PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXVIII cycle, 2022-25)

Project draft

1.Field of interest

AGR13 ***: biomass recovery, circular economy, bioeconomy***

2.Project title

Use of geological natural gas emission by bioelectrochemical approaches for power to gas

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4. Relevance of the topic and state of the art:

Microbial bioelectrochemical systems (BES) are highly innovative biotechnologies, the study of which has established itself in the scientific community in the last twenty years, with an exponential growth. However, real-world applications have yet to reach a pre-competitive level of development in the many areas that research has focused on. Electromethanogenesis is an innovative microbial electrochemical systems for the production of methane from CO_2 in a power-to-gas concept. With an innovative approach, the proposed research involves the experimentation of systems for interception of CO_2 natural geological gases vent from the subsoil and convert this gas, otherwise discharged into the atmosphere, into energy resources (methane) by natural microorganisms growing on polarized electrodes. The activity will initially focus on the study and measurement of gas flows in order to establish the minimum flow conditions and chemical-physical parameters (temperature, pH, presence of oxygen or other elements) for a possible recovery of gases with technologies of electromethanogenesis. Different sources and discharges of volcanic and geological gas will be investigated and mapped on the Italian territory. The study of the relevant chemical-physical and microbiological parameters of the soils impacted by gas vents and the set-up of monitoring tools is a relevant part of the research. Experimental laboratory tests of electromethanogenesis will be carried out, to test environmentally sustainable materials which can be used for the construction of electrodes and structural parts of the electrochemical cells to be used in sites impacted by gas discharges.

5.Layout of the project (draft)

5.1. Materials & Methods:

Electrochemical tests at laboratory level will be performed with microbial electrochemical systems. Microbial pools will be analyzed and sequenced (by NGS analyses).

An electrochemical monitoring of bacterial biofilms will be studied, set up and tested for monitoring the presence and activity of anaerobic bacteria and archaea underground.

Other tools for the characterization of the chemical-physical parameters of the soils (red-ox potential, conductivity, pH, etc.) will be developed to carry out a real-time monitoring of the gas conversion processes in the subsoil.

DATA sets and GIS mapping of the soils will be used and implemented.

5.2. Schedule and major steps (3 years):

1) First year: Identification and characterization of sites of volcanic gas emissions on the Italian territory of potential interest for the application of the electromethanogenesis process and set up of tools and for monitoring microbial activity and chemical-physical parameters to be used on site
3)Second year: monitoring of site parameters and set up of electrochemical cell with geometries suitable for the identified sites in lab.
2) Third year: select the most suitable site and electromethanogenesis test in field

6. Available funds. Fabrizio Adani-UNIMI and RSE funds**.**

6. Literature:

B. Zakaria e B. Dhar, «Progress towards catalyzing electro-methanogenesis in anaerobic digestion process: Fundamentals, process optimization, design and scale-up considerations,» *Bioresource Technology* , vol. 289, n. 121783, 2019.

F. Geppert, D. Liu, M. van Eerten-Jansen, E. Weidner, C. Buisman e A. Ter Heijne, «Bioelectrochemical power-to-gas: State of the art and future perspectives,» *Trens Biotechnol*, vol. 34, pp. 879-894, 2016.

N. Aryal, T. Kvist, F. Amman, D. Pant e L. D. Ottosen, «An overview of microbial biogas enrichment,» *Bioresource Technology*, vol. 264, pp. 359 - 369, 2018.

A. Kokkoli, Y. Zhang e I. Angelidaki, «Microbial electrochemical separation of CO2 for biogas upgrading,» *Bioresour. Technol.* , vol. 247, p. 380–386, 2018.

C. Pierangela, L. Lott Bothrel, M. Ferri e N. Lamanna, «Stato dell'arte sulle tecnologie di elettrometanogenesi microbica,» Ricerca di Sistema, RSE, Milano, Dicembre 2019.

P. Cristiani, M. Tribuzio e M. L. Carvalho, «Prove di laboratorio e in campo di sistemi elettrochimici microbici alimentati con biomasse da reflui e scarti,» *Rapporto RSE - RDS n. 11000521*, 2011