

Supplementary information

Life cycle assessment of valorisation processes for industrial saline residues

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S1 - Composition of contaminated salt and contaminated brine

Table S1. Chemical composition of the contaminated salt generated in the tanning industry.

Parameters	g/kg contaminated salt
Sodium	379.1
Chlorine	584.6
Carbon (organic)	1.3
Nitrogen	0.6
Phosphorus	0.3
Water	34.1

Table S2. Chemical composition of the contaminated brine generated in the codfish industry.

Parameters	g/kg contaminated brine
Sodium	93.7
Chlorine	144.5
Carbon (organic)	4.6
Nitrogen	2.3
Phosphorus	0.6
Water	754.3

S2 - Ecoinvent datasets

Table S3. Ecoinvent datasets used for the disposal of contaminated salt from the tanning industry in a landfill.

Parameters	Ecoinvent datasets (as adopted in SimaPro)
Deposition of contaminated salt in landfill	Modelled with a calculation tool
Transport to landfill	Transport, freight, light commercial vehicle, fleet average {Europe without Switzerland} transport, freight, light commercial vehicle, fleet average Cut-off, U

Table S4. Ecoinvent datasets used for the pickling process with virgin salt.

Parameters	Ecoinvent datasets (as adopted in SimaPro)
Virgin salt	Sodium chloride, powder {RER} sodium chloride production, powder Cut-off, U
Water	Water, non-irrigation, well, in ground, PT
Sulfuric acid	Sulfuric acid {RER} sulfuric acid production Cut-off, U
Formic acid	Formic acid {RER} formic acid production, methyl formate route Cut-off, U
Surfactant	Alkyl sulfate (C12-14) {GLO} alkyl sulfate (C12-14) production Cut-off, U
Additive	Cocamide diethanolamine {RER} cocamide diethanolamine production Cut-off, U
Biocides	Pesticide, unspecified {RER} pesticide production, unspecified Cut-off, U
Grid electricity	Electricity, medium voltage {PT} market for electricity, medium voltage Cut-off, U
Photovoltaic electricity	Electricity, low voltage {PT} electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted Cut-off, U
Transport of virgin salt, sulfuric acid, and formic acid	Transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 {RER} transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 Cut-off, U
Transport of surfactant, additive and biocides	Transport, freight, lorry, 3.5-7.5 metric ton, diesel, EURO 6 {RER} transport, freight, lorry, 3.5-7.5 metric ton, diesel, EURO 6 Cut-off, U

Table S5. Ecoinvent datasets used for the electrocoagulation treatment of contaminated salt from the tanning industry.

Parameters	Ecoinvent datasets (as adopted in SimaPro)
Water	Water, non-irrigation, well, in ground, PT
Iron electrodes	Cast iron {GLO} market for cast iron Cut-off, U
Filter bags	Polypropylene, granulate {GLO} market for polypropylene, granulate Cut-off, U
Grid electricity	Electricity, medium voltage {PT} market for electricity, medium voltage Cut-off, U
Photovoltaic electricity	Electricity, low voltage {PT} electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted Cut-off, U
Screenings for landfill	Modelled with a calculation tool
Sludge for landfill	Modelled with a calculation tool
Transport of waste to landfill	Transport, freight, light commercial vehicle, fleet average {Europe without Switzerland} transport, freight, light commercial vehicle, fleet average Cut-off, U

Table S6. Ecoinvent datasets for the pickling process with treated brine (instead of virgin salt)

Parameters	Ecoinvent datasets (as adopted in SimaPro)
Sulfuric acid	Sulfuric acid {RER} sulfuric acid production Cut-off, U
Formic acid	Formic acid {RER} formic acid production, methyl formate route Cut-off, U
Surfactant	Alkyl sulfate (C12-14) {GLO} alkyl sulfate (C12-14) production Cut-off, U
Additive	Cocamide diethanolamine {RER} cocamide diethanolamine production Cut-off, U
Biocides	Pesticide, unspecified {RER} pesticide production, unspecified Cut-off, U
Grid electricity	Electricity, medium voltage {PT} market for electricity, medium voltage Cut-off, U
Photovoltaic electricity	Electricity, low voltage {PT} electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted Cut-off, U
Transport of sulfuric and formic acids	Transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 {RER} transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 Cut-off, U
Transport of surfactant, additive and biocides	Transport, freight, lorry, 3.5-7.5 metric ton, diesel, EURO 6 {RER} transport, freight, lorry, 3.5-7.5 metric ton, diesel, EURO 6 Cut-off, U

