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Planning the Management of Municipal Solid Waste: The Case of Region “Puglia (Apulia)” in Italy

Ludovico Spinosa¹ and Carmine Carella²

¹*Commissariat Env. Emerg. in Region Puglia (Apulia), Bari*

²*Technical Director of MSW treatment plant, Massafra (Taranto)
Italy*

1. Introduction

The management of wastes, in particular of municipal solid waste, in an economically and environmentally acceptable manner is one of the most critical issues facing modern society, mainly due to the increased difficulties in properly locating disposal works and complying with even more stringent environmental quality requirements imposed by legislation.

In addition, in recent years the need to achieve sustainable strategies has become of greater concern, also because some traditional disposal options, like landfilling, are progressively restricted, and in some cases banned, by legislation, so the development of innovative systems to maximize recovery of useful materials and/or energy in a sustainable way has become necessary.

The sustainability concept is today widely used when speaking of the development of human activities, especially in the environmental field. According to the original definition of 1987 by the United Nations, which defined sustainable developments as those that “*meet present needs without compromising the ability of future generations to meet their needs*”, sustainability occurs when natural or renewable resources are consumed less than, or at least equal to, nature’s ability to replenish them.

As shown in Figure 1, for achieving effective sustainability, three elements of fundamental importance are strongly interconnected to one another and cannot be separately considered (Adams, 2006). They are:

- the environmental element (environmentally robust, and supported by consistent and applicable normative and legal requirements),
- the economic element (economically affordable, technologically feasible, operationally viable),
- the social element (socially desirable, culturally acceptable, psychologically nurturing).

That's particularly true for Western European countries, due to land scarcity and population density, but will also become in short time of major concern for Central and Eastern European Countries that already joined the European Union (EU), or are preparing to do that.

From a general point of view, the waste management policy should be addressed to both the development of management procedures able to reduce the waste mass production, and the application of reuse options instead of simple disposal ones.

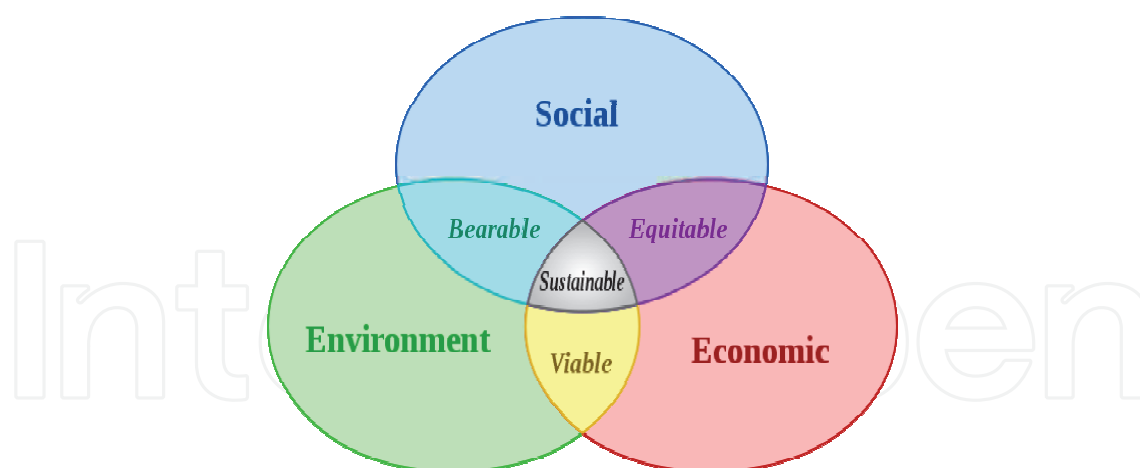


Fig. 1. Interconnection of elements affecting sustainability (Adams, 2006)

In this chapter the criteria staying behind the definition of plans for municipal solid waste management in the Region Puglia (Apulia), south-east of Italy, are discussed, together with the treatment and disposal facilities of the first installation fulfilling the requirements of the above mentioned plan.

2. Technical aspects

Main options for the management of municipal solid waste (from now on abbreviated as MSW) include stabilisation, incineration and landfilling (Williams, 2005).

Stabilisation can occur in aerobic environment (stabilisation, composting) or in anaerobic one (digestion).

Stabilisation and composting involve the aerobic degradation of biodegradable organic waste which allows to obtain a stabilised product to be utilised, after maturation or curing, for agricultural purposes. However, to obtain a compost of good quality, the organic (wet) fraction of the waste requires separation from the other (dry) fraction; if the organic fraction is not separately collected, but separation takes place in mechanical separation plants, then the process can be used to obtain a stabilised wet fraction which can be usefully reused for environmental restoration purposes or as a cover material in landfill operations.

Composting has the advantage of producing a safe and hygienic product which can be easily stored, transported and used on times and sites different from those of production. Therefore, the separate collection of the MSW wet fraction is a fundamental prerequisite for a successful composting operation (Spinosa, 2007a).

The main operating variables affecting the process performance are the moisture content (optimal 50-60%) and the carbon to nitrogen ratio (optimal 25-30), to avoid slow composting (at high C/N ratios) or ammonia volatilization (at low C/N ratios).

Anaerobic digestion takes place in a closed reactor in the absence of free oxygen with the production of gas (biogas), rich in methane, and of a solid residue that can be used for agricultural purposes. The conditions are similar to those occurring in a landfill, but better controlled. Also in this case, the separation of the wet fraction from the dry one is required for good performances.

Incineration and other thermal processes, require that economics be carefully evaluated, but could be a cost-effective solution in large urban areas, where the distance to landfill site

makes transportation prohibitively expensive, and when restrictions on landfilling are imposed. Further, thermal processes can usefully deal with materials which do not meet beneficial use requirements (Spinosa, 2007b).

Potential advantages of high temperature processes include reduction of volume and weight of waste, destruction of toxic organic compounds, and potential recovery of energy.

Most important physical-chemical characteristics affecting thermal processes performance are the dry matter and the volatile solids contents. Dry matter affects both fuel requirement and exhaust gas production, while the volatile solids content is important because it affects the calorific value, i.e. the monetary value of the material.

For above reasons, screening and stabilisation of unsorted MSW is a valid pre-treatment process to obtain a combustible dry fraction with good calorific value.

An aspect that needs to be put in evidence regards the sequence of waste separation and stabilisation processes. Separating the waste materials before stabilisation involves smaller area or cell volumes because only the wet fraction is to be stabilised, but organic pollution of the dry fraction could remain unacceptable for its subsequent handling. On the contrary, a better separation is obtainable after stabilisation of the unsorted waste: higher treatment volumes should be in this case required, but the overall performance of the treatment system results generally higher.

Landfilling of municipal solid wastes is a well known and consolidated practice; it is a convenient solution where enough space is locally available at reasonable disposal fees. A landfill is also the necessary support to all others waste handling systems for the final disposal of materials no more eligible to reutilization and during shutdown periods for maintenance and/or emergency (Spinosa, 2005).

