Wastewater Impact Assessment Tool V1
Science and Methods

March 2023

Content

1. Global Indicators

The global indicators are intended to report on the status of water security issues at the global level. These indicators are classified in 3 different groups, the first one is the population indicator, which is used to observe how the population is distributed in the world. The next group is water quantity, in which there are all the indicators related to water quantity (available water, ratios of availability and demand, risk of flooding or drought ...). The third major group is water quality.

Population			
		Population	
Water quantity			
	Water availability		
		Water variability	
			Seasonal variability
			Interannual variability
		Water supply	
		Flow accumulation	
		Stream flow	
	Water demand		
		Water demand	
	Water scarcity ratios		
		Water stress	
		Water depletion	
		Aridity index	
	Groundwater		
		Groundwater table decline	
	Flood risk		
		Riverine flood risk	
		Coastal flood risk	
	Drought risk		
		Drought risk	
Water quality			
	Pollution		
		Coastal Eutrophication Potential	

Surface Water Pharmaceutical Pollution Coastal Pharmaceutical Pollution Unimproved/ No drinking water Unimproved/ No sanitation BOD Nitrates

1.1. Population

The population indicator indicates the number of inhabitants in each region. The objective of this indicator is to inform about the number of people that can be affected by an industry in a region if it has a negative impact on the quality or quantity of water.

Name	Population
Sub-group	Population
Spatial resolution	60 X 60 arc minute cells
Temporal resolution	5 years
Temporal range	2000 – 2020
Unit	Amount of people
Source	CEISIN
Description	Data set whit the current world population and a 2030 BAU future scenario projection. (*Documentation » Gridded Population of the World (GPW), v4 | SEDAC*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.2. Water Quantity

Quantity indicators report on issues related to water quantity. There are 4 different subgroups related to water quantity:

- Water availability informs about what is the quantity of water we find at a point, calculated in different ways and with different sources of information, in this subgroup are also the indicators that show the variability of quantity.
- Water demand informs about the demand of water for different uses.
- The availability and demand indicators are combined to create water scarcity ratios. Groundwater availability over demand is illustrated through the decline status of aquifers .

- Finally, the flood and drought indicators indicate the risk in each zone of being impacted by a flood or drought period and which population is going to be affected by it.

1.2.1. Water availability (surface water)

Name	Seasonal variability
Sub-group	Water availability
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 – 2014
Unit	-
Source	Aqueduct
Description	Seasonal variability measures the average within-year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations of available supply within a year. (Hofste et al., n.d.)
Equation	$seasonal\ variability = \frac{SD_{[jan...dec]}Q_m}{mean_{[jan...dec]}Q_m}$ $SD: Standard\ deviation$ $Q_m: Average\ available\ water\ per\ month$
Risk categories	• <0,33 Low • 0,33 – 0,66 Low – medium • 0,66 – 1,00 Midium – High • 1,00 – 1,33 High • >1,33 Extremely high (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Interannual variability
Sub-group	Water availability
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 – 2014

Unit	-
Source	Aqueduct
Description	Interannual, or between year, variability is defined as the coefficient of variation (CV) of available water for each sub-basin. The CV is the standard deviation (SD) of the available water, divided by the mean. (Hofste et al., n.d.)
Equation	$$interannual\ variability = \frac{SD_{[1960\ldots2014]}Q_m}{mean_{[1960\ldots2014]}Q_m}$$ $SD: Standard\ deviation$ $Q_m: Average\ available\ water\ per\ month$
Risk categories	• <0,25 Low • 0,25 – 0,50 Low – Medium • 0,50 – 0,75 Medium – high • 0,75 – 1,00 High • >1,00 Extremely high (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Water supply
Sub-group	Water availability
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 -2014
Unit	mm/year
Source	Aqueduct
Description	Water supply is the amount of surface water available at one point, it takes into account the up-stream consumptive use and the flow accumulated upstream. It does not take in account groundwater resources. The units used are mm/year, each mm is one litre of water in one square meter of surface, to calculate the available water in an area it is necessary to multiply the value of mm/year to the number of square meters that have the area (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)

Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Flow accumulation
Sub-group	Water availability
Spatial resolution	3,75 X 3,75 arc minute cells
Temporal resolution	Annual
Temporal range	2019
Unit	m^3/year
Source	Global Fate
Description	Flow accumulation indicates the amount of water accumulated at each cell as the sum of all the cells upstream over a year. It counts the run-off values from High-resolution fields of global runoff combining observed river discharge and simulated water balances. (Acuña et al., 2020)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Streamflow
Sub-group	Water availability
Spatial resolution	30 X 30 arc minute cells
Temporal resolution	Annual
Temporal range	2000 - 2016
Unit	m^3/second
Source	WaterGap2.2d
Description	Stream flow is the volume of superficial water flowing at one point, it considers the extraction of water for irrigation, livestock, domestic use, manufacturing process and thermal power. The source of this indicator is the WaterGap v2.2.d, a global hydrological model that quantifies human use of groundwater and surface water as well as water flows, water storage and thus water resources on all land areas worldwide. Stream flow has a spatial resolution of 0,5o X 0,5o grid cells (55km X 55km at the Equator) (Müller Schmied et al., 2021). To obtain the stream flow, we calculate the mean of the 2000 - 2016 monthly data. To create the 2030 BAU future scenario values we implement a lineal progression with the data from the WaterGap.
Used for	Calculating metrics that are related to the amount of surface water available in the water body that serves as water supply or discharge point.

1.2.2. Water demand (surface water)

The water demand indicator provides information on the water demand at each point.

Name	Water demand
Sub-group	Water demand
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 - 2014
Unit	mm/year
Source	Aqueduct
Description	Water demand measures the amount of water that is withdrawn at each point for domestic, agricultural, or industrial use.
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.2.3. Water scarcity ratios

This subgroup of indicators relates the water demand or consumption with the amount of water available. Some of these are focused on human actions while the others do focus more on water consumption by vegetation.

Name	Water stress
Sub-group	Water scarcity ratios
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 - 2014
Unit	%
Source	Aqueduct
Description	Baseline water stress measures the ratio of total water withdrawals to available renewable surface and groundwater supplies. Water withdrawals include domestic, industrial, irrigation, and livestock for both consumptive and no consumptive uses. Available renewable water supplies include the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate more competition among users. (Hofste et al., n.d.)
Equation	$WS = \frac{Gross\ Water\ Withdrawal}{Available\ Water\ - Net\ water\ Withdrawal}$
Risk categories	• <10% Low • 10 – 20% Low – medium

	• 20 – 40% Medium – high • 40 – 80% High • >80% Extremely high (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Water depletion
Sub-group	Water scarcity ratios
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 - 2014
Unit	%
Source	Aqueduct
Description	Baseline water depletion measures the ratio of total water consumption to available renewable water supplies. Total water consumption includes domestic, industrial, irrigation, and livestock consumptive uses. Available renewable water supplies include the impact of both upstream consumptive water users and large dams on downstream water availability. Higher values indicate larger impact on the local water supply and decreased water availability for downstream users.
Equation	$WD = \frac{Net\ Water\ Withdrawal}{Available\ Water\ - Net\ water\ Withdrawal}$
Risk categories	• <5% Low • 5 – 25% Low – medium • 25 – 50% Medium – high • 50 – 75% High • >75% Extremely high (Brauman et al., 2016)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Aridity index
Sub-group	Water scarcity ratios
Spatial resolution	30 X 30 arc seconds cells
Temporal resolution	Annual
Temporal range	1970 - 2000

Unit	-
Source	(Zomer et al., 2008)
Description	The second version of the Global Aridity Index (Zomer et al., 2008)provides global climate data for the 1970-2000 period, related to evapotranspiration processes and rainfall deficit for potential vegetative growth, based on the implementation of a Penman-Montieth Reference Evapotranspiration (ET0) equation. It provides information about the potential availability of water in regions with low water demand, thus they are used to better account for deserts and other arid areas in the risk assessment. Aridity is usually expressed as a generalized function of precipitation, temperature and potential evapo-transpiration. An Aridity Index can be used to quantify precipitation availability over atmospheric water demand.(*WWF Water Risk Filter Methodology Documentation*, 2021)
Risk categories	• >0,65 Humid • 0,5 – 0,65 Dry sub-humid • 0,2 – 0,5 Semi-arid • 0,03 – 0,20 Arid • <0,03 Hyper-arid (Middleton & Thomas, 1992)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.2.4. Groundwater

In this group there is only one indicator, Groundwater table decline, which can be used to see which is the trend of the amount of water in the groundwater aquifers, and whether it is decreasing or increasing.

Name	Groundwater table decline
Sub-group	Groundwater
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 - 2014
Unit	mm/year
Source	Aqueduct
Description	Groundwater table decline measures the average decline of the groundwater table as the average change for the period of study (1990–2014). The result is expressed in centimetres per year (cm/yr). Higher values indicate higher levels of unsustainable groundwater withdrawals. (Hofste et al., n.d.)
Risk categories	• <0cm/y Low

	• 0 – 2cm/y Low-medium • 2 – 4 cm/y Medium-high • 4 – 8 cm/y High • >8 cm/y Extremely high
Used for	Used to find which water withdraws take place areas with groundwater table decline.

1.2.5. Flood risk

Flood indicators aim to show the number of people who may be affected by flooding, by not only considering the frequency of flooding but also exposure and vulnerability.

Name	Riverine flood risk
Sub-group	Flood risk
Spatial resolution	30 X 30 arc minute cells
Temporal resolution	Annual
Temporal range	2010
Unit	-
Source	Aqueduct
Description	Riverine flood risk measures the percentage of population which is expected to be affected by riverine flooding in an average year, accounting for existing flood-protection standards. Flood risk is assessed using hazard (inundation caused by river overflow), exposure (population in flood zone), and vulnerability. The existing level of flood protection is also incorporated into the risk calculation. It is important to note that this indicator represents flood risk, not in terms of maximum possible impact but as an average of the annual impact instead. The impacts from infrequent, extreme flood years are averaged with more common, less newsworthy flood years to produce the "expected annual affected population." Higher values indicate that a greater proportion of the population is expected to be impacted by riverine floods on average. (Hofste et al., n.d.)
Risk categories	• 0 to 1 in 1.000 Low • 1 in 1.000 to 2 in 1.000 Low – medium • 2 in 1.000 to 6 in 1.000 Medium – high • 6 in 1.000 to 1 in 100 High • More than 1 in 100 Extremely high
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Coastal flood risk
Sub-group	Flood risk

Spatial resolution	30 X 30 arc minute cells
Temporal resolution	Annual
Temporal range	2010
Unit	-
Source	Aqueduct
Description	Coastal flood risk measures the percentage of the population expected to be affected by coastal flooding in an average year, accounting for existing flood protection standards. Flood risk is assessed using hazard (inundation caused by storm surge), exposure (population in flood zone), and vulnerability. The existing level of flood protection is also incorporated into the risk calculation. It is important to note that this indicator represents flood risk not in terms of maximum possible impact but as an average of the annual impact. The impacts from infrequent, extreme flood years are averaged with more common, less newsworthy flood years to produce the "expected annual affected population." Higher values indicate that a greater proportion of the population is expected to be impacted by coastal floods on average. (Hofste et al., n.d.)
Risk categories	• 0 to 9 in 1.000.000 — Low • 9 in 1.000.000 to 7 in 100.000 — Low – medium • 7 in 100.000 to 3 in 10.000 — Medium – high • 3 in 10.000 to 2 in 1000 — High • More than 2 in 1000 — Extremely high
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.2.6. Drought risk

Drought risk indicators show the number of people who may be affected by a period of drought, not only considering the frequency of droughts but also the exposure and vulnerability of the population affected.

