Interreg North-West Europe
WOW!
European Regional Development Fund

REPORT

DATE: September 2023

Authors: Hobus, Inka; Kolisch, Gerd;

ACTION: A1 High quality PHA production from residual streams from food processing industries

SUBJECT: D 2.4 Report on market analysis and economic assessment of promising applications of PHA produced from industrial residual streams

WOW! is supported by the Interreg North-West Europe program.

WWW.NWEUROPE.EU/WOW

Content

List of figures

1 Introduction

WOW! has proven that recovery of PHA (a bioplastic) from municipal sewage water (primary sludge) is possible and has a promising future (Uhrig et al., 2022; WOW, 2020). Activity 2 of the capitalisation project focusses on further valorisation of PHA from industrial sewage water streams. This can produce higher quality PHA and therefore open new markets opportunities. After testing sewage water streams from different industries on lab scale, two promising sewage water streams from the brewery and juice industry were tested in a PHA pilot. Considering the results of the PHA pilot (Laumeyer et al., 2023) production as well as collectable quantities at the juice and brewery industry are described. Furthermore, the dimension of a PHA enrichment plant at the production site is shown. A survey was conducted to gain insight into the social acceptance of PHA products from residual streams.

2 PHA-production from residual streams: brewery industry

2.1 Sewage water characteristic and amount of the brewery industry

Figure 2-1 shows the beer production and the number of breweries in NWE for each country. In 2022, a total of 136 million hl of beer was produced in 6,701 breweries (Brewers of Europe; 2021). Studies on the wastewater composition of brewery water can be found e. g. in (DWA-M 732, 2022), (Rosenwinkel, 2000), (König, 2016). The COD concentration is in the range of 1,400 to 5,000 mg/l (Table 2-1). Brewery sewage water still contains sufficient nitrogen and phosphorus so that the biological processes for PHA production can usually take place without the addition of nutrients (see also (Laumeyer, 2023)). In the study by (Giner Santonja et al., 2019), the sewage water of 34 breweries in the European Union was evaluated. The specific wastewater production varies between 0.1 and 0.6 m³/hl (see Figure 2-2).

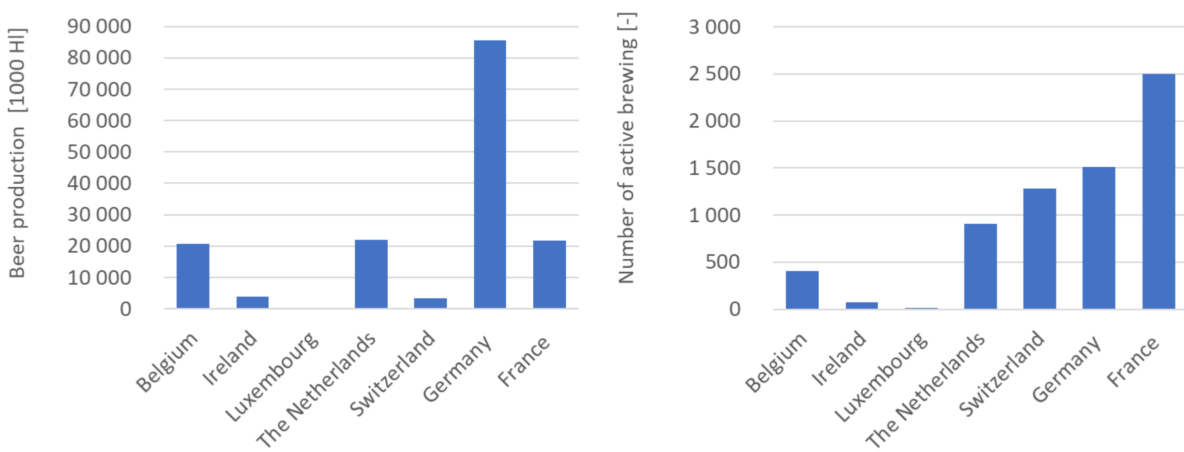
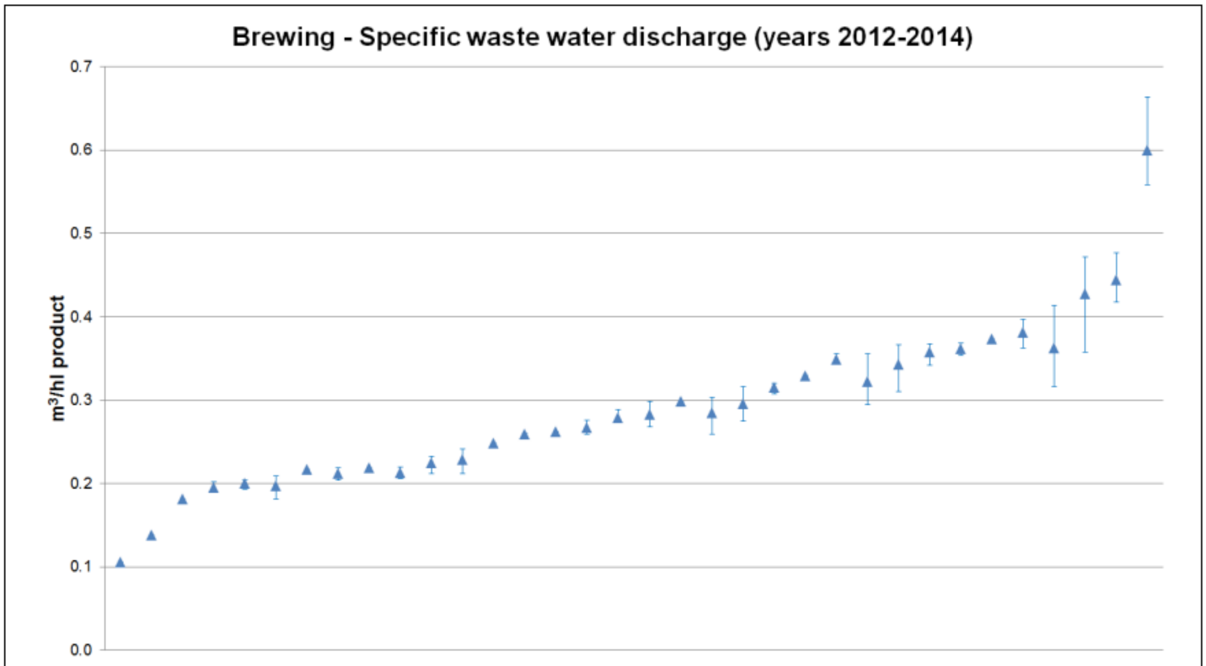


Figure 2-1: Beer production and number of active brewing 2021 in NWE (Brewers of Europe; 2021)

Table 2-1: Brewery sewage water composition (König, 2016)

	COD [mg/l]	BOD_5 [mg/l]	SS [mg/l]	TKN [mg/l]	P_{tot} [mg/l]
brewery	1.500 - 4000	800 - 2.000	120 - 1.000	30 - 100	10 - 30



Source: [193, TWG 2015]

Figure 2-2: Specific sewage water discharge (m3 /hl of products) in brewing for all types of discharges (Giner Santonja et al., 2019)

Table 2-2 shows the beer production of the breweries and the number of breweries depending on the size class as an example for Germany in 2022. This shows that 22 breweries with a beer production of over 1 million hl produce 56 % of the total beer production in Germany. Taking into account a specific sewage water production of 0.3 m³/hl beer results in a wastewater volume of 13,775 m³/a at only a few production sites, which could be used to produce PHA.

Table 2-2: Beer production, number of active brewing and calculated sewage water in 2022 in Germany (source: Statistisches Bundesamt 2022)

	Unit	up to 1.000	up to 3.000	up to 5.000	up to 10.000	up to 50.000	up to 100.000	up to 200.000	up to 500.000	up to 1 Mio.	up to 2 Mio.	over 2 Mio.	total
Beer production	[hl]	214,834	288,308	222,531	696,988	4,047,546	3,679,049	4,834,886	7,883,050	14,803,236	23,622,238	22,294,292	82,586,958
	[%]	57.4%	11.1%	4.0%	6.4%	11.0%	3.4%	2.3%	1.6%	1.3%	1.0%	0.5%	100%
number of brewerys	[-]	865	168	60	96	166	51	35	24	20	15	7	1,507
	[%]	0.3%	0.3%	0.3%	0.8%	4.9%	4.5%	5.9%	9.5%	17.9%	28.6%	27.0%	100%
sewage water*	[m³]	64,450	86,492	66,759	209,096	1,214,264	1,103,715	1,450,466	2,364,915	4,440,971	7,086,671	6,688,288	24,776,087

* calculated with a specific sewage water amount of 0.3 m³/hl

2.2 PHA-Yield derived from the pilot results: brewery industry

Figure 2-3 shows the flow diagram of PHA accumulation and extraction for the pilot plant. The set-up of the pilot plant and the results on PHA production with the pilot plant are described in detail in (Laumeyer, 2023). For the calculation of the PHA yield rate, the mean concentrations, sewage water flows to the reactors and the PHA yield of the biomass were used (see Table 2-3). The PHA-yield for sewage water from the beer industry is calculated to 26 g PHA/m³ with a mean COD concentration of the sewage water of 3,7 g/m³. For calculation of the yield rate, all the batches carried out with the pilot plant were taken into account, therefore there is still an optimisation potential to increase the PHA-yield. Additional the large amount of process water used to balance the process conditions in the enrichment reactor should be reduced in a large-scale implementation.

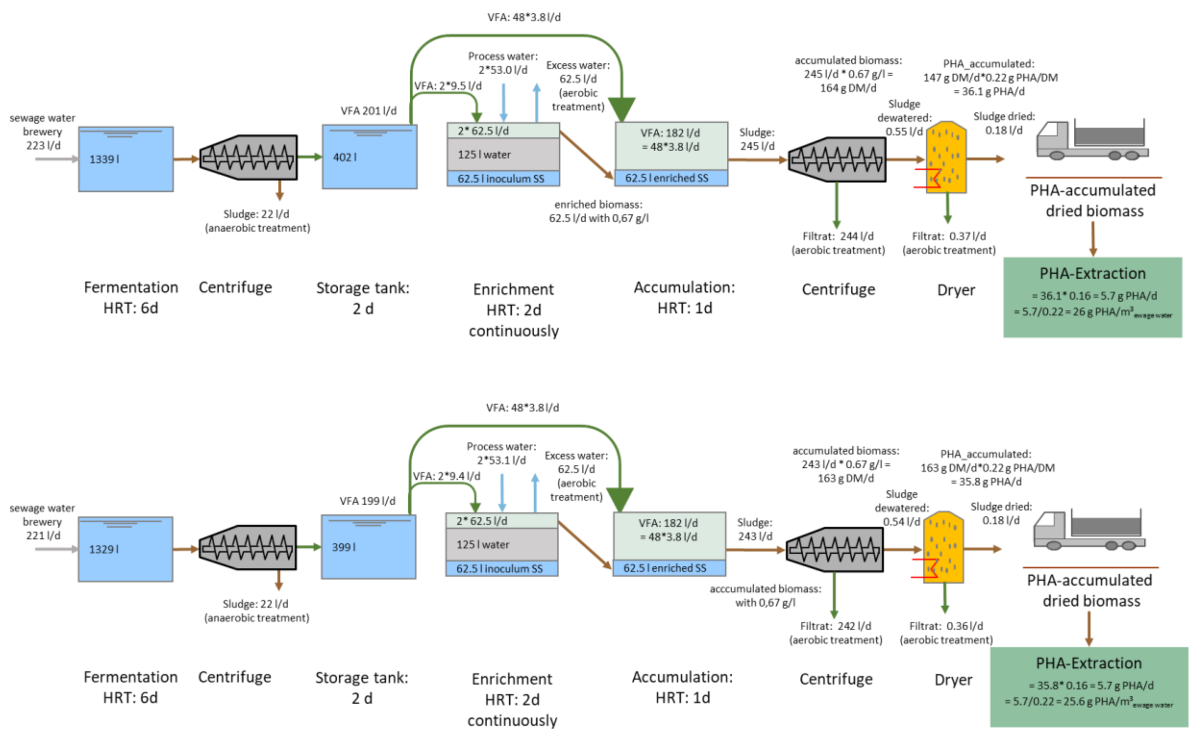


Figure 2-3: Flow diagram of PHA enrichment, accumulation and extraction with sewage water from the brewery industry for the pilot plant (Mean values from the PHA-pilot (Laumeyer et al., 2023))

Table 2-3: COD-concentration, volumetric load and yields for the PHA enrichment, accumulation and extraction with sewage water from the brewery industry for the pilot plant (Mean values from the PHA-pilot (Laumeyer et al., 2023))

	c_COD (influent) g COD/m³	Volumetric Load (reactor) g COD_VFA/l/d	c_COD_VFA (influent) g COD_VFA/m³	Y_PHA,accu (Biomass) g PHA/g DM	Y_PHA_extrac. (Biomass) g PHA/g DM	Y_PHA (sewage water) g PHA/m³
Beer fermentation	3693					
Beer selection		0.125	1,662			
Beer accumulation		1.235	1,662	0.22	0.16	25.6

2.3 Potential PHA-production in NWE: brewery industry

Taking into account a PHA yield of 3 g PHA/hl sewage water from brewery (see chapter 2.2) and a beer production for the year 2021 according to Figure 2-1, the possible PHA production quantity is calculated to be about 957 t PHA/y (Figure 2-4). The evaluation of the size distribution of the production sites for Germany according to Table 2-2 shows that with only a few production sites more than 50% of the beer production is covered. Taking these production sites into account, the result is a PHA-production quantity of up to 480 t PHA/y. This corresponds to PHA production from primary sludge from a sewage water treatment plant with a size of 380,000 PE. Therefore, the theoretical PHA production potential of the brewery industry is relatively low in comparison to PHA production potential from primary sludge. However, under market aspects the acceptance of the consumers for PHA from industrial streams is much higher (see chapter 5).

