Environmental Impact Assessment for an integrated microsieving-drying-gasification pilot plant for biosolids to electric energy in Rethymno, Greece

A. Manali[1], N. Mavrakis[1], P. Gikas[1]

[1]Design of Environmental Processes Laboratory, School of Environmental Engineering Technical University of Crete, Chania, Greece

Presenting author email: amanali@isc.tuc.gr

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Environmental Impact Assessment (EIA)-challenges and specifications

An integrated microsieving-drying-gasification industrial scale pilot plant, for biosolids to electric energy, is currently under installation at the Wastewater Treatment Plant (WWTP) of Rethymno, Crete, Greece. The construction and operation of such size demonstration plant requires the issuing of Environmental Terms, so an EIA has been carried out. To the best of the knowledge of the authors, this is the first EIA for exclusive gasification of biosolids, thus, the composition of such study posed a number of challenges. As the aforementioned project is partially financed by the European research programme LIFE (LIFE16 ENV/GR/000298), by definition it is characterized by high innovation and originality (no project with similar characteristics has been executed).

The EIA follows the standard structure: detailed description of the process and of the surrounding environment, assessment, evaluation and recommendations for the mitigation of environmental impacts, as well as environmental management and monitoring. However, a number of special issues due to the magnitude, location and nature of the project, had to be assessed, the most important of which are the following: the lack of full characterization of the expected by-products (solid residue, liquid and gaseous emissions), the high temperatures involved (above 1100 at the core of the gasifier), the fact that lethal intermediate products will be formed (such as CO and H_2S), the need for the continuous use of a lighting flair (for the combustion of excess syngas) and the potential odour emissions (from the biosolids drying system). The above particularities, along with the fact that Rethymno is a city with very developed tourism industry, and that the location of the WWTP is near a residential area, make the EIA exceptionally demanding. It is notable, that the Greek legislation (Common Ministerial Decision No 2471/2016), in an effort to promote innovation, has enacted a special favorable procedure for issuing environmental terms, for research projects executed in the premises of existing industrial facilities, such as WWTPs; thus, a special, less bureaucratic procedure (compared to the usual one), has been followed. However, the said procedure required the submission of a full EIA study.

Project description

By definition, the design of extended aeration WWTPs, requires large amounts of electric energy per unit volume of wastewater, for adequate treatment. The above problem is more pronounced for overloaded WWTPs (a common situation for a large number of European WWTPs). The above, makes wastewater treatment a particularly energy consuming process, for any municipality. On the other hand, biosolids management possesses a number of threats, due to high organic and microbial content, which also adds to energy consumption. However, wastewater contains (in the form of chemical energy) more than three times the energy required for complete conventional treatment, which is largely unexploited (apart of the occasional partial energy recover through biogas production). The aim of the present project is to investigate a viable solution for the improvement of the quality of WWTPs effluent, at reduced energy needs, with parallel management of the biosolids problem. The examined process involves the upfront removal of biosolids (upstream of the aeration tank), using a microseive, followed by moisture removal and then gasification for the produced syngas. Syngas is then combusted in an Internal Combustion Engine (ICE) for the production of thermal energy (used for biosolids drying) and electric energy (used for the operation of the plant, while the excess may be exported to the WWTP or to the grid) (Manali and Gikas, 2019). In detail, the system consists of a self-cleaning, rotating belt filter, with filter openings of 350 μm (microsieve), for the removal of Suspended Solids (SS) upfront of the aeration tank (Gikas, 2017a). The produced Primary Sieved Solids (PSS) have a high solids content (40-45%), with volatile solids fraction between 82-85% (dry basis) and Higher Heating Value (HHV) of about 23 MJ/kg (Batistatos and Gikas, 2017); all the above values are significantly higher compared with other types of biosolids (i.e. primary or secondary ones). The low moisture content and high HHV of PSS make them ideal as gasification feedstock (Gikas, 2017b). Although PSS have already high solids content, they require further drying prior to gasification, to achieve solids content of about 85%.

An industrial scale demo pilot plant is under installation at the premises of the municipal WWTP of Rethymno, Greece (a town with population of about 35,000 inhabitants, with daily wastewater flow between 10,000-15,000 m^3. The capacity of the demo plant will be 5,000 m^3/d, with expected PSS production of about ½ ton/d (dry basis). The gasifier has been designed so to consume all the daily production of PSS, operating on a 24h per day basis. An ICE will be employed to combust the produced syngas, so that the produced thermal energy to be conveyed to the dryer (to cover 100% of its thermal needs), while the electrical energy to cover 100% of the needs of the demo plant and the excess electric energy to be exported to the grid. From the EIA point of view, the input to the demo plant is municipal wastewater (along with small quantities of industrial wastewater), while the main outputs are exhaust gases from the ICE along with the evaporated water from the dryer, solid residue (ash) and scrubber effluents from the gasifier. The demo plant is outlined in Figure 1.

