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DATA NOTE

Benchmarking CO_2 emissions and wastewater as feedstocks in biological processes

[version 1; peer review: awaiting peer review]

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Abstract

Rapid population growth, industrialization, and increasing energy demands have intensified environmental challenges, driven by raising wastewater and exhaust gas discharge. Along with fossil fuel depletion, more pressing energy needs have widely accelerated research into renewable energy sources, as well as diverse waste-to-value strategies, converting waste streams into biofuels, energy and commodity chemicals. Several approaches such as carbon capture and utilization (CCU), carbon capture and storage (CCS) and wastewater reuse are gaining meaningful attention to prompt carbon emission reduction and circular economy benefit. However, information available in literature about these sources is dispersed, and a dataset detailing the composition of these feedstocks is lacking, despite its potential to optimize bioprocesses such as gas fermentation, microbial electrosynthesis or microalgae cultivation.

A dataset comprising distinct feedstock composition analyses is presented. The feedstocks are categorised into gaseous and liquid effluents and further classified according to the industrial processes from which they originate. The dataset was compiled through a systematic review applied to relevant articles published between the years 1990 and 2025, sourced from the Science Direct database.

Plain language summary

In the present data note, the physicochemical characterization of liquid and gas waste streams from the most contaminating industries is provided, intending to judge their fitness as feedstock for biological processes. Key parameters within the whole dataset include pH, chemical oxygen demand (COD), biological oxygen demand (BOD),

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nutrients, heavy metals, and other contaminants and impurities. Gaseous streams encompass their composition and impurities. Through the provision of a detailed characterization for the industrial effluents, this dataset acts as a valuable resource for optimizing and for conceptualizing more sustainable

Keywords
Waste-to-value, industrial effluents, feedstock composition, carbon capture, wastewater reuse, circular economy, contaminants.



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Introduction

Rapid population growth, industrialization, and rising energy demands have further intensified ongoing environmental challenges, largely driven by the discharge of wastewater and exhaust gases. This trend, together with the gradual depletion of fossil fuels, is driving researchers' activity towards alternative and renewable energy sources, as well as strategies to reduce overall wastewater and gaseous emissions. Currently, one of the most attractive approaches in the industry 4.0 is the use of waste streams to produce valuable commodity chemicals and biofuels through bioconversion processes, commonly referred to as the *waste-to-value* concept. Innovative approaches such as carbon capture and utilization (CCU), carbon capture and storage (CCS) and wastewater (WW) reuse are gaining significant attention. CCUs allow the capture of carbon dioxide (CO_2) and its transformation into useful products, contributing to emission reduction and circular economy principle[1]. Meanwhile, the reuse of process water as biorefinery feedstock could be beneficial to prompt circular economy, improve overall energy efficiency of wastewater treatment processes and enhance freshwater resource management[2].

Several studies have focused on the reuse of wastewater and off-gas wastes to produce chemicals and value-added products, including biofuels such as biodiesel[3–6], bioethanol[7–9], biogas[10,11], and many more. Some of these technologies have reached a high development stage, among all, biogas production in anaerobic digestion[12]. However, further research needs to be applied to increase the sustainability of other industries to meet the 2050 goals of the EU Zero Pollution Action Plan (ZPAP) (EC, 2021).

In this context, ALGAESOL ("Sustainable aviation and shipping fuels from microalgae and direct solar BES technologies"; https://algaesol.eu/) is a publicly funded Horizon Europe project (GA No. 101147112), that aims to develop and evaluate innovative solutions for the sustainable conversion of sunlight into fuels. ALGAESOL advances the current state-of-the-art by creating and consolidating new value chains for shipping and aviation biofuels based on micro-algae and direct solar renewable microbial electrosynthesis technologies. To achieve sustainable fuels production, both waste gas and wastewater should be used as carbon source, mitigating emissions and enhancing circular economy.

As part of this initiative, the selection of appropriate feedstock for various bioprocesses is a critical factor in ensuring the project's success. Benchmarking feedstocks and analysing their characteristics supports the identification of the most suitable raw materials for efficient biofuel production. To facilitate data accessibility for the research community, the results of this benchmark analysis have been stored in the public repository ZENODO and made openly available. This paper, which accompanies the published datasets, provides comprehensive metadata to be used in supporting bioprocess design within the framework of Industry 4.0. It includes a detailed description of wastewater and gaseous effluents matrixes, along with potential contaminants.

