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ASSESSMENT OF THE AIR POLLUTION DUE TO COMBUSTION PROCESSES OF DIFFERENT WASTES

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Abstract
The continuous increase of the volume of waste, in direct correlation with the number of the population represents an important problem for the specialists involved in waste management and the identification of the most efficient solutions for their management in an environmentally friendly way with minimal impact on the environment. A large-scale waste reduction solution is to incinerate them in dedicated installations with strict control over air pollutant emissions from the incineration process. The paper presents the results of the tests carried out in two types of waste incinerators for the assessment of pollutant emissions in the air in order to reduce them and to meet the requirements of the environmental regulations in this field.

Keywords*: combustion gases, combustion process, incinerator, pollutants, waste*

Introduction

Among many environmental problems that threaten our planet, a major problem are, without a doubt, wastes, as the result of multiple human activities. The wastes represent an important issue due to both the continuous increase of the quantities and their types (which, by degradation in the natural environment, can pose a danger to the environment and the health of the population), as well as to the significant quantities of raw materials, reusable materials and energy, which can be recovered and introduced into the economic circuit (Bucur & Danet 2016; Danciulescu and all 2015; Danciulescu and all 2017). The most important waste disposal advantage is incineration as a fast waste treatment method, which means that very large quantities can be destroyed in a relatively short time. The amount of solids resulting from combustion represents only 15-20% of the initial weight of the waste, leading to a reduction in storage space (Bratu and all 2016; February 2018; Guta and all 2007; Ramona and all 2007; September 2010; Serbanescu and all 2018). The environmental effects of municipal waste incineration are mainly related to emissions released into the atmosphere by incinerators ,losses of organic matter and other biomass-containing materials. The overall environmental performance of municipal waste incineration, including bio-waste, depends on a multitude of factors, in particular fuel quality, plant energy efficiency and the replaced energy source that can greatly influence air emissions. (Danciulescu and all 2017, Petrescu and all 2017, January 2015). As a result of the incineration process of different types of waste, a number of pollutants are evacuated to the environment.

The paper presents the results of the tests carried out in two types of waste incinerators for the assessment of air pollutant emissions in order to reduce them and to meet the requirements of the environmental regulations in this field; the tests were carried out in an animal waste incinerator and a municipal waste incinerator. The obtained values are compared to in force legislation, depending on the type of incinerator and waste used in incineration (Bratu and all 2018, Directive 2008/98; Law 211/2011; Petrescu and all 2017).

Materials and methods

The tests that were the subject of this study were conducted between 2016-2018 and assumed the measurement of the concentration of pollutants specific to air emissions from waste incineration, combustion gases, powders, volatile organic compounds (VOC) and dioxins and furans in May , September and December of each year. For a series of pollutants measurements were made in 2019, too.

Waste incinerators

Technological waste incineration processes, indiferent of the type of waste used, include: the combustion system, the heat recovery system, the treatment of waste gases and the residues resulting from incineration (Fig. 1). The research in this paper is carried out for two categories of incinerators: i) Municipal waste incinerators: plastics material with traces of oils, paint, toothpaste with expired validity periods, residues from different industries, sanitary materials, solid or liquid detergents, chlorine, laundry conditioners , medical waste, and (ii) animal waste incinerators (poultry or pig bodies)

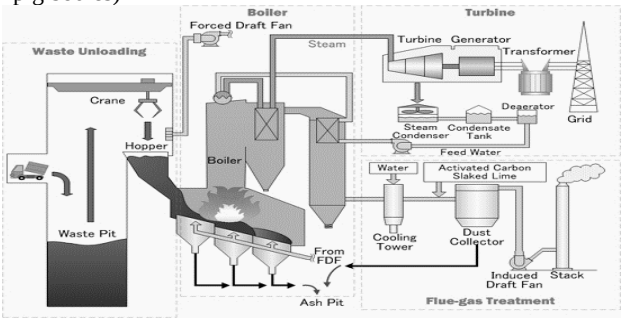


Figure 1. Scheme of the technological process of waste incineration

Pollutants discharged into the atmosphere following the burning process from incinerators are: combustion gases, dusts, volatile organic compounds (VOCs) and dioxins and furans, compounds whose emission levels are set by law 278/2013 (Tabel 1). (Law 278/2013).

