

3rd MATER MEETING

INNOVATION & TRENDS IN WASTE MANAGEMENT

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Session 1

STRATEGIES AND PERCEPTIONS ON WASTE MANAGEMENT

An underestimated technology for renewable energy and climate control

N.J. Themelis, Earth and Environmental Engineering, Columbia University, New York City

Corresponding author's e-mail address: njt1@columbia.edu

Abstract

One of the achievements of the 20th century is what we have accomplished with a major waste stream of humanity, wastewater: The time old solution, of discarding it in cesspools (or "septic tanks"), has been replaced by the technology of modern wastewater treatment plants that produce clean water and recover some biogas. No one claims that cesspools are better. In the last few decades, scientists and engineers have also developed a superior technology for managing solid wastes. It is called waste-to-energy (WTE) and has been adopted in about 20% of the world. However, one billion tons of urban solid wastes are still landfilled and, regrettably, there are still people and organizations who oppose WTE and thus perpetuate landfilling. If all the greenfields of the world, that are now transformed to landfills in one single year, were to be located at one place, they would occupy an area of 100 square kilometers, about the size of metropolitan Paris, and would be visible from outer space. There is talk of inhabiting Mars to provide living space for humanity. What would it cost for humans to create 100 square kilometers of livable surface, each year, on Mars? If thermal processing with energy recovery ("Waste-to-Energy") is applied universally, it will result in the generation of over five hundred million MWh of electricity and the mitigation of over one billion tons of greenhouse gas.

Waste logistics optimisation: from collection of MSW to treatment and disposal flow management

M. Pozzi^a, D. Vigo^{a,b}

^a *Optit Srl, via Calcinaro, 2097 - 47521 Cesena (FC), Italy*

^b *Alma Mater Studiorum Università di Bologna - DEI - Dip. di Ingegneria dell'Energia Elettrica e dell'Informazione "Guglielmo Marconi", viale Risorgimento, 2 - 40136 Bologna, Italy*

Corresponding author's e-mail address: matteo.pozzi@optit.net

Abstract

Designing and planning waste collection and disposal services is a notably complex issue, both in logistic and industrial terms, with significant economic, environmental, social and urban impacts.

Yet, use of mathematical models and a set of methodologies and resolution strategies that fall into the domain of Operations Research (OR) can provide strategic decision makers and operations planners with powerful tools to manage such complexity.

Optit, accredited spin-off company of the Alma Mater Università di Bologna, leverages on state-of-the-art OR to deliver innovative Decision Support System to business and institutional organizations in Italy and abroad and has developed a long-lasting experience with some of the leading Italian Utilities.

We will present two particularly significant industrial applications in waste logistics:

- OptiRoute is a solution that supports all phases of the analysis and design of Municipal Solid Waste collection systems, based on underlying opensource GIS technologies, capable of leading to significant cost savings and quality of service enhancements;
- OptiWasteFlow is an Enterprise Web Application to manage the full value chain of waste treatment and disposal/re-use, taking into account the combined system of logistics and plants optimization. The solution, originally conceived to manage strategic scenario generation, has now evolved into a full, co-operative planning and management system, accessed everyday by hundreds of players throughout the end-to-end process.

In both cases operating margins are maximized, which leads to minimal use of resources (vehicles, fuel, human resources) and reduces impacts on traffic, air pollution and GHG emissions.

Circular economy principles and waste management system of Brescia

M.L. Venuta¹, I. Beretta², M. Castellani³, M. Locatelli⁴, L. Alengoz³, C.Braga², E.Cabini¹, C.Castelazzo⁴

¹*Physics and Mathematics Department, Università Cattolica*

²*Faculty of Social Sciences and ASA UniCatt; 3 Economics and Management Department, Università Statale BS; 4 Entertainment and Communication Faculty, UniCatt*

Corresponding author's e-mail address: marialuisa.venuta@unicatt.it

Abstract

The Action Plan of the European Union for the circular economy adopted at the European Commission on 2 December 2015 (COM (2015) 614) provides that products are seen in their lifetime beyond the principle called "cradle to grave ". The goal is to create a continuous cycle of recovery and reuse of materials following a logic concept called "cradle to cradle".

In the summer of 2017 the introduction of curbside collection of municipal waste in the city of Brescia will be completed. The modification of the collection allows a better quality of differentiated fractions that can be recovered and used again in the production of components or new high quality products.

In the paper we present some of the activities and the on going process of the Working Table on the Circular Economy and Waste System established as A2a for the 2016-2018 period, involving Public University and Catholic University. In this way, A2a analyzes its operating system than the new model of development adopted at European level circular economy.

We present these actions:

1. Study of the organic waste fraction life cycle in the collection door to door in the circular economy system in Brescia. The objective of this activity is to relate the gesture of care of the people to know and differentiate products / waste compared to the environmental benefits the system. On the basis of cases European study, literature, and with the data provided by A2a takes place a macro analysis of the product / waste / recycled resource so as to calculate also the impacts avoided compared to the good behavior required by door-to-door collection to individual citizens .

2. The creative communication applied to the collection in the A2a and analysis system of corporate communication, technical and user involvement. The goal is to identify what are the modes of communication of A2a about the importance of waste reduction and the knowledge of the composition of the products and of the recyclables in terms of eco-recycling. It also puts in action a study for the creation of new modes of expression with an emphasis on young creativity (digital media).

3. The social representation of environmental protection with respect to waste management and circular economy before and after the introduction of curbside collection system. The goal of the action is to understand the main characteristics that define the cognitive framework with which citizens perceive a complex and articulated as that of waste management through sociological investigations in the field using the Delphi method and focus groups.

Lung cancer risk assessment at receptor site of an incinerator plant in Italy

G. Buonanno^{3,2,1}, G. Ficco¹, A. Russi¹, M. Scungio^{*1}, L. Stabile¹

¹*Department of Civil and Mechanical Engineering, University of Cassino and Southern Lazio, via G. di Biasio 43, 03043 Cassino (FR), Italy*

²*Queensland University of Technology, GPO Box 2434, Brisbane Qld, 4001, Australia*

³*Department of Engineering, University of Naples "Parthenope", Isola C4 Centro Direzionale, Naples, Italy*

Corresponding author's e-mail address: m.scungio@unicas.it

Abstract

The toxicity of particulate matter emitted from waste-to-energy plants, is associated to the compounds attached to the particles, several of which have been classified by the International Agency for Research on Cancer (IARC) in the Group 1 carcinogens. In this paper a modified risk-assessment model, deriving from an existing one, was applied to estimate the lung cancer risk related to both ultrafine and coarse particles emitted from an incinerator whose people living nearby are exposed to. To this end, the measured values of Polycyclic Aromatic Hydrocarbons (PAHs), heavy metals (As, Cd, Ni) and PCDD/Fs (Polychlorinated dibenzodioxins/furans) emitted from an incinerator placed in Italy were used to calculate the Excess Lifetime Cancer Risk (ELCR) at the stack of the plant. The estimated ELCR was then used as input data in a numerical CFD (Computational Fluid Dynamics) model that solves the mass, momentum, turbulence and species transport equations to study the influence of wind speed and chimney height on the ELCR at receptor sites. Furthermore, combining meteorological data (wind speed and direction), and hypothesizing different exposure scenarios on the basis of time-activity patterns of people living nearby the plant, specific risk maps were obtained by evaluating ELCR around the incinerator. Results show that with the increasing of wind speed, the ELCR value downwind at the plant decreases and its point of maximum risk becomes closer to the stack. On the other hand, increasing the stack height decreases the ELCR, moving away from the stack the point of maximum risk. Finally, the risk maps for people living or working nearby the plant have highlighted that the excess risk of lung cancer due to the presence of the incinerator is below the WHO target (1×10^{-5}).

