

## RESEARCH TO INDUSTRY AND INDUSTRY TO RESEARCH

### RETHINKING THE ENVIRONMENTAL CRITERIUM FOR THE END-OF-WASTE STATUS OF INERT WASTE

Facilitating waste recycling is crucial to promote materials circularity and reach the objectives established by the EU Directive on Circular Economy (European Parliament and European Council, 2018).

This is particularly important for the management of non-hazardous inert waste, which should be aimed at the recovery of bulk mineral resources, recently defined as “recovered aggregates”, to be used as secondary raw material by the civil engineering sector. Hence, the term “recovered aggregates” includes both recycled and manufactured aggregates as defined by EN 12620 and by EN 13242. To understand the scale of the issue, the 2016 major mineral waste (i.e. non-hazardous waste from construction and demolition, foundry slags and residues from the incineration of municipal solid waste) production was estimated in almost 1.6 billion tons within the EU28 group, corresponding to a pro-capita share of about 3 tons per EU citizen and per year (Eurostat 2017 and 2019).

In this context, adopting sustainable End-of-Waste (EoW) criteria, which legally establish when recovered materials cease to be considered as waste and obtain the status of marketable products, is a fundamental step to allow circular reuse of recovered aggregates while reducing the amount of inert waste to be landfilled.

Within the five generic requirements laid down by the European Waste Framework Directive (European Parliament and European Council, 2008a), the compliance assessment of the so-called environmental criterium (“Will the use of the material lead to overall adverse environmental or human-health impacts?”) still represents a regulatory issue potentially hindering the stakeholders (both producers and controllers) involved in the waste recovery sector.

As a general trend, EU Member States regulations establish that environmental impacts of recovered material must be assessed through the comparison of results from chemical analyses, performed on the recovered material itself or on water extracts obtained through conventional leaching tests (e.g. standards from the EN 12457 series), with fixed concentration limits (CL). In Italy, this approach was originally introduced by a ministerial decree regulating the so-called “simplified procedures” for defined categories of waste recovery processes (Decreto Ministeriale 5-02-1998). This decree regulated the achievement of EoW status for recovered materials according to proven compliance with a list of fixed CL for several chemical-physical parameters, which must be measured in a waste eluate de-

rived through a leaching test performed according to the EN 12457-2. The same approach (with identical CL) is included in the Italian EoW regulation laid down specifically for the so-called “bituminous conglomerates”, recovered from asphalt waste (Decreto Ministeriale 28-03-2018).

Lately, several issues have been highlighted by the involved parts on the high degree of protection characterizing the aforementioned approach. The use of a set of conservative CL reflected the approach used by the regulator to set simplified waste recovery procedures. In fact, these latter do not require full and ordinary authorization processes but just simple communication to the intended authority of the undergoing waste treatment activity.

Besides, in these last years, questions such as the definition of more realistic CL in the field of aggregate applications, the necessity of defining approaches able to provide information on the real bioavailability of all the chemicals of the tested material, etc. have been raised to better clarify this technical and regulatory framework.

In this context, a scientific working group was established in Italia, aimed at proposing a protocol to update current technical procedures approaches, involving the Veneto technical round-table on circular economy applied to infrastructures, and independent experts. After several meetings, preliminary results were presented during the technical seminary “Construction and demolition waste” held on 27-02-2019 in Padua and the workshop on “Environmental criteria for the achievement of end-of-waste status for inert waste” held on 6-11-2019 in Rimini, during the “Ecomondo”, the green technology expo.

In this document, the scientific committee wants to summarize the principles underlying the protocol, addressing the issue of environmental assessment of EoW criteria for inert waste.

- The working group addresses the need to provide a scientifically-sound protocol, which will allow the involved stakeholders (producers and controllers) to verify the compliance of environmental criteria to obtain EoW status for the so-called “recovered aggregates”, derived from inert waste treatment. Both analytical protocol and concentration limits will be proposed according to the professional experience of the involved stakeholders. The aim is to update the current Italian CL and procedures (Decreto Ministeriale 5-02-1998), too conservative for certain parameters (e.g. sulfates and chemical oxygen demand).
- According to the Waste Framework Directive 98/2008/EC (European Parliament and European Council, 2008a), both the protocol and the EoW criteria will be

based on the general principles of technical feasibility, economic viability and environmental protection.