Table S7. Ecoinvent datasets for the treatment of contaminated brine from the codfish industry in a wastewater treatment plant

Parameters	Ecoinvent datasets (as adopted in SimaPro)
Grid electricity	Electricity, medium voltage {PT} market for electricity, medium voltage Cut-off, U
Photovoltaic electricity	Electricity, low voltage {PT} electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted Cut-off, U
Wastewater treatment	Modelled with a calculation tool

Table S8. Inventory data for the electro-Fenton treatment of contaminated brine from the codfish industry.

Parameters	Ecoinvent datasets (as adopted in SimaPro)
Iron electrodes	Cast iron {GLO} market for cast iron Cut-off, U
Filter bags	Polypropylene, granulate {GLO} market for polypropylene, granulate Cut-off, U
Hydrogen peroxide	Hydrogen peroxide, without water, in 50% solution state {RER} market for hydrogen peroxide, without water, in 50% solution state Cut-off, U
Grid electricity	Electricity, medium voltage {PT} market for electricity, medium voltage Cut-off, U
Photovoltaic electricity	Electricity, low voltage {PT} electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted Cut-off, U
Waste for landfill	Modelled with a calculation tool ¹
Transport of brine	Transport, freight, lorry, 3.5-7.5 metric ton, diesel, EURO 6 {RER} transport, freight, lorry, 3.5-7.5 metric ton, diesel, EURO 6 Cut-off, U
Transport of waste to landfill	Transport, freight, light commercial vehicle, fleet average {Europe without Switzerland} transport, freight, light commercial vehicle, fleet average Cut-off, U

S3 - Total impact assessment results for System 1

Table S9. Total impact of baseline (A) and valorisation (B) scenarios for curing salt.

	Scenario A	Scenario B
Global warming - GW [kg CO ₂ eq]	4.78×10^{-1}	3.83×10^{-1}
Stratospheric ozone depletion - SOD [kg CFC11 eq]	6.04×10^{-7}	5.62×10^{-7}
Ionizing radiation - IR [kBq Co-60 eq]	2.89×10^{-2}	1.86×10^{-2}
Ozone formation, Human health - OFHH [kg NO _x eq]	1.14×10^{-3}	9.39×10^{-4}
Ozone formation, Terrestrial ecosystems - OFTE [kg NO _x eq]	1.31×10^{-3}	1.10×10^{-3}
Fine particulate matter formation - FP [kg PM2.5 eq]	1.03×10^{-3}	9.20×10^{-4}
Terrestrial acidification - TA [kg SO ₂ eq]	3.05×10^{-3}	2.79×10^{-3}
Freshwater eutrophication - FE [kg P eq]	2.14×10^{-4}	1.52×10^{-4}
Marine eutrophication - ME [kg N eq]	4.39×10^{-4}	2.97×10^{-4}
Terrestrial ecotoxicity - TEco [kg 1,4-DCB]	1.59×10^{-0}	1.05×10^{-0}
Freshwater ecotoxicity - FEco [kg 1,4-DCB]	4.31×10^{-2}	3.21×10^{-2}
Marine ecotoxicity - MEco [kg 1,4-DCB]	4.72×10^{-2}	3.30×10^{-2}
Human carcinogenic toxicity - HCT [kg 1,4-DCB]	9.96×10^{-2}	7.83×10^{-2}
Human non-carcinogenic toxicity - HNCT [kg 1,4-DCB]	8.17×10^{-1}	5.72×10^{-1}
Land use - LU [m ² a crop eq]	1.86×10^{-1}	1.80×10^{-1}
Mineral resource scarcity - MRS [kg Cu eq]	2.95×10^{-3}	2.20×10^{-3}
Fossil resource scarcity - FRS [kg oil eq]	1.40×10^{-1}	1.22×10^{-1}
Water consumption - WC [m ³]	3.70×10^{-2}	3.54×10^{-2}