Session 2.1

ECONOMIC REGULATION OF WASTE MANAGEMENT

Rates regulation of access to the waste treatment plants: an overview

A. Moretto^a M. Favot^b

^a*Ente per lo smaltimento dei rifiuti solidi urbani Bacino Padova 2, Via N. Tommaseo 60, 35131 Padova, Italia*

^b*Dipartimento di Scienze Economiche e Statistiche (DIES) dell'Università degli Studi di Udine, Via Tomadini 30/A 33100 Udine, Italia*

Corresponding author's e-mail address: annamore@libero.it

Abstract

The knowledge of the waste sector has progressively increased in the recent years. On the one hand, information on waste flows and technological features of plants (pre-treatment and treatment plants, composting plants, incinerators and landfill) is available. On the other hand, there is limited or not clear information on the fees for accessing these plants ("gate fees").

In Italy, approximately 26% of municipal solid waste (MSW) is sent to material recycling, 18% to organic recycling (from separated collection), 19% to incineration while 26% is still landfilled (ISPRA, 2016). Nevertheless, often disposal operations come after Mechanical Biological Treatment (MBT) which makes it difficult to identify the several waste management activities. Despite "think tank" which aims for the zero-waste paradigm, available data confirms that in Europe incineration of waste accounts for 30-60% of total (Massarutto, 2015). Disposal and landfill are reduced where an integrated waste management system is performed.

Our analysis is justified in light of the relevance of the topic, the economic impact of the treatment phase on the waste management costs, the lack of shared knowledge and authoritative, up-to-date and homogenous information.

The Italian Regional administrations adopt heterogenous approach in setting the fees for the treatment and disposal plants. Therefore, an inquiry which starts from the "gate fees" of the several national plants have different purposes: 1) publicize information in a systematic way; 2) create benchmarks inspired by the Portuguese model called "sunshine regulation"; 3) promote efficiency; 4) highlight application of fees that significantly differ from the benchmark practices. Therefore, our study presents an overview of the approved treatment and disposal fees followed by a detailed analysis of fees and their components applied to some incineration plants.

In Italy, there is not yet an operating and independent authority which regulates the waste management sector. The Antitrust authority (A.G.C.M., 2016) suggests that the technical regulation model and the criteria that define the "gate fees" of the treatment plant are set by an appointed authority. But what are the principles, methods, and experiences upon which such model and fees rules should be based? The Antitrust authority expects a reduced use of landfill disposal. Nevertheless, first it should be clearly defined the boundary between recovery and disposal and the minimum level of recovery rate should be set: underneath this minimum recovery rate, the treatment activity becomes pre-treatment activity on waste disposal.

Finally, it is necessary to foster the industrial development of the sector, make the service more transparent, empower the actors involved in order to build an homogeneous system across the national territory, which ensures adequate levels of quality in terms of efficiency and cost-effectiveness of the administration, by harmonizing the economic-financial goals with the general social and environmental goals. This ambition seems difficult if we consider the present fragmented and patchy situation.

Session 2.2

CLOSING THE LOOP: POTENTIALITY AND CRITICAL ISSUES

Environmental impacts of the different schemes for the management of municipal waste in Galicia (NW Spain)

P. Villanueva-Rey^{1,2}, S. González-García¹, G. Feijoo¹, MT. Moreira¹

¹*Dept. of Chemical Engineering, Institute of Technology, University of Santiago de Compostela, 15782 Santiago de Compostela, Spain*

²*Centre of Environmental and Marine Studies (CESAM), Department of Environment and Planning, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.*

Corresponding author's e-mail address: sara.gez.garcia@gmail.com

Abstract

Management of municipal solid waste (MSW) has become most critical during the last decades, mainly due to the complexity of waste streams together with the continuous increase in produced volumes. Thus, MSW management is still an unresolved topic in Europe, mostly for southern countries. In Spain, a growing attention is being paid on the MSW management by means of different directives and integrated plans.

Galicia is a region located in the Northwestern coast of Spain and has a population of around 2,700,00 inhabitants. Three different waste management scenarios can be clearly identified, mainly focused on different strategies for separation in origin. The main goal of this study is to evaluate and compare from an environmental perspective the three current MSW scenarios presented in Galicia. To do so, an environmental sustainability index is also defined with the aim of evaluating the capacity in closing materials loops of each specific scenario in a specific time period. Therefore, a ratio between recovered materials and the total amount of waste generated will be allocated to each MSW management scheme. Moreover, improvement alternatives will be proposed taking into account future restrictions projected by both the Spanish government and European Commission. As an important aspect, it has been assumed that MSW composition does not present remarkable deviations between both the current and future projections in line with the surveys carried out in this field.

System boundaries for the comparative assessment of the three strategies will be based on the Municipal administrative borders considering the Life Cycle Assessment perspective. The environmental comparison is also performed in terms of four impact categories: Climate Change, Terrestrial Acidification, Freshwater Eutrophication, Marine Eutrophication and Fossil Depletion. According to the results obtained for the environmental sustainability index, a tendency towards self-sufficiency is foreseen for all the scenarios that is, they present ability to treat their own residues with low exporting rates, closing material loops. In addition, it is expected an enhancement on the values after the integration of the improvement strategies mainly focused on modifications of the treatment capacity and technical feasibility. These improvements for each scenario are also expected in terms of the four impact categories considered for evaluation. Energy such as electricity obtained from the valorization processes of wastes would contribute to reduce the environmental burdens.

A methodology to estimate benefits from WEEE recycling (Waste Electrical and Electronic Equipment) - Ecodom case study

L. Campadello^a, M. Gandino^a, M. Sala^a, S. Ruocco^a, S. Sedini^a, G. Arienti^a

^a Ecodom – Consorzio Italiano Recupero e Riciclaggio Elettrodomestici, Via Ungaretti 34, 21047 Saronno (VA), Italy

Corresponding author's e-mail address: campadello@ecodom.it

Abstract

WEEE is Waste Electrical and Electronic Equipment and its proper treatment is one of the challenges Europe is facing, because of essential materials recovery and of proper treatment of environmentally critical components they contain (CFC, PCB, lead). Ecodom has developed the methodology presented here, which covers all the phases of the WEEE recycling system, and considers the impacts in term of energy used (GJ) and of equivalent CO₂ emissions caused.

The considered system starts from waste generation, when users decide to dispose of electrical and electronic equipment, and it ends with the recycling or final disposal of the components obtained through WEEE treatment.

The information used for the computation come from Ecodom activity (data come from business data-mining operations); for what concerns the coefficients (e.g. Italian electrical mix), they come from literature (database Ecoinvent or information from Transportation Ministry).

The novelty of this approach stands in evaluating environmental benefits through the comparison with a scenario in which Ecodom does not exist and WEEE is managed by other individuals (scenario B).

The easiest hypothesis is to consider a scenario B in which WEEE is landfilled and all the materials it contains need to be mined. However, this option seems far from reality and overestimates the benefits. In the scenario used, instead, half WEEE is managed by existing operators, with lower treatment performances, as recorded in 2008; the other half is managed by operators only interested in valuable materials (iron, aluminum and copper).

From this comparison, it is possible to highlight that environmental benefits from Ecodom activity, for each tonnes of WEEE managed in year 2015, are equal to 10.4 t CO₂ eq/t WEEE and 4.1 GJ/t WEEE. The highest contribution is provided by Temperature exchange equipment with a benefit of more than 23 t CO₂ eq per each tonnes of Temperature exchange equipment treated.

In conclusion, thanks to the introduced methodology, it is possible to evaluate environmental impacts of WEEE management activity and, through the comparison scenario, to calculate the environmental benefits, with complete transparency in hypothesis and calculations applied.