However, organic matter deposited in a landfill is not available for agricultural needs, but the production of landfill gas (biogas) is allowed. Biogas, if not captured, considerably contributes to the greenhouse effect, because it is mainly composed of methane, which is about 20 times more powerful than carbon dioxide in terms of climate change effects. Therefore, wastes must be subjected to treatment before landfilling, where treatment means the physical, thermal, chemical or biological processes, including sorting, that change the characteristics of the waste in order to reduce its volume or possible hazardous nature, facilitate its handling and enhance recovery. In particular, landfill gas should be treated and used to produce energy, other ways it must be flared.

Another aspect to be considered is that MSW is often handled by following routes different from those of other organic wastes, mainly sewage sludge, each waste under the responsibility of different authorities, with the consequence that specific technical problems and considerable diseconomies arise. For this reason, integrated co-management systems for waste handling, including such operations as composting, incineration and landfilling, should be developed to allow optimisation of operating modalities and reduction of costs to be obtained (Spinosa, 2008).

Composting is the typical process in which the different characteristics of solid wastes and sewage sludge can be usefully integrated to obtain a final product of better quality, because the relatively high solids content and the carbon to nitrogen ratio (C/N) of solid wastes can counterbalance the low solids concentration and C/N ratio of sludge.

In co-incineration, sewage sludge drying can take place at expenses of the excess heat recovered from solid waste combustion, but greater attention in designing and operating furnaces and exhaust gas abatement systems is required.

Finally, co-landfilling, if permitted by national regulations, allows a faster stabilisation, a better leachate quality and a higher biogas production to be obtained, but the operating modalities must be carefully planned due to scarce physical consistency of sludge.

3. Regulatory aspects

Italy is member of European Union since its establishment in 1957, so national legislation must be issued in agreement and/or application of European Directives.

3.1 European

From the European Union (EU, Figure 2a) regulatory point of view, the Directive 91/156 on wastes, also designated as the “Waste Basis Directive”, has been of outstanding significance, as it is always to be observed even with the application of any other specific regulations. This means that the particular requirements deriving from other Directives addressed to particular waste groups additionally apply to general regulations deriving from above Directive. In particular, liquid and solid wastes, and sludge must fulfil the requirements imposed by specific normative, such as the:

- Directive 91/271/EEC on the treatment of urban wastewaters;
- Directive 86/278/EEC on sludge utilization in agriculture;
- Organic Farming Regulation 91/2092/EEC;
- Landfill Directive 1999/31/EC;
- Commission Decision 2001/688/EC for the ecolabel for soil improvers and growing media;
- normative on incineration of waste (e.g. Directives 89/369, 94/67 and 00/76), when applicable.

Further, to favour the material and energy recovery options instead of the simply disposal ones, the Directive 99/31 introduced targets for the reduction of biodegradable municipal waste to be landfilled as follows: reduction by 2006 to 75% of total biodegradable municipal waste produced in 1995, reduction by 2009 to 50%, and reduction by 2016 to 35%.

However, above legislation has been primarily addressed to generally reduce the impact of waste on the environment, while a limited attention has been given to the positive aspects of biodegradable wastes (Marmo, 2002).

Within this framework, a crescent interest has been focused in recent years towards the recovery aspects of biodegradable wastes, so that the development of a Biowaste Directive has been undertaken aiming at promoting the biological treatment of wastes by harmonising the national measures concerning their management.

General principles include, among others, the (i) prevention or reduction of biowaste production and its contamination by pollutants, (ii) composting or anaerobic digestion of separately collected biowaste that is not recycled into the original material, (iii) mechanical/biological treatment of biowaste, and (iv) use of biowaste as a source for generating energy.

Member States are requested to encourage home and on-site composting whenever there are viable outlets for the resulting compost, and setting up of community composting schemes as a way of involving the general public in the management of their own waste, reducing transport of waste and increasing awareness in waste recycling practices.

However, this process has not yet been completed because subjected to the development of a basis legislation on “soil protection”, that will then become the reference regulation for the proposed new legislation on biodegradable waste.

Recently, a new Directive (98/2008/CE) has been issued to regulate recovery activities of wastes, including their energy recovery within the general framework of sustainable integrated management systems.

Further, to properly perform the utilization and disposal operations and correctly fulfil the legal requirements, a fundamental role is played by the definition of standardized procedures for the chemical, biological and physical/mechanical characterization of wastes, and by setting up guidelines of good practice for their management. For this reason, the European Committee for Standardization (CEN), which supports EU Commission in Directives issuing, established, among others, Technical Committees whose scope is the standardization of methods and procedures employed for characterisation of waste (TC292) and sludge (TC308).

3.2 Italian

As told before, each EU Member Country has to develop its local legislation by adopting the communitarian one, but has the possibility to introduce changes specific to local situation, provided they are not in contrast with general requirements of EU normative.

In the case of Italy (Figure 2b), the legislation on wastes is now fundamentally based on the recent Legislative Decree nr. 205, issued on December 2010, that, in application of the European Directive 98/2008/CE, replaced the previous Legislative Decree nr. 152/2006.

With specific reference to MSW, Italian national legislation fundamentally gives the Regions “planning” responsibilities, the Provinces “authorisation and control” ones, and the Municipalities “service operations” duties.

In addition, decisions and/or determinations on specific aspects by other institutional Bodies are necessary to obtain all the necessary permits or authorisations. This fragmentation of competences has brought in some cases to administrative conflict between different public Institutions, so in some Regions a Governmental Commissariat has been established which takes upon himself all responsibilities, by-passing and replacing those of most institutional Bodies.

This is the case of Region Puglia (Apulia), located in south-east of Italy (Figure 2c), where a “Commissariat for waste emergency”, then more generally modified in “Commissariat for environmental emergencies”, was established since 1997. The position of Commissary has been almost always covered by the President of Region Puglia.

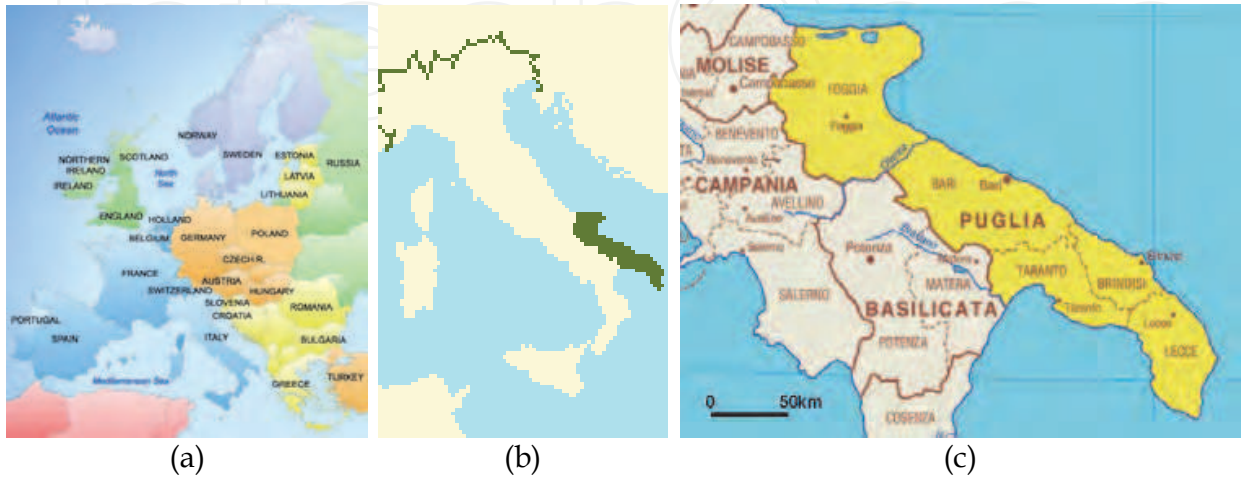


Fig. 2. Maps of EU (a), Italy (b), and Region Puglia (Apulia) (c)

