FOOD & BEVERAGE

Application Bulletin

Improving Sustainability in Brewing Through Diatomaceous Earth/Kieselgur (DE) Replacement in Beer Filtration

Learn more about how Pall can contribute to making beer brewing more sustainable. These insights will make you re-evaluate using DE for beer clarification. www.pall.com/en/food-beverage/beer-corporate.html

The Aspects of Sustainability

Sustainability isn't just one single facet or action. It isn't a check box on your corporate strategy or a sentence on your website. For companies looking to move the needle, sustainability needs to be approached in multiple ways to be an effective business strategy and to support corporate social responsibility ("CSR", also sometimes "ESG" (Environment, Social, Governance)) goals.

There are three facets to sustainability: environmental, social, and economic. Each of these play a key role in driving better business outcomes.

According to Global Data, 74% of global consumers say that environmental issues are quite or extremely important to them and even 41% of global consumers somewhat or completely agree to "I will boycott a brand if it doesn't align with my personal beliefs/values".[1]

So, let's take a look at each of these facets of sustainability to better understand what they are and how they can impact a business.

Environmental sustainability comprises of improvement in these areas:

- Greenhouse gas reduction
- Water reduction
- Decreasing environmental pollution (*e.g.*: CO_2 emissions)
- Waste reduction

Economic sustainability means businesses need to be cost effective and profitable in their respective markets. If a company is environmentally sustainable but cannot drive profit, the business is not viable long-term.

Social sustainability is about identifying and managing business impacts on people.[2] Directly or indirectly, companies' decisions affect what happens to employees, workers in the value chain, customers and communities. For example, this comprises promoting decent wages in their own operations or elimination of child labor and forced labor from the value stream. In addition, safety and health practices are a part of sustainable operations.

What Drives Brewers to Become More Sustainable

Brewers should consider when they contemplate more sustainable production that apart from positioning themselves in the market and getting ready to appeal to more environmental conscious customers, there is also a changing mindset in legislation that drives producing companies to become more sustainable.

Research indicates that 85 percent of people worldwide have shifted their purchase behavior towards being more sustainable in the past five years[3] and as MEP National Network states: "The food industry is likely to face increases in regulations pertaining to emissions, resource use and waste."[4]

With the 2030 Agenda adopted in 2015, the world community under the umbrella of the United Nations committed itself to 17 goals for a better future. These goals include economic, ecological and social aspects. The 2030 Agenda underlines the joint responsibility of all actors: politics, business, science and civil society.[5] Many countries have set ambitious goals

to achieve the targets of the 2030 Agenda. Legislation will follow local logic and be specific, but it is a fact that there are regulations with which governments start to drive change into a more sustainable direction.

Some regulations will impact the way breweries work directly. Not every brewery will be affected, but for a growing number the legal environment will change more and more with respect to sustainability of production. For example:

- EU rules require large companies to publish regular reports on the social and environmental impacts of their activities. The companies have to follow Directive 2014/95/ also called the Non-Financial Reporting Directive. This helps investors, civil society organisations, consumers, policy makers and other stakeholders to evaluate the non-financial performance of large companies and encourages these companies to develop a responsible approach to business.[6]
- Frameworks, standards, and reporting requirements for the ESG landscape are constantly evolving in Asia.[7]
  - As of mid-2020, 1,021 Chinese A-share companies had published annual ESG reports (including those labelled as "sustainability", "CSR", etc), up from 371 companies in 2009[8]
- All over the world, different policies and practices are being implemented to prevent and control industrial emissions to ensure a high level of environmental and human health protection. Many of these policies incorporate the concept of best available techniques (BAT) to establish evidence-based environmental permit conditions for industrial installations. In the "Guidance Document on Determining BAT, BAT-Associated Environmental Performance Levels and BAT-Based Permit Conditions" the OECD lists key criteria for determination of BAT, such as[9]
  - the use of low-waste technology
  - the use of less hazardous substances
  - the nature, effects and volume of the emissions concerned
  - the consumption and nature of raw materials (including water) used in the process and energy efficiency
  - the need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it
- Crystalline silicon dioxide was classified as carcinogenic for humans by the IARC (International Agency for Research on Cancer) in 2011. The German TRGS 906 classifies activities or processes in which employees are exposed to respirable dusts of crystalline silicon dioxide in the form of quartz and cristobalite as carcinogenic. For quartz and cristobalite-containing dust, an assessment standard for quartz dust of 0.05 mg/m³ air has been in force since 2016. For diatomaceous earth, calcinated, in the respirable dust fraction, a value of 0.03 mg/m³ air applies.[10] These values are to be used to control the effectiveness of the protective measures that need to be taken to protect operators.

