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Description of the funded research project
1st Call for H.F.R.I. Research Projects to Support Faculty
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Research Equipment



Title of the research project: Development of a **Novel** concept for Integrated **M**anagement of Municipal Wastewater and Biowaste

Principal Investigator: Professor Gerasimos Lyberatos

Reader-friendly title: DENOMINATE

Scientific Area: Engineering Sciences & Technology

Institution and Country: NTUA, Greece

Host Institution: School of Chemical Engineering, National Technical University of Athens

Budget: 188000,00 euro

Duration: 36 months



Research Project Synopsis

The scope of the DENOMINATE project is to develop an innovative approach in the field of municipal waste and wastewater management. More specifically, DENOMINATE will focus on the Fermentable Municipal Solid Waste (FMSW) and the Municipal Wastewater (MWW) streams. These two streams are currently being treated as separate waste streams; FMSW is collected as part of the mixed solid waste and landfilled and MWW is led to a wastewater treatment facility through the sewer. We hereby propose to explore an alternative that is much more meaningful and sustainable: To co-manage the liquid fraction of the Fermentable Municipal Solid Waste (condensate) and the Municipal Wastewater streams. We have recently developed a method to separate the solid and the liquid fraction of the Fermentable Municipal Solid Waste (drying and shredding process) and we aim to build upon this experience to develop an innovative and sustainable treatment framework that can revolutionize the field of waste and wastewater management.

The main objectives of the DENOMINATE project are:

- ❖ To carry out complete characterization of the condensate resulting from drying and shredding the fermentable fraction of municipal solid waste, collected at the source, as a function of drying conditions (temperature and duration)
- ❖ To develop a new sustainable treatment scheme for the combined municipal wastewater/ FMSW condensate stream based on state-of-the art technology for wastewater treatment
- ❖ To investigate the feasibility of incorporating Microbial Fuel Cell (MFC) technology as an alternative in the treatment scheme
- ❖ To examine the anaerobic co-digestion of waste activated sludge with household fermentable waste condensate as an alternative
- ❖ To design an overall management scheme for handling solid waste and municipal wastewater for a medium size city (population equivalent circa 100.000)
- ❖ To evaluate this management paradigm in comparison with the existing (standard) management scheme, using a life cycle approach

Project originality

Historically, the management of municipal solid waste and that of wastewater have evolved in two independent streams, defined by the main phase in each case; solid and liquid, respectively.

Currently, the benchmark approach to municipal wastewater management consists of sewer collection, treatment in a facility aiming at removal of suspended solids through primary sedimentation, biological oxidation of organic matter, biological nutrient removal and disposal of the clarified effluent following disinfection by chlorination. The process generates a mixture of primary and excess secondary sludge which are typically mixed, stabilized by anaerobic digestion and dewatered before disposal.

Concerning solid waste management, for many years, the fermentable organic matter, mostly food waste, is collected mostly mixed with commingled waste in green bin and then led to a landfill. This type of management (currently 86% of the municipal solid wastes are handled in Greece in this manner) has as a result

- (a) the “loss” of recyclables, implying poor resource management and
- (b) the generation of biogas, at least 50% of which, in the best case, is released from landfills to the atmosphere, contributing to the greenhouse effect.

EU regulations have pushed for proper solid waste management which amounts to

- (a) separate collection of recyclables at the source and
- (b) diversion of fermentables from the landfill to energy and energy carriers through technologies such as anaerobic digestion.

The DENOMINATE project relies on developing a scenario in which the liquid fraction (condensate) of the municipal fermentable household waste will be combined and co-managed with either the municipal wastewater in a common collection sewer system or will be transported and mixed with the excess sludge generated in conventional treatment plants, enhancing the generation of biogas.

Expected results & Research Project Impact

The novelty of DENOMINATE project relies on developing a scheme based on which the liquid fraction (i.e. condensate) of the municipal fermentable household waste will be co-managed with the municipal wastewater. The condensate contains substantial organic load. It is then proposed to mix the condensate with the municipal wastewater and handle this as a new wastewater type in an optimal manner. Hence, this is the scope of the proposed research in this project, i.e. to devise an overall energy-effective treatment scheme for the co-management of the wastewater and solid waste condensate streams.

The alternative options proposed will be assessed through laboratory experiments and the experimental results will be used as inputs in environmental footprint and economic feasibility models. Specifically, each sub-module of the proposed waste management scheme will be assessed as follows:

- ❖ A high-rate anaerobic digestion system (PABR) for biogas production will be studied and the operation will be optimized.
- ❖ Microbial Fuel Cell (MFC) : System efficiency and stability will be studied and the operation will be optimized.
- ❖ A Sequencing Batch Reactor will be studied and the operation will be optimized.
- ❖ A CSTR anaerobic digestion system for co-digesting activated sludge and condensate will be assessed and the operation will be optimized.

The economic, environmental and social benefits are obvious. It is expected that the outcome of this project will open up new business opportunities in the environmental engineering and technology sectors, leading also to new employment opportunities. Moreover, an integrated waste management approach will lead to important social and public health benefits in the local and national level.

The importance of this funding

We aspire to develop an innovative, robust, environmentally sound and economically feasible household fermentable waste and wastewater co-management scheme, challenging the existing separate management schemes which are based on separation of wastes on the basis of phase (solid and liquid wastes separately collected and managed). We will use the experimental results as a basis to assess the overall efficiency of the proposed scheme in a Life Cycle approach for both the environmental footprint (Life Cycle Analysis) and the economic feasibility (Life Cycle Costing) of the scheme.

The funding from ELIDEK for the DENOMINATE project enables the study and development of the specific waste management plan. The DENOMINATE project has the potential to be a milestone in this direction.



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