4. The solid waste management in Puglia

With the Commissary Decree nr. 296/2002, based on the Italian Legislative Decree 22/1997 that was at that time a comprehensive law regulating waste issued in compliance with various EU directives, the “Regional Plan for Solid Waste Management” was approved, and then completed and adjourned by the Commissary Decree 187/2005. In previous Decrees, issued on 1997 and 1998, Guidelines for the mechanical-biological treatment of residual waste remaining after separation at source of selected fractions were introduced.

The Region Puglia has an extension of about 20,000 km² and a population of a little bit more than 4 millions. The Region is characterised by a coast length of about 800 km, and a hill-shaped profile, also including both vast flat areas and mountains (up to 1000 m) ones.

Administratively speaking, at the time of Plan issuing, the Region included 5 Provinces (i.e. Bari - the Region’s Capital, Foggia, Brindisi, Lecce, and Taranto). A new Province, the BAT (Barletta, Andria, and Trani) Province, has been established in 2004 and really started to operate in 2009. This Province, which includes 10 towns originally part of northern Bari Province and southern Foggia Province was obviously not included in 2002 planning, but will be considered in the revised waste management Plan to be approved in 2011.

Basically, above mentioned Decrees (296/2002 and 187/2005) require the:

- a. development of “source separation” schemes with the target for 2010 of 55% of MSW separately collected to be handled for material recovery,
- b. “biostabilization” of urban waste, remaining after source collection, followed by separation of a treated wet fraction to be landfilled (abbreviated in RBD) or used for environmental purposes (RBM), and of a dry fraction (FSC) to be used for the production of refuse derived fuel (RDF).

Regarding the biostabilisation treatment, the following two options can be adopted:

4.1 Option 1

This option includes the following operations:

- Pretreatments, e.g. storage, moderate shredding by systems compatible with the characteristics of organic materials, ferrous materials separation;
- Biostabilisation for an approx period of 2-4 weeks, depending on the technology adopted, to obtain a material having a Dynamic Respirometric Index (DRI) of max 800 mg-O₂/kg-VS_h;
- Selection/Screening, at max 80 mm;
- Landfilling of the undersized fraction (RBD), at an amount not higher than 35% of the untreated urban waste;
- Processing of the oversized fraction (FSC), amounting to about 40% of the untreated urban waste, to produce refuse derived fuel (RDF).

4.2 Option 2

This option includes the following operations:

- Pretreatments, e.g. storage, moderate shredding by systems compatible with the characteristics of organic materials, ferrous materials separation;
- Biostabilisation for an approx period of 2-4 weeks, depending on the technology adopted, anyway to obtain a material having a Dynamic Respirometric Index (DRI) of max 800 mg-O₂/kg-VS_h;
- 1st Selection/Screening, at max 80 mm;

- Maturation/Curing of the undersized fraction for an approx period of 4-8 weeks, depending on the technology adopted, to obtain a material with a DRI of max 400 mg- O_2 /kg-VS $\cdot$ h;
- 2nd Selection/Screening, at max 25 mm;
- Utilisation/Recovery of the undersized fraction, at an amount of about 25% of the untreated urban waste, for use as landfill cover material or land reclamation (closed mines, etc.);
- Processing of the 1st and 2nd oversized fractions (FSC), at an amount of about 45% of the untreated urban waste, to produce RDF.

The overall bloc diagram of such integrated system for management of unsorted MSW is shown in Figure 3. As told, all MSW is biostabilised before selection/screening to get a more efficient separation and reduction of possible malodours.

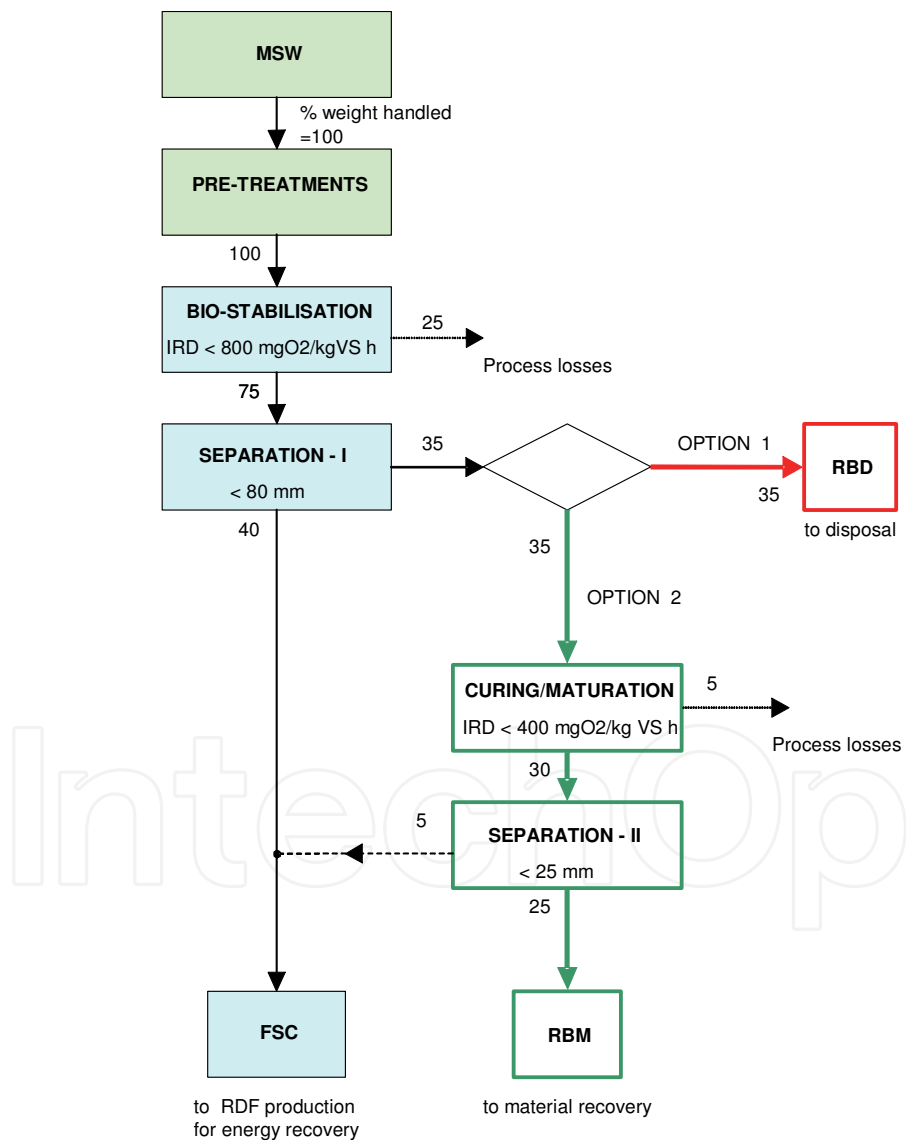


Fig. 3. Bloc diagram of integrated system for management of MSW

For the practical application of above schemes, the regional territory has been divided in 15 “Optimal Territorial Basins” (OTB): 4 in Province of Foggia (FG/1, FG/2, FG/4 and FG/5), 4