Replacing Diatomaceous Earth (DE)/Kieselgur in Beer Clarification

For decades, using DE as a filter aid has been the dominating technology in both wine and beer filtration. DE or kieselgur/kieselguhr is a naturally occurring powder. It has a particle size ranging from typically around 10 to some few hundred µm. The typical chemical composition of DE is 80–90% silica, with a 2–4% of alumina and up to 2% iron oxide. Other substances may be present in small amounts.[11]

DE-Free Process and Sustainability

Stepping away from DE usage and leveraging crossflow membrane filtration for beer clarification can help you achieve your sustainability objectives – environmental, social, and economic.

- **Crossflow Membrane Filtration's Impact on Environmental Sustainability**
  - The production of membranes compared to producing DE powder for an equivalent amount of beer results in drastically less amounts of CO_2 eq. The total CO_2 footprint for beer clarification can be reduced significantly (*i.e.,* 20–40%, depending on the source to quote). Much of the savings go back to the production of the filter aid itself that includes heat treatment and transportation from only a few mines to places all over the world.
  - By omitting the necessity for pre and post runs, membrane filtration has the potential to reduce both water consumption and product loss significantly. This effect is supported by the small vessel volumes necessary for membrane filters. Depending of course on specific conditions and processes that are compared, the improvement of water efficiency can be up to around 40% and the improvement of raw materials efficiency by reducing beer loss by up to around 50%.
  - DE is used in traditional filtration as a dry powder that is dosed into the beer passing through the filter. For larger breweries the needed quantities add up to many tons of solid matter a year. After use, the DE is discharged together

with imbibition and organic matter that has been filtered out of the beer. As a result, the quantity of dry matter that must be transported multiplies by 3 – 4 times, making even more tons of waste that have to be transported away from the brewery. The logistics of transporting both dry powder supply into the brewery and DE waste out of the brewery add to the carbon footprint of the process. Membranes have a relatively long lifetime and when they need to be exchanged, they represent a few hundred kilograms compared to a few hundred tons of DE waste at a comparable brewery size. Additionally, DE is considered a hazardous waste in many countries.