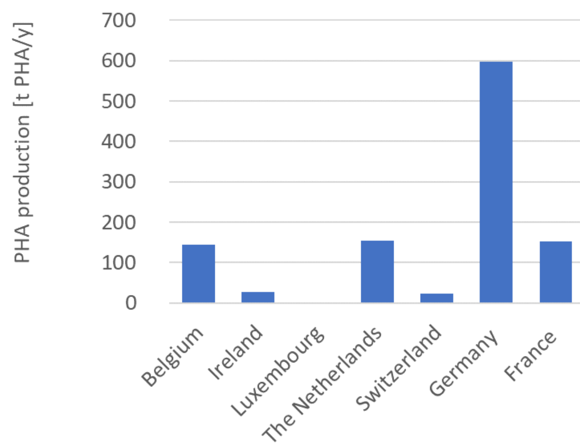


Figure 2-4: Potential PHA-production in NWE: brewery industry

3 PHA-production from residual streams: juice industry

3.1 Sewage water characteristic and amount of the juice industry

Figure 3-1 shows the juice production and the number of juice enterprises in NWE for each country. In 2022, a total of 41 million hl of juice was produced in 755 juice enterprises (statista, 2023). Studies on the wastewater composition of juice production can be found, e. g., in (DWA-M 766, 2012), (König, 2016). The COD concentration is in the range of 4,000 to 8,000 mg/l (Table 3-1). Sewage water from the juice industry contains lower C:N:P ratio in comparison to the brewery sewage water. The addition of nutrients for the biological processes for PHA production can therefore be necessary (see also (Laumeyer, 2023)). In the study by (Giner Santonja et al., 2019), the sewage water of 10 juice production sites in the European Union was evaluated. The specific sewage water amount varies between 0.1 and 0.2 m³/hl (see Figure 3-2).

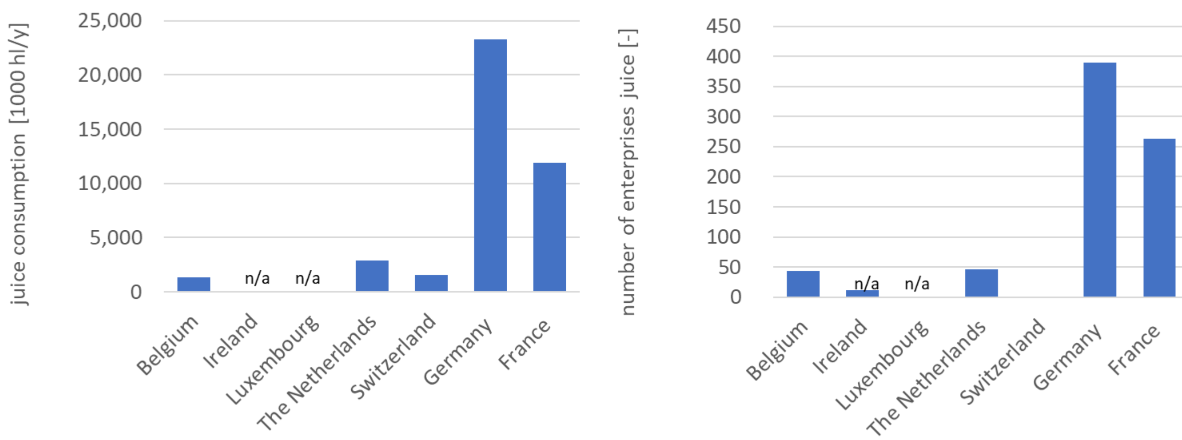


Figure 3-1: Juice consumption 2022 (VdF, 2023) and number of enterprises in the juice industry 2020 in NWE (statista, 2023)

Table 3-1: Juice industry sewage water composition (König, 2016)

	COD [mg/l]	BOD_5 [mg/l]	SS [mg/l]	TKN [mg/l]	P_{tot} [mg/l]
juice	4.000 - 8.000	2.500 - 4.000	200 - 1.000	10 - 30	8 - 30

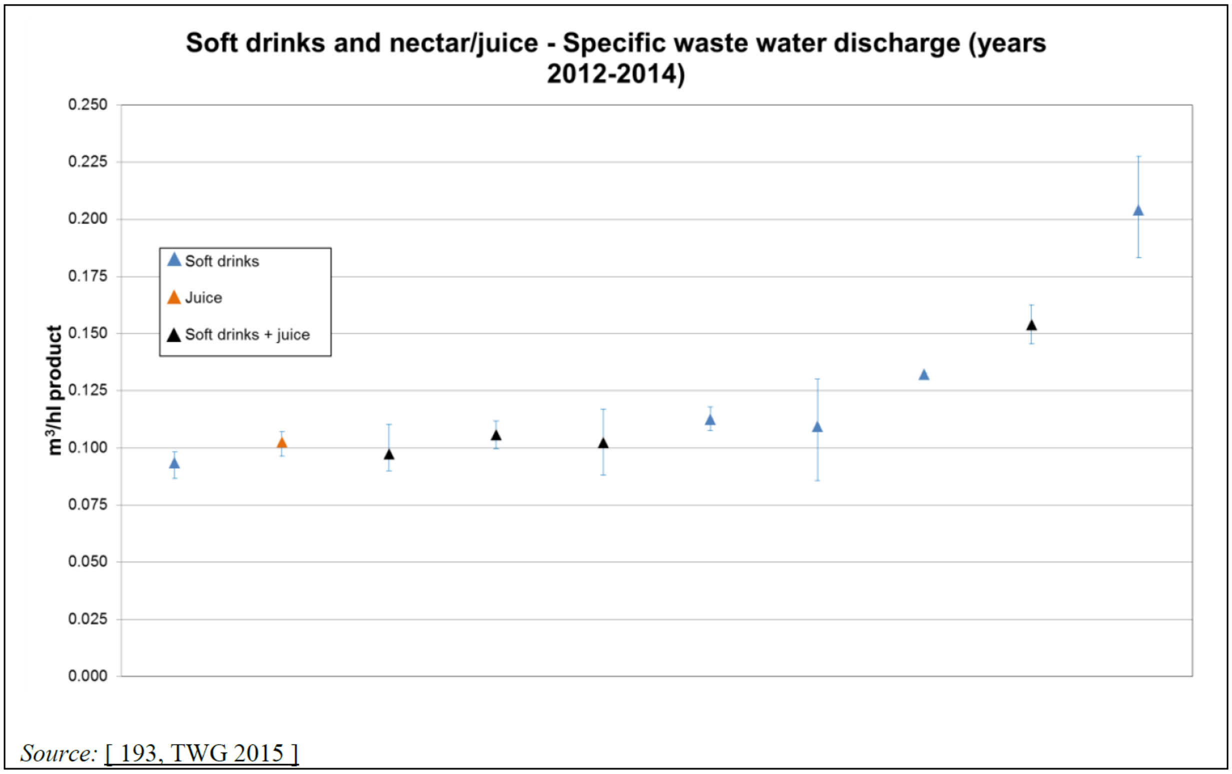


Figure 3-2: Specific sewage water discharge (m³/hl of products) in soft drinks and nectar/juice production for all types of discharges (Giner Santonja et al., 2019)

Table 3-2 shows the total turnover and the number of production sites of the juice industry depending on the size class of companies organised in the "Association of the German Fruit Juice Industry" in 2022. Comparable to the brewing industry, a large part of the turnover in the juice industry is generated by only a few companies. From the companies organised in the Association of the German Fruit Juice Industry, 7 companies generate 68 % of the turnover. A focus for PHA production should therefore be on the few large producers.

Table 3-2: Total turnover and number of juice production sites of companies who are organised by the "Association of the German Fruit Juice Industry"" in 2022 (VdF, 2023)

Revenues in Mio. [€]	up to 0.26	up to 0.50	up to 1.00	up to 2.00	up to 5.00	up to 10.00	up to 25.00	up to 50.00	up to 100.00	greater 100.00	Total
Number of Companies 2022 (2021)	54 (57)	19 (19)	15 (14)	21 (24)	23 (23)	4 (3)	9 (11)	8 (7)	7 (6)	7 (7)	167 (171)
Percentage	32,3%	11,4%	9,0%	12,6%	13,8%	2,4%	5,4%	4,8%	4,2%	4,2%	100,0%
Total Revenue in Mio. [€] 2022	5	7	11	32	65	26	138	273	486	2.214	3.257
Percentage Revenue	0,1%	0,2%	0,3%	1,0%	2,0%	0,8%	4,2%	8,4%	14,9%	68,0%	100,0%

3.2 PHA-Yield derived from the pilot results: juice industry

Figure 3-3 shows the flow diagram of PHA accumulation and extraction for the pilot plant. The set-up of the pilot plant and the results on PHA production with the pilot plant are described in detail in (Laumeyer, 2023). For the calculation of the PHA yield rate, the mean concentrations, sewage water flows to the reactors and the PHA yield of the biomass were used (see Table 3-3). The PHA yield for sewage water from the beer industry is calculated as 30 g PHA/m³ with a mean COD concentration of the sewage water of 11,495 g/m³. Despite the high COD concentration in the sewage water of the juice industry, the PHA yield rates are of the same order of magnitude compared to the brewery sewage water. This is due to the lower ratio of VFA concentration in the fermenter effluent compared to the COD concentration in the juice industry effluent at 0.20 and in the brewery effluent at 0.44 respectively. For calculation of the yield rate, all the batches carried out with the pilot plant were taken into account, therefore there is still an optimisation potential to increase the PHA-yield. Additional the large amount of process water used to balance the process conditions in the enrichment reactor should be reduced in a large-scale implementation.

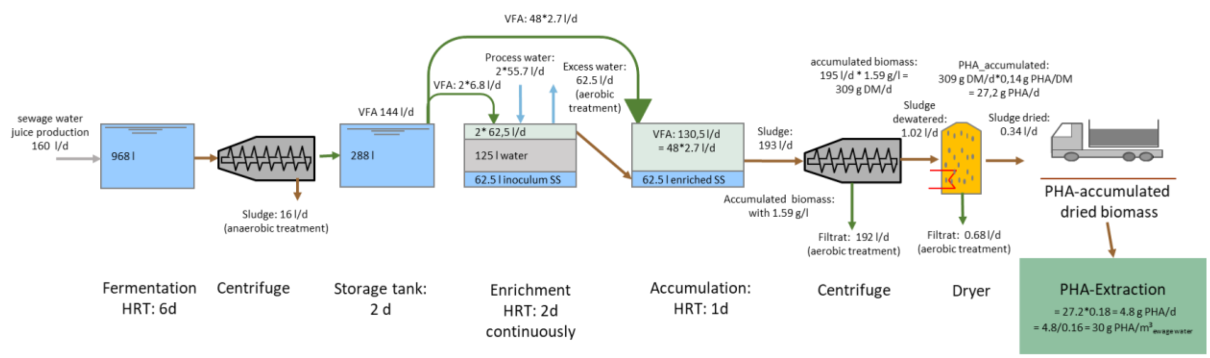


Figure 3-3: Flow diagram of PHA enrichment, accumulation and extraction with sewage water of the juice industry for the pilot plant (mean values from the PHA-pilot (Laumeyer et al., 2023))

Table 3-3: COD-concentration, volumetric load and yields for the PHA enrichment, accumulation and extraction for the pilot plant for sewage water from the juice industry (Mean values from the PHA-pilot (Laumeyer et al., 2023))

	c_COD (influent) g COD/m³	**Volumetric Load (reactor)** g COD_VFA/l/d	**c_COD_VFA (influent)** g COD_VFA/m³	**Y_PHA,accu (Biomass)** g PHA/g DM	**Y_PHA_extrac. (Biomass)** g PHA/g DM	**Y_PHA (sewage water)** g PHA/m³
Juice fermentation	11,495					
Juice selection		0.125	2,299			
Juice accumulation		1.554	2,299	0.14	0.18	29.5

3.3 Potential PHA-production in NWE: juice industry

Taking into account a PHA yield of 3 g PHA/hl sewage water from the juice industry (see chapter 3.2) and a juice production for the year 2021 according to Figure 3-1, the potential possible PHA production quantity is calculated to be 123 t PHA/y (Figure 3-4). The evaluation of the size distribution of the production sites for Germany according to Table 3-2 shows that with only a few production sites more than 50% of the juice production is covered. Taking these production sites into account, the result is a PHA-production quantity of about 60 t PHA/y. This corresponds to PHA production from primary sludge from a sewage water treatment plant with a size of 50,000 PE. The theoretical PHA production potential of the fruit juice industry is relatively low in comparison to PHA production potential from primary sludge. Like for beer sewage water, the acceptance of the consumers for PHA from industrial streams might be much higher than for PHA yield from sewage sludge (see chapter 5).