in Province of Bari (BA/1, BA/2, BA/4 and BA/5), 2 in Province of Brindisi (BR/1 and BR/2), 2 in Province of Taranto (TA/1 and TA/3) and 3 in Province of Lecce (LE/1, LE/2 and LE/3). Each OTB is served by treatment plants for:

- a. “qualification” of recyclable fractions deriving from “source separation or separate collection” of MSW;
- b. “pre-treatment” of residual waste deriving from conventional “not-separate collection”;
- c. “biostabilisation” of above pretreated waste, followed by “mechanical separation” into a “wet fraction” and a “dry fraction”, being the former (RBD) landfilled or submitted to further curing for the production of RBM to be possibly reused for environmental purposes, the latter (FSC) processed for conversion into RDF;
- d. “landfilling” of process rejects or untreated waste during shutdown periods for maintenance or emergency.

Operation of above point a) has the purpose to have a higher amount of selected fractions of better quality just to give them a higher market value.

It has to be observed that, to optimise economic balances, the production of RDF and its utilisation is planned not to be done in all OTBs, but in a few centralised Centres serving more OTBs. This is the case of Province of Foggia, where 1 RDF production Centre is planned to serve 4 OTBs, of Province of Brindisi to serve 2 OTBs, of Province of Lecce to serve 3 OTBs, of Province of Taranto to serve 2 OTBs, and of OTB BA/1 serving also OTB BA/4.

At the time of writing 10 treatment plants are in operation (OTBs of FG/3, FG/4 and FG/5; BA/2 and BA/5; TA/1 and TA/3; LE/1, LE/2 and LE/3) and 1 is completed and ready to start (OTB of BR/1).

4.3 Guidelines

To guarantee uniform technical designing of plants in the different OTBs, specific Guidelines for each treatment section have been issued by the Commissariat Offices (Commissariat for waste emergency, 1997, 1998a, 1998b, 1998c).

Guidelines require that, besides main working structures, all Centres shall be provided with facilities destined to Support Services, subdivided into Management Services and Technical Services.

The Management Services include:

- weighing;
- waste classification and recording;
- guardhouse;
- administration;
- social services for personnel,

while the following services and/or technological installations belong to the group of Technical Services:

- motive/driving power and lighting electric installations;
- water supply system for drinking, hygienic and services uses;
- effluents treatment plant;
- surface water disposal system;
- fire protection system;
- earth plant and lightning strokes protection systems;

- storage, handling and materials loading/unloading areas, with sizes and characteristics suitable for passage and operation of lorries, trucks and trailers;
- parking areas for vehicles and demountable containers, spare parts store.

4.3.1 Centres for qualification of recyclable fractions from separate collection

Such Centres shall be used for paper and cardboard, plastics, glass, aluminum cans, ferrous and non ferrous metals (Commissariat for waste management, 1997).

The main equipment is the selection system, essentially consisting in a belt conveyor located on a platform equipped with a sound-proof cabin and an air-change system. Operators, standing at belt side(s), manually pick up the different fractions and store them in containers placed below the belt. From the material remaining after the above selection, the ferrous material is separated by a permanent magnet deferrization system, whilst aluminum and non ferrous materials by an eddy current separator. The other materials deriving from the selection which cannot be recycled are discharged in special containers, compatible with the material itself, for disposal at authorized plants. Paper, cardboard and plastics must be pressed and pressing devices must assure, for plastic wastes, their pressing in bales sizing 120x80x80 cm, each weighing 100-140 kg. A baling press for the compression of aluminum cans must be also installed.

As far as the storage sites of glass, plastics, paper, cardboard and cans are concerned, Guidelines require the realization of 3 sides walls cells in reinforced concrete with a height of 2.5 m, width and length not lower than 3 m and 6 m, respectively, smooth concrete pavement and protection against wear and tear, with a light slope (max 2%) towards the open loading side, with a grating for collection and conveying of meteoric waters. The storage sites for processed plastics and paper/cardboard must have a capacity sufficient for the storage of, at least, a quantity corresponding to 2 units of useful load, equivalent to 200 bales, while the storage capacity of processed cans must be sufficient for the storage of at least a quantity correspondent to 1 useful load, equivalent to 30 tons.

The Centres must be also equipped with a 80 t weighing balance with 18x3 m² platform, and with additional equipment for materials handling, loading/unloading, storing, etc., in number according to the potentiality of the Centre.

4.3.2 Centres for selection of unsorted wastes

Such Centres allow waste residuals from separate or undifferentiated collection or from separate dry/wet collection to be delivered (Commissariat for waste management, 1998b).

Such plants must be located at least 1,500 m far from the limit of urban agglomerations and of important or touristic areas and at 2,000 m far from hospitals, health or thermal centres. Providing that all sectors must be equipped with suitable systems for odors and dust control, in case using biofiltration apparatus, collection and storage of entering waste to be sent to selection must occur in a confined space. The size of such sectors must allow the storage of the maximum quantity of daily production for a period of 3 days, at least.

The separation system of the wet fraction from the dry one must allow (i) the bags breaking and the waste size reduction preferably through shredding systems, excluding thin comminuting techniques, incompatible with the organic materials nature, (ii) the separation, through screening, of the wet fraction (undersize) from the dry one (oversize), (iii) the separation of ferrous and non ferrous metallic materials.

Above system must be located in a shed with an industrial type pavement, water-proof and suitable for the passage of mechanical means, as well as with a wastewater collection and disposal system.

Residuals from separation must be stored in special containers or tanks or piles properly protected, compatible with the material characteristics for their subsequent treatment or disposal at authorized plants. The size of the storing sector must allow a storing capacity of the separates combustible material corresponding at least to 7 days, or in such a way as to avoid any risk of hygienic and sanitary problems.

4.3.3 Centres for stabilisation / composting.

Such Centres allow solid waste residuals from separate collection and/or of separated organics to be stabilised. As told, good quality compost can be obtained only if the organic fractions are separately collected.

Such plants must be located at least at 2,000 m far from the limit of urban agglomerations and of important or touristic centres and at 2,500 m far from hospitals, health or thermal centres. All sectors must be equipped with suitable systems for odors and dust control, eventually using biofiltration apparatus, while the collection and storage of entering waste to be sent to selection must take place in a confined space. The size of such sectors must allow the storage of the maximum quantity of daily production for a period of at least 3 days (Commissariat for waste management, 1998a).

