ScienceDirect

Journal of Cleaner Production

Volume 239, 1 December 2019, 118041

Recycling of 'alperujo' (olive pomace) as a key component in the sintering of lightweight aggregates

José Manuel Moreno-Maroto [a], Manuel Uceda-Rodríguez [a], Carlos Javier Cobo-Ceacero [a], Mónica Calero de Hoces [b], María Ángeles MartínLara [b], Teresa Cotes-Palomino [a], Ana B. López García [a], Carmen Martínez -García [a]

Show more

Share Cite

https://doi.org/10.1016/j.jclepro.2019.118041

Get rights and content

Abstract

The current environmental problems that threaten our society can only be mitigated with a radical change in the paradigm of production and consumption. Recycling waste is a key element in this. This work has focused on the valorization of a widely spread agricultural waste: the so-called 'alperujo' (olive pomace). For the first time, olive pomace (OP) has been used as a component in the manufacture of lightweight aggregates (LWAs). Mixtures with 0, 1.25, 2.5, 5 and 10 wt% OP have been prepared from three different clays. The research results show that the addition of OP in low proportions (mainly 2.5%) is more positive to achieve aggregate bloating, pore formation and a lighter structure. The high calorific value of OP also helps to reduce the firing temperature significantly, which would result in energy savings. In the same way, bloating would be favored with the increase of the time and the temperature, especially with this last one. The materials obtained have excellent properties. In addition, the study of leachate in the most expanded aggregate shows that the concentration of heavy metals is very low, representing no danger to the environment. According to these findings, the recycling of olive pomace can be an excellent alternative in the manufacture of LWAs.

Introduction

According to the data recorded by the International Olive Council from 1990 until today, the olive sector is of great economic importance in a large number of countries (IOC, 2019a). The annual production of table olive has tripled in the last thirty years, estimating a production close to 3 million tonnes for the period 2018–2019 (IOC, 2019a). Something similar happens with olive oil, whose production in the period 1990–1991 was approximately 1.4 million tonnes, while it is expected to exceed 3.1 million tonnes at the end of the period 2018–2019 (IOC, 2019b). This would indicate not only that the sector is maintaining itself, but that it is also booming.

Spain is historically the largest producer of olive oil in the world, generating more than 1.2 million tonnes per year based on data from the last triennium (IOC, 2019b). Specifically, Andalusia (southern Spain) is one of the main producing regions of olive products worldwide, with an agro-industrial network consisting of more than 1000 facilities dedicated to olive processing, most of them for the production of olive oil (AGAPA, 2015). As a consequence of the activity of this sector, large volumes of waste and by-products are generated. These by-products mainly include the *hojín* (leaf), the olive stone and the *alperujo* (AGAPA, 2015), although, the olive stone could also be considered as a phase within the alperujo (De la Casa et al., 2012).

‘Alperujo’ is the olive pomace (also called wet pomace), a combination of olive husk and pulp (~20 wt%), crushed olive stone (~15 wt%) and olive mill waste water (De la Casa et al., 2012), reaching a moisture content of around 65% (Arjona et al., 1999). According to the results estimated by AGAPA (2015), from the 5.8 million tonnes of olives that are processed on average annually in the olive agro-industries, more than 4 million tonnes of olive pomace are generated, representing approximately 65% of the initial weight. This figure surpasses 80% if we also count the olive stone and other residues associated. According to Williams et al. (2017 and references therein), the disposal of these wastes in landfills or in aquatic ecosystems (rivers, seas, lakes, etc.) leads to their pollution, as well as other adverse effects, such as undesirable odours or an increase in phytotoxicity. As a consequence, the recovery of the residues from the olive oil industry is essential.

The by-products of olive agro-industries have a wide variety of uses. These applications include animal feed, direct incorporation into the soil, composting and bioenergy production. Among the industries in which these wastes and by-products are used or transformed in Andalusia, there are 24 pomace composting plants, 20 biomass electricity generation plants and numerous end consumers, such as industries, livestock farms, as well as the tertiary and domestic sectors (AGAPA, 2015). The main uses of these by-products in Andalusia are energy; specifically, 47.0% of the total amount generated of these by-products is used for electricity generation or cogeneration, and 32.9% for thermal uses (together, energy uses account for 79.9%). The incorporation of soil organic matter represents 14.3%, and the rest of uses such as animal feed, waste management, etc. represent 5.9% (AGAPA, 2015).

