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Importance of process design on carbon footprint from drinking water treatment by enhanced coagulation-filtration

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ABSTRACT

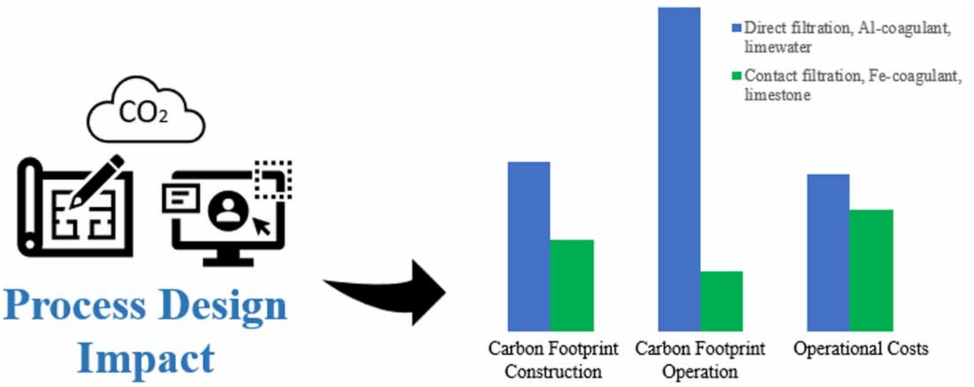
There are several process design options for enhanced coagulation-filtration in drinking water treatment plants (DWTPs). This study compares the carbon footprint and economic impact of two common process designs based on enhanced coagulation-filtration with pH, Ca, and alkalinity adjustment for corrosion control. The process designs are direct filtration (DF) using Al coagulant with limewater (DF-Al) and contact filtration (CF) using Fe coagulant with alkaline filter layers (CF-Fe). The operational data are retrieved from full-scale DWTPs. The results show that the carbon footprint from operations is five times larger for the DF-Al compared to the CF-Fe. Operational costs covering chemicals and energy are almost 30% higher for the DF-Al. Simplified material intensity estimations for the construction phase show that the carbon footprint and investment cost increase with increasing process area, which are larger for the DF-Al. Therefore, to reduce environmental impacts and costs, the design of drinking water treatment processes should be carefully considered even for very similar processes. The results should motivate both water professionals and decision-makers to include a carbon footprint evaluation as a routine step in the DWTP selection and design phases.

Key words: carbon footprint, coagulation-filtration, drinking water treatment, enhanced coagulation, NOM removal, process design

HIGHLIGHTS

- It is important to include carbon footprint estimation in the early process design phase.
- Similar treatment processes can have huge differences in carbon footprints.
- The carbon footprint and costs can be significantly reduced by the proper design of similar treatment processes.
- When selecting water treatment chemicals, their carbon footprints should be considered.

GRAPHICAL ABSTRACT



INTRODUCTION

Drinking water suppliers must meet increasing demand, stricter quality regulations, and additional challenges due to climate change. Better knowledge of the impacts of pollutants on human health has led to more stringent drinking water quality standards. Improved drinking water quality, treatment, and capacity often result in higher costs, increased resource consumption, and a greater environmental impact (Venkatesh & Brattebø 2012; Ribera *et al.* 2014; Molinos-Senante *et al.* 2022). Climate change is a growing challenge for the water sector. More extreme weather, drought, floods, longer growing seasons, increased temperatures, and intense precipitation affect raw water quality. Decreased raw water quality in turn results in reduced production capacity and increases the resources needed for water treatment (Eikebrokk *et al.* 2004; Delpla *et al.* 2009; Ritson *et al.* 2014; Moona *et al.* 2018; Herrador *et al.* 2021). Thus, climate change is linked to increased environmental emissions, and the water sector needs to minimize its own environmental emissions.

Enhanced coagulation-filtration processes, combined with pH, calcium (Ca), and alkalinity adjustment for corrosion control, UV disinfection, and/or chlorine disinfection, are widely used for natural organic matter (NOM) removal in drinking water treatment. Despite the development of novel technologies for NOM removal, coagulation-filtration is still one of the most common technologies. This process has proved to be efficient at removing NOM and it is relatively inexpensive.

