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CRITICAL ANALYSIS OF MATERIAL AND ENERGY RECOVERY PROCESSES OF MUNICIPAL SOLID WASTE IN SATU MARE COUNTY

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ABSTRACT. This study suggests the description and the analysis on the ways of material and energy recovery of municipal solid waste, emphasizing on the stream that cannot be integrated into the classical recycling flux. We refer to the waste of this kind that includes, in a degraded state, plastic, paper and textiles that cannot be recycled or recovered through the existing procedures.

Among the principal's targets of this study, we enumerate: the analysis of stored waste composition in the regional DOBA store and its recovery potential; the material, energetical and environmental value determination of waste with recovery potential; Critical analysis on material and energetical recovery procedure of municipal solid waste.

The motivation of this study is determined by the increasing of the volume of wrapping waste, plastic, paper and wood and by the low level of recycling that leads to finding alternative solutions for depositing, especially for components that have no recycling solutions. For these components, we are looking for alternatives developing the concept of material value; energetical value and environmental value for public waste, witch in this structure are identified, with their history, as "unusefull components" of a specific management process of circular economy. In concrete manner, appreciations are made on the following procedures: the material recovery, after a quick processing, selection and chopping; waste can be integrated in different composite materials, that can be used later, in constructions or urban furniture manufacturing; the energetical recovery, by co incineration in technological processes or by transforming waste into refuse derived fuel. Waste composition and value realization is made for specific Satu Mare county area.

Key words: *municipal solid waste; material recovery, energetical recovery, environmental value, un-useful component*.

REASONS FOR WORK

The paper proposes to identify and solve two current problems: reducing the volume of landfilled waste and reducing fossil fuel consumption by exploiting the energy potential solutions thereof. There are different technologies to convert municipal waste into heat and electricity, such as incineration, incineration in co-generation plants, and incineration in the cement industry (Soporan et al., 2008). These technologies present two major inconvenient: the high investment in the combustion plant and waste transportation problem. Based on these considerations, it appears to be necessary to develop new methods and technologies for incorporation of municipal waste in different materials and perfecting recipes for solid fuel briquette type (Njenga, 2009). Therefore, work motivation is driven by developing technologies that help to solve the two problems arising from the current EU public policies: reducing the large volume of waste bound for storage and need their energy potentials. Given the prevailing conditions in Romania, the collection is not performed selectively and disposal is at 98%, we believe that the motivation shown is real, very current and pressing.

OBJECTIVE OF WORK

This paper aims to find a method of determining the potential material and energy of existing materials in the waste, given that it is not subject separately collected and its use is the disposal in landfills, as a prerequisite to establishing a recovery methods and technologies.

PROBLEM FORMULATION

The research expressed in this work, is to establish a methodology for determining the potential material and energy waste which have not undergone separately collected and pre-collection has made improper use of materials and / or energy methods become traditional. Extending the scope of the waste deposits reached the level becomes an important part of the problem.

RESEARCH METHOD

Solving the problem formulated is achieved in the present paper, by establishing factors that influence material and energy potential of waste and critical analysis of methods and technologies to optimize recovery and adoption of optimal variant for the state are waste. The working method as preliminary stage experiments, the study is based on information provided by the literature. Concretization accumulations informative develop a methodology that applies to waste generated in the county of Satu Mare, mainly on regional landfill DOBA.

RESEARCH ACHIEVEMENTS

Research conducted in a solution formulation of the problem posed is related to the following aspect: the waste structure analysis at regional landfill DOBA and capitalized on their potential; determining the value of materials, energy and environmental waste potentially valorification; critical analysis of material and energy recovery processes municipal waste.

Waste composition analysis

According to data from the Regional Waste Management Service of the Satu Mare County Council, waste deposited in 2012 have the following composition: 9.1% cardboard paper; wooden 1.26%; Textile 4.64%; 4% glass; 5% metal; 14% plastic; 45% biodegradable materials; others 17%;

Total 100% (E211-2013 feasibility study, the closing of cell nr.1 urban waste landfill DOBA, Satu Mare, 2013).

These data resulted in the composition of waste daily determinations over a period of a week. Sampling was done in both urban waste - Satu Mare and in rural areas. As methodology, it analyzed a daily amount of 0.25 m^3 approximately by manual separation. Data were processed and confronted with the literature.

