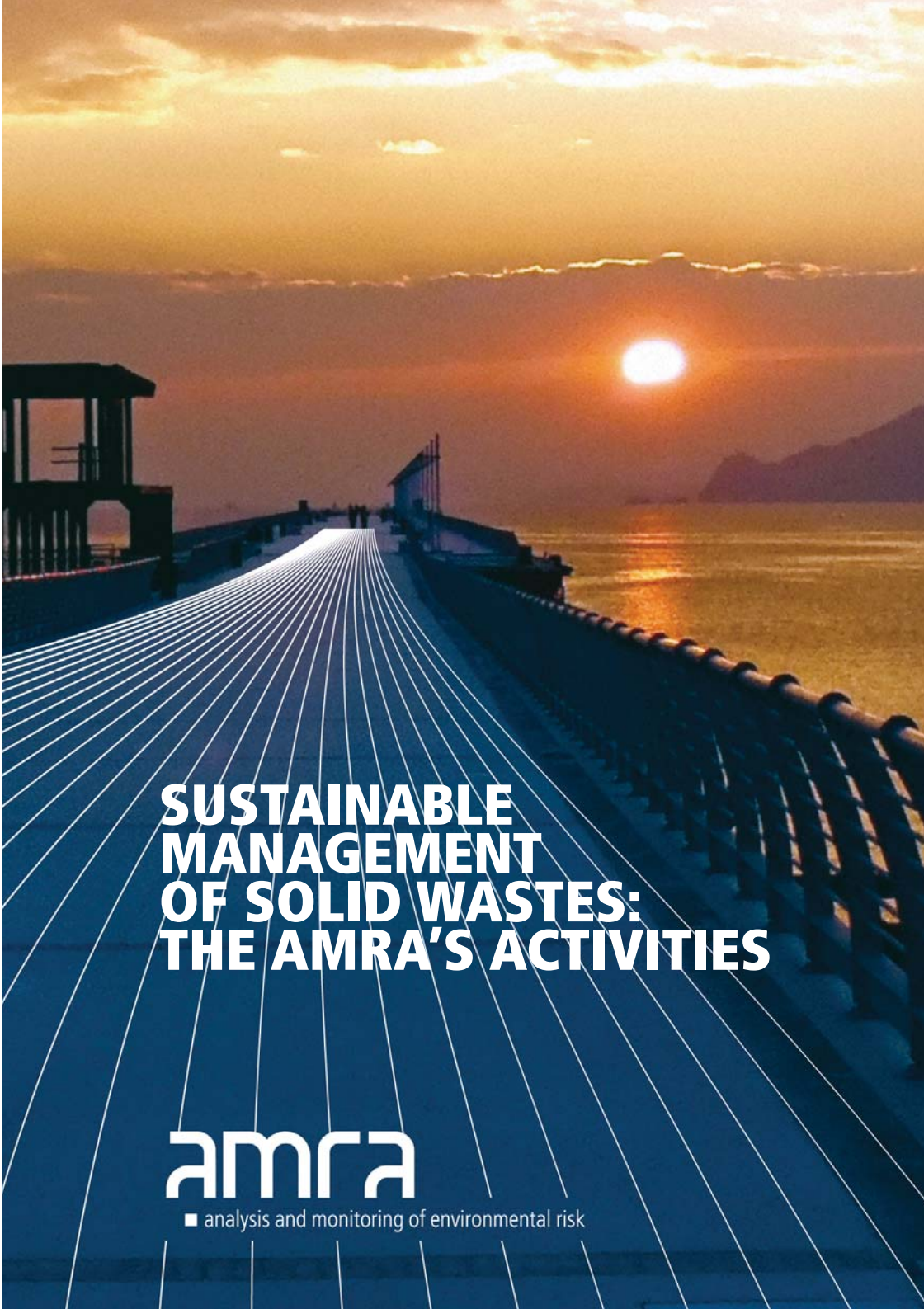


SUSTAINABLE MANAGEMENT OF SOLID WASTES: THE AMRA'S ACTIVITIES

amra

■ analysis and monitoring of environmental risk

ABOUT AMRA'S ACTIVITIES IN THE ANTHROPOGENIC RISK

AIR, WATER AND SOIL POLLUTION

Amra approaches scientific and technological aspects of several issues related to pollution of air, surface and underground water courses and soils. The AMRA's activities are supported by:

- an innovative equipment for characterization and detection of fine and ultrafine particles;
- an analytical and simulation laboratory for soil characterization and restoration (**Mesocosm**);
- a specific know-how in dealing with issues related to the pollution of water courses.