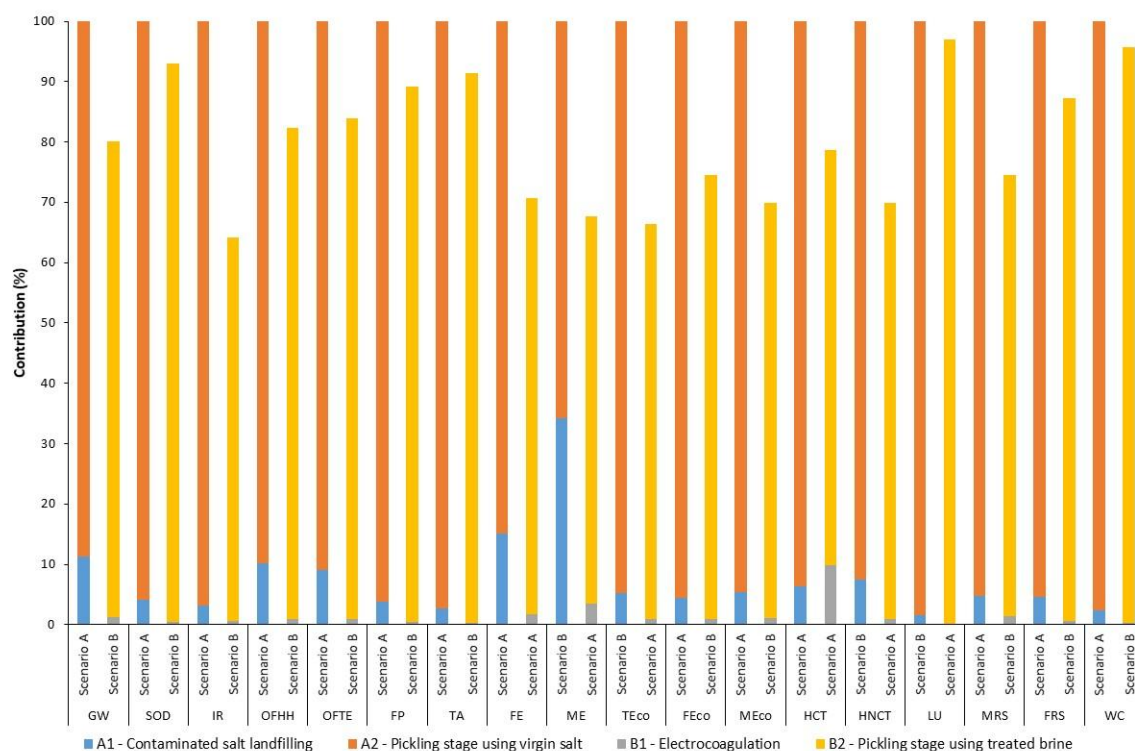


Figure S1. Comparison between baseline (A) and valorisation (B) scenarios for curing salt. The scenario with the greatest impact in each category is assigned a value of 100%.

