

Global Artisan C-Sink – Rule update for biochar in concrete construction materials

Preamble

In the Global Artisan C-Sink (version 2.1A and older), the primary focus of biochar production was on C-Sink Farmers using their self-produced biochar to enhance soil quality and increase farm resilience to climate change. In contrast, Artisan Pros and Biochar Processors (such as those from C-Sink Villages) often sell biochar as fertilizer to farmers, while soil application remains a key priority.

Recently, new application pathways for biochar have emerged, showing promise, particularly in low- and middle-income countries where the Global Artisan C-Sink is applicable.

In the Global Biochar C-Sink, the application of biochar in concrete construction materials is explained in detail in chapter 12.3. The Global Artisan C-Sink standard will align with the Global Biochar C-Sink, generally following the arguments and scientific background that support the establishment of biochar as a carbon sink in this context.

Nevertheless, some adjustments and restrictions will be implemented to align with the specific aims and focus of the Global Artisan C-Sink.

Aim of the document

This document aims to provide a clear understanding of the steps involved, the background, and additional requirements for applying biochar produced under the Global Artisan C-Sink in concrete construction materials. This rule update will remain in effect to guide the validation and verification process until the Global Artisan C-Sink is updated and the subsequent chapters and definitions are incorporated.

This document serves as an annex to Chapter 7 (Application and Trade of Biochar) of the Global Artisan C-Sink version 2.1A.

1. Application in concrete construction materials

Biochar incorporated into cement-, lime-, clay-, or geopolymer-based construction materials is considered a carbon sink.

Structures like the Roman Colosseum, the Egyptian pyramids, and the old city of Fulda show that buildings may last longer than empires and constitutions. However, the average life cycle of reinforced cement-based concrete constructions is specified by various standards and publications, such as LEED v4.1 and Minergy/SNBS, to be approximately 60 years (20 years for logistic and production structures). These relatively short life cycles are primarily due to steel corrosion and urban planning. While extending the lifetime of these materials is both possible and desirable, given the current state of the global building industry, an average lifespan of 60 years for buildings and urban infrastructures and 20 years for logistics and production facilities is representative.

During the building's existence, the concrete matrix protects the biochar, e.g., from water, air, and chemicals, so it does not mineralize, and no carbon is released to the atmosphere. No biochar carbon is lost when incorporated into the construction material for as long as the building exists, and the biochar carbon contained in the construction material can be registered with 100% carbon persistence. This holds true regardless of the binder used in the construction material, whether cement, lime, clay, or geopolymers

1.1. End-of-life scenarios

While the preservation of biochar carbon during a building's lifetime is undisputed, the end-of-life scenario becomes crucial for certifying it as a permanent carbon sink. Different scenarios must be considered at this stage.

1.1.1 Landfill

Demolished building materials are often deposited in dedicated construction and demolition (C&D) landfills and are, thus, indirectly applied to the soil. However, demolished concrete placed in C&D landfills is a persistent, mineral material. In the buried, intermittently moist, and relatively low-CO₂ conditions typical of such landfills, concrete fragments (centimeters to decimeters in size) undergo only very slow surface carbonation and limited leaching. Bulk disintegration does not occur on any human-planning horizon (decades to centuries). Consequently, biochar embedded within these fragments is largely shielded from microbial and chemical attack until progressive fragmentation or rare exposure events reach it. While concrete-embedded biochar carbon will eventually, on geological timescales, be exposed to environmental conditions, the diminution and dissolution of concrete debris - which is essentially the same as rock weathering - do not occur in a landfill within any meaningful human timeframe. This interpretation aligns with well-established knowledge of concrete durability and carbonation kinetics, as well as with landfill studies that focus on leachate composition rather than concrete mass loss (Aneja et al., 2022; Chen et al., 2022; You et al., 2022). If a construction is demolished and applied to a C&D landfill, the biochar contained in the concrete matrix is considered persistent for at least 100 years without any accountable carbon losses to the atmosphere (C-Sink₁₀₀ = 100%).

1.1.2 Concrete recycling

Demolished concrete is increasingly recycled into new construction materials or fillers. The Global Biochar C-Sink considers conventional concrete recycling as well as thermo-oxidative cement recycling in detail. It concludes that under normal circumstances,

thermo-oxidative cement recycling can be excluded as an end-of-life scenario for biochar-containing concrete materials. However, the evolution of the recycling technology will be closely observed, and if the recycling technology develops unexpectedly into a scaling solution, the present standard will adapt in due time.

For conventional recycling the rubble must be crushed. During the crushing process, the biochar remains embedded within the resulting pebbles. The pebbles are large enough to prevent rapid geological weathering (Aneja et al., 2022; Chen et al., 2022; You et al., 2022), and the embedded biochar can be considered persistent for at least 100 years (C-Sink₁₀₀ = 100%).