Enhanced coagulation, using elevated coagulant doses and strict pH control, targets NOM removal, whereas conventional coagulation targets primarily turbidity removal. Options for enhanced coagulation processes include:

- **Direct filtration**, where a flocculation basin is utilized prior to filtration.
- **Contact filtration**, where coagulated raw water is led directly to the filters.
- **Conventional filtration**, where coagulation, flocculation, and sedimentation take place prior to filtration.

Direct and contact filtration (CF) processes are widely used for raw waters with low turbidity and low-to-moderate NOM levels. Their footprint is much smaller than that of conventional filtration, which requires large sedimentation basins. Therefore, conventional filtration often has a footprint several times larger than that associated with direct or CF plants.

The environmental impact on the life cycle of a water treatment plant includes construction and operation, as well as demolition and disposal of the plant at the end of its lifetime. Several authors have estimated that the operation phase accounts for 80% or more of the total environmental emissions, while construction accounts for 4–15% of the emissions during the plant's lifetime (Muñoz & Fernández-Alba 2008; Bonton *et al.* 2012; Choe *et al.* 2013; Igos *et al.* 2014; Amini *et al.* 2015; Roth *et al.* 2022). Igos *et al.* (2014) conclude that the overall environmental impact of a water treatment plant is driven by the consumption of fossil resources mainly related to energy production. When taking into consideration that energy consumption is linked to all value chains at a water treatment plant such as constructing the plant, pumping, operating treatment processes, manufacturing chemicals, and transporting materials to the site, there is great potential in reducing environmental emissions by choosing low-emission energy whenever possible (Biswas & Yek 2016; Zib *et al.* 2021; Cruz-Perez *et al.* 2022). Hofs *et al.* (2022) have investigated a future scenario for a new DWTP taking into account the EU goals for lower emissions for future energy production for plants with a lifetime of 50 years. The results suggested that when emissions from energy production are minimized, the environmental emissions from the construction phase can exceed 50% of the total emissions.

Manufacturing coagulants and pH-adjusting chemicals also have a large environmental impact on coagulation-filtration processes (Jones *et al.* 2018). Most environmental emissions are derived during the operation phase, and therefore strategic process design including water treatment chemicals should be a priority effort in addition to optimization of operation performance for safety, environmental emissions, and cost efficiency.

This study aims to assess how treatment process design, including the water treatment chemicals, affects the carbon footprint. Both the direct filtration (DF) and contact filtration (CF) processes compared in this study use the same basic technology, enhanced coagulation-filtration. The objectives of this study are to (1) compare carbon footprints (CO_2-eq) originating from the construction phase, (2) calculate carbon footprints (CO_2-eq) originating from resource consumption during the operational phase, and (3) identify key opportunities to reduce carbon footprint and costs.

METHOD

Figure 1 presents flow diagrams for the two enhanced coagulation-filtration process designs studied here:

1. DF using Al coagulant and limewater (DF-Al)
2. CF using Fe coagulant and alkalizing limestone filter layers (CF-Fe)

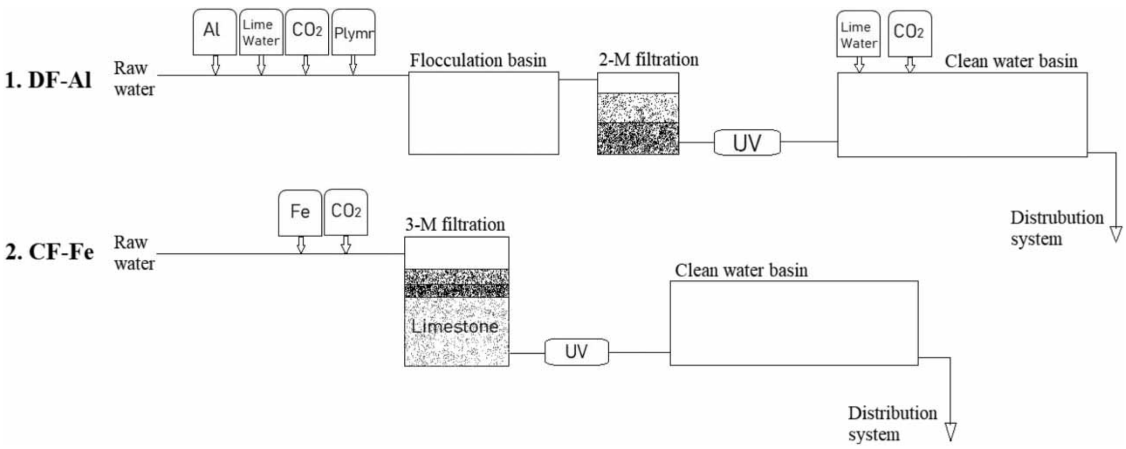


Figure 1 | Flow chart for (1) DF-Al direct filtration using Al coagulant and limewater and (2) CF-Fe contact filtration using Fe coagulant and alkalizing filters.

