Bio-aerosol and particulate matter evaluation in presence of a LAB-scale Anaerobic Digester for Volatile Fatty Acids (VFAs) production

Leone Mazzeo, Vincenzo Piemonte

Department of Engineering, University Campus Biomedico of Rome, Via Alvaro del Portillo, 21, 00128 Rome, Italy
Keywords: Anaerobic Digestion, Bio-aerosol, fine PM, Volatile Fatty Acids.
Presenting author email: l.mazzeo@unicampus.it

The term *Green jobs* is used to indicate all those working activities that induce a positive effect on the environment in terms of pollution removal, reduction or mitigation (Traversi, 2018). The rapid increase in this kind of occupational employment follows the ecological need of preventing irreversible climate change. In this context the Anaerobic Digestion (AD) of biomasses gained attention for its capability to generate valuable products from food waste (Tuck, 2012). Although AD is commonly used for the production of biogas (CH_4, CO_2 mixture), currently it was investigated as an environmentally friendly alternative for the production of bulk chemicals such as Volatile Fatty Acids (VFAs) (Chen, 2017). Since AD is rich in microorganisms it is crucial to monitor the level of air biological contamination (Anedda, 2019) and of breathable particulate matter (PM_{10}) to prevent the risk of developing health disease for the working operators involved in the daily care of the Digester. The aim of this work is to evaluate the air contamination to bio-aerosol and particulate matter in presence of a LAB-scale anaerobic digester for the production of VFAs.

The experimental activity was conducted in an indoor laboratory at IRSA (Istituto di Ricerca Sulle Acque, Montelibretti, Italy) which hosted a 10 L reactor for the production of VFAs. The working activity consisted in the removal of digestate from the reactor and to loading it with fresh biomass.

Bio-aerosol sampling was performed using a SAS Super ISO 180 sampler (PBI International), which allows microbial monitoring through the use of air contact on apposite Petri plates provided with a cultural medium. The cultural mediums were chosen according to the different microbiologic parameters under investigation: Plate Count Agar (PCA) growth medium was selected for total bacteria count at 22°C and at 37°C; Sabouraud Dextrose Agar (SDA) growth medium was selected for total yeast/fungi count at 22°C. The amount of volume sampled was of 50 L. Once completed the sampling, the Petri plates were incubated at the specific temperature of the particular microbiologic parameter analyzed (specified above). The time required for incubation was 48h for the total bacterial count while 5 days for the total yeast/fungi count. Colony count was performed to quantify the amount of Colony Forming Units (CFU) and to calculate the concentration of biological agents in air in terms of CFU/m3 of air collected. The microbiological contamination was evaluated by applying the Global Index of Microbiological Contamination (GIMC) introduced by Dacarro et al. (Dacarro, 2000).

Particulate monitoring was performed by means of a portable fine dust monitoring unit named PersonalDustMonit (CONTEC Engineering s.r.l.). The instrument is able to measure the mass concentration (µg/m3) of fine particulate in air (PM_{10}, $PM_{2.5}$, PM_1). Moreover, it reports simultaneously the number of particles classifying them in different dimension ranges. The particle size fractions detected were: 0.3 - 0.5 µm ($PM_{0.3\text{-}0.5}$), 0.5 – 0.7 µm ($PM_{0.5\text{-}0.7}$), 0.7 – 1 µm ($PM_{0.7\text{-}1}$), 1 – 2 µm ($PM_{1\text{-}2}$), 2 – 3 µm ($PM_{2\text{-}3}$), 3 – 5 µm ($PM_{3\text{-}5}$). The Principal Components Analysis (PCA) was selected to analyze the variation with time of the number of particles for each size fraction of fine dust.

In Figure 1 the results obtained from Bio-aerosol sampling were reported. The contamination value during the working activity was obtained as the average of three different measurements: sludge removal from the reactor (red dot in Figure 1); reactor loading (black dot in Figure 1); few minutes later the two previous activities (green dot in Figure 1). The concentration of biological agents in air significantly rises during those activities: the amount of biological agents detected in air were 315 ± 140 CFU/m^3 at 22°C and 405 ± 158 CFU/m3 at 37°C with an increase of 350% for both incubations at 22°C and 37°C. Moreover, in Figure 1 it is possible to observe that the critical step of the activity is the removal of digestate from the reactor during which the concentration of biological agents in air reaches the value of 500 CFU/m^3 at 22°C and 600 CFU/m^3 at 37°C. Those result are comparable to the ones obtained by Traversi et al. (Traversi, 2015) . The experimental evaluation of yeast and fungi in air was also performed: an average of CFU/m^3 of 21 and 114 before and during the food waste treatment respectively was observed. The value of the biological contamination index was calculated GIMC=834 which lies in the range 500<GIMC<1000 which corresponds to a low degree of contamination (Traversi, 2015).