Methodology

Data collection and selection criteria

The data for this study was obtained from research articles with a quartile ranking of Q1 or Q2 available on Scopus, SpringerLink and Wiley Online Library, as well as governmental/institutional reports found on official websites. A comprehensive search was conducted using keywords such as "CO_2 emissions," "wastewater treatment," and "environmental impact," with a focus mostly on articles published between 2010 and 2024. Additionally, governmental reports and institutional documents were consulted, available through official websites, to complement the scientific data Only peer-reviewed articles and reputable governmental reports were included to ensure the reliability and representativity of the data. The inclusion criteria prioritized peer-reviewed sources and reputable governmental reports, although some biases may arise from the availability of reports or articles from specific regions.

CO_2 emissions dataset

To collect data on off-gases rich in CO_2 emissions and their impurities, a bibliographical research approach was conducted as previously described. Scientific articles were gathered through three databases: Scopus, SpringerLink, and Wiley Online Library.

All references were analysed and filtered to extract relevant information on wastewater composition. After the search and eliminating duplicates, a total of 51 unique articles and governmental reports were processed. The dataset includes the typical CO_2 concentration, expressed in percentage, along with impurities such as sulphur oxide (SO_x), nitrogen oxides (NO_x), particulate matter, and heavy metals, which were reported where available in %, ppm, or mg/Nm^3 depending on the source.

The emission sources considered in this chapter include large stationary sources (>0,1 $MTCO_2$/year) involving fossil fuel and biomass use, primarily from fossil fuel and biomass combustion. The dataset provides detailed information on the composition of off-gases, as well as insights into the transport and industrial sectors contributing to these emissions.

Wastewater dataset

To collect data on the composition of different types of wastewaters, a bibliographical research approach was conducted as described in 1.1. All references were analysed and filtered to extract relevant information on wastewater composition. After the search and eliminating duplicates, a total of 256 unique articles were processed. The obtained database includes data on physicochemical indicators, such as pH, total suspended solids (TSS), total dissolved solids (TDS), volatile suspended solids (VSS), total solids (TS), volatile solids (VS), total organic carbon (TOC), chemical oxygen demand (COD_s and COD_t), biological oxygen demand (BOD_5), and the BOD/COD ratio. It also covers nutrient-related indicators, such as total Kjeldahl nitrogen (TKN), ammonium, total nitrogen, nitrate, nitrite, and total phosphorous, as well as inorganic components like hardness, chloride, sulphates, sulphides, sulphites, and metals. Additional measurements include phenol

content, oil and greases, alkalinity, conductivity, volatile fatty acids (VFA), and other reported characteristics. Each record is referenced to its original source article, ensuring traceability and credibility throughout the dataset.

CO_2 emissions benchmark

When including indirect energy emissions, the industrial sector becomes the largest CO_2 emitter. Major contributors to these emissions are cement, chemical and petrochemical manufacturing, iron and steel production, pulp and paper mills and refineries[13]. The largest CO_2 emissions result from the oxidation of carbon during fossil fuel combustion[14]. Additionally, CO_2 emissions unrelated to combustion are found in a variety of industrial processes that chemically, physically, or biologically transform materials[15].

Off-gases from industrial processes often contain more than just CO_2, making it essential to carefully evaluate the full range of emissions before they can be utilized as feedstock. These emissions can generally be divided into two sub-groups: CO_2-rich effluents and effluents with lower CO_2 concentrations.

The CO_2-rich effluents (~95% CO_2) can be directly used in a wide range of bioprocesses, including microbial electrosynthesis technologies, gas fermentation, or microalgae cultivation. On the other hand, the second group includes the rest of industrial emissions, such as those from cement production, refineries, or the iron and steel industries. These generally include more impurities that need to be carefully analysed and considered before their utilization[16,17]. In many cases, they might only be suitable for direct use with robust microorganisms such as some microalgae or certain types of bacteria[4,18].

This consideration is particularly important, as many CO_2-fixing microorganisms have strict anaerobic requirements and/or are sensitive to toxic compounds commonly found in industrial gaseous effluents[19]. This might pose the need for a carbon capture process or at least the removal of pollutants such as NO_x or SO_x. In the following paragraphs an overview of the most relevant CO_2-emitting industries is presented, grouped according to the origin of their emissions and detailing their typical composition.

