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New software for identification and evaluation of environmental and waste management in the companies

Rodica BUCUROIU
Petroleum-Gas University of Ploiesti, Romania
rodica_bucuroiu@yahoo.com
Marius Gabriel PETRESCU
Petroleum-Gas University of Ploiesti, Romania
marius.petrescu@gmail.com

Abstract. *Reducing environmental pollution by finding optimal solutions for waste management is an ongoing concern both within companies and in landfills. The need to develop waste management integrated systems should have the effect of reducing the impact on the environment in the context of a sustainable development. This paper proposes a solution for waste management, which is already applied in a warehouse that collects non-hazardous types of waste in three major cities: Campina, Ploiesti and Boldesti-Scaieni. Using the software application called "mediu.conturweb" provides a comprehensive framework for monitoring the total amount of waste stored and recycled, for monitoring environmental factors like CH4 and CO2 emissions. The application achieved its goal of reducing emissions back in 2015, when it was first implemented, for a huge amount of waste of approximately 131,909.36 t to the values of 384 tons/year for CH4 and of 998 tons/year for CO2.*

Keywords: waste, smart waste management, software, emission.

JEL Classification: Q53, Q56.

Introduction

Environmental impact assessment (EIA) is a process that identifies and predicts the effects that a certain socio-economic activity (initiated, designed, developed and put into operation, see Andrei et al., 2014; Bel and Fageda, 2010; Bombos et al., 2016a; Bombos et al. 2016b; Cristea et al., 2015; Matei, 2013; Merrild et al., 2012; Panaitescu et al. 2015; Panaitescu and Bucuroiu, 2014; Panaitescu and Onutu, 2013) might have on the environment as well as on the human health and the well-being of the population. The most effective way of preventing unnecessary amounts of new waste used by all systems is called "smart waste management". Product reusing, separating or selling may reduce the amount of waste to be disposed of in landfills. Waste production minimisation features a set of possibilities which leads to waste production prevention or reduction straight from the production phase, all the way to goods consumption, also including storage and distribution (Bel and Fageda, 2010; Merrild et al., 2012; Panaitescu and Bucuroiu, 2014; Panaitescu and Onutu, 2013). Identification and assessment of environmental issues is an environmental management tool. In this sense, this step must be quantified in the activity of each company that has or may have an impact on the environment in the future.

All the studies presented in literature identified a direct relationship between waste management programs and the quality of the environment (Anghelache, 2011; Panaitescu and Bucuroiu, 2014; Panaitescu and Onutu, 2013). Most of these studies used models or methods that are taken from other related areas, namely water and soil quality protection, the management of sludge coming from wastewater treatment plants (Anghelache et al., 2013; Bombos et al., 2016a; Bombos et al., 2016b; Buzoianu et al., 2016; Cristea et al., 2015; Panaitescu et al., 2016a; Panaitescu et al., 2016b; Panaitescu et al. 2015; Panaitescu et al., 2016; Panaitescu and Stoica, 2016; Panaitescu, 2016; Păunică et al., 2009; Strătulă et al., 2005).

The present study proposes a solution for waste management by monitoring the quality and quantity of waste. The ecological landfill where this method was applied has the main activity collecting only non-hazardous waste. The software used for monitoring and managing of this ecological landfill was developed with the help of a company called WEB SC Contur LTD and is called "mediu.conturweb". The application has been designed so that it can be used by any company that wants an advanced waste management system that minimizes its impact on the environment.

