SLOVENSKI STANDARD
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Alge in izdelki iz alg - Merjenje obnovljivih surovin iz alg za energetske in neenergetske namene

Algae and algae products - Measurement for renewable algal raw material for energy and non-energy applications

Algen und Algenprodukte - Charakterisierung nachwachsender Algenrohmaterialien für Energie- und Nichtenergieanwendungen

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Algae and algae products - Measurement for renewable algal raw material for energy and non- energy applications

Algen und Algenprodukte - Charakterisierung nachwachsender Algenrohmaterialien für Energie- und Nichtenergieanwendungen

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Page

European foreword

This document (prEN 17983:2023) has been prepared by Technical Committee CEN/TC 454 “Algae and algae products”, the secretariat of which is held by NEN.

This document is currently submitted to the CEN Enquiry.

This document has been prepared under a Standardization Request given to CEN by the European Commission and the European Free Trade Association.

Introduction

This document has been prepared by the experts of CEN/TC 454 "Algae and algae products".

The European Committee for Standardization (CEN) was requested by the European Commission (EC) to draft European standards or European Standardization deliverables to support the implementation of Article 3 of Directive 2009/28/EC for algae and algae-based products or intermediates.

This request, presented as Mandate M/547, also contributes to the Communication on "Innovating for Sustainable Growth: A Bio economy for Europe".

The former working group CEN Technical Board Working Group 218 "Algae" was created in 2016 to develop a work program as part of this Mandate. The technical committee CEN/TC 454 "Algae and algae products" was established to carry out the work program that will prepare a series of standards.

The interest in algae and algae-based products or intermediates has increased significantly in Europe as a valuable source of, including but not limited to, carbohydrates, proteins, lipids, and several pigments. These materials are suitable for use in a wide range of applications from food and feed purposes to other sectors, such as textile, cosmetics, biopolymers, biofuel and fertilizer/biostimulants. Standardization was identified as having an important role in promoting the use of algae and algae products.

The work of CEN/TC 454 should improve the reliability of the supply chain, thereby improving the confidence of industry and consumers in algae, which include macroalgae, microalgae, cyanobacteria, Labyrinthulomycetes, algae-based products or intermediates and will promote and support commercialization of the European algae industry.

In industrial and scientific assessments, many methodological differences occur with regard to mass and energy balances. This constitutes a major issue, as the results often are difficult to compare.

The goal of this document is to define basic metrics for carbon accounting of algae, so as to allow a more scientifically sound comparison between algae systems and other biomass feedstocks.

The need for such metrics and methodology is related to the wide existing differences in algae growth sites and strategies. For example, there are significant differences in the application of the "green box concept" to closed cultivation units and wild harvested algae. However, common sustainability and life-cycle-analysis (LCA) approaches are needed.

These metrics can be used to apply existing LCA standards to algae systems.

Clarifications, considerations, practices, simplifications and options for the different LCA applications are beyond the scope of this document. This document may be applied in studies that do not cover the whole life cycle, such as cradle-to-gate studies, e.g. algal biomass farming or wild collection. The downstream processes, generally referred to as "biorefining", are not covered since it is deemed to be equivalent to plant biomass. An overview of LCA standards is given in Annex C.

This document aims to provide specific life cycle assessment requirements and guidance for algae cultivation, based on EN ISO 14040 *Environmental management – Life cycle assessment – Principles and framework*, EN ISO 14044 *Environmental management – Life cycle assessment – Requirements and guidelines* and EN 16760 *Bio-based products – Life Cycle Assessment*. These standards are all applicable to algae-based products, but the topic which is not clearly defined in these standards is the accounting of the main parameters of algae cultivation sites. The sustainability aspects of algae cultivation can be assessed either by EN 16751, *Bio-based products – Sustainability criteria* when the outcome is a product, or by ISO 13065, when the outcome is energy. Both these documents provide a framework for considering environmental, social and economic aspects that can be used to facilitate the evaluation and comparability of biomass for products or energy, respectively.