The DF-Al process is set up as coagulation with an aluminium coagulant (Al), flocculation, and filtration followed by pH, Ca, and alkalinity adjustment with limewater for corrosion control. The CF-Fe process combines coagulation with an iron coagulant (Fe), filtration, and pH, Ca, and alkalinity adjustment in one filtration step using alkalizing limestone filter media as the bottom filter layer. This makes the process footprint smaller even though the filter bed is deeper than in conventional filters. Raw waters in Norway are mostly soft (low alkalinity and pH) surface water with low turbidity and low-to-moderate NOM levels, making enhanced coagulation-filtration the most applied drinking water treatment process (Eikebrokk 1999). DF and CF processes supply over 40% of the produced water in Norway with over 170 drinking water treatment plants (DWTPs). Both DF-Al and CF-Fe are widely used in Norway (Norwegian Institute of Public Health 2022).

The DF process includes a flocculation basin before the dual media filtration (2-M) stage. The dual media filters apply expanded clay (Filtralite) or anthracite and quartz sand as filter media. Al coagulation requires pH control to ensure optimal coagulation and an additional pH and alkalinity adjustment step for treated water for corrosion control (increase pH, Ca, and alkalinity). Limewater and CO_2 are used for the final pH and alkalinity adjustment in a clean water basin.

The CF process with integrated corrosion control is more compact, where NOM removal and corrosion control are performed in one filtration step. This process applies Fe-based coagulation and three media (3-M) filters using expanded clay (Filtralite) or anthracite, quartz sand, and limestone as the bottom filter layer.

In this study, both process alternatives are scaled to treat the same raw water quality and to meet the same finished water quality at the local conditions in Bergen, Norway (Table 1). Plant engineering design is retrieved from

Table 1 | Average raw water and treated drinking water qualities

	Raw water	Treated water	
Color	35	<5	mg Pt/l
Turbidity	0.8	0.1	FNU
UV-absorbance	0.154	0.025	/1 cm
DOC	3.4	<2	mg/l
pH	6.2	8	
Alkalinity	<0.1	0.7	mmol/l
Calcium	<2	15–25	mg/l

existing DWTPs and scaled to the same production capacity. To simplify very detailed and case-specific environmental emission estimations, the volume of concrete for the main civil structure is used as a proxy indicator of resource intensity during the construction phase (Foley *et al.* 2010). Because both enhanced coagulation-filtration processes compared in this study have similar building and treatment components, it is assumed that a fair comparison can be made between the two process design alternatives.

System boundaries are determined by the raw water intake and finished water quality. Both plants use UV for disinfection, and this process is not included in the evaluation. The operational data for this study are obtained from full-scale treatment plants in Norway operating at optimum or close to optimum conditions. As the plants have somewhat different sizes, the operational parameters used in this study are adjusted to model the water production of 80,000 m^3/day over a plant lifetime of 30 years. The operational data cover the chemical and energy inputs. The contribution of filter media production is found to be negligible and therefore not included (Jones *et al.* 2018). The waste generated during enhanced coagulation is mainly originating from the water treatment chemicals. The sludge production rate from coagulation can be estimated from the following equation.

$$SS_{SP}(\text{mg/l}) = SS_{RW} + k * \text{Dose} \quad (1)$$

where SS_{SP} is the sludge production rate (mg/l), SS_{RW} represents suspended solids in raw water (mg/l), dose is the coagulant dose in mg Al/l or mg Fe/l, and $k = 4.2$ for aluminium-based and 2.5 for iron-based coagulants (Eikebrokk *et al.* 2006).

Typically, suspended solids (SS) in Norwegian raw waters are very low, often below 1 mg SS/l. For this study, the raw water is the same quality for both process alternatives, and therefore SS_{RW} is set to zero. The applied coagulant doses for the DF-Al (2.4 mg Al/l) and CF-Fe (4.0 mg Fe/l) process alternative both give a sludge production rate of 10 mg SS/l. Thus, the wastes generated in both processes are very similar and waste generation rates are therefore excluded from subsequent carbon footprint assessments.

