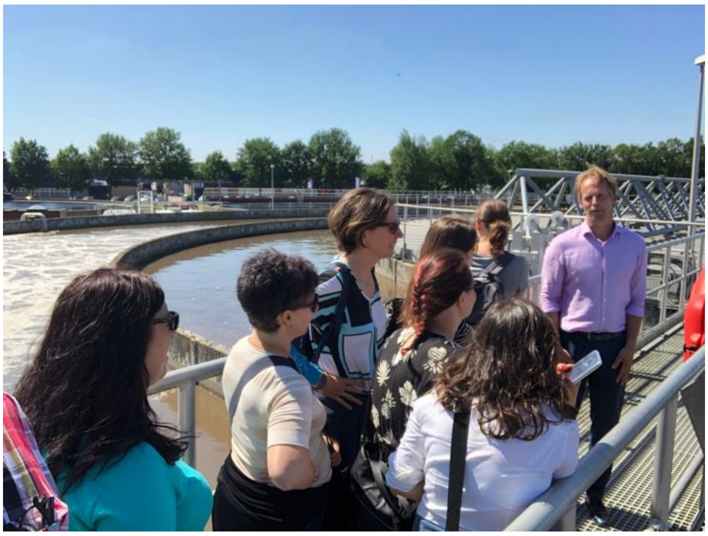
Report on good practices to promote the transition to circular economy in urban and industrial water management: A new water circularity index - Addendum



Wastewater in Natural Environment WINE

2020/13

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Executive summary: This Report is the result of the work of the “Wastewater in Natural Environment” project team. It intends to be an addendum of the report on Water Circularity Index and shows the use of the Water Circularity Index into two new installations which allowed to strengthen the application of this tool. It was also initiated a study of a specific industry, namely a regional and seasonal industry, the production of rhum from sugarcane in Madeira Island (Portugal), which is intended to use in the project’s next phase in year 2021.	
Disclaimer: This report is the result of a project within the IMPEL network. The content does not necessarily represent the view of the national administrations.	

Introduction to IMPEL

The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) is an international non-profit association of the environmental authorities of the EU Member States, acceding and candidate countries of the European Union and EEA countries. The association is registered in Belgium and its legal seat is in Bruxelles, Belgium.

IMPEL was set up in 1992 as an informal Network of European regulators and authorities concerned with the implementation and enforcement of environmental law. The Network's objective is to create the necessary impetus in the European Community to make progress on ensuring a more effective application of environmental legislation. The core of the IMPEL activities concerns awareness raising, capacity building and exchange of information and experiences on implementation, enforcement and international enforcement collaboration as well as promoting and supporting the practicability and enforceability of European environmental legislation.

During the previous years, IMPEL has developed into a considerable, widely known organisation, being mentioned in a number of EU legislative and policy documents, e.g. the 6th Environment Action Programme and the Recommendation on Minimum Criteria for Environmental Inspections.

The expertise and experience of the participants within IMPEL make the network uniquely qualified to work on both technical and regulatory aspects of EU environmental legislation. Information on the IMPEL Network is also available through its website at www.impel.eu.

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Introduction

In a classical context the "transition to the circular economy" is described by the water use efficiency taken into account primarily the quantitative aspects. According this approach the transition should be promoted by the reduction of freshwater consumption, minimization of leaks and losses, through the promotion of reuse practices, such as the use of treated wastewaters and rain waters and also by the valorisation of urban depuration sludge and other solids like manure, namely as sources of organic matter, nutrients and energy.

However, a more complex approach is needed and the real transition to a circular model can only be achieved by the conjunction of above factors with the related processes. To ensure a true transition to a circular model, water must be seen under an integrated approach as mean of transport, as source of energy and a service. Other factors that also should be emphasized in this kind of assessment is the energy consumption, the emission of green gases and the content of water in terms of microplastics and compounds of emergent concern.

During the project's previous phase, a tool applicable to the aspects of the water use and reuse at industrial and urban level was developed. This tool was named circularity index and it was constructed taking into account the main factors of water use cycle linked with the principles of circular economy, which allowed to see that the use of a more integrated and holistic vision for water reuse at industrial and urban level may, subsequently, encourage practices with a better contribution to the transition for a circular economy.