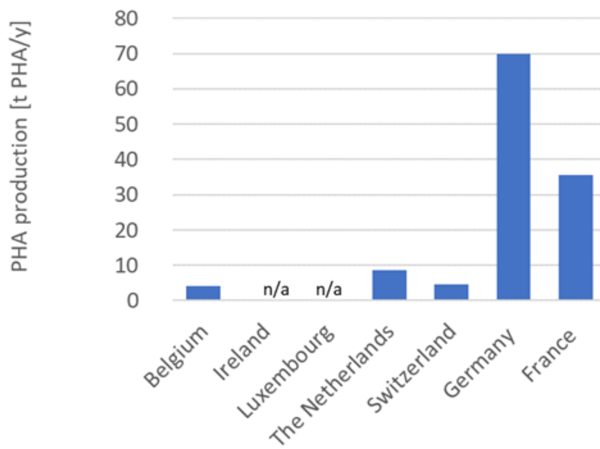


Figure 3-4: Potential PHA-production in NWE: juice industry

4 Integration of a PHA enrichment plant for sewage water from the food industry

The sewage water from a production site can either be discharged after pre-treatment indirectly via the sewer system to a municipal sewage water treatment plant or after treatment at the site directly into the receiving water body. Sewage water treatment directly at the site is usually carried out with a combination of anaerobic and aerobic processes for wastewater streams with high COD concentrations. Figure 4-1shows an example of the process steps and a possible integration of a PHA enrichment plant. If a fermentation tank is available, the effluent from the fermentation tank can be used directly for the PHA enrichment plant. This stream is first dewatered and the residue is returned to the existing anaerobic reactor. Since UASB and IC reactors in particular are sensitive to high solids concentrations, dilution of the recycled sludge may be necessary. Alternatively, only part of the effluent of the fermentation tank could be used. The filtrate is stored temporarily, as the enrichment tank and the accumulation tank are charged batchwise. Due to fluctuations in concentration, the possibility of diluting the filtrate should be provided. The effluent of the aerobic treatment stage can be used for the process water. For the enrichment process, a regular addition of excess sludge (inocculation) from the aerobic treatment stage must be considered. The frequency of addition depends on the sludge losses in the effluent of the enrichment tank. The accumulated PHA-rich sludge is dewatered and then dried. The resulting process water is charged to the aerobic stage. PHA extraction and compounding is carried out centrally at a separate location.

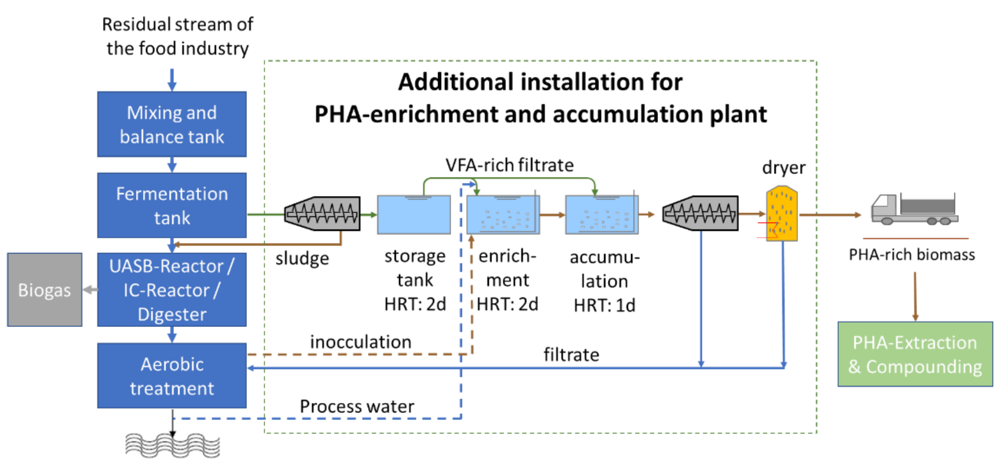


Figure 4-1: Implementation of a PHA- enrichment and accumulation plant for a production site of food industry with high COD-concentration

Figure 4-2 and Figure 4-3 show the layout of a PHA enrichment and accumulation plant for a brewery and for a production site of juice industry with a yearly production of 2 million hl beer respective juice. The determined volumes are based on the results derived from operation of the pilot plant (see chapter 2.2 und 3.2). For the brewery a specific wastewater share of 0.3 m³/hl was used to determine the sewage water volume. This results in a wastewater volume of 1,644 m³/d. The PHA quantity extracted from this amounts to 15.3 t $PHA_{extracted}$ /y. Due to the significantly lower specific wastewater volume in the juice industry of 0.1 m³/hl$_{juice}$, this results in a wastewater amount of 548 m³/d and a much lower PHA production of only 5.9 t PHA$_{extracted}$/y.

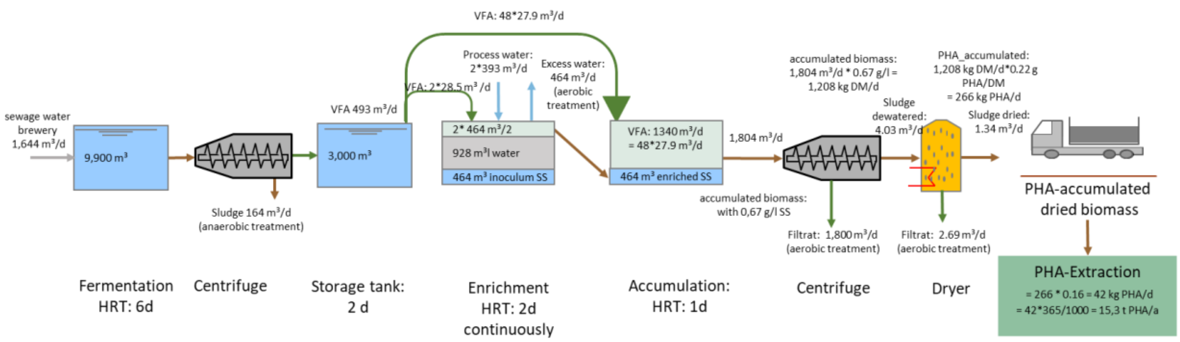


Figure 4-2: Layout of a PHA- enrichment and accumulation plant for a brewery with a yearly beer production of 2 million hl

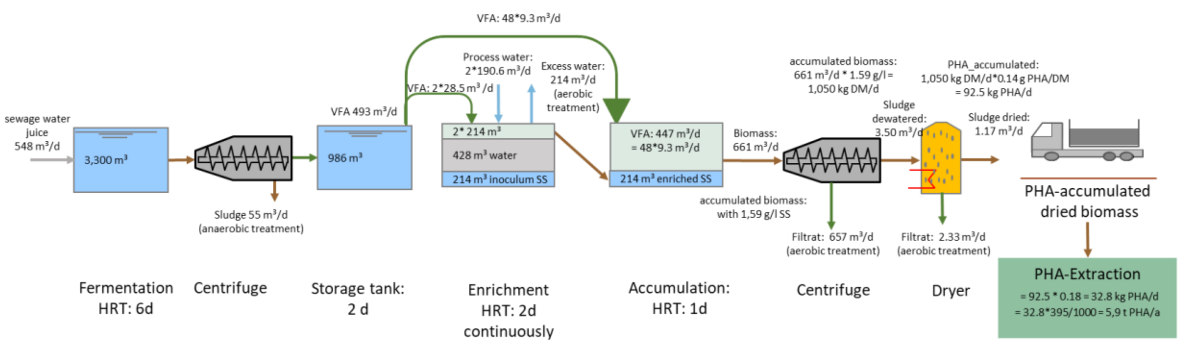


Figure 4-3: Layout of a PHA- enrichment and accumulation plant for a production site of juice industry with a yearly beer production of 2 million hl

5 Acceptance of products from residual streams

A survey was conducted among consumers to gain insight into the social acceptance of PHA products from residual streams. Altogether, 47 participants took part in the survey. When evaluating the results, it should be taken into account that the majority of participants are active in the environmental sector. The results of the survey are summarized in chapter 8.1 (German) and 8.2 (English). The main message of the survey is that the fact that the bioplastic is gained from organic carbon from wastewater influences consumers. For almost 50 % of the consumers, the origin of the bioplastic has an impact on their consumption behaviour (Figure 5-1). However, Figure 5-2 shows that the use of PHA from wastewater streams depends on the product use. Only 13% of respondents would not use bioplastics from sewage water streams for garden items or packaging of products other than food. However, 36% would not use bioplastics from sewage water streams for packaging for food or disposable tableware. For these products, the proportion of users who prefer renewable raw materials or wastewater from the food industry as a source to produce bioplastic is also slightly higher than from municipal sewage water. 84 % of the respondents would pay more for bioplastic from renewable or residual streams (see Figure 5-3).

In addition to the consumer survey, large breweries and fruit juice industry producers in NWE were contacted. There was only a response from two breweries. The results are summarised in 8.3. The statements of the two breweries show that the use of wastewater streams for bioplastics production is seen as a competitive advantage. However, the integration of the process should show a cost advantage.

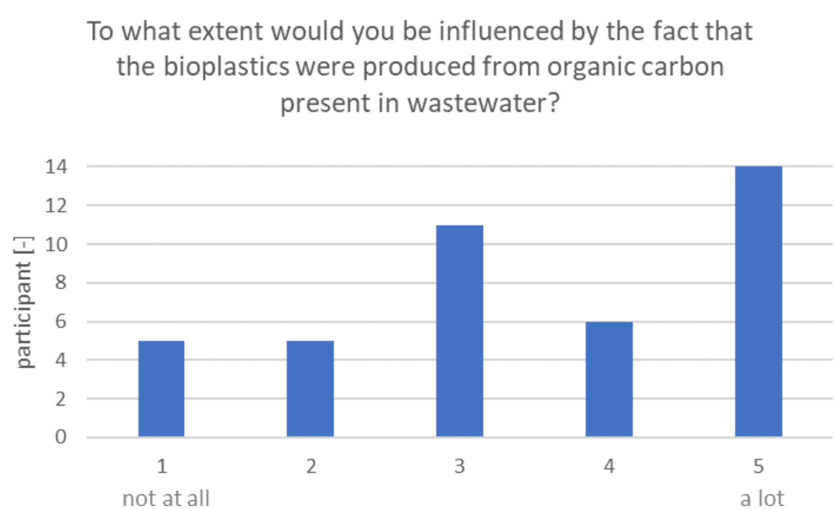


Figure 5-1: Survey results - Use of bioplastics production from organic carbon in wastewater

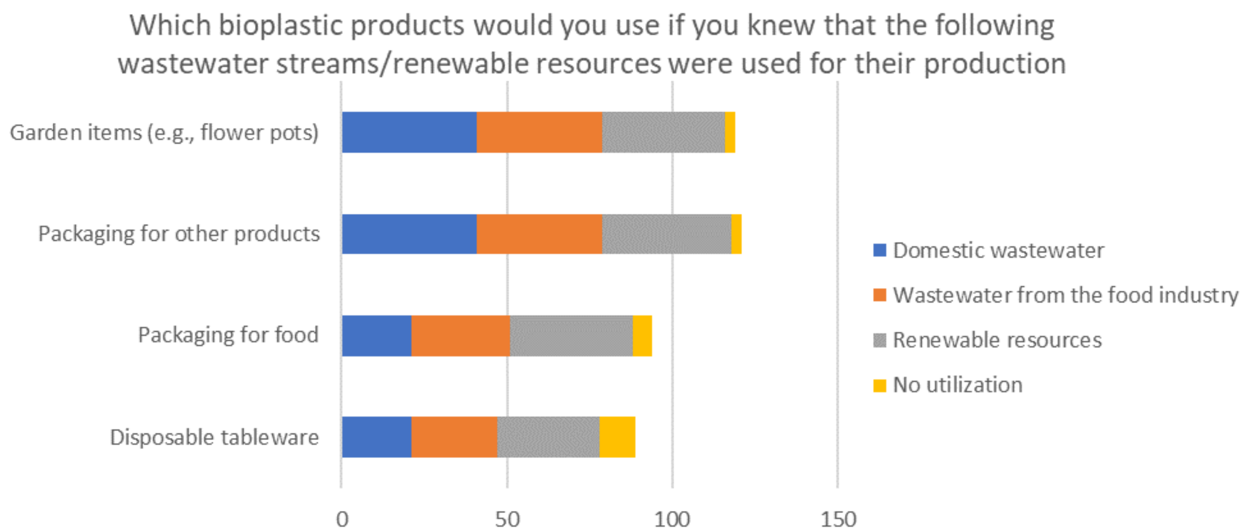


Figure 5-2: Survey results - preference for bioplastic products based on utilized wastewater streams and renewable resources