With EN 16785-1 *Bio-based products – Bio-based content – Part 1: Determination of the bio-based content using the radiocarbon analysis and elemental analysis* application to algae the problem of fossil CO_2 as photosynthesis feed arises which calls for proper application criteria opposite to plant photosynthesis. A similar situation can arise for nitrogen and phosphorus capture in open seas.

1 Scope

This document specifies the methods to be used for the measurement of energy content and main elements balances of algae from cultivation or from wild growth and algae products to provide biomass, intended for renewable algal raw material used as bioenergy and in bio-based products.

This document does not apply to methods of algae and algae products sampling, harvesting and pre/postprocessing.

This document does not apply to algae and algae products intended for the food and feed sector.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 14268, *Irrigation techniques - Meters for irrigation water*

EN 17399, *Algae and algae products - Terms and definitions*

EN 17480, *Algae and algae products - Methods for the determination of productivity of algae growth sites*

EN 17605, *Algae and algae products - Methods of sampling and analysis - Sample treatment*

EN ISO 4064-1, *Water meters for cold potable water and hot water - Part 1: Metrological and technical requirements (ISO 4064-1)*

EN ISO 18125, *Solid biofuels - Determination of calorific value (ISO 18125)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 17399, EN 17480, EN 17605 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp/

— IEC Electropedia: available at https://www.electropedia.org/

3.1
biomass dry matter
material remaining after removal of moisture under specific conditions

[SOURCE: EN ISO 16559:2022 3.71 – modified, biomass added to the term]

3.2
moisture content
loss on drying
ratio of algae sample mass lost after drying under test conditions till constant weight and initial mass

3.3
biomass ash content
mass of microalgae and macroalgae residue remaining after the sample is placed in a muffle furnace at a temperature of (575 ± 10) °C

3.4
illumination
exposition to light from other sources than sun

3.5
photosynthetic production area
insolated horizontal surface of the cultivation unit where photosynthesis is driven by natural light in natural basins, natural sites and insolated ponds

Note 1 to entry: The production area of non-horizontal systems results in multi-interpretable outcomes; therefore, non-horizontal systems use the volume productivity formula to calculate productivity.

Note 2 to entry: Wild growth areas are excluded.

Note 3 to entry: Systems that use illumination (see 3.11) use volume productivity formula to calculate productivity.

3.6
algae growth site area
area of a single or multiple algae cultivation unit(s)or natural sites, including auxiliary equipment needed to operate the unit and service area

Note 1 to entry: Cultivation unit area includes ponds, bubble columns, tubular photobioreactors, green-wall panels or any kind of devices utilized to grow algae, and all the equipment, tubing and connections necessary for the specific unit to function (e.g. the area occupied by the pumps and recirculating reservoir/ degasser in a tubular photobioreactor), and the service area around. If the service area is not clearly defined, it is by default 1 m all around the cultivation unit.

Note 2 to entry: Cultivation unit area does not include equipment upstream and downstream of the cultivation unit, e.g. the reservoirs for water preparation and/or harvesting.

Note 3 to entry: The specification of the area in a wild growth site where macroalgae are growing in nature without human interference, except when harvesting, is misleading for the calculation of productivity as many factors influence the growth (e.g. currents, mixture of species, natural regeneration cycles, etc.). For an investigation on the productivity and its sustainability of an aquatic ecosystem an area estimation is possible, but this exceeds the scope of this document.

3.7
total carbon
TC
quantity of carbon present in a product in the form of organic, inorganic and elemental carbon

[SOURCE: EN 16575:2014, 2.17]

3.8
dissolved inorganic carbon
DIC
carbon dissolved in water in inorganic form as carbonates and bicarbonates in equilibrium with gaseous dissolved CO_2

Note 1 to entry: Dissolved CO_2 molecules are notated CO2aq.

3.9
dissolved organic carbon
DOC
carbon dissolved in water in organic molecules

Note 1 to entry: Glycerol, acetic acid and sugar are examples of DOC molecules.

