BIOGAS IMPACT MITIGATION THROUGH BIOCOVERS:
LAB TESTS AND ANALYSIS IN SITU FOR THE CHARACTERIZATION
OF FILTERING MEDIA

Extended abstract

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Background

Among the several technologies for mitigation of landfill gas emission, this research deals with interim systems which can be used as daily cover.

Aiming to identify the parameters that can help to define the quality of filtering material suitable for daily biocovers, several research were carried out, both lab tests that field trials. It is estimated that in 2010 more than 2 million tons of Stabilized Humid Fraction (SHF) from mechanical-biological treatment were produced in Italy, and that more than the 80% of this fraction is disposed in landfill and the remaining parts is used to realized the final covers. Furthermore, the legislation allows the use of this material for the daily covers, but in landfills where this is done, problems of odor nuisance perceived by the neighbor population are very common.

Objectives

The objective of this research is therefore to define quality parameters that suggest that the SHF analyzed is suitable for daily biocovers for gas emission mitigation. In particular, Biochemical Methane Potential (BMP) and Dynamic Respiration Index (DRI) tests have been performed as well as specific test to determine the mitigation efficiency of the daily biocover (emission measurement).

Our paper will show the main results of three work steps:
1. determination of stabilization parameters (BMP, DRI, SV, Water content);
2. study of the possible reactivation of aerobic or anaerobic processes in the SHF sample through a specific lab test;
3. monitoring campaign on the daily cover to assess the mitigation effect of the SHF.

Methods

At the beginning, in order to characterise the different filtering materials many parameters were carried out, in particular for every SHF analysed it was determined: BMP, DRI, SV, Water content and pH.

Moreover, to measure the emission flux on daily covers the accumulation chamber was used in field tests. Finally, during the pilot tests, two batch reactors were used in order to create aerobic or anaerobic conditions and to simulate the emissions naturally present in a landfill cover. Both determination parameters and lab test were carried out on different sample of SHF. The flux of biogas form the cover was measured according with the Static Accumulation Chamber method (Corti et al., 2009; Huber-Humer et al., 2011).

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An infrared concentration level detector, Ecoprobe, was used for the first time used with the accumulation chamber method. Ecoprobe 5, produced and calibrated by RS Dynamics Ltd. (Prague, Czech Republic) is a tool for a fast and cost-effective in-situ mapping of hydrocarbons and other organic contaminants in the subsurface environment.

For every measurement point, the following procedure was repeated:
- Location of sampling point by means of a GPS (Global Position System) instrument following a regular grid;
- Preparation of the sampling surface in order to ensure optimal adhesion of the chamber to the soil, thereby preventing gas from escaping during measurement;
- Survey and acquisition for 2-3 minutes of the concentration (ppm) of CO2 and CH4 inside the chamber.

To determine the possibility that in the SHF filtering materials the degradation process are reactivated, the residual biogas potential production and the residual respiration index after the mechanical-biological treatment were evaluated.

To estimate the biogas potential production of each SHF, the BMP analysis were carried out in duplicate and both the BMP21 (biogas produced at 21 days) and the BMPf (when no significant biogas production is detected) were measured. For analysis a modified manometric method has been applied (Ponsa et al., 2008; Hansen et al., 2004).

The BMP was determined using 1L stainless steel bottles, incubated in a water bath at 37.7°C, tightly closed by special cap provided with a ball valve to enable the gas sampling. To ensure anaerobic conditions, the bottles were flushed with inert gas. All the equipment, 2 bar proof pressure, was specifically design and developed.

The dynamic respiration index was determined according to Adani et al. (2008). The oxygen uptake was determined by measuring the difference in oxygen concentration between the inlet and outlet air flow, the air having passed through the biomass, as well as by using knowledge of the absolute content of starting SV in the biomass, the flow rate, and the time during which oxygen consumption was measured. The time test length depended by the material stability degree and lag-phase occurred and ranged from few hours to three days.

In order to assess the potential reactivation of aerobic or anaerobic degradation on the top of daily cover, some batch reactor tests were carried out. In particular it was tested every filtering materials during a period of 24 hours; during the test several parameters were monitored to detect possible degradations events as temperature (both internal and external), air or biogas in-let flow, atmospheric pressure, methane and CO2 emission flux. Two adiabatic cylindrical batch reactors are used. To perform the tests specific measurement protocols were preliminarily defined.

Results and discussion

1. Lab tests results

With the aim to assess the range of emission flux on daily cover in an active landfill measurement campaigns with the accumulation chamber were carried out.

The flux measurements were performed directly on the waste and during working activity. The range of methane flux was found to be about 11.31±3.3 CH4 mol/m2*day and in case of CO2 flux is about 40.87±3.7 CO2 mol /m2*day. The CH4/CO2 ratio was about 0.3 because in the daily cover oxygen concentration don’t allow to start the anaerobic process. From the data analysis it was observed a variability of the measured data; observing the pressure values measured at the time of each flow measurement, the atmospheric pressure seems to be a forcing parameter.