Determining the value of material and energy

Presented at the level of waste composition shows that the potential for material and energy recovery is particularly high, with a condition that they have a pre-collection and collection process to preserve potential they have.

From the point of view of the problem to be solved we deal with waste altered by mixing some with a significant loss in that they have already reached storage. This position is confirmed by the judgment "Georgescu-Roegen" which makes a parallel between physical economic system and mainframe systems, introducing the notion of entropy, which describes the degree of degradation of inputs intervening in manufacturing goods. So, from this point of view we can appreciate the "energy value", "material value" and "environmental value". The loss of these values increases entropy, reducing resilience (Pop, 2015).

In light of circular economy, the goal should be keeping entropy initial conditions of factors of production, avoiding degradation to be reused in other words "the amount consumed in production of the category values renewable" (Pop, 2015), or a solution of compromised given the state of waste to value some material or energy value. From this perspective, the amount of waste is expressed by the following: the energy value; material value and environmental value.

Value of materials that can be recovered from waste

This indicator quantifies the value of materials which can be recovered from waste and can be expressed by the following relationship:

$$V_m = \sum (V_{mi} - C_{ri}) \times P_i$$

Where: V_m - value of waste material;

V_{mi}- The value of the material i;

C_{ri} - Costs and material recovery i;

P_i- Share the material I in goods become waste.

This value can be expressed in lei / ton waste.

According to data on the composition of waste deposited and the rate recovered to 70% can be recovered from each ton of waste deposited: Plastic 0098 t, paper 0.064 t, metal 0.035 t, glass 0.025 t of each ton of waste stored.

Resource material consumed in the recovery process is water, the amount of material recovered from waste deposited ton: 9.8 m^3. Energy consumption in the processing of materials is estimated: 10.19 GJ / t processed waste.

The energetic value

The two aspects of the energy value of waste, the total energy consumed in the production process of goods become waste.

To determine that value requires in depth analysis of manufacturing processes to take into account the total amount of energy consumed in the manufacturing process and transportation energy consumed by raw materials or finished products. According to this reasoning, the energy value of "un-usefull component” waste can be broken down into two components, one with a fixed value that expresses the amount of energy consumed in the manufacturing process and a variable value that expresses the energy consumed in transportation (Pop, 2015).

The calculation formula can be expressed as follows:

$$E_t = E_f + E_v$$

Where

E_f - The total energy consumed in the production process, including energy consumption for raw materials.

E_v - The total energy consumed in transporting raw materials and distribution of goods.

The total energy consumed in the production process of the waste materials: 27 GJ / t deposited waste and energy consumption in the process of recovery is 10.19 GJ / t processed waste (Prawisudha, 2012).

Energy recovered from "the unequipped" municipal waste, we can define as energy that is released by burning them and is expressed in calorific value.

To determine calorific value, literature indicates two ways: by measuring the energy released experiment with oxidative, in caloric bomb, and analytical of which the best known is the empirical formula of Mendeleyev. Calorific components are: paper 12.29 MJ / kg, wooden 15.68 MJ / kg, plastic 46.08 MJ / kg. Proposed empirical formula of the best known is that of Mendeleev:

$$Q_s = 81C + 300H - 26(O - S) \text{ [GJ / t]}$$

The recoverable energy through energy recovery: 53.34 GJ / t deposited waste, including biodegradable waste.

The environmental value of waste

This component quantifies all emissions generated by the production and transport of materials and finished products become waste. The indicator relative to climate change due to emissions of greenhouse gases is measured by Global Warning Potential (GWP) defined by the IPCC (Intergovernmental Panel of Climate Change) is an organization of UNED (United National Environment Programme) and WMO (World Meteorological Organization).

GWP expressed for a given gas, the ability to absorb infrared rays with respect to a reference gas which is carbon dioxide. Therefore, each component gas emission flow is converted into a stream of CO_2 equivalent, representing the contribution to the increase in the greenhouse effect.

This can be accompanied by equivalent expression, depending on the type of part of municipal waste, other elements that can be quantified in the value of the environment.

The total emissions calculated with 16 WARM calculation model developed by EPA, is as follows:

- For storage: 19 t CO_2 / year;
- In case of partial recovery by energy recovery, savings reach 20 t CO_2 emissions / year.

