Cluster technological innovation: sludges recovery

The upgrading of treatment plants and related technologies, have significantly reduced the amount of excess sludge to dispose of. Throughout the past 20 years the **excess sludge production drop from 180.000 ton/y on 1995 to 15.000 ton/y on 2015**. Despite of this, the massive flows still remain huge and the landfil disposal.

The **Ecoespanso s.r.l. plant was built in 2001** for the purpose **to solve the environmental issues related to the excess sludge landfill disposal**, in order to improve the environmental sustainability of the whole tanning process.

The **final product** of Ecoespanso's process is the **sintered granules** (KEU) which is usually mixed with Calcium Carbonate to make the filler mixes HSC and HBC. HSC is used as component for the **production of cement**, while HBC could be used for the **production of asphalts**.

Sludges recovery process (1)

Ecoespanso has a maximum treatment capacity of about 20.000 ton/y of dry substance which correponds to a sludge flow of more than 500.000m3/y, that is more than currently produced by Consorzio Aquarno.

A dedicated "sludge-pipe" directly conveys Aquarno's sewerage sludge to the only receiver inside Ecoespanso plant, which, due to its 3.000m3 of volumetric capacity, is able to guarantee the continuity of the whole treatment process, consisting of 5 main sections:

1. **Dehydration (centrifugation)**
2. **Drying**
3. **Pyrosintering**
4. **Energy recovery and fumes treatment**
5. **Plastofill production (HSC e HBC) containing KEU (sintered granules)**

Sludges recovery process (2)

1. DEHYDRATION

Thickened sludge (with about 3% of total solid content) incoming from both Santa Croce sull'Arno and Fucecchio plants, is centrifuged to get the dry content up to 26-30% as TS content. This way a primary mass and volumetric reduction of about 10 times is obtained, allowing a significant energy saving over the following drying stage.

2. DRYING

This section aims to dry the sludge up to 80-85% of Total Solid content.

This process takes place inside three ovens equipped with an internal sludge conveyor and a hot air drying system. This stage of the treatment process is splitted on two subsequent sections: the first with two ovens and the second with only one. The heating system consists of several hot air blowers which recycle the steam produced during the drying process. This steam flow arises from an heat recovery system located nearby the plant in an Ecoespanso's premise, where four Rolls-Royce engines are used for Electrical Energy production (30 MW) by methane combustion

Sludges recovery process (3)

3. PYROSINTERING

Dryed sludge coming out from the drying tunnels is then pyrolised and sintered in order to obtain the sintered granules (KEU). These two process phases are accomplished inside two rotatory ovens, physically connected each other for the purpose to allow the continuous sludge transfer from one stage to the other.
Two methane/oxygen burners, one for each oven, supply the thermal energy needed respectively by the pyrolysis and sintering processes. A direct flame heat exchange system is used, adopting stoichiometric oxygen/methane ratio in order to prevent oxidative side reactions.

Sludges recovery process (4)

4. ENERGY RECOVERY AND FUMES TREATMENT

Hot fumes generated by the final two ovens are mixed with the drying section incondensable gases and *then conveyed to their treatment and energy recovery*. This exhaust gas stream *contains a significant percentage of methane* and combustible gases produced by the pyrolysis and sintering processes. *The mix, thus, is burnt inside the post-combustion* system where urea is added for the NOx abatement.

The heat generated in that stage is recovered inside an economizer that produces *overheated steam, which is then recycled within the drying section, reducing*, this way, *the fresh steam consumption*. Subsequently off gases stream passes through a water quencher column to remove dust and control its temperature; after this, a further dust abatement occurs within two different bug filter batteries, before the stream passes through a wet scrubber for the acid gases removal and then the prified exhaust gas is released through the final chimney.

All *dust trapped in bug filters* as well as those suspended in the quench water, could contain hexavalent Chromium, thus, in order to eliminate this problem, both these stream flows are treated inside three different reactors , where a slution of Ferrous Chloride 30% is dosed to convert Cr(VI) into Cr(III).

Sludges recovery process (5)

5. PLASTOFILL PRODUCTION (HSC E HBC) CONTAINING KEU (sintered granules)

Plastofill HSC and HCB are obtained due to the mixing and subsequent grinding of sintered granules (KEU) with Calcium Carbonate, originating from Campiglia (LI) marble quarry as ballast. The KEU leaving the hot inertisation section is mixed with precises amount of ballast and then finely crushed in order to obtain particles size up to few microns. The produced silico-calcareous filler could be sold as additive for asphalts (HCB: 30% KEU 70% Calcium Carbonate) and for cements (HSC 10% KEU, 90% Calcium Carbonate)

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Cluster key actors of sustainability

Cuoiodepur wastewater treatment plant receives about 1.700.000 m3 of industrial water emissions per year and it recoveries its sludge as fertilizers.

It is composed of 155 member companies, which work together with the Municipality of San Miniato, to form a social structure. 40 operators are employed in the plant.

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Cluster technological innovation: shavings and fleshings recovery

Consorzio S.G.S. Spa (*Shavings and fleshings waste recovery plant*): this private company is composed of 230 member tanneries (mostly SMEs) which produce flashings. This plant is focussed on recovering the fleshings.
The plant employs a staff of 50 and processes 70,000 tons of fleshings per year.

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Cluster technological innovation: shavings and flashings recovery (2)

Production process

In the tanning cycle, during the preliminary operations (soaking), after the calcination-unhairing phase (**removal of hair and epidermal structure by a prolonged bath in a solution of lime and hydrated sodium sulphide**), the hide is subjected to the operations of fleshing, namely the elimination of tissues adhering to the skin (**fleshing**) and splitting (splitting the skin into several layers). Subsequently, the tanned hide is shaved to obtain a uniform thickness.

In the SGS plant, these by-products are subjected to a recovery process aimed at **the production of animal fat and protein hydrolysate** marketed either in the liquid state or as water-soluble powder.

The recovery methods for these products vary in other tanning districts inside the EU, and include, for example, anaerobic digestion with the production of biogas (Sweden, Germany), the production of collagen and food jellies (Germany, France, Netherlands), incineration aimed at energy production (France), obtaining products for agriculture (compost) and animal feed (Poland)

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Cluster technological innovation: shavings and flashings recovery (3)

The company operates in compliance with all national and European regulations concerning the processing of animal by-products: the plant was awarded (ID no. ABP154UFERT3) under Article 24 of the "EC Regulation no. 1069/2009 laying down health rules as regards animal by-products and derived products not intended for human consumption", as a technical plant for the processing of category 3 material.

The company is also entered with no. 068/06 in the "Register of biological fertilizer Producers" pursuant to Italian Legislative Decree no. 75 of 29 April 2010.

The Company is constantly involved in research programmes in the field of plant nutrition and testing of new formulations, it monitors and ensures the quality of all its products with the help of its modern laboratory and, thanks to the experience and knowledge acquired by its Technical Department, is able to meet the specific demands and needs of its customers by providing technical assistance and preparing, on request, formulations with specific titres.

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Cluster technological innovation: shavings and fleshings recovery (4)

The manufacturing process can be briefly described as follows:

1. Alkaline hydrolysis in a controlled environment
Through a careful and accurate temperature control, we "monitor" with great precision pH and time as a function of the type of raw material and of the final use of the finished product (content of free amino acids).
2. Sterilisation
Carried out only for products from fleshing at 133°C for 20 minutes (parameters set by Reg. no. 1069/2009 for the processing method 1)
3. Filtration
The diluted protein broth (soluble liquid phase) is separated from gypsum (insoluble solid phase)
4. Concentration
By evaporation under vacuum we obtain a finished, preservable product (absence of free water) with 58-60% of dry substance.
5. Drying in a spray tower
By means of a flow of hot air, we obtain water-soluble powder with 97% of dry substance

Cluster technological innovation: chromium recovery

Consorzio Recupero Cromo Spa (*Chromium recovery plant*)**:** established in 1981 is a consortium composed of 250 member tanning companies from all over the district. These companies send the exhaust chrome liquor to the consortium for chrome extraction. The recovered chrome is returned to the original companies which use it directly in tanning processes.
This plant can produce over 21.000 kilos of basic chrome sulphate per day.

Assessment of environmental benefits achieved in the cluster of S. Croce of process eco-innovation with Life Cycle Assessment (LCA)

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Objective of the study

LCA and industrial symbiosis are two strictly linked topics.

Many papers used LCA to highlight the benefits of industrial symbiosis and circular economy even if the way on how to use LCA in these fields is still under discussion.

The originality of our paper is the use LCA **to assess the environmental benefits of industrial symbiosis at the territorial level**, by using as case study a tannery industrial park of SMEs

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Using Life Cycle Assessment (LCA) to measure the environmental benefits of industrial symbiosis in an industrial cluster of SMEs

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ABSTRACT

Collaborative approach and infrastructures sharing are key industrial symbiosis initiatives adopted in clusters of SMEs. Several studies have dealt with the environmental benefits of industrial symbiosis however only a few have adopted a Life Cycle Assessment (LCA) to assess the benefits of these initiatives on the typical product of the cluster. Our paper presents the case of an Italian tannery cluster located in Tuscany. Through the calculation of an LCA with average data, our study compares the impact category results between two scenarios: the existing scenario where the IS initiatives are implemented and the other where these initiatives are less developed. The results show the positive contribution of these initiatives in several LCA impact categories such as climate change and terrestrial eutrophication.

Research questions

RQ1: Which kind of environmental benefits are producing these initiatives grounded on industrial symbiosis principles?

RQ2: Can these benefits be measured with a LCA perspective?

The framework of the study: PREFER project

Product environmental footprint Enhanced by Regions

PREFER - *PRoduct Environmental Footprint Enhanced by Regions* is a project co-financed by the European Commission LIFE Plus Programme.

The project is aimed to test a new european methodology to assess the environmental footprint of products and services. "*PEF – Product Environmental Footprint*" is a Life Cycle Assessment (LCA) based methodology approved by European Commission and will be tested to assess the environmental impacts of 8 products selected in 8 industrial parks and clusters

Method

1. Calculate an **average LCA** of a representative m2 of finished leather of the industrial cluster in the current situation with large presence of "circular economy initiatives" (SCENARIO 1)

2. Identify the **LCA impact categories** values of SCENARIO 1

3. Suppose a **second scenario** (SCENARIO 2) where the industrial symbiosis initiatives are less developed or not present

4. Identify average **LCA impact categories values of scenario 2**

5. **Compare the difference** between LCA results of **scenario 1 and scenario 2**