- The protocol should be detailed enough to be fully adopted as a Ministerial Decree or as an authorization case-by-case for waste treatment plant operations. For this reason, the final document must define both environmental criteria to be met to obtain the EoW status and technical instructions, laying down precise requirements for sampling, transport, storage and sample preparation, together with technical guidelines for required analyses and criteria for analytical results interpretation.
- Both protocol and criteria will be developed specifically for recovered aggregates when applied as unbound materials, i.e. not applied in bound-like applications containing binders (e.g. hydraulically bound materials). When recovered aggregates are used in bound application, the protocol should be further developed considering i) the role of specific binder used, ii) alternative leaching test (i.e. monolithic leaching test) and iii) relative specific CL considering the peculiar features of this kind of applications.
- According to the general requirement regulating EoW criteria, the proposed protocol should allow the assessment of the overall environmental impact, due to solid and leachable fractions of materials constituents and the related different exposure pathways. For this reason, the protocol must include chemical analyses (and eventually ecotoxicological) both on solid samples and on its water extract (derived according to EN 12457-2, or EN 12457-4). The established CL for solid samples will be related to a limited set of parameters, considered significant for this kind of recovered materials.
- The proposed protocol will include chemical-physical relevant analyses on solid samples and leachates, with the possibility to conduct ecotoxicological tests, whether the results from chemical characterization does not comply with the CL necessary to obtain EoW status. In this latter case, results derived from bioassays must prevail, in accordance with the regulation on ecotoxicity classification of waste (Regulation 997/2017/EC, European Council, 2017).
- Ecotoxicological assessment will be based on the following test battery, according to the proposal of Pandard and Römbke, 2013: terrestrial bacteria (*Arthrobacter globiformis*), plants (*Brassica rapa*) and terrestrial invertebrate decomposers (*Eisenia fetida*) for solid samples; aquatic bacteria (*Vibrio Fischeri*), freshwater algae (*Pseudokirchneriella subcapita*), freshwater crustaceans (*Daphnia magna*) for water extracts. The experimental results expressed as effect concentration (EC50) will be assessed through the comparison with proposed ecotoxicological concentration limits (EC50,L).
- The proposed methodology will be based, for each analytical phase, on technical guidelines currently established for the characterization of waste material. In fact, the material not showing compliance with all the EoW criteria will remain a waste. Procedures aimed at labeling and classification of products and substances will be evaluated if they are not less precautionary than

the waste legislation.

- Consequently, the analytical procedures laid down for ecotoxicological EoW assessment are independent from European regulation establishing criteria for products classification and labeling (CLP 2008/1272/EC, European Parliament and European Council, 2008b), in accordance with Waste Framework Directive 2008/98/EC amended by Directive 2008/851/EC (European Parliament and European Council, 2008, European Parliament and European Council, 2018). Indeed, article 6 of the WFD currently states that EoW criteria must be met prior to the application of the regulation on substances and products. The ecotoxicological classification methods of the CLP can lead to a less cautious evaluation if compared to the results derived from the analytical methods used for the ecotoxicological characterization of the waste HP 14 according to the approach described in Hennebert (2018) and Pivato (2019). As an extreme consequence, a recovered aggregate considered compliant with EoW criteria established in accordance with the CLP methods, could at the same time be classified as hazardous waste according to HP 14 classification method.
- Interpretation criteria for experimental results (chemical-physical characterization of solid samples and water extracts and eventual ecotoxicological characterization) are listed in following Table 1.

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**TABLE 1:** Proposed environmental criteria for obtaining the “End-of-waste” status for recovered aggregates. C = Concentration measured, specifically for each required parameter, in solid samples and/or water extracts. C = Limit concentration, established for each parameter as required by the chemical characterization of solid samples and water extracts. EC50 = Concentration expected to produce 50% of the effect measured in each considered bioassay. EC50,L = Limit concentration producing 50% of the effect measured in each considered bioassay.

Chemical characterization of solid sample	Chemical characterization of water extract	Ecotox characterization of solid sample	Ecotox characterization of water extract	OUTCOME
Positive (C < CL)	Positive (C < CL)	Not necessary (-)	Not necessary (-)	Compliant with EoW environmental criteria
Negative (C ≥ CL)	Positive (C < CL)	Positive (EC50 ≥ EC50,L)	Not necessary (-)	Compliant with EoW environmental criteria
Negative (C ≥ CL)	Positive (C < CL)	Negative (EC50 < EC50,L)	Not necessary	Waste status
Positive (C < CL)	Negative (C ≥ CL)	Not necessary (-)	Positive (EC50 ≥ EC50,L)	Compliant with EoW environmental criteria
Positive (C < CL)	Negative (C ≥ CL)	Not necessary (-)	Negative (EC50 < EC50,L)	Waste status
Negative (C ≥ CL)	Negative (C ≥ CL)	Positive (EC50 < EC50,L)	Positive (EC50 ≥ EC50,L)	Compliant with EoW environmental criteria
Negative (C ≥ CL)	Negative (C ≥ CL)	Negative (EC50 ≤ EC50,L)	Positive (EC50 ≥ EC50,L)	Waste status
Negative (C ≥ CL)	Negative (C ≥ CL)	Positive (EC50 ≥ EC50,L)	Negative (EC50 < EC50,L)	Waste status
Negative (C ≥ CL)	Negative (C ≥ CL)	Negative (EC50 < EC50,L)	Negative (EC50 < EC50,L)	Waste status

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