In Figure 2 a) the concentration in air of PM_x was reported. The Italian law (D.Lgs n. 155/10) allows a maximum year average concentration in air of 40 µg/m^3 and 24 µg/m^3 for PM_{10} and $PM_{2.5}$ respectively. As observed in Figure 2 a), the amount of PM_x measured in this case is far below such threshold. By means of the PCA, it was find out that only the first two principal components are enough to describe more than the 90% of the

total variance of the system. In Figure 2 b) the two principal components were plotted versus time highlighting the activities that were conducted. Figure 2 b) shows that both the components increased during the Reactor loading/sludge discharging activity.

In conclusion this work assesses the release of biological agent and of particulate matter in the working environment that contains an anaerobic digester for the production of VFAs.

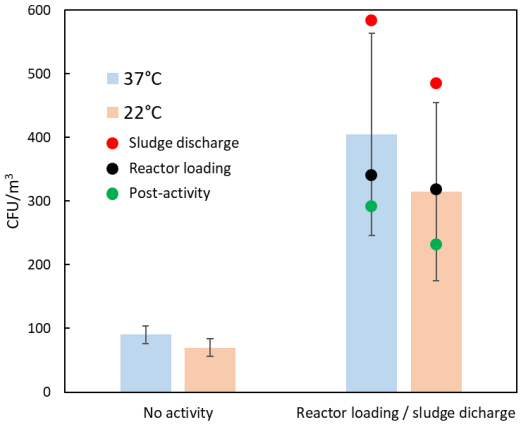

Figure 1. CFU/m3 recorded in air counted on a Plate Count Agar growth medium and incubated at 22°C and 37°C. The red, black and green dots indicate the level of biological agents in air during the sludge exiting operation, during the reactor loading activity and the environment after a few minutes respectively.

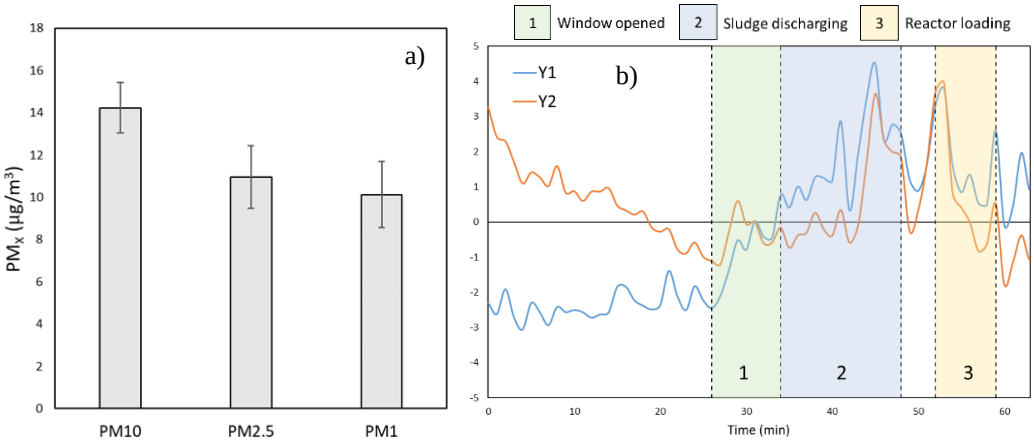

Figure 2. Concentration of PMx particles a); plot of the first (Y1) and the second (Y2) principal component during time b).

Anedda E, Carletto G, Gilli G, Traversi D (2019) Monitoring of air microbial contaminations in different bioenergy facilities using cultural and biomolecular methods. Int J Environ Res Public Health 16(14). https://doi.org/10.3390/ijerph16142546

Chen Y, Jiang X, Xiao K, Shen N, Zeng RJ, Zhou Y (2017) Enhanced volatile fatty acids (VFAs) production in a thermophilic fermenter with stepwise pH increase – Investigation on dissolved organic matter transformation and microbial community shift. Water Res 112:261–268. https://doi.org/10.1016/j.watres.2017.01.067

Dacarro, C., et al., 2000. Proposed microbiological indexes for the assessment of air quality in buildings. G. Ital. Med. Lav. Ergon. 22, 229–235.

Traversi D, Gorrasi I, Bonetta S, Leinardi R, Pietrangeli B, Carraro E, Gilli G (2015) Green job bio-aerosol exposure during anaerobic digestion for biomass energetic valorisation. Environ Res 138(2015):425–431. https://doi.org/10.1016/j.envres.2015.02.035

Traversi D, Gorrasi I, Pignata C, Degan R, Anedda E, Carletto G, Vercellino G, Fornasero S, Bertino A, Filippi F, Gullo M, Gilli G (2018) Aerosol exposure and risk assessment for green jobs involved in biomethanization. Environ Int 114(November 2017):202–211. https://doi.org/10.1016/j.envint.2018.02.046

Tuck CO, Pérez E, Horváth IT, Sheldon RA, Poliakoff M (2012) Valorization of biomass: Deriving more value from waste. Science (80-) 337(6095):695–699. https://doi.org/10.1126/science.1218930