Since a deeper knowledge of the best practices was still needed, namely to understand the real impact of the circularity index in the products that are produced with reclaimed water, it was planned to extend the study to final products, to assess the impact of promoting the compliance of environmental legislation on the "reuse markets". This would allow to understand the differences between having products just assessed in terms of a quantitative water footprint and its evaluation in terms of the qualitative aspects, namely in terms of real impacts over water bodies.

Taking into account the concepts of water reuse and circular economy, the project was renamed to Wastewater in Natural Environment (WINE) to integrate the real idea of water circularity.

Therefore, it was proposed to extend the study and the reassessment of the index during the year of 2020. However, since the abnormal pandemic situation due to the SARS-CoV-2 virus occurred, the proposed activities for the project were impacted and the information that was possible to collect under this atypical period didn't allowed the reassessment of the tool in form to be applied to final products.

In this way, during 2020 it was initiated the study of a specific industry, namely a regional and seasonal industry, the production of rhum from sugarcane in Madeira Island (Portugal), which is intended to use in the project's next phase in year 2021.

The index developed in 2019 was also applied to two new installations in two different countries, which allowed to strengthen the application of the tool.

Main outcomes from the 2019 IWA project

During the 2019 project phase an index applicable to the aspects of the water use and reuse at industrial and urban level was produced. The index was named Water Circularity Index (I_c) and it was constructed taking into account the main factors of water use cycle linked with the principles of circular economy. The key-factors that build the index are: Freshwater consumption; Wastewater discharges (Non-IED installations and IED installations); Water reuse, best management practice and technologies; priority substances (PS), priority hazardous substances (PHS) and other pollutants (OP) and specific pollutants (SP), microplastics and/or compounds of emergent concern, biodiversity, recovery of nutrients, internal industrial symbiosis, sludge and voluntary and incentive instruments.

This index can be, therefore, used as an indicator to measure the circular principles linked with the urban and industrial water use cycle and it was applied to several case studies from several EU countries and clearly illustrated the efforts promoted inside different installations for a sustainable water use, namely in terms of circular principles, and its application to urban cycle also illustrates that the discharges more linked with the WFD principles lead to high circularity values.

Furthermore, this index can be seen as tool to promote a better compliance of natural and water laws in line with the 9-point Action Plan adopted by the European Commission to increase compliance with and improve governance on EU environmental rules on activities.

A study of which key-factor and sub-key factor, within the circularity index, effectively contributes to a high or low circularity was also performed. From this evaluation, it was possible to see that the factors that contribute to negative circularity cases were: measures to reduce consumption without linking the impacts on the quality of wastewaters and contributing directly to its degradation; compliance of BREF-EAV without link to the WFD; promotion of water reuse with negative impacts on final concentration with negative impact on surface water; measures without removal of nutrients with visible negative effects on water bodies and without adoption of regulatory instruments. On the other hand, the factors that contribute to higher circularity cases are: compliance of ELV (ELV defined according WFD principles, where ELV needs to be lower than BREF-EAV, according check-list); the use of new technologies; actions to foreseen the ceasing or phase-out discharges, emissions and losses of priority hazardous substances; promotion of water reuse with positive impacts on biodiversity; promotion of integrated approach for competitive advantages; minimization of sludge production without impacts on final concentration and adoption of regulatory instruments.

Production of rhum from sugarcane

Regional and seasonal industries may play an important role for local economies, with higher impact in small regions. Some of these industries have historical importance but due to specific characteristics or "older" practices may have severe impacts for environment, namely for aquatic environment. However, for local products markets the use of sustainable practices presents an advantage for its public acceptance and exportation. Therefore, the use of a water circularity index could present an opportunity to promote a better environmental compliance and encourage practices with a better contribution to the transition for a circular economy, since it could be used as an indicator for these environmental good practices.

Therefore, a first example was chosen to study the possibility to redesign the circularity index to be applied to a final product. This example is the production of sugarcane rhum in Madeira Island (PT).