Literature review

Panaitescu and Bucuroiu (2014) have studied the composition of waste at municipal level for the urban areas in Prahova. Anghelache (2011) analyzes the management of environmental risk. Panaitescu and Onutu (2013) have approach the quality monitoring process for sludge drawn following the treatment of waste water. Bel and Fageda (2010) present an analysis on the Galicia (Spain) case of cost for solid management waste. Merrild et al. (2012) have evaluated the dilemma of waste recycling vs. incineration. Bombos et al. (2016a) have studied the impact of wastewater's oxidation with nanostructured catalysts. Cristea et al. (2015) have approached the treatment of sunflower oil over Co-Mo catalyst, while Bombos et al. (2016b) studied the Ru-Sn catalyst in water denitrification. Panaitescu et al. (2015) study the reduction of hexavalent chromium, Panaitescu and Stoica (2015) contribute to the enhancement of COD treatment in the case of refinery wastewater plant. Stratula et al. (2005) analyze some characteristics of the fraction reaction on 1,2 – dicloropropanate. Panaitescu (2016) describes a new method used to separate ethylenediamine; Panaitescu, Jinescu and Mares (2016) approach the ethylenediamine separation from wastewater in textile industry waste recycling. Panaitescu et al. (2016a) have studied the stabilization of dolomite aqueous suspension, Panaitescu et al. (2016b) analyze the decrease of demand for biological oxygen during wastewater purification. Buzoianu et al. (2016) consider the increase in efficiency for aeration reactors. Bucuroiu et al. (2016) approach the treatment of oil wastewater by using polymeric agents. Anghelache et al. focus on the usefulness of time-series in analyses. Păunică et al. (2009) develop on the application of business intelligence systems. Andrei, Panait and Ene (2014) focus on three factors that influence the companies' attitude towards the protection of environment, a previous study by Matei (2013) develops on the connection between corporate social responsibility and the sustainable development of Romania.

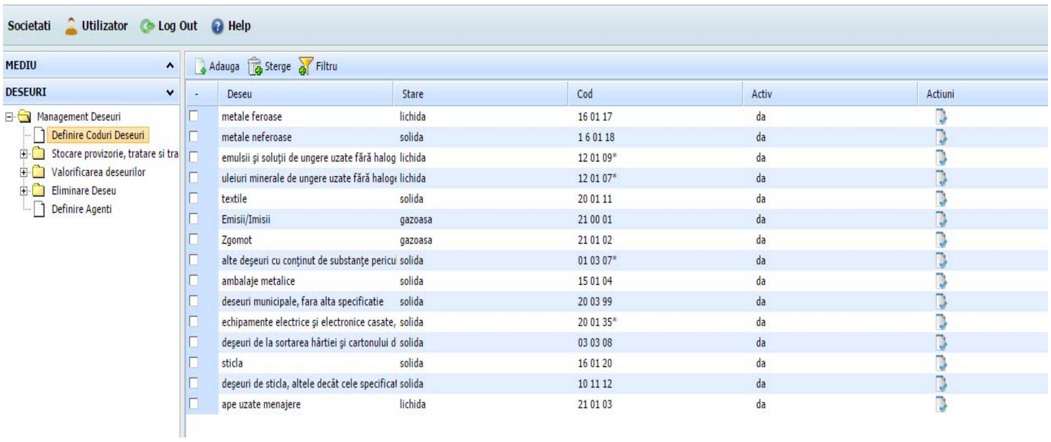
Materials and methods

The application used for monitoring and managing the landfill has been designed to fit the official regulations provided by Law 211/2011. The application "mediu.conturweb" was conceived in the Romanian language. The hardware requirements are minimal, the software requires a minimum of 10GB of space for running the application in optimal conditions.

The data base, on which the information collected from the landfill and its influence on the environment are evaluated, is called "previous modules of software".

The nature of these requirements is:
- the type of waste;
- the waste's code;
- the source of origin;
- the date on which the waste was delivered;
- the date on rejected shipments;
- the date on any waste mixing;
- the amount produced;
- the date of waste evacuation;
- the storage mode;
- the data on recycling: volume, recycling methods, usage areas of waste recycled.
- Choosing the type of waste is done according to code GD 856/ 2002 (Figure 1).