Session 3

PROCESSES AND TECHNOLOGIES FOR ENERGY RECOVERY

Wood combustion ash for the upgrading of biogas from anaerobic digestion

E.A. Carnevale^a, L. Lombardi^b, E. Nincheri^a, D. Papurello^c, S. Silvestri^c, L. Tomasi^c

^a *Industrial Engineering Department, University of Florence, via Santa Marta 3, 50139 Florence, Italy*

^b *University Niccolò Cusano, via Don Carlo Gnocchi 3, 00166 Rome, Italy*

^c *Fondazione Edmund Mach, Biomass and renewable energy Unit, via E. Mach 1, 38010 San Michele a/A (TN), Italy*

Corresponding author's e-mail address: lidia.lombardi@unicusano.it

Abstract

Several technologies are available for the upgrading of biogas produced during the anaerobic digestion (AD) of biowaste. The main aim is the gas cleaning from CO₂ with subsequent concentration of CH₄ up to minimum 95-96% to obtain biomethane for grid injection or/and transport use. Biomethane substitutes natural gas and can contribute to the EU objectives of 10% of biofuel for transport within year 2020.

Generally the upgrading technologies available on the market are economically sustainable only for large plants (>300-500 Nm³/hour of entering biogas), thus the development of low cost solutions devoted to small biogas plants - or for processing the surplus biogas which cannot be converted to power - seems to be a topic of interest.

Previous projects carried out by the University of Florence since 2010 showed the capacity of bottom ash from a municipal solid waste incineration (MSWI) to capture the CO₂ present in the landfill gas (Mostabuer et al., 2014; Lombardi et al., 2016). As an alternative to MSWI bottom ash, in alpine regions the availability of ash deriving from the combustion of wood biomass, generally carried out in district heating plants, represents an opportunity to better use this kind of waste before final disposal.

In the present work wood ash (WA) generated by the combustion of wood in a central heating plant was used to capture CO₂ from laboratory simulated biogas, with the aim to evaluate its application for biomethane production.

The results of preliminary tests carried out by at laboratory scale are presented. The process was realized in a static single-stage reactor, made of a fixed bed of WA crossed by a gas flow rate of simulated gas, as a mixture of 45-48% CO₂ (in volume) and N₂ as remaining amount, to simulate the composition of biogas from AD (N₂ substituting CH₄ for safety reasons; CH₄ does not react with ashes as neither N₂ does).

The results showed a very good removal of CO₂, which was about 100% in the first 30 hours of the tests. With respect to other typologies of ash used in the cited previous projects the capacity of WA to capture the CO₂ seems to be higher, reaching in the reported test values higher than 120 g of captured CO₂ per kg of dry WA.

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Anaerobic digestion laboratory test to evaluate the efficiency of biogas production from biowaste

M. Soldano^a, N. Labartino^a, C. Fabbri^a, S. Piccinini^a

^a CRPA, Research Centre on Animal Production, Viale Timavo 43, 42121 Reggio Emilia, Italy

Corresponding author's e-mail address: m.soldano@crpa.it

Abstract

The separate collection of recyclables waste in Italian municipalities (including biowaste, packaging waste, WEEEs and others) has reached a quota of 45.2% of all MSW managed in Italy in 2014 (29.66Mtons/yr), with a rather stable total production of waste (CIC, 2016). In Italy, the number of Anaerobic Digestion plants has constantly increased in the last decade. By 2015, 46 AD-plants have been realized a total authorized capacity of about 2 million tons of biowaste. Italy being the third world producer of biogas, the economic valuation of the option of purifying biogas and obtaining biomethane is currently a major line of inquiry. This study was carry out with an anaerobic laboratory scale reactor filled with OFMSW (organic fraction from separate collection of municipal solid waste, biowaste), in order to evaluate its performance in terms of energy recovery. The study was performed under the LIFE+ project Biomether (www.biomether.it) on the promotion of biomethane in Emilia-Romagna region for vehicles use, as substitute of fossil fuel, and to integrate the natural gas in domestic, commercial and industrial consumption.

The aim of the contribution is to evaluate the feasibility and efficiency of biogas production from "biowaste juice". It was sampled in a full-scale plant after treatment with a centrifugal separator machine, from which an organic liquid fraction (juice) was obtain, cleaned from inert (such as glass, plastic, wood). The dry matter content (10.3%) obtained by the treatment makes it easy to use in anaerobic digestion plant.

The process was carried out in mesophilic conditions (40 °C), with an average volumetric organic rate (OLR) of 2.9 kg m³d⁻¹ and the average hydraulic retention time (HRT) was 29 days.

The methane yield on raw materials, an important parameter for the sizing of an anaerobic digestion plant that operates on "biowaste juice" was 30 m³ t⁻¹. The methane percentage measured in biogas produced was good, 67%, due to the high level of organic matter present in biowaste and the absence of unwanted fractions. The production in methane has reached good values equal to 387 Nm³tVS⁻¹. The pre-treatment process of the OFMSW, separating the solid phase, allows to send only the liquid phase to the anaerobic digester thereby avoiding that in the digestate are present large quantities of inert solid substance or not convertible into biogas, resulting in lower production digestate material difficult to treat. The results of the laboratory test confirm that the quality of the biogas is satisfactorily, and that the production rate may be considered economically interesting.

Mass balance and economic performance of a green waste composting plant – case study of Rodengo Saiano plant

D. Alberti^a, P. Baldini^a, A. Carrara^a, E. Vitto^a

^a Linea Energia SpA, via XXV Aprile 18, 25038 Rovato, Italy

Corresponding author's e-mail address: a.carrara@linea-energia.it

Abstract

This paper investigates the mass balance and economic performance of a material recovery plant located in Rodengo Saiano, in the Northern Italy. The plant is owned by Linea Energia, a business unit of LGH, Linea Group Holding. LGH is a multi-utility working in the area of Brescia, Cremona, Crema, Lodi and Pavia and Linea Energia is the business unit working in the sector of energy production.

Rodengo Saiano plant is composed of one composting section and one energy recovery section. Composting section has a treatment capacity of 33,000 tons per year of: yard wastes from gardens; green waste from parked and wooden packaging. The composting section has two kinds of output: compost and woodchips.

Woodchips are burned in the energy generation section, which is based on an air – cooled moving grate furnace with integrated an Organic Rankine Cycle. At maximum continuous rating (MCR) condition the plant produces a gross electric power of 1 MW.

The composting section is based on open air windrow process, without forced aeration, a technology typically used in garden waste composting process.

Compost produced from green waste has wide use in floriculture and agriculture; however, composting process has high operating costs, and its economic sustainability depends strongly from tariffs paid by municipal and private collectors.

In this paper workflow, internal logistic and mass flow and balance of the composting section are described. The specific costs of each activity are determined and analyzed.

Technical assessment of gasification and pyrolysis technologies in the USA

D. Tsiamis and M.J. Castaldi

Earth Engineering Center|CCNY

Chemical Engineering Department

The City College of New York, CUNY, New York, NY 10031, USA

Corresponding author's e-mail address: mcastaldi@ccny.cuny.edu

Abstract

Energy recovery from waste materials has been practiced for decades. The recent focus on the environment and sustainable energy production has increased the awareness toward using waste, in particular municipal solid waste (MSW), for base load energy generation. This has also led to an increase in the development and demonstration of new technologies to convert waste to valuable products such as liquid fuels and chemicals. The heterogeneous nature of the waste streams necessitates the use of novel designs and materials to ensure robust performance and long term operation. Recently we have examined a number of gasification and pyrolysis processes that range from non-recycled plastics to very wet wastes. This presentation will compare the material and energy balances of some unique pilot scale units that convert waste streams to energy and fuels. Quantitative comparisons, along with emission measurements will be discussed and put into context compared to conventional waste to energy systems.