RESULTS AND DISCUSSION

Construction phase

The construction of a water treatment facility requires resources such as capital, land area, building materials, treatment components, transport of materials, and energy/power supply. The carbon footprint and financial costs are unique to each facility, depending on raw water quality, selected process design, location, climate, terrain excavation, access for building and treatment materials, production, transport of materials to and from the site, etc. The carbon footprint and investment costs for the construction phase are related to resource intensity, which in turn increases with increasing facility size.

In this study, the process footprints and volumes needed were calculated based on the engineering design of the two plants. These values are used to estimate the concrete volumes required for the main civil structures (Table 2).

Table 2 | Process footprints, process volumes, and volumes of concrete for the main civil structures

	Process area footprint (m^2)	Process volume (m^3)	Volume of concrete (m^3)	Comments
(1) DF-Al				
Flocculation	350	1,750	443	Flocculation basin depth 5 m
Filtration 2-M	500	1,600	424	Filter basin depth 3 m
Total	850	3,350	867	
(2) CF-Fe				
Filtration 3-M	500	2,535	620	Filter basin depth 5 m
Total	500	2,535	620	

As shown in Table 2, the process footprint for the DF-Al was estimated to be 70% larger than for the CF-Fe. The space required for flocculation (DF-Al) is responsible for 40% of the DF-Al process footprint. A larger process footprint requires a larger building and more land, thus increasing both the costs and resource intensity for the construction. The volume of concrete for the main civil structure for the DF-Al is 40% larger than that required for the CF-Fe. The volume of concrete for the main civil structure can be used as a multiplier to estimate the required quantities of other building materials. Calculations based on these volumes show that the process footprint is 70% higher and the emissions are 40% higher for the for DF-Al process alternative.

Operational phase

Water treatment chemicals

There are large differences in CO_2 emissions for the manufacturing of different water treatment chemicals. Figure 2 shows the environmental emissions as CO_2-eq for manufacturing several common water treatment chemicals. Thus, the choice of chemicals has a major impact on the carbon footprint for water treatment, especially for water treatment plants that use chemicals for coagulation and corrosion control (Barrios *et al.* 2008; Bonton *et al.* 2012; Jones *et al.* 2018). Fe coagulants often have significantly lower CO_2 emissions compared to Al coagulants. Emissions from manufacturing Fe coagulants range from 29 to 395 kg CO_2-eq per ton, whereas Al coagulants range from 148 to 537 kg CO_2-eq per ton. This difference is a result of the raw materials used (virgin mineral or by-product), the type of processing needed during manufacturing, and the transport of the raw material to the production site (INCOPA 2014). An example of using by-products for coagulant manufacturing is ferrous (II) sulfate $Fe(SO)_4$, a by-product of titanium oxide production. Ferrous (II) sulfate can be utilized as such in wastewater treatment or can be utilized as a raw material for the production of several Fe coagulants, such as ferric sulfate and iron chloride sulfate. The production sites for such Fe coagulants are often located onsite or near titanium oxide production to minimize environmental emissions from the transport of raw materials (INCOPA 2014).