Figure 1. *Choosing the type of waste*



Note: the English equivalents for the labels in the above interface (in Romanian) are presented below: *Societati:* Societies; *Utilizator*: User; *Mediu*: Environment; *Deseuri*: Waste; *Adauga*: Add; *Sterge*: Delete; *Filtru*: Filter; *Stare*: Status; *Cod*: Code; *Activ*: Active; *Actiuni*: Actions; *Lichida*: Liquid; *Solida*: Solid; *Management deseuri*: Waste Management; *Definire coduri deseuri*: Define waste code; *Stocare provizorie, tratare*: Provisional storage, treatment; *Valorificarea deseurilor*: Capitalization of waste; *Eliminare deseu*: Waste disposal; *Definire agenti:* Define agents; *Metale feroase*: ferrous metals, *Metale neferoase*: Non-ferrous metals, *Emulsii si solutii de ungere uzate fara halogen*: Emulsions and waste lubricant solutions without halogen; *Uleiuri minerale de ungere uzate fara halogen*: Waste lubricant mineral oils without halogen; *Textile*: Textiles; *Emisii/Imisii*: Emissions/Ambient emissions; Zgomot: *Noise;* Alte deseuri cu continut de substante periculoase: *Other waste containing dangerous substances*; Ambalaje metalice: *Metallic wrappings*; Deseuri municipale, fara alta specificatie: Municipal waste, without other specification; *Echipamente electrice si electronice, casate*: Electrical and electronical equipments, cashiered; *Deseuri de la sortarea hartiei si cartonului*: Waste from sorting paper and carton; *Sticla*: Glass; *Deseuri de sticla, altele decat cele specificate*: Glass waste, other than specified; *Ape uzate menajere*: Domestic wastewater.

The landfill should have minimal impact on the environment. In order to achieve this purpose it is necessary:

- to monitor the quality of the environment;
- to monitor the exploitation of the deposit.

Following the waste's disposal, emissions result. Their amount has to be kept under control. The main emissions arising and whose concentrations are influenced directly and in a short time by the quantity and quality of stored waste are the warehouse gasses (Bucuroiu et al., 2016). Emissions sources from the warehouse location are a free open source. During the operation, the warehouse compartments represent the source and will be a trigger of unguided surface emissions. The main constituents of warehouse gas are: CH_4, CO_2, N_2, traces of H_2S and small amounts of non-methane organic compounds (COVnm).

Based on the waste quantities, the calculation of CH_4 and CO_2 amounts emitted by the warehouse were made using the APM method for 2010-2015 [1]. This period of time was chosen because the waste management was implemented starting with 2015. Emission values of 2015 were compared with values from previous years.

Determination of the amount of methane emitted between 2014 and 2015 was done using the following equation 1:

$$CH_{4\ (tons/year)} = [\ (\ TWG_T \times TWS_F \times G_o\ ) - RM\ ] \times\ (1 - F_{OX}) \quad (1)$$

where:

TWG_T represents the total quantity of generated wastes (tons/year);

TWS_F – the waste fraction cleared to warehouse;

G_o – the generating potential of methane (tons C/tons DMS) which depends on the morphological composition of wastes;

RM – the methane recovered in inventory year (tons/year) = 0 (the default value is recommended, assuming that methane is not collected and is burned).

F_{OX} – the oxidation factor with 0.1 fractional value for well equipped warehouses.

The generating potential of methane is calculated using equation 2:

$$G_{o\ (tons\ C/\ tons\ DMS)} = [MCF \times DOC \times DOC_F \times F \times 16/12] \quad (2)$$

where:

MCF – the correction factor for methane, usually equals 1 because of the administrated amplasament for year 2015 and 0.6 for year 2014;

DOC – degradable organic carbon (tons C/ tons DMS);

DOC_F – DOC fraction = 0.55 for year 2015 and 0.6 for year 2014;

F – the methane fraction in biogas (by volume) with a recommended value of 0,5, at a national level;

16/12 – the conversion factor of carbon (C) into methane for year 2015.

Degradable organic carbon value (DOC) is calculated using equation 3:

$$DOC\ (tons\ C/\ tons\ DMS) = (0.4 \times u) + (0.17 \times v) + (0,15 \times y) + (0,3 \times z) \quad (3)$$

where:

u –DMS fraction represented by paper and textiles;

v – DMS fraction represented by garden waste, parks and other biodegradable organic waste (except food);

y – DMS fraction represented by food waste;

z – DMS fraction represented by wood and straw waste.