Modeling gasification of waste-derived fuels in a rotary kiln converter operated with oxygen staging

C. Tregambi^a, F. Montagnaro^b, P. Salatino^a, R. Solimene^c

^a *Dipartimento di Ingegneria Chimica, dei Materiali e della Produzione Industriale, Università degli Studi di Napoli Federico II, Piazzale V. Tecchio 80, 80125 Napoli, Italia*

^b *Dipartimento di Scienze Chimiche, Università degli Studi di Napoli Federico II, Complesso Universitario di Monte Sant'Angelo, 80126 Napoli, Italia*

^c *Istituto di Ricerche sulla Combustione, Consiglio Nazionale delle Ricerche, Piazzale V. Tecchio 80, 80125 Napoli, Italia*

Corresponding author's e-mail address: claudio.tregambi@unina.it

Abstract

Thermal conversion of waste-derived fuels is gaining a clear role in the general frame of the circular economy as one pathway to close the recycle loop when a material or chemical recycle is impossible or economically unfeasible. Sewage sludge derived from the treatment of urban wastewaters is currently facing rapidly increasing production volumes and severe restrictions of the conventional disposal options: thermal conversion stems out as the most viable strategy, entailing large reduction of the sludge volume and thermal destruction of the toxic organic constituents. In the frame of thermochemical processing of waste-derived fuels, pyrolysis/gasification presents several advantages over the direct waste-to-energy combustion path, mostly related to the generation of syngas and condensable species which can be easily transported, burned or even exploited in gas-to-liquid fuel or chemical processes. The present study addresses the development of a process for oxy-pyrolysis of sewage sludge in a rotary kiln converter. The aim of the process is the production of syngas from devolatilization of a waste-derived fuel, with oxygen playing the role of promoting autothermal operation of the pyrolyzer by controlled oxidation of volatile compounds. The specific concern of the study is the assessment of the effectiveness of staged oxygen feeding, as opposed to localized feeding at the reactor inlet, as a tool to selectively promote desired secondary reactions occurring in gas phase, like partial oxidation of tars. The converter consists of a rotary kiln in which the oxidizer is fed at multiple coordinates along the reactor axis, so as to obtain a reactant contacting pattern resembling that of a Zwietering reactor. The reactor is modelled at steady state using a 1.5D frame. Material and energy balances are set up considering a semi-lumped kinetic mechanism that was purposely developed to represent the complex chemical pathways of the solid fuel, of the gaseous compounds, of different tar components and of soot. Model results are analyzed with a focus on the effect of axial staging of the oxidizer on the quality of the produced gas and on the performance of the reactor.

Session 4

PROCESSES AND TECHNOLOGIES FOR MATERIAL RECOVERY

Sludge from mining and processing stone: strategies to improve resource efficiency and promote recycling according to the pillars of the European Commission

L. Zichella^a, R. Bellopede^a, P. Marini^a

^a *Department of Environment, Land and Infrastructure, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10139 Torino, Italy*

Corresponding author's e-mail address: lorena.zichella@polito.it

Abstract

The world increasingly need of greater varieties of raw materials and minerals, this leads to take action to promote the recovery of Critical Raw Materials (CRMs).

According to the new European mining management vision and with the EU pillars, the European Raw Materials strategy must lay the foundations for a European policy of production of strategic raw materials that raises extraction mining option, promoting recovery of CRM from recycling, provide incentives for study and research at European level for the introduction of elements and alternative technologies and encourage the creation of a European Innovation Partnership for and the dissemination of new technologies.

The waste resulting from the extraction and processing of stones, can be disposed of in authorized landfills, but properly treated and recovered, might find relocation on the market as "secondary raw material".

The following research is therefore aimed at the characterization of sludge, to determine which treatments (for normal industrial practice) can be applied to sludge in order to avoid the dangerous substances derived from the wear of cutting tools. The investigation was conducted on sludge from cutting with diamond wire, diamond saw blades, and mixed sludge. The tests performed are: particle size analysis, chemical analysis, wet magnetic separation, diffraction and SEM analysis. Magnetic separation is carried out in order to obtain two secondary materials: very fine-grained mineral fraction and metals fraction. The study performed is useful for evaluating the possible reuses of both the metal (containing CRM), and the mineral part, through the implementation of a proactive waste management strategy in order to avoid a subsequent environmental degradation.

This study is part of the WeCARE commitment (Wastes from Construction industry As a Resource) recognized by EIP Raw Material, which involve several European institutions, with the common aim of seeking a solution to recover and recycle sludge from construction industry and in particular processing stone.

Challenges in carbon-fiber disposal and recycling

M. Limburg, J. Stockschröder, P. Quicker

^a Unit of Technology of Fuels, RWTH Aachen University, Wüllnerstraße 2, 52062 Aachen, Germany

Corresponding author's e-mail address: limburg@teer.rwth-aachen.de

Abstract

The increase in carbon fiber reinforced polymer usage makes tackling the challenges of their disposal unavoidable. The high production costs make fiber recycling desirable over disposal. Reclaiming the fibers from their polymer matrix however is not without challenges. With chemical, mechanical and thermal processes available, thermal processes are so far favored by the industry. Pyrolysis leads to a decay of the polymer matrix, but may also leave solid carbon residues on the fiber. These residues prevent fiber sizing and thereby reuse in new materials. In the state of the art, these residues are removed with oxygen. This however may damage the fiber's tensile strength. In order to avoid damaging the fibers oxidizing non-oxygen atmospheres, especially carbon dioxide and water vapor, were used, to reduce the char residues from carbon fibers while causing minimal or no fiber damage. Still even under ideal recycling conditions, a production based fiber shortening will occur with every new life-cycle. Fiber disposal pathways will therefore always be necessary. Utilizing the energy stored within the fibers, thermal disposal is favorable, but aggravated by thermal fiber fragmentation.

Future challenges for the Italian biowaste recycling sector

M. Centemero^a, A. Confalonieri^b

^a Consorzio Italiano Compostatori, sede operativa loc. Cascina Sofia, 20873 Cavenago Brianza (MB)

^b Scuola Agraria del Parco di Monza, viale Cavriga 3, 20900 Monza (MB)

Corresponding author's e-mail address: confalonieri@compost.it

Abstract

Biowaste separate collection and recycling plays as a driver of increasing importance when addressing the overall Municipal Solid Waste performances in Italy, as recently confirmed by the Italian Environment Agency (ISPRA) through its report on MSW management in 2015.

The recycling sector counts over 300 facilities in operation, characterized by a growing technological and layout diversity, above all thanks to the introduction of Anaerobic Digestion as an integration of the traditional composting process.

The new challenges to take on in order to strengthen both reliability and competitiveness of biowaste sector are increasingly related to the improvement of biowaste quality (the main role being played by the separate collection services), the optimization of recycling processes and the diversification of the final products achievable, which range from fertilizers (soil improvers, growing media, inorganic fertilizers) to the products deriving from anaerobic digestion (biogas, biomethane).

Starting from the experience gained by the Italian Composting and Biogas Association (CIC) – above all focused on the evolution of the quality of biowaste taken to the recycling facilities, and on the quality of compost labeled as “CIC quality compost” – the presentation aims at foreseeing the tendencies on the diversification of the products generated by biowaste recycling facilities, increasingly shaped as actual biorefineries.