Cement industry: The primary product of the cement industry is clinker, composed of calcium minerals, resulting from the thermal decomposition of limestone ($CaCO_3 \rightarrow CaO + CO_2$) in the kiln at approximately 1450 °C[20] and followed by chemical reactions of the resulting calcium oxide (CaO) with iron, aluminium, and silica to produce complex compounds such as silicates, aluminates, and ferrites[21]. This process generates large volumes of off-gas, primarily during the calcination step. Approximately two-thirds of the total CO_2 emissions from a cement plant originate from the raw material itself, mainly from the decomposition of limestone. The remaining one-third typically comes from the combustion of fossil fuels (coal, natural gas or petcock), which are used to achieve the high temperatures (~1450°C) necessary for calcination in the kiln[22]. The kiln off-gas generally contains CO_2 concentrations ranging from 8% to 33%, oxygen levels between 9% and 15,5%, and elevated concentrations of pollutants such as NO_x (up to 1900 ppm), SO_x (up to 2500 ppm), and CO (up to 2600 ppm)[23–27]. Another critical component is cement kiln dust (CKD). CKD is considered highly toxic and may contain compounds such as silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3)[28], as well as heavy metals like copper (Cu), manganese (Mn), molybdenum (Mo), and selenium (Se)[16,23,27] Additionally, the off-gas may contain other highly toxic substances, even at low concentrations, such as lead (Pb)[27], mercury (Hg)[28], nickel (Ni) and chlorine compounds (e.g., HCl) or ammonia (NH_3)[23,25,27]

Iron and steel industry: Steel is mostly produced by two routes: blast furnace-basic oxygen furnace (BF-BOF), with 70% share of steel world production and scrap-electric arc furnace (scrap-EAF), with 23% share. Being the blast furnace-basic oxygen furnace (BF-BOF), the biggest CO_2 emitter (2.0–2.2 tCO_2/t_{HM})[29].

Before the blast furnace, two crucial preparatory processes are required: coal coking and iron ore agglomeration. In the coking step, coal is converted into coke in coke ovens. Simultaneously, fine iron ores are processed into agglomerated forms such as sinter to ensure efficient reduction in the blast furnace. These two processes generate different gaseous effluents. Coke oven gas contains 3–27% CO_2, along with high concentrations of methane (22–31.5%) and hydrogen (54–62.8%). Depending on the combustion degree and the possible presence of sulphur small amounts of carbon monoxide (CO), oxygen (O_2), and nitrogen oxides (NO_x) and sulphur oxides (SO_x) may also be present[18,30–39]. Meanwhile, sintering generates a more diluted off-gas with 5–10% CO_2 and low concentrations of impurities[35,38].

Continuously, the blast furnace transforms the inputs from the coking and sintering processes into molten iron, generating gas effluents mostly composed of nitrogen coming from air (50–70%) and CO_2 (20–30%) coming from the reduction of hematite and the combustion of coke. Additionally, a 20–30% of CO might also be released as well as low levels of SO_x, NO_x, dust dioxins and heavy metals[18,34,38,40–44]. Finally, to produce steel from the molten pig iron, the basic oxygen furnace (BOF) is used, generating an off-gas mostly composed of CO (55–80%), lower concentration of CO_2 (10–20%) and almost no oxygen or nitrogen[18,34,38,40–46].

Refineries and petrochemical industries: Refineries and petrochemical industries are significant contributors to global CO_2 emissions due to the complex nature of their processes, which involve multiple stages of fuel processing, cracking, and chemical reactions[47]. These industries release CO_2 during various operations, particularly in the refining of crude oil and the production of petrochemical feedstocks such as ethylene, propylene, and benzene. Within a refinery, the major sources of CO_2 are the furnaces, boilers, and utilities, which burn fossil fuels to provide heat for refining processes and generate electricity and steam whose emissions depends mostly

on the fuel used. Another significant contributor is the Fluid Catalytic Cracker (FCC), that breaks down heavy hydrocarbons into lighter products that generate a gaseous effluent with a moderate-low concentration of CO_2 (8–15%), moderate to high concentrations of SO_x (200–15000 ppm) and NO_x (90–300 ppm), generated during the combustion process[48–51].