The ecological warehouse management and its influence on the reduction of the amount of waste at source and/or its recycling should be based on the recycling rate "U" (equation 4):

$$U = \frac{total\ waste\ recycled}{total\ waste\ stored}. \quad (4)$$

Results and discussions

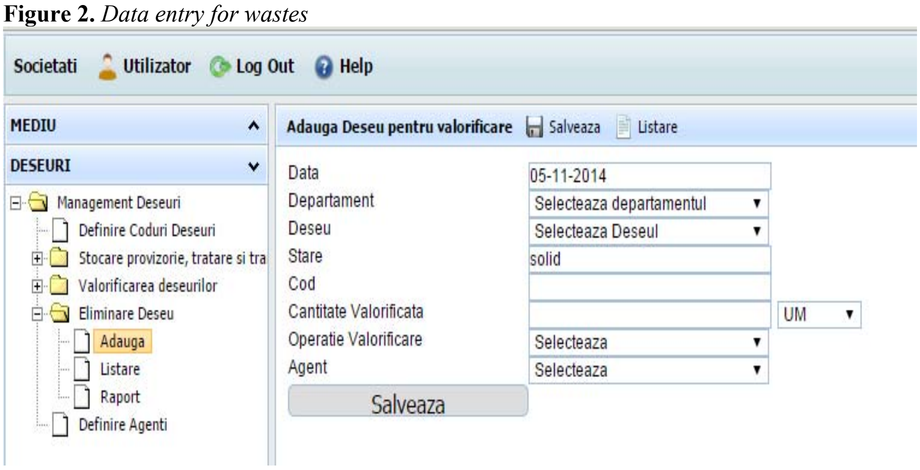
After the Environmental Issues folder is accessed, a window opens where the environmental issues identified in the respective structure can be selected (the waste code must also be inserted if applicable) according to conducted activities. If environmental issues which are not in the program database are identified, they can also be easily added. The waste report folder contains all the information on the stock, capitalised amount, real-time eliminated quantities and the waste record sheet (according to GD 856:2002). Taking into consideration that within an organisation waste reporting is centralized, the program cumulates all the waste quantities generated by the entire organisational structure as they are introduced into the system.

Annual quantities of waste stored in the ecological landfill from 2013 until 2015 used as the database for the “mediu.conturweb” software (Figure 2). They are presented in Table 1.

The Report folder contains information relating to wastes stock, amounts capitalized and amounts cleared and also the Record of evidence of waste (according to HG 856: 2002).

Because, within an organization, waste reporting is a centralized process, the program accumulates whole quantities of waste generated by the organization's structures, as they are entered into the system (Figure 2).

Figure 2. *Data entry for wastes*



Note: the English equivalents for the labels in the above interface (in Romanian) are presented below. *Societati:* Societies; *Utilizator*: User; *Mediu*: Environment; *Deseuri*: Waste; *Management deseuri*: Waste Management; *Definire coduri deseuri*: Define waste code; *Stocare provizorie, tratare*: Provisional storage, treatment; *Valorificarea deseurilor*: Capitalization of waste; *Eliminare deseu*: Waste disposal; *Adauga*: Add; *Listare*: Print; *Raport*: Report; *Definire agenti:* Define agents; *Adauga deseu pentru valorificare*: Add waste for capitalization; *Data*: Date; *Departament*: Department; *Selecteaza departamentul*: Select department; *Deseu:* Waste; *Selecteaza Deseul*: Select waste; *Stare*: State; Cod: Code; *Cantitate valorificata*: Capitalized quantity; *Operatie valorificare*: Capitalization operation; *Selecteaza*: Select; *Salveaza*: Save.

Table 1. *Waste storage situation*

Year	Total Waste	Domestic waste	Inert Waste	Street waste	Construction waste
2012	141109.55	56158.88	22108.45	16453.32	46388.90
2013	102042.05	55241.74	8610.62	18383.51	19806.18
2014	112263.12	63271.72	13165.36	16694.98	19131.06
2015	135094.56	75909.58	21377.26	18363.30	19444.42

The analysis of the data presented that the annual average of waste brought to the warehouse in 2015 was about 131909.36 t of urban solid domestic waste, representing the total amount of domestic waste produced in three main towns and belonging to the following cities: Campina, Ploiesti and Boldesti-Scaieni.