As can be seen, olive pomace is a residue with enormous technological potential. Despite this, its recycling has hardly been studied in sectors such as construction and the ceramics industry. An almost isolated example is the work of De la Casa et al. (2012), who observed that the addition of olive pomace can help reduce the density and thermal conductivity in sintered ceramic specimens.

Lightweight aggregate is a granular material used mainly to develop concrete with lower density, reduced thermal conductivity and improved internal curing (ESCSI, 2018). Other LWA applications are masonry, pavements, geotechnical engineering, water treatments, green roofs or horticulture, among others (ESCSI, 2018). Because of the positive aspects of LWA, its market is expected to grow in the coming years, as the demand for lightweight and thermally insulating concrete increases (Ayati et al., 2018). In this regard, the LWA industry offers an excellent opportunity to produce highly technological products from the valorization of a broad range of residues, as reflected in many recent studies on this topic: the study by Moreno-Maroto et al. (2019) shows how metallic ore mining tailings and its combination with polymeric wastes can produce high quality lightweight aggregates. Gyurkó et al. (2019) investigated the potential of autoclaved aerated concrete wastes as concrete aggregate, prefabricated concrete tiles, concrete blocks, shuttering blocks and cement supplementary material. The article of Zhao et al. (2018) demonstrates that waste clay bricks are promising raw materials in the production of lightweight concrete with excellent properties when used as coarse and fine aggregates. Peyne et al. (2018) obtained LWAs at low temperatures by geopolymerization using different residues. Tang et al. (2017) and Narattha and Chaipanich (2018) employed bottom and fly ash, respectively, to produce lightweight aggregates by cold bonding technique. Wei and Ko (2017) sintered hazardous stainless steel sludge in combination with clay into lightweight aggregates. Similarly, the review conducted by Aslam et al. (2016) addresses the use of oil-palm-boiler clinker as an effective constituent in lightweight concrete. Also, other wastes, such as the mineral sludge generated in the ornamental stone sector, can give rise to high quality LWAs when sintered. Two examples of this are the works of Soltan et al. (2016) and Moreno-Maroto et al. (2017).

However, although the use of waste has been very common in the sintering of artificial lightweight aggregates (LWAs), there is no literature on the use of olive pomace as a component in LWA manufacturing. The objective of this research is therefore to study whether olive pomace can be used as an additive in the manufacture of lightweight aggregates. Taking into account its organic character and high calorific value, it is expected that its decomposition can help the formation of a highly porous structure, also helping to reduce the firing temperature in the kiln. Satisfactory results would not only mean an improvement from an environmental point of view, but could also open up a new market line for this by-product. Such aspects have been addressed in this investigation.

Section snippets

Sampling and initial preparation of raw materials

The olive pomace (OP) was supplied by the Consejo Regulador de la Denominación de Origen Sierra del Segura (La Puerta de Segura, Jaén, Spain), which is an olive oil producer. OP was a dark colored residue of granular appearance and a high moisture content. In addition to OP, three clays (white, yellow and black: WC, YC and BC, respectively) supplied by Comercial Cerámicas de Bailén, S.A (Bailén, Spain) were selected to form the main component of the mixtures. These three clays were selected…

Plasticity and pelletizing

The pelletizing process is highly conditioned by the plasticity of the material. According to the results of Table 1, the three clays are plastic, which agrees with their mineralogy rich in phyllosilicates such as smectite or illite (Table 2). Based on the classification of Moreno-Maroto and Alonso-Azcárate (2018), the white and black clays are actually silty clays, while the yellow sample would correspond to a clay since its PI/LL ratio exceeds 0.5 (Table 1). The compressibility is moderate,…

Conclusions

This work shows how, for the first time, *alperujo* (olive pomace) is used as an additive (0, 1.25, 2.5, 5 and 10 wt%) in the manufacture of lightweight aggregate (LWA) in combination with clays.