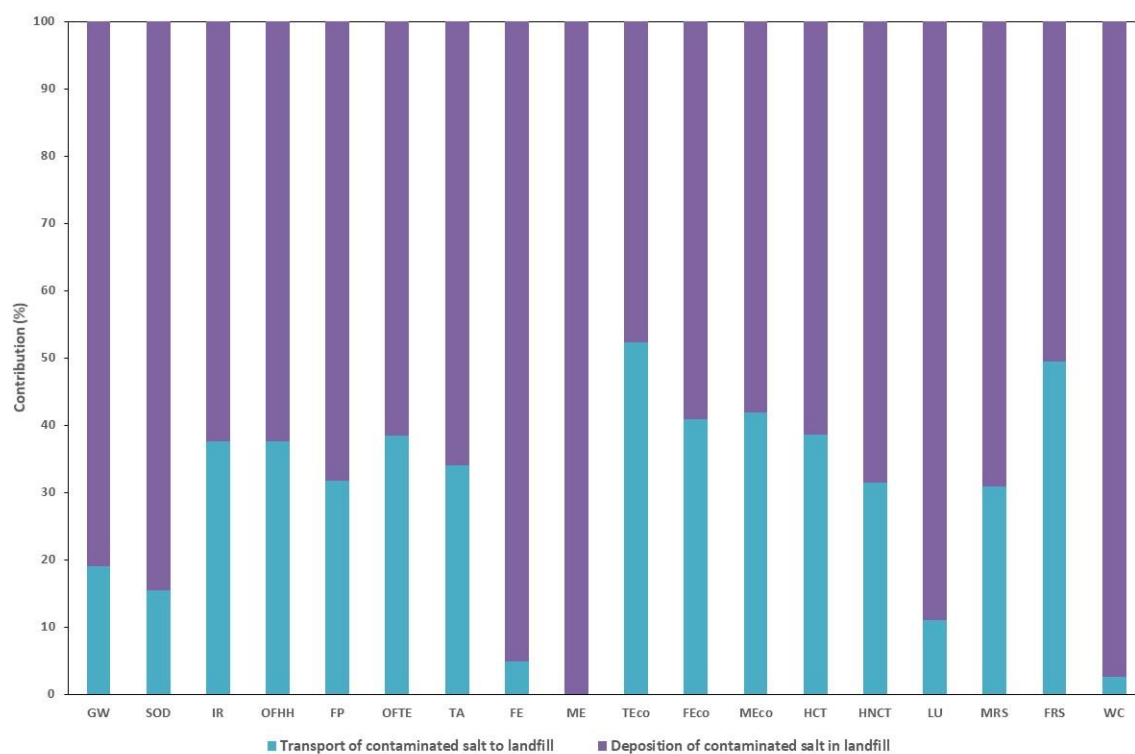


Figure S2. Contributions of disposal of the contaminated salt from the tanning industry in landfill (A_1).

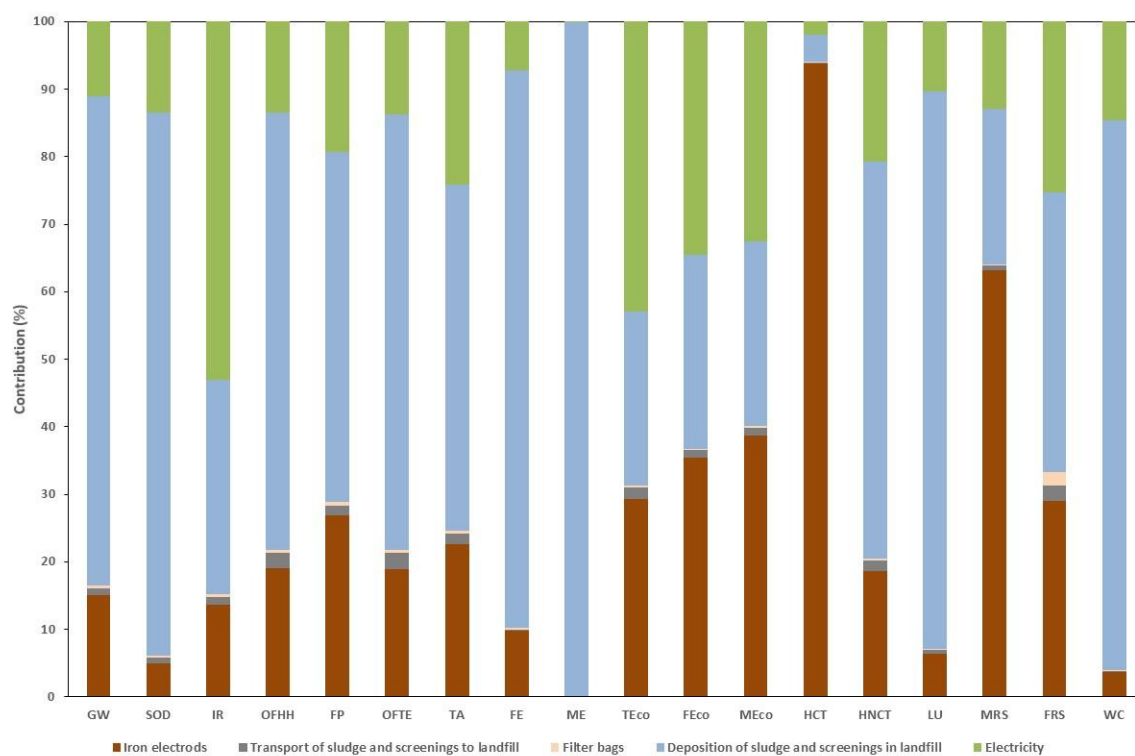


Figure S3. Contributions of treated contaminated salt by the electrocoagulation process (B_1).