WASTE AND INDUSTRIAL RISK MANAGEMENT

The focus is on fundamental and applied research as well as technology transfer in the fields of municipal and industrial solid waste management (collection, sorting, recycling, material and energy recovery, final disposal) and of industrial risk (industrial pollution control, quantitative risk assessment, environmental risk). The research activity is supported by a series of equipments unavailable elsewhere in Italy and through much of Europe:

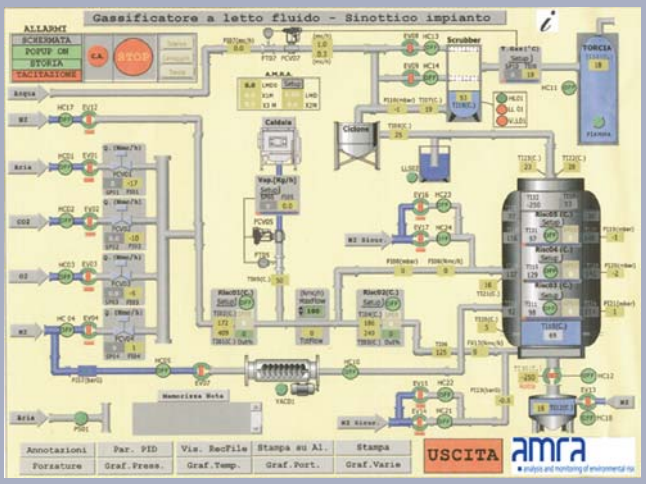
- a fluidized bed gasifier (**FluGas**), able to treat up to 100kg/h of waste and/or alternative fuels (RDF, PDF, biomass);
- an integrated laboratory (**CARMA**) for environmental analyses;
- an experimental apparatus for evaluation of explosion limits of different chemical compounds and mixtures.

THE CARMA LABORATORY

- On-line analysers for CO, CO_2, O_2, H_2, CH_4 content in the syngas
- On-line analyser for tar content and type in the syngas
- On-line analyser for PM2.5 in the syngas
- TG-DTA coupled with MS
- Gas-cromatograph with MS
- HPLC with MS
- ICP with MS
- CHNS elemental analyser
- SEM and TEM microscopes

The FluGas pilot plant
fluidized bed gasifier

The lab-scale fluidized bed gasifiers



The FluGas pilot plant
fluidized bed gasifier

HOLISTIC TOOLS FOR SUSTAINABLE MANAGEMENT OF MSW

THE FRAMEWORK

The increasing production of solid wastes imposes that sustainable waste management systems act as a "filter" between human activities and the environment. Some objectives appear to be crucial: i) *protection of health and the environment*; ii) *conservation of resources* such as materials, energy, and space; iii) *after-care-free waste management*, meaning that neither landfills nor incineration, recycling or other treatments leave problems to be solved by future generations.

Since the first two objectives, both depend on the content of certain substances in wastes, a substance oriented approach is necessary. Waste management and treatment cannot focus on the level of wastes as products only: it must address the level of substances contained in waste, too. The reason is that these substances determine whether a waste has a resource potential or constitutes hazardous material. In order to assess whether the goals are reached by a certain waste management system, **a comprehensive material flow analysis is needed** that covers waste flows, chemical composition of waste, and transfer coefficients of waste treatment processes.

The *after-care free waste management* objective has severe implications on landfilling and recycling. Today's landfills require leachate treatment, monitoring and control for several centuries. "Clean" recycling cycles are required: hazardous substances have to be eliminated from cycles when waste is recycled into new products, and the eliminated hazardous substances need to be disposed of in safe final sinks. **The whole life cycle of the waste management**, from resource extraction to ultimate end-of-life treatment must be taken into account.

THE AMRA'S APPROACH

AMRA adopts an holistic and systematic approach to the definition of waste management system for industrial and municipal solid wastes:

- **substance flow analysis (SFA)** and
- **life cycle analysis (LCA)**

are currently utilized as valid tools to ensure proper examination of the management scenarios.

THE ACTIVE RESEARCH AGREEMENTS

- **ARPAC (Environmental Protection Agency of Italy-Dept. of Campania).** Planning of industrial waste management for the Regione Campania (an area in the South of Italy with about 6 millions of inhabitants), with definition of type and capability of treatment plants and their localization. Financial support: 100keuro.
- **Environmental Department of Regione Campania.** SFA of MSW management in Regione Campania and definition of future scenarios of waste management. Financial support: to be defined.
- **CONAI – Italian National Consortium for Packagings.** LCA of plastic and paper recycling chains in Italy. Financial support: 200keuro.

MAIN SCIENTIFIC PAPERS

1. Arena U., Mastellone ML and Perugini F. The Environmental Performance of Alternative Solid Waste Management Options. *Chemical Eng. Journal*, 2003; 96:1-3, 207-222.
2. Arena U., Mastellone ML and Perugini F. Life Cycle Assessment of a Plastic Packaging Recycling System. *Int. J. of Life Cycle Assessment*, 2003; 8: 2, 92-98.
3. Perugini F, Mastellone ML and Arena U. Environmental aspects of mechanical recycling of PE and PET: a life cycle assessment study. *Progress in Rubber, Plastics and Recycling Technology*. 2004; 20/1:69-84.
4. Arena U., Mastellone ML, Perugini F and Clift R. Environmental Assessment of Paper Waste Management Options by means of LCA Methodology. *Ind. Eng. Chem. Res.* 2004; 43:5702-5714.
5. Arena U., Mastellone ML and Perugini F. *The Environmental Performance of Alternative Options for the Management of the Organic Fraction of Municipal Solid Waste: a Life Cycle Study*. Proc. of LCM 2005- Innovation by Life Cycle Management, Barcellona, September 2005.
6. Perugini F, Mastellone ML and Arena U. A Life Cycle Assessment of Mechanical and Feedstock Recycling Options For Management of Plastic Packaging Wastes. *Env. Progress.* 2005; 24/2:137-154.
7. Mastellone ML, Brunner PH and Arena U. SFA Based Scenarios of Waste Management for a Waste Emergency Area. *J. of Industrial Ecology*, 2009, submitted.