Glass waste³ recovery: new technologies for corks and plastic separation

R. Bellopede^a, P. Marini^a, V. Ramon^b, G. Zanotti^a

^a *Department of Environment, Land and Infrastructure, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10139 Torino, Italy*

^b *SASIL s.r.l*

Corresponding author's e-mail address: rossana.bellopede@polito.it

Abstract

Nowadays the selection and the treatment of the glass waste is implemented in processing plants where, through sorting the foreign bodies and separation from Pb crystal, opaque bodies and the metals, a secondary raw material (SRM) - named cullet - is obtained, suitable for glass products and a glassy waste (glass waste ²) still not accepted by the glass factories. While the recovery of primary glass waste is already spread and technological known, the secondary glass waste (glass waste²) is recovered by few companies in Italy from some years. Consequently the recovery of the waste of this secondary recovery process of glass waste is new (glass waste³) and therefore to optimize, in order to reach an economic and sustainable industrial process solution.

With the aim of optimizing the plant of SASIL already existing for the recovery of the "glass waste³", innovative technologies have been studied and executed. The major difficulty is in the automatic separation of materials as plastic lightweight, synthetic stoppers and cork stoppers that can nowadays find a market. In particular the solved problem is the separation for materials whose density is < 1, using non-impacting methods. The particle distribution and characterization of the waste in entrance in plant and the products obtained in different stage of treatment have been used to dimension the new plant and to suggest new kind of treatment. Among the innovative process suggested two density separation have been performed:

- separation by means jig concentrators;
- separation of new method of bath suction.

In this research the jig concentrator, at difference of the previous research don't use floatation principle but only fluid motion (without chemical addition and collectors). The same is for the "bath suction apparatus" that it needs only of water to execute the separation. The separation of efficiencies are major than 80% both for jig concentrators, for the separation of heavy plastic and glass from plastic lightweight and synthetic stoppers and cork stoppers, and for bath suction apparatus that led to separate plastic lightweight from synthetic stoppers and cork stoppers.

On the base of laboratory results, a new treatment plant has been designed and economic evaluation have been made. The materials to be trade as secondary raw materials (SRM) are about 87.5% of the total feeding and they are glass, plastic lightweight, ferrous metals, non-ferrous metals, synthetic stoppers and cork stoppers. These percentage should be related to the high amount of this kind of waste to be valorized (glass waste ³), landfilled in the plant in Italy and ready to be recovered, after the implementation of the right industrial technology.

The reuse of solid residues from mass-burning and fluidized-bed reactors for concrete production

A. Abbà^a, S. Sorlini^b, M.C. Collivignarelli^a

^a *Department of Civil and Architectural Engineering, University of Pavia, via Ferrata 1, 27100 Pavia, Italy*

^b *Department of Civil, Environmental, Architectural Engineering and Mathematics, University of Brescia, via Branze 43, 25123 Brescia, Italy*

Corresponding author's e-mail address: abba78@unipv.it

Abstract

The present work concerns the evaluation of MSWI solid residues reuse as partial replacement of natural aggregates for concrete production. The residues studied are: bottom ash derived from two mass-burning kilns (MB(A) and MB(B)) that treat MSW; exhausted sand and bottom ash derived from a fluidized-bed incinerator (FB(C)) that receive MSW-derived solid recovered fuel (SRF).

The bottom ash derived from MB(A) were pre-treated by means sieving and iron removal processes; moreover, additional washing was applied. Sieving and iron removal processes with a subsequent ageing (for two months) were performed on the bottom ash derived from MB(B). Natural aggregate was partially replaced (with a weight percentage from 7% to 40%) with different residues for the production of some concrete mixtures, casted adopting different types or dosages of residues and two different type of cement.

Regarding the mechanical characterization of concrete mixtures, the use of 400 kg/m³ (corresponding to 23% of natural aggregate replacement) of bottom ash from fluidized-bed reactor (with the use of CEM42.5R) showed the best results: in this case concrete mixtures could be classified in concrete class C16/20, suitable for structural elements made of reinforced concrete.

The results of the leaching test showed that only the washed bottom ash from the mass-burning kiln could be reused following the simplified procedures according to Ministerial Decree 186/2006. For the exhausted sand derived from the fluidized-bed incinerator, the release of some pollutants (especially chromium and arsenic) was higher than the other residues. As concerns the leaching behaviour, concrete mixtures containing the residues derived from fluidized-bed reactor showed a release of pollutants higher than the other mixtures.

POSTER Session

Environmental sustainability of food waste management strategies at regional level

I. Noya, S. González-García, G. Feijoo, M.T. Moreira

*Department of Chemical Engineering, School of Engineering, University of Santiago de Compostela,
15782 Santiago de Compostela, Spain*

Corresponding author's e-mail address: inovalopez@gmail.com

Abstract

Municipal solid waste (MSW) is responsible for relevant environmental impacts affecting human health and ecosystems quality (Vandermeersch et al., 2014; Bernstad and la Cour Jansen, 2012), so that appropriate management systems that address these environmental problems as well as contribute to move towards a more environmental friendly framework are demanded by society (Halloran et al., 2014). This explains also the need for analysing the practices available for the management of food waste – with a critical role in MSW – from an environmental perspective. In this context, numerous studies based on the Life Cycle Assessment (LCA) approach for analyzing food waste treatment alternatives can be found in literature (Bernstad and la Cour Jansen, 2012); however, none of them has still focused on Northwest Spain.

The main goal of this study was to analyse the environmental sustainability of different technologies focused on the management of food waste within the Galician region through the LCA methodology. To this aim, different strategies were evaluated – landfilling, incineration and biological treatment – in order to evaluate their environmental performance. The following environmental indicators were assessed: climate change, acidification potential, eutrophication potential and resources depletion. Major findings are expected to support stakeholders to improve the environmental profile of the different treatment strategies involving food waste management concerns.

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Respirometry role in the MSW sector under the EU circular economy perspective

Ragazzi M.¹, Dallago L.², Rada E.C.^{1,3}, Cioca L.I.^{3,4}, Andreottola G.¹

¹Department of Civil, Environmental and Mechanical Engineering, University of Trento, via Mesiano, 77, 38123, Trento, Italy

²I.S.E.R., Loc. Acquaviva, 4 – 38060, Besenello (Trento), Italy

³Department of ^bIndustrial Engineering and Management, Faculty of Engineering, Lucian Blaga University of Sibiu, Str. Emil Cioran, 4, 550025, Sibiu, Romania

⁴Academy of Romanian Scientists, Splaiul Independentei, 54, sector 5, 050094 Bucharest, Romania

Corresponding author's e-mail address: marco.ragazzi@unitn.it

Abstract

In 2015, EU published several documents concerning circular economy applied to municipal wastes. In this way the waste management scenario in 2030 is figured out.

The goals are clearly quantified and ambitious (i.e.: the amount of wastes in landfill should not be over 15%).

In this context, the present work aims to analyse the effects on the respirometry applied to solid matrix, developed to support some management problems in particular for municipal solid wastes.

A critical analysis of the respirometric methods is discussed, to verify the adequacy with the actual scenario of waste management in the European context (for this evaluation the Italian case is used, where a couple of anomalies are present in the definition of respirometric methods and in the available models of respirometries).

In particular, the needs of two contexts, clearly different concerning the efficiency of separated collection of solid waste, are taken into account: the Autonomous Province of Trento (Italy), which recently reached the threshold of 80% of separated collection and the Sibiu County (Romania), which is following the path of Trento Province, with some years of delay. It is reliable that the Province of Trento will be able to satisfy the EU goal of 2030, while the County of Sibiu will reach in 2030 the actual performance of Trento Province. There are many implications due to this temporal difference: this work analyses all of them under the point of view of the role of respirometry.