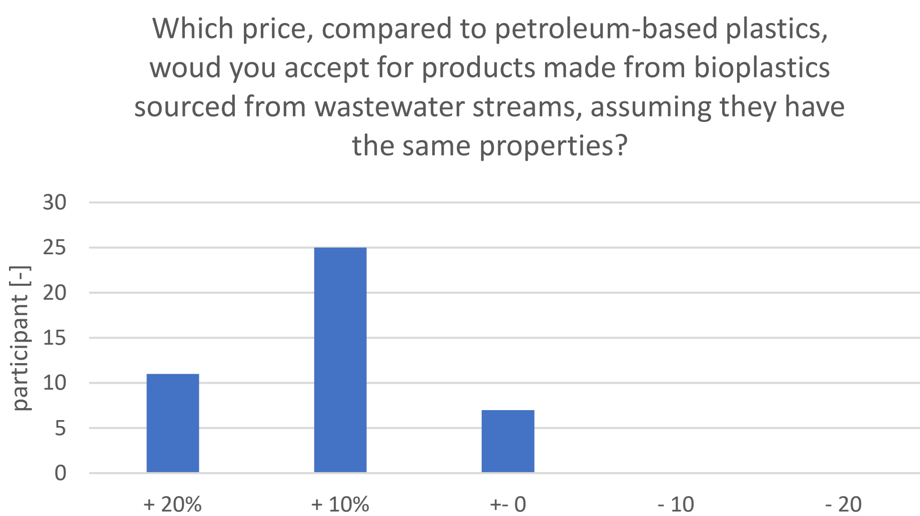


Figure 5-3: Survey results - price acceptance for bioplastics from wastewater

6 Conclusions

The pilot tests conducted by (Laumeyer et al., 2023) showed in principle that the sewage water stream from the beer and juice industry is suitable for the enrichment and extraction of PHA. However, there is still potential for optimisation to increase the PHA yield rate. The advantage of wastewater from the beer and juice industry is that there are only a few large plants that account for most of the total production. So only a few production plants are needed to recover a huge amount of PHA from these sewage water streams. However, the theoretically possible PHA production from these sewage water streams is small. Similar to PHA production from primary sludge, a combination of different production sites is required. Furthermore, when integrating the PHA enrichment plant at a production site, the interactions with the gas production in the IC reactor or digester must be taken into account. A next step could be a pilot project at the production site to obtain results under real operating conditions and to further optimise the process. The acceptance problems identified in the survey could be resolved through education.

7 Literature

Brewers of Europe (2022): European Beer Trends - 2022 Edition https://brewersofeurope.eu/european-beer-trends-2022-edition-and-previous-years/ Accessed on 28.9.2023

DWA-M 732 (2022): Abwasser aus Brauereien, DWA-Merkblatt, Hennef.

DWA-M 766 (2012): Abwasser der Erfrischungsgetränke-, der Fruchtsaftindustrie und der Mineralbrunnen, DWA-Merkblatt, Hennef.

Giner Santonja, G.; Karlis, P.; Raunkjær Stubdrup, K.; Brinkmann, T.; Roudier, S. (2019): Best Available Techniques (BAT) Reference Document for the Food, Drink and Milk Industries. Science for Policy report by the Joint Research Centre.

König, E. (2016): Abwasser in der Lebensmitelindustrie – Anforderungen und Rahmenbedingungen individuell angepasste Lösungen mit Projektbeisspielen aus der Praxis – Prosuktionsleiter-Tagung 19-20.1.2016 in Dortmund, 9. Fresenius-Jahresauftakttreffen. https://www.koenig-abwasser.de/resources/Download/Ko%CC%88nig_Produktionsleiter-Tagung-2016_HZ_2.pdf Accessed on 28.9.2023

Laumeyer, C.; Andrade Leal, M.; Zimmer, J.; de Best, J.; Steinmetz, H. (2023): Technical report on pilot scale testing of PHA production and extraction from industrial residual streams. Project report, Wider business Opportunities for raw materials from Wastewater – Capialisation, Interreg North-West-Europe.

Rosenwinkel, K.-H.; Schrewe, N. (2000): Brauereien und Malzfabriken. In: ATV-Handbuch Industrieabwasser Lebensmittelindustrie, K.-H. Rosenwinkel. Berlin: Verlag Ernst & Sohn.

statista (2023): Number of enterprises in the manufacture of fruit and vegetable juice industry in the European Union from 2017 to 2020, by country https://www.statista.com/statistics/421680/fruit-juice-manufacturers-by-country-eu/ Accessed on 28.9.2023.

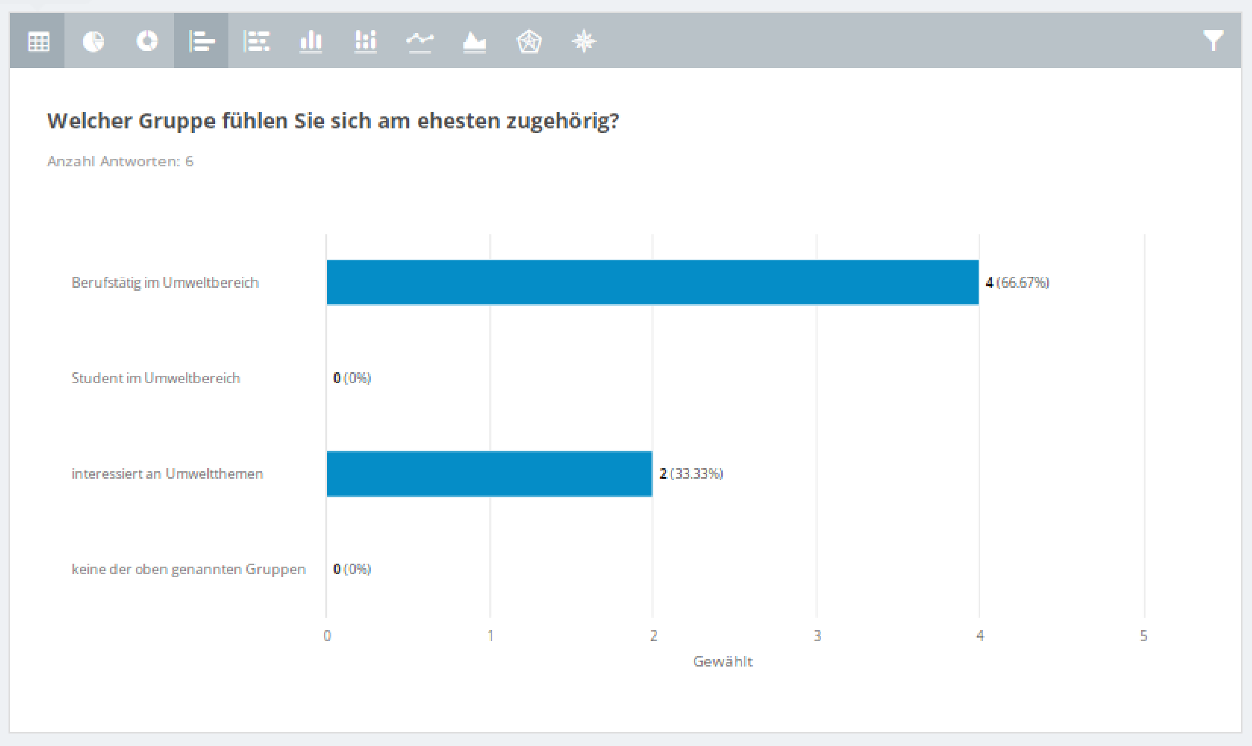
Uhrig, T.; Zimmer, J.; Bornemann, C.; Steinmetz, H. (2022): Report on optimised PHA production process layout. WOW-Report, https://www.nweurope.eu/media/17027/wpt2_delivarable-21-pha-pilot.pdf, Accessed on 21.03.2022

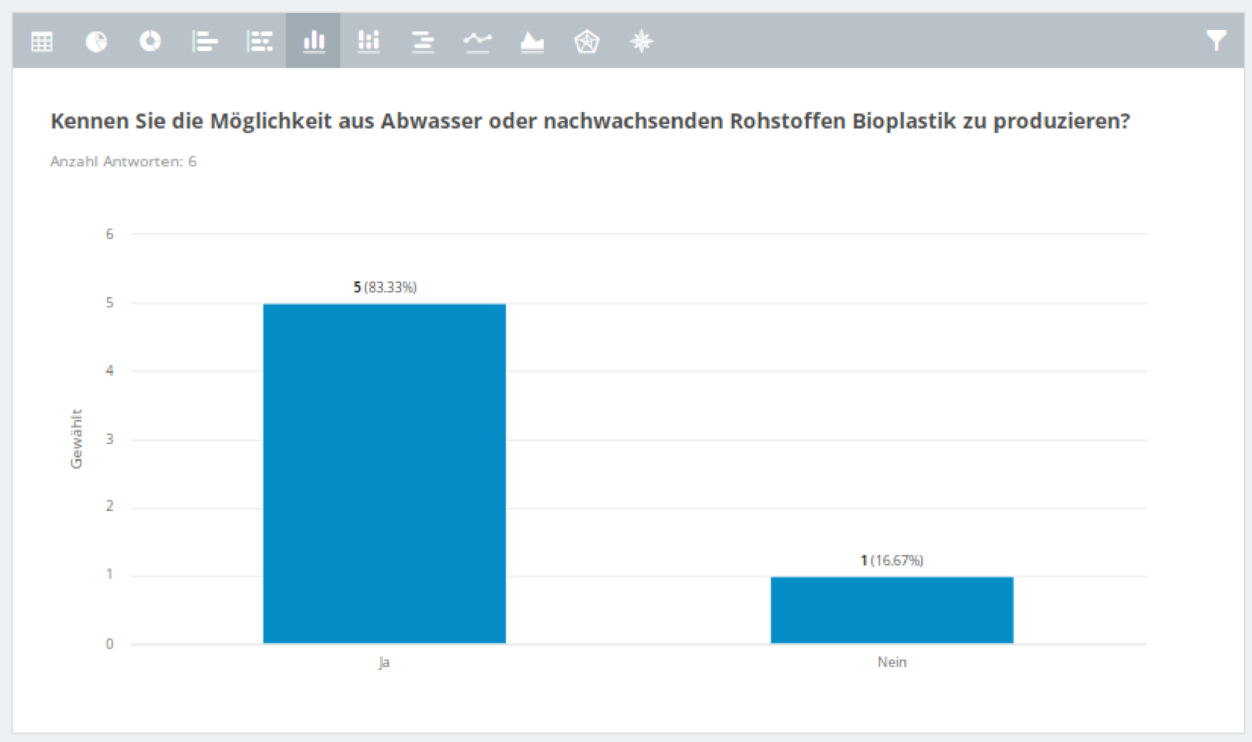
VdF: Verband der deutschen Fruchtsaftindustrie e. V. (2023) Deutsche Fruchtsaft-Industrie DATEN & FAKTEN.

WOW (2020): Designing value chains for carbon based elements from sewage water: A market potential study. https://www.nweurope.eu/media/12964/201230_market-potential-study-final_01.pdf, Accessed on 7.03.2022.