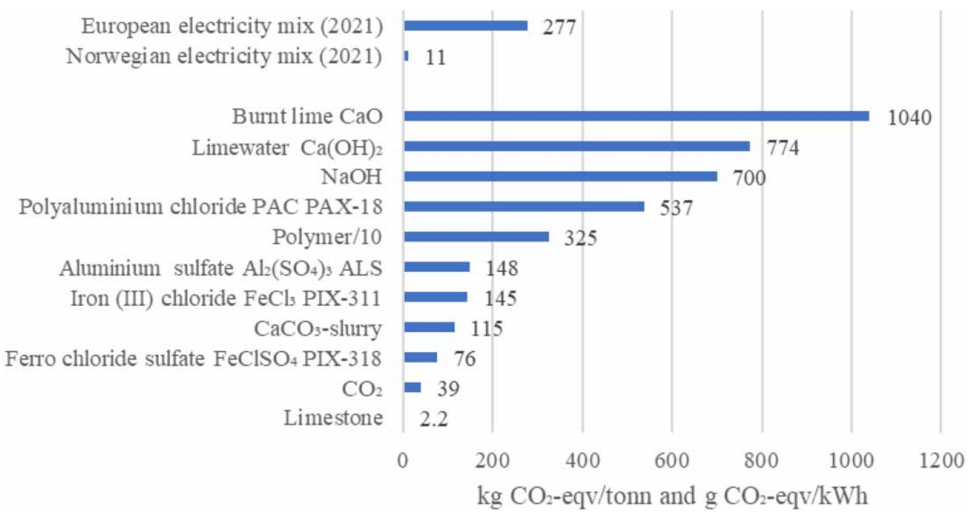


Figure 2 | Environmental emissions as CO_2 equivalents for energy and different water treatment chemicals (EuLA 2014; INCOPA 2014; European Environmental Agency 2019, 2022; Franzefoss Minerals AS 2021, 2023a, 2023b; Braun *et al.* 2022; NVE 2022).

Calcium oxide (CaO) is a water treatment chemical that is commonly used despite the very large CO_2 emissions. This chemical can be either slaked at the plant or purchased as liquid calcium hydroxide slurry, commonly known as limewater. Calcium oxide production starts with quarrying and crushing limestone and transporting it to a manufacturing site. Limestone is burnt in a lime kiln where thermal decomposition takes place. Thermal decomposition breaks limestone down into calcium oxide and carbon dioxide. Production of calcium oxide produces CO_2 in two ways: energy used for heating the lime kiln for thermal decomposition and the CO_2 released from the chemical decomposition of limestone. Thermal decomposition is a very energy-demanding process, and CO_2 emissions for calcium oxide production are typically 950–1,200 kg CO_2-eq per ton product (EuLA 2014; European Environmental Agency 2019).

The production of crushed limestone is a much less intensive process. After quarrying limestone, the mineral is crushed to the desired grain size (1–3 mm) to be utilized as an alkalizing filter media. The CO_2 emissions for crushed limestone are low, only around 3 kg CO_2-eq per ton product (Kittipongvises 2017; Franzefoss Minerals 2021).

Corrosion control with crushed limestone, limewater, or slaked lime requires the addition of CO_2. When using crushed limestone, one mole of CO_2 is needed to release one mole of Ca^{2+} and two moles of bicarbonate, whereas, with limewater, two moles of CO_2 are needed to achieve the same effect. Stoichiometrically, limewater binds two times more carbon dioxide per mole than crushed limestone. For raw waters with a low free CO_2 concentration, the CO_2 addition required is twice as high for limewater than for crushed limestone. On the other hand, raw waters with a high concentration of free CO_2 do not always require the addition of CO_2 when using limestone-based products.

Preparation of limewater at the DF-Al water treatment plants requires additional investments and process area. This includes powder storage and several saturators for preparing the lime solution and removing impurities. Limewater can contain up to 20% solid impurities, which must be removed before use to ensure proper quality of the limewater. Impurities are usually discharged to the sewer through the bottom drainage of the saturation unit. Limewater requires mixing and settles easily. Careful design and operation as well as regular maintenance are needed both in the preparation of limewater and to avoid clogging of the limewater pumps. Hydrated lime and burnt lime, especially in powder form, require special attention from operators and designers of the lime preparation unit as these chemicals can cause skin irritation, skin burns, eye damage, and respiratory irritation.

At the CF-Fe water treatment plants, crushed limestone is added to the filters before backwashing. Limestone is stored and added to the filters either in a silo with a water ejector system or by lifting it into the filters in 1,000 kg bags with an overhead crane built above the filters. Limestone is not hazardous to work with and requires very little operation and attention from operators. When limestone is loaded into a silo with trucks, the limestone generates some dust, so appropriate safety equipment should be used.

Backwashing filters with limestone filter layers will always yield to small loss of fine limestone particles, thereby increasing pH, alkalinity, and calcium levels in spent backwash water and in the sludge.

Another group of chemicals used to improve flocculation and filtration performance in water treatment is synthetic polymers. CO_2 emissions for synthetic polymers are estimated to be 3,250 kg CO_2-eq per ton product (Braun *et al.* 2022). These polymers are usually manufactured from raw oil in a process with high energy demand. The amount of polymer used in water treatment is small compared to other chemicals, and although the emissions per ton are substantial, the CO_2 emissions from polymer use are relatively low per unit of treated water.