Chemical industries: Two of the most CO_2 emitter chemical products are ammonia, which is generally used as fertilizer and methanol, used as a fuel and chemical building block. The CO_2 emissions in these industries mostly occur during the hydrogen production step, which generally utilizes a steam methane reformer (SMR) powered by coal or natural gas[52]. This units normally generate a gas effluent low in CO_2 content between (10–15%)[53,54], This stream is further purified utilizing carbon capture technologies such as amine scrubbing, pressure swing adsorption (PSA), or membrane separation. Generating two effluents, one rich in hydrogen and one rich in CO_2. The effluent is very rich in CO_2 (40–100%) with values varying according to the adsorption method, being amine scrubbing and solvent extraction the most effective methods[51,55–59]. In case PSA is used, possible impurities could be present such as hydrogen and methane as the extraction is not as effective. In the case of ammonia production, part of the CO_2 could be further used in urea synthesis which might limit its availability and amount to be used as feedstock[52].

Paper, board and pulp industry: Chemical pulping based on the Kraft process is the main pulp production process and emits significantly more CO_2 than mechanical pulping (European IPPC Bureau, 2015). The CO_2 emissions from a modern Kraft pulp mill are originated from three specific sources: the recovery boiler, the lime kiln and the multi-fuel boiler. The recovery boiler utilizes the black liquor coming from the pulping process to recover chemicals such as sodium carbonate. The burning process of the black liquor generates a flue gas containing 10–13% CO_2, nitrogen, low oxygen, and trace levels of NO_x (55–300 ppm) and SO_x (up to 500 ppm) due to incomplete combustion and sulphur compounds[34,50,60–62]. The power boiler, although using different fuels, produces a similar off-gas composition with comparable concentrations of CO_2, NO_x, and SO_x[34,61–63]. The lime kiln emits an off gas with a similar composition than that of the cement industry, with high CO_2 concentrations up to 25% and variable concentrations of NO_x and SO_x and variable amounts of NO_x and SO_x depending on the fuel and raw materials used[34,61,62,64].

Fermentation and biogas production industries: Fermentation and biogas production industries include all industries where biological agents are present and contribute to the off gas via fermentation or anaerobic digestion. This includes breweries, wineries, pharmaceutical and food companies and biogas units. The purity of its gaseous effluents makes them ideal candidates for carbon capture and utilization (CCU) technologies. In breweries, wine cellars, and bioethanol production plants, the gaseous effluents are often highly pure, with concentrations of CO_2 approaching a 100 %, primarily due to cellular respiration during fermentation processes[65–67]. Another process that generates rich in CO_2 gaseous effluents is anaerobic digestion, which produces biogas, a mixture generally composed of 30–50% CO_2, 50–70% CH_4, and traces of hydrogen sulphide and ammonia[68–70].

Wastewater benchmark

The composition of the wastewater heavily impacts its usability as feedstock for bioprocesses, as it directly influences microorganisms activity, conversion efficiency and overall process stability[71–73]. Wastewater composition varies widely depending on its industrial source and specific processes[74]. For wastewater to serve as a feedstock in conventional fermentation processes, cultivation of heterotrophic/mixotrophic microalgae, anaerobic digestion or as an anolyte in microbial electrosynthesis (MES) technologies, careful consideration must be given to its organic content—measured by chemical oxygen demand (COD) and biochemical oxygen demand (BOD)—as well as its nutrient composition. Key nutrients include nitrogen (in the form of urea, ammonia, nitrates, and nitrites), phosphorus (as phosphate), and sulphur (as sulphate)[75].

Agro-industrial wastewater

Agro-industrial wastewater is notably a source of valuable feedstocks for bioprocesses[76,77]. Despite the wide range of variability within these industries, these wastewaters generally have high levels of COD and BOD, close to neutral pH (depending on the process phase) and high content of nitrogen and phosphorous making them suitable for a wide range of bioprocesses from mixotrophic/heterotrophic microalgae cultivation, yeast, fungi or microbial fermentations or as an anolyte in MES. The agro-industry includes various sectors that transform raw materials into consumable products. This includes seafood (fish and shellfish), meat production (slaughtering and processing), cereals and grains (rice, starch), sugar and confectionery (chocolate, molasses), dairy (yogurt, cheese, butter), alcoholic beverages (wine, beer), and non-alcoholic drinks (soft drinks, juices).