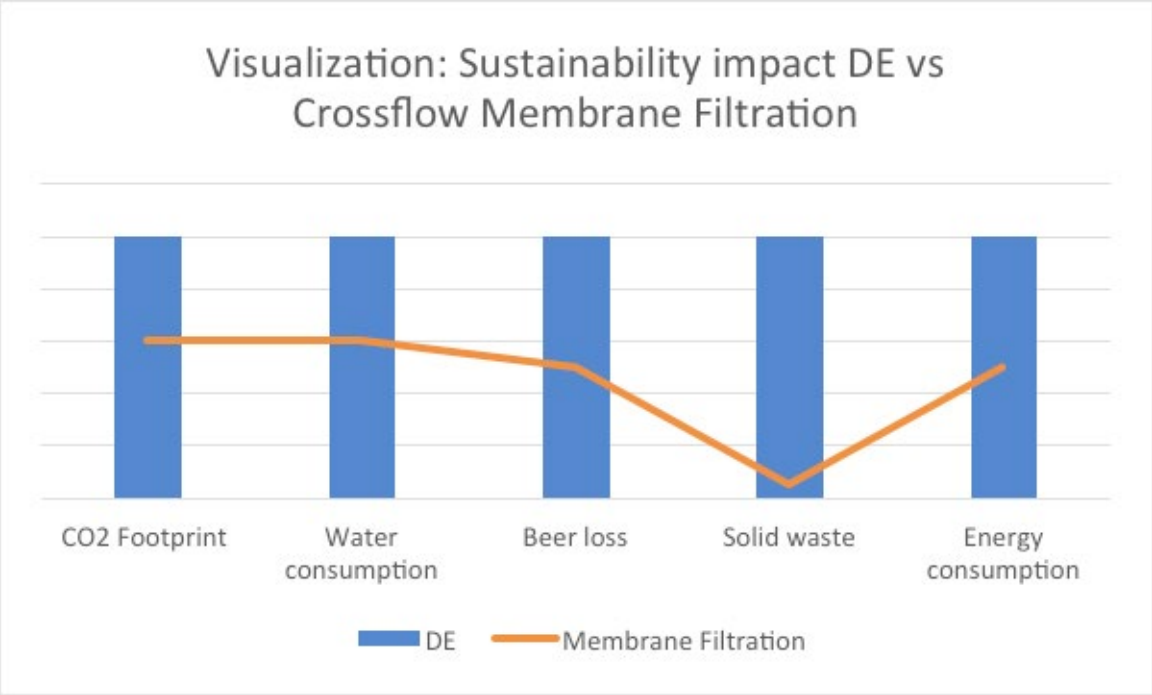

Figure 1: Visualization of sustainability factors in DE filtration vs crossflow membrane filtration (impact varies depending on technology and technical factors of lines)

- **Crossflow Membrane Filtration's Impact on Social Sustainability**
  - DE as used in breweries can contain cristobalite. "Activities or processes where workers are exposed to respirable dusts of crystalline silica in the form of quartz and cristobalite" have been added to the list of carcinogenic activities acc. TRGS 906, because already in June 1998 the IARC reclassified "crystalline silica" from group 2A "probable human carcinogen" to group 1 "human carcinogen".
    - The danger for operators working with DE lies in the possibility of inhaling the dust, making it necessary for the operators to wear protection equipment and making it necessary for the breweries (in many countries) to control the amount of DE dust in the air in the working space.
    - **Simply put: DE is a hazardous health risk for your employees.**
    - Although DE is almost inert in a beer environment, there is a risk of certain ions leaching into the beer. Some can actually be relevant when it comes to food safety aspects. For example, elevated levels of arsenic have been found in beer, and investigations have identified the DE being used as filter aid as a source.[1,2]
    - **Not only is it a health risk for your employees, DE can influence the final product in an undesirable way.**

Eliminating DE from your brewing process shows your conscious social efforts to protect your employees and customers from health hazards.

- **Crossflow Membrane Filtration's Impact on Economical Sustainability**
  - Moving away from DE to crossflow filtration can help you reduce water consumption, beer loss and overall energy usage. While these may be considered environmental sustainability initiatives, they also equate to financial savings or economical sustainability for your brewery.
  - Beyond operational savings, brewers can rest assured knowing material expenses are also reduced with crossflow filtration.
    - An economically sensible reuse of DE can hardly be achieved. Therefore, fresh DE powder must always be purchased over the entire service life of the filter. This adds running costs both for the purchase and for the disposal of the used DE. Secondary costs, which are rarely considered, come from the need to implement the necessary health protection for employees and from the need to consider food safety. Here, extensive analyses can be necessary for both the DE powder purchased and for the product after filtration. In addition, cost is added to the process by the handling of the DE, including electrical energy for its transportation and by pre and post runs that must be treated. Sometimes microbiological risks and increased oxygen uptake through the dosing process are also drivers of hidden costs of DE filtration.
    - The OPEX for crossflow membrane filtration is typically lower than a DE filter process which can lead to a favorable TCO, depending on time frame of analysis.

