An integrated approach for management of agricultural industries wastewaters

Industries processing agricultural products use as raw materials various fruits, vegetables, meat, milk etc. a large number of which are not produced on a year-round basis. Some of these industries, such as olive-mills and dairies have a specific product that is seasonally produced. Other industries vary their production during the year, as the raw material that they process depends on the season. Ganneries, for instance may be processing carrots, celery, potatoes etc. during different periods in the calendar year. In either case, the immediate consequence is that the wastewaters generated from these industries vary significantly during the year both in quantity and characteristics.

An additional characteristic of many agroindustries is that in many cases we deal with many small-scale enterprises scattered in an area of interest. Thus, for instance, there are approximately 30 olive-mills in the Patras area alone, and more than 2000 olive mills in Greece as a whole.

An additional characteristic of many agroindustries is the fact that the wastewaters that they generate are hard to treat since they contain a high organic content. Since olive-mill wastewater has a typical GOD value of 100.000 mg/l, when typical sewage wastewater has a GOD value of 400 mg/l, an olive-mill producing 1 ton/d has the same organic load as 250 tons/d of sewage wastewater (a population equivalent of approx. 1000 people). Indeed, agroindustrial wastewaters are responsible for most of the organics burden imposed on the Mediterranean Sea.

The high organic load that agroindustrial wastewaters carry makes regular treatment processes, such as the activated sludge process completely inappropriate, so that the only viable treatment process is the anaerobic digestion process. Anaerobic treatment, a complicated microbial process that involves many bacterial groups, has the advantages of producing small amounts of sludge, requiring substantially less energy than an aerobic treatment process, whereas the generated biogas (a mixture of methane and carbon dioxide at ratios that depend on the wastewater characteristics) is a potentially useful by-product, as it can be used as an energy source. The main disadvantages are the stability problems that may arise if not closely controlled, and the long start-up times required.

Long digester start-up times may be particularly limiting for agroindustries that operate only during part of the year. Individual treatment units can be prohibitively expensive for small scale agricultural products processing industries when compared with the total investment associated with these enterprises.

The scattered and seasonal nature of such agroindustries suggest that a truly viable option would be to have a centrally located anaerobic digestion plant that would be servicing a whole area, providing thus the required economies of scale to make any treatment process possible! This plant may be receiving different wastewaters during the year, securing that no down-times will be necessary, and avoiding thus the cost associated with long star-up times. In addition, mixed wastewaters may provide a more balanced «mix» that may be more readily digested, without the need for external nutrient additions. Thus, for instance a wastewater with nitrogen deficiency may be well digested if treated together with a wastewater exhibiting nitrogen surplus.

Codigestion has been used in the past as an incidental practice rather than an intended alternative. Sewage sludge anaerobic digesters have been fed with other wastewaters only on an occasional basis. The difference in the proposed approach lies precisely on the fact that we are aiming at deliberate design of codigestion of different wastewaters. The technical background required for co-treating wastewaters from various sources either for a single multi-product processing company, or for multiple specialized small-size companies distributed in an area, needs to be developed. This will render the treatment of the generated wastewaters much more economical, while at the same time it will secure a stable year-round operation.

A specific question of special interest is whether anaerobic degradability of mixed agroindustrial wastewaters can be related with their composition. It is a well known fact that total organic content, as measured e.g. by the COD, does not adequately reflect the ability to codigest a wastewater. Same organic compounds are readily digestable whereas others are hardly biodegradable. If we are able to correlate codigestibility with a more detailed knowledge of the organic content, e.g. the lipid, protein and carbohydrate content of, then we will be able to design an optimized schedule for co-treatment of wastewaters.

This paper focuses on two representative for Greece high organic content, seasonally produced agroindustrial wastewaters: dairy wastewater (production period January-June) and olive-mill wastewater (production period November-February). Piggery wastewater is also considered as a base year-round wastewater feed. The objective of this work is to employ a mathematical model describing the codigestion process in order to determine a safe year-round operation for a centrally located anaerobic digestion facility receiving sequentially piggery, piggery and olive-mill and eventually piggery and dairy wastewaters.

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