The sugarcane (*Saccharum officinarum*) is one of the most important crops in the history of Madeira Island. The production of sugarcane in this location dates back to the XV century, having contributed inexorably to the economic, social and cultural development of the Region through trade and sugar exports. Currently, sugarcane is mainly used in the production of cane honey and sugarcane rhum (agricultural rhum).

The largest areas of sugarcane production are in the municipalities of Ponta do Sol and Machico (with a respective relative importance of 29% and 28%), followed by the municipality of Santana (14%) and Calheta (8%), counting 79% of the area dedicated to the crop production in Madeira Autonomous Region (MAR). The other municipalities have a residual importance (figure 1).

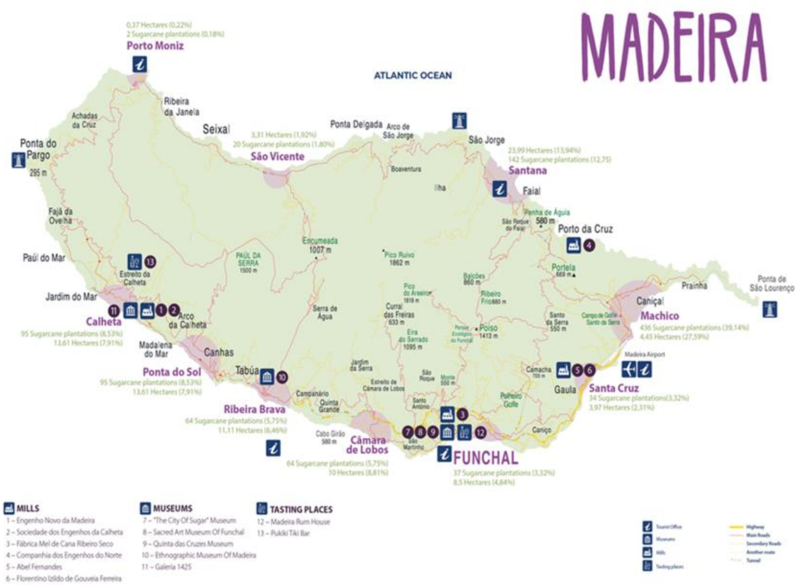

Figure 1: Madera Island and its municipalities

In 2017, the sugarcane production was 10,812 tons, in a dedicated area of 172 ha. The production of sugarcane and its processing are characterized by the production of several wastes and by-products.

During the crop phase stands out the production of a large amount of organic waste, namely tops and straws that include leaves, sheaths and the sugarcane pointer, as well as a variable amount of stem fragments. These wastes result from the cleaning process of canes, carried out to help their transport to the processing centers. Nowadays, these wastes are left in the fields where they suffer natural decomposition. In this phase, wastes from fertilizer and corrective packaging are also produced which remains in the fields or are managed through municipal waste management systems. Packaging residues of plant protection products are also produced.

Once harvested, the sugarcane is sent to processing centers for the production of honey or rhum. The sugarcane processing is associated with the production of a large amount of organic wastes, namely sugarcane bagasse. During the rhum production, in addition to the bagasse, is also produced an effluent called "vinasse", which has a large potential to cause negative impacts in the environment.

During project’s next phase is intended to assess the information related with this process and is intended to redesign the circularity index to be directly applied to Madeira’s rhum. This process may also allow to understand which practices are needed or could be implemented to improve environmental compliance in this industry.

Application of Water Circularity Index to real cases: 2020

To continue to explore the application of the Water Circularity Index to installations, two new cases, from different countries, were assessed during 2020, namely an urban wastewater treatment plant and a sugar beet factory.

The results of the application of the tool for the determination of the circularity index from these real cases are reported in table 1. For a detailed overview of the examples of application of the Circularity Index on national cases of participant Member States see Annex I.

The main results can be summarised as follow (table 1). The results are in line with the previous report, where major positive impacts are given by the compliance of ELV with link to the WFD.