Recycling olive pomace has been demonstrated to be an alternative for producing lightweight aggregates in a cleaner way. In general, and except for certain variations that depend on the clay used as a mineral base, the addition of low percentages of olive pomace (1.25–2.5 wt%) implies a significant…

Acknowledgements

This research was carried out as part of the project “Implementación de una alternativa sostenible para la gestión integral del alpeorujo, un residuo contaminante de la industrial oleícola (CTM2016-75977-R)”, funded by the Spanish Ministry of Economy and Competitiveness and FEDER (MINECO-FEDER). The authors also acknowledge with gratitude the technical and human support provided by the CICT of the University of Jaén and the SCAI of the University of Málaga (UJA, UMA, MINECO, Junta de Andalucía, …

Recommended articles

Research data for this article

Raw Data. Olive pomace LWA production

Original Data

Original data included in article "Recycling of ‘alperujo’ (olive pomace) as a key component in the sintering of lightweight aggregates

Get data from Mendeley Data ↗

ⓘ Further information on research data ↗

References (36)

R. Arjona *et al.*
The drying of alpeorujo, a waste product of the olive oil mill industry
J. Food Eng. (1999)

M. Aslam *et al.*
Oil-palm by-products as lightweight aggregate in concrete mixture: a review
J. Clean. Prod. (2016)

B. Ayati *et al.*
Use of clay in the manufacture of lightweight aggregate
Constr. Build. Mater. (2018)

G.E. Barnes
An apparatus for the determination of the workability and plastic limit of clays

Appl. Clay Sci. (2013)

J.A. De la Casa *et al.*
Fired clay masonry units production incorporating two-phase olive mill waste (*alperujo*)
Ceram. Int. (2012)

M. Dondi *et al.*
Lightweight aggregates from waste materials: reappraisal of expansion behavior and prediction schemes for bloating
Constr. Build. Mater. (2016)

E. Fakhfakh *et al.*
Effects of sand addition on production of lightweight aggregates from tunisian smectite-rich clayey rocks
Appl. Clay Sci. (2007)

Z. Gyurkó *et al.*
Sustainable applications for utilization the construction waste of aerated concrete
J. Clean. Prod. (2019)

J.M. Moreno-Maroto *et al.*
What is clay? A new definition of "clay" based on plasticity and its impact on the most widespread soil classification systems
Appl. Clay Sci. (2018)

J.M. Moreno-Maroto *et al.*
Astudy on the valorization of a metallic ore mining tailing and its combination with polymeric wastes for lightweight aggregates production
J. Clean. Prod. (2019)

View more references

Cited by (34)

Study of the synergistic impact of Fe<inf>3</inf>O<inf>4</inf>, Na<inf>2</inf>CO<inf>3</inf> and organic C on kaolin-based lightweight aggregates by a DOE (Mixture Experiments) approach
2023, Construction and Building Materials

Show abstract

Influence of firing temperature on the ceramic properties of illite-chlorite-calcitic clays
2023, Ceramics International

Show abstract

Can statistical methods optimize complex multicomponent mixtures for sintering ceramic granular materials? A case of success with synthetic aggregates

2023, Ceramics International

Show abstract

Utilising olive-stone biomass ash and examining its effect on green concrete: A review paper

2023, Journal of Materials Research and Technology

Show abstract

Effect of the addition of organic wastes (cork powder, nut shell, coffee grounds and paper sludge) in clays to obtain expanded lightweight aggregates

2023, Boletin de la Sociedad Espanola de Ceramica y Vidrio

> *Citation Excerpt :*
> …It is therefore essential to equalize as far as possible the waste input and output flows, so that the integration of such waste into products produced in large volumes could be an intelligent strategy. In this regard, for years, the manufacture of artificial lightweight aggregates (LWAs) seems to be an interesting alternative for three reasons: (i) it is a product that can be produced totally or partially from waste [2–4]; (ii) it is a product that can be applied in large volumes and in different sectors, such as agriculture, environment, urban planning, civil engineering and construction, highlighting fundamentally its application in lightweight concrete and masonry [5]; and (iii) LWA presents technological properties in terms of high porosity, lightness and low thermal conductivity, which make it, among other aspects, a potentially strategic material in the construction of the future [6], facilitating better energy efficiency of housing without sacrificing mechanical integrity, among other advantages. With these points in mind, the present work presents as a novelty the investigation of four widely spread organic wastes, of which there are no precedents or, if there are, they are very few in their application as additives in LWAs: coffee grounds, ground nut shell from almonds and hazelnuts, paper money sewage sludge and cork powder.…

Show abstract

Roasting mechanism of lightweight low-aluminum–silicon ceramisite derived from municipal solid waste incineration fly ash and electrolytic manganese residue

2022, Waste Management

Show abstract

View all citing articles on Scopus ↗

View full text