Petrography of Construction and Demolition Waste (CDW) from Abruzzo Region (Central Italy)

Galderisi A. *[1,2], Iezzi G. [1,3], Bianchini G. [4], Paris E. [5] and de Brito J. [6]

[1] Dipartimento INGEO, Università di Chieti-Pescara, Chieti, Italy. [2] IGAG, CNR, Rome, Italy. [3] INGV, Rome, Italy. [4] Dipartimento di Fisica e Scienze della Terra, Università di Ferrara, Ferrara, Italy. [5] Scuola di Scienze e Tecnologie, sez. Geologia, Università di Camerino, Camerino, Italy. [6] CERIS, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal.

Keywords: Petrography, CDW, Recycling. Presenting author email: g.iezzi@unich.it

Introduction. The "ceramic-like" construction and demolition waste (CDW) from the Abruzzo region were characterised in this study to constrain their chemical, mineralogical and physical features. They represent the most abundant CDW of the region and are mainly made of natural stones, concretes, bricks, perforated bricks, tiles and roof-tiles. The knowledge of their physical and petrographic features are important to evaluate the possibility to sort them *via* efficient and cheap methods, i.e. separate starting heterogeneous CDW in different groups with relative high homogeneous characteristics.

Material and methods. The 18 single CDW samples considered here were collected in various cities and towns of the Abruzzo region. They were divided in several groups according to their mesoscopic appearance and commercial using (Table 1 and Fig. 1a). For each sample the texture, density, mesoscopic and powder colour were determined. The identification and semi-quantitative (RIR method) amount of crystalline phases were analysed *via* X-Ray Powder Diffraction (XRPD) (Fig. 1b). Based on the XRPD outcomes, the chemical compositions (major, minor and trace elemental features) of 11 samples were obtained using a X-Ray Fluorescence Wavelength Dispersive Spectroscopy (XRF-WDS) analysis (Fig. 1c, d).

Results and discussion. The colour (appearance), texture, density, mineralogy and chemical composition show low to moderate similarities within each group (natural stone, concrete, brick, perforated brick, tile and roof tile) (Fig. 1a). The differences are instead high among different groups, especially between concrete plus natural stone *versus* the other four groups (Fig. 1a). Typical concretes and natural stones from Abruzzo are white to grey, while the other CDW groups are mainly coloured (Table 1 and Fig. 1a). Also, concretes and natural stones have moderate to high density (2 to 2.7 g/cm^3), whereas the other groups are instead more scattered, with a tendency to be close or lesser than 2 g/cm^3 (Table 1). All these mesoscopic features suggest that the separation of CDW from Abruzzo, as well as those from similar geographical and geological regions, can only be poorly enforced using sorting based on density; conversely, sorting procedures based on colour will be more efficient.

The mesoscopic and physical differences between concrete plus natural stones versus bricks, perforated bricks, tiles and roof tiles reflect petrographic attributes. The former two one groups are rich (> 50 wt.%) to exclusively (100 wt.%) made up of calcite and obviously present high values (> 50 wt.%) of CaO and LOI, reflecting the high amount of CO_2 of the carbonate aggregates (Figs. 1b, c, d). On the other hand, bricks, perforated bricks, tiles and roof tiles are calcite-poor or -free and rich in crystalline and non-crystalline SiO_2 and silicate phases (Figs. 1b, c, d). Thereby, the separation of concrete plus natural stones from bricks, perforated bricks, tiles and roof tiles in Abruzzo can be further enhanced by a separation based on chemical compositions, since the former are CaO-rich and SiO_2-poor, while the latter show the inverse characteristics.

The amounts of the various crystalline phases in the CDW from Abruzzo are compared with those provided in four previous studies performed on CDW from the Veneto region in north-east of Italy (Panizza et al., 2018), central Spain (Frias et al., 2020), Portugal (Rodrigues et al., 2013) and southern part of Greece (Alexandridou et al., 2014). The mineralogy of CDW concrete from Abruzzo is very similar to that analysed in southern Greece and relatively close to that coming from Veneto. By contrast, the mixed CDW from Spain and Portugal show a low to moderate amount of carbonates (calcite + dolomite) (Fig. 1b), probably reflecting the mixing of concrete with masonry materials, as well as different lithological features characterising those geographical areas.