Table 1: Results from the application of Circularity Index to case-studies

Case study	IED Installation	NON IED Installation	Description of WWTP	I_c
F		X	Urban wastewater treatment plant	**1,01**
G	X		Sugar beet factory	**0,07**

Final remarks

The abnormal pandemic situation due to SARS-CoV-2 led to some obstacles in the development of the activities proposed to be taken under this project phase, including the site visit that was scheduled for the 4^{th} quarter of 2020. Therefore, it was not possible to collect all the information required to initiate the development of the improved circularity index to be applied to products.

Despite this situation, some information was already collected and it was possible to understand the importance that a water circularity index may present to a regional and seasonal product. The index presents an opportunity to improve and promote a better environmental compliance, since this kind of indicator may be used to show to the consumers the incorporation of real sustainable practices in terms of water uses, and subsequently promoting a real transition for circular economy.

To endure the application of the Water Circularity Index to installations, two new cases, from different countries, were also assessed and the results, such as the previous phase ones, reveal major positive impacts are given by the compliance of ELV with link to the WFD.

During this phase the translation of previous phase report from English to Italian and to Portuguese was also performed to promote a wide disclosure of the IMPEL work.

A deeper knowledge of the best practices is still needed, namely to understand the real impact of the circularity index in the products that are produced with reclaimed water. This kind of assessment could be applied to “reuse markets” already in place or to promote new ones by assessing “low circularity” products and identifying possible ways for the transition by the use of circularity indexes. The study of several products from several types of activities (e.g., IED, agriculture and food production, regional/seasonal activities) will allow to identify specific needs and will be the main focus of project’s next phase in year 2021.

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ANNEX I: Examples of circularity index applied on national cases of participant Member States

In this annex two examples of application of the Circularity Index on national cases of participant Member States are reported.

CASE STUDY F

The keys factors were applied to an urban wastewater treatment plant. The key operation details are:

- Load capacity (p.e): 950 000 p.e. (1 p.e. = 60g BOD5 per day)
- Annual average wastewaters input: 30 000 000 m3
- Treatment process: Mechanical-Biological-Chemical (only for phosphorous reduction)
- The sludge is passed through the process of fermentation and stabilization followed by dehydration; From the fermentation process the biogas is collected separately.

ID Key Factor	Key and sub-key factors	Key factor value (F_{key})	Sub-Key factor value ($f_{i\ s\text{-}key}$)	Key factor (applicable-1; Non applicable - 0)	Sub-key factor(applicable-1; Non applicable - 0); All sub key factors are applicable when key factor applies	Sub-Key factor value ($f_{i\ s\text{-}key}$) (0 to measures/situations not in place and 1 for measures/situations in place)	Weighting factor ($f_{i\ w}$)	$f_{i\ s\text{-}Key} \times f_{i\ w}$
1	**Freshwater consumption**	9		1				
	Measures to reduce consumption without linking the impacts on the quality of wastewaters and contributing directly to its degradation		-9,00		1	0	0,00	0,00
	Measures to reduce consumption without linking impacts on the quality of wastewaters (with non-significant variation on wastewater quality, e.g., reduction on groundwater abstraction with low impacts on wastewaters)		1,00		1	1	0,01	0,01
	Measures to reduce consumption with measures to reduce possible effects of effluents concentration		4,00		1	0	0,00	0,00
	Reducing abstraction directly from water body (ex. Rainwater collection and reuse) promoting replenishment.		4,00		1	0	0,00	0,00
2.a	**Wastewater discharges non IED installations**	9		1				
	Compliance of ELV without link to the WFD (flat values) and with effects on water status		-9,00		1	0	0,00	0,00
	Compliance of ELV without link to the WFD (flat values) and with no known effects on water status		2,00		1	0	0,00	0,00
	Compliance of ELV with link to the WFD		7,00		1	1	0,07	0,49
3	**Water Reuse**	9		0				
	Promotion of water reuse with negative impacts on final concentration of the wastewaters discharged with negative impact on surface water		-6,00		0	0	0,00	0,00
	Promotion of water reuse with negative impacts on final concentration of the wastewaters discharged and no impact on groundwater abstraction		-3,00		0	0	0,00	0,00
	Promotion of water reuse without negative impacts on final concentration of the wastewaters discharged		3,00		0	0	0,00	0,00
	Promotion of water reuse with positive impacts on final concentration of the wastewaters discharged		6,00		0	0	0,00	0,00
4	**Best management practice & technologies**	9		1				
	Use of lower level than BAT		-9,00		1	0	0,00	0,00
	Use of BAT		1,00		1	1	0,01	0,01
	Promotion of management solutions to reduce CO2 emissions		3,50		1	1	0,04	0,12
	Use of new technologies (go beyond BAT, with promotion of new developments) (ex. Equipment, maintenance and process improvement to reduce the microplastic release into effluent)		4,50		1	0	0,00	0,00
5	**Priority substances (PS) / priority hazardous substances (PHS) and other substances (OS)/ specific pollutants (SP)**	9		0				
	With PHS and no actions to foreseen the ceasing or phase-out discharges, emissions and losses		-6,00		0	0	0,00	0,00
	With PS/OS/SP and no actions to foreseen the reduction of discharges, emissions and losses		-3,00		0	0	0,00	0,00
	With PS/OS/SP and actions to foreseen the reduction of discharges, emissions and losses		3,00		0	0	0,00	0,00
	With PHS and actions to foreseen the ceasing or phase-out discharges, emissions and losses		6,00		0	0	0,00	0,00
	∑KF +++			3	11			