NEW TECHNOLOGIES FOR ENERGY AND MATERIAL RECOVERY FROM MSW

THE FRAMEWORK

The world needs more sustainable solid waste management techniques, which focus on greater value recovery from waste and easier plant acceptance by the interested people. Despite its many drawbacks, *landfill* is still the preferred option even in many industrialised countries although there are several countries that are currently experiencing huge difficulties in finding landfill sites. The traditional waste-to-energy *combustion* process is a proven alternative with about 130 million tonnes of municipal solid waste that are combusted annually in over 600 facilities. However, it still has some drawbacks, such as low energy efficiency, high capital and maintenance costs harmful final process residues.

In the last decade, a number of **novel technologies utilizing pyrolysis and gasification processes** have emerged to address the issue of greater environmental sustainability and to improve the value of energy or materials output. These technologies are expected to play a key role in the future of solid waste management since the conversion of municipal and industrial solid wastes to a gaseous fuel (producer gas or synthesis gas) significantly increases its value.

THE AMRA'S APPROACH

Amra research efforts are mainly address to:

- **Approach and solve the main problem of gas cleaning, that of tar removal, within or downstream of the gasifier.** Tar is a complex mixture of a broad spectrum of condensable hydrocarbons. They are undesirable because of various problems associated with condensation, formation of tar aerosols and polymerization of more complex structures, which cause problems in the process equipments as well as the devices for end-use application of the syngas. The pilot plant bubbling fluidized bed gasifier *Flugas* is used for this kind of studies.
- **Investigate the possibility to obtain high-value materials from different kind of wastes by means of pyrolysis and gasification processes.** A new process for a massive production of multi-wall carbon nanotubes from plastic wastes has been recently proposed.

THE ACTIVE RESEARCH AGREEMENTS

- **CONAI – Italian National Consortium for Packagings.** 3-yr research program (2006-2008) to define operating and design criteria for fluidized bed gasifiers of packaging-derived fuels (PDF) and refuse-derived fuels (RDF). Financial support: 600keuro.
- **Private companies.** Specific test on different PDFs and RDFs to test the feasibility of gasification process. Financial support: 100keuro.
- **ANSALDO Energy.** Research program to test different materials and surface coatings to be used in gasification and pyrolysis reactors. Financial support: 80keuro.
- **National and Local Authorities with a group of private companies.** BIOTEN (BIOmass-To-ENergy) research program to test the feasibility of co-gasification process where the organic fraction of municipal and industrial solid waste is processed together with paper and plastic wastes. Financial support: 8,000keuro.
- **CONAI – Italian National Consortium for Packagings.** 2-yr research program (2008-2010) to optimizing the design of a gasifier to be fired with two or three PDFs. Financial support: 300keuro.

MAIN SCIENTIFIC PAPERS

1. Arena U and Mastellone ML. Defluidization phenomena during the pyrolysis of two plastic wastes. *Chemical Engineering Science*. 2000; 55:2849-2860.
2. Mastellone ML and Arena U. Fluidized bed pyrolysis of polyolefins wastes: a predictive defluidization model. *AIChE Journal.* 2002; 48/7:1439-1447.
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4. Arena U and Mastellone ML. *Fluidized pyrolysis and gasification of solid wastes*. In: Proc. of Industrial Fluidization South Africa 2005. The South African Institute of Mining and Metallurgy (ISBN 1-919782-83-0), 2005:53-68.
5. Arena U and Mastellone ML. *Fluidized bed pyrolysis of plastic wastes*. In: Scheirs J and Kaminsky W. Feedstock Recycling and Pyrolysis of Waste Plastics. Chichester: J. Wiley&Sons Ltd, 2006:435-474.
6. Arena U, Mastellone ML, Camino G, Boccaleri E. An Innovative Process for Mass Production of Multi-Wall Carbon Nanotubes by means of Low-Cost Pyrolysis of Polyolefins. *Polymer Degradation & Stability*. 2006; 91:763-768.
7. Arena U, Romeo E, Mastellone ML. Recursive operability analysis of a pilot plant gasifier. *J. Loss Prevention in the Process Industries.* 2008; 21/1:50-65.
8. Mastellone ML and Arena U. Olivine as a Tar Removal Catalyst During Fluidized Bed Gasification of Plastic Waste. *AIChE Journal.* 2008; 54: 1656-1667.
9. Arena U, Zaccariello L, Mastellone ML. Tar Removal During the Fluidized Bed Gasification of Plastic Waste. *Waste Management.* 2008; in press.

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