As example, for the Trento case, in 2030 respirometry will be:

- Not relevant for the assessment of biological stability of wastes destined to landfill, since the extreme separation of organic waste (today around 90%) and green waste, together with sanitary waste (in future separately collected) will lead to the quasi-zero biological reactivity of urban solid waste
- Relevant for the assessment of compost stability (presumably produced after anaerobic digestion)
- Relevant for the assessment of refuse derived fuel ("CSS" in Italian) stability
- Potentially relevant for the measurement of biological stability of digestate before its destination to the following maturation phase (in case of activation of anaerobic digestion). In this case, the actual respirometric techniques seem to be conditioned by the long time interval requested by the analysis

In the case of Sibiu County, the probable necessity of a landfill pre-treatment process will open a discussion concerning which respirometric index should be considered (nowaday respirometry is still not used in that area). The critical analysis of the first part of the work will show how this aspect is managed in Italy with a lack of attention.

Optimization of waste collection systems: development and application of a decision model

C. Magrini^a, D. Vigo^a, A. Laghi^a

^a *Laboratory for Optimization on Operations Management, Department of Electrical, Electronic and Information Engineering "Guglielmo Marconi"(DEI), University of Bologna*

Corresponding author's e-mail address: chiara.magrini7@unibo.it

Abstract

Planning the urban waste collection system in a Municipality is a strategic long-term decision, which involves many factors and large consumption of economic resources. The optimization model described in this presentation aims at supporting such decisions by determining the most convenient collection method for each waste fraction, taking into account some characteristics of the town and target levels of separated collection. The model has been created using the data of the Municipalities of Emilia-Romagna region for the years 2013 and 2014, considering two main collection systems: door-to-door collection and kerbside bins collection. The model is tested on realistic scenarios from Emilia-Romagna region.

Techno-economic assessment of the municipal solid waste management system in the context of the circular economy: the case study of Brescia, Italy

G. Bertanza^a, C. Collivignarelli^a, E. Ziliani^b, A. Bonomo^c, M. Nenci^c, L. Zaniboni^c, S. Zetera^d, L. Manili^c

^a *DICATAM - Department of Civil Engineering, Architecture, Land, Environment and Mathematics, University of Brescia, Via Branze 43, 25123 Brescia, Italy*

^b *DICAr - Department of Civil Engineering & Architecture, University of Pavia, via Ferrata 1, 27100 Pavia, Italy*

^c *A2A Ambiente S.p.A., Via Lamarmora 230, 25124 Brescia, Italy*

^d *Aprica S.p.A., Via Lamarmora 230, 25124 Brescia, Italy*

Corresponding author's e-mail address: giorgio.bertanza@unibs.it

Abstract

During the year 2016 a work group on "Circular Economy and waste" was created with the aim of achieving a complete evaluation of the municipal solid waste (MSW) management system of the city of Brescia after the introduction of a new collection system. An interdisciplinary group is working on this project: A2A as well as both the universities of Brescia (Università degli Studi and Università Cattolica del Sacro Cuore) are involved. The presentation is focused on the activity carried out by the Department of Civil Engineering, Architecture, Land, Environment and Mathematics.

The main objective of this work is to propose a general overview of the MSW management strategies adopted in the city of Brescia. In this context, a set of techno-economic indicators for comparing the old and new collection system was proposed. These indicators consider different aspects that influence the efficiency of MSW collection systems such as the type of service provided, the labour required, the equipment used (vehicles and containers) and take into account both aspects related to the characterization of collected waste and the assessment of operational and economic performance of the collection strategies. For this reason, four performance indicators (P), that have the function to show the efficiency of the adopted strategies and the used equipment, and four economic indicators (E), that provide an evaluation

of the principal cost drivers of collection systems, were elaborated. A detailed comparison of the different collection systems adopted will be presented.

Furthermore, the first results of the evaluation of the impact of the different collection strategies on the performance of the whole MSW management system (from collection to disposal) will be illustrated.

Diversion of municipal solid waste from landfills: recycling and waste-to-energy facilities

D. Sharma and M.J. Castaldi *

Earth Engineering Center|CCNY

Chemical Engineering Department

The City College of New York, CUNY, New York, NY 10031, USA

Corresponding author's e-mail address: mcastaldi@ccny.cuny.edu

Abstract

Municipal solid waste generation is one of the leading problems in the world. In the current scenario most of the solid waste is diverted towards landfill. The preferred method of sustainable waste management is to follow the waste hierarchy. This presentation explores the difficulties experienced in completely diverting MSW to recycling facilities and achieving total recovery of resources. Complete material recovery from paper and plastic waste streams has been a pivotal point for the success or failure of achieving zero waste targets although it is still considered the highest of priorities it is not possible. The highest reported recovery of material from paper and plastic waste streams are 85% and 73% respectively. However, the question that arises is what happens to the remaining 15% and 27% of paper and plastic waste? Due to technical limitation of the current equipment used for recycling, it is not possible to completely recycle all paper and plastic. For example, state-of-the-art recycling equipment used for the paper still has a 66.4% recovery rate (~50,000 tons) from 2008-2013 although the amount of paper available for recycle due is near 78,000 tons. Plastic recycling is a similar case where a maximum of only 79% can be technically recovered due to problems associated with tensile and impact strength requirements. Importantly, these limitations are independent of the actual market available for the recycled material. This presentation will quantitatively show that recycling faces technical limitations that necessitates the thermal conversion systems to achieve high landfill diversion rates.

Characterization and evaluation of the generation and separate collection of restaurant waste: a case study in central Italy

F. Tatano^a, T. Paolini^a, L. Tripolone^a, E. Laici^b, M. Pezzolesi^c, G. Tombari^b

^a DiSPeA - Department of Pure and Applied Sciences, Environmental Section, University of Urbino "Carlo Bo", Campus Scientifico "E. Mattei", 61029 Urbino, Italy

^b ASET S.p.A. multi-utility group, Via Enrico Mattei 17, 61032 Fano, Italy

^c Coomarpesca, Viale Adriatico 48, 61032 Fano, Italy

Corresponding author's e-mail address: fabio.tatano@uniurb.it

Abstract

Because restaurants (as a division of the hospitality sector) contribute to the generation of commercial and institutional waste, thus representing both a challenge and an opportunity, the objective of the present study was to deepen the knowledge of restaurant waste in terms of the qualitative and quantitative characteristics of waste generation and the performance achievable by the implementation of a separate collection scheme. In this study, the generated waste was characterized and the implemented separate collection was evaluated at a relevant case study restaurant in a coastal tourist area of Central Italy (Marche Region, Adriatic Sea side). The case study restaurant can be categorized as fast casual restaurant. This type of restaurants is a quality variant of quick (or limited) service restaurants, generally characterized by higher quality of food, service, and atmosphere and by higher or even complete eat-in ratios compared to the traditional variant of fast food restaurants. This study was based on a continuous monitoring period of 164 days at the case study restaurant, which was significantly longer than the survey times limited to a few days or weeks generally used for previous studies or reports. The qualitative (compositional) characterization of the generated total restaurant waste showed the considerable incidences of, in decreasing order, food (28.2%), glass (22.6%), paper/cardboard (19.1%), and plastic (17.1%). The quantitative (parametric) characterization of the generated restaurant waste determined the unit generation values of total waste and individual fractions based on the traditional employee and restaurant area parameters and the peculiar meal parameter. The evaluation of the monthly variation of the monitored separate collection, ranging from an higher level of 52.7% to a lower level of 41.4%, indicated the following: a reduction in the separate collection level can be expected at times of high working pressure or the closing of a seasonal business (typical for restaurants in tourist areas); and the monthly variation of the separate collection level is inversely correlated with that of the unit generation of total waste per meal. Finally, the original concept of the "customer equivalent person (P_{ce})" was introduced and behaviorally evaluated at the case study restaurant in terms of food waste generation and landfilling of biodegradable waste.

