Characterization of main industrial wastes in Bulgaria and possibilities for their utilization

I. Djobov, R. Andreeva, M. Peshova, A. Karamanov

Institute of Physical Chemistry, Bulgarian Academy of Sciences, Sofia, 1113, Bulgaria
Keywords: fly ash, industrial waste, sintering
Presenting author e-mail: i.djobov@ipc.bas.bg

Introduction

The industrial waste generation has increased extremely around the world in recent decades. This is due to a number of factors, such as population growth, urbanization, and economic growth, as well as consumer shopping habits.

In Figure 1 is presented the data of total waste generated per capita in the EU Member States. It highlights that the high values recorded for Finland where on average 20 t of waste were generated per inhabitant in 2022, followed by Estonia with 16,8 t, Sweden with 15,6 t, Luxemburg with 15,2 t and Bulgaria with 14,6 t. The value for Bulgaria is about three times higher than in the EU average of 5 t per inhabitant. The levels of waste generated in Finland and Sweden are high because metal mining industry is currently experiencing a marked boom in both country, while in Bulgaria is mainly related with open pit mining and coal power plants.

The Figure 2 shows the distribution of waste by economic activities and households in Bulgaria - the percentage of M&Q is riches 72,4 % of the total waste while C&D are only 1,6 %. Practically this ratio is opposite of that of the EC. That is why is so important to be make a detail study of the type of the available wastes and potential methods for their utilization.

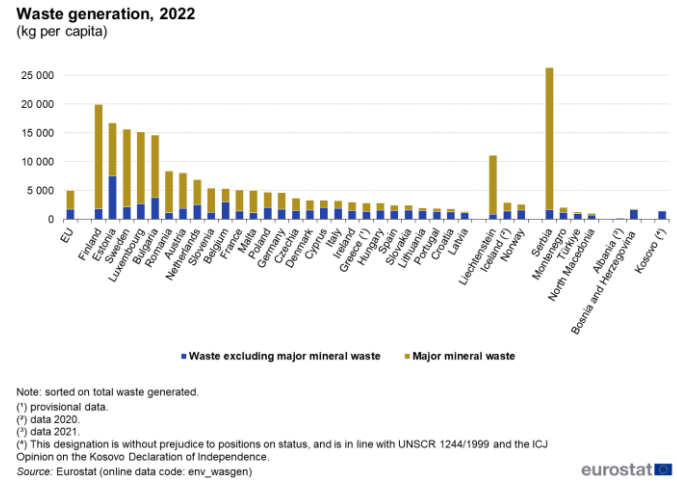

Figure 1. Waste generation in 2022 (kg per capita)

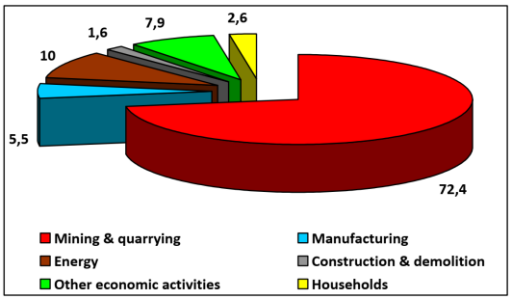

Fig. 2. Waste generation by economic activities and households in Bulgaria in 2022 (% share of total waste)

The clays from coal surface mining have largest portion in the country. The possibilities for their usage had studied and results had been published. This preliminary analysis elucidates that clays could be applied as raw materials for ceramic industry and geopolymers. The aim of current report is to describe the other main M&Q streams in Bulgaria and to give the recommendation or examples for their possible usage as raw materials for high volume building productions.

Experimental

The object of research are different types of waste generated in Bulgaria during the mining, processing, beneficiation of minerals and smelting. Several samples were analysed: bottom and fly ashes from the lignite power plants "Maritsa East 2" and "AES ContourGlobal" (labelled C_1 and C_2 respectively); fayalite from copper slags of "Aurubis – Pirdop" smelter (labelled C_3); clinker and lead&zink slags of "KCM – Plovdiv" smelter (labelled C_4, and C_5 respectively); blast furnace slags of "Kremikovtzi" (labelled C_6).

The chemical compositions of the samples were evaluated by XRF analysis (Zetium Spectrometer – Malvern Panalytical). The particle size distributions of powdered samples were studied by laser diffraction. The measurements were performed with Mastersizer 3000 MALVERN (UK) instrument. The phase compositions of the bottom and fly ashes samples were evaluated by powder XRD analysis by automatic powder diffractometer system Philips, generator PW1830 and goniometer PW1050.

Results and discussions

The results from chemical XRF analysis of main elements of studied samples are given in Table 1.

Table 1. Results from chemical analysis of the industrial wastes (Wt.%)

Powders Elements	Bottom ash C_1	Fly ash C_2	Fayalite C_3	Clinker steel dust C_4	Pb slag C_5	Blast furnace slag C_6
Fe_2O_3*	24,8	24,9	62	40,8	29,4	1
SiO_2	22	33,9	24,5	8,5	16,9	35,1
CaO	18,2	12,5	2,4	34	29,4	40,5
Al_2O_3	10,2	17	3,7	3,4	6	9,3
SO_3	20,6	5,1	0,4	4,4	3,6	-
MgO	1,4	2,1	0,8	1,5	1,5	5,1
TiO_2	0,9	1,1	0,3	0,3	0,5	-
K_2O	0,8	1,2	1,2	0,2	0,6	1
Na_2O	0,3	1,3	0,6	0,4	1,1	0,3
ZnO	-	-	2,2	0,4	4	-
CuO	-	-	0,5	0,6	0,6	-
PbO	-	-	0,3	0,4	1,8	-
MnO	0,1	0,2	-	3,7	2	2,6
BaO	0,2	0,2	-	0,2	0,3	3,2
Other	0,5	0,5	1,1	1,2	2,3	1,9

**iron oxides and the metallic iron are presented as F_2O_3.*

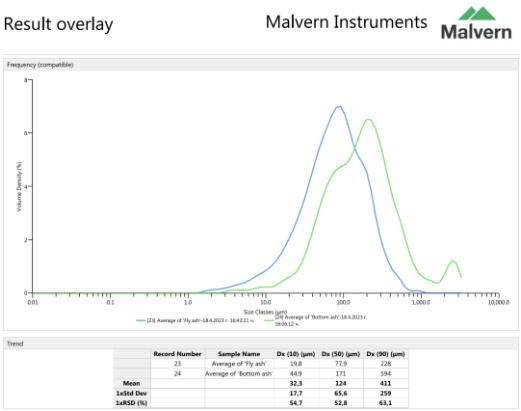

Fig.3. Results overlay of bottom and fly ash

The studied industrial wastes in general are fine-grained, which is positive from practical point of view. The typical results from particle size of C_1 and C_2 are shown in Figure 3. These bottom and fly ashes have an average particle size (d50) of approximately 7 μm respectively.

The XRD results of C_1 (Fig.4) shows a typical for similar wastes phases as gypsum, quartz and magnetite, while C_2 (Fig.5) contains magnetite, quartz and mullite. This means that only the fly ash, due to the lower % of sulphur, can be considered as alternative raw material.

In the other wastes different silicate phases are presented, so they also might be considered as raw materials for silicate industry. Only C_4, due to present of high amount of carbon and some iron, can be excluded.

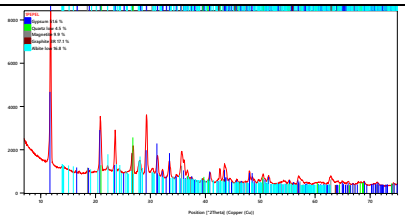

Fig. 4. Phase analysis of bottom ash sample

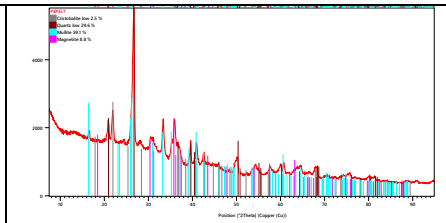

Fig. 5. Phase analysis of fly ash sample

Conclusions

The results of chemical, mineralogical and fractional analysis of studied wastes show that the main part of them are suitable for recycling as raw materials for silicate industries. This could decrease the ecological impact, as well as can reduce the usage of traditional natural raw materials. For example, considering the obtained data, the blast furnace slags could be used in cement industry or in alternative ceramics, the fayalite slag is appropriated for the synthesis of new iron-rich ceramics and geopolymers. The fly ash and Pb slag also might find application as a raw material for building industry or as filler in the production of drywall.

Acknowledgements: This research was financially supported by the BSF projects KP-06-N67/13 “Use of Bulgarian marl raw materials with additives from other natural and industrial sources for the synthesis of high-quality ceramics of the „yellow“ pavers type”.