The results of the laboratory tests had proved the absence of reactivation of the biological stabilization...
Fig. 1 compares the reactor temperature measured in the lab tests. The internal temperatures of the reactor, both in the case of aerobic than anaerobic conditions, measured on the sample of SHF1 were found to be greater than those recorded for the SHF2, up to a maximum difference 23 °C with reference to the first 24 hours, and 49 °C when considering the entire duration of the aerobic conditions test. It should be noted that in both cases the samples SHF1 in phase transfer were characterized by higher temperatures.

Table 1. Stabilization parameters

<table>
<thead>
<tr>
<th>Density</th>
<th>Porosity</th>
<th>TS</th>
<th>VS</th>
<th>pH</th>
<th>BMP21</th>
<th>DRI, potential</th>
<th>DRI, real</th>
<th>Initial Temp.</th>
<th>Initial CH₄ flux</th>
<th>Initial CO₂ flux</th>
<th>Initial H₂S conc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/m³</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td></td>
<td></td>
<td>moliCH₄/m²*day</td>
<td>moliCO₂/m²*day</td>
<td>ppm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHF1 2811A</td>
<td>575</td>
<td>49</td>
<td>60</td>
<td>43</td>
<td>6</td>
<td>276</td>
<td>1195</td>
<td>59</td>
<td>1.82</td>
<td>19.80</td>
<td>1.2</td>
</tr>
<tr>
<td>SHF2 0512A</td>
<td>431</td>
<td>56</td>
<td>82</td>
<td>42</td>
<td>8</td>
<td>180</td>
<td>849</td>
<td>53</td>
<td>0.03</td>
<td>3.37</td>
<td>1.8</td>
</tr>
<tr>
<td>SHF1 1212AN</td>
<td>537</td>
<td>46</td>
<td>52</td>
<td>46</td>
<td>6</td>
<td>344</td>
<td>1126</td>
<td>34</td>
<td>0.03</td>
<td>3.31</td>
<td>1.2</td>
</tr>
<tr>
<td>SHF2 1912AN</td>
<td>428</td>
<td>57</td>
<td>89</td>
<td>41</td>
<td>9</td>
<td>241</td>
<td>993</td>
<td>63</td>
<td>0.03</td>
<td>0.66</td>
<td>5.3</td>
</tr>
</tbody>
</table>

The results of the laboratory tests had proved the absence of reactivation of the biological stabilization.

Fig. 1 compares the reactor temperature measured in the lab tests. The internal temperatures of the reactor, both in the case of aerobic than anaerobic conditions, measured on the sample of SHF1 were found to be greater than those recorded for the SHF2, up to a maximum difference 23 °C with reference to the first 24 hours, and 49 °C when considering the entire duration of the aerobic conditions test. It should be noted that in both cases the samples SHF1 in phase transfer were characterized by higher temperatures.

Moreover the temperatures recorded during the aerobic tests are much higher than those recorded during the anaerobic test in which, as said before, no reactivation phenomena were recorded.

The CO₂ fluxes measured during the tests, agree with what is observable in the temperature graph. The flow measured testing SHF1 under aerobic condition results to be very high and higher to those measured in the other tests by about an order of magnitude.

In laboratory tests there was no evidence about reactivation of degradation processes in anaerobic conditions, and this is probably due to the fact that the kinetics are slower anaerobic with activation times longer than 24-48 hours, more so than the time intervals of interest.

Furthermore, between the two tested SHF, the SHF2 resulted to be more suitable for bio-filtration process because of the lower emissions measured; for this reason it has been used in the field test.

2. Field tests results

In the field test, to assess the mitigation effect of a SHF daily cover a specific monitoring campaign was done. The measurements were done in four different times in the working period:

- before the waste deliveries;
- in the middle of the working day;
- at the end of the waste deliveries

![Fig. 1. Temperature, Comparison between the lab tests performed](image-url)
after the waste covering, on the experimental daily cover.

In particular, for the test, two experimental daily cover were prepared: one in SHF and one in natural soil.

The average daily flow was approximately 5 mol CH₄/m²*day and about 20 mol CO₂/m²*day, and an average H₂S concentration of about 3 ppm is detected in the control volume in contact with the emissive surface.

With reference to the pressure trend in Fig. 2, in the monitoring day a decrease of few millibar was recorded. The emitted flux is low in the first measure when the pressure value is greater (1001 mbar), and stood on the constant values during the other measures of the day.

The flows recorded on natural soil cover show higher CH₄/CO₂ ratio than the ones measured on the SHF cover. In particular, the measured flows show an oxidative capacity of the SHF probably due to the development of methanotrophs bacteria, which usually grow in porous media rich in nutrients (such as compost), able to convert methane emissions into CO₂.