Combustion optimisation on moving grates

M. Lukic, D. Zibrat

TG Mess-, Steuer- und Regeltechnik GmbH

Corresponding author's e-mail address: matthias.lukic@technikgruppe.com

Abstract

Combustion on moving grate is a very complex process. Quality of combustion has influence on energy efficiency and on generation of gases. In this speech basic procedures of combustion optimisation by system WIC are explained. Principles of optimisation are based on control of stroke of grate, frequency of grate movement, primary air control and secondary air control. For appropriate control up to 30 actuators are powered, and up to 40 measurements, from existing system, are used. Implementation of this system has considerable influence on quantity of carbon in ash, demand for chemicals in flue gas cleaning systems, capacity of combustion and amount of energy generation. Financial benefits of usage of this system can provide fast return of investment. This system does not replace existing control systems than only recalculate set points. Implementation of WIC system is controlled by hardware or software switch and user can in any time switch to set points control of the existing system.

Combustion grate as completion of existing rotary kiln WTE plants

A good technologies connection to maximise capacity and energy efficiency, preserve structure and respect bottom ash TOC limit

A. Carminati^a, M. Carollo^a

^a Forni Engineering srl, Via Marcona 15, 20129 Milano, Italy

Corresponding author's e-mail address: forneq@iol.it

Abstract

What is the way to combine the rotary kiln versatility with the combustion grate efficiency?

An Italian rotary kiln WTE plant has been upgraded with the installation of a water/air cooled combustion grate. The partially burned material from rotary kiln discharge falls onto the grate, where the combustion is completed by independent air injection.

In this way:

it is possible to treat sludgy and liquid waste, with high variation of LCV, and at the same time, to control the air excess in the combustion system.

It is possible to operate the rotary kiln in a more drying and a pyrolyzing way, and to complete the combustion of the fixed carbon on the grate

It is possible to achieve the following important targets.

1. Increase of WTE production capacity.
2. Increase the control of refractory lining wear because of the less oxidative kiln conditions.
3. Increase of the energy efficiency of the system (lowering the fume flow, reduction of the heat loss through the kiln shell, completion of the fixed carbon combustion and reduction of the bottom ash temperature at discharge.
4. Respect of unburnt limit (TOC)
5. Increase environment standard respect thanks to point 3 and 4

With this solution existing rotary kiln plants can be run with more steady process conditions.

Sludge Disposal: what alternatives to agriculture

T. Vollmeier^a, A. Castorini^a, U. Ballabio^a

^a TBF + Partner AG, Consulting Engineers, Strada Regina 70, 6982 Agno (Switzerland)

Corresponding author's e-mail address: tv@tbf.ch

Abstract

Foreword

In Italy sludges deriving from waste water treatment plant (WWTP) are still widely used in agriculture as fertilizer/improver. Recent events in Lombardy have shown the weakness of this choice and solicited many local operators to look for alternative solutions.

The current situation in Europe

The use of WWTP sludge for agricultural purposes is still the preferred disposal way in Europe, but the situation is slowly changing. In addition to heavy metals, which are accumulating in the grounds, the attention is now growing toward micropollutants, like antibiotics and hormones, whose effects on living organisms and human beings are not very clear yet and there are comprehensible worries about them. At the same time the shortcut of landfill disposal has been progressively forbidden.

In the latest times there is a trend in many European countries, which goes in the direction of less agricultural use and more thermal mineralization treatments. As a matter of fact it is not possible to exclude that on the middle term the relevant European legislation will also be updated accordingly.

Another issue, which is becoming more and more important, is phosphor recovery; this chemical element, which is essential for the growth of life organism and its natural sources are not unlimited, is contained in high percentage in the WWTP sludge. In Germany has recently come to force a new law, which obliges to recover the sludge phosphor content. This new law is leading to new activities for planning and building new dedicated sludge thermal treatment plant.

This work will give a comprehensive description of the current situation in the main European countries and will give information about EU legislation.

Possible disposal ways

As an alternative to agricultural use or landfill disposal, it is possible to mention following proven ways, in order to treat/dispose WWTP sludges:

- Drying and combustion (in cement factory or other dedicated plants);
- Co-combustion with RDF;
- Dedicated combustion (mono-incineration).

This work will give a description of the most commonly used disposal ways, underlying their strong and weak points, giving information about environmental impact, construction and operation costs, offering also examples of existing and operating plants.

Other alternative technologies will be as well presented, such as:

- Pyrolysis
- Wet Oxidation
- HTC (HydroThermal Carbonisation)

For above mentioned technologies main characteristics and actual degree of industrial development will be illustrated.

The bio2energy project: bioenergy, biofuels and bioproducts from municipal solid waste and sewage sludge

I. Pecorini^a, D. Bacchi^a, E. Albin^b, F. Baldi^a, P. Rossi^a, P. Paoli^a, E.A. Carnevale^a, L. Lombardi^c, G. Ferrara^a

^a*Industrial Engineering Department, University of Florence, via Santa Marta 3, 50139 Florence, Italy*

^b*PIN S.c.r.l. - Servizi didattici e scientifici per l'Università di Firenze, Piazza G. Ciardi, 25 - 59100 Prato, Italy*

^c*University Niccolò Cusano, via Don Carlo Gnocchi 3, 00166 Rome, Italy*

Corresponding author's e-mail address: lidia.lombardi@unicusano.it

Abstract

The EU's effort to the full implementation of Circular Economy principles is an important driving force towards the development of a more effective recovery of resources (materials and energy) from organic fraction of municipal and industrial wastes. Anaerobic digestion (AD) is an efficient waste treatment for biodegradable residues that has gained interest during the last years as it converts organic matter into biogas, a renewable source of energy, and digestate, a valuable fertilizer and soil conditioner (Iacovidau et al., 2012). Nowadays AD is a well-established process but the production of more valuable by-products such as hydrogen and bioplastics continues to be a challenge.

This paper presents Bio2Energy project, research project related to biohydrogen and biomethane production from co-digestion of the organic fraction of municipal solid waste (OFMSW) and sewage sludge and fertilizers production for the improvement of public utility facilities. Bio2Energy project started in September 2016 and will last two years. The project is co-funded by the Tuscany Region and involves several partners that include waste and wastewater companies, local enterprises and R&D centres.

The main goal of the project is to increase the production of renewable energy in Tuscany exploiting the potential energy of the OFMSW. The enhancement of the renewable energy production is achieved through a synergistic management of OFMSW and sewage sludge from wastewater treatment plant. The co-digestion of these two valuable fractions allows producing both biohydrogen and biogas and renewable fertilizers from the digestate. The biofuel production will take place in the wastewater treatment plant of Viareggio (Lucca, Italy), managed by SEA Risorse S.p.A., with the purpose to revamp the present sludge treatment plant.

Results of the preliminary phases of the project, concerned with biohydrogen and biomethane production at laboratory scale, co-processing sewage sludge and OFMSW, are presented.