Name	Drought risk
Sub-group	Drought risk
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	2000 - 2014
Unit	-
Source	Aqueduct
Description	Drought risk measures where droughts are likely to occur, the population and assets exposed, and the vulnerability of the

	population and assets to adverse effects. Higher values indicate higher risk of drought. (Hofste et al., n.d.)
Risk categories	• 0,0 – 0,2 Low • 0,2 – 0, 4 Low – medium • 0,4 – 0,6 Medium • 0,6 – 0,8 Medium - high • 0,8 – 1,0 High (Carrão et al., 2016)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.3. Water Quality

Water quality indicators show the state of the water and whether it is heavily polluted or not, as well as the percentage of people that have access to treated water and the percentage of people using pit latrines without a slab, platform or directly disposing human waste in fields.

1.3.1. Coastal Eutrophication Potential

Name	Coastal Eutrophication Potential
Sub-group	Water quality
Spatial resolution	30 X 30 arc second cells
Temporal resolution	Annual
Temporal range	2000
Unit	kgC-equivalent/km^2/day
Source	Aqueduct
Description	Coastal eutrophication potential (CEP) measures the potential for riverine loads of nitrogen (N), phosphorus (P), and silica (Si) to stimulate harmful algal blooms in coastal waters. The CEP indicator is a useful metric to map where anthropogenic activities produce enough point-source and nonpoint-source pollution to potentially degrade the environment. When N and P are discharged in excess over Si (in terms of diatoms), a major type of undesirable algal species often develop. The stimulation of algae leading to large blooms may result in hypoxia (excessive biological growth and decomposition that reduces oxygen available to other organisms). It is therefore possible to assess the potential for coastal eutrophication from a river's N, P, and Si loads. Higher values indicate higher levels of excess nutrients with respect to silica, creating more favourable conditions for harmful algal growth and eutrophication in coastal waters downstream.(Hofste et al., n.d.)

Risk categories	• < -5 Low • -5 – 0 Low – medium • 0 – 1 Medium – high • 1 – 5 High • > 5 Extremely high (*The Open Ocean Status and Trends SUMMARY FOR POLICY MAKERS International Hydrological Programme*, 2016)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.3.2. Surface Water Pharmaceutical Pollution

Name	Surface Water Pharmaceutical Pollution
Sub-group	Water quality
Spatial resolution	3,75 X 3,75 arc minute cells
Temporal resolution	Annual
Temporal range	2011 - 2013
Unit	Ng/L
Source	Global Fate
Description	Surface Water Pharmaceutical Pollution Indicates the concentration of the Diclofenac on the rivers from domestic uses, it takes in count the population consumption, the in-stream attenuation, excretion, and the removal at sanitation facilities. (Acuña et al., 2020)
Risk categories	• 0 Null • > 0 – 10 Low - medium • 10 – 30 Medium - high • 30 – 100 High • > 100 Extremely high (Acuña et al., 2020)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.3.3. Coastal Pharmaceutical Pollution

Name	Coastal Pharmaceutical Pollution
Sub-group	Water quality
Spatial resolution	3,75 X 3,75 arc minute cells
Temporal resolution	Annual
Temporal range	2011 - 2013
Unit	g/km*year

Source	Global Fate
Description	Coastal Pharmaceutical Pollution Indicates the amount of Diclofenac exported by the rivers to the ocean.(Acuña et al., 2020)
Risk categories	• < 10 Null • 10 – 50 Low - medium • 50 – 1.000 Medium - high • 1.000 – 100.000 High • > 100.000 Extremely high (Acuña et al., 2020)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.3.4. Unimproved/ no drinking water

Name	Unimproved/ no drinking water
Sub-group	Water quality
Spatial resolution	Country (rural/urban)
Temporal resolution	Annual
Temporal range	2015
Unit	%
Source	WHO & UNICEF
Description	Unimproved/no drinking water reflects the percentage of the population collecting drinking water from an unprotected dug well or spring, or directly from a river, dam, lake, pond, stream, canal, or irrigation canal (WHO & UNICEF, 2017). Specifically, the indicator is aligned with the unimproved and surface water categories of the Joint Monitoring Programme (JMP)—the lowest tiers of drinking water services. Higher values indicate areas where people have less access to safe drinking water supplies. (Hofste et al., n.d.)
Risk categories	• <2,5% Low • 2,5 – 5,0% Low – medium • 5,0% - 10,0% Medium – high • 10,0 – 20,0% High • >20,0% Extremely high (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.3.5. Unimproved/ no sanitation

Name	Unimproved/ no sanitation
Sub-group	Water quality
Spatial resolution	Country (rural/urban)
Temporal resolution	Annual
Temporal range	2015
Unit	%
Source	WHO & UNICEF
Description	Unimproved/no sanitation reflects the percentage of the population using pit latrines without a slab or platform, hanging/bucket latrines, or directly disposing human waste in fields, forests, bushes, open bodies of water, beaches, other open spaces, or with solid waste.(WHO & UNICEF, 2017) Specifically, the indicator aligns with JMP's unimproved and open defecation categories— the lowest tier of sanitation services. Higher values indicate areas where people have less access to improved sanitation services. (Hofste et al., n.d.)
Risk categories	• <2,5% Low • 2,5 – 5,0% Low – medium • 5,0% - 10,0% Medium – high • 10,0 – 20,0% High • >20,0% Extremely high (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.3.6. Biological Oxygen Demand (BOD)

Name	BOD
Sub-group	Water quality
Spatial resolution	0.5x0.5-degree grid cell
Temporal resolution	Annual
Temporal range	1992-2010
Unit	mg/l
Source	World Bank Water Data
Description	Globally gridded dataset of BOD in surface water for the years 1992-2010, monthly observations. Data is available at the 0.5x0.5-degree grid cell level. Units are mg/l. Data is generated using a machine learning model, as described in the report Quality unknown: The Invisible Water Crisis.
Risk categories	• 0-1,4 mg/L Low • 1,4 – 1,7 mg/L Low – medium

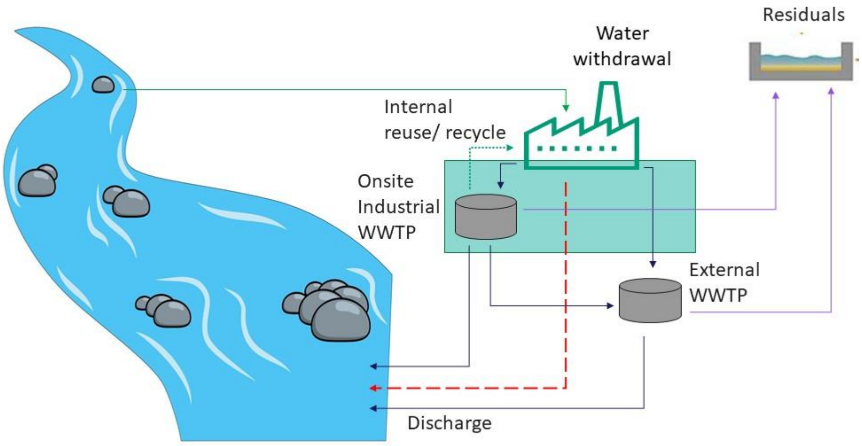
	• 1,7 - 2,5 mg/L Medium – high • >2,5 mg/L High
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.3.7. Nitrates

Name	Nitrates
Sub-group	Water quality
Spatial resolution	0.5x0.5-degree grid cell
Temporal resolution	Annual
Temporal range	2015
Unit	%
Source	World Bank Water Data
Description	Globally gridded dataset of nitrate-nitrite in surface water for the years 1992-2010, monthly observations. Data is available at the 0.5x0.5-degree grid cell level. Units are mg/L. Data is generated using a machine learning model, as described in the report Quality unknown: The Invisible Water Crisis.
Risk categories	• 0 - 0,2 mg/L Low • 0,2 – 0,35mg/L Low – medium • 0,35 - 65 mg/L Medium – high • 0,65 - 1 mg/L High • >1 mg/L Very high
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

2. Impact assessment

The impact assessment of the industry is done from a series of calculations or metrics that quantify this impact by considering different factors, some of which are more focused on water quality and the impact on the ecosystem whereas some others are more focused on the amount of water or the emission of greenhouse gases.



2.1. Water Quality

The following metrics calculate the impact of pollutants on the river. There are 3 main groups of metrics, those related to industrial effluent, those related to the impact on the ecosystem and those ones which are dealing with the efficiency of water treatment.

The list of pollutants measured to calculate the impact is chosen by the user, except for COD, Total Nitrogen (TN) and Total phosphorus (TP), which are mandatory. Alongside with these nutrients, WIAT has default values (related with TU and EQS, described below) with a selection of Priority Pollutants (PP). The PP can threaten human health or ecosystems. The list of the 33 priority substances (complete list in Appendix 6.1) was composed by the European Commission with a panel of experts in the field of chemistry and maritime pollution, delegates of the member states and European firms and the European Environment Agency (*Priority Substances - Water - Environment - European Commission*, n.d.). The table below shows which of those PP the ecosystem impact metrics included in WIAT. The choice of these 11 pollutants is based on the availability of data by type of activity (or ISIC code) in (Barré et al., 2016). For the other pollutants added by the user, these parameters must be added as well.

PP Name
1,2-Dichloroethane
Cadmium
Hexachloro-benzene
Mercury
Lead
Nickel
Chloroalkanes
Hexachlorobutadiene
Nonylphenols
Tetrachloroethylene
Trichloroethylene

2.1.1. Change in the state of nature

The change in the state of nature relating in terms of water quality is related to the pollution load added to the aquatic environment.

Name	Increase in toxic units in the receiving water body after discharge
Description	Toxic units in the receiving water body indicates if the concentration after the effluent discharge on the water body exceed the EC50, supposing the receiving water has a concentration of 0. This metric does not calculate values for COD, TN, TP, just for PP.
Unit	TU/day
Equation	$$Delta\_ecotox_{PP} = \frac{1000 \cdot D_{PP}}{EC50_{PP}}$$ Where: $Delta\_ecotox_{PP}$: Increase in TU in the receiving water body caused by the PP D_{PP}: delta concentration of a PP (see table "Increase in the concentration of the pollutant in the receiving water body" below) $EC50_{PP}$: Value of EC50 from the databases for PP
Impact categories	• > 2 Very high impact • 1 – 2 High impact • 1 – 0,2 Medium impact • < 0,2 Low impact The impact categories have been established by a panel of ICRA experts.

Name	Increase of the concentration of the pollutants in the receiving water body after discharge (with respect to EQS)
Description	Increase of the concentration of the pollutants after dilution in the receiving water body after discharge (with respect to EQS). Indicates if the increase in concentration caused by the effluent discharge on the water body exceeds the Environmental Quality Standards (> 100%). This metric does not calculate values for COD, TN, TP, just for PP.
Unit	%
Equation	$DeltaEQS_{PP} = \frac{D_{PP}}{EQS_{PP}} \cdot 100$ Where: $DeltaEQS_{PP}$: Increase of the concentration of a PP in the receiving water body (with respect to the maximum allowable concentration in the EU's Water Framework directive) D_{PP}: delta $concentration\ of\ a\ PP\ after$ dilution of the effluent in the river EQS_{PP}: Maximum allowable concentration of a PP in the EU's Water Framework directive
Impact categories	• > 200 % Very high impact • 200 – 100 % High impact • 100 – 20 % Medium impact • < 20 % Low impact The impact categories have been established by a panel of ICRA experts.

