

“Capacity Building and Strengthening Institutional Arrangement”

Workshop: “Best Available Techniques (BAT)”

BAT on Plastics and its Recycling Industries

Mr. Giorgio De Benedetti, Mr. Giorgio Grimaldi

APAT

Agency for Environmental Protection and Technical Services

Index

1. Introduction
2. Operative phases of the plastic production
3. Environmental issues and pertinent BAT
4. Recycling of plastic packing in Italy
5. Organisation of the recycling process
6. Use of the recycled plastic materials
7. A typical application: *the refrigerators recycling plant*

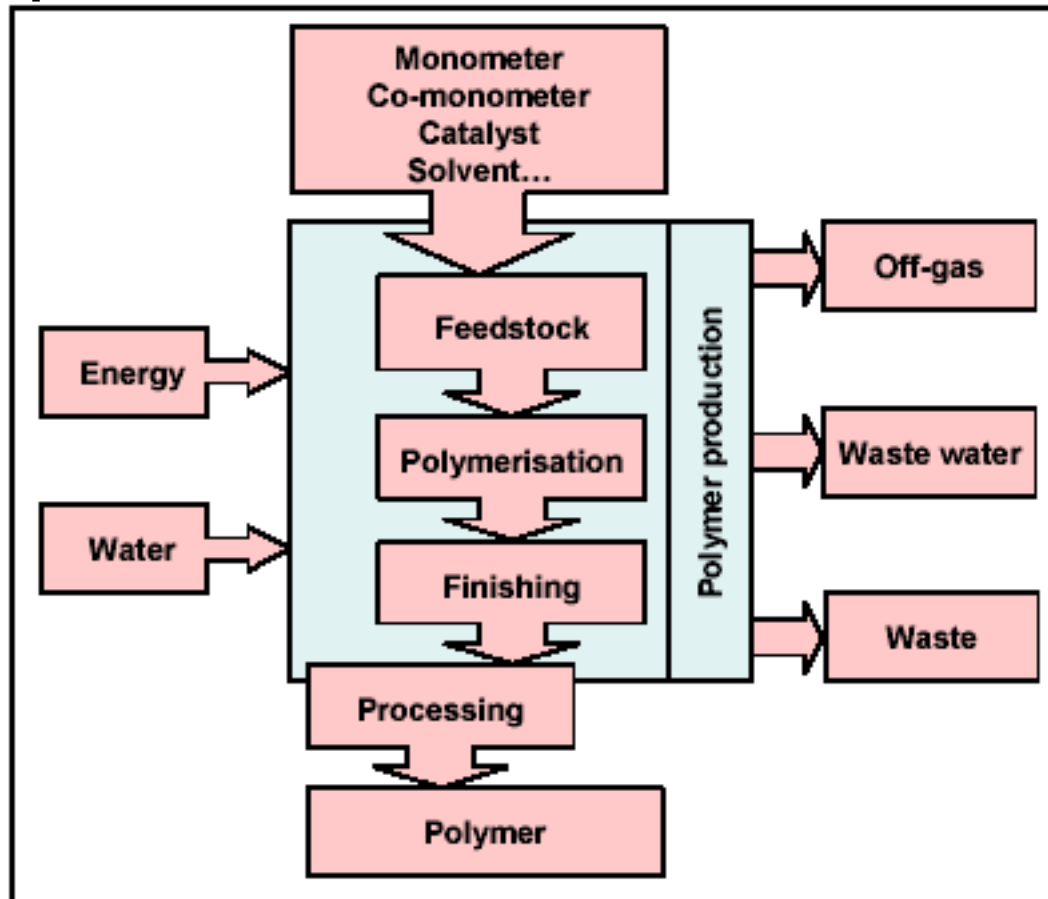
1. Introduction

- Production of plastics is a complex process, mainly of chemical nature, involving a lot of materials with significant potential risk for health and safety and for the environment.
- Potential dangerous effluents emission and significant energy consumption in the production cycle (blend preparation and moulding) are to be attentively faced.
- The products span from raw plastic (polymers) for further working to a large variety of objects, widely present in every part of our daily life.
- The life cycle of plastic objects is of a relatively short duration, thus requiring short term replacement.
- The large amount of plastic objects put in the environment calls for a great attention to the heritage that could be leaved to the future generations. Then recycling and reuse have to be strongly encouraged.