ID Key Factor	Key and sub-key factors	Key factor value (F_{key})	Sub-Key factor value ($f_{i\ s\text{-}key}$)	Key factor (applicable-1; Non applicable - 0)	Sub-key factor(applicable-1; Non applicable - 0); All sub key factors are applicable when key factor applies	Sub-Key factor value ($f_{i\ s\text{-}key}$) (0 to measures/situations not in place and 1 for measures/situations in place)	Weighting factor ($f_{i\ w}$)	$f_{i\ s\text{-}Key} \times f_{i\ w}$
6	**Microplastics and/or Compounds of emergent concern**	5		0				
	Promotion of removal solutions to reduce microplastic content in wastewater discharge		2,50		1	0	0,00	0,00
	Promotion of removal solutions to reduce compounds of emergent concern content in wastewater discharge		2,50		1	0	0,06	0,00
7	**Biodiversity**	5		0				
	Promotion of water reuse with negative impacts on biodiversity (water quality and quantity index)		-5,00		0	0	0,00	0,00
	Promotion of water reuse without negative impacts on biodiversity (water quality and quantity index)		2,00		0	0	0,00	0,00
	Promotion of water reuse with positive impacts on biodiversity (water quality and quantity index)		3,00		0	0	0,00	0,00
8	**Recovery of nutrients**	5		1				
	Without removal of nutrients with visible negative effects on water bodies (directly linked with the installation)		-5,00		1	0	0,00	0,00
	Removal of nutrients to prevent negative effects on water bodies without further nutrient uses		0,50		1	0	0,00	0,00
	Just recovery of nutrients for further uses (without influence on water bodies)		1,50		1	1	0,04	0,06
	Removal of nutrients to prevent negative effects on water bodies with further nutrient uses (ex. Struvite recovery)		3,00		1	0	0,00	0,00
9	**Internal industrial symbiosis**	5		1				
	Without promotion of integrated approach for competitive advantages.		-5,00		1	1	0,13	-0,63
	Promotion of integrated approach for competitive advantages through the exchange of water, materials and energy between industries (ex. Wastewater with metals reused in a metal factory)		5,00		1	0	0,00	0,00
	∑KF ++			2	8			
10	**Sludge**	1		1				
	Minimization of sludge production, bio-thermal energy production from anaerobic digestion and reuse of treated sludge from aerobic digestion with impacts on final concentration of the wastewaters discharged		-1,00		1	0	0,00	0,00
	Minimization of sludge production, bio-thermal energy production from anaerobic digestion and reuse of treated sludge from aerobic digestion without impacts on final concentration of the wastewaters discharged		1,00		1	1	0,50	0,50
11	**Voluntary and incentive instruments**	1		0				
	Without adoption of regulatory instruments, economic instruments, certification and labelling rules, environmental management systems)		-1,00		0	0	0,00	0,00
	Adoption of regulatory instruments, economic instruments, certification and labelling rules, environmental management systems as measures towards the circular economy		1,00		0	0	0,00	0,00
	∑KF +			1	2			