Preliminary treatments shall allow the (i) size reduction of input waste, using systems compatible with the organic materials nature, (ii) selection of ferrous and non ferrous metallic materials, and (iii) the separation, through screening, of the other non processable fractions (oversize).

The working cycle includes the two phases of primary biooxidation and curing, which must take place in aerated windrows or closed reactors or mechanized vessels or confined piles. Reactors and vessels must be tight, and the surfaces which the piles are placed on must be water-proof and appropriately protected with industrial type floor suitable for the passage of mechanic means. In anycase, wastewater drainage and collection systems, to be sent to water conditioning or to reuse in the treatment cycle are required.

The total duration of the two above processing phases must fulfill normative requirements; in particular, temperature must be kept for at least 3 consecutive days over 55 °C. A sufficient oxygen quantity must be assured to keep the aerobic conditions of the mass through the use of both fixed aeration systems and electromechanical equipments, and handling means and/or mechanical turning machine to turn the material under treatment. A final refining phase is also required to separate the foreign material eventually still present in the mass of treated materials, to make uniform the product particle size and to reach the desired final degree of humidity.

The final product must be stored in containers or tanks or piles adequately protected in order to preserve its quality and agronomic characteristics and to avoid hygienic problems due to recontamination. Packaging in bags with label in compliance with the law is recommended.

4.3.4 Centres for production of refuse derived fuel

Centres for production of RDF are plants which get the selected fractions of fuel material (e.g. FSC) for their transformation into a solid product to be reused for energy purposes in existing industrial plants or in dedicated ones (Commissariat for waste management, 1998c). In this case too, all sectors must be equipped with suitable systems for odors and dust control, eventually through biofiltration apparatus. The collection and the storage of

materials to be sent to RDF production must take place in a confined space, dimensioned to allow the storage of the maximum quantity of daily production for a period of at least 7 days. The flooring of the shed must be of industrial type and equipped with a washing water and wastewater collection and disposal systems, in conformity with the applicable regulations.

The production of RDF, to be realized in a suitable closed shed, must allow the (i) separation of the dry fraction into light, thin and heavy fractions (ballistic systems or equivalent ones), and (ii) production of a material in compliance with the quality standards established in the agreements with the users (densifying systems or equivalent ones).

The final product must be stored in containers or vessels or piles adequately protected and with a volume suitable to the Centre potentiality; in anycase it must assure a storage capacity corresponding at least to 7 days of production.

4.3.5 Centres for energetical utilisation of refuse derived fuel

Centres for energetic utilization of (RDF) are plants which receive the selected fractions of fuel material separated in the Centres for production of refuse derived fuel for its combustion and energy production. Such plants must be located at least at 1,500 m far from the limit of urban agglomerations and of important or touristic centres and 2,000 m far from hospitals, health or thermal centres.

The characteristics of RDF to be sent to combustion must be in conformity with the current technical standards, including the Standard UNI 9903-1.

All sectors must be planned in order to reduce dust, volatile organic compounds and odors emissions, according to the best technologies available. The collection and the storage of materials to be sent to combustion must take place in a confined space, dimensioned in order to allow the storage of the maximum quantity of daily production for a period of at least 7 days; the plant must be equipped with specific devices for the abatement of particulate/dust, NO_x, HCl, HF, SO₂, organic micropollutants, and other inorganic pollutants.

The other technical requirements are:

- stack height able to assure a good dispersion of pollutants and to protect human health and environment;
- pavement and floorings of industrial type, equipped with washing water and wastewaters collection systems;
- suitable energetic recovery section under thermal or electric form, with total efficiency not lower than 20% with regard to electric energy production, to be calculated according to the real value of RDF lower calorific value;
- measurement and recording of main working parameters of the energy production plant;
- ash and slag storage in containers or vessels or piles adequately protected and with a volume able to assure a storage capacity corresponding at least to 7 days of production;
- quantification and characterization of mass flows coming out from the Centre;
- data visualization system to the public.

For handling the materials treated in the Centre, the same equipments of other above mentioned Centres must be available.

5. The Massafra plant

The first plant complying with requirements of the Puglia waste management regional plan was that located in Massafra, serving the OTB TA/1 (Photo 1). The plant, whose technical

specifications are summarised in Table 1, was built in 2003 and operated since 2004 by CISA s.p.a., so has now cumulated almost 7 years of successful operations.



Photo 1. General view of the Massafra plant

Authorised capacity	110,000 t/y
Operating days	312 d/y
Daily capacity	350 t/d
Operating hours of mechanical systems	12 h/d
Throughput capacity	30 t/h

Table 1. Technical specifications of Massafra plant

Typical composition of RSU treated in the plant is shown in the following Table 2.

Main constituents of the plant are:

- waste receiving area with weigh-bridge;
- two-floors building for waste receiving and production of RDF, being the section for waste receiving elevated of 2.5 m with respect to that for RDF production;
- two-floor building for offices and general services with controlling, monitoring and supervision systems located on the second floor;
- building for biostabilisation of waste separated from that for production of RDF by a 10 m width road; this building includes a total of 13 biotunnels, being 4 of them possibly utilized for RBM or compost production, and annexed auxiliary equipments, storage containers/boxes for materials to be stabilized, and feeding system for wet-dry separation and production of RDF;
- biofilter located close to the building for waste receiving and production of RDF, but at the opposite side of the offices.

All the external access areas and the operating ways and roads are fully paved, and all the plant area is confined by walling and wire fence.

All the produced RDF is recovered for energy generation at the Appia Energy power station, that is located by the side of the waste treatment plant.

Item	% (according to UNI 9246)
Paper	24.20
Plastics	25.94
Cloth / Fabric	0.76
Wood	1.68
Glass	3.85
Metals	2.07
Inerts	2.66
Organics	10.00
Undersize <20 mm	27.53
Evaporation losses	1.31
Total	100.00

Table 2. Typical composition of MSW at Massafra plant

5.1 Biological treatment cycle

The overall biological treatment cycle is shown in Figure 4.

Receiving area

The MSW conferring occurs in a closed building which is maintained under light vacuum; access doors are automatically operated for fast opening and closing. Wastes are downloaded directly from trucks on the pavement of the building, and are handled by a tyred loading shovel; during this operation, the operator of the tyred loading shovel checks the waste to verify the absence of non-processable materials.

Pre-treatment

This operation includes primary shredding and separation of ferrous materials by a 50 t/h slow-speed shredder with hydraulic control. The transferring belt is placed in storage pit, thus making easier the loading operation of materials by the handling means. The transferring speed is regulated by frequency variation.

The shredded waste is then transferred to storage boxes, where is taken by a tyred loading shovel for its loading into the biostabilisation tunnels.

Biostabilisation

The biological stabilization process takes place in 13 tunnels (Photo 2). The process, which includes stabilization and drying, requires 7 to 14 days, depending on the quality of waste. Exhaust air is sent to a centralized biofilter to control odours.

Biotunnels are fully constructed in reinforced concrete, and equipped of an insufflating air system from the pavement, through holes of squared mesh of 40 cm. Air fluxes and process parameters are automatically controlled by a computerized system.