Name	Eutrophication potential
Description	Eutrophication potential (EP) is defined as the potential to cause over-fertilization of water and soil, which can result in increased growth of biomass. It will always have positive values; higher values indicate higher potential impact. It converts the pollutants to PO4 equivalent to calculate the total Eutrophication potential.
Unit	gPO4eq/m3
Equation	The Table of PO4 equivalent is used
Impact categories	• < 0.5 Low impact • 0.5 – 1 Medium impact • 1 – 2 High impact • > 2 Very high impact **Note:** Please note that these varies greatly depending on the source consulted.

	(*CARACTERITZACIÓ DE MASSES D'AIGUA I ANÀLISI DEL RISC D'INCOMPLIMENT DELS OBJECTIUS DE LA DIRECTIVA MARC DE L'AIGUA (2000/60/CE) A CATALUNYA (Conques Intra i Intercomunitàries) Octubre de 2005*, n.d.) **Note:** Please note that these vary greatly depending on the source consulted.

Tables of PO4 equivalent

Pollutants	Kg pollutant	Kg PO4 eq
Ammonia	1	0,35
Ammonium, ion	1	0,33
COD, Chemical Oxygen Demand	1	0,022
Nitrate	1	0,1
Nitric acid	1	0,1
Nitrite	1	0,1
Nitrogen	1	0,42
Nitrogen oxides	1	0,13
Nitrogen, total	1	0,42
Phosphate	1	1
Phosphoric acid	1	0,97
Phosphorus	1	3,06
Phosphorus pentoxide	1	1,34
Phosphorus, total	1	3,06

(*CML-IA Characterisation Factors - Leiden University*, n.d.)

Name	Increase in temperature in the receiving water body due to industry discharge
Description	Increase in the temperature in the receiving water body after discharging water
Unit	°C
Equation	$\Delta T = \frac{(W_a - W_w) \cdot T_{WB} + W_{effl} T_{effl}}{W_a + W_{effl} - W_w} - T_{WB}$

	Where: W_a: amount of water available in the river (streamflow global indicator) (m3/day) W_w: amount of water withdrawn from the river (m3/day) T_{WB}: temperature in water body before discharge (°C) W_{effl}: Amount of water discharged (m3/day) T_{effl}: Temperature of water discharged (°C)
Impact categories	• > 0.5 Low impact • 0.5 -1 Medium impact • 1-2 High impact • >2 Very high impact The impact categories have been established by a panel of ICRA experts.

2.1.2. Levers for action

Name	Percentage of treatment efficiency (compared to WWTP influent)
Description	This metric indicates which is the percentage of pollutant load that the WWTP eliminates from the industry water.
Unit	%
Equation	$Eff_P = \frac{P_{infl} - P_{effl}}{P_{infl}} \cdot 100$ Where: Eff_P: percentage of treatment efficiency of p (compared to WWTP influent) P_{infl}: load of P in the influent (g/day) P_{effl}: load of P in the effluent (g/day)

Name	Percentage of treatment efficiency (compared to intake water)
Description	This metric indicates whether there is an improvement in water quality due to its use by the industry. If the quality of the water after treatment is better than the industry withdrawal water quality (surface water only), then the value of this metric is greater than 100. This is only calculated for COD, TN and TP when the "advanced inputs" provide a value under "Industry withdrawal water quality (surface water only)"
Unit	%

Equation	$$Eff_P = \frac{P_{effl}}{P_{industry}} \cdot 100$$ Where: P_{effl}: load of pollutant in the industry effluent (after being treated by WWTP) (g/day) $P_{industry}$: load of water withdrawn by industry (g/day)

Name	Treated water factor
Description	This metric indicates the ratio between the water remaining after the industry consumption and the water that is treated in the WWTP.
Unit	%
Equation	$$TWF = \frac{W_t}{OWWTP_i + EWWTP_i + DD} \cdot 100$$ *Where:* TWF: ratio between the water remaining after the industry consumption and the water that is treated W_t: amount of water used by the industry that is treated in a WWTP *(m3/day)* $OWWTP_i$: Onsite industrial WWTP influent *(m3/day)* $EWWTP_i$: External WWTP influent *(m3/day)* DD: Directly discharged water *(m3/day)*

Concentration of pollutants in the industry effluent

Name	Concentration of the water discharged
Description	Concentration of pollutants in the water after treatment in the WWTP
Unit	g/m3
Equation	

	$$C = \frac{PP_{effl}}{W_{effl}}$$ Where: C: Concentration of water discharged PP_{effl}: load of the PP in the effluent (g/day) W_{effl}: amount of water discharged to the water body *(m3/day)*

Name	Toxic units in the effluent
Description	Toxic units in the effluent aims to calculate how toxic is an industry effluent for the ecosystem. To calculate the ecotoxicity potential, we have used the PP concentrations values, which can cause the death or lack of movement of 50% of *Daphnia magna* individuals within 24 hours. These values (EC50) have been extracted from different studies compiled into two different databases, the ECOTOX Knowledgebase from the United States Environmental Protection Agency (*ECOTOX | Home*, n.d.) and from the NORMAN Ecotoxicology Database. (*NORMAN Ecotoxicology Database*, n.d.) This metric has no impact categories because it is calculated based on the industry effluent and not based on the water body.
Unit	TU/Day
Equation	$$EC_{toxPP} = \frac{PP_{effl}}{W_{effl}} \cdot \frac{1000}{EC50_{PP}}$$ Where: EC_{toxPP}: ecotoxicity potential of one PP PP_{effl}: load of the PP in the effluent (g/day) W_{effl}: amount of water discharged to the water body (m3/day) $EC50_{PP}$: Values of EC50 from the database

Table of EC50 values

PP name	Scientific name	Duration (h)	Endpoint	Effect	Concentra-tion (µg/L)	Source Freitag et a
1,2-Dichloroethane	*Daphnia magna*	24	EC50	immobile	150000	(Freitag et al., 1994)
Cadmium	*Daphnia magna*	24	EC50	mortality	9,5	(Kim et al., 2017)
Hexachloro-benzene	*Daphnia magna*	24	EC50	Immobile	30	(Calamari D et al., 1983)
Mercury	*Daphnia magna*	24	EC50	mortality	1,4	(Kim et al., 2017)
Lead	*Daphnia magna*	24	EC50	mortality	440	(Kim et al., 2017)
Nickel	*Daphnia magna*	24	EC50	immobile	1000	(Haley & Kurnas, 1993)
C10-13 Chloroalkanes	*Daphnia magna*	24	EC50	mortality	65000	(Freitag et al., 1994)
Hexachloro-butadiene	*Daphnia magna*	24	EC50	immobile	500	(Knie et al., 1983)
Nonylphenol	*Daphnia magna*	24	EC50	immobile	150	(Brennan et al., 2006)
Tetrachloro-ethylene	*Daphnia magna*	24	EC50	immobile	3200	(Bringmann & Kuehn, 1982)
Trichloroethylene	*Daphnia magna*	24	EC50	Immobile	76000	(Bazin et al., 1987)

Name	Concentration of the pollutants in the effluent (with respect to EQS)
Description	The Environmental Quality Standards (EQS) are the limits approved by the EU's Water Framework Directive. The directive sets environmental quality standards for priority pollutants (PP) and eight other pollutants. These substances include the metals cadmium, lead, mercury and nickel, and their compounds; benzene; polyaromatic hydrocarbons (PAH); and several pesticides. Several of these priority substances are classed as hazardous. Each PP has a maximum allowable concentration (MAC) for inland surface waters. The metric of impact indicates if the concentration of the pollutant in the industry effluent is higher than the MAC (> 100%) or lower (< 100%). (*Priority Substances - Water - Environment - European Commission*, n.d.) This metric has no impact categories because it calculates with respect to the industry effluent and not with respect to the water body.

Unit	%
Equation	$$EEQSI_{PP} = \frac{PP_{effl}}{W_{effl}} \cdot \frac{1}{EQS_{PP}} \cdot 100$$ Where: $EEQSI_{PP}$ *Indicates the* concentration of a given PP in the effluent compared to its maximum allowable concentration in the EU's Water Framework directive PP_{effl}: load of the PP in the effluent (g/day) W_{effl}: amount of water discharged to the water body (m3/day) EQS_{PP}: Maximum allowable concentration of a PP in the EU's Water Framework directive

Table of EQS values

PP Name	EQS [mg/l]
1,2-Dichloroethane	0,01
Cadmium	0,001
Hexachloro-benzene	0,0005
Mercury	0,00007
Lead	0,0072
Nickel	0,02
C10-13 Chloroalkanes	0,0014
Hexachloro-butadiene	0,0006
Nonylpheno	0,002
Tetrachloro-ethylene	0,01
Trichloro-ethylene	0,01

(*Priority Substances - Water - Environment - European Commission*, n.d.)

Concentration of pollutants in the receiving water body

The below indicators support understanding the dilution of the discharge and the relative weight of the discharge compared to the river flows and concentrations. The lever for action is actually **Reducing the volume and/or concentrations of the effluent discharged**, as this will reduce the concentration of pollutants in the receiving water body.

Name	Concentration of the pollutant in the water body after discharge
Description	Concentration of pollutants in the water body after discharge of the effluent. It accounts for the river body concentration prior to discharge if river quality data prior to discharge was entered by the user. If the river concentration prior to discharge is not documented by the user, the tool assumes a concentration of Zero, and this indicator becomes the same as the next indicator "increase of the concentration".
Unit	g/m3
Equation	$C = \frac{C_{WB} \cdot W_a - C_{WB} \cdot W_w + C_{effl} \cdot W_{effl}}{W_a - W_w + W_{effl}}$ Where: C: Concentration of pollutant in the same water body where water was withdrawn after discharging water C_{WB}: river concentration prior to discharge (g/m3) W_a: amount of water available in the river (streamflow global indicator) (m3/day) W_w: amount of water withdrawn from the river (m3/day) C_{effl}: concentration of pollutant in the industry effluent discharged to the same water body where water was withdrawn (g/m3) W_{effl}: amount of water dischaarged to the water body (m3/day) *Note:* If no data was entered by the user on the intake concentration, this indicator will display the same value as the next indicator "increase of the concentration".