2. Operative phases of the plastic production

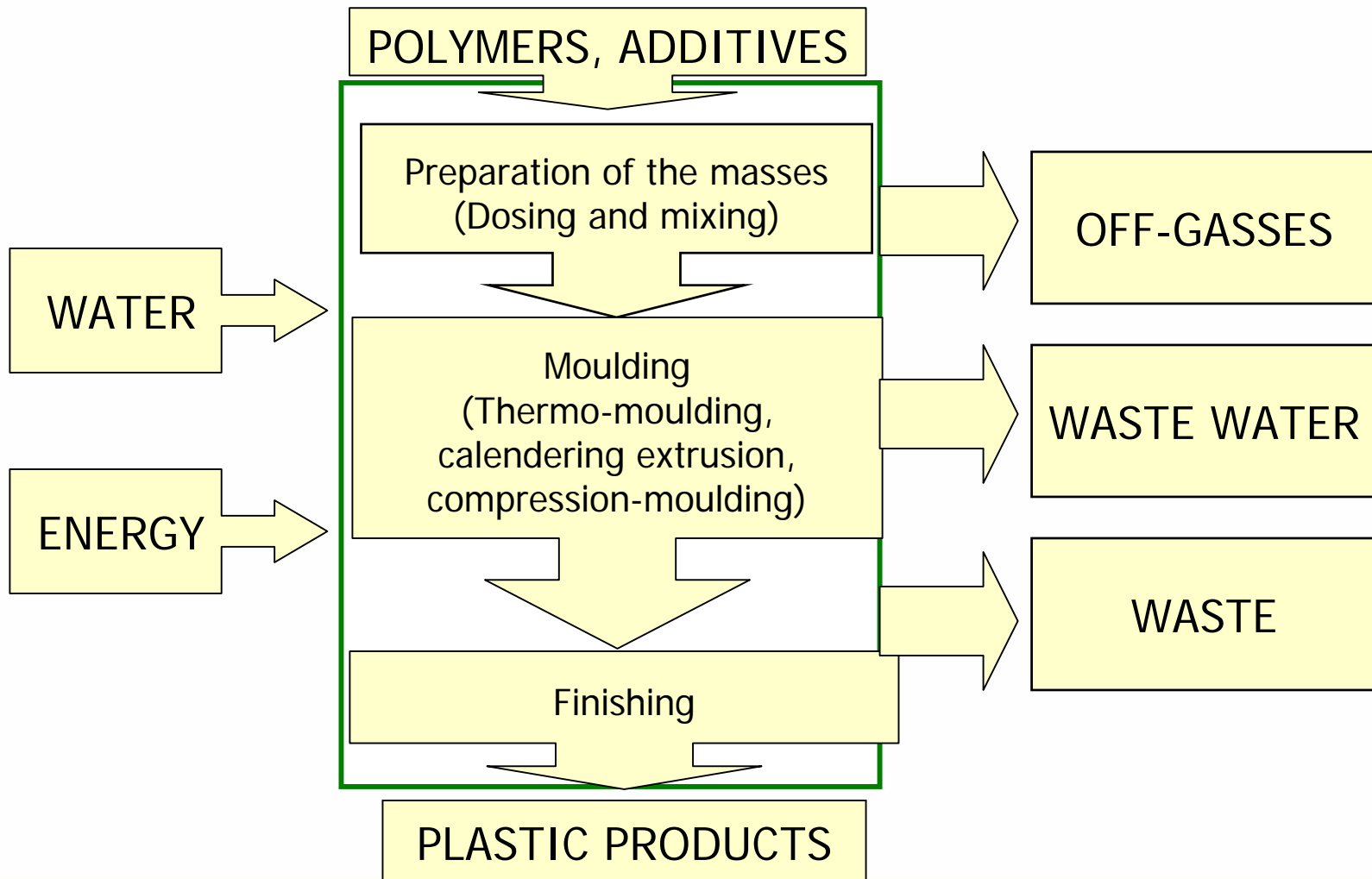
Production cycle for polymers preparation

raw material production



2. Operative phases of the plastic production

Production cycle for plastics industry



2. Operative phases of the plastic production

Production cycle for plastics industry

Operating Phases (1/2)