A further reappraisal of the similarities and differences between CDW from different regions worldwide can be obtained through their chemical features. The concrete groups from Abruzzo and southern Greece (Alexandridou et al., 2014) are both very rich in CaO and poor in SiO_2 + Al_2O_3, in line with XRPD outcomes (Fig. 1c, d); conversely, the three CDW concrete samples from London (UK) (Limbachiya et al., 2007) are poor in CaO and rich in SiO_2. The former two groups reflect the extremely high abundance of carbonate rocks in Central Italy and southern Greece, whereas those from London mirror the paucity of carbonate rocks in this area

At the same time, all the CDW from other regions, made up of mixed CDW, have a content of CaO invariably lower than that of SiO_2 + Al_2O_3, SiO_2 + MgO + Fe_2O_3 and SiO_2 + Na_2O + K_2O (Fig. 1c, d). Again, these features reflect both their mixed CDW signature and the scarcity of carbonate rocks from these areas. Finally, CDW from Abruzzo is strongly different from that sampled in Ferrara, Emilia-Romagna region, although these two areas are located at a distance of only few hundreds of km and with a very similar architectural styles. The abundance of carbonates rocks in Abruzzo and their scarcity in the Po River plain settlements determine this significant variability between these two Italian regions.

These petrographic characterisations argue on the necessity to investigate the petrography of CDW at a local level to identify their main chemical and mineralogical features, to design sorting procedures based on their petrography.

Conclusions. Geographical areas rich in limestone can be expected to share similar CDW features, i.e. abundance of high density and whitish to pale grey concretes coupled with scarcity of CaO- and carbonate-poor phases with moderate to low density and mainly coloured. These aspects are relevant for the sorting of CDW in areas rich and poor in limestones.

References.

Alexandridou C., Angelopoulos G. N., Coutelieris F. A., 2014. Physical, Chemical and min-eralogical characterization of construction and demolition waste produced in Greece. International Scholarly and Scientific Research & Innovation, 8(9).

Bianchini G., Marrocchino E., Tassinari R., Vaccaro C., 2005. Recycling of construction and demolition waste materials: a chemical–mineralogical appraisal. Waste Management, 25, pp. 149–159.

Bianchini G., Ristovski I., Milcov I., Zupac A., Natali C., Salani G. M., Marchina C., Brom-bin V., Ferraboschi A., 2020. Chemical Characterisation of Construction and Demolition Waste in Skopje City and Its Surroundings (Republic of Macedonia). Sustainability 12, 2055.

Favaretto P., Hidalgo G.E.N., Sampaio C.H., de Almeida Silva R., Lermen R.T., 2017. Char-acterization and use of construction and demolition waste from south of brazil in the production of foamed concrete blocks. Applied Science, 7, 1090.

Frias M., de la Villa R.V., Ramírez S.M., Carrasco L.F., Cociña E.V., Giménez R.G., 2020. Multi-technique characterization of a fine fraction of CDW and assessment of reactivity in a CDW/lime system. Minerals, 10, 590.

Komnitsas K., Zaharaki D., Vlachou A., Bartzas G., Galetakis M., 2015. Effect of synthesis parameters on the quality of construction and demolition wastes (CDW) geopolymers. Advanced Powder Technology, 26, pp. 368–376.

Limbachiya M.C., Marrocchino E., Koulouris A., 2007. Chemical–mineralogical characterisation of coarse recycled concrete aggregate. Waste Management, 27, pp. 201–208.