- **Animal-based industries**

Animal-based industries involve the raising and processing of animals for food or animal feed. In the case of meat and seafood, this includes the slaughtering of animals, while dairy processing focuses on collecting and processing milk from livestock.

Meat, seafood, and manure wastewater: Effluents from these industries (Table 1) typically have a neutral pH ranging between 6 and 7, a high organic content primarily composed of complex proteins, blood, and fats, and a moderate biodegradability, with a COD/BOD_5 ratio between 0,5 and 0,6. These effluents also contain high concentrations of organic phosphorus and nitrogen, primarily from ammonia, proteins, and amino acids[78]. In contrast, shellfish industries typically generate effluents with lower concentrations of these nutrients. This, together with the high content in organic matter, could support the growth of biomass in biorefinery processes[79,80]. Special attention needs to be paid to the salinity of seafood

Table 1. Physicochemical characteristics of animal-based industries wastewaters: seafood processing wastewater, slaughterhouse wastewater, manure wastewater (after solid-liquid separation) and dairy wastewater.

	pH	TSS (mg/L)	BOD/COD	TN (mg/L)	EC (mS/cm)	TP (mg/L)	References
Seafood processing wastewater	6.77 ± 0.48	1412 ± 1731	0.50 ± 0.16	63 ± 12	-	66 ± 66	81–109
Slaughterhouse wastewater	7.10 ± 0.59	3733 ± 6585	0.46 ± 0.17	538 ± 586	-	152 ± 445	110–138
Manure wastewater (after solid-liquid separation)	7.50 ± 0.50	9467 ± 10746	-	-	10.7 ± 7.0	398 ± 309	139–144
Dairy Wastewater	6.14 ± 2.00	13057 ± 14186	0.63 ± 0.32	1159 ± 1016	5.5 ± 4.6	501 ± 1046	145–175

effluent, since due to the nature of the process sometimes sea water is utilized.

Dairy industry wastewater: Effluents from dairy processing can vary in pH, with cheese and cheese whey typically producing slightly acidic effluents, while butter production generates more alkaline effluents due to the use of alkaline substances (Table 1). Effluents from dairy processing generally have a lower organic content, primarily composed of lactose, proteins, and fats with a higher biodegradability than meat, seafood and manure, except for cheese whey, which is the most abundant dairy effluent and has a typical COD of 43 g/L. These effluents also contain high concentrations of organic phosphorus and nitrogen, primarily from ammonia, proteins, and amino acids.

- **Plant-based industries**

Plant-Based industries include a broad range of sectors that utilize raw materials derived from agriculture. These can be further subdivided into three main categories: beverage industries, confectionery and cereal processing, and oil refining. The wastewaters from these sectors share many similarities with those from animal-based industries, with some notable exceptions and special cases.

Oils and fats wastewaters: Palm oil mill effluents and olive oil mill wastewater share lots of similarities, having a slightly acidic pH and being both rich in COD, TSS as well as nitrogen and phosphorous and with a low biodegradability (Table 2). Especially in the case of olive oil mill wastewater the high presence of polyphenols with typical concentrations around 5 g/L, pectin and inorganic salts such as magnesium, potassium or phosphate make it non feasible as a feedstock unless pretreated by an alkaline-oxidative procedure[176,177].

Grains, starches, sugars and confectionery processing wastewaters: Sugar/confectionery, grains and starch processing industries generate wastewater that is typically high in solids, rich in carbohydrates and sugars, resulting in high COD and BOD levels and high biodegradability (Table 2). Thus, it is also considered as a commendable feedstock to produce bio-products through fermentation or other biological pathways. However, when used for cultivating certain species of microalgae in starch-rich wastewater, prior hydrolysis of the starch or co-cultivation with starch-degrading microorganisms may be necessary to degrade starch into simple sugars[178].

Beverage's production wastewaters: These include non-alcoholic and alcoholic beverages effluents (Table 2). Both types of wastewaters are typically non-toxic and viable as feedstocks. It is high in COD and BOD as well as moderate-high biodegradability due to the high presence of sugars and organic acids. Alcoholic beverages also contribute ethanol to the wastewater composition.