3.10
carbon accounting
evaluation of carbon-containing mass flows transferred from inputs to biomass in algae cultivation for sustainability and/or credit claims

3.11
bio-based product
product wholly or partly derived from biomass

Note 1 to entry: The bio-based product is normally characterized by the bio-based carbon content or the bio-based content. For the determination and declaration of the bio-based content and the bio-based carbon content, see the relevant standards of CEN/TC 411.

Note 2 to entry: Product can be an intermediate, material, semifinished or final product.

Note 3 to entry: "Bio-based product" is often used to refer to a product which is partly bio-based. In these cases, the claim should be accompanied by a quantification of the bio-based content.

[SOURCE: EN 16575:2014, 2.5]

3.12
carbon footprint
CFP
sum of GHG emissions and GHG removals in a product system, expressed as CO_2 equivalents and based on a life cycle assessment using the single impact category of climate change

[SOURCE: EN ISO 14067:2018, 3.1.1.1 – modified. Note 1 and 2 to entry omitted]

3.13
greenhouse gas
GHG
gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the earth's surface, the atmosphere, and clouds

[SOURCE: EN ISO 14067:2018, 3.1.2.1 – modified. Note 1 and 2 to entry omitted]

3.14
flue gas
gases produced by combustion of a fuel that are normally emitted to the atmosphere

Note 1 to entry: Flue gas from combustion processes exploited for other purposes than CO_2 production are examples of flue gas, e.g. power plants CO_2 emissions.

[SOURCE: ISO/TR 27912:2016, 3.31 – modified. Note 1 to entry added]

3.15
cryogenic CO_2
liquid CO_2 stored and transported as industrial product

3.16
biogenic CO_2
carbon dioxide generated from the combustion or degradation of biogenic carbon (biobased carbon) (3.25)

3.17
carbon neutral CO_2
carbon dioxide generated as byproduct or waste, after its carbon footprint is fully cleared over the production system

Note 1 to entry: Examples of this carbon dioxide are flue gas from combustion of fossil fuels for energy production, roasting of carbonates, steam reforming of natural gas, as far as the CFP (carbon footprint) of these sources are completely accounted for over the main product, e.g. electric power, calcium oxide, hydrogen.

Note 2 to entry: An overview on carbon/CO_2 neutrality is reported in Annex B.

3.18
open land-based cultivation
controlled growth cultivation performed on land without totally controlled mass flow referring to all solid and liquid mass flows which enter or exit the system without passing a measurable section, e.g. unlined pond

3.19
closed cultivation
controlled growth cultivation performed with controlled mass flow

Note 1 to entry: Uncontrolled gaseous mass flow from/to atmosphere is possible, e.g. CO_2 absorption and/or O_2 release and water vapor release.

Note 2 to entry: Open ponds without bottom liner including natural basins are not considered as closed cultivation systems.

3.20
open water
aqueous environment where algae exchange elements without controlled mass flow

3.21
photosynthetic system
algae cultivation based on phototrophy as defined in EN 17399

3.22
mixotrophic system
algae cultivation based on mixotrophy or photoheterotrophy as defined in EN 17399

3.23
heterotrophic system
algae cultivation based on heterotrophy as defined in EN 17399

3.24
biomass
material of biological origin excluding material embedded in geological formations and/or fossilized

EXAMPLES (Whole or parts of) plants, trees, algae, marine organisms, microorganisms, animals, etc.

[SOURCE: EN 16575:2014]

3.25
bio-based carbon
biogenic carbon
carbon derived from biomass

Note 1 to entry: Biogenic carbon is defined in EN ISO 14067:2018, by the same definition.

[SOURCE: EN 16575:2014, 2.2 – modified. Note 1 to entry updated]

3.26
photosynthetic conversion efficiency
η
ratio between energy content of algae biomass and energy inputs to phototrophic algae cultivation

Note 1 to entry: The photosynthetic efficiency is the fraction of light energy (photons) converted into algae chemical energy during phototrophic algae cultivation. The ratio between energy content of the grown algae biomass and energy needed to cultivate them is the efficiency.