Name	Increase of the concentration (in the receiving water body)
Description	Increase in the concentration of the pollutant in the receiving water body calculates the increment of the industry pollutants on the receiving water, it calculates the final concentration in the river supposing the receiving water has a concentration of 0. This is why this indicator is named "increase", as the

	value obtained needs to be added to the river concentration prior to the discharge point, in order to obtain the concentration after discharge (see previous indicator "concentration of pollutants"
Unit	g/m3
Equation	$$Delta = \frac{PP_{effl}}{W_a - W_w + W_{effl}}$$ Where: $Delta$: Increase in the concentration in the receiving water body after industry discharge, considering the concentration of the industry discharge before industry discharge is 0 PP_{effl}: load of the PP in the industry effluent (g/day) W_a: amount of water available on the river, which is extracted from the streamflow global indicator (m3/day) W_{effl}: amount of water that the industry discharge on the river (m3/day) W_W: amount of water withdrawn from the river (m3/day)

Name	Toxic units in the receiving water body
Description	Toxic units in the receiving water body after dilution of the industry discharge into the water body.
Unit	TU/Day
Equation	$$TU = \frac{1000 \cdot C_{PP}}{EC50_{PP}}$$ Where: TU: ecotoxicity potential of a PP C_{PP}: $Concentration\ of\ PP\ in\ the\ water\ body\ after\ discharging\ water\ (g/m3)$ $\mathrm{EC50_{PP}}$: Values of EC50 from the database

Name	Concentration of the pollutants in the water body (with respect to EQS)
Description	The Environmental Quality Standards (EQS) are the limits approved by the EU's Water Framework Directive. The directive sets environmental quality standards for priority pollutants (PP) and eight other pollutants. These substances include the metals cadmium, lead, mercury and nickel, and their compounds; benzene; polyaromatic hydrocarbons (PAH); and several pesticides. Several of these priority substances are classed as hazardous. Each PP has a maximum allowable concentration (MAC) for inland surface waters. This metric indicates if the concentration of the pollutant in the industry effluent is higher than the MAC (> 100%) or lower (< 100%). (*Priority Substances - Water - Environment - European Commission*, n.d.)
Unit	%
Equation	$EQS = \frac{100 \cdot C_{PP}}{EQS_{PP}}$ Where: $EQS: Concentration\ of\ a\ PP\ compared\ to\ EQS_{PP}$ C_{PP}: Concentration of PP in the receiving water body after industry discharge (g/m3) EQS_{PP}: Maximum allowable concentration of a PP in the EU's Water Framework directive

2.2. Water availability

2.2.1. Change in the state of nature

Name	Dilution factor
Description	The dilution factor (DF) can be defined as the ratio between receiving water body flow and the total industrial wastewater effluent generated within a catchment. Higher values indicate less impact on the river.
Unit	-

Equation	$$DF = \frac{W_a + W_{effl} - W_w}{W_{effl}}$$ *Where:* W_a: amount of water available on the river, which is extracted from the stream flow global indicator (m3/day) W_{effl}: amount of water that the industry discharges on the river (m3/day) W_W: amount of water withdrawn from the river (m3/day)
Impact categories	• >100 Low impact • 10 – 100 Medium impact • 1 – 10 High impact • <2 Very high impact (Rice & Westerho, 2017)

Name	Withdrawal ratio (level of water stress)
Description	This metric is calculated from the relationship between the amount of water withdrawn by the industry and the amount of water available. It indicates the percentage of the available water withdrawn by the industry's consumption. This metric may have values ranging from 0, to a value greater than 100, indicating that the demand for water within the watershed is higher than the available.
Unit	%
Equation	$$W_s = \frac{W_w}{W_a} \cdot 100$$ Where: W_s: Withdrawal ratio W_w: Amount of water withdrawn from the same watershed as the discharge (m3/day) W_a: Amount of water available on the river (**Streamflow global indicator**) (m3/day)

Impact categories	• 0 – 2 % Low impact • 2 – 5 % Medium impact • 5 – 20 % High impact • + 20 % Very high impact The impact categories have been established by a panel of ICRA experts.

Name	Consumptive use from different watersheds
Description	Amount of water that comes from external sources (e.g. purchased) located in a different watershed than the discharge point.
Unit	m3/day
Equation	*Value as entered by the user*
Impact categories	• > 0 Very high impact • 0 Low impact The impact categories have been established by a panel of ICRA experts.

Name	Groundwater withdrawals (only in areas with GW decline)
Description	Amount of groundwater withdrawals that take place in areas where the water table declines.
Unit	m3/day
Equation	*Value as entered by the user*
Impact categories	• > 0 Very high impact • 0 Low impact The impact categories have been established by a panel of ICRA experts.

2.2.2. Levers for action

Name	Recycled water factor
Description	This metric indicates the percentage of reused water used by the industry respect the water discharged by industry (to direct discharge, onsite industry WWTP effluent and to external WWTP effluent). Values that may have this metric range from 0 to 100, the larger its value the more efficient the water recycled is.
Unit	%

Equation	$$\text{WRF}=\frac{W_r}{OWWTP_i+EWWTP_i+DD}\cdot 100$$ *Where:* WRF: percentage of the reused water used by the industry respect the water that leaves the industry W_r: amount of water that the industry reuses/recycles from the WWTP *(m3/day)* $OWWTP_i$: Onsite industrial WWTP influent *(m3/day)* $EWWTP_i$: External WWTP influent *(m3/day)* DD: Directly discharged water *(m3/day)*

Name	Specific water consumption
Description	Specific water consumption is a metric that indicates the amount of water consumed to produce one unit of the user's specified product (by default, tonnes). Note that water is considered consumed if : - it is not returned to the river it was taken from, - it not returned to the river with a sufficient quality, as this water will therefore not properly support downstream ecosystems and usages. Higher values indicate higher water demand.
Unit	m3/unit specified by the user
Equation	$$SWC = \frac{W_c}{A}$$ $$W_c = Ww + We - Wd \rightarrow if\ discharged\ water\ has\ concentrations\ below\ the\ EQS$$ $$W_c = Ww + We \rightarrow otherwise$$ Where: SWC: Specific water consumption A: Ammount of unit selected by the user W_W: Water withdrawn (both surface and groundwater) (m3/day)

	W_d: Water discharged at the same watershed where the water is withdrawn (m3/day) W_a: Amount of water available on the river (**Streamflow global indicator**) (m3/day) W_e: Amount of water that comes from external sources (m3/day) W_c: Water consumptive use (m3/day) *Note: until a science-based target setting approach can be used, the tool assumes the water use is consumptive if the discharge doesn't meet the EQS concentrations*

Name	Net consumptive use
Description	Amount of water withdrawn by the industry minus the amount of water discharged into the same watershed that meets the EQS
Unit	m3/day
Equation	$W_c = Ww + We - Wd \rightarrow if\ discharged\ water\ has\ concentrations$ $below\ the\ EQS$ $W_c = Ww + We \rightarrow otherwise$ Where: SWC: Specific water consumption W_W: Water withdrawn (both surface and groundwater) (m3/day) W_d: Water discharged at the same watershed where the water is withdrawn (m3/day) W_e: Amount of water that comes from external sources (m3/day) W_c: Water consumptive use. Until Science based targets are set, the tool assumes that the discharge should be equal or better than EQS to be considered "non consumptive" (m3/day)

Name	Percentage of water withdrawn for consumptive use
Description	Water consumptive use divided by water withdrawn

Unit	%
Equation	$$W_{frac} = \frac{W_c}{W_w} \cdot 100$$ $W_c = Ww + We - Wd \rightarrow if\ discharged\ water\ has\ concentrations\ below\ the\ EQS$ $W_c = Ww + We \rightarrow otherwise$ Where: W_{frac}: Percentage of consumptive use over water withdrawn W_W: Amount of water withdrawn, both surface and groundwater (m3/day) W_d: Water discharged at the same watershed where the water is withdrawn (m3/day) W_e: Amount of water than comes from external sources (m3/day) W_c: Water consumptive use (m3/day) *Note: until a science-based target setting approach can be used, the tool assumes water use is consumptive if the discharge doesn't meet the EQS concentrations.*

2.3. GHG emissions from wastewater treatment

2.3.1. Change in the state of nature

This metric indicates the GHG emissions from the industry. It counts the amount of CO2 equivalent that is produced during the water treatment, water discharge, the emissions from sludge management and the emissions from biogas. It will always have positive values; higher values indicate higher impact. The methodology to calculate the global warming potential is from the Energy Performance and Carbon Emissions Assessment and Monitoring Tool (ECAM). (*Sanitation Treatment*, n.d.)

Name	Emissions from CO2, CH4 and N2O
Unit	KgCO2eq/day
Description	Amount of CO2, CH4 and N2O during wastewater treatment process

Equation	See table GHG emissions by source

2.3.2. Levers for action

Name	Energy used
Description	Energy used by the industry to treat a m3 of water
Unit	kWh/m3
Equation	$$\frac{WT_O \cdot EC_O + WT_E \cdot EC_E}{WT_O + WT_E} \cdot 100$$ *Where:* WTP_O: Volume of water treated in an onsite WWTP *(m3/day)* WTP_E: Volume of water treated in an external WWTP *(m3/day)* EC_O: Electricity consumed from the grid of the onsite wastewater treatment per cubic meter treated *(kWh/m3)* EC_E: Electricity consumed from the grid of the external wastewater treatment per cubic meter treated *(kWh/m3)*

Name	Effluent concentration prior to discharge
Description	TN and COD concentration of the effluent which are triggering N2O and methane emissions
Unit	g/m3
Equation	$$C = \frac{N_{effl}}{W_{effl}}$$ Where: C: Concentration of water discharged N_{effl}: load of nutrients in the effluent (g/day) W_{effl}: amount of water discharged to the water body *(m3/day)*

Name	Potential to capture CO_2 (from exhausts)
Description	When burning the biogas in a flare or through an energy valorisation system such as a CHP engine or a heater, the CO2 emissions in the exhaust can be captured to be valorised or stored. Assessing these emissions allows to evaluate whether source is large enough to consider investing in capturing this CO2. The CO2 from the exhaust can be considered biogenic only if the organic matter processed by the industry is non-fossil based. If the organic matter is fossil based, it allows the displacement of emissions from the equivalent product that would otherwise have been produced with other carbon-energy sources.
Unit	KgCO2eq/day
Equation	$biogas_{produced} = \frac{P \cdot V}{R \cdot T}$ $biogas_{flared} = biogas_{produced} \cdot \frac{biogas_{flared}}{100} \cdot \frac{44}{1000}$ $biogas_{valorised} = biogas_{produced} \cdot \frac{biogas_{val}}{100} \cdot \frac{44}{1000}$ $captureable_{emissions} = biogas_{flared} + biogas_{valorised}$ *Where:* *P: 1.013 · 10^5 Pa* *V: Volume of biogas produced in the WWTP (Nm3/day)* *R: 8,31446261815324 J/K.mol* *T: 273,15K* *$Biog_{flrared}$: Biogas flared (%volume)* *$Biog_{CH4}$: Percent of the methane content in the produced biogas* *$Biog_{val}$: Percentage of biogas valorised in the treatment plant to heat the digesters or the building and/or run a Co-generator to generate heat and electricity*
Source	*IPCC 2006, Volume 5, Chapter 4 Biological treatment of solid waste, equation 4.1, page 5*

2.3.3. GHG emissions by source

Name	Indirect emissions from electricity consumption (IEFEC)
Unit	KgCO2eq/day
Equation	$\mathrm{IEFEC} = convkwh \cdot nrgcons \cdot W_t$ Where: $convkwk$: Emission factor for grid electricity (kgCO2eq/kWh) $nrgcons$: Electricity consumed from the grid for wastewater treatment per cubic meter treated *(kWh/m3)* W_t: Amount of water treated *(m3/day)*

Name	Emissions from fuel engines (EFFE)
Description	Direct CO2 emitted from on-site engines in wastewater stages based upon sum of CO2, CH4 and N2O emission from stationary combustion
Unit	KgCO2eq/day
Equation	$ECO_2 = \frac{V \cdot FD_{CO_2} \cdot NCV_{CO_2} \cdot EF_{CO_2}}{1000}$ $EN_2O = \frac{V \cdot FD_{N_2O} \cdot NCV_{N_2O} \cdot EF_{N_2O} \cdot EQ_{N_2O}}{1000}$ $ECH_4 = \frac{V \cdot FD_{CH_4} \cdot NCV_{CH_4} \cdot EF_{CH_4} \cdot EQ_{CH_4}}{1000}$ $\mathrm{EFFE} = ECO_2 + ECH_4 + EN_2O$ Where: V: Volume of fuel consumed (m3) EQ_{N_2O}: *Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$*)* EQ_{CH_4}: *Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)*

Table of equation values

Fuel type	EFCH4 (kg/TJ)	EFN2O (kg/TJ)	EFCO2 (kg/TJ)	FD (kg/L)	NCV (TJ/Gg)
Diesel	3	0,6	74100	0,84	43
Gasoline/Petrol	3	0,6	69300	0,74	44,3
Natural Gas	10	0,1	56100	0,75	48

(Wagner & Walsh, n.d.)