Table 1. Limit values in the law 278/2013

Pollutant	Limit values	Measure units
CO	100	mg/Nmc
NO_x	200	mg/Nmc
SO_2	50	mg/Nmc
powders	10	mg/Nmc
dioxins & furans	0.1	ng/Nmc
volatile organic compounds	10	mgC/Nmc

To measure the concentration of pollutants emitted in the air, automatic methods (CO, NO_x, SO_2, volatile organic compounds (VOC) were used, as well as manual methods involving field sampling and laboratory analysis (dioxins and furans, powders). In Fig. 2 shows a series of equipment used for the sampling / measurement of airborne pollutants.

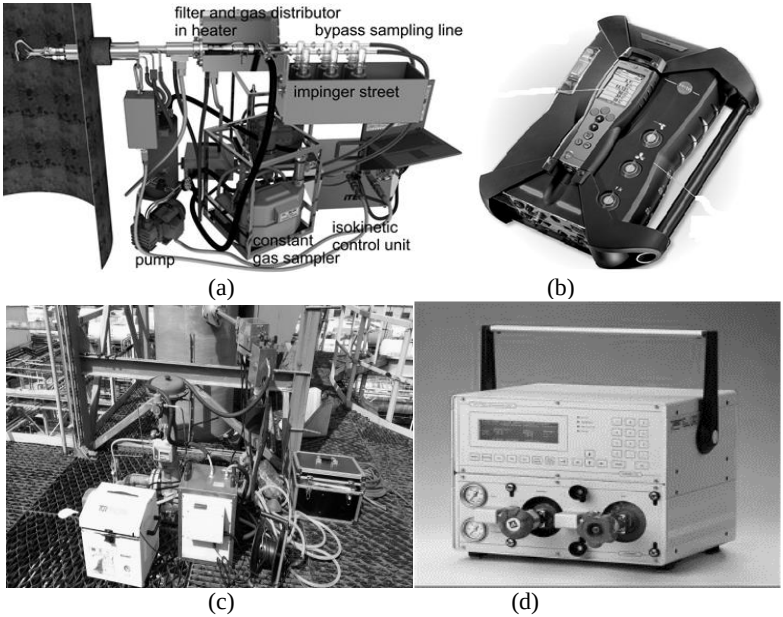


Figure 2. Equipment used for the emission / measurement of pollutants emitted in the air: isokinetic particle sampler (a) burn gas analyzer (b) dioxin and furans sampler (c) and automatic volatile organic compounds analyzer (d).

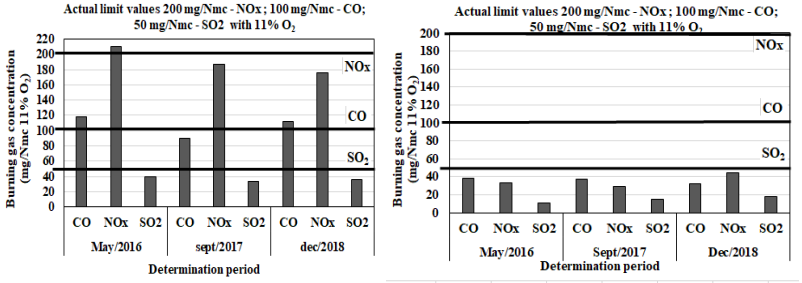
For the isokinetic powder extraction, the equipment shown in Figure 2a was used. In order to obtain an isokinetic sampling, it is necessary to determine and introduce in the isokinetic calculation some physical parameters: the dynamic pressure [mbar] of the gaseous effluent at the point of measurement; gas temperature [K]; chemical composition of gaseous effluent for gas density determination (kg/m³); gas humidity