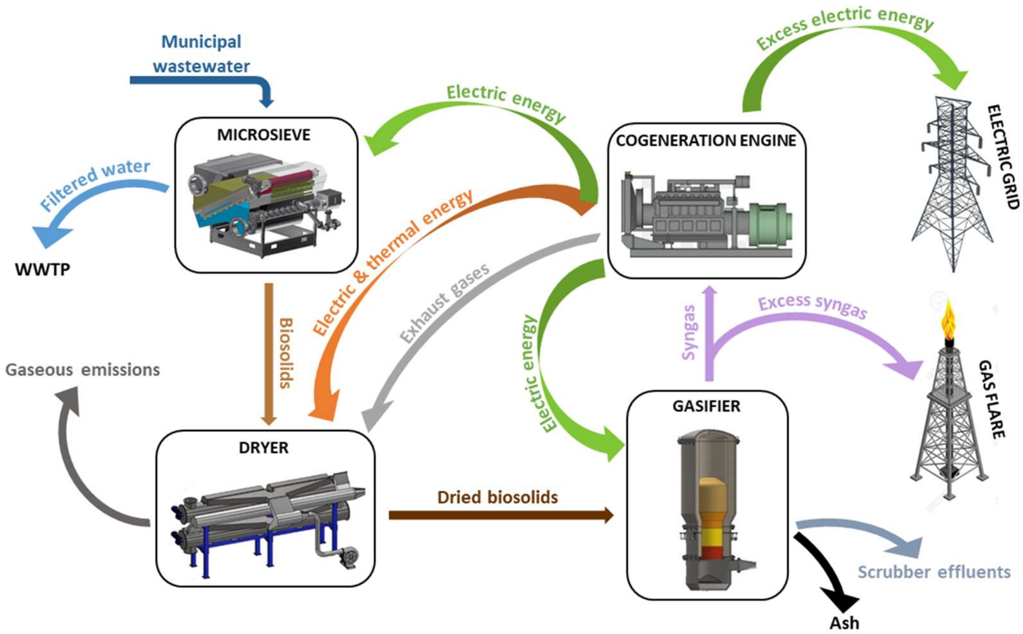

Figure 1. Mass and energy flows in the integrated system.

Overall environmental impacts and mitigation measures

The demo plant will have an overall positive environmental footprint, as the process will enhance the performance of the WWTP, due to the removal of a large fraction of SS and BOD from the wastewater (about 30-50% of SS and 20-30% of BOD will be removed by the microsieve), prior to the aeration tank. Moreover, net electric energy will be produced, so there will be a reduction of the energy requirements of the whole WWTP of Rethymno. Also, the production of municipal sludge (a nuisance substance) will be reduced. Along with the above, a net reduction of about 140 kgCO_2/day is expected.

As for any industrial system, negative impacts are primarily related to the production of various by-products. In the studied case, the main by-products are (i) the scrubber effluents from the syngas cleaning process, which have been considered as industrial wastewater, and may be treated in the existing WWTP, along with the incoming wastewater, (ii) the solid residue (ash) which will be analysed and if it will be classified as hazardous waste it will be managed accordingly, while if it will not be classified as hazardous waste it may be disposed along with the secondary sludge, (iii) the evaporated water from the dryer along with the exhaust gases from the ICE which may generate unpleasant odours (in such case, an activated carbon filter will be installed to absorb potential odours). A tight inspection and maintenance program will be followed, for the early identification of leaks or failures, which will be instantly addressed.

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References

N. Batistatos and P. Gikas, 2017. "Use of microsieves for primary wastewater treatment. Industrial scale application at the municipal wastewater treatment plant of Rethymnon, Greece". *6th International Conference on Environmental Management, Engineering, Planning and Economics (CEMEPE 2017)*, 25-30 June, Thessaloniki, Greece.

P. Gikas, 2017a. "Towards energy positive wastewater treatment plants", *J. Environ. Manage.*, **203**, 621-629.

P. Gikas, 2017b. "Ultra high temperature gasification of municipal wastewater primary biosolids in a rotary kiln reactor for the production of synthesis gas". *J. Environ. Manage.,* **203**, 688-694.

A. Manali and P. Gikas, 2019. "Utilization of primary sieved solids for gasification and energy production", *17th International Waste Management and Landfill Symposium*, 30 September-4 October, Sardinia, Italy.