8 Appendix

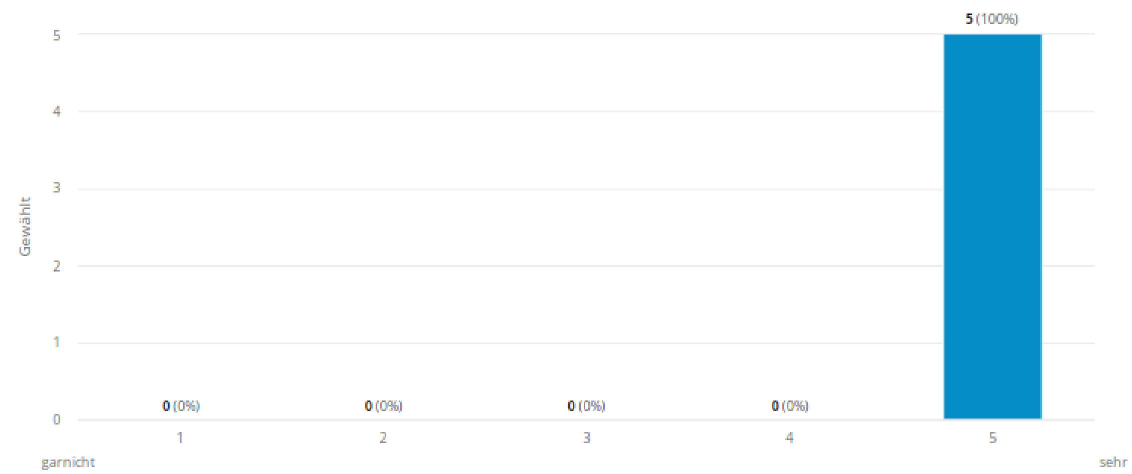
8.1 Survey: PHA production from residual streams General (German)





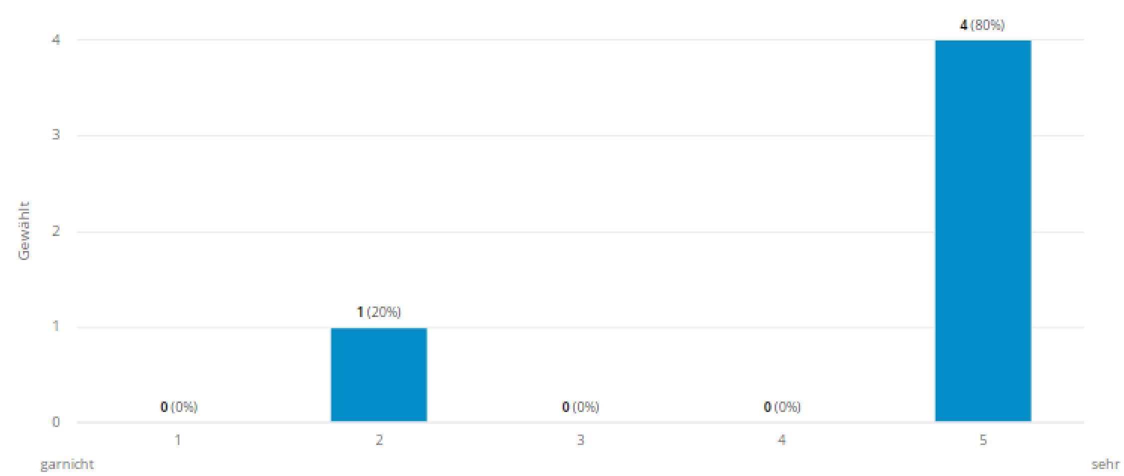
Inwieweit würden Sie die Herstellung von Bioplastik aus häuslichen oder industriellen Abwasserströmen (z.B. Bier- und Saftindustrie) begrüßen.

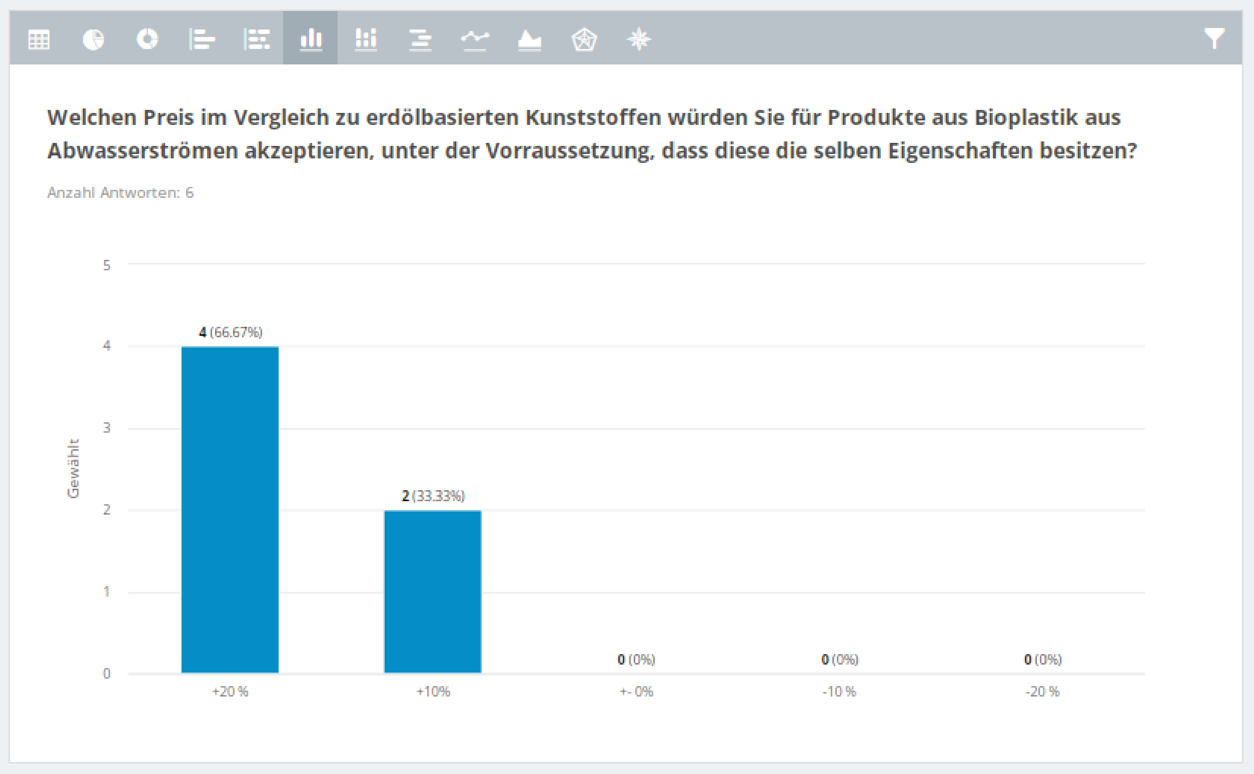
Anzahl Antworten: 5

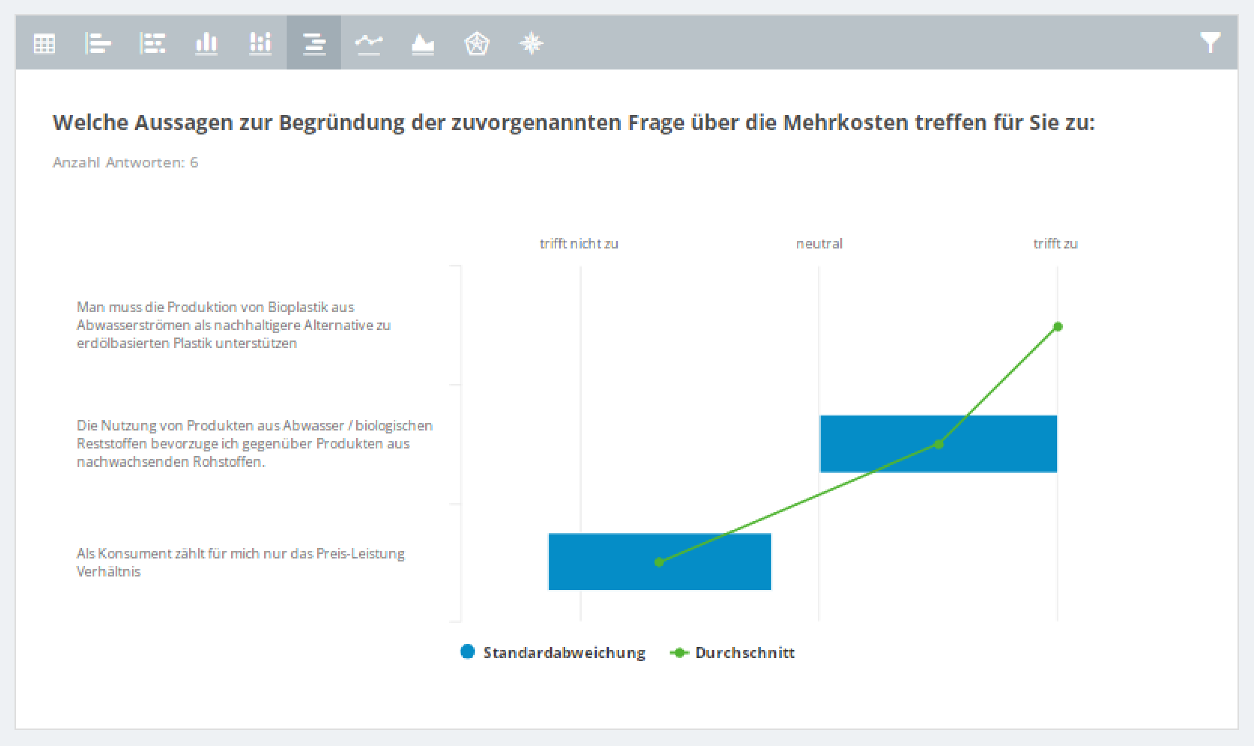


Inwieweit würde Sie die Information, dass das Produkt durch die Rückgewinnung aus häuslichen oder industriellen Abwasser gewonnen wurde, beeinflussen.

Anzahl Antworten: 5

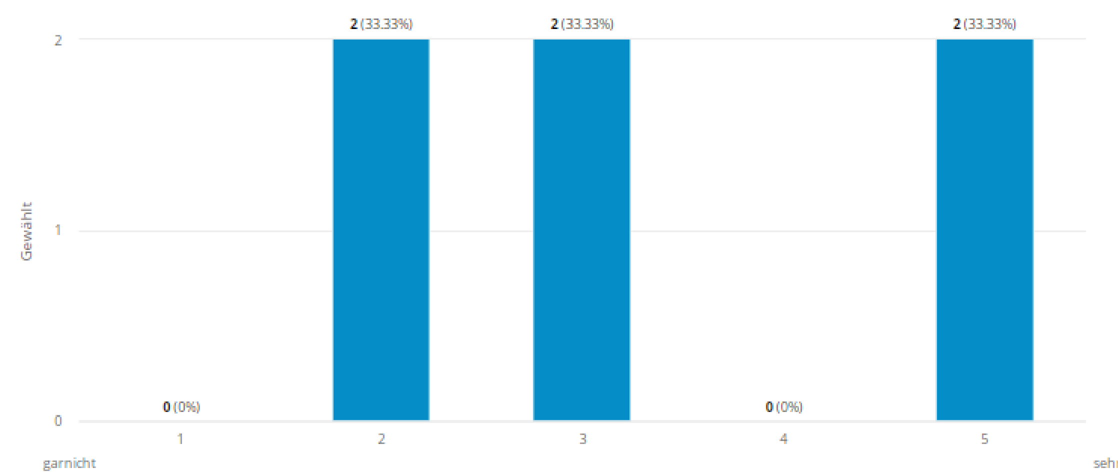



Welchen Preis im Vergleich zu erdölbasierten Kunststoffen würden Sie für Produkte aus Bioplastik aus Abwasserströmen akzeptieren, unter der Vorraussetzung, dass diese die selben Eigenschaften besitzen?
Anzahl Antworten: 6
Gewählt
5
4
3
2
1
0
4 (66.67%)
2 (33.33%)
0 (0%)
0 (0%)
0 (0%)
+20 %
+10%
+- 0%
-10 %
-20 %


Welche Aussagen zur Begründung der zuvorgenannten Frage über die Mehrkosten treffen für Sie zu:
Anzahl Antworten: 6
trifft nicht zu
neutral
trifft zu
Man muss die Produktion von Bioplastik aus Abwasserströmen als nachhaltigere Alternative zu erdölbasierten Plastik unterstützen
Die Nutzung von Produkten aus Abwasser / biologischen Reststoffen bevorzuge ich gegenüber Produkten aus nachwachsenden Rohstoffen.
Als Konsument zählt für mich nur das Preis-Leistung Verhältnis
Standardabweichung
Durchschnitt