Name	Emissions from treatment (EFT)
Description	Emissions from treatment are related to the production of Nitrous oxide (N_2O) and methane (CH_4) converted into equivalent CO_2. The IPCC methodology assumes that organic carbon present in wastewater derives from modern (biogenic) organic matter; consequently, CO2 emissions from wastewater treatment are considered wholly biogenic and are discounted from the inventories as they do not represent a transfer of carbon from the lithosphere to the atmosphere. The presence of fossil organic carbon in sewage implies the emission of additional fossil CO2 from wastewater treatment facilities, sludge management, and environmental recipients of treated or untreated wastewater. As stated in the appendix 6 Ap.1 from IPCC chapter 6 on wastewater treatment and discharge presents a discussion of non-biogenic (fossil) CO2 emissions there is no yet agreement on this issue. We are aware of the fact that some industries produce mostly non-biogenic organic matter and hence WIAT might be underestimating the CO2 emissions. In a future version of the tool this aspect will be addressed with care, in line with the IPCC new developments.
Unit	KgCO2eq/day
Equation	$CH_4 = (bodinfl - bodslud) \cdot CH_4efactre \cdot CH_4eq$ $N_2O = (\mathrm{tninfl}) \cdot N_2Oefactre \cdot NtoN_2O \cdot N_2Oeq$ $EFT = CH_4 + N_2O$ Where: $bodinfl$ *: influent COD load (kg/day)* $bodslud$*: COD removed as sludge* (kg/day) *CH4efactre: CH4 emission factor (kgCH4/kgCOD)*

	CH_4eq: *conversion of CH4 emissions to CO2 equivalent emissions (34 kgCO2eq/kgCH4)* tninfl*: Total Nitrogen load in the influent (kg/day)* $N_2Oefactre$ *: N2O emission factor (kgN2O-N/kgN)* $NtoN_2O$ *: N2O-N to N20 conversion factor (1.57 gN2O/gN2O-N)* N_2Oeq *: conversion of N2O to CO2 equivalent emissions (298 kgCO2eq/kgN2O)* (Deborah Bartram et al., 2019)

Name	Biogas (anaerobic digestion of sludge)
Description	*GHG emissions from biogas*
Unit	KgCO2eq/day
Equation	$$biogas_{produced} = \frac{P \cdot V}{R \cdot T}$$ $$biogas_{leaked} = biogas_{produced} \cdot \frac{biogas_{leaked}}{100} \cdot \frac{biog_{CH_4}}{100} \cdot \frac{16}{1000} \cdot EQ_{CH_4}$$ $$EFB = biogas_{leaked}$$ *Where:* *P: 1.013 · 10^5 Pa* *V: Volume of biogas produced in the WWTP (Nm3/day)* *R: 8,31446261815324 J/K.mol* *T: 273,15K* *$Biog_{CH4}$: Percent of the methane content in the produced biogas* *$Biog_{leaked}$: Biogas leaked to the atmosphere (%volume)* EQ_{CH_4}*: Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)*
Source	*IPCC 2006, Volume 5, Chapter 4 Biological treatment of solid waste, equation 4.1, page 5*

Name	Fuel (digester)
Description	Amount of CO2 eq emissions due to fuel employed for digester
Unit	KgCO2eq/day
Equation	$CO_2 = \frac{vol \cdot fuelFD \cdot fuelNCV \cdot fuelEFCO_2engines}{1000}$ $N_2O = \frac{vol \cdot fuelFD \cdot fuelNCV \cdot fuelEFN_2Oengines \cdot ctN_2Oeq}{1000}$ $CH_4 = \frac{vol \cdot fuelFD \cdot fuelNCV \cdot fuelEFCH_4engines \cdot ctCH_4Oeq}{1000}$ $fuel = CO_2 + N_2O + CH_4$ Where: *vol:* Volume of fuel consumed (m3/day) *ctN_2Oeq: Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$) *$ctCH_4eq$: Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)* *fuel: Amount of CO_2 eq due to fuel employer for digester.*
Source	IPCC 2006, Volume 2, Chapter 3: Mobile Combustion, Table 3.2.2 (page 21)

Table of equation values

Fuel type	EFCH4 (kg/TJ)		EFN2O (kg/TJ)		EFCO2 (kg/TJ)	FD (kg/L)	NCV (TJ/Gg)
	engines	vehicles	engines	vehicles			
Diesel	3	3.9	0.6	3.9	74100	0.84	43
Gasoline/Petrol	3	3.8	0.6	1.9	69300	0.74	44.3
Natural Gas	10	92	0.1	0.2	56100	0.75	48

Name	Total emissions from Sludge management
Description	GHG emissions from sludge management operations (storing, composting, incineration, land application, landfilling, stockpiling and truck transport).
Unit	KgCO2eq/day
Equation	$CO_2SM = CO_2SC + CO_2SI + CO_2LA + CO_2LFS + CO_2SP + CO_2SS + CO_2TTS$ *CO_2SM: Total emissions from Sludge management* *CO_2SC: Amount of CO_2eq emissions due to sludge composted* *CO_2SI: Amount of CO_2eq emissions due to sludge incineration* *CO_2LA: Amount of CO_2eq emissions due to land application of sludge* *CO_2LFS: Amount of CO_2eq due to Landfilling of sludge* *CO_2SP: Amount of CO_2eq emissions due to sludge composted* *CO_2SS: Amount of CO_2eq emissions related to sludge storage* *CO_2TTS: Amount of CO_2eq due to truck transport of sludge.*

Name	Water reuse transport (EFWRT)
Unit	KgCO2eq/day
Equation	$ECO_2 = \frac{V \cdot FD_{CO_2} \cdot NCV_{CO_2} \cdot EF_{CO_2}}{1000}$ $ECH_4 = \frac{V \cdot FD_{CH_4} \cdot NCV_{CH_4} \cdot EF_{CH_4} \cdot EQ_{CH_4}}{1000}$ $EN_2O = \frac{V \cdot FD_{N_2O} \cdot NCV_{N_2O} \cdot EF_{N_2O} \cdot EQ_{N_2O}}{1000}$ $E_{TOTAL} = ECO_2 + ECH_4 + EN_2O$ *V: Volume of fuel consumed (m3)*

	EQ_{N_2O}: *Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$) EQ_{CH_4}: *Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)*

Table of equation values

Fuel type	EFCH4 (kg/TJ)	EFN2O (kg/TJ)	EFCO2 (kg/TJ)	FD (kg/L)	NCV (TJ/Gg)
Diesel	3,9	3,9	74100	0,84	43
Gasoline/Petrol	3,8	1,9	69300	0,74	44,3
Natural Gas	92	0,2	56100	0,75	48

(Davies Waldron, 2006)

Name	Emissions from water discharged (EFWD)
Unit	KgCO2eq/day
Equation	$CH_4 = bodeffl \cdot CH_4efacdis \cdot CH_4eq$ $N_2O = tneffl \cdot N_2Oefacdis \cdot NtoN_2O \cdot N_2Oeq$ $DW_e = CH_4 + N_2O$ $bodeffl$ *: Effluent COD load (kg/day)* $CH_4efacdis$*: CH4 emission factor (kgCH4/kgCOD)* CH_4eq*: conversion of CH4 emissions to CO2 equivalent emissions (34 kgCO2eq/kgCH4)* $tneffl$ *: Total Nitrogen load in the effluent (kg/day)* $N_2Oefacdis$*: N2O emission factor (kgN2O-N/kgN)* $NtoN_2O$*: N2O-N to N20 conversion factor (1.57 gN2O/gN2O-N)* N_2Oeq*: conversion of N2O to CO2 equivalent emissions (298 kgCO2eq/kgN2O)*

Sludge Management

Name	Sludge storage
Description	Amount of CO2eq emissions related to sludge storage
Unit	KgCO2eq/day
Equation	$TVS = \frac{slustoTVS}{100}$ $\quad FCH_4 = \frac{slustoFCH_4}{100}$ $\quad CH_4EF = \frac{slustoEF}{100}$ $CH_4potential = sludgemass \cdot TVS \cdot TVStoOC \cdot OCtoCH_4 \cdot FCH_4$ $CH_4 = CH_4potencial \cdot CH_4EF \cdot ctCH_4eq$ $CO_2SS = CH_4$ Where: $sludgemass$: Amount of sludge that is stored prior to disposal (kg) $slustoEF$: Emission factor due to storage (%) $slustoTVS$: Total Volatile Solids (TVS) content of sludge stored *(% of dry weight).* $slustoFCH_4$: CH4 potential factor (%) $TVStoOC$: *Organic Carbon content in Volatile Solids (0,56*gOC/gVS*)* $OCtoCH_4$: *Organic C to CH4 conversion factor (=16/12* gCH_4/gOC*)* $ctCH_4eq$: *Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)* *CO_2SS: Amount of CO_2 eq due to sludge storage*
Source	(*ECAM V3*, n.d.)

Name	Sludge composted
Description	Amount of CO2eq emissions due to sludge composted
Unit	KgCO2eq/day
Equation	$TVS = \frac{slucompTVS}{100}$ $\quad Ncont = \frac{slucompNcont}{100}$ $\boldsymbol{If\ emissions\ are\ treated, or\ piles\ covered}: CH_4 = 0$

	Else: $CH4 = \ sludgemass \ \cdot TVS \cdot TVStoOC \cdot \mathrm{upEF} \ \cdot \ \mathrm{OCto}CH_4 \cdot ctCH_4eq$ $\boldsymbol{If\ ratio\ CN} > \mathbf{30}: N_2O = 0$ $\boldsymbol{Else\ if}: \boldsymbol{solid\ content\ of\ compost} > \mathbf{55}: N_2O = 0$ ***Else***: $N_2O = sludgemass \ \cdot Ncont \cdot lowCNE\mathrm{F} \cdot \mathrm{ctNto}N_2O4428 \cdot ctN_2Oeq$ $CO_2SC = \ CH_4 + N_2O$ ***Where:*** $sludgemass$ *: Amount of sludge that is sent to composting (dry weight) (kg)* $slucompTVS$*: Total Volatile Solids (TVS) content of sludge composted (% of dry weight).* $TVStoOC$ *: Organic Carbon content in Volatile Solids (0,56 gOC/gVS)* upEF *: CH4 emission factor for uncovered pile (fraction of initial C in solids)* $\mathrm{OCto}CH_4$*: Organic C to CH4 conversion factor (=16/12* gCH_4/gOC*)* $ctCH_4eq$*: Conversion of CH4 emissions to CO2 equivalent emissions (34 kgCO2eq/kgCH4)* $slucompNcont$*: N content of sludge stored (% of dry weight)* $lowCNE\mathrm{F}$ *: N2O emission factor for low C:N ratio (kgN2O-N/kgN)* $\mathrm{ctNto}N_2O4428$*: N2O-N to N2O conversion factor (44/28 gN2O/gN2O-N)* ctN_2Oeq*: Conversion of N2O emissions to CO2 equivalent emissions (298 kgCO2eq/kgN2O)* CO_2SC: Amount of CO2eq emissions due to sludge composted
Source	Section 12.8 "Composting", Beam page 147 (page 169 in PDF)

Name	Sludge incineration
Description	Amount of CO2eq emissions due to sludge incineration CO2 emissions from the organic carbon burnt is considered biogenic, so the CO2eq emissions correspond to CH4 and N2O emissions, which occur when the incinerator temperature is below 1023deg K.
Unit	KgCO2eq/day