$\sum(f_{i\ s\text{-}Key} \times f_{i\ w})$	0,72
N_f	0,64
Ic	**1,01**

Ic <0	Negative Circularity: Negative inputs for the circular economy
Ic = 0	No inputs for circular economy
0 < Ic ≤ 0,85	Low Circularity: Low level of inputs for circular economy
0,85 < Ic ≤ 1,5	Medium Circularity: Medium level of inputs for circular economy
Ic > 1,5	High Circularity: High level of inputs for circular economy

CASE STUDY G

The keys factors were applied to a sugar beet factory. The key operation details are:

- Production of sugar : 1700 ton/day
- Discharge of treated wastewater: 375 m³/hour; 1 400 000 m³/year
- Extraction of groundwater: 380.000 m³/year

ID Key Factor	Key and sub-key factors	Key factor value (F_{key})	Sub-Key factor value ($f_{i\ s\text{-}key}$)	Key factor (applicable-1; Non applicable - 0)	Sub-key factor(applicable-1; Non applicable - 0); All sub key factors are applicable when key factor applies	Sub-Key factor value ($f_{i\ s\text{-}key}$) (0 to measures/situations not in place and 1 for measures/situations in place)	Weighting factor ($f_{i\ w}$)	$f_{i\ s\text{-}Key}$ x $f_{i\ w}$
1	**Freshwater consumption**	9		1				
	Measures to reduce consumption without linking the impacts on the quality of wastewaters and contributing directly to its degradation		-9,00		1	0	0,00	0,00
	Measures to reduce consumption without linking impacts on the quality of wastewaters (with non-significant variation on wastewater quality, e.g., reduction on groundwater abstraction with low impacts on wastewaters)		1,00		1	0	0,00	0,00
	Measures to reduce consumption with measures to reduce possible effects of effluents concentration		4,00		1	1	0,02	0,09
	Reducing abstraction directly from water body (ex. Rainwater collection and reuse) promoting replenishment.		4,00		1	1	0,02	0,09
2.b	**Wastewater discharges IED installations**	9		1	1			
	Compliance of BREF-EAV without link to the WFD		-9,00		1	0	0,00	0,00
	Situations where BREF-EAV can be equal to ELV, according check-list		2,00		1	0	0,00	0,00
	Compliance of ELV (ELV defined according WFD principles, where ELV needs to be lower than BREF-EAV, according check-list)		7,00		1	1	0,04	0,29
3	**Water Reuse**	9		1				
	Promotion of water reuse with negative impacts on final concentration of the wastewaters discharged with negative impact on surface water		-6,00		1	0	0,00	0,00
	Promotion of water reuse with negative impacts on final concentration of the wastewaters discharged and no impact on groundwater abstraction		-3,00		1	0	0,00	0,00
	Promotion of water reuse without negative impacts on final concentration of the wastewaters discharged		3,00		1	1	0,02	0,05
	Promotion of water reuse with positive impacts on final concentration of the wastewaters discharged		6,00		1	0	0,00	0,00
4	**Best management practice & technologies**	9		1				
	Use of lower level than BAT		-9,00		1	0	0,00	0,00
	Use of BAT		1,00		1	1	0,01	0,01
	Promotion of management solutions to reduce CO2 emissions		3,50		1	0	0,00	0,00
	Use of new technologies (go beyond BAT, with promotion of new developments) (ex. Equipment, maintenance and process improvement to reduce the microplastic release into effluent)		4,50		1	0	0,00	0,00
5	**Priority substances (PS) / priority hazardous substances (PHS) and other substances (OS)/ specific pollutants (SP)**	9		1				
	With PHS and no actions to foreseen the ceasing or phase-out discharges, emissions and losses		-6,00		1	0	0,00	0,00
	With PS/OS/SP and no actions to foreseen the reduction of discharges, emissions and losses		-3,00		1	1	0,02	-0,05
	With PS/OS/SP and actions to foreseen the reduction of discharges, emissions and losses		3,00		1	0	0,00	0,00
	With PHS and actions to foreseen the ceasing or phase-out discharges, emissions and losses		6,00		1	0	0,00	0,00
	∑KF +++			5	19			
ID Key Factor	Key and sub-key factors	Key factor value (F_{key})	Sub-Key factor value ($f_{i\ s\text{-}key}$)	Key factor (applicable-1; Non applicable - 0)	Sub-key factor(applicable-1; Non applicable - 0); All sub key factors are applicable when key factor applies	Sub-Key factor value ($f_{i\ s\text{-}key}$) (0 to measures/situations not in place and 1 for measures/situations in place)	Weighting factor ($f_{i\ w}$)	$f_{i\ s\text{-}Key}$ x $f_{i\ w}$

