND DISCUSSION

Calculate the colony count as follow:

$$\text{colony count (ml of water)} = \frac{\text{numbers of colonies}}{\text{volume tested}} \text{ x dilution factors}$$

3.1 Results of tests in laboratory

The obtained results will be shown in schematic form in order to make the data acquisition more immediate.

Table 1: Results of the parameters analyzed at time zero "white".

Parameter	Units	Time zero "white"				
		Time 0	Time 1	Time 2	Time 3	Time 4
CFU/cm^3	CFU	70 * 10^2	100 * 10^2	110 * 10^2	90 * 10^2	100 * 10^2
COD	mg/l	1060	1100	1000	1075	1110
BOD_5		880	910	950	900	950
Total N		1200	1310	1150	1220	1200
Sulfur compound		65	50	55	50	55

Table 2: Results of the parameters analyzed for test concentration to 1% by volume.

Parameter	Units	Test concentration to 1% by volume				
		Time 0	Time 1	Time 2	Time 3	Time 4
CFU/cm^3	CFU	$85 * 10^2$	$50 * 10^3$	$320 * 10^3$	$120 * 10^3$	$100 * 10^3$
COD	mg/l	1100	1005	1090	950	930
BOD_5		930	1095	1265	1200	1250
Total N		1100	1050	1000	975	990
Sulfur compound		60	35	40	35	35

Table 3: Results of the parameters analyzed for test concentration to 5% by volume.

Parameter	Units	test a concentration of 5% by volume				
		Time 0	Time 1	Time 2	Time 3	Time 4
CFU/cm^3	CFU	$85 * 10^2$	$50 * 10^3$	$240 * 10^3$	$300 * 10^3$	$260 * 10^3$
COD	mg/l	1150	1100	1100	990	975
BOD_5		1000	1250	1425	1395	1400
Total N		1065	995	845	810	800
Sulfur compound		60	40	25	30	30

In the following figures it can be seen, in graphic form, the pattern of results of the experimental tests.

3.2 Results of field testing

The obtained results will be shown in schematic form in order to make the data acquisition more immediate.

Table 4: Results of the parameters analyzed for field testing.

Parameter	Units	Field testing				
		Time 0	Time 1	Time 2	Time 3	Time 4
CFU/cm^3	CFU	$400 * 10^2$	$2800 * 10^3$	$7500 * 10^3$	$1800 * 10^3$	$100 * 10^3$
COD	mg/l	1830	1705	1770	1940	1735
BOD_5		1250	1990	2100	1845	1770
Total N		1300	1410	1260	1035	940
Sulfur compound		70	65	45	50	30

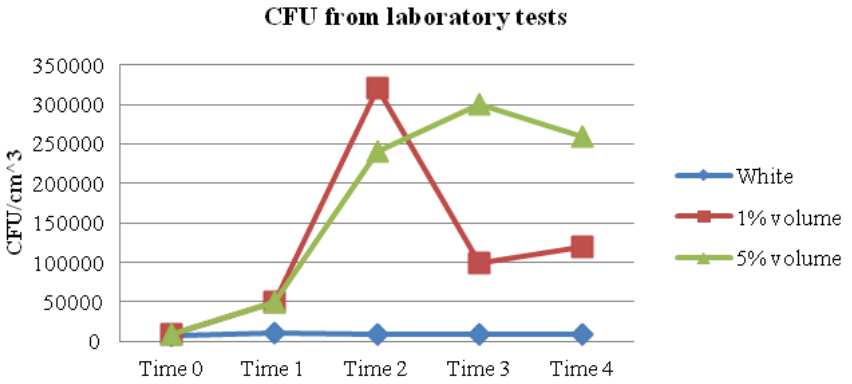

Fig. 3: Results of CFU from laboratory tests.

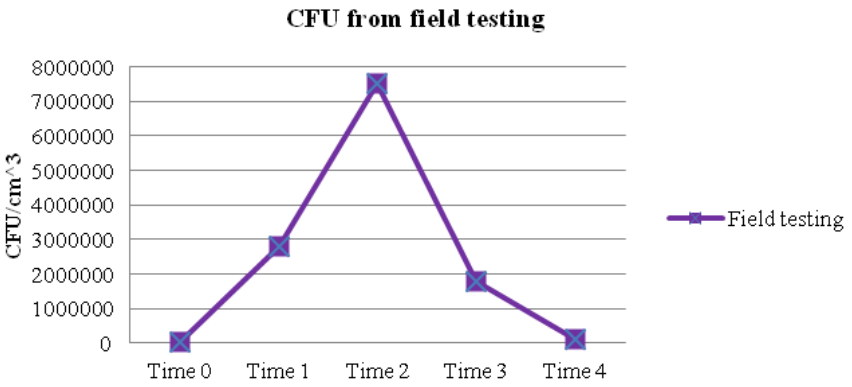

Fig. 4: Results of CFU from field testing.