1. Storage and dispensing of solid raw materials
2. Storage in process small tank and dispensing of liquid raw materials
3. Mixing and volumetric dosing
4. Hot operations on polymers
5. Hot operations on rigid or semirigid plastic handworks
6. Recycle of plastic polymers
7. Preparation of blending without solvents
8. Plasticization and surface treatment of handworks with plastic polymers
9. Preparation of polymeric fibre and of fabric-non-fabric

2. Operative phases of the plastic production

Production cycle for plastics industry Operating Phases (2/2)

10. Production of expanded polymers
11. Preparation of the mixture for coating, straining, soaking
12. Coating a surface with plastic polymer in watery/organic emulsion
13. Moulding expanded plastic, polymerization, maturing
14. Rotogravure, offset, enamelling, coupling flexible packaging made of plastic polymer
15. Printing, offset, flexography, enamelling and coupling of film with other substratum
16. Finishing of handworks
17. Hot finishing

3. Environmental issues and pertinent BAT

Storage and dispensing of solid raw materials

Operations of storage bin, dispensing , pneumatic transport of solid raw materials, manual or automatic weighing of solid material.

Effluents

Inert powder toxic and noxious, very toxic

BAT for powder

DRY FILTERING

3. Environmental issues and pertinent BAT

Storage in tank and dispensing of liquid raw materials

Operations of storage in process tanks, dispensing, dispensing by pump of the liquid raw materials, manual or automatic weighing of liquid material.

Effluents

Volatile Organic and Inorganic Compounds

3. Environmental issues and pertinent BAT

Mixing and volumetric dosing

Mixing, granulation, milling and drying of raw or recycled plastic material. Operations made to prepare the solid blending to be send to the press by pneumatic transport or by drop from storage bin or by turbo mixer.

Effluents

Inert powder toxic and noxious, very toxic, lead, cadmium and mercury

BAT for powder

DRY FILTERING

3. Environmental issues and pertinent BAT

Hot operations on polymers

Hot-pressing, extrusion, pressure-injection, rotating extrusion, hot-drawing. The polymer, in granular or powder status, get soft due to high temperature. Operations made to prepare rigid or semirigid handworks.

Effluents

Grease powder and fog, Volatile Organic Carbon (VOC), acrylnitrile, formaldehyde and total aldehyde, hydrochloric acid, chlorinated compounds, ammonia and phosphine

BAT for powder: DRY FILTERING

BAT for phosphine: TOWER DAMP ABSORBER

BAT for smelling compounds: BIOFILTRATION PLANT

3. Environmental issues and pertinent BAT

Hot operations on rigid or semirigid plastic handworks

Hot or vacuum thermomoulding, calendering of plate flexible or multilayer material, rotating pressing and for casting of polyurethane handworks, pressing of polymeric material soaked of volatile organic compounds, mechanical finishing, followed by cleaning of the dies by detaching agents.

Effluents

Grease powder and fog, VOC, formaldehyde and total aldehyde, ammonia and aliphatic amine.

BAT for powder: Dry Filtering

BAT for VOC: Activated Carbon Absorber – External RIGENERATION; Wet Filtering – Tower Scrubber; Recovering Thermal Combustion; Regenerative Thermal Combustion

BAT for NON-VOC: Wet Filtering – Tower Scrubber

3. Environmental issues and pertinent BAT

Recycle of plastic polymers

Recovery, storage, selection, milling and condensing of recycled plastic materials.

Effluents

Inert powder, volatile inorganic and organic compounds.

BAT for powder: Dry Filtering

BAT for smelling compounds: Tower Wet Filtering;

Biofiltration Plant

3. Environmental issues and pertinent BAT

Preparation of blending without solvents

Blending of PVC, plastisol and other solvent free material, in close or open blender, prepared at cold, but to gel after that at more than 150°C temperature.

Effluents

Powder, chloridric acid and plasticizers.