6	**Microplastics and/or Compounds of emergent concern**	5		0				
	Promotion of removal solutions to reduce microplastic content in wastewater discharge		2,50				0,00	0,00
	Promotion of removal solutions to reduce compounds of emergent concern content in wastewater discharge		2,50				0,00	0,00
7	**Biodiversity**	5		1				
	Promotion of water reuse with negative impacts on biodiversity (water quality and quantity index)		-5,00		1	0	0,00	0,00
	Promotion of water reuse without negative impacts on biodiversity (water quality and quantity index)		2,00		1	1	0,04	0,09
	Promotion of water reuse with positive impacts on biodiversity (water quality and quantity index)		3,00		1	0	0,00	0,00
8	**Recovery of nutrients**	5		1				
	Without removal of nutrients with visible negative effects on water bodies (directly linked with the installation)		-5,00		1	0	0,00	0,00
	Removal of nutrients to prevent negative effects on water bodies without further nutrient uses		0,50		1	0	0,00	0,00
	Just recovery of nutrients for further uses (without influence on water bodies)		1,50		1	1	0,03	0,05
	Removal of nutrients to prevent negative effects on water bodies with further nutrient uses (ex. Struvite recovery)		3,00		1	0	0,00	0,00
9	**Internal industrial symbiosis**	5		1				
	Without promotion of integrated approach for competitive advantages.		-5,00		1	1	0,11	-0,56
	Promotion of integrated approach for competitive advantages through the exchange of water, materials and energy between industries (ex. Wastewater with metals reused in a metal factory)		5,00		1	0	0,00	0,00
	∑KF ++			3	9			
10	**Sludge**	1		1				
	Minimization of sludge production, bio-thermal energy production from anaerobic digestion and reuse of treated sludge from aerobic digestion with impacts on final concentration of the wastewaters discharged		-1,00		1	0	0,00	0,00
	Minimization of sludge production, bio-thermal energy production from anaerobic digestion and reuse of treated sludge from aerobic digestion without impacts on final concentration of the wastewaters discharged		1,00		1	1	0,25	0,25
11	**Voluntary and incentive instruments**	1		1				
	Without adoption of regulatory instruments, economic instruments, certification and labelling rules, environmental management systems)		-1,00		1	1	0,25	-0,25
	Adoption of regulatory instruments, economic instruments, certification and labelling rules, environmental management systems as measures towards the circular economy		1,00		1	0	0,00	0,00
	∑KF +			2	4			

$\sum(f_{i\ s\text{-}Key} \times f_{i\ w})$	0,06
N_f	0,93
Ic	**0,07**

Ic <0	Negative Circularity: Negative inputs for the circular economy
Ic = 0	No inputs for circular economy
0 < Ic ≤ 0,85	Low Circularity: Low level of inputs for circular economy
0,85 < Ic ≤ 1,5	Medium Circularity: Medium level of inputs for circular economy
Ic > 1,5	High Circularity: High level of inputs for circular economy
Ic <0	Negative Circularity: Negative inputs for the circular economy