After passing through the material, air is recirculated. Material temperatures are continuously monitored and air fluxes consequently regulated through variation of the cycle of each fan which biotunnel is equipped with. The MSW biostabilisation cycle lasts 7-8 days,

thus allowing a max Dynamic Respirometric Index of 800 mg-O₂/kg-VS·h to be got, useful for subsequent production of RDF.

The phases of the biostabilisation process are:

- hygienisation cycle with temperature continuously higher than 55 °C for at least 3 days; the concrete biotunnels guarantee the uniformity of treatment for all the waste mass thanks to the high insulating index of walls;
- after hygienisation, temperature is maintained at about 50 °C which is the optimal one for the development of microflora and micetes working on organic substance degradation; recirculation of treatment air guarantees uniform conditions of temperature, moisture and aeration of the mass;
- treatment air flow rate is higher than 40 m³/h per ton of material; this allows availability of enough air for cooling phases so the total time of treatment can be conveniently reduced and time useful for biostabilisation consequently increased.

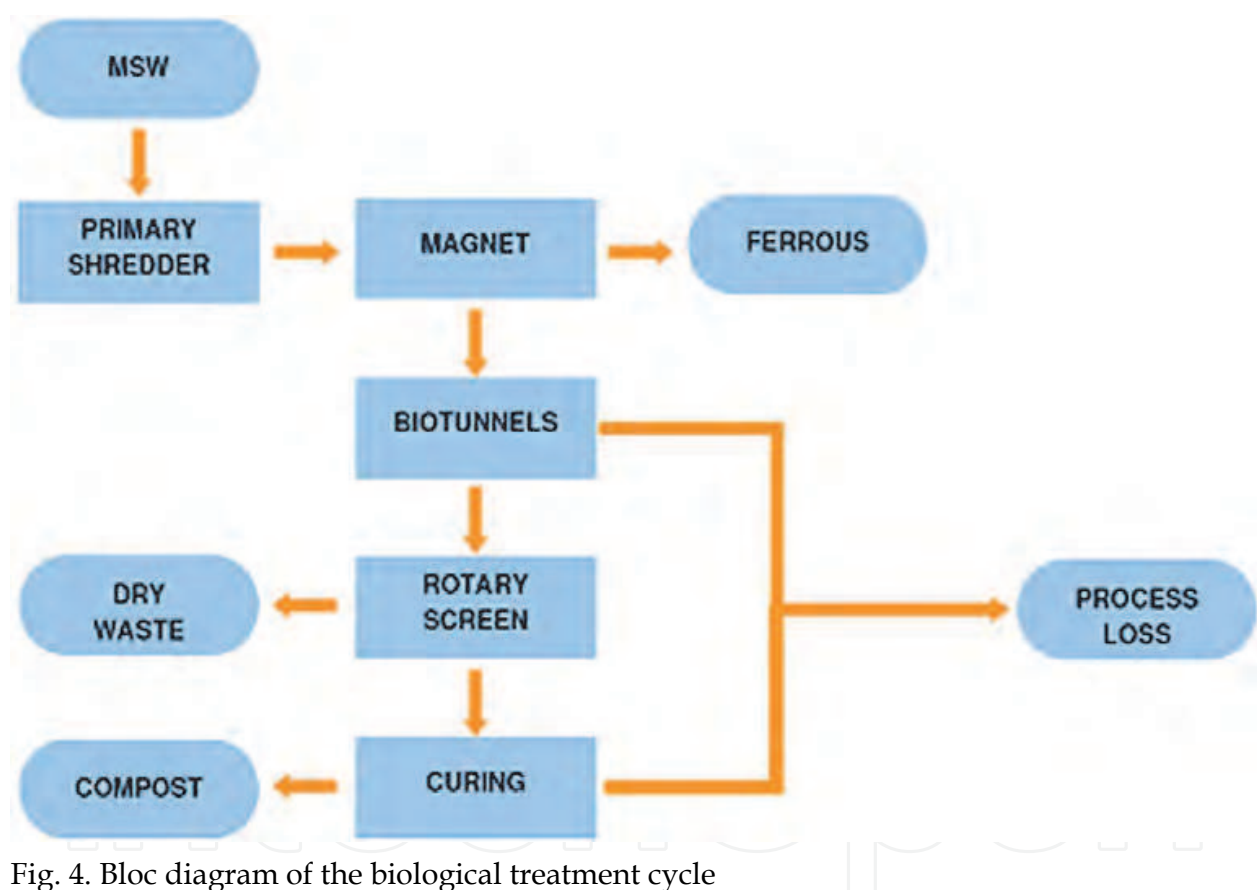


Fig. 4. Bloc diagram of the biological treatment cycle

Parameters controlled in each biotunnel are:

- inflated temperature, directly measured within the pile by thermometric probe inserted through the biotunnel cover;
- temperature of air to be recirculated to the biotunnel and of exhaust air to be treated in the biofilter;
- flow rates of fresh air and exhaust air;
- pressures inside the biotunnel, in air pipes, etc.

At the end of the biostabilisation treatment, the material is transferred to the wet-dry separation section by a tyred loading shovel.



Photo 2. Biostabilisation tunnels

The analysis of control and monitoring system data evidenced that a fundamental requisite for optimizing the biostabilisation process is the material size and homogeneity which strictly depends on the previous shredding operation. Optimal size of the material to be stabilized should range 120–150 mm, thus giving the material the necessary porosity and also guarantee the flaking off of parceled and compressed materials. The type of shredder installed in the plants is able to work in this direction.

In addition, the shredded material has to be submitted to biostabilisation in very short time, just to fully utilize the organic load of waste for a fast and natural temperature increase inside the waste pile during the initial biostabilisation phases. This fact occurs because the fresh shredded material does contain soluble and easy degradable compounds which are utilized by the mesophilic microorganism with production of heat necessary for the subsequent thermophilic phase; a delayed load of biotunnels involves the dispersion of the thermal energy accumulated during the mesophilic phase and, consequently, a not correct development of the process. Such a procedure allows a hygienisation temperature of 55 °C to be reached in 18 h.

For above reason, the choice of a porous pavement in the receiving area, instead of a storage pit, showed to be successful because in a pit the material downloaded from the first trucks remains at the bottom, so it is the last to be treated with possible developments of anaerobic conditions which are dangerous for the process itself, and also causes malodors and leachate release. Aeration through the pavement also avoids the negative effects of pressure on the material, such those caused by systems adopting covered windrow systems.

The determination of Dynamic Respiriometric Index on treated material is done on bi-monthly base, while that of raw MSW entering the plant once a year, and any time the collection system is modified or new wastes are conferred to the plant. Sampling procedures are those standardized by the norm 9246 of the Italian standardization body, UNI.

Separation- I

As shown in the process diagram (Figure 3), after biostabilisation the material is screened in a 80 mm openings equipment (Photo 3) where two fractions are separated.