1.2. Persistence

To register the concrete-embedded biochar C-sink, the PAC fraction of the biochar is registered as persistent for > 1000 years. The SPC fraction of the biochar is registered without decay for the first 100 years since its first use in a concrete matrix. Starting at year 101, the concrete embedded biochar is conservatively considered as applied to soil independent of the recycling or landfill deposition scenario (c.f., figure A1), and the SPC decay function applies (c.f., equation A1).

Accordingly, the persistence of concrete-embedded biochar carbon is:

$$\text{C-Sink}_{100} = 100\%$$

$$\text{C-Sink}_{1000+} = 75.0\%$$

A concrete embedded biochar C-Sink of 1000 t CO₂e can, thus, be classified as a C-Sink₁₀₀ of 1000 t CO₂e. However, it could also be divided into a C-Sink₁₀₀₀₊ of max 750 t CO₂e (i.e., the PAC fraction) and a C-Sink₁₀₀ of 250 t CO₂e (i.e., the SPC fraction over 100 years).

The C-Sink₁₀₀₀₊ can be used to offset emissions from C-sink generation. The remaining C-Sink₁₀₀₀₊ that was not used to offset emissions can be converted to and marketed as C-Sink₁₀₀.

The biochar persistence is calculated with the following conservative approximation for year >100:

$$C_{\text{remain}}(\text{year}) = M_{BC} * C_{\text{cont}} * (0.75 + 0.25 * e^{-0.5337 * (\text{year}-100)} + 0.8237 * e^{-0.00997 * (\text{year}-100)})$$

Equation A1. Decay function of biochar presenting an H to C_{org} ratio < 0.40. M_{BC} = mass of biochar; C_{cont} = carbon content of biochar; C_{remain} = Mass of biochar-carbon remaining in a C-sink after the years of decay since soil application. The equation is valid for 101 to 1000 years.

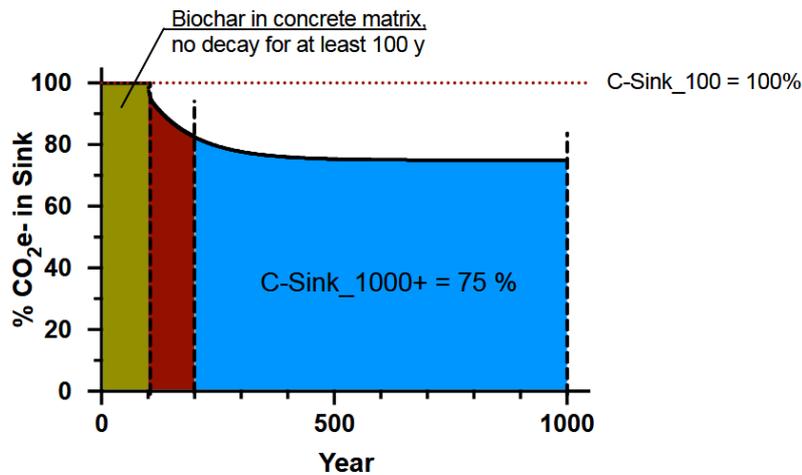


Figure A1. C-sink curve of concrete embedded biochar with an H/Corg ratio < 0.4. The PAC fraction is registered with a persistence of > 1000 years. The SPC fraction is registered without decay for 100 years. After 100 years, the concrete embedded biochar is conservatively considered as if applied to soil independent of the recycling or landfill deposition scenario. The C-Sink₁₀₀ of a construction C-Sink is 100% and the C_{Sink}₁₀₀₀₊ is 75.0%.

1.3. Additional requirements and restrictions

1.3.1. Artisan Biochar Producer

To respect the original reason of the Global Artisan C-Sink (enabling smallholder farmers to enhance their soil quality), only biochar produced from Artisan Pro's is allowed to be applied into concrete construction materials.

1.3.2. Biochar Particle Size

To avoid exposing biochar particles during shredding of construction debris, and to ensure they remain sufficiently protected by the mineral matrix, biochar used in construction materials should be milled to a particle size below 1 mm.

1.3.3. Monitoring, Tracking and Inspections

Biochar applied in construction materials, such as buildings, urban constructions, and infrastructure, is typically pre-mixed at a processor's site. In most cases, these pre-mixed materials are transported as bulk material, measured by weight or volume, rather than in packaging units. Therefore, any processing facility involved in the supply chain has to be registered within the dMRV and inspected by the Artisan C-Sink Manager at least once per calendar year. In alignment with Global Biochar C-Sink, the VVB has to do an on-site audit once per calendar year.

For each processor, specific emission factors for the mixing processes must be calculated by the Artisan C-Sink Manager and validated and verified by the VVB before being deducted from the C-sink. Additionally, all emissions associated with concrete construction materials are not included within the margin of security.

Depending on the individual systems in place, appropriate tracking of the materials to the construction site, and thus to the carbon sink site, must be developed and submitted to Carbon Standards International for approval.

Only when the tracking to the construction site is verified, and the building itself is registered as the carbon sink location can the biochar carbon sink be registered.

The packaging/delivery note of certified biochar-containing construction materials must clearly state that the biochar carbon contained in the concrete material has already been registered as C-sink and must not be registered again as part of a construction or any other use.