Equation	$CH_4 = (4{,}85e - 5) \cdot sludgemass \cdot ctCH_{4eq}$ $\boldsymbol{If\ Tf < 1023}: Tf = 1023$ $n = \frac{161{,}3 - 0{,}14 \cdot Tf}{100}$ $\boldsymbol{If\ n < 0}: n = 0$ $N_2O = sludgemass \cdot Ncont \cdot n \cdot ctN_2Oeq$ $\boldsymbol{If\ SNCR\ methods\ are\ used}^*$: $N_2O = 1{,}2 \cdot sludgemass \cdot Ncont \cdot n \cdot ctN_2Oeq$ $CO_2SI = CH_4 + N_2O$ Where: $sludgemass$: *Amount of sludge that is sent to incineration (dry weight) (kg/day)* $ctCH_{4eq}$: *Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)* $Ncont$ *: N content of sludge incinerated (% of dry weight)* *Tf: Average highest temperature of combustion achieved in a Fluidized Bed incinerator (K)* ctN_2Oeq: *Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$*)* CO_2SI: Amount of CO2eq emissions due to sludge incineration *SNCR (Selective Non-Catalytic Reduction) uses the injection of ammonia or urea into the backend of the combustion chamber to reduce NO to N2
Source	Section 12.10 "Combustion (Incineration)", Beam, page 161

Name	Land application of sludge
Description	Amount of CO2eq emissions due to land application of sludge
Unit	KgCO2eq/day
Equation	

	$Ncont = \frac{slulaNcont}{100}$ $TVS = \frac{slucompTVS}{100}$ $Ccontent = sludgemass \cdot TVS \cdot TVStoOC$ $Ncontent = sludgemass \cdot Ncont$ $ratioCN = \frac{Ccontent}{Ncontent}$ $\boldsymbol{If\ ratioCN > 30}: N_2O = 0$ $\boldsymbol{Else\ if\ biosolids\ are > 80\%\ Dry\ Matter}$: $N_2O = 0{,}5 \cdot sludgemass \cdot Ncont \cdot EF \cdot ctNtoN_2O4428 \cdot ctN_2Oeq$ $\boldsymbol{Else:}$ $N_2O = sludgemass \cdot Ncont \cdot EF \cdot ctNtoN_2O4428 \cdot ctN_2Oeq$ $CO_2LA = N_2O$ **Where**: $sludgemass$ *: Amount of sludge that is sent to land application (dry weight) (kg/day)* $TVStoOC$*: Organic Carbon content in Volatile Solids (0,56* gOC/gVS*)* $slulaNcont$*: N content of sludge sent to land application (% of dry weight)* *SlucompTVS: Total Volatile Solids (TVS) content of sludge composted (% of dry weight).* EF : Amount of Nitrogen converted to N2O (kgN2O-N/kgN) $ctNtoN_2O4428$*: N2O-N to N2O conversion factor (=44/28* gN_2O/gN_2O-N*)* *ctN2Oeq: Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$) CO_2LA: Amount of CO2eq emissions due to land application of sludge
Source	Section 12.11 "Land application", Beam page 166
Name	Landfilling of sludge
Description	Fugitive methane emissions from biosolids decomposition in the landfill during the first 3 years after placement, and N2O emissions from landfilled biosolids

Unit	KgCO2eq/day
Equation	$DOCf = \frac{slulfDOCf}{100}$ $CH_4gas = \frac{slulfCH_4ingas}{100}$ $TVS = \frac{slucompTVS}{100}$ $Ncont = \frac{slulfNcont}{100}$ $dc3ry = \frac{slulfdecomp3yr}{100}$ $CH_4 = sludgemass \cdot TVS \cdot TVStoOC \cdot un \cdot OCtoCH_4 \cdot CH_4gas \cdot DOCf \cdot dc3yr \cdot MCF \cdot ctCH_4eq$ $CO_2LFS = CH_4 + N_2O$ $N_2O = sludgemass \cdot Ncont \cdot lowCNEF \cdot NtoN_2O \cdot ctN_2Oeq$ ***Where***: $sludgemass$: *Amount of sludge that is sent to landfilling (dry weight) (kg/day)* $slucompTVS$: *Total Volatile Solids (TVS) content of sludge composted (% of dry weight)* $TVStoOC$: *Organic Carbon content in Volatile Solids (0,56*gOC/gVS*)* un: *Model uncertainty factor* $OCtoCH_4$: *Organic C to CH4 conversion factor (=16/12* gCH_4/gOC*)* $slulfCH_4ingas$: *CH4 in landfill gas* $slulfDOCf$: *Decomposable organic fraction of raw wastewater solids* $slulfdecomp3yr$: *Percentage decomposed in first 3 years of the decomposable organic fraction of raw wastewater solids.* MCF: *Methane correction for anaerobic managed landfills* $ctCH_4eq$: *Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)* $slulfNcont$: *N content of sludge sent to landfilling (% of dry weight)* $lowCNEF$: *N2O emission factor for low C:N ratio (kgN20-N/kgN)* $NtoN_2O$: *N2O-N to N2O conversion factor (=44/28* $gN_2O/gN_2O\text{-}N$*)* ctN_2Oeq: *Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$*)* CO_2LFS: *Amount of* CO_2 *eq due to Landfilling of sludge*

Source	Section 12.9 "Landfill disposal", page 153, Beam methodology document

Name	Sludge stockpiling
Description	Amount of CO2eq emissions due to sludge stockpiling
Unit	KgCO2eq/day
Equation	$$lifespan\_int = \lfloor lifespan \rfloor$$ $$lifespan\_dec = lifespan - lifespan\_dec$$ $$rate_{CH4}(i) = \begin{cases} sludgemass \cdot 0.2 \cdot 10^{-3} & \text{if } i < 1 \\ sludgemass \cdot 2 \cdot 10^{-3} & \text{if } 1 <= i < 3 \\ sludgemass \cdot 9.8 \cdot 10^{-3} & \text{if } 3 <= i < 20 \\ 0 & \text{if } i >= 20 \end{cases}$$ $$rate_{N2O}(i) = \begin{cases} sludgemass \cdot 60 \cdot 10^{-3} & \text{if } i < 1 \\ sludgemass \cdot 26.8 \cdot 10^{-3} & \text{if } 1 <= i < 3 \\ sludgemass \cdot 17.4 \cdot 10^{-3} & \text{if } 3 <= i < 20 \\ 0 & \text{if } i >= 20 \end{cases}$$ $$rate_{CO2}(i) = \begin{cases} sludgemass \cdot 30.1 \cdot 10^{-3} & \text{if } i < 1 \\ sludgemass \cdot 30.5 \cdot 10^{-3} & \text{if } 1 <= i < 3 \\ sludgemass \cdot 10.1 \cdot 10^{-3} & \text{if } 3 <= i < 20 \\ 0 & \text{if } i >= 20 \end{cases}$$ $$CH_4 = lifespan\_dec \cdot rate_{CH4}(lifespan\_int) + \sum_{i=0}^{lifespan\_int-1} rate_{CH4}(i)$$ $$N_2O = lifespan\_dec \cdot rate_{N2O}(lifespan\_int) + \sum_{i=0}^{lifespan\_int-1} rate_{N2O}(i)$$ $$CO_2 = lifespan\_dec \cdot rate_{CO2}(lifespan\_int) + \sum_{i=0}^{lifespan\_int-1} rate_{CO2}(i)$$ $$CO_2SP = CH_4 + N_2O + CO_2$$ Where: $sludgemass$: Amount of sludge that is stockpiled (dry weight) (kg/day) $lifespan$: Expected timespan than the biosolid stockpile (BSP) will be emitting GHGs (years) CO_2SP: Amount of CO2eq emissions due to sludge composted
Source	Majumder, R., Livesley, S., Gregory, D., & Arndt, S. (2014, 05 15). Biosolids stockpiles are a significant point source for greenhouse gas emissions. Journal of Environmental Management, 143, pp. 34-43.

Name	Truck transport of sludge
Description	Indirect CO2 emitted from sludge transport off-site
Unit	KgCO2eq/day
Equation	$$CO_2 = \frac{vol \cdot fuelFD \cdot fuelNCV \cdot fuelEFCO_2vehicles}{1000}$$ $$N_2O = \frac{vol \cdot fuelFD \cdot fuelNCV \cdot fuelEFN_2Ovehicles \cdot ctN_2Oeq}{1000}$$ $$CH_4 = \frac{vol \cdot fuelFD \cdot fuelNCV \cdot fuelEFCH_4vehicles \cdot ctCH_4eq}{1000}$$ $$CO_2TTS = CO_2 + N_2O + CH_4$$ Where: *V: Volume of fuel consumed (m3)* *ctN_2Oeq: Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$) *$ctCH_4eq$: Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)* *CO_2TTS: Amount of CO_2 eq due to truck transport of sludge.*
Source	IPCC 2006, Volume 2, Chapter 3: Mobile Combustion, Table 3.2.2 (page 21)

3. Indicators for external reporting

As there are different pages and methods that can be used to calculate the impact of industries, WIAT also gives the values needed to generate their reports. This section explains the different metrics needed and how they are calculated. The two pages are the GRI and CDP Water Security.

GRI (Global Reporting Initiative) is the independent, international organization that supports businesses and other organizations take responsibility for their impacts by providing them with the global common language to communicate them.

CDP's work with water security motivates companies to disclose and reduce their environmental impacts by using the power of investors and customers. The data CDP collects helps influential decision makers to reduce risk, capitalize on opportunities and drive action towards a more sustainable world.

Name	What are the total volumes of water withdrawn, discharged, and consumed across all your operations – W1.2B
Reporting	Reporting to CDP Water Security 2021 Questionnaire

Name	Indicate whether water is withdrawn from areas with water stress and provide the proportion – W1.2D
Reporting	Reporting to CDP Water Security 2021 Questionnaire

Name	Provide total water withdrawal data by source – W1.2H
Description	Fresh surface water and groundwater
Reporting	Reporting to CDP Water Security 2021 Questionnaire

Name	Provide total water discharge data by destination – W1.2I
Description	Fresh surface water and third-party destinations
Reporting	Reporting to CDP Water Security 2021 Questionnaire

Name	Within your direct operations, indicate the highest level(s) to which you treat your discharge – W1.2J

Description	Tertiary treatment, secondary treatment, primary treatment only, discharge to the natural environment without treatment, and discharge to a third party without treatment
Reporting	Reporting to CDP Water Security 2021 Questionnaire

Name	Describe the water-related detrimental impacts experienced by your organization, your response, and the total financial impact – W1.2A
Description	Type of impact driver and primary impact driver
Reporting	Reporting to CDP Water Security 2021 Questionnaire

Name	For each facility, provide coordinates and water accounting data – W5.1
Description	Coordinates, says if industry is located in area of water stress, total water withdrawals, total discharges and total water consumption
Reporting	Reporting to CDP Water Security 2021 Questionnaire

Name	Water withdrawal – Requirements (303-3a, 303-3b)
Description	Water withdrawal by source (surface water, groundwater and total)
Reporting	Reporting to GRI 303: Water and effluents 2018

Name	Water withdrawal – Recommendations (Clause 2.2.1)
Description	Water withdrawal in areas with water stress
Reporting	Reporting to GRI 303: Water and effluents 2018

Name	Water discharge – (303-4)
Description	Water discharge by destination and by level of treatment
Reporting	Reporting to GRI 303: Water and effluents 2018

4. Industry inputs

4.1. Industry typology

Some of the values of the industry inputs can be estimated depending on the industry typology. During the advance inputs you can choose what is your industry type, according to the NACE level 2 typology of industries. (*EUROPA - Competition - List of NACE Codes*, n.d.)