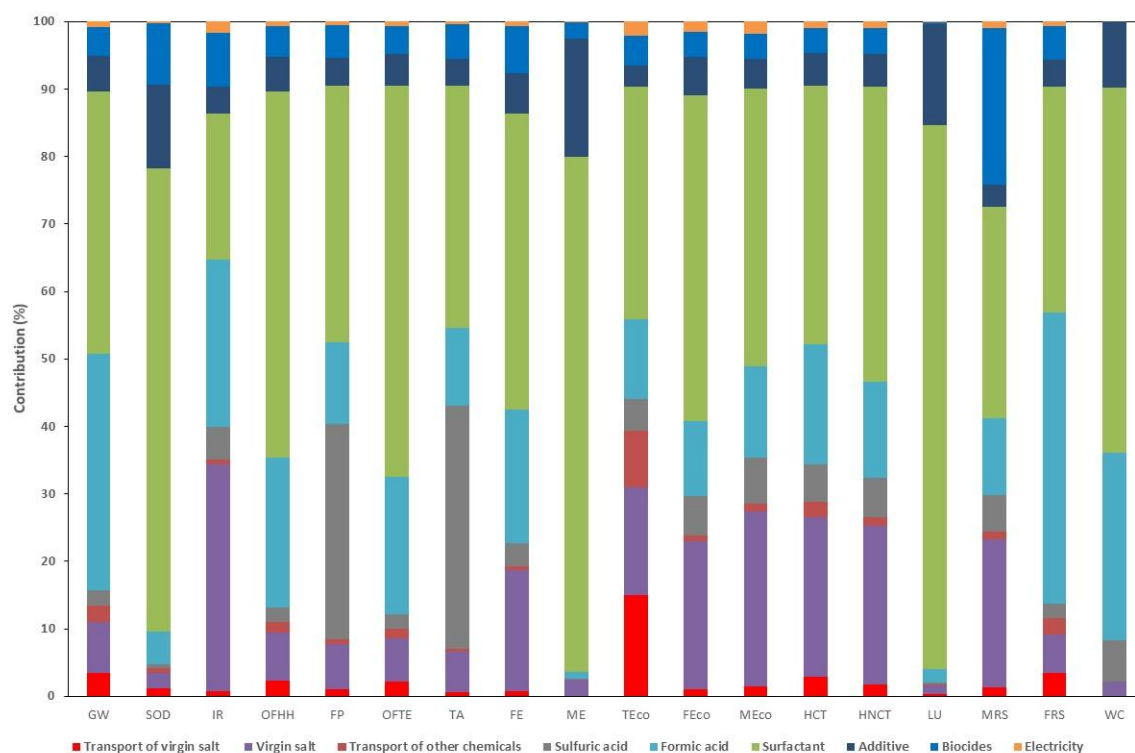


Figure S4. Contributions of the pickling process with virgin salt (A₂)