4 Measurement for renewable algal raw material

4.1 General

4.1.1 General

The measurement for renewable algal raw material can be carried out by means of the “Green Box” approach [1], see Figure 1. It describes the industry’s environmental, economic, and carbon footprint via quantifying the inputs and outputs of an algae growth site. These input/output measurements systematically allow for economic projections (through techno-economic analyses) and sustainability calculations (through life cycle assessments).

4.1.2 Green box inputs and outputs

Inputs may include the carbon, water, energy, and nutrients required by the algae, as well as land requirements, process consumables, and human resources required by the infrastructure. Green Box outputs include the different classes of algal products as well as industrial waste emissions including gas, liquid, and solid discharges.

Together, the measured inputs and outputs generically carve out the total economic and environmental footprint of any algal operation. Identifying this total footprint is central in the technical and

sustainability review of an expanding algae industry. For sample treatment of algae and algae products see EN 17605.

Figure 1 — Green box for the measurement of renewable algal raw material

4.1.3 Green box boundaries

The boundaries for algae production are limited by the Green Box approach where it accounts for one year production or other relevant operative time in natural sites, open land-based cultivation, and closed cultivation.

These production pathways need to be separately considered as in natural sites, water, carbon, nutrients inputs and energy, gas and liquid emissions are not measured. In open land-based cultivation, liquid streams in not-controlled flow are present (leakage from unlined ponds, spreading in agriculture, etc.) which cannot be measured. In closed cultivation all mass flow is controlled and can be measured except CO_2 and O_2 release/absorption from atmosphere. In the same way, all other non-controlled gas exchange (diffusion) from algae to atmosphere can happen and is neglected (e.g. ammonia release, etc.).

Examples of the processes are shown in Figure 2, Figure 3 and Figure 4.

In all the cases, infrastructure (e.g. facility capex and component materials) shall be considered (see EN ISO 14064-1). Infrastructure can be referred to as its amortization figures (e.g. measured in €/(time∗kg) units and component materials weight divided by life time.

When there are other bio-products as outputs or associated energy production, system can be subdivided or expanded to include the additional impacts related to the co-products or allocation concept should be considered (EN ISO 14044). The environmental impact can be allocated to the products (outputs of the Green Box) by weight, energy, or economic value.

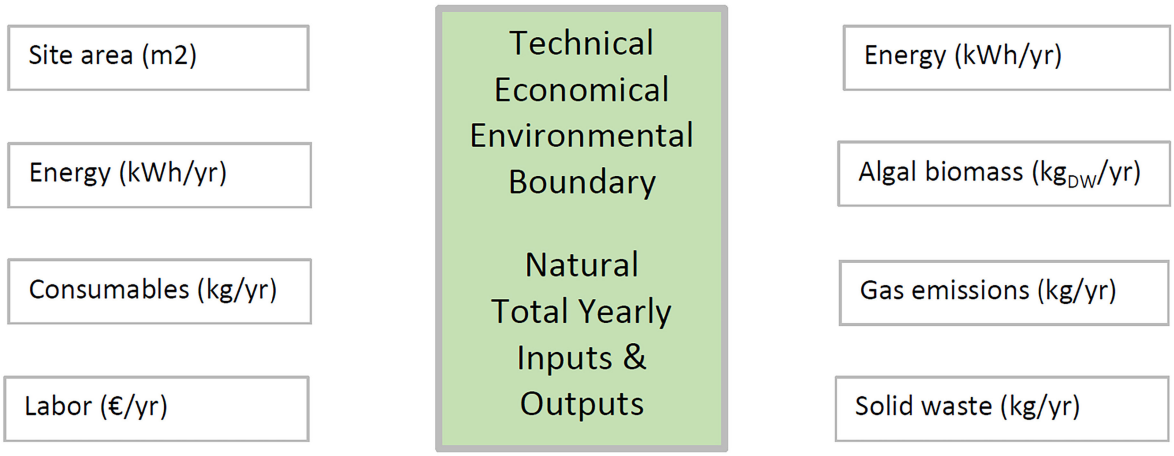

Figure 2 — Green box boundaries for natural sites