CCAE	NACE_I	ISIC_I	DESCRIPTION
C10	C10	C10	Manufacture of food products
C11	C11	C11	Manufacture of beverages
C12	C12	C12	Manufacture of tobacco products
C13	C13	C13	Manufacture of textiles
C14	C14	C14	Manufacture of wearing apparel
C15	C15	C15	Manufacture of leather and related products
C16	C16	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	C17	C17	Manufacture of paper and paper products
C18	C18	C18	Printing and reproduction of recorded media
C19	C19	C19	Manufacture of coke and refined petroleum products
C20	C20	C20	Manufacture of chemicals and chemical products
C21	C21	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	C22	C22	Manufacture of rubber and plastic products
C23	C23	C23	Manufacture of other non-metallic mineral products
C24	C24	C24	Manufacture of basic metals
C25	C25	C25	Manufacture of fabricated metal products, except machinery and equipment
C26	C26	C26	Manufacture of computer, electronic and optical products
C27	C27	C27	Manufacture of electrical equipment
C28	C28	C28	Manufacture of machinery and equipment n.e.c.
C29	C29	C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	C30	C30	Manufacture of other transport equipment
C31	C31	C31	Manufacture of furniture
C32	C32	C32	Other manufacturing
C33	C33	C33	Repair and installation of machinery and equipment

4.2. Industry estimated pollution values

To facilitate user input, some of the contaminants can be estimated by taking into account the type of industry, so if the user does not know some data, it can be estimated based on previous inputs. Those contamination values according to industry are extracted from the report "les substances dangereuses pour les milieu aquatique dans les rejets industriels. (Barré et al., 2016)

	C10	C11	C13	C14	C15	C16	C17
1,2-Dichloroethane µg/L	-	-	-	-	-	-	100,00
Anthracene µg/L	-	-	-	-	-	-	-
Benzene µg/L		-	-	-	0,58	0,37	-
Cadmium µg/L	0,32	0,46	-	-	0,89	0,90	1,19
Chloroalkanes µg/L	-	-	-	-	3,35	-	-
Hexachloro-benzene µg/L	-	-	-	-	-	-	-
Hexachloro-butadiene µg/L	-	-	-	-	-	-	-
Mercury µg/L	95,00	0,13	-	-	0,20	0,16	0,17
Nickel µg/L	4395,00	15,11	-	-	24,96	8,27	7,55
Nonylpheno µg/L	0,73	1,22	654,55	-	555,00	1,67	441,50
Lead µg/L	1985,00	12,36	-	-	12,06	11,76	5,36
Tetrachloro-ethylene µg/L	-	-	-	-	156,16	-	100,00
Trichloro-ethylene µg/L	75,00	0,10		-	0,61	0,18	100,00
BOD5 mg/L O2	336,26	231,09	410,10	40,00	-	33,33	366,27
TOC mg/L C	414,29	-	171,67	-	-	-	-
Phosphorus mg/L	26,11	20,45	32,59	10,00	-	10,00	27,53
Nitrogen mg/L N	12,95	-	-	-	-	-	-
Phosphate mg/L	-	-	-	-	-	-	-
Nitrate mg/l N	41,41	95,71	42,73	-	-	-	20,00

	C18	C19	C20	C21	C22
1,2-Dichloroethane µg/L	-	-	647,13	-	-
Anthracene µg/L	-	0,06	0,15	0,02	-
Benzene µg/L	0,37	2,43	47,44	-	-
Cadmium µg/L	0,60	0,33	0,58	0,73	-
Chloroalkanes µg/L	-	-	8,60	-	-
Hexachloro-benzene µg/L	-	2,00	0,01	-	-
Hexachloro-butadiene µg/L	-	-	4,94	-	-
Mercury µg/L	-	105,00	0,19	0,26	-
Nickel µg/L	6,60	8,87	92,76	4,58	-
Nonylpheno µg/L	3,33	-	56760,86	1,26	1000,00
Lead µg/L	3,32	1,22	14,40	3,48	-
Tetrachloro-ethylene µg/L	0,50	95,00	5,16	0,20	-
Trichloro-ethylene µg/L	0,27	-	0,67	0,19	-
BOD5 mg/L O2	750,00	300,00	598,81	559,87	603,10
TOC mg/L C	-	300,00	276,00	250,00	-
Phosphorus mg/L	40,19	30,00	39,81	35,97	35,00
Nitrogen mg/L N	90,00	-	-	-	-
Phosphate mg/L	30,00	90,00	68,00	90,00	10,00
Nitrate mg/l N	10,00	100,00	74,81	-	80,00

	C23	C24	C25	C26	C27	C28
1,2-Dichloroethane µg/L	-	-	-	-	-	-
Anthracene µg/L	0,01	0,02	-	-	-	0,01
Benzene µg/L	-	-	-	-	-	-
Cadmium µg/L	1,31	21,67	-	-	-	10015,00
Chloroalkanes µg/L	-	5,81	-	-	-	5105,00
Hexachloro-benzene µg/L	-	-	-	-	-	-
Hexachloro-butadiene µg/L	-	-	-	-	-	-
Mercury µg/L	33,48	0,18	-	-	-	85,00
Nickel µg/L	18,51	619,92	3854,17	-	2000,00	20,14
Nonylpheno µg/L	0,96	1,06	-	-	-	-
Lead µg/L	339,66	35,68	-	-	-	2212,80
Tetrachloro-ethylene µg/L	-	0,21	-	-	-	-
Trichloro-ethylene µg/L	-	0,34	-	-	-	-
BOD5 mg/L O2	59,04	586,54	641,41	33,33	86,67	328,75
TOC mg/L C	-	-	-	-	-	-
Phosphorus mg/L	11,28	10,00	40,87	10,00	25,71	32,86
Nitrogen mg/L N	18,44	-	70,00	-	-	-
Phosphate mg/L	-	-	-	-	20,00	20,00
Nitrate mg/l N	-	-	89,84	-	-	100,00

	C29	C30	C31	C32	C33
1,2-Dichloroethane µg/L	-	-	-	-	-
Anthracene µg/L	-	-	-	-	-
Benzene µg/L	-	-	-	-	-
Cadmium µg/L	-	-	-	-	-
Chloroalkanes µg/L	-	-	-	-	-
Hexachloro-benzene µg/L	-	-	-	-	-
Hexachloro-butadiene µg/L	-	-	-	-	-
Mercury µg/L	-	-	-	-	-
Nickel µg/L	-	-	-	-	-
Nonylpheno µg/L	-	-	-	-	-
Lead µg/L	-	-	-	-	-

	C29	C30	C31	C32	C33
Tetrachloro-ethylene µg/L	-	-	-	-	-
Trichloro-ethylene µg/L	-	-	-	-	-
BOD5 mg/L O2	563,16	-	35,00	35,00	40,00
TOC mg/L C	-	-	-	-	-
Phosphorus mg/L	39,25	-	10,00	38,75	10,00
Nitrogen mg/L N	-	-	-	-	-
Phosphate mg/L	30,00	-	-	-	-
Nitrate mg/l N	94,74	-	-	-	-

4.3. Wastewater treatment plants estimated pollutants removal values

For most of the PP, the values of the removal percentage depending on the type of WWTP can be estimated by following the table results below. The values are from a non-published, yet bibliography research done by ICRA.

	WWTP typology		
PP Name	Primary	Secondary	Tertiary
1,2-Dichloroethane	21,25	58,50	80,00
Cadmium	21,50	45,50	63,00
Hexachloro-benzene	-	-	57,25
Mercury	36,00	16,70	-
Lead	41,50	53,49	67,75
Nickel	17,00	50,10	39,00
C10-13 Chloroalkanes	10,00	40,00	-
Hexachloro-butadiene	5,00	80,00	-
Nonylpheno	43,00	79,00	95,00
Tetrachloro-ethylene	23,50	80,00	94,00
Trichloro-ethylene	10,00	75,33	94,00

4.4. Other estimated values

The rest of the WIAT estimated values have the following sources and values or formulas.

Estimation	**Values, explanation, or equation**	**Used to calculate**	**Source**
Emission factor for grid electricity	The values estimated for emissions factor for grid electricity comes from the European Investment Bank. The values of the emission factor depend in which country the industry is located.	Indirect emissions from electricity consumption	(*EIB Project Carbon Footprint Methodologies Methodologies for the Assessment of Project GHG Emissions and Emission Variations*, 2020)

Estimation	Values, explanation, or equation	Used to calculate	Source
% Biogas produced that is flared	The value of % of biogas produced that is flared is usually 98.	Biogas (anaerobic digestion of sludge)	(*ECAM V3*, n.d.)
Biogas leaked to the atmosphere (% volume)	Biogas leaked to the atmosphere (% volume) is usually 2.	Biogas (anaerobic digestion of sludge)	(*ECAM V3*, n.d.)
Biogas valorised as heat and/or electricity	$Bval = 100 - Bf - Bs - Bleak$ Bval: biogas valorised as heat or electricity Bs: biogas sold Bf: biogas that is flared Bleak: biogas leaked to the atmosphere	Biogas (anaerobic digestion of sludge)	(*ECAM V3*, n.d.)
Biogas sold (% volume)	$Bs = 100 - Bf - Bval - Bleak$ Bs: biogas sold Bf: biogas that is flared Bval: biogas valorised as heat or electricity Bleak: biogas leaked to the atmosphere	Biogas (anaerobic digestion of sludge)	(*ECAM V3*, n.d.)
N_2O emission factor for low C:N ratio	1,5%	Sludge composted Landfilling of sludge	(Brown et al., 2008)
CH_4 emission factor for uncovered pile (factor of initial C in solids)	2,5%	Sludge composted	(Brown et al., 2008)
CO2eq equation rate	0,25	Emissions from fuel engines Emissions from treatment Sludge composted Sludge incineration Land application of sludge Landfilling of sludge Sludge stockpiling Amount of CO2 eq emissions related to sludge storage Emissions from water discharged	(*The Biosolids Emissions Assessment Model (BEAM): A Method for Determining Greenhouse Gas Emissions from Canadian Biosolids Management Practices Final Report*, 2009)
Average highest temperature of combustion achieved in a Fluidized Bed incinerator	1023	Sludge incineration	(*The Biosolids Emissions Assessment Model (BEAM): A Method for Determining Greenhouse Gas Emissions from Canadian Biosolids Management*

Estimation	Values, explanation, or equation	Used to calculate	Source
			Practices Final Report, 2009)
Uncertainty factor	0,9	Landfilling of sludge	(*CDM: Approved Baseline and Monitoring Methodologies for Large Scale CDM Project Activities*, n.d.)
CH_4 in landfill gas	50%	Landfilling of sludge	(*CLEAN DEVELOPMENT MECHANISM 2008 IN BRIEF*, n.d.)
Decomposable organic fraction of raw wastewater solids	80%	Landfilling of sludge	(Bani Shahabadi et al., 2009)
Percentage decomposed in first 3 years	69,9%	Landfilling of sludge	(*CDM: Approved Baseline and Monitoring Methodologies for Large Scale CDM Project Activities*, n.d.)

5. References

Acuña, V., Bregoli, F., Font, C., Barceló, D., Corominas, L. L., Ginebreda, A., Petrovic, M., Rodríguez-Roda, I., Sabater, S., & Marcé, R. (2020). Management actions to mitigate the occurrence of pharmaceuticals in river networks in a global change context. *Environment International*, *143*. https://doi.org/10.1016/j.envint.2020.105993

Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0. (n.d.).