[%]; atmospheric pressure [mbar]. Also, for the determination of the combustion gas concentration was used the combustion gas analyzer shown in Figure 2b, and the isokinetic sampling equipment provided with sampling pump and condenser was used for the sampling of dioxins and furans - Figure 2c. Also, the dust particles and gas aerosols are retained to determine the concentration of dioxins and furans on the filter and XAD resin. The condenser allows condensation of the gaseous effluent leaving the sampling probe so that the condensed fluid is analyzed analytically to determine the concentration of dioxins and furans. To determine the concentration of volatile organic compounds, the Thermo-FID analyzer presented in Figure 2d was used. Sampling in this work is done according to the standards SR EN 15259:2009; SR EN 13284-1:2008; SR ISO 10396:2008; SR EN 12619: 2013 (SR EN 15259:2009, SR EN 13284-1:2008; SR ISO 10396:2008; SR EN 12619: 2013)

Results and discussion

The values obtained for the pollutants studied in this paper are shown graphically in the following figures.

i. *Burn gases*

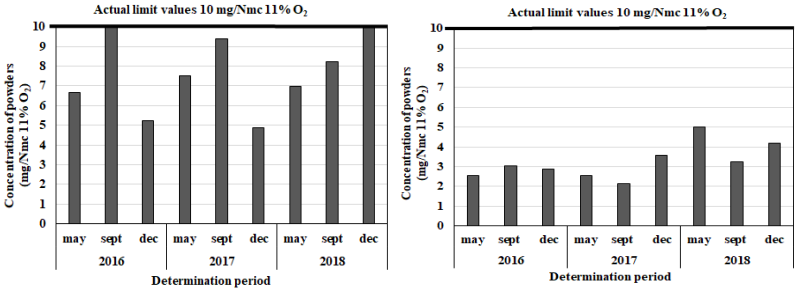


(a) (b)

Figure 4. Variation on the concentration of CO, NOx, SO2 during 2016-2018; 4a. animal waste incineration, 4b. municipal waste incineration

The limit values in the legislation for the studied pollutants are: CO-100mg/Nm^3; NO_x-200 mg/Nm^3; SO_2-50mg/Nm^3. Thus, concentrations higher than the limits for CO for May 2016 and December 2018 for the animal waste incinerator are observed. Also high NOx values were determined in May 2016 at the animal waste incinerator.

ii. *Total powders.*

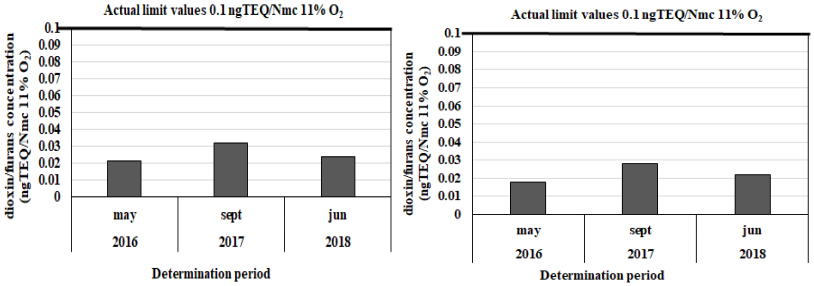


(a) (b)

Figure 5. The variation in the total powder concentration during the period 2016-2018; 5a. animal waste incineration, 5b. municipal waste incineration

Total powder concentration values are calculated in mg/Nm_3 with O_2 reference of 11%. From the graphs shown in Figure 5a for the animal waste incinerator and Figure 5b for the Municipal Waste Incinerator it is observed that values were shown showing a higher concentration of total dusts emitted in the case of the animal waste incinerator for September / 2016 and December / 2018. Exceedings of combustion gases and dusts produced by the animal waste incinerator are caused by the fact that the incinerator is old, without reduction systems for the pollutants discharged into the environment, so the construction of high performance incinerators has been imposed.