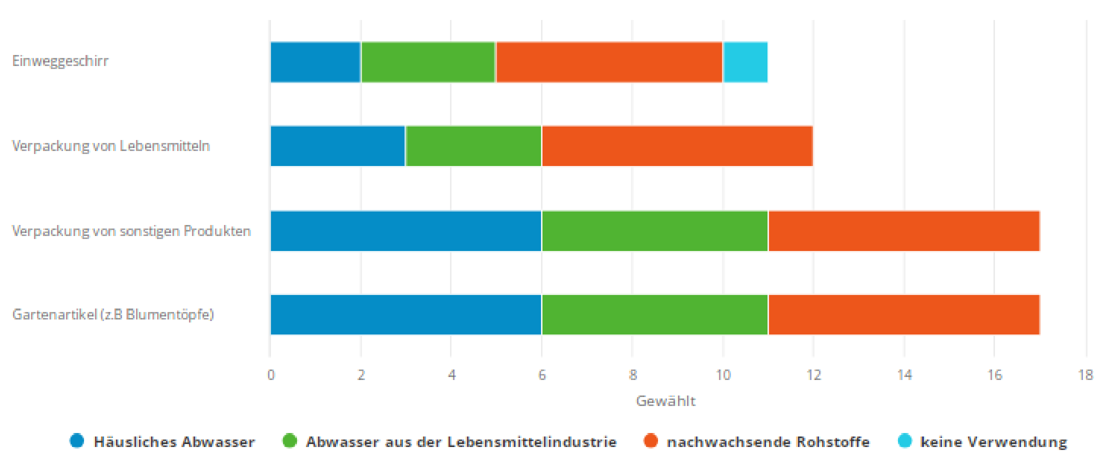
Inwieweit würde es Sie beeinflussen, dass das Bioplastik aus im Abwasser enthaltenen organischen Kohlenstoffs hergestellt wurde

Anzahl Antworten: 6

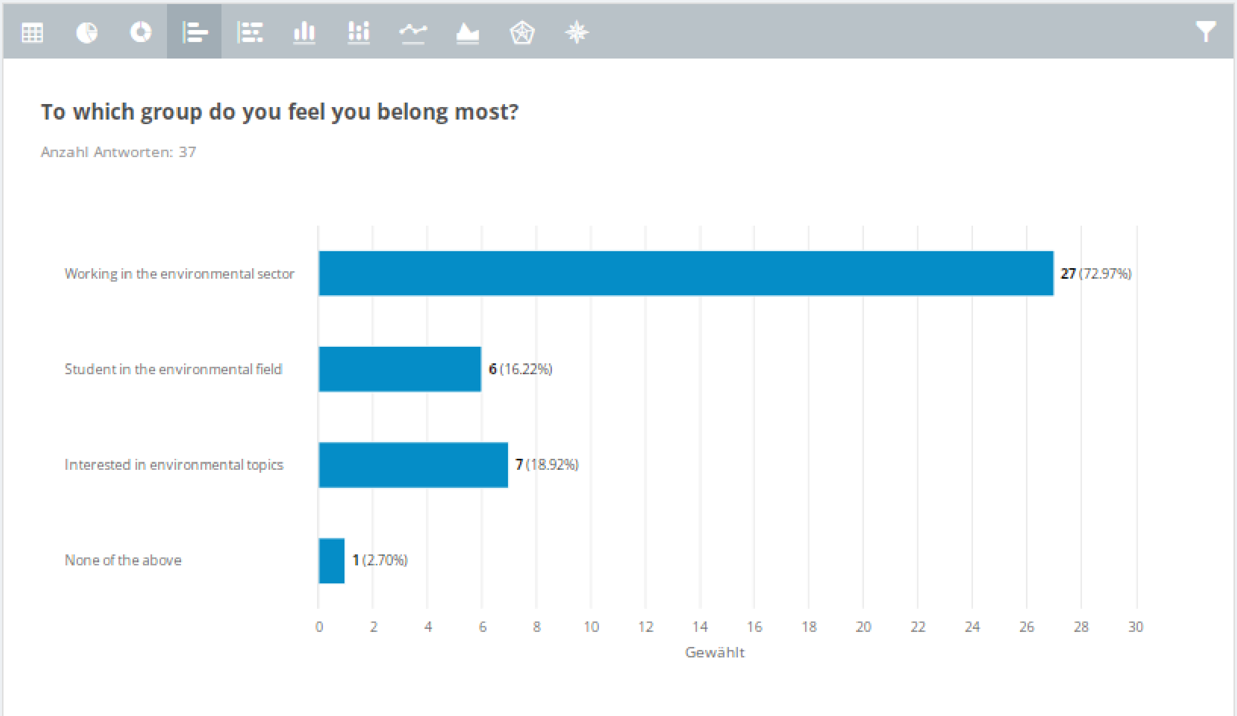


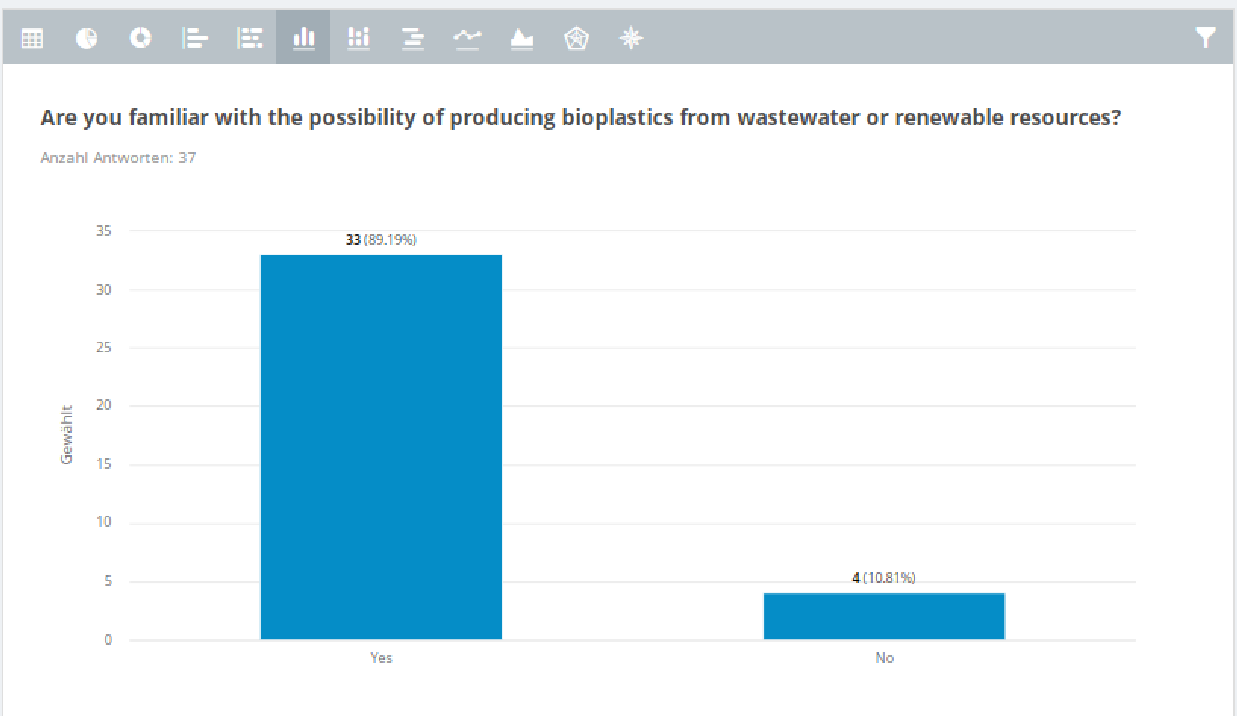
Welche Produkte aus Bioplastik würden Sie verwenden, wenn Sie Wissen das für die Herstellung folgende Abwasserströme / nachwachsende Rohstoffe genutzt wurden.

Anzahl Antworten: 6



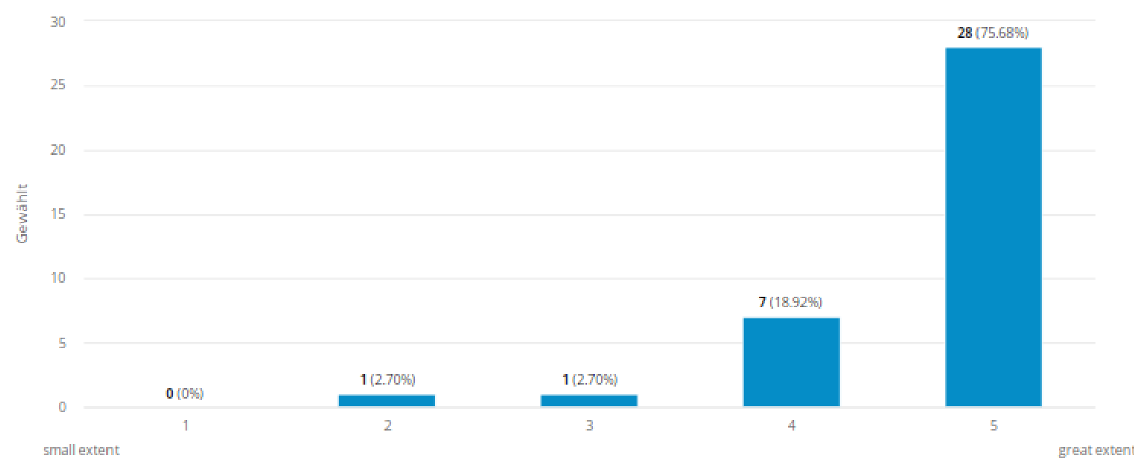
8.2 Survey: PHA production from residual streams General (English)





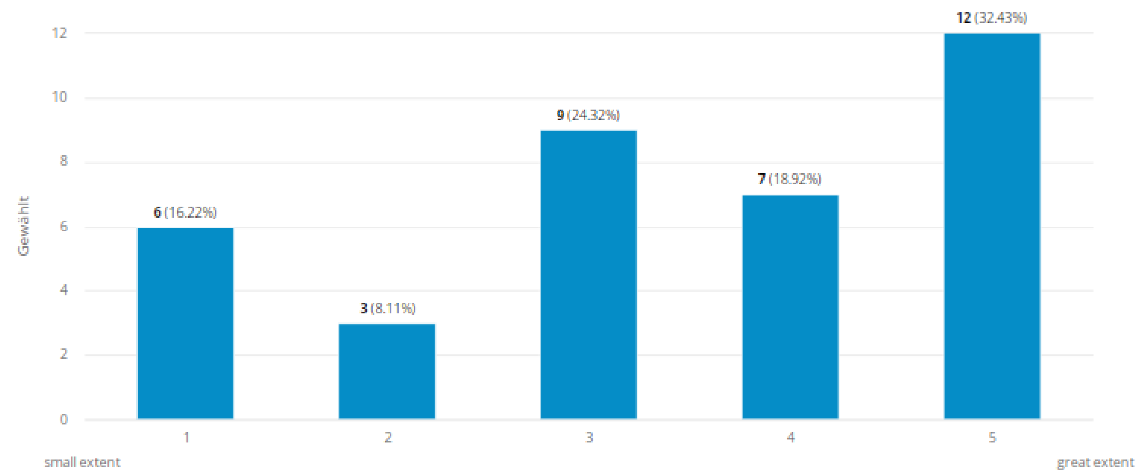
To what extent would you welcome the production of bioplastics from household or industrial wastewater streams (e.g., beer and juice industries)?

Anzahl Antworten: 37



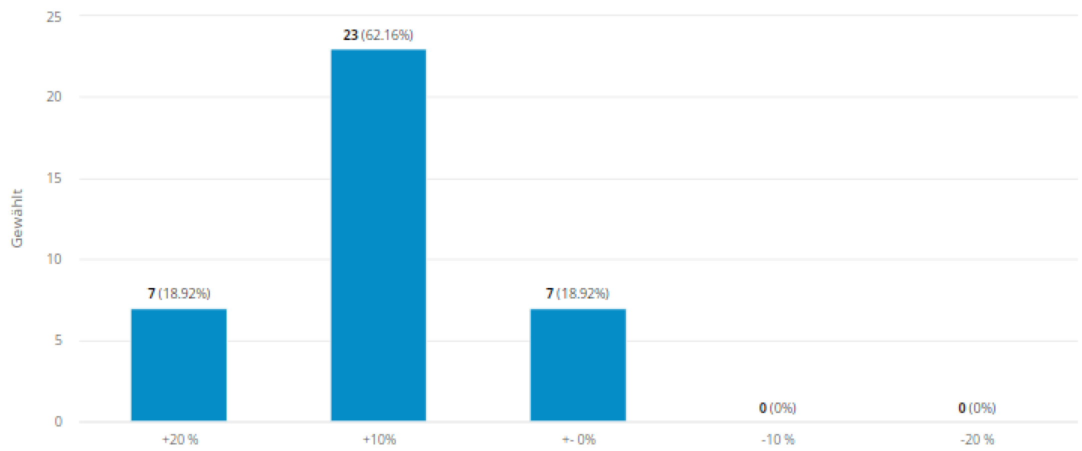
To what extent would the information that the product is derived from resources from household or industrial wastewater influence your perception?