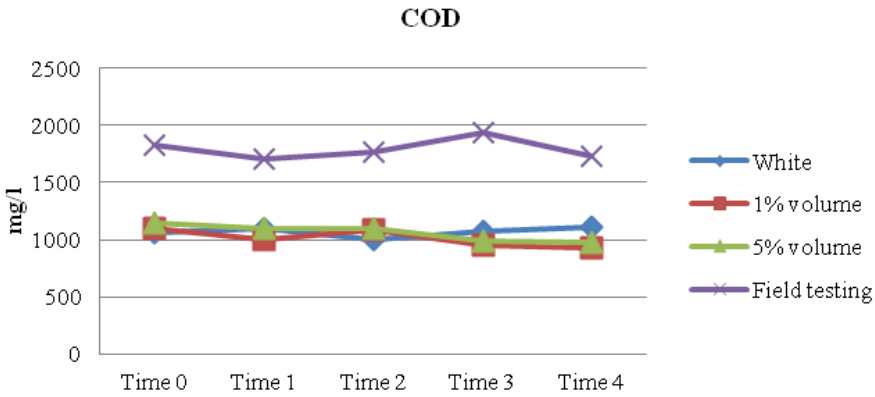

Fig. 5: Results of COD from laboratory tests and field testing.

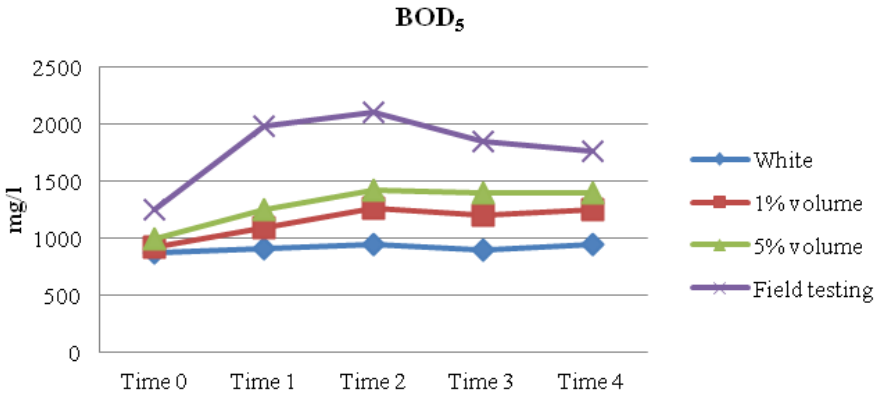

Fig. 6: Results of BOD_5 from laboratory tests and field testing.

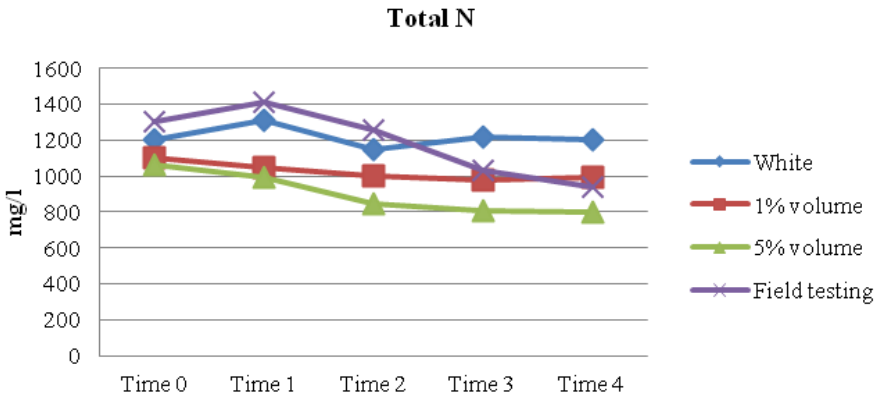

Fig. 7: Results of Total N from laboratory tests and field testing.