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Life cycle assessment analysis of biomass lignocellulosic of S.A.B.A.R. S.p.A.: from waste to resource

E. Minarelli^{a, b}, G. Allesina^b, S. Pedrazzi^b, P. Tartarini^b, P. Neri^a, R. Spinelli^a, M. Pini^a, A.M. Ferrari^a

^a *Dip. di Scienze e Metodi dell'Ingegneria, Università di Modena e Reggio Emilia, Via
Amendola 2, 42122 Reggio Emilia, Italia*

^b *Dip. di Ingegneria "Enzo Ferrari", Università di Modena e Reggio Emilia, Via Vivarelli
10/1, 41125 Modena, Italia*

Corresponding author's e-mail address: andre.enri@hotmail.it

Abstract

The issue of waste management has been the focus of attention for a long time due to the vast quantities of waste produced every year. In the last few years, increasing efforts have been made to reduce the production of waste and to use this as a resource: it is a sort of "evolved recycling", where the waste of a certain process is not disposed of, but becomes the raw material to be recovered as material or energy source. The present study fits into this context, with the aim of assessing the life cycle environmental impacts (ISO 14040, 2006; ISO 14044, 2006) of the management of the "green" waste conferred in S.A.B.A.R (Environmental Services Bassa Reggiana), a public affiliated company of Novellara (RE). Two specific scenarios have been investigated: "as is" Scenario and "to be" Scenario, which involves the use of combustion plants for the production of heat and electricity by means of an ORC (Organic Rankine Cycle), which is the best technology in terms of reliability and productivity for the system studied. The system function is the management of "green" waste collected in the Bassa Reggiana. The functional unit is the mass of "green" waste (20,000 tons of cuttings and prunings) collected by S.A.B.A.R and partly by Iren in 2013. The system boundaries include all processes, from the collection of waste to its enhancement. In the LCA analysis, carried out using the SimaPro 8.0.4 software and the IMPACT 2002+ evaluation method, three different system boundaries were used: System 1 - considers the damage being caused 100% by the function being evaluated. System 2 - considers the damage being caused by the function and by the co-products. This is the criterion used by Ecoinvent 3.1 in processes with the Alloc Def extension (attributional version with allocation). System 3 - the users of co-products are also considered, defining the coproducts as avoided products. This is the criterion of the expansion system, which Ecoinvent 3.1 applies to processes with the Conseq extension (system expansion). Analysis of the results shows that the definition of the system and the choice of its boundaries has a considerable influence on the environmental damage: a) using the model that confers 100% of the damage to the function, the "to be" Scenario produces a greater damage than the "as is" Scenario by 31.91%; b) using the multi-output model, the "to be" Scenario produces a lower damage than the "as is" Scenario by 15.11%; c) using the model with system expansion, the "to be" Scenario produces an advantage 11.9 times greater than the current scenario.

Magaldi Ecobelt® WA

Dry waste bottom ash handling system

F. Bassetti¹, M. Carfagno¹, D. Ricci¹

¹Magaldi Power S.p.A., Via Irno 219, 84135 Salerno

Corresponding author's e-mail address: daniele.ricci@magaldi.com

Abstract

The world's demand for resources will endlessly increase in future with a negative impact on their availability and final prices. The only way to satisfy the future demand is to minimize the dissipation of the natural resources and try to maximize the resource recovery from wastes.

In case of municipal solid wastes (MSW), recyclable resources are very depleted and/or integrated in complex composite materials. The most efficient and reliable way to get rid of any organic material from MSW and to generate heat and power is through an incineration process realized in grate fired boilers.

The residues from the incineration process are mainly the bottom ash (15÷30% by waste weight on average) and the fly ash (2÷3%), collected from the flue gases. The incineration bottom ash, commonly known as IBA, is a mix of inert materials (80÷85% by weight) and both ferrous and non-ferrous metals.

The bottom ash is separated at the end of the combustion grate and discharged by gravity into the relevant ash handling system at around 400 °C. In case of conventional "wet" handling systems, the bottom ash falls into a water bath for immediate quenching and downstream handling in a wet state.

Nowadays, an innovative solution is available to extract the bottom ash in a completely "dry" way. This process allows to eliminate the usage of water for quenching the bottom ash and it is relevant for the quality of the metals in the bottom ash. Therefore, the "dry" handling system reduces the overall amount of the bottom ash by weight. In addition, it increases the yields of the downstream metals recovery system, minimizing metals landfilling and providing high-quality raw materials.

Since the incineration process cleans and separates metals from organic components, a dry extraction approach is the key factor to allow a more effective metal separation from inert matter. In fact, avoiding the reaction of bottom ash with water provides the key to recover metals in their highest quality, as well as to very fine particle size (as 0.2 mm). The surface of metal particles is only slightly oxidized, thus the metals can mostly be physically separated from each other and from the mineral matter.

Based on a deep experience gained over the years in conveying extremely hot and abrasive materials as dry bottom ash produced in coal-fired power plants, Magaldi patented in 2012 the Ecobelt® WA for dry extraction, cooling and handling of bottom ash produced by WTE plants.

The Ecobelt® WA can be implemented either in new projects or as a retrofit replacing conventional wet ash extractors.

Downstream the Ecobelt® WA, the bottom ash can be released completely dry or conditioned, according to the material characteristics and Client's needs.

Stabilization of MSWI fly ash through a combined separation-immobilization method using sodium carbonate

E. Atanes*, A. Nieto-Márquez, F. Fernández-Martínez

Departamento de Ingeniería Mecánica, Química y de Diseño Industrial. Escuela Técnica Superior de Ingeniería y Diseño Industrial. Universidad Politécnica de Madrid, Ronda de Valencia, 3, 28012, Madrid

Corresponding author's e-mail address: evangelina.atanes@upm.es

Abstract

The municipal solid waste incineration (MSWI) fly ash are classified by the European Regulation as hazardous waste, mainly due to the high content of soluble salts, such as chlorides and sulfates, and to the presence of heavy metals. All these compounds present a high potential for leaching being an important risk for the environment, plants, animals and humans, and this is a key point for the management of the MSWI fly ash.

The objective of this work is to characterize the MSWI fly ash and to evaluate a wet treatment process using sodium carbonate as a stabilizing agent to decrease their hazardous character, with special focus in soluble chlorides and heavy metals. The influence of the salt concentration and the solid/liquid relation in the chloride removal from the ash were studied.

The characterization of the MSWI fly ash (FA) and treated fly ash (TFA) by means of XRD, DTA/TGA and elemental analysis show that the main components of the FA are portlandite $[\text{Ca}(\text{OH})_2]$, calcite $[\text{CaCO}_3]$, anhydrite $[\text{CaSO}_4]$, KCl, NaCl and calcium hydroxichloride $[\text{CaClOH}]$. The soluble chlorides content is around 11 wt% and traces of several metals, such as Pb, Zn, Ba, Sb, Cu, Cr and others classified as hazardous are found. The TFA are composed mainly by calcite, portlandite and anhydrite. So, the main difference in the mineralogical composition of the FA and TFA concerned the disappearance of chlorine compounds.

The leaching test for the FA show that the values of TDS and chloride concentration of the leachate are higher than the limits for hazardous waste landfills so the FA must be treated to be accepted in this kind of landfills. Concerning the heavy metals, they are classified as non-hazardous wastes except for the Pb that exceed this limit and will classify the FA as hazardous waste. The leaching test for the TFA show that all studied parameters decrease compared to the original FA, and can be classified as non-hazardous wastes, and even as an inert waste concerning the value of cadmium. Thus, it is proved that stabilization procedure has succeeded to reduce the hazardousness of the MSWI FA waste.

The chemical analysis of the waste stream liquid coming from the stabilization process shows that a great part of the heavy metals remains retained in the TFA with percentages of immobilization higher than 87%. The proposed method removes the chloride from the ash as sodium chloride, due to high solubility of heavy metals chlorides, whereas the metal remains stabilized and non-leachable in the treated fly ash, as insoluble heavy metal carbonates/hydroxides.

As a conclusion, the method is very promising at industrial level, being fast, cheap, simple in unit operations and with a double function in a one step: separation -for chloride- and immobilization -for heavy metals-. The reduction of the hazardous characteristics of the TFA allow to dispose them in less stringent requirements landfills, and promote the possibility of recycling according to the waste management scheme (Figure 1) established in National and European Regulations.

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