Anzahl Antworten: 37



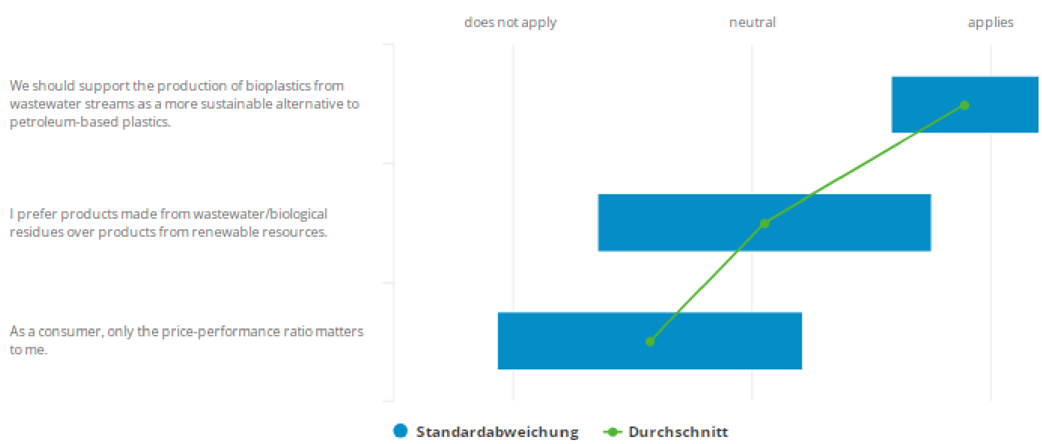
What price, compared to petroleum-based plastics, would you accept for products made from bioplastics sourced from wastewater streams, assuming they have the same properties?

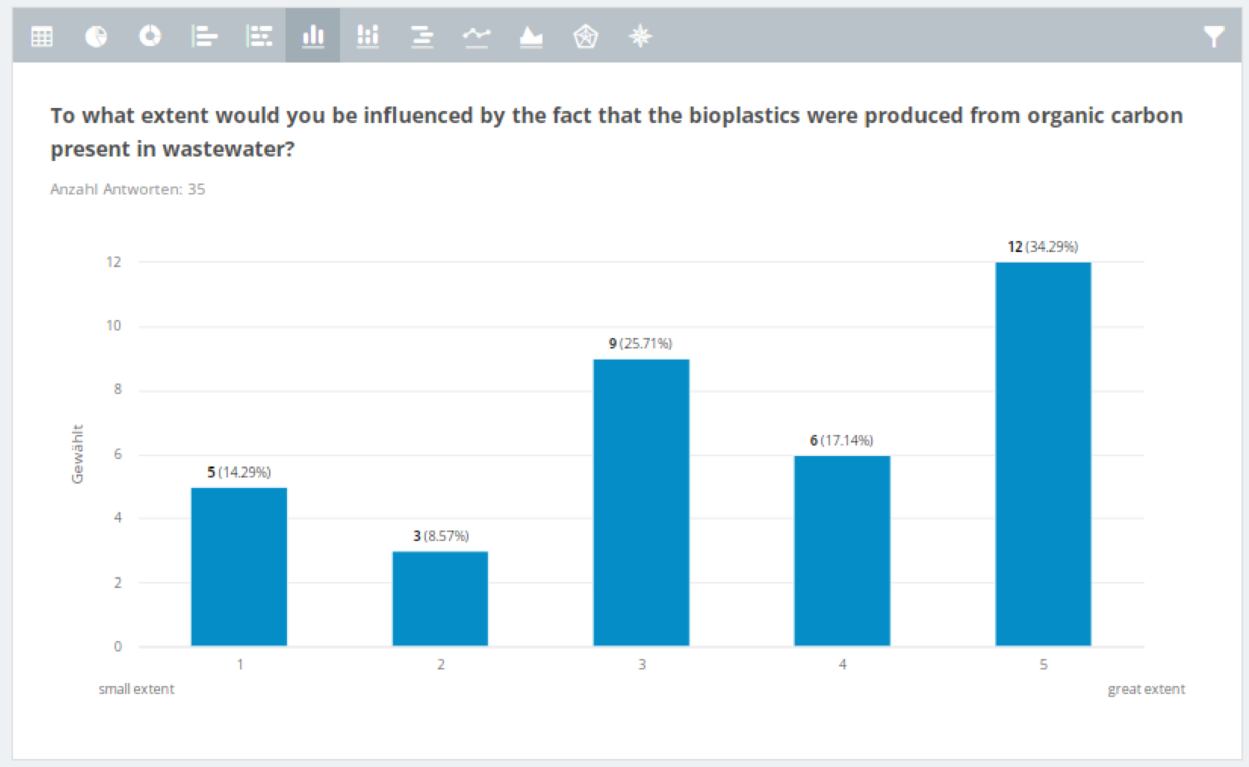
Anzahl Antworten: 37



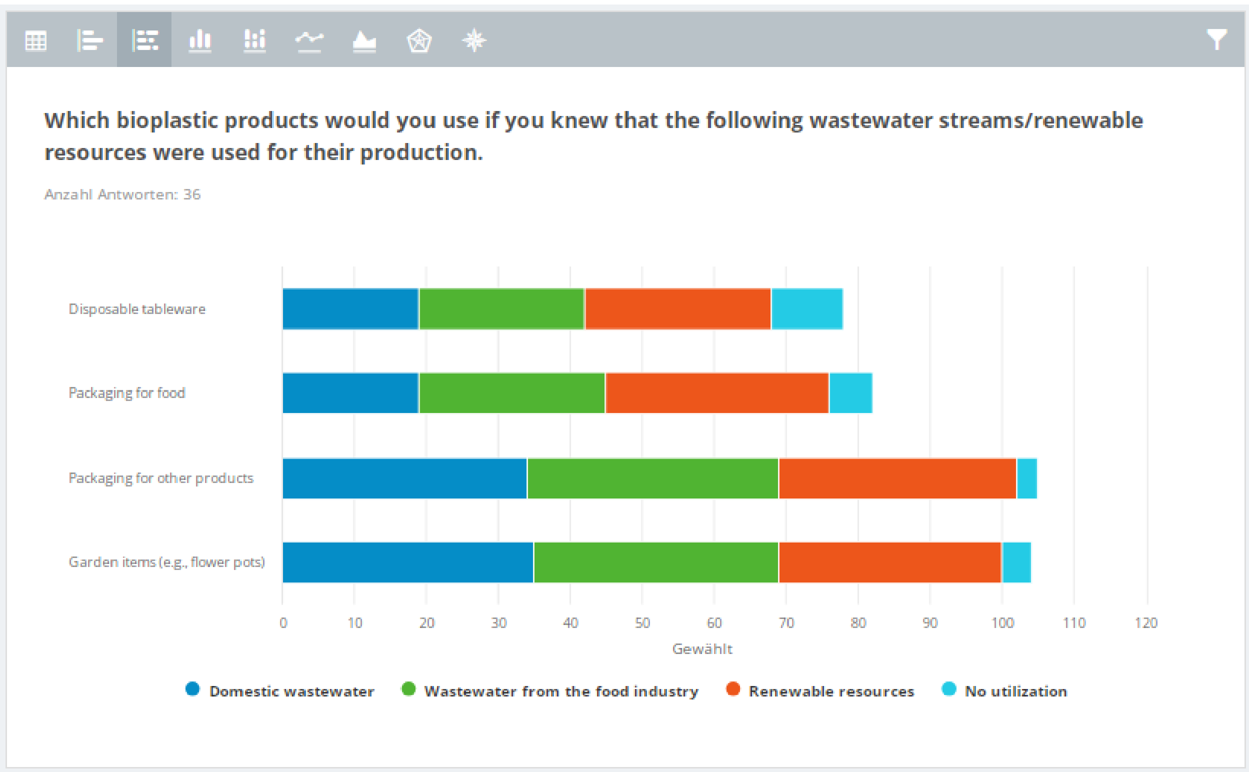
Which of the following statements regarding the justification for the additional costs in the previous question apply to you:

Anzahl Antworten: 37



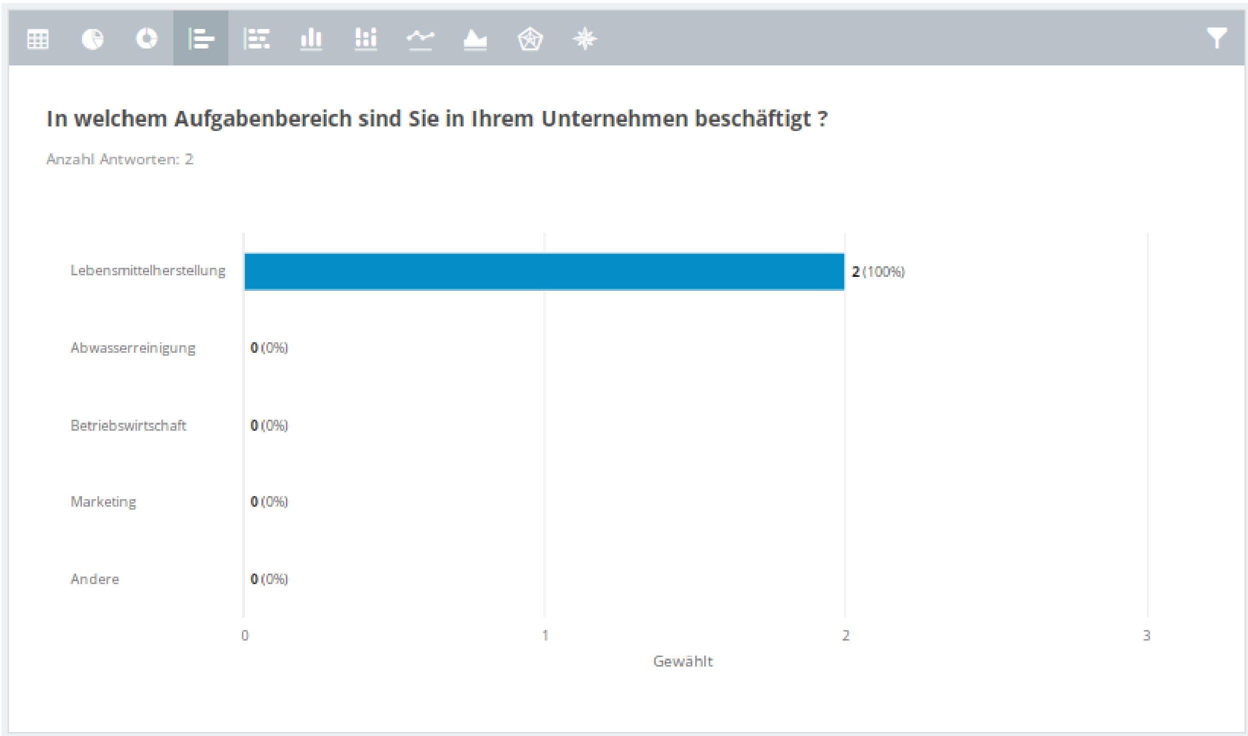


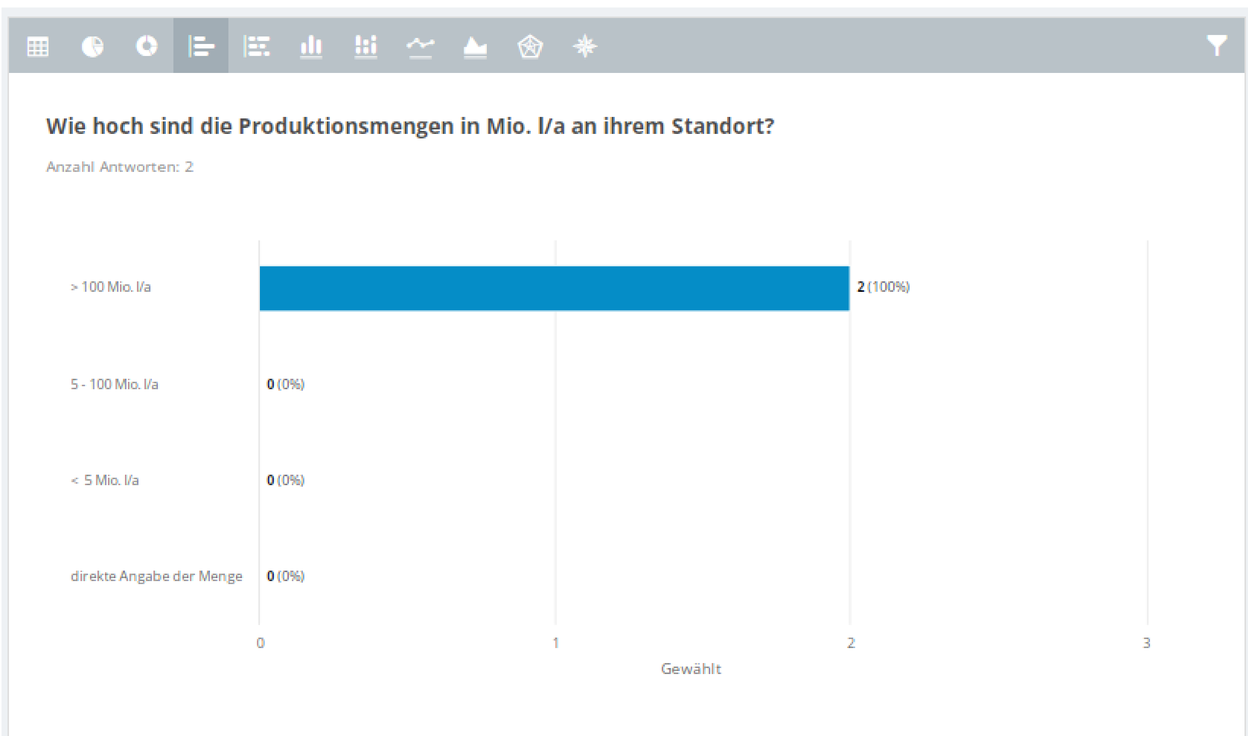
To what extent would you be influenced by the fact that the bioplastics were produced from organic carbon present in wastewater?
Anzahl Antworten: 35
12
10
8
6
4
2
0
Gewählt
5 (14.29%)
3 (8.57%)
9 (25.71%)
6 (17.14%)
12 (34.29%)
1
2
3
4
5
small extent
great extent