BAT for powder: Dry Filtering

BAT for Plasticizers : DRY ELECTROSTATIC PRECIPITATOR;

Coalescece Plants

3. Environmental issues and pertinent BAT

Plasticisation and surface treatment of handworks with plastic polymers

Coating of metallic or other material handworks by plastic polymers such as PVC, polietilene, etc., through fluid bed process, immersion and subsequent hot drying/polimerization.

Effluents: Powder, ammonia, plasticants, chloridric acid, 1, 3-butadiene and volatile organic carbon, volatile inorganic compounds.

BAT for powder: Dry Filtering

BAT for VOC:

Activated Carbon Absorber – External Rigeneration; Wet Filtering – Tower Scrubber

BAT for VIC: Wet Filtering – Tower Scrubber

BAT for 1, 3-Butadiene

Activated Carbon Absorber – External Rigeneration

BAT for plasticizers : Dry Electrostatic Precipitator; Coalescece Plants

3. Environmental issues and pertinent BAT

Preparation of polymeric fibre and of fabric-non-fabric

Preparation of fibre through draw-plate with or without outgassing, stretched texturing, twisting of fibre, drawing up and soaking by watery glue intended to make fabric-non-fabric.

Effluents:

Grease powder and fog, Volatile Organic Carbon (VOC), formaldehyde and total aldehyde, ammonia and aliphatic amine.

BAT for powder, grease fog -aerosol: Dry Filtering; Dry Electrostatic Precipitator; Coalescence Plants

BAT for VOC:

Activated Carbon Absorber – External Regeneration; Wet Filtering – Tower Scrubber (only for VOC soluble in the drawing fluid)

BAT for VIC: Wet Filtering – Tower Scrubber

3. Environmental issues and pertinent BAT

Production of expanded polymers

Manual or automatic weighing of the blending, prepared by grinding and calendering.

Effluents: Volatile Organico Carbon (VOC), Volatile Inorganic compounds (VIC), particulate, phenol, acetone, NO_x .

BAT for particulate: Dry Electrostatic Precipitator

BAT for VOC

Dry Electrostatic Precipitator; Wet Filtering – Venturiscrubber; Wet Filtering – Tower Scrubber (only for VOC soluble in the drawing fluid)

BAT for VIC

Wet Filtering – Tower Scrubber; Wet Filtering – Venturi Scrubber

3. Environmental issues and pertinent BAT

Preparation of blending for coating, straining, soaking

Mixing of liquid or solid raw material in order to prepare the watery/organic solution-suspension-emulsion to coat-soak-pour on a surface, except for material dispersed in a solvent or for material used in printing.

Effluents:

Volatile Inorganic and Organic Compounds, methyl acrylate, ethyl, propyl, butyl, amyl and their isomer and powder

BAT for powder: Dry Filtering

BAT for VOC:

Activated Carbon Absorber – External Rigeneration; Wet Filtering – Tower Scrubber (only for VOC soluble in the drawing fluid); Recovering Thermal Combustion; Regenerative Thermal Combustion

Bat for VIC: Wet Filtering – Tower Scrubber

3. Environmental issues and pertinent BAT

Coating a surface with plastic polymer in watery/organic emulsion (1/2)

Blending of polyurethane, on fabric or synthetic leather.

Blending based on PVC and plastisol, used for printing.

Production of panels and handworks made by material soaked with prepolymerized resin, by hot and vacuum processes.

Panels and rolled handworks made by coating-soaking-spraying a surface with resin in watery emulsion and subsequent drying/polymerization process.

Self-sticking tape made by non solvent plastic film or fabric.

Polymeric resin sandwich panels.

3. Environmental issues and pertinent BAT

Coating a surface with plastic polymer in watery/organic emulsion (2/2)

Effluents: VOC, plastificants, particulate, hydrochloric acid, ammonia, acrylate from C1 to C5, Volatile Organic Carbon, formaldehyde.