Carbon footprints

Water treatment with DF-Al and CF-Fe requires different types and quantities of chemicals. The chemical dose is dependent on the raw water quality, the process design, and the type and properties of the chemicals used. The specific chemical dose data retrieved from the full-scale DWTPs used for this study are presented in Table 3. The higher head loss generated at 3-M filters for the CF-Fe alternative results in higher energy demand. To make a fair comparison between the two alternatives, pumping of filter effluent water is therefore added to the CF-Fe alternative, resulting in higher energy consumption.

The carbon footprints derived from the operation phase are significantly different (Table 3, Figure 3). A comparison of carbon footprints shows that the CO_2 emissions from the DF-Al are almost six times larger than those from the CF-Fe process: 1,258 tons of CO_2-eq per year for DF-Al and 236 tons of CO_2-eq per year for CF-Fe. The largest CO_2 emissions arise from the manufacturing of the chemicals, where the biggest contributors are limewater and Al coagulant with 61 and 25% of the CO_2 emissions for the DF-Al alternative. CO_2 emissions from the transport of the chemicals are similar for both alternatives – 114 tons of CO_2-eq for DF-Al and 133 tons of CO_2-eq for CF-Fe.

CO_2 emissions originating from energy used at the treatment plant are similar for the two alternatives, i.e., 32- and 39-ton CO_2-eq for DF-Al and CF-Fe, respectively. The origin of energy in this study is Norwegian hydropower with low CO_2 emissions, but if, for example, a European energy mix is used, the carbon footprint connected to energy consumption would be 25 times higher (809 and 971-ton CO_2-eq for DF-Al and CF-Fe, respectively). Even though the CO_2 emission intensity of energy production has a large impact on the results, the treatment process design also has a great impact. Using the European energy mix, the DF-Al alternative has more than a 70% larger carbon footprint than CF-Fe – 850 tons CO_2-eq larger (Figure 3).

Table 3 | Annual chemical consumption and energy input needed for DWTP operation and their CO_2 emissions

Input	kg CO_2-eq./ton	Dose bulk chemical g/m³	Annual total Ton or kWh	Manufacturing chemicals CO_2-eq. tons	Transport of chemicals CO_2-eq. tons
(1) DF-Al					
PAX-18 (2.4 mg Al/l)	537	19.5	568	305	27
Limewater $Ca(OH)_2$	774	34	993	768	62
CO_2-gas	39	25	730	28	25
Polymer	3250	0.1	3	8	0.1
Energy (kWh) NO 2021	11	0.1	2,920,000	32	
Total				1,144	114
(2) CF-Fe					
PIX-318 (4 mg Fe/l)	76	23	664	50	31
Limestone	2.2	50	1,460	3	91
CO_2-gas	39	10	292	11	10
Energy (kWh) NO 2021	11	0.12	3,504,000	39	
Total				103	133