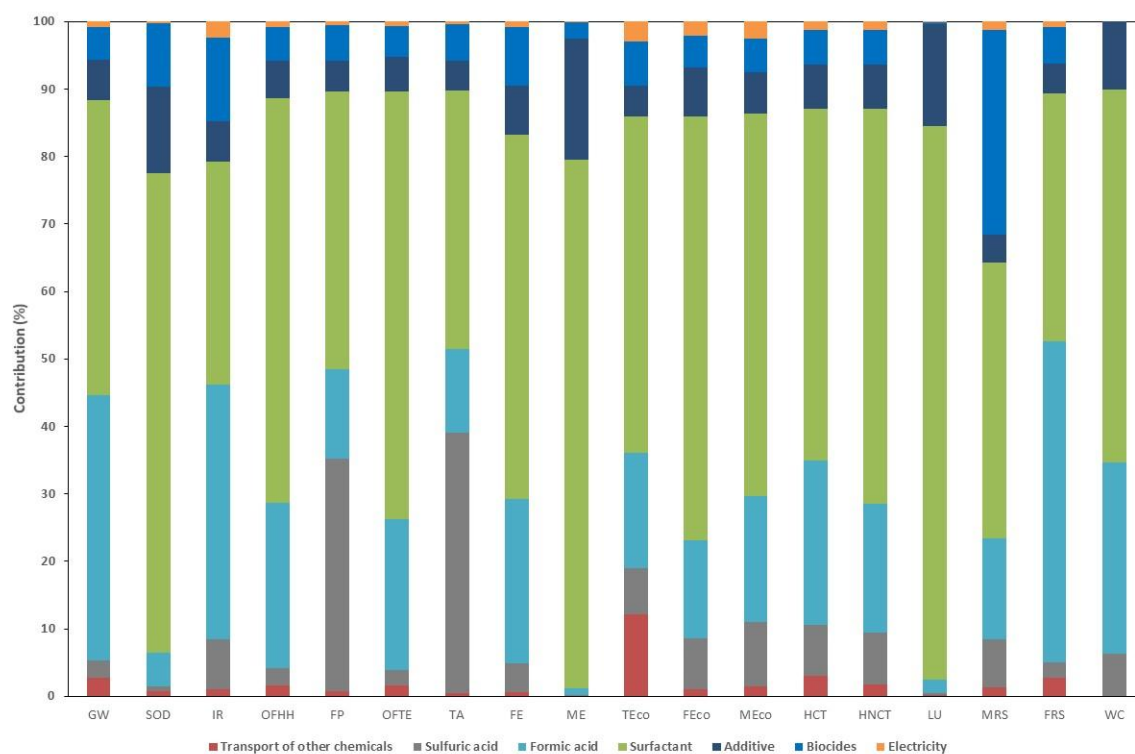


Figure S5. Contributions of the pickling process with treated contaminated salt by the electrocoagulation process (B₁).

S4 - Total impact assessment results for System 2

Table S10. Total impact of baseline (A) and valorisation (B) scenarios for codfish brine.

	Scenario A	Scenario B
Global warming - GW [kg CO ₂ eq]	1.50×10^{-2}	1.59×10^{-2}
Stratospheric ozone depletion - SOD [kg CFC11 eq]	2.30×10^{-4}	2.02×10^{-4}
Ionizing radiation - IR [kBq Co-60 eq]	9.97×10^{-0}	7.58×10^{-0}
Ozone formation, Human health - OFHH [kg NO _x eq]	3.70×10^{-1}	3.59×10^{-1}
Ozone formation, Terrestrial ecosystems - OFTE [kg NO _x eq]	4.28×10^{-1}	4.20×10^{-1}
Fine particulate matter formation - FP [kg PM2.5 eq]	3.46×10^{-1}	3.34×10^{-1}
Terrestrial acidification - TA [kg SO ₂ eq]	1.03×10^0	1.00×10^0
Freshwater eutrophication - FE [kg P eq]	4.64×10^{-1}	5.56×10^{-2}
Marine eutrophication - ME [kg N eq]	1.05×10^{-1}	9.81×10^{-2}
Terrestrial ecotoxicity - TEco [kg 1,4-DCB]	5.25×10^2	5.67×10^2
Freshwater ecotoxicity - FEco [kg 1,4-DCB]	1.43×10^1	1.27×10^1
Marine ecotoxicity - MEco [kg 1,4-DCB]	1.56×10^1	1.37×10^1
Human carcinogenic toxicity - HCT [kg 1,4-DCB]	3.26×10^1	3.59×10^1
Human non-carcinogenic toxicity - HNCT [kg 1,4-DCB]	2.64×10^2	2.28×10^2
Land use - LU [m ² a crop eq]	6.31×10^1	6.28×10^1
Mineral resource scarcity - MRS [kg Cu eq]	9.79×10^{-1}	8.42×10^{-1}
Fossil resource scarcity - FRS [kg oil eq]	4.64×10^1	5.08×10^1
Water consumption - WC [m ³]	1.25×10^1	1.26×10^1

