material and resources could be utilized to generate revenue to fund waste management. This forms the premise for integrated solid waste management system based on "Reduce, Reuse and Recycle" principle. In fact, it has been shown that with appropriate segregation and recycling system significant quantity of waste can be diverted from landfills and converted into resource. Developing and implementing this kind of waste management systems requires comprehensive data on present and anticipated waste situations, supportive policy frameworks, knowledge and capacity to develop plans/systems, proper use of environmentally sound technologies, and appropriate financial instruments to support implementation.

THE COMPANY

OWAC Engineering Company is located in Palermo, Via Resuttana 360, Sicily, Italy; the company has been operating in the "waste to energy" for many years and has a long time experience in the field of management consultings for the development and diversification of industrial assets. In particular the company develops its activities in the designing and building of waste treatment plants and environmental remediation.

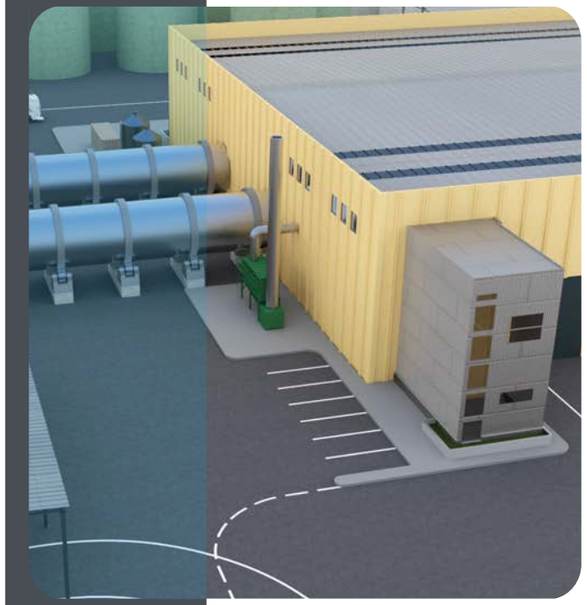
The more relevant characteristic of OWAC's activities is the development of an idea, the designing of the system and the management of the construction works all culminating with the start-up of the initiative. Therefore OWAC is the catalyst for all the phases which bring to the nal start-up of industrial plants.

The working team is very flexible, qualified and adaptable, able to develop all the required activities with care, high precision and "tailor made" solutions.
Company references and activities, both in progress and already made, are available on our website.

In collaboration with:
Institute of National Reseach Council
(CNR), Palermo, Italy

Palermo / Brescia / Tortona
info@owac.it - www.owac.eu

OWAC
Engineering Company



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ENZYMATIC CONVERSION OF ORGANIC MATTER

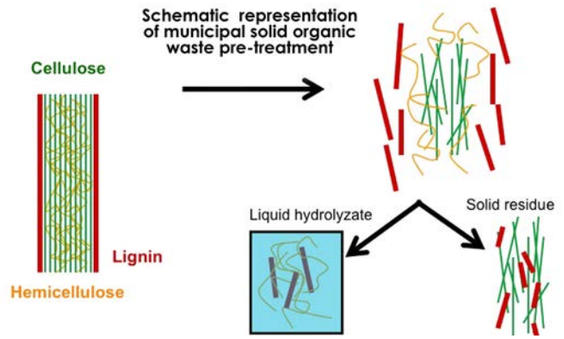
INTRODUCTION

Generation and accumulation of waste is one of the world's fastest growing environmental problems. The increasing rate of solid waste generation is a result of increasing population, industrialization, and urbanization. This becomes to be a serious problem for national and local governments to ensure effective and sustainable management of waste.
Although considerable efforts are being made by many Governments and other entities in tackling waste-related problems, there are still major gaps to be filled in this field. For example in developing countries, it is common for municipalities to spend 20÷50% of their available budget on solid waste management (open dumping with open burning is the norm), even though 30÷60% of all the urban solid wastes remain uncollected and less than 50% of the population is served.

In low-income countries, collection alone drains up 80÷90% of municipal solid waste management budget.
In mid-income countries, collection costs 50÷80% of total budget.
In high-income countries, collection only accounts for less than 10% of the budget, which allows large funds to be allocated to waste treatment facilities, facilitating the recycling and energy recovery.
If most of the waste could be diverted for material and resource recovery, then a substantial reduction in final volumes of waste could be achieved and the recovered

THE CASE STUDY
WHAT'S NEW

A new research has been carried out to test the treatment efficiency of using enzymes to enhance the bio-conversion of organic matter of municipal solid waste. Lab-scale tests have been performed in collaboration with the IBIM Institute of National Research Council (CNR) in Palermo (Italy); MSW liquefaction process-parameters have been evaluated and commercial cellulolytic enzymes have been used, according to the waste characteristics, to test the industrial application efficiency using enzyme bio-conversion in place of thermal process.