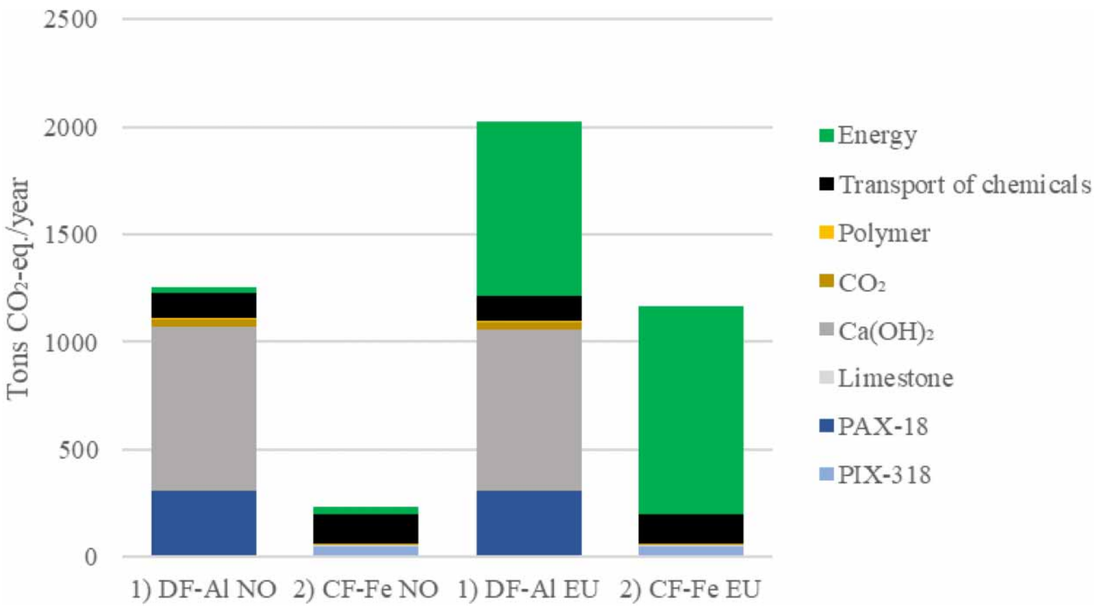


Figure 3 | Annual CO_2 emissions from energy consumption and the manufacturing and transport of chemicals needed for DWTP operation, shown for the use of both low-emission energy such as energy produced in Norway (NO) and more fossil fuel-based energy, as in Europe (EU).

During 1 year of operation in the local conditions using low-emission energy, the total carbon footprint is estimated to be 1,000 tons CO_2-eq larger in the DF-Al process than for a plant using CF-Fe. The high CO_2 emissions connected to limewater manufacturing should raise awareness when choosing the process design and finding solutions/alternatives for existing DWTPs to apply more environmentally friendly chemicals for pH and corrosion control.

A comparison of operating costs (price level in 2021) shows that the DF-Al alternative is almost 30% more expensive to operate than CF-Fe (Figure 4). This difference is due to higher total chemical consumption and the higher price of the chemicals used. The energy price for non-household consumers is similar in Europe and Norway (European Environmental Agency 2022). Several authors have estimated the cost of reducing

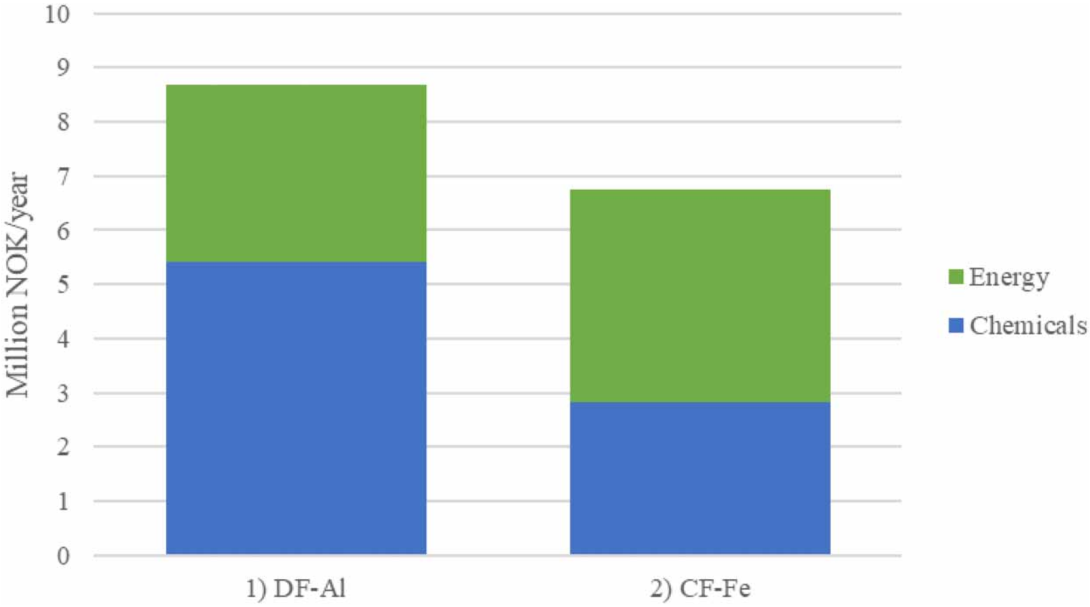


Figure 4 | Operational cost estimates based on the year 2021 prices for chemicals and energy for (1) DF-Al and (2) CF-Fe.

CO_2 emissions, all of them concluding that reduction requires increased costs (Barrios *et al.* 2008; Sala-Garrido *et al.* 2021; Molinos-Senante *et al.* 2022). The results from this study show the opposite: a significantly lower carbon footprint can be achieved with lower costs if carbon footprint evaluations are included in the early process design phase.