Which bioplastic products would you use if you knew that the following wastewater streams/renewable resources were used for their production.
Anzahl Antworten: 36
Disposable tableware
Packaging for food
Packaging for other products
Garden items (e.g., flower pots)
0
10
20
30
40
50
60
70
80
90
100
110
120
Gewählt
Domestic wastewater
Wastewater from the food industry
Renewable resources
No utilization

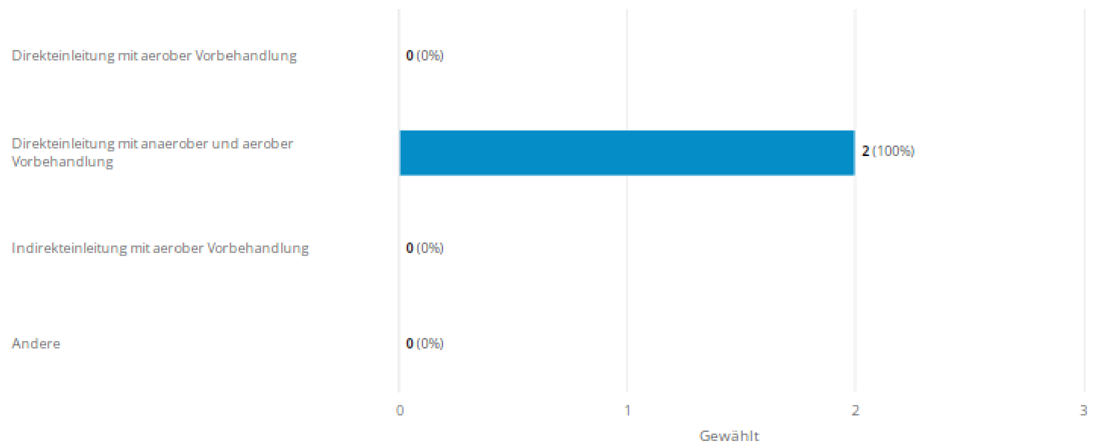
8.3 Survey: PHA production from residual streams from the brewery industry (German)





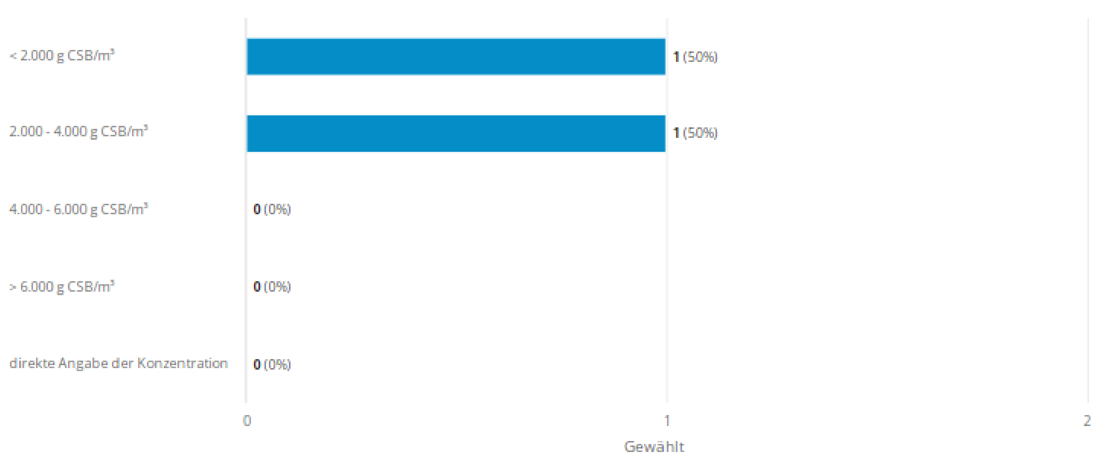
Wie erfolgt die Abwasserreinigung an Ihrem Produktionsstandort?

Anzahl Antworten: 2



In welchem Bereich liegt die mittlere CSB-Konzentration im Ablauf Ihrer Produktionsanlage?

Anzahl Antworten: 2



Wie hoch ist die Jahresabwassermenge in m^3/a und die Jahresabwasserfracht bezogen auf den Parameter CSB in kg/a im Ablauf der Produktionsanlage?

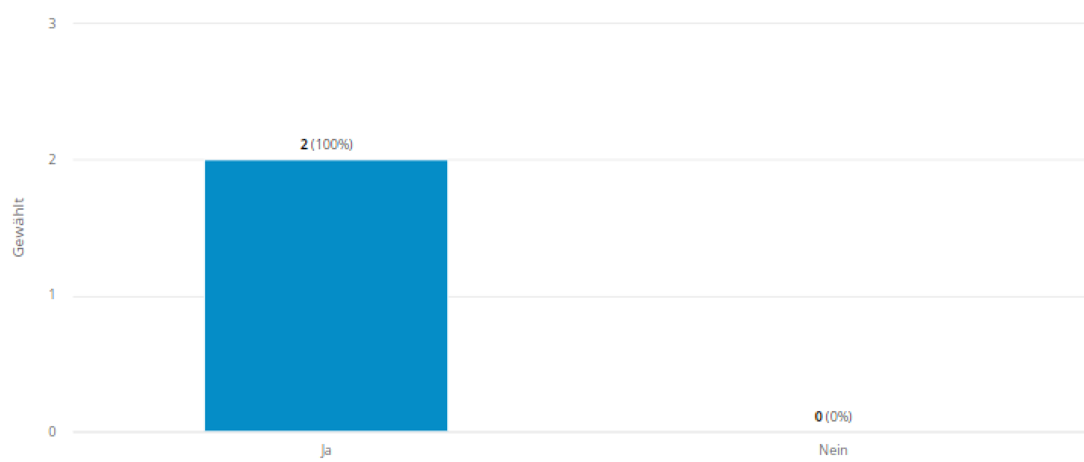
Anzahl Antworten: 2

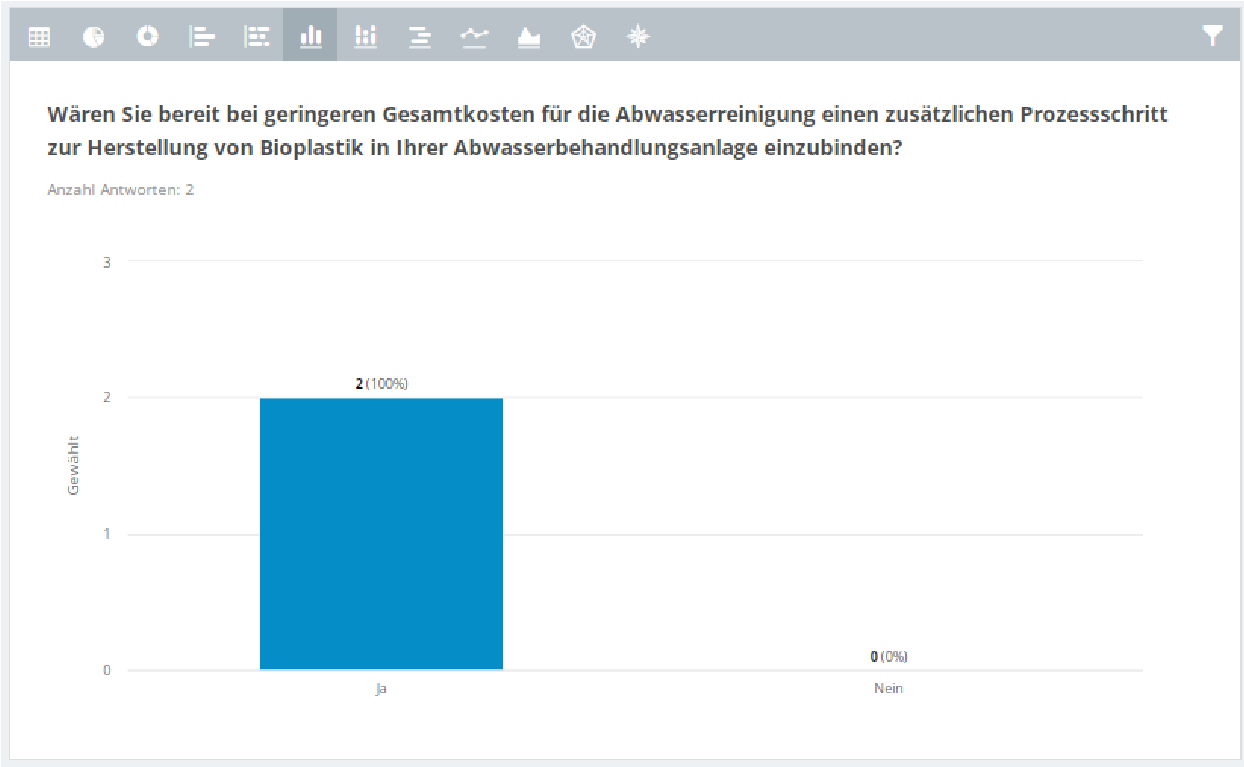
Text Antworten:

keine Angaben
650.000 m^3 Abwasser/a

Ist Ihnen die Thematik der Produktion von Bioplastik aus Abwasser bekannt?

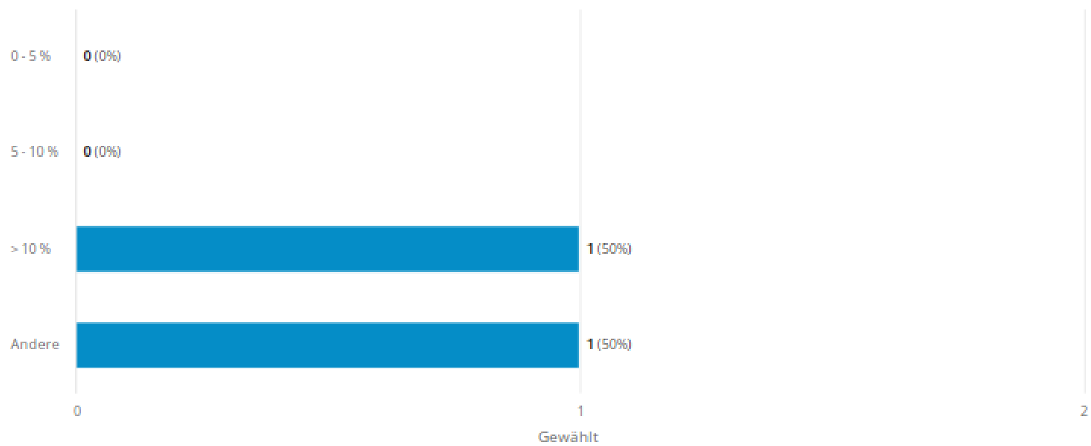
Anzahl Antworten: 2




Wären Sie bereit bei geringeren Gesamtkosten für die Abwasserreinigung einen zusätzlichen Prozessschritt zur Herstellung von Bioplastik in Ihrer Abwasserbehandlungsanlage einzubinden?
Anzahl Antworten: 2
Gewählt
3
2
1
0
2 (100%)
0 (0%)
Ja
Nein

Wie hoch müssten die Einsparungen sein, dass Sie einen weiteren Prozessschritt zur Herstellung von Bioplastik in Ihrer Abwasserbehandlungsanlage implementieren würden?

Anzahl Antworten: 2



"Andere" Text Antworten:

Es muss eine Ermitlung vom ROI stattfinden

Würden Sie es als Marketingvorteil sehen, wenn Sie die Ressourcen in Ihrem Abwasser wiederverwenden würden?

Anzahl Antworten: 2