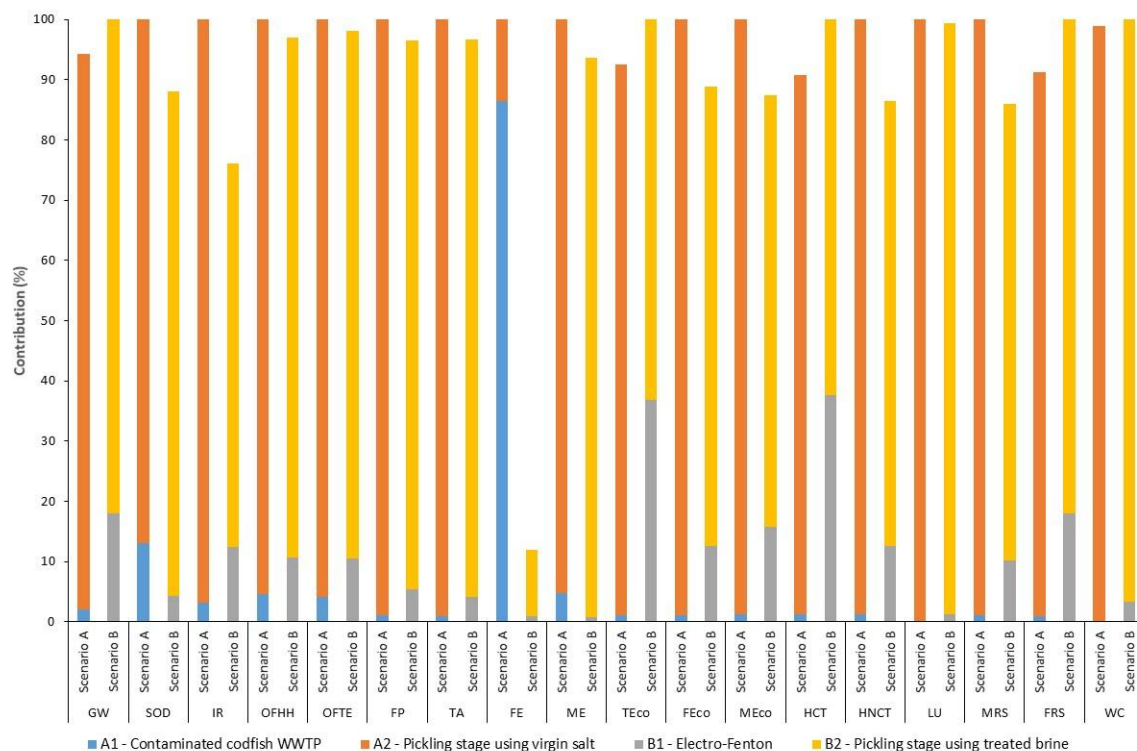


Figure S6. Comparison between baseline (A) and valorisation (B) scenarios for codfish brine. The scenario with the greatest impact in each category is assigned a value of 100%.