The energy consumption for heating, de-humidifying, and ventilation of the building mass that is part of the treatment plant also contributes to the total carbon footprint during the operational phase. The footprint is significantly larger for the DF process design, which in turn, requires a larger building. These factors are, however, not taken into consideration in the energy estimations for the operational phase.

An overdosing of chemicals during water treatment implies unnecessary costs, an increased load on the water treatment process, and increased carbon footprints. For example, a process operator who overdoses chemicals by 15% in the DF-Al process will increase the annual CO_2 emissions by 189 tons. This is close to the annual CO_2 emissions from the production of 80,000 m^3 of water per day with the CF-Fe process. Similarly, a process operator who overdoses chemicals by 15% using the CF-Fe process would result in an increase in annual CO_2 emissions by 35 tons.

The carbon footprint derived from the operational phase of coagulation-filtration processes is dependent on the raw water quality, the selected water treatment process and process design, energy consumption, emissions intensity connected to the energy production, and the type and dose of chemicals used. Based on these results, environmental impact estimations should be included in the traditionally cost-driven evaluation of treatment alternatives, both when building new DWTPs and renewing existing ones. In addition, more emphasis should be devoted to finding alternative treatment chemicals with small CO_2 emissions.

Sensitivity analyses

Sensitivity analyses were performed for the operational phase by changing the inputs of energy and chemicals by 15%. The corresponding relative percentual changes were calculated for both CO_2 emissions and costs. The results showed that the most sensitive variable for the CO_2 emissions from the DF-Al process was limewater, with more than a 10% impact on overall emissions. The increase in CO_2 emissions was mainly connected to the manufacturing of the chemicals. The most sensitive variable for costs was energy, with more than a 6% impact overall. It should be noted that if a chemical dose (such as a limewater dose) is increased, other chemical consumption often increases as well, which makes the overall CO_2 emissions and cost impact larger than when calculated for a single variable.

For CF-Fe, the most sensitive variable (over 6%) was limestone in terms of CO_2 emissions, where the increase was connected mostly to the transport of limestone from the production site to the treatment facility. The most sensitive variable for costs was energy, with more than a 9% overall impact on the CF-Fe process.

As an additional sensitivity analysis, the energy cost input was changed by 70% due to the current fluctuations and increase in energy prices in Europe. This resulted in an overall energy cost impact of 29% for DF-Al and 43% for CF-Fe. However, a cost increase of 325% for the operational energy input is required before the DF-Al and CF-Fe would have the same annual operational costs. The price increases for other inputs, such as the manufacturing of chemicals and transport, are also influenced by the energy price. Manufacturing chemicals for the DF-Al alternative is more energy-intensive, and the price for manufacturing these chemicals is assumed to be more affected by the increasing energy prices.

CONCLUSIONS

Carbon footprints from a plant's operational phase are estimated based on full-scale DWTP data. The results show that the annual carbon footprint for production of 80,000 m^3/d drinking water from a direct dual media (2-M) filtration plant using Al coagulant and limewater (DF-Al) is over five times (1000 tons CO_2-eq) larger than that produced by a three media (3-M) contact filtration plant using Fe coagulant and an alkalizing limestone filter bottom layer (CF-Fe).

The simplified carbon footprint and investment cost comparison for the construction phase for the direct filtration (DF-Al) and contact filtration (CF-Fe) enhanced coagulation process alternatives indicate a large difference, both in the carbon footprint and investment costs (both are significantly greater for DF-Al). This difference is explained mainly by the larger process footprint area (70% larger) for the direct filtration than for the alternative contact filtration process. The larger process footprint area means increased resource consumption during construction, resulting in higher investment costs and a higher carbon footprint in the construction phase.

This study reveals significant differences in the carbon footprint for two similar water treatment processes based on enhanced coagulation-filtration (contact and direct filtration). It is well-known that the carbon footprint and treatment costs are affected by the selected water treatment processes. The results from this study show that the carbon footprint and costs can also be significantly reduced by the proper design of similar treatment process alternatives and a careful selection of water treatment chemicals.

Therefore, to reduce environmental impacts and costs, the design of drinking water treatment processes should be carefully considered even for very similar processes. The results also indicate that the alternative with the largest carbon footprint also has the highest construction and operation costs, which should motivate both water professionals and decision-makers to include a carbon footprint evaluation as a routine step in the water treatment process selection and design phases.

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DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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