Analysis material and energy recovery

For the capitalization of waste materials stored, the options are reduced; practically, the only solution is energy recovery. This can be achieved by two methods, incineration in the cement production process, or briquetting of waste and use of them as solid fuel. Variant advantageous economically is briquetting, thus saving the costs of incineration.

Worldwide there are a variety of studies aimed at turning waste into useful fuel and transport. They are studying various aspects of the manufacturing process, such as humidity, particle size, composition of the feedstock, the temperature and pressure influence.

As the composition of the raw material, we meet a huge variety of raw materials used for example in crop residues (Chuen-Shii, 2009) and industrial residues of coal (coal dust) using binder waste plastics (Massaro et al., 2014). Mechanical, pyrolysis, and combustion characterization of briquetted coal fines with municipal solid waste plastic (MSW binders) pelletizing municipal solid waste composted (Pasek et al., 2013), study mixtures of waste from agriculture waste plastic degraded (Auprakul et al., 2014).

Recipes studied 80% coal dust, 20% binder HDPE (Massaro et al., 2014), or 75% paper 25% pills recycled (PET, PP and HDPE), coal 80%, DSM 17% (paper, plastic and wood) bonded 3% (Orsulik and Jachyra, 2013) presented the good results in terms of the physical properties of the briquettes (resistance to compression). Studied literature focuses on two directions regarding recipes: using mostly coal dust and waste from agriculture (straw) in combination with DSM, mostly paper, plastic and wood, using recycled plastic binder. Considering the composition of the waste described in the previous chapter, with a calorific value of 52 MJ / kg, there is a real chance that directs briquetting to lead to optimal results.

Grain feedstocks have a great influence on the physical properties and combustion properties of lighters. It found that grain feedstock should not exceed 8mm, the best being 2-6 mm (Massaro et al., 2014). This grain feedstock can blend in, so that burning briquettes to be optimal.

Another important aspect is the moisture content; the DSM has high moisture content (30-40%). Therefore, it is necessary to include in the manufacturing process, the drying step to a moisture content of max. 10 to 20%.

In terms of pressing technology, there are two technologies: extrusion (Zafar and Kianmehr, 2012; Marsh et al, 2007) for manufacturing pellets or briquettes manufacturing pressing (Orsulik and Jachyra, 2013), the concept of energy production on the basis of modern alternative fuel). If the binder is used in the composition of the waste plastics, the optimum temperature ranges pressing cycle through 110-150 °C. The pressure necessary to produce briquettes depends on particle size and temperature of the mixture and ranges from 1 to 10 MPa (Gug, et al., 2015).

The fuel thus obtained can be used in boilers with gasification, combustion furnace where the temperature reaches 1200 °C, at which temperature, all harmful components from waste plastics are burned completely.

MAJOR CONTRIBUTION OF RESEARCH

As a novelty, we propose converting waste into briquettes /pellet type fuel. Required combustion temperature is over 850 ºC, the condition that a majority of gasifying solid fuel boilers.

The mix of materials, paper, plastic, wood proportions of waste deposited, provides a calorific value of briquettes 21 MJ / kg, higher calorific related biomass briquettes.

The proposed technology consists of four phases: grinding, mixing, pressing and drying lighters.

CONCLUSIONS

To achieve a sustainable waste management, it requires a more realistic application of Directive 2008/98/EC, which defines solutions for waste management, namely prevention, preparation for reuse, recycling, energy recovery and storage.

Efforts are big on the implementation of this Directive, in order to reduce the amount of deposited waste. Although there have been great advances in recycling materials still remains a considerable amount of material that cannot be recycled because of degradation or lack of specific infrastructure. Analyzing the Eurostat data it can be seen, that in countries where technology for energy recovery exists (incinerators, co incinerators) recyclability rate is much higher. The costs of incineration with energy recovery installations are very high (Buica, 2012).

At DOBA Regional landfill, by making a briquetting line, volume of stored waste can be reduced by 27% and can achieve consistent income.

REFERENCES

Buica M., 2012, *Theoretical contributions and experiment with the use of biogas installations related to household waste dumps"* Thesis UTCN.

Chuen-Shii C., 2009, The optimum Preparing Conditions for solid fuel briquette of rice straw by the piston-mold process Using the Taguchi method. *Fuel Processing Technology*, **90** (7).