The undersized fraction, or wet fraction, which does mainly contain organic material, is for 80% directly landfilled as RBD, while a 20% portion is cured in an aerated static pile to obtain RBM for subsequent use as cover material for landfill or other environmental purposes.

The oversized fraction, or dry fraction (FSC), is destined to production of RDF.

Curing and Separation-II

The maturation section of the plant, consisting of 4 specific biotunnels, has not been used up to now for the production of compost due to difficulties:

- in supplying the plant of selected organic material deriving from separated collection at source;
- in finding a destination for the compost to be eventually produced, so this section is only used for production of landfill cover material or land reclamation one.

However, above additional biotunnels can be used to expand the overall plant capacity and flexibility.



Photo 3. Selection / Screening equipment

Production of CDR

As told, the oversized fraction from separation is processed to convert it into densified RDF. After ferrous separation, an aeraulic device separates heavy components from light ones, the latter consisting of pieces of plastics, paper, cardboard, polystyrene, insulating material, etc., which are treated by two secondary shredders which reduces the material size thus making it acceptable to be treated by the subsequent horizontal draw bench densifiers, working in parallel, to produce pellets.

A magnetic separator attracts further ferrous material, before the material is processed by the densifiers, and again after them.

Figure 5 shows the bloc diagram of RDF production, and Photo 4 a particular of the pellettizing equipment.

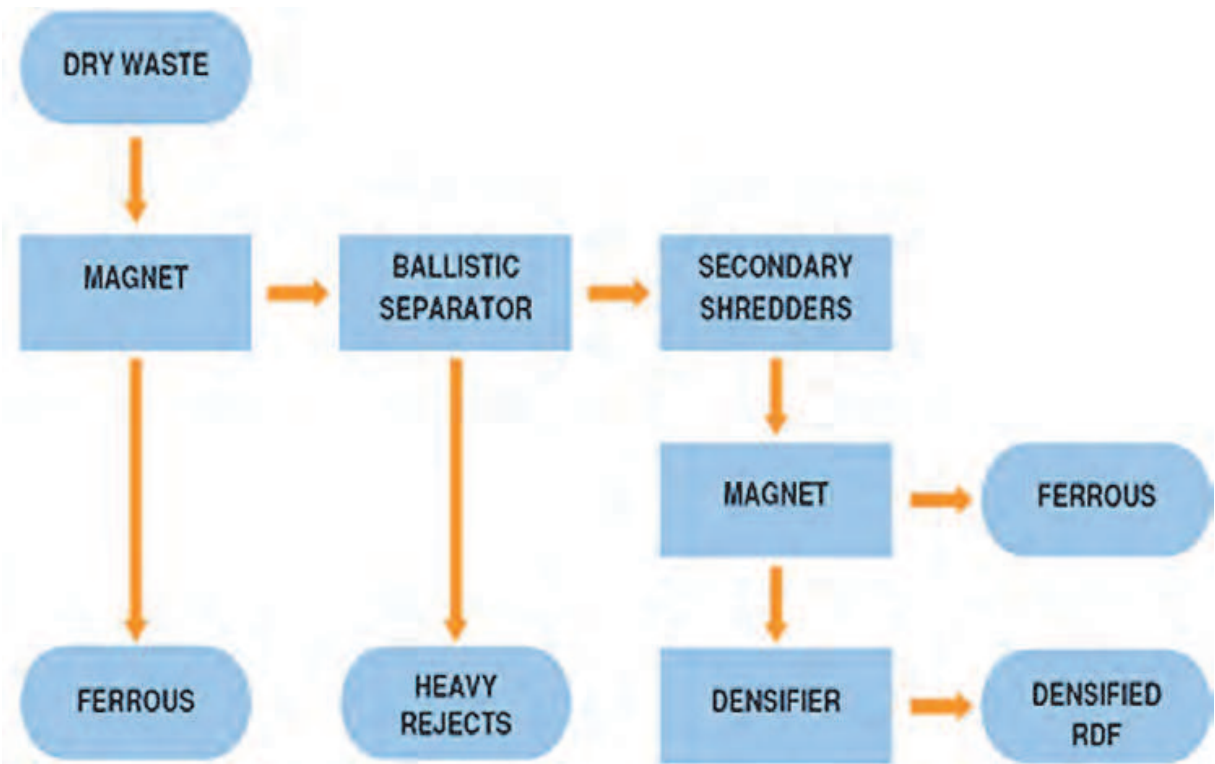


Fig. 5. Bloc diagram of RDF production

The densified material is automatically stored in containers for transporting to the Centre for its energetic utilization, while the heavy components and other manufacturing rejects are belt transferred to storage containers for subsequent disposal at authorized plants

In Table 3 the typical composition of RDF produced by the plant is summarized.

Process control

The control system manages not only all plant devices and equipment, but also records all data of field instrumentations whose analysis made possible the optimization of the entire treatment system.

The plant is also equipped with installations to control dust in the building of production of RDF and air from all plant sections. As a matter of fact, all equipment in the building of RDF production can produce some dust, so they are equipped with suction caps which are connected to a bag filter. The filtered air is then returned to the biostabilisation building which are maintained under light vacuum to avoid air emission outward.

Item	%
Cellulose	20.77
Wood	1.67
Polyethylene LWD	6.27
Polyethylene HD and Polypropylene	3.72
PET	1.91
Polystyrol	1.47
PVC	3.40
Cloth and Fabrics	2.89
Aluminum	0.58
Inerts	0.08
Undersize <20 mm	55.80
Losses	1.44
TOTAL	100.00

Table 3. Typical composition of produced RDF



Photo 4. Particular of the pellettizing equipment

All the closed ambients are maintained under vacuum to avoid diffusion of bad odors. Picked up air is utilised in the biotunnels and then sent to the biofiltration system. In the

biofilter plenum, condensate collecting wells connected to the network ending in the corresponding tank of humidification waters for their recirculation are placed.

Leachate from biotunnels, and water drained from all transit areas are collected and transferred to treatment by static grate filter, storage and treatment at authorized plants.

5.2 Energy recovery plant

The energy recovery plant, whose general view is shown in Photo 5, occupies an area of about 90,000 m². It is operated by Appia Energy s.r.l.

It consists of the following sections:

- fuel transport and dosing;
- combustion and steam generation;
- combustion gas treatment;
- ash evacuation and storage;
- condensation;
- energy supply and automation.

By means of the pre-heating and superheating phases, produced steam gets pressure and temperature conditions required by the turbine, where it is converted to mechanical energy and then to electric energy through the alternator. All the produced energy is forced into the national energy lines network due to agreement with the network operator.

The low pressure steam from the last turbine expansion stage is condensed to water in air condenser and enters again the thermodynamic cycle.



Photo 5. General view of the power station for energy recovery

Combustion gases, after exchanging their heat with water steam, are submitted to treatment for abatement of polluting compounds.

Steam generator is supported by a steel construction which is covered to protect the generator from atmospheric agents. Maximum height of the structure is 40 m. The stack is 45 m tall and has a diameter of 1.6 m.

The turbo-group is installed in a fire-resistant and sound adsorbing cabin. The interconnecting system to the national electrical network is located near the turbo-group and close to the existing electric lines; it includes a transformer (6.3 - 150 kV). The following Table 4 summarizes the main operating data of the energy recovery plant.