Waste from offices and resulting from operational activities of the target are cleared directly on warehouse, their amount being insignificant in relation to the warehouse capacity.

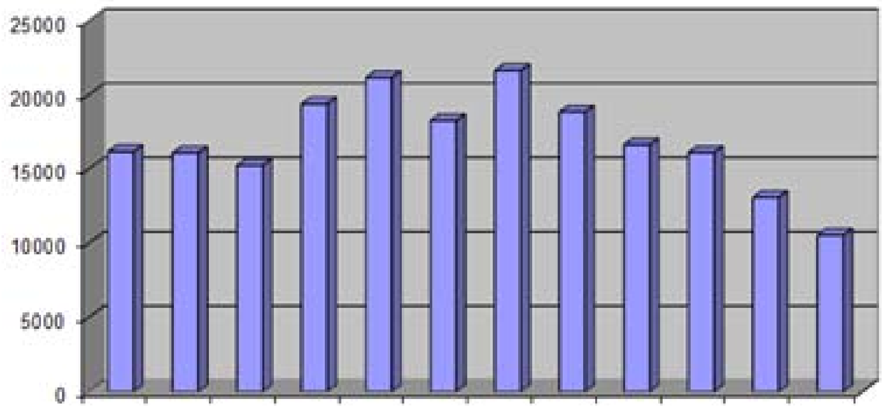
Is it estimated that it should be:

0.5 kg/person/day x 16 persons x 365 days = 2.920 kg/year ≅ 3 tons/year

“Mediu.conturweb” application offers the possibility of a monthly representation of total amount of waste as is shown in Figure 3.

Figure 3. *Monthly amount of waste in 2015*

Tons

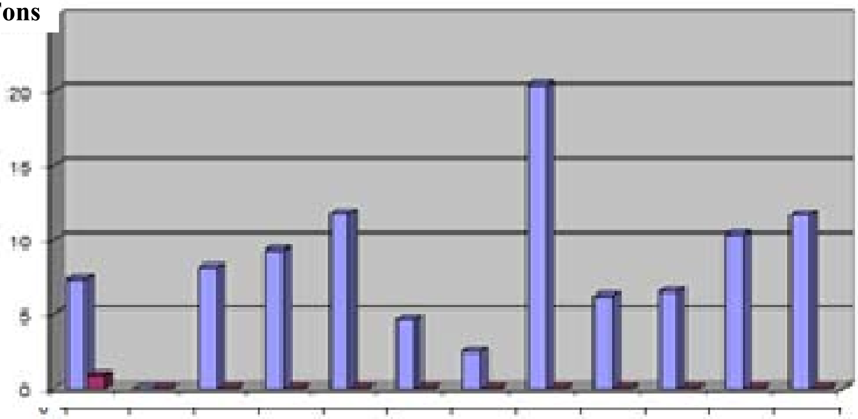


1 4 7 10 12 Month

Depending on the category of waste, quantities are distributed differently every month. Monthly distribution of the categories of waste is represented in Figures 4, 5 and 6.

Figure 4. *Monitoring the stored amount of waste from wood prelucration during January-December 2015*