Gug J., Cacciola D., Sobkowicz M.J., 2015, Processing and properties of the solid fuel energy from municipal solid waste (MSW) and recycled plastics. *Waste Manag.*, **35**, pp. 283-392.

Kers J., Kulu P., Aruniit A., Laurmaa V., Križan P., Šooš L., Kask Ü., 2010, Determination of physical, mechanical and Burning Characteristics of waste polymeric material briquettes. *Estonian Journal of Engineering,* **16** (4), pp. 307-316

Marsh R., Griffiths A.J., Williams K.P., Wilcox J., 2007, Physical and thermal propreties of extruded refuse derived fuel. *Biofuels for Transportation,* **88** (7), pp. 701-706

Njenga M., Karanja N., Prain G., Malii J., Munyao P., Gathuru K., Mwasi B., 2009, *Community-based urban energy from organic waste Briquette production at Kahawa Soweto Informal Settlement, Nairobi, 26 p.*

Massaro M. M., Son S.F., Groven L.J., 2014, Mechanical, pyrolysis, and combustion characterization of municipal solid briquetted coal fines with plastic waste (MSW) binders. *Fuel*, **115**, pp. 62-69.

Orsulik E., Jachyra J., 2013, The concept of energy production on the basis of modern alternative fuel. *Archives of Thermodynamics*.

Prawisudha P., Namioka T., Yoshikawa K., 2012, Coal alternative fuel production from municipal solid wastes employing hydrothermal treatment. *Applied Energy*, **90** (1), pp. 298-304.

Pasek A. D., Gultom K. W., Suwono A., 2013, Feasibility of Recovering Energy from Municipal Solid Waste to Generate Electricity. *J. Eng. Technol. Sci.,* **45** (3), pp. 241-256.

Pop A., 2015, Raport Cercetare IV.
Soporan V., Rusu T., Nemes O., 2008, *Waste and recovery technologies*, Publisher UTPRESS, Cluj Napoca.
Auprakul U., Promwungkwa A., Tippayawong N., Chaiklangmuang S., 2014, Densified Fuels from Mixed Plastic Wastes and Corn Stover. *Advanced Materials Research.* **931-932**, pp 1117-1121.
Zafar A., Kianmehr M. H., 2012, Effect of raw material propierties and die geometry on the density of biomass pellets from composted municipal solid waste, *BioResources*, **7** (4), pp. 4704-4714.
*** Waste-to-Energy in Europe Third report on WTE plants in Italy CEWEP - April 2012
*** Directive 2000/73 / EC
*** Directive 2008/98 / EC
*** H.G no. 128/2002 on waste incineration (Official Gazette no. 160 of 6 March 2002) as amended by Government Decision no. 268/2005 (Official Gazette no. 332 of 20 April 2005);
*** Order no. 756/2004 for the approval of Technical Norms on the incineration of waste (Official Gazette no. 86 dated 26 January 2005, published in Official Gazette no. 86bis of 26 January 2005);
*** Order 1274/2005 regarding the issuance of the environmental closure of waste disposal or storage and incineration (Official Gazette no. 1180 of 28 December 2005), complemented by the MESD Order no. 636/2008 (Official Gazette no. 425 of 6 June 2008
*** SR EN 12390-6: 2002 / AC: 2006
*** SS 187 120 (pellets) and SS 187 121 (briquette)
*** STAS 3361 / 2-87
***http://agrobiobrichet.ro/presa-brichetat-masina-brichetat.html (accessed 06/12/2015)
***http://www.undp.md/projects/Biomass/Ghid%20pentru%20furnizorii%20de%20Bio-Combustibil.pdf (accessed 12/06/2015)
***http://appsso.eurostat.ec.europa.eu/nui/setupDownloads.do (accessed 12/06/2015)
***http://www.waste-management-world.com/articles/print/volume14/issue5/featu-res /time-out-for-waste-to-energy-in-europe.html -Last access 12/06/2015
***http: //www.martingmbh.de/index_en.php? Level = 2 & CatID = 6.73 & inhalt_id = 60 -Last http://centrale-buderus.com.ro/accesare 12.06. 2015
***Integrated Waste Management System in Satu Mare
***Studiu de Fezabilitate NR. E211-2013, Inchidere celula nr.1 Depozit Regional DOBA – Ecotec Invest Satu Mare