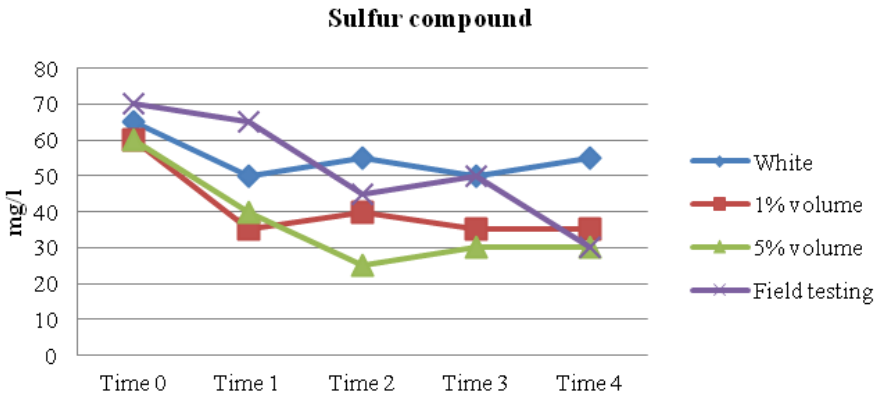

Fig. 8: Results of Sulfur compound from laboratory tests and field testing.

4. CONCLUSIONS

Starting from results just been reported it is possible to say that the biotic conditions put in place following the distribution of the test substrate above the substrate present in the biofilter, can significantly affect the density of microbial colonies present on the wood chips. It is possible to indicate the period of maximum effectiveness in the time interval between 15 and 45 times days of test 3 and 4. In order to assert hipotesys expressed before.

In support of the above argument is also useful to observe the evolution of the concentration of nitrogen compounds and sulfur. In both cases it is noted a significant reduction of both classes of pollutants monitored.

REFERENCES

1. Cabrol, L., Malhautier, L.; Poly, F.; Roux, X. L., Lepeuple, A.S., Fanlo, J.L. (2012): Resistance and resilience of removal efficiency and bacterial community structure of gas biofilters exposed to repeated shock loads, Bioresource Technology 123, 548-557.
2. DIN 18910. (1974): Klima in geschlossenen Stallen, Wasserdampf und Warmehaushalt im Winter, Luftung, Beleuchtung.
3. Don J.A. (1986): The rapid development of biofiltration for the purification of diversified gas streams, VDI-Berichte, Dusseldorf, VDI Verlag GmbH., 561, 63-74.
4. Fischer, G.; Albrecht, A., Jäckel, U.; Kämpfer, P. (2008): Analysis of airborne microorganisms, MVOC and odour in the surrounding of composting facilities and implications for future investigations, International Journal of Hygiene and Environmental Health 211, 132-142.
5. Fischer, K. et al. (1990): Biologische Abluftreinigung. Anwendungsbeispiele. Moglichkeiten und Grenzen fur Biofilter und Biowascher, TAE Kontakt und studium, Bd.212 Ehningen, Expert Verlag.
6. Hoja, L. (1987): Abluftreinigung mit Biofiltern. Biotechnologie, Berlin. Techn. Universitat, 7-8 87, S.8.
7. Jager, J. u H. Schildknecht. (1979). Grundlagen der biologischen Abluftreinigung, Teil I – Chemie der organischen Luftverunreinigungen und Geruchsstoffe, Staub. Reinh. Luft 39, 5, S.149.
8. Mao, I. F.; Tsai, C. J., Shen, S. H.; Lin, T. F.; Chen, W. K.; Chen, M. L. (2006): Critical components of odors in evaluating the performance of food waste composting plants, Science of the Total Environment 370, 223-229.
9. Schirz, S. (1986): Mit Biofiltern gegen Dicke Luft Landfreund, Bern (CH), Verlag Hallwag AG, 23 v.6.11.86, S.31 36 .
10. Schlegelmilch, M.; Streese, J.; Biedermann, W.; Herold, T.; Stegmann, R. (2005): Odour control at biowaste composting facilities, Waste Management 25, 917-927.
11. Steinmuller, W., G. Claus u. H.-J. Kutzner (1979): Grundlagen der biologischen Abluftreinigung, Teil II – Mikrobiologischer Abbau von Luftverunreinigenden Stoffen. Staub. Reinh. Luft 39, 5, S.149-152.
12. Tyrrel, S.F.; Seymour, I.; Harris, J.A. (2008): Bioremediation of leachate from a green waste composting facility using waste-derived filter media, Bioresource Technology 99, 7657-7664.