Bani Shahabadi, M., Yerushalmi, L., & Haghighat, F. (2009). Impact of process design on greenhouse gas (GHG) generation by wastewater treatment plants. *Water Research*, *43*(10), 2679–2687. https://doi.org/10.1016/J.WATRES.2009.02.040

Barré, H., Gaucher, R., Jouglet, P., & Lepot, B. (2016). *LES SUBSTANCES DANGEREUSES POUR LE MILIEU AQUATIQUE DANS LES REJETS INDUSTRIELS Action nationale de recherche et de réduction des rejets de substances dangereuses dans l'eau par les installations classées (RSDE)-Seconde phase RESULTATS DE SURVEILLANCE INITIALE RSDE DETAILLES PAR SECTEUR*.

Bazin, C., Chambon, P., Bonnefille, M., & Larbaigt, G. (1987). Compared sensitivity of luminescent marine bacteria (Photobacterium phosphoreum) and Daphnia bioassays. *Sciences de l'eau*, *6*, 403–413.

Brauman, K. A., Richter, B. D., Postel, S., Malsy, M., & Flörke, M. (2016). Water depletion: An improved metric for incorporating seasonal and dry-year water scarcity into water risk assessmentsWater depletion: Improved metric for seasonal and dry-year water scarcity. *Elementa*, *2016*. https://doi.org/10.12952/journal.elementa.000083

Brennan, S. J., Brougham, C. A., Roche, J. J., & Fogarty, A. M. (2006). Multi-generational effects of four selected environmental oestrogens on Daphnia magna. *Chemosphere*, *64*(1), 49–55. https://doi.org/10.1016/j.chemosphere.2005.11.046

Bringmann, G., & Kuehn, R. (1982). [Results of toxic action of water pollutants on Daphnia magna Straus tested by an improved standardized procedure]. *Wasser und Abwasser in Forschung und Praxis*, *15*(1), 1–6. https://heronet.epa.gov/heronet/index.cfm/reference/download/reference_id/18804

Brown, S., Kruger, C., & Subler, S. (2008). Greenhouse Gas Balance for Composting Operations. *Journal of Environmental Quality*, *37*(4), 1396–1410. https://doi.org/10.2134/jeq2007.0453

Calamari D, Galassi S, Setti F, & Vighi M. (1983). TOXICITY OF SELECTED CHLOROBENZENES TO AQUATIC ORGANISMS. In *Chemosphere* (Vol. 12, Issue 2).

CARACTERITZACIÓ DE MASSES D'AIGUA I ANÀLISI DEL RISC D'INCOMPLIMENT DELS OBJECTIUS DE LA DIRECTIVA MARC DE L'AIGUA (2000/60/CE) A CATALUNYA (conques intra i intercomunitàries) Octubre de 2005. (n.d.).

Carrão, H., Naumann, G., & Barbosa, P. (2016). Mapping global patterns of drought risk: An empirical framework based on sub-national estimates of hazard, exposure and vulnerability. *Global Environmental Change*, *39*, 108–124. https://doi.org/10.1016/j.gloenvcha.2016.04.012

CDM: Approved Baseline and Monitoring Methodologies for Large Scale CDM Project Activities. (n.d.). Retrieved January 19, 2022, from https://cdm.unfccc.int/methodologies/PAmethodologies/approved

CLEAN DEVELOPMENT MECHANISM 2008 IN BRIEF. (n.d.). http://cdm.unfccc.int/Reference/COPMOP/index.html

CML-IA Characterisation Factors - Leiden University. (n.d.). Retrieved December 2, 2021, from https://www.universiteitleiden.nl/en/research/research-output/science/cml-ia-characterisation-factors

'Davies Waldron, C. (2006). *Chapter 3 Mobile combustion: Vol. Chapter 3* (IPCC).

Deborah Bartram, Michael D. Short, Yoshitaka Ebie, Juraj Farkaš, Céline Gueguen, Gregory M. Peters, Nuria Mariana Zanzottera, & M. Karthik. (2019). *Chapter 6: Wastewater Treatment and Discharge*.

Documentation » Gridded Population of the World (GPW), v4 | SEDAC. (n.d.). Retrieved December 2, 2021, from https://sedac.ciesin.columbia.edu/data/collection/gpw-v4/documentation

ECAM v3. (n.d.). Retrieved January 10, 2022, from https://ecam.icradev.cat/

ECOTOX | Home. (n.d.). Retrieved December 2, 2021, from https://cfpub.epa.gov/ecotox/

EIB Project Carbon Footprint Methodologies Methodologies for the Assessment of Project GHG Emissions and Emission Variations. (2020). https://doi.org/10.2867/401801

EUROPA - Competition - List of NACE codes. (n.d.). Retrieved December 9, 2021, from https://ec.europa.eu/competition/mergers/cases/index/nace_all.html

Freitag, D., Ballhorn, L., Behechti, A., Fischer, K., & Thumm, W. (1994). STRUCTURAL CONFIGURATION AND TOXICITY OF CHLORINATED ALKANES. In *Chemosphere* (Vol. 28, Issue 2).

Haley, M. v, & Kurnas, C. W. (1993). Aquatic Toxicity and Fate of Nickel-Coated Graphite Fibers, With Comparisons to Iron and Aluminum Coated Glass Fibers. Final Report, June-December 1991. *Gov. Res. Announc. Index(USA)*, 17.

Hofste, R. W., Kuzma, S., Walker, S., Sutanudjaja, E. H., Bierkens, M. F. P., Kuijper, M. J. M., Sanchez, M. F., van Beek, R., Wada, Y., Rodríguez, S. G., & Reig, P. (n.d.). *AQUEDUCT 3.0: UPDATED DECISION-RELEVANT GLOBAL WATER RISK INDICATORS*. https://www.wri.org/publication/aqueduct-30.

Kim, H., Yim, B., Bae, C., & Lee, Y. M. (2017). Acute toxicity and antioxidant responses in the water flea Daphnia magna to xenobiotics (cadmium, lead, mercury, bisphenol A, and 4-nonylphenol). *Toxicology and Environmental Health Sciences*, *9*(1), 41–49. https://doi.org/10.1007/s13530-017-0302-8

Knie, J., Halke, A., Juhnke, I., & Schiller, W. (1983). [Results of studies on chemical substances with four biotests]. *Deutsche Gewaesserkundliche Mitteilungen*, *27*(3), 77–79.

Middleton, Nick., & Thomas, D. (1992). *World atlas of desertification.* ix, 69 p. : http://digitallibrary.un.org/record/246740

Müller Schmied, H., Caceres, D., Eisner, S., Flörke, M., Herbert, C., Niemann, C., Asali Peiris, T., Popat, E., Theodor Portmann, F., Reinecke, R., Schumacher, M., Shadkam, S., Telteu, C. E., Trautmann, T., & Döll, P. (2021). The global water resources and use model WaterGAP v2.2d: Model description and evaluation. *Geoscientific Model Development*, *14*(2), 1037–1079. https://doi.org/10.5194/gmd-14-1037-2021

NORMAN Ecotoxicology Database. (n.d.). Retrieved December 2, 2021, from https://www.norman-network.com/nds/ecotox/ecotoxIndex.php

Priority substances - Water - Environment - European Commission. (n.d.). Retrieved December 2, 2021, from https://ec.europa.eu/environment/water/water-dangersub/pri_substances.htm

Rice, J., & Westerho, P. (2017). High levels of endocrine pollutants in US streams during low flow due to insufficient wastewater dilution. *Nature Geoscience*, *10*(8), 587–591. https://doi.org/10.1038/NGEO2984

Sanitation Treatment. (n.d.). Retrieved December 2, 2021, from https://ecam.icradev.cat/

The Biosolids Emissions Assessment Model (BEAM): A Method for Determining Greenhouse Gas Emissions from Canadian Biosolids Management Practices Final Report. (2009). www.sylvis.com

The Open Ocean Status and Trends SUMMARY FOR POLICY MAKERS International Hydrological Programme. (2016).

Wagner, F., & Walsh, M. P. (n.d.). *MOBILE COMBUSTION*.

WHO & UNICEF. (2017). *Progress on Drinking Water, Sanitation and Hygiene Update and SDG Baselines 2017 Launch version July 12 Main report*. http://apps.who.int/bookorders.

WWF Water Risk Filter Methodology Documentation. (2021). https://ceowatermandate.org/terminology/

Zomer, R. J., Trabucco, A., Bossio, D. A., & Verchot, L. v. (2008). Climate change mitigation: A spatial analysis of global land suitability for clean development mechanism afforestation and reforestation. *Agriculture, Ecosystems and Environment*, *126*(1–2), 67–80. https://doi.org/10.1016/j.agee.2008.01.014

6. Appendix

6.1. Priority Substances

List of priority substances in the field of water policy: (*Priority Substances - Water - Environment - European Commission*, n.d.)

Number	CAS numberi	EU number	Name of priority substance	Identified as priority hazardous substance
(1)	15972-60-8	240-110-8	Alachlor	
(2)	120-12-7	204-371-1	Anthracene	X
(3)	1912-24-9	217-617-8	Atrazine	
(4)	71-43-2	200-753-7	Benzene	
(5)	not applicable	not applicable	Brominated diphenyletheriv	X
	32534-81-9	not applicable	Pentabromodiphenylether (congener numbers 28, 47, 99, 100, 153 and 154)	
(6)	7440-43-9	231-152-8	Cadmium and its compounds	X
(7)	85535-84-8	287-476-5	Chloroalkanes, C10-13 iv	X
(8)	470-90-6	207-432-0	Chlorfenvinphos	
(9)	2921-88-2	220-864-4	Chlorpyrifos (Chlorpyrifos-ethyl)	
(10)	107-06-2	203-458-1	1,2-Dichloroethane	
(11)	75-09-2	200-838-9	Dichloromethane	
(12)	117-81-7	204-211-0	Di(2-ethylhexyl)phthalate (DEHP)	

(13)	330-54-1	206-354-4	Diuron	
(14)	115-29-7	204-079-4	Endosulfan	X
(15)	206-44-0	205-912-4	Fluoranthenevi	
(16)	118-74-1	204-273-9	Hexachlorobenzene	X
(17)	87-68-3	201-765-5	Hexachlorobutadiene	X
(18)	608-73-1	210-158-9	Hexachlorocyclohexane	X
(19)	34123-59-6	251-835-4	Isoproturon	
(20)	7439-92-1	231-100-4	Lead and its compounds	
(21)	7439-97-6	231-106-7	Mercury and its compounds	X
(22)	91-20-3	202-049-5	Naphthalene	
(23)	7440-02-0	231-111-4	Nickel and its compounds	
(24)	25154-52-3	246-672-0	Nonylphenols	X
	104-40-5	203-199-4	(4-nonylphenol)	X
(25)	1806-26-4	217-302-5	Octylphenols	
	140-66-9	not applicable	(4-(1,1',3,3'-tetramethylbutyl)-phenol)	
(26)	608-93-5	210-172-5	Pentachlorobenzene	X
(27)	87-86-5	201-778-6	Pentachlorophenol	
(28)	not applicable	not applicable	Polyaromatic hydrocarbons	X
	50-32-8	200-028-5	(Benzo(a)pyrene)	X
	205-99-2	205-911-9	(Benzo(b)fluoranthene)	X
	191-24-2	205-883-8	(Benzo(g,h,i)perylene)	X
	207-08-9	205-916-6	(Benzo(k)fluoranthene)	X
	193-39-5	205-893-2	(Indeno(1,2,3-cd)pyrene)	X

(29)	122-34-9	204-535-2	Simazine	
(30)	not applicable	not applicable	Tributyltin compounds	X
	36643-28-4	not applicable	(Tributyltin-cation)	X
(31)	12002-48-1	234-413-4	Trichlorobenzenes	
(32)	67-66-3	200-663-8	Trichloromethane (chloroform)	
(33)	1582-09-8	216-428-8	Trifluralin	