BAT for powder aerosol:

Dry Filtering; Wet Filtering- Venturi Scrubber

BAT for powder methyl acrylate, ethyl, propyl, butyl, amyl and their isomer and powder: Wet Filtering-tower Scrubber

BAT for VOC: Activated Carbon Absorber – External Regeneration; Wet Filtering – Tower Scrubber (only for VOC soluble in the drawing fluid);

Recovering Thermal Combustion; Regenerative Thermal Combustion

BAT for VIC: Wet Filtering – Tower Scrubber

3. Environmental issues and pertinent BAT

Moulding expanded plastic, polymerization, maturing

The expanded handwork is made by plasticization of the polymer through an extruder, by drawing, by continuous expansion, often coated by hydrocarbon on its surface. Operation must be made in a closed ambient, equipped by local exhaust fan and ad hoc filtering system.

Effluents: VOC, plastificants, particulate, isocyanate, ammonia, Volatile Organic Carbon, formaldeyde.

BAT for aerosol

Dry Filtering; Wet Filtering- Tower Scrubber; Wet Filtering- Venturi Scrubber

BAT for VOC

Activated Carbon Absorber – External Rigeneration; Wet Filtering – Tower Scrubber; Recovering Thermal Combustion; Regenerative Thermal Combustion

BAT for VIC: Wet Filtering – Tower Scrubber

BAT for isocyanate

Wet Filtering – Tower Scrubber

3. Environmental issues and pertinent BAT

Rotogravure, offset, enamelling, coupling packaging made of plastic polymer

Mixing, granulation, milling of raw plastic materials, their drying and extrusion in order to prepare plastic flexible film through a degassing equipment.

Rotogravure, enamelling and coupling of the flexible plastic film with different materials are made directly on line with printing and its specific processes (watery and grease inks).

Effluents: Volatile Organic Carbon, ozone, amine, ammonia, isocyanate.

BAT for ozone and isocyanate: Wet Filtering- Tower Scrubber

BAT for VOC: Activated Carbon Absorber – External Regeneration; Wet Filtering – Tower Scrubber

3. Environmental issues and pertinent BAT

Printing, offset, flexography, enamelling and coupling of film with other substratum

Preparation of watery or UV based materials, to associate to a printing process.

Effluents

Volatile Organic Carbon, ozone, ammonia, isocyanate, acrylate from C1 to C5

BAT for Volatile Organic Carbon, ozone, ammonia, acrylate, isocyanate

Wet Filtering - Tower Scrubber

3. Environmental issues and pertinent BAT

Finishing of handworks

Cutting and trimming of finished handworks, calendering, embossing and other cold mechanical operations.

Effluents

powder, ammonia, plastificants.

BAT for ammonia

Wet Filtering – Tower Scrubber

BAT for plastificants and powder

Dry Electrostatic Precipitator; Dry Powder Absorber; WET FILTERING – Venturi SCRUBBER

3. Environmental issues and pertinent BAT

Hot finishing

Finishing of intermediate and final handworks, cleaning of equipments (i. e. draw-plate) by hot operations in oven with post combustion.

Effluents

Emission of powder, Volatile Organic Carbon, carbon and nitrogen oxide, heavy metals (Cr, Ni, Co, As, Sb, Cd).

BAT for Volatile Organic Carbonio:

Wet Filtering – Tower Scrubber

BAT for powder

Dry Electrostatic Precipitator;

Dry Powder Absorber;

Wet Filtering – Venturi Scrubber

4. Recycling of plastic packing in Italy

Organisation

- CO.RE.PLA (National consortium for collection, recycling and renewal of plastic packing waste)
 - 911 conventions, 6791 Municipalities, 36 Collection centers, 368000 tons collected in the 2005
- ASSORIMAP (National association recyclers and regenerators of plastic materials) - most of the independent operators
- Recycling system
 - Conveyance
 - Seletion
 - Reworking

4. Recycling of plastic packing in Italy

Quantitative data

Recycling activities in Italy (thousand tons)

	2005	2006*
Plastic Packing consumed in Italy	2080	2110
COREPLA recycling	243	257
COREPLA recycling (%)	11,6	12,1
Indipendent Operators –extra COREPLA recycling	304	305
Indipendent Operators –extra COREPLA recycling (%)	14,6	14,5
Total national recycling	547	562
Total national recycling (%)	26,2	26,6

*Estimated data

Source: COREPLA – PSP 2005

5. Organisation of the recycling process

Selection of material

- Separation at source is very difficult, therefore the following machine are used:
 - Magnetic separators
 - Mechanical systems for screening and separation
 - Air separators
 - Grindings