iii. *Dioxins & Furans*

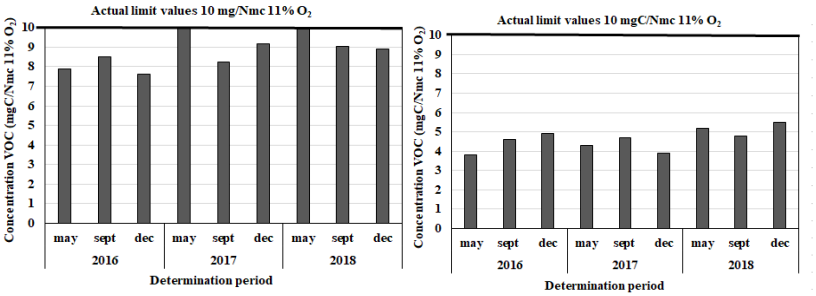


(a) (b)

Figure 6. The variation in the dioxins & furans concentration during the period 2016-2018; 6a. animal waste incineration, 6b. municipal waste incineration

From the graphs shown in Figure 6 it is observed that for the animal waste incinerator higher values were obtained for the concentration of dioxins and furans compared to the concentrations obtained for the municipal waste incinerator. Higher values were recorded in 2017, namely 0.033 ngTEQ / Nmc (TEQ-toxic equivalency factor). The maximum limit value for this pollutant is 0.1 ngTEQ / Nmc.

iv. *Volatile organic compounds*



(a) (b)

Figure 7. The variation in volatile organic compounds concentration during the period 2016-2018; 7a. animal waste incineration, 7b. municipal waste incineration

Volatile organic compounds determined over the period studied in this paper show higher values at the animal waste incinerator for May 2017 and 2018 calculated with measured oxygen and reference oxygen of 11%. Compared with the concentrations of volatile organic compounds determined by another type of technological process (Figure 8, according to Subsidiary contract No. 2142 / 12.02.2019), the concentrations of volatile organic compounds are lower for incinerators than for other types of technological processes.

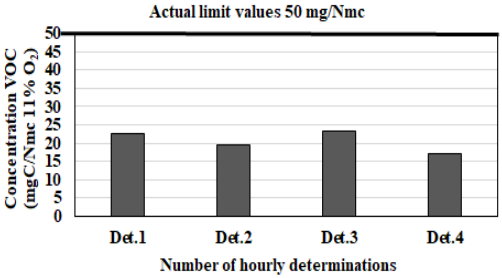


Figure 8 Values of volatile organic compound concentration in technological processes

However, given the limit value in the legislation (Law 278/2013) of 50 mgC / Nm3 and in this case the measured values are within limits.

Conclusions

The resulting values for pollutants discharged into the environment depend on both the combustion conditions and the waste used for incineration. Thus, the values exceeding the limits of the legislation for the pollutants studied in this paper are due to incineration plants. So, municipal waste incinerators are reliable, efficient installations, made up of complex equipment with filtering and cleaning systems that are discharged into the environment. Incinerators for animal waste where the

pollutant determinations made in this paper have been made do not have gaseous effluent filtration equipment. Therefore, it is recommended to modernize the incineration / burning technology of animal waste so that the concentration values of pollutants discharged into the environment fall within the limit values in the legislation.

Acknowledgements

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***SR EN 13284-1:2008 - Stationary source emissions - Determination of low range mass concentration of dust - Part 1: Manual gravimetric method

***SR ISO 10396:2008 · Emissions from fixed sources. Sampling for automatic determination of the gas concentrations emitted for fixed monitoring systems

***SR EN 12619: 2013 Stationary source emissions - Determination of the mass concentration of total gaseous organic carbon - Continuous flame ionisation detector method