The enzyme, used for the bio-conversion, is extracted by Trichoderma reesei, that is a mesophilic and lamentous fungus. The extracted enzime has the ability to catalyze the degradation of organic material. Specifically, the endo-1,4-β-glucanase catalyses the hydrolysis of β-glycosidic bonds of the polysaccharide chains, releasing simple sugars. Higher efficiency in industrial processes is obtained. The enzymatic reaction also allows to reduce the particlae size of the material, obtaining more homogeneous biomass for industrial systems (i.e. biodigester).
Before starting the experiment, an assay for assessing the activity of the enzyme has been performed, through the use of DNS reagent (3,5 dinitrosalicylic acid) which triggers a color reaction.
This reaction is necessary to calculate the enzymatic activity in Filter Paper Units (FPU / ml). The products of the colorimetric reaction were read at the spectrophotometer with wavelength 600 nm.

URBAN BIODEGRADABLE WASTE SORTING

All lab-scale tests have been carried out on organic waste produced in a mechanical sorting plant which operates in Sicily; the organic waste has average dimension of acm and it is produced by shredding and sorting steps starting from mixed municipal solid waste.
The average composition of the waste is shown in the following table:

BIODEGRADABLE MATTER		77.3 %
Paper and Cardboard	54.0 %	
Organic substances	20.4 %	
Wood	2.0 %	
Fabrics	0.7 %	
Rubber	0.2 %	
NON-BIODEGRADABLE MATTER		9.8 %
Plastics	9.8 %	
INERT MATERIAL		12.9 %
Glass	7.3 %	
Ferrous metals	0.3 %	
Non-ferrous metals	0.9 %	
Inert material	4.4 %	

RESULTS

The tested waste is composed by 60% of Dry Matter (DM) and the hydrolysable part of dry matter (the biodegradable one) is around 35%. Water is added to obtain a DM concentration of 18%. The research has been carried out to evaluate how the effciency of liquefaction process of organic matter is in uenced by the enzyme concentration (FPU). The trial volume for lab-scale test is 100 mg. Five samples have been prepared with different FPU plus the control one without enzyme:
- Sample 1: 1 FPU/mg;
- Sample 2: 3 FPU/mg;
- Sample 3: 5 FPU/mg;
- Sample 4: 7.5 FPU/mg;
- Sample 5: 15 FPU/mg.

Each sample has been:
- heated up to 95°C for 50 min,
- cooled at 55°C,
- added with a volume of water to reach the percentage of 18% DM,
- added with the reported concentration of enzyme
- and kept at 55°C for16 hours with agitation at 160 rpm.

By the e ect of the enzyme, the large part of degradable compoents ends up in the lique ed fraction (around 80%). An increased amount of sludge fraction after enzymatic digestion has also been detected, in response to the increased amount of the enzyme.

PROJECT DESCRIPTION

The Municipal Solid Waste bioconversion plant is based on an enzymatic hydrolysis process that converts the organic substances into bio-liquid. After the mechanial separation of the non-biodegradable matter, the bio-liquid is transformed into biogas by anaerobic digestion process; the non-biodegradable and dry matrial is divided by mechanical sorting steps into three different flows: inert, 2D and 3D material, for recycling. The plant, which is about 6 ha (14,83 acres) large, is divided into the following sections:
- pre-treatment: to prepare incoming waste for the biolocal process;
- enzymatic treatment: waste is mixed with water at 55°C and enzymes in the bioreactor, which guarantee a retetion

time of 16 hours approximately;
- mechanical treatment: it consists in an automatic sorting phase to separate bioliquid and solid substances (which are mainly non-biodegradable), divided into 2D and 3D material;
- mechanical posttreatment:this step consists in additional mechanical sorting of 2D and 3D material to maximize material recycling (plastics like PET, PE, PVC, etc.) and obtain RDF (Refuse Derived Fuel);
- anaerobic digestion: to obtain biogas from the bio-liquid, which is better then un-treated waste for the methane producing phase; the digestate, instead, can be re-used in agriculture;
- energy producing section: the methane produced during anaerobic digestion is expolited in Combined Heat ans Power (CHP) station to produce energy;
-water treatment: chemical-physical process is used to purify water after mechanical and biological treaments; After that the purified water is reused for the enzymatic process.