Produced Energy	Power consumption (auto consumptions)	Energy forced to national network	Gasoil for combustion
kWh	kWh	kWh	Litres
69,672,000	12,524,000	59,040,000	463,286

Table 4. Main operating data of the energy recovery plant

Other power plant data are:

- gross electric power ~12.5 MW_{el};
- net electric power ~10.0 MW_e;
- thermal power ~49.5 MW_t;
- net efficiency ~21%.

Industrial water needs have been estimated in about 18 m³/h during the start-up phase and in about 7.2 m³/h during the operation one, but experience showed that real needs during the operation phase could be as low as 2-3 m³/h.

The plant can be fed with RDF (main fuel) produced by the MSW treatment plant, and with gasoil (auxiliary fuel) during start-up and emergency periods. RDF consumption is estimated in about 100,000 t/y.

Interferences of the energy recovery plant with environment include gaseous, liquid, solid, noise, and electromagnetic emissions.

Gaseous emissions into the atmosphere are summarized in Table 5. Legal limits are reduced by 20% with respect to the national ones because the plant area is classified at environmental risk due to the presence of many industrial installations.

Item	Units	Value
Wet gases flow rate	Nm ³ /h	80,000 - 100,000
Dry gases flow rate	Nm ³ /h	60,300 - 89,000
Oxygen (as O ₂)	%	~ 11
Exit temperature	°C	~ 170

Table 5. Characteristic emission values of power plant

Reduction of sulphur oxides is obtained within the combustion camera by injection of lime above the fluidised bed. Reduction of nitrogen oxides is obtained through injection of ammonia solution in the post-combustion zone of the furnace. Finally, reduction of acid gases and organic micropollutants is obtained through chemical reactions after dry injection of alkaline substances, such as sodium bicarbonate and activated carbon, in a reaction tower downstream the steam generator. The treatment is completed by a bag filter which retains particulate/dust produced during the combustion process, and residues of the reaction for the abatement of acid gases.

The plant is also equipped with a double system of continuous monitoring of emitted pollutants (CO, NO₂, O₂, Particulate, SO₂, HCl, HF). Other pollutants, such as IPA, Heavy metals, Dioxins, Furans, are also periodically checked.

The authorized limits for stack emissions are reported in the following Table 6.

The system dealing with emissions of liquids is based on appropriate systems which allow most of the liquid wastes to be reutilized in the plant.

Two independent networks respectively collect raining waters and/or those coming from roads, service ways and areas, buildings roofs and coverings, and process waters and sanitary effluents.

Waters from the first network are treated by sedimentation, separation of solids substances and oils removal. At the end of the treatment their characteristics allow their reutilization and/or disposal with respect of the applicable normative.

Waters from the second network are treated by sedimentation, oils removal, biological treatment, pH correction and chlorination. At the end of the treatment, a portion is sent to external treatment plants for treatment and disposal, while another portion is utilized to moisten fly ashes for the abatement of their dustiness.

Main solid waste produced by the energy recovery plant include sand, bottom ashes and fly ashes which are disposed of according to the applicable normative. Bottom ashes amount to 5,000-6,500 t/y, and fly ashes to 14,000-17,500 t/y.

Compund	Max allowed concentration (mg/m ³)
Particulate / dust	8
Total Carbon (TOC)	8
Hydrochloric acid (HCl)	8
Hydrofluoric acid (HF)	0.8
Sulphur oxides (SO ₂)	40
Nitrogen oxides (NO _x)	160

Table 6. Authorized limits for gaseous emissions

Periodical monitoring campaigns to check the acoustic emissions of the plant are also planned and carried out by the official Institutions charged of this duty.

Analogously, during plant operation measurements of the electro magnetic field are done to verify the respect of the normative limits of non ionizing radiation emissions.

Since 2006, the plant got and operates a certified ISO 14001:2004 EMAS system of environmental management.

6. Conclusion

The correct management of municipal solid waste, in a context of a sustainability concept, requires adoption of appropriate integrated systems to:

- maximize the use and utilisation of waste material and energy content;
- minimize the impact of waste on the environment.

In the Region Puglia (Apulia), SE of Italy, the “Commissariat for Environmental Emergency” was established since 1997 having, among others, the duty to develop the

regional plan for municipal solid waste management in conformity with European and National regulations.

With the Commissary Decree 296/2002, as completed and adjourned by the Decree 187/2005, the Commissary approved the “Regional Solid Waste Management Plan”, after introducing on 1997 and 1998 technical specifications for the mechanical-biological treatment of solid waste remaining after separation at source of selected fractions.

Basically, above mentioned Commissary Decrees, require the:

- development of “source separation” schemes with the target for 2010 of 55% of MSW separately collected to be subsequently handled for material recoveries;
- operation of Centres for the “qualification” of specific recyclable fractions deriving from above “source separation or separate collection”;
- “biostabilisation” of urban waste remaining from separate collection prior to the separation of a treated wet fraction to be landfilled, or used for environmental purposes, and a dry fraction to be used for the production of refuse derived fuel.

The management plan split up the regional territory into 15 “Optimal Territorial Basins” each mainly served by treatment plant for:

- “qualification” of specific recyclable fractions deriving from “source separation or separate collection” of urban waste;
- “pre-treatment” of residual urban waste deriving from conventional “not-separate collection”;
- “biostabilisation” of above pretreated waste;
- “mechanical separation” of biostabilised material into a “wet fraction” and a “dry fraction”, being the former landfilled or submitted to further curing for the production of materials to be possibly reused for environmental purposes, the latter (FSC) processed for conversion into RDF;
- “landfilling” of process rejects or of untreated waste during shutdown periods for maintenance and/or emergency.

The first plant complying with requirements of the waste management regional plan was that located in Massafra, with an authorised capacity of 110,000 t/y.

Core of the plant is the biological stabilization process that takes place for 7-14 days in 13 biotunnels. The biostabilised material is then screened to obtain a “wet” (undersized) fraction and a “dry” (oversized) one. Then the dry fraction is processed to be converted into densified refuse derived fuel.

Finally, produced RDF is burnt in a dedicated power plant to recover energy. Main characteristics of the power plant are a gross electric power of about 12.5 MW_e, a net electric power of about 10.0 MW_e, a thermal power of about 49.5 MW_t, and a net efficiency of about 21%.

The plant has now cumulated almost 7 years of successful operations fully complying with limits imposed by applicable regulations.

7. Abbreviations

DRI	Dynamic Respirometric Index
EU	European Union
FSC	Treated (biostabilised) dry fraction for production of refuse derived fuel (RDF)
MSW	Municipal solid waste
OTB	Optimal territorial basin

RBD	Treated (biostabilised) wet fraction for disposal in landfill
RBM	Further treated (cured/matured) wet fraction for environmental utilisation
RDF	Refuse derived fuel

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To this purpose, opinions and statements expressed in the Chapter are those of the authors and not necessarily those of above mentioned Institutions and Companies.

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Phone: +86-21-62489820
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