Heavy industry and other manufacturing processes wastewater

Heavy /manufacturing industry wastewater can be a viable feedstock for various biorefinery processes, depending on their composition, production process and treatment. Special attention needs to be paid to organic and inorganic contaminants, including metals, oils, chemical compounds and other industrial byproducts. Most of these sectors are unable to be used as feedstock due to the beforementioned presence of contaminants. Three sectors that generate particularly high levels of

Table 2. Plant-based industries wastewaters. OMW: olive mill wastewater, RMW: rice mill wastewater, FJW: fruit juice wastewater, WDW: wine distillery wastewater, BWW: brewery wastewater, SDW: soft drink wastewater, MWW: molasses wastewater, SIW: sugar industry wastewater, POME: palm oil mill effluent, CIW: chocolate industry wastewater, SPIW: starch processing industry wastewater.

	pH	TSS (mg/L)	BOD/COD	TN (mg/L)	EC (mS/cm)	TP (mg/L)	References
OMW	5.10 ± 0.50	23758 ± 24484	0.31 ± 0.20	350.75 ± 297.41	6.1 ± 4.1	697 ± 593	179–194
RMW	5.77 ± 1.45	8370 ± 14040	0.57 ± 0.30	-	4.9 ± 5.9	22 ± 11	195–203
FJW	4.74 ± 1.40	1617 ± 1650	0.50 ± 0.20	-	0.7 ± 0.3	-	204–210
WDW	5.50 ± 1.40	2428 ± 3205	0.49 ± 0.20	43.38 ± 32.94	3.9 ± 1.5	27 ± 32	211–230
BWW	6.60 ± 2.50	867 ± 589	0.57 ± 0.10	179.56 ± 173.75	2.6 ± 0.3	24 ± 29	231–246
SDW	7.30 ± 2.00	-	0.31 ± 0.30	-	1.5 ± 1.2	-	247–250
MWW	8.20 ± 0.70	1294 ± 1528	-	-	-	-	251–255
SIW	6.52 ± 1.17	404 ± 223	-	201.86 ± 293.49	4.1 ± 2.7	25 ± 45	256–264
POME	4.70 ± 0.30	32491± 11561	0.41 ± 0.24	1754.75 ± 1433.55	-	-	265–275
CIW	5.20 ± 1.00	865 ± 753	-	-	-	80 ± 84	276–279
SPIW	5.20 ± 1.62	3598 ± 2540	-	-		2166 ± 3384	280–287

pollution and are not suitable to be used as feedstocks in biorefinery: tannery, refinery and chemical/pharmaceutical industries. Tanneries and refineries produce effluents with extremely high salinity levels (up to 17910 mg/L with tannery WW[288]) and recalcitrant compounds, including sulphide and sulphate (up to 662 mg/L with tannery WW[288]) and heavy metals. Within the heavy metals, special attention must be given to the presence of cadmium (up to 1,47 mg/L in refinery WW[289]), arsenic (up to 1,92 mg/L in refinery WW[289]), mercury (up to 2,50 mg/L in refinery WW[290]) and chromium (up to 570 mg/L[291]), which are highly toxic for most microorganisms even at low concentrations[292–295]. On the other hand, in the case of pharmaceutical and chemical wastewaters, it is possible to observe high heterogeneity depending on the process operated. However, these WW are typically complex with low organic content and may contain toxic organic compounds, inorganic salts, and pharmaceutical active compounds such as antibiotics[296]. Although, some microorganisms like microalgae could successfully go through bioremediation processes and, as a result of a secondary process, obtain valuable products[71,72]. Other industrial processes, such as pulp and paper mill WW and textile WW, might be good candidates to be used as feedstock in bioprocessing. These two wastewaters generally do not present highly toxic or limiting compounds, have a low content of suspended solids and a not too low biodegradability (20–30%). However, the presence of chlorine agents for bleaching in the case of the pulp and paper industry as well as the presence of certain dyes in textile wastewater might inhibit the growth of certain microorganisms[297].

Ethical approval and consent

Ethical approval and consent were not required.

Data availability

Underlying data

The two complete datasets are available in ALGAESOL's project Zenodo repository: Benchmarking CO2 emissions and wastewater as feedstocks in biological processes - DATA SET https://doi.org/10.5281/zenodo.17494756[298].

This project contains the following underlying data:

- **WW_Database** contains an excel all the wastewaters characterizations, including the reference where the information was extracted.
- **CO2_Database** contains in excel format all the gaseous effluent characterizations, including the reference where the information was extracted from.

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

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