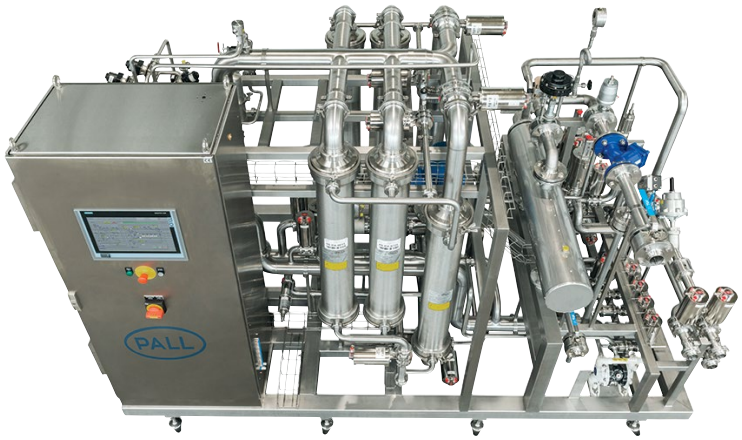

Figure 2: PROFi Craft System

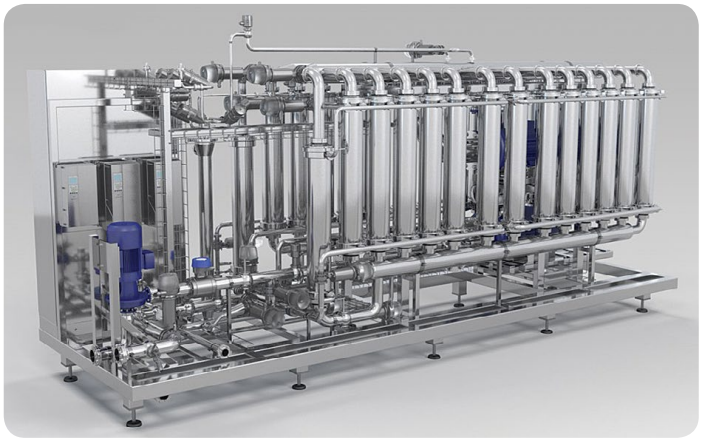

Figure 3: PROFi Block System

What Can Be Achieved — An Example For an Industrial Size Brewery

In a real example, brewery vessel filters using DE were exchanged with PROFi membrane filtration for processing around 350–400 hl/h. This change yielded the following improvements:

- Beer loss reduced to 0.02% extract
- Temperature uptake over the complete filter line of < 1 °C
- Water consumption reduced to 33% → annual savings in water of more than 16,000 m^3/year
- Electrical consumption reduced by > 50%
- Savings in heat energy of around 140,000 kWh/year
- CO_2 consumption reduced by appr. 20%
- Complete elimination of DE removing all side effects related to health and safety regulations and secondary costs as previously mentioned.
- Beer quality:
  - Haze measurement at 90° was 0.1 to 0.2 EBC lower than with DE
  - In forward scatter turbidity measurement, the reading was significantly lower than with DE (0.03 to 0.08 EBC)
  - The oxygen uptake over the complete filtration was at or below 0.02 ppm right from the beginning

Conclusion

While sustainability might not be a new term, it is becoming increasingly more important to consumers AND breweries. It is morally and ethically important to implement sustainability initiatives as a good business practice; but beyond that, legal ramifications are becoming more prevalent for business that do not implement it into their business strategies. Also, if done right, becoming more sustainable offers the opportunity of decreasing operating and material expenses.

In summary, moving away from using Kieselgur or DE to crossflow filtration offers opportunity to improve environmental, social and economic aspects.

To learn more about Pall crossflow filtration, **download this brochure** or contact us.

Footnotes

1 Global Data: Foodservice in the 2020s: Meeting the Demand for Sustainability
2 https://www.unglobalcompact.org/what-is-gc/our-work/social
3 https://www.businesswire.com/news/home/20211014005090/en/Recent-Study-Reveals-More-Than-a-Third-of-Global-[2]Consumers-Are-Willing-to-Pay-More-for-Sustainability-as-Demand-Grows-for-Environmentally-Friendly-Alternatives
4 Five Trends That Will Impact the Food Industry For Many Years, MEP National Network
5 https://sdgs.un.org/2030agenda
6 https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en
7 https://www.asiafundmanagers.com/gbr/increasing-esg-regulations-in-asia/
8 https://www.weforum.org/agenda/2021/03/chinese-business-leapfrog-moment-esg-reporting/
9 https://www.oecd.org/chemicalsafety/risk-management/best-available-techniques.htm
10 https://www.bgn-branchenwissen.de/daten/asi/a8_02/2.htm
11 https://en.wikipedia.org/wiki/Diatomaceous_earth
12 https://www.wissenschaft.de/erde-umwelt/raetsel-um-arsen-im-bier-geloest/

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Across 80 locations and 10,000 people worldwide, we are unified by a singular drive: to solve our customers' biggest fluid management challenges. And in doing so advance health, safety and environmentally responsible technologies.

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