5. Organisation of the recycling process

Recycling technics

- Homogeneous mechanical recycling
- Heterogeneous mechanical recycling
- Chemical recycling
- Energy production

5. Organisation of the recycling process

Mechanical recycling

- Thermal or mechanical working
 - Plastic granules, used to make other products, can be obtained from thermoplastic material;
 - Thermosetting composition is grinded and used as inert filler in the raw polymers

5. Organisation of the recycling process

Chemical recycling

- Pyrolysis: the breaking apart of complex molecules into simple units by the use of heat: the product is a mixture of liquid and gaseous hydrocarbons petrol-like
- Hydrogenation: treatment based on hydrogen and heat: polymers are converted into liquid hydrocarbons
- Gasification: heating and lack of air produce a mixture of carbon oxide used in other materials working
- Chemolysis: convert used material into raw material

5. Organisation of the recycling process

Energy production

- Direct combustion of waste (thermal valorization from municipal waste, thermal valorization from reject of the selection process)
- Combustion of Package Derived Fuel (PDF) or CDR (Combustible derived from waste).

6. Use of recycled plastic materials

- Recycling of PET (polyethylene terephthalate) production of plastic bottles and textile fibre and yarns
- Recycling of PE (polyethylene) containers for cleansing agents, sheets and films, pipes and building materials
- Recycling of PVC (polyvinyl chloride) pipes, connectors, telephone or electric cables

7. A typical application: the refrigerators recycling plant

“Refrigerators” treatment plant features

- Features of a typical industrial plant
 - Up to 60 refrigerators/hour treated
 - Refrigerator up to 1050x950x2000 mm, 80 Kg processed
 - Purity of the separated fractions
 - Polyurethane foam 95% volume
 - Iron fraction 98% weight
 - Aluminium/copper fraction 93% weight
 - Plastic fraction 96% weight

7. A typical application: the refrigerators recycling plant

Recovery plastics and not only “Refrigerators” treatment plant

- Iron, plastic, copper, aluminium, polyurethane and cooling gas are selectively extracted
- Phases
 - Selection – the refrigerators are divided in different categories
 - Refrigerators with refrigerant circuit intact
 - Industrial or domestic refrigerators
 - Typology of refrigerator gas (R12, R22, R134, ect)
 - Preparation of the refrigerators – Extraction of the cooling gas, removal of compressor, wiring and glass
 - Grinding and separation of the waste material- Refrigerator is reduced in 20/30mm pieces
 - Separation of iron
 - Separation of copper and aluminium
 - Grinding and pulverization – using a mill for plastic material
 - Dust collection – Sorting of polyurethane from plastic
 - Process gas extraction – Gas is extracted, purified and brought back in the cycle, while the condensed fluid is stored into a tank

8. Final considerations

- Plastic production can give a considerable impact on the environment, due to the specific nature of the involved processes, resulting in air and water pollution, but mainly in large non biodegradable waste production.
- Implementation of BAT in every production phase (from raw material selection to the final handworks production) can significantly reduce emission of dangerous pollutants in every environmental matrix.
- Attentive water and energy balances in the affected production phases can result in both primary resources saving and significant economic advantages.
- A sound priority should be given to the recovery of plastic material at the end of life of products, in order both to reduce the amount of dangerous material left in the environment and to produce energy, thus saving other sources.

9. Reference documents

- A specific BREF (Reference Document on Best Available Techniques) has not still been prepared. Some indications could be found only for polymers production, thus covering just the preparation of the raw materials used in the plastic industry. <http://eippcb.jrc.es/pages/Fmembers.htm>

- Methodology for environmental analysis of production cycles – APAT 36/2006 (*Italian language*)
http://www.apat.gov.it/Media/cicli_produttivi/Avvio.htm

- Analysis of dangerous materials in Emilia Romagna Region (Cap. 3: Painting, Cap. 5 Plastics)
ARPA Emilia Romagna, 2005 (*Italian language*)

- Atmospheric pollution reduction from industrial activities Lombardia Region Official Bullettin, 2003 (*It. language*)