Analysis of the environmental compatibility of the use of different types of recycled aggregates from C&D waste based on the results of leaching tests and risk assessment

L. Acampora[1], G. Costa[1], F. Lombardi[1], F. Onorati[2], A. Paina[2], N. Tonolo[1], A. Tornambé[2], A. Vecchio[2], I. Verginelli[1]

[1]Department of Civil Engineering and Computer Science Engineering, University of Rome Tor Vergata, Rome, 00133, Italy

[2] ISPRA, Institute for Environmental Protection and Research, Rome, 00144, Italy

Keywords: construction and demolition waste, recycled aggregates, leaching tests, risk assessment.

Presenting author email: costa@ing.unioma2.it

The waste produced from the construction and demolition of buildings and infrastructure accounts for more than one third of all the waste generated in the EU, amounting to 374 million tonnes in EU-28 countries in 2016, excluding excavated soil (EEA, 2019). It is a very heterogeneous type of waste, that may contain a variety of materials including concrete, bricks, wood, glass, metals, asphalt, and plastics (Butera *et al*, 2014). Its composition varies significantly in fact on the basis of the type of building/infrastructure considered, construction techniques and materials employed, but also on the demolition practices adopted, that may differ widely on a regional basis.

As for the management of Construction and Demolition (C&D) waste, EU countries have been reporting increasing recovery rates in the last decade, in accordance with the circular economy principles fostered by EU policy, and specifically with the 70% recovery by weight target set by the 2008 Waste Framework Directive to be achieved by 2020. As highlighted by the European Environment Agency however, the recovery of construction and demolition waste relies to a large extent on backfilling or other low-grade recovery options such as the use of recycled aggregates from the mineral fraction of C&D waste in applications such as road sub-base construction (EEA, 2019). This applies also to Italy, where in 2022 non-hazardous C&D waste amounted to over 50 million tons, which were mostly recovered (39 million tons) (ISPRA, 2022). In particular, the mineral fraction of C&D waste in Italy is mainly treated mechanically, by crushing and particle size classification, and then used as a filler or recycled aggregate in concrete, asphalt mixtures or in road sub-base construction. The technical requirements of the obtained recycled aggregates and fillers are defined by specific norms that depend on the type of utilization strategy considered, whereas environmental compatibility requirements are based on the compliance with limits regarding the total content and leaching at native pH of the materials, regardless of how they are utilized. In particular, in 2022 a Decree introducing End-of-waste criteria for recycled aggregates from the treatment of non-hazardous C&D waste was introduced (Decree n.152 of September 27th, 2022). This decree reports limits on the total content of asbestos and organic contaminants such as polycyclic aromatic hydrocarbons (PAHs), BTEX, and others, as well as limits regarding the results of the EN 12457-2 leaching compliance test, with specific regard to the release of inorganic contaminants such as metals, metalloids and anions and the pH value that should be between 5.5 and 12. As previously mentioned, there is one set of limit values that applies to any type of non-hazardous C&D waste, regardless of the utilization strategy and scenario considered.

Given the wide range and heterogeneity of these types of materials, as well as the different scenarios they could be employed in, it is of great importance to analyse the characteristics and behaviour of recycled aggregates from C&D waste treatment as a function of the considered utilization scenario, with reference for example to changes in pH owing to weathering reactions, or as a function of the amount of water that can come into contact with it once it is employed in its final application. When the material is applied in a utilisation scenario, it often presents pH conditions that are very different from those evaluated in laboratory tests; in fact, when in contact with atmospheric carbon dioxide, carbonation reactions may take place, leading to a reduction in alkalinity over time (Butera *et al*, 2015). From a physical point of view, however, it is very important to take into account of the particle size of the material under analysis, since finer particles provide a greater contact surface between the solid and the liquid, therefore yielding a greater release of potential contaminants (Engelsen *et al*, 2009). The main potential risk posed to the environment and human health by the utilization of these materials for example in road sub-base construction is related to the release of elements of environmental concern into percolating rainwater that may subsequently migrate to contaminate soil, groundwater and surface water, therefore potentially drinking water quality.

In this study, we present the outcomes of a risk-based methodology used to assess the environmental compatibility of the use of treated non-hazardous C&D waste as recycled aggregates or filler materials in unbound applications. The approach focuses on leaching tests, the results of which are interpreted through a risk assessment procedure considering reasonable worst-case scenarios. Standardized column percolation tests (EN 14405 method)

and various batch tests, including the pH-dependence leaching test (CEN/TS 14429 method) and the compliance leaching test (EN 12457-2 method), were carried out. For the pH-dependence leaching test, according to CEN/TS 14429, parallel batch tests were performed on the samples at a Liquid-to-Solid (L/S) ratio of 10 L/kg. Percolation column tests were carried out using 30-cm tall Plexiglas columns with a 5-cm inner diameter, according to the standard method CEN/TS 14405, see Figure 1. In each test, seven distinct leachates were collected at incremental L/S ratios (0.1, 0.2, 0.5, 1, 2, 5, and 10 L/kg). The collected leachates underwent chemical analysis for major and trace inorganic elements, anions, total hydrocarbons, and polycyclic aromatic hydrocarbons (PAH). The results of these tests were employed to assess the release mechanisms (i.e. solubility or availability controlled) and subsequently integrated into a risk assessment procedure, evaluating the environmental compatibility of the analysed samples for potential use as unbound aggregate materials in geotechnical engineering projects. Namely, the results of the lab-scale leaching tests were incorporated in specifically-developed fate and transport models to quantify potential risks to the groundwater resource.

The outcomes derived from the application of this procedure to five different types of materials derived from C&D waste treatment, characterized by different compositions and particle size distributions, will be presented and discussed during the conference.

Figure 1 Picture of the experimental set-up employed to carry out the percolation leaching tests.

References

Butera S., Christensen T. H., Astrup T. F., 2014. Composition and leaching of construction and demolition waste: Inorganic elements and organic compounds, Journal of Hazardous Materials, Volume 276, 302-311

Butera S., J. Hyks, Christensen T. H., Astrup T. F., 2015. Construction and demolition waste: Comparison of standard up-flow column and down-flow lysimeter leaching tests, Waste Management, Volume 43, 386-397

Engelsen C.J., van der Sloot H.A., Wibetoe G., Petkovic G., Stoltenberg-Hansson E, Lund W., 2009. Release of major elements from recycled concrete aggregates and geochemical modelling, Cement and Concrete Research, Volume 39, Issue 5, 446-459, ISSN 0008-8846

EEA, European Environment Agency, 2019. Construction and demolition waste: challenges and opportunities in a circular economy, Briefing no. 14/2019, PDF TH-AM-19-016-EN-N, doi: 10.2800/07321

ISPRA, Institute for Environmental Protection and Research, 2022. Report on special waste, 2022 edition, in Italian. ISPRA Report n. 368/2022 ISBN 978-88-448-1117-4