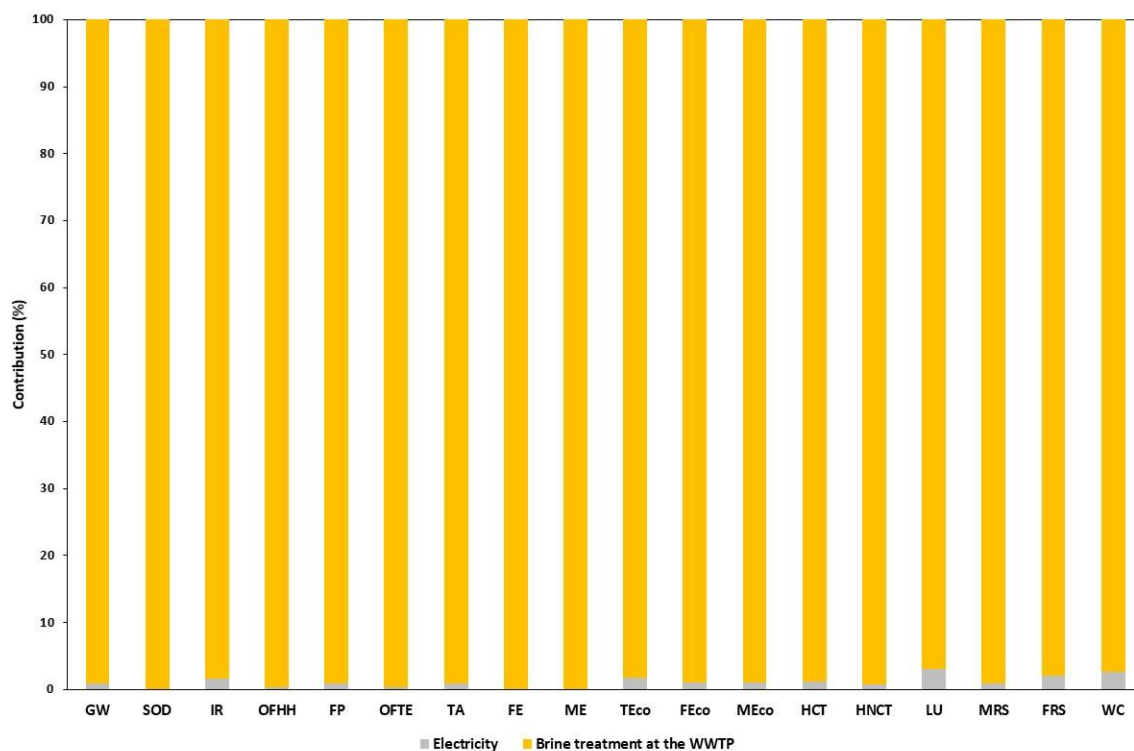


Figure S7. Contributions of treated contaminated brine from the codfish industry in a wastewater treatment plant (A₁)

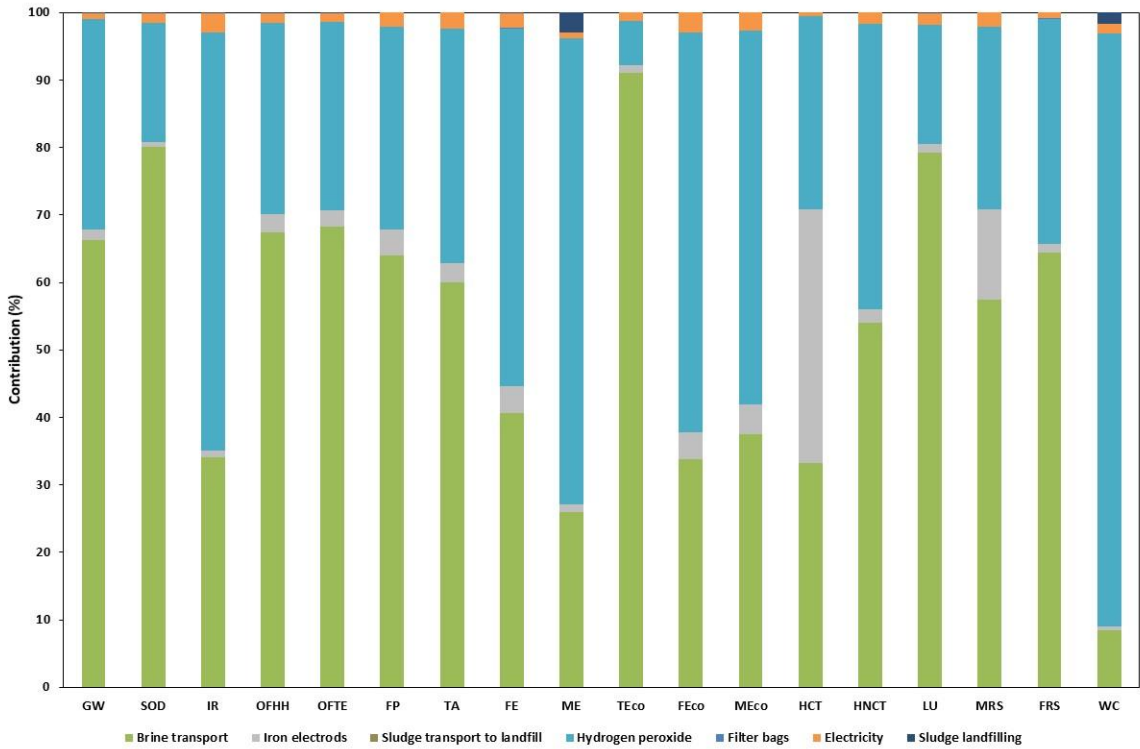


Figure S8. Contributions of treated contaminated codfish brine by electro-Fenton process (B₁)