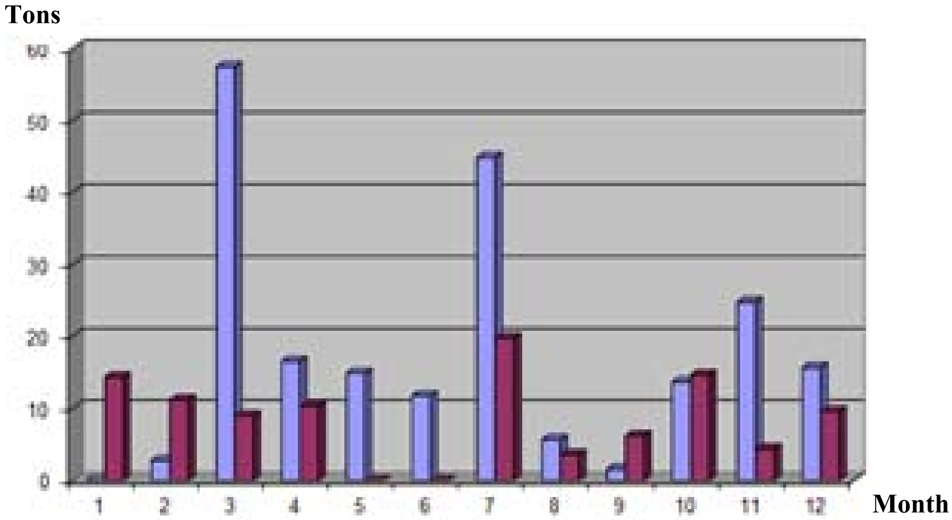
Tons



1 4 7 10 12 Month

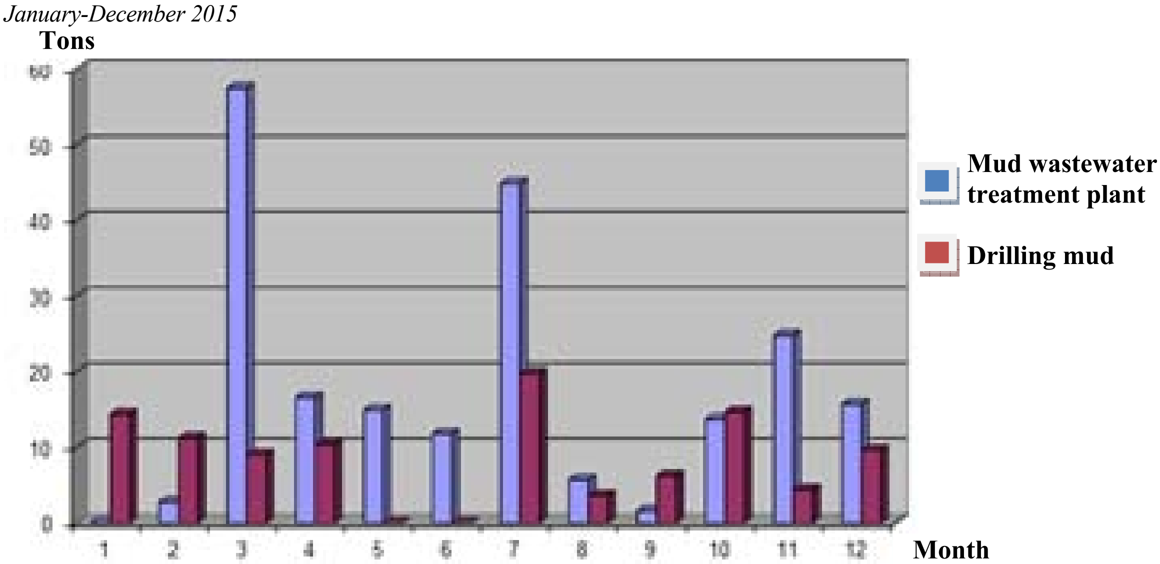
For instance, the chart in Figure 4 reveals the stored amount of waste resulting from wood processing for each month of the year 2015. There can be observed that the highest amount was measured in August, with values slightly over the half of maximum in May and December. A sizable amount of waste was also recorded in April and November.

Figure 5. *Monitoring the stored amount of mud waste from wastewater treatment plants during January-December 2015*



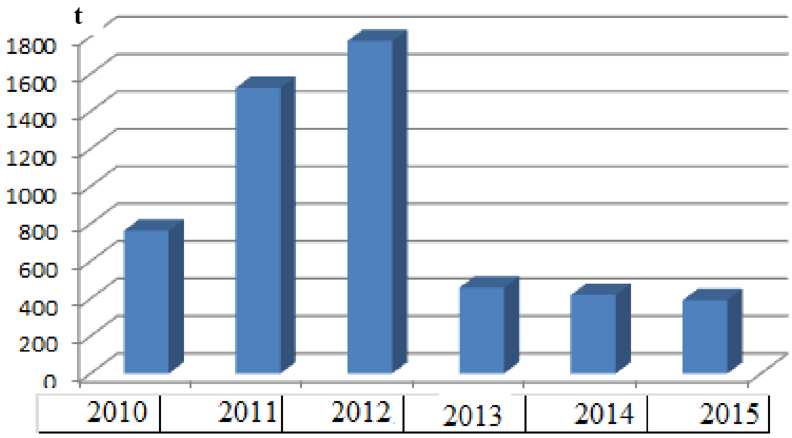
This type of chart allows the observation of mud waste obtained during the processes run by wastewater treatment plants. Like the previous figure, the data are measured for each month (in 2015). The highest amount of mud waste was recorded in March, with July, November and December following with lower values.

Figure 6. *Monitoring the stored amount of mud from wastewater treatment plant and drilling mud during January-December 2015*



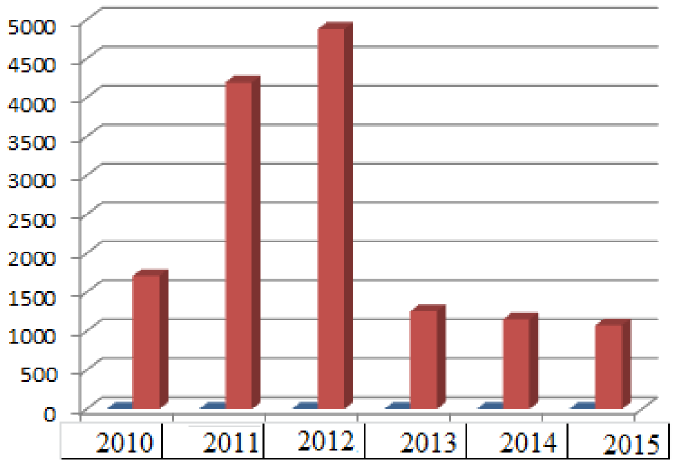
The emissions quantities between 2010 and 2015 generated by the software and based on the calculation model presented above. The same results are generated in the form of graphs presented in Figures 7 and 8.

Figure 7. *Annual quantity of methane emissions*



Analyzing the data we can observe that there was a peak of CH_4 emissions in 2012 which corresponded to a maximum of 141109.55 tons of waste. From the maximum value of CH_4 – 1789 tons we reached in 2015 – the year when "mediu.conturweb" software was implemented – to the amount of 384 tons/year.

Figure 8. *Annual quantity of CO_2 emissions*



The amount of CO_2 emissions recorded the same variation, namely: decreased from the value of 4650 tons/year in 2012 to the value of 998 tons /year in 2015. Establishing the recycling rate and variation of quantity / quality of waste are correlated parameters by the "mediu.contur.web" software with the amount of annual emissions. Analyzing the data presented in Figures 7 and 8 shows that alongside with an increase in the recycling rate at the value of 5 for a larger amount of waste, the annual quantity of emissions decreases.

Conclusions

The need to reduce the amount of waste in the context of its growth and considering the enlargement of its diversity required a new approach of waste management in companies and landfills. Waste management should be done both at the source and in the transfer and storage areas. This paper proposes waste management solutions based on both the storage/recycling component and also on the economic component as well. Developing an application based on the data collected could offer real-time solutions. The application “mediu.conturweb”, besides offering an efficient monitoring of the amount of waste recycled, also finds solutions depending on the nature, origin and final destination of the recycled products. Emission's monitoring in waste disposal sites is one of the current legal requirements. The influence the amount of waste disposed/recycled is directly seen in close relation with the amount of emissions. The application “mediu.conturweb” implemented in 2015 resulted in a decrease of emissions to the value of 384 tons/year for CH_4 and of 998 tons/year for CO_2, thus allowing us to obtain an optimal value depending on the waste component which considers recycling rate 5.

Note

(1) See http://www.anpm.ro/anpm_resources/migrated_content/files/APM%20BRASOV/2013/Inventar%202012/Ordin-emisiiAnexa1-partea1.pdf

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