Moreno-Pérez E., Hernández-Ávila J., Rangel-Martínez Y., Cerecedo-Sáenz E., Arenas-Flores A., Reyes-Valderrama M. I., Salinas-Rodríguez E., 2018. Chemical and mineralogical char-acterization of recycled aggregates from construction and demolition waste from Mexico City. Minerals, 8, 237.

Panizza M., Natali M., Garbin E., Tamburini S., Secco M., 2018. Assessment of geopolymers with Construction and Demolition Waste (CDW) aggregates as a building material. Construction and Building Materials, 181, pp. 119–133.

Rodrigues F., Carvalho M. T., Evangelista L., de Brito J., 2013. Physical-chemical and min-eralogical characterization of fine aggregates from construction and demolition waste recycling plants. Journal of Cleaner Production, 52, pp. 438-445.

Sabai S. M. M., Lichtenberg J. J., Egmond E. L., Florea M. V. M., Brouwers H.J.H., 2016. Construction and Demolition Waste Characteristics in Tanzania. Journal of the Open University of Tanzania, 23(1), pp 1-19

Table 1. Mesoscopic and physical features of CDW samples from the Abruzzo region

groups		concrete				natural stone		brick			tile			roof tile			perforated brick		
sample		MPA-03	MPA-10	MPA-13	MPA-18	MPA-08	MPA-19	MPA-02	MPA-04	MPA-14	MPA-07	MPA-11	MPA-17	MPA-09	MPA-12	MPA-16	MPA-01	MPA-05	MPA-15
mescoscopic color	bulk	grey	grey	grey	grey	white	grey	havana	havana	havana	grey	havana	havana	fire-brick	fire-brick	ocher	havana	red	ocher
	powder	white	white	havana	havana	white	havana	havana	havana	havana	grey	havana	havana	red	red	havana	havana	red	havana
texture		porphyric	porphyric	porphyric	porphyric	aphanitic	porphyric	porphyric	porphyric	aphanitic	aphanitic	aphanitic	aphanitic	aphanitic	aphanitic	porphyric	aphanitic	aphanitic	porphyric
density (g/cm3)		2.49	2.03	2.24	2.02	2.74	2.1	2.01	2.25	1.7	2.08	1.83	2.3	2.09	2.22	1.71	1.82	1.94	1.73

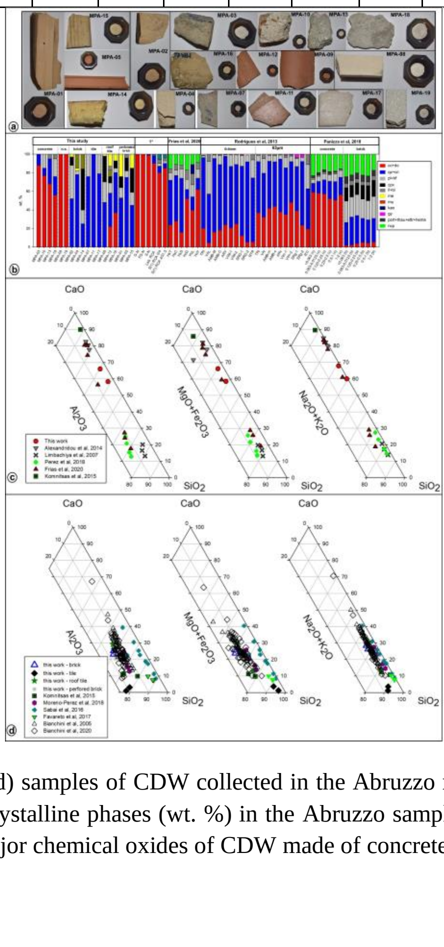

Fig. 1. a) mesoscopic (bulk and as-received) samples of CDW collected in the Abruzzo region (Central Italy), and resulting powder samples; b) semi-quantitative content of crystalline phases (wt. %) in the Abruzzo samples and different provenance worldwide, 1* refers to Alexandridou et al, 2014; c, d) Major chemical oxides of CDW made of concrete (c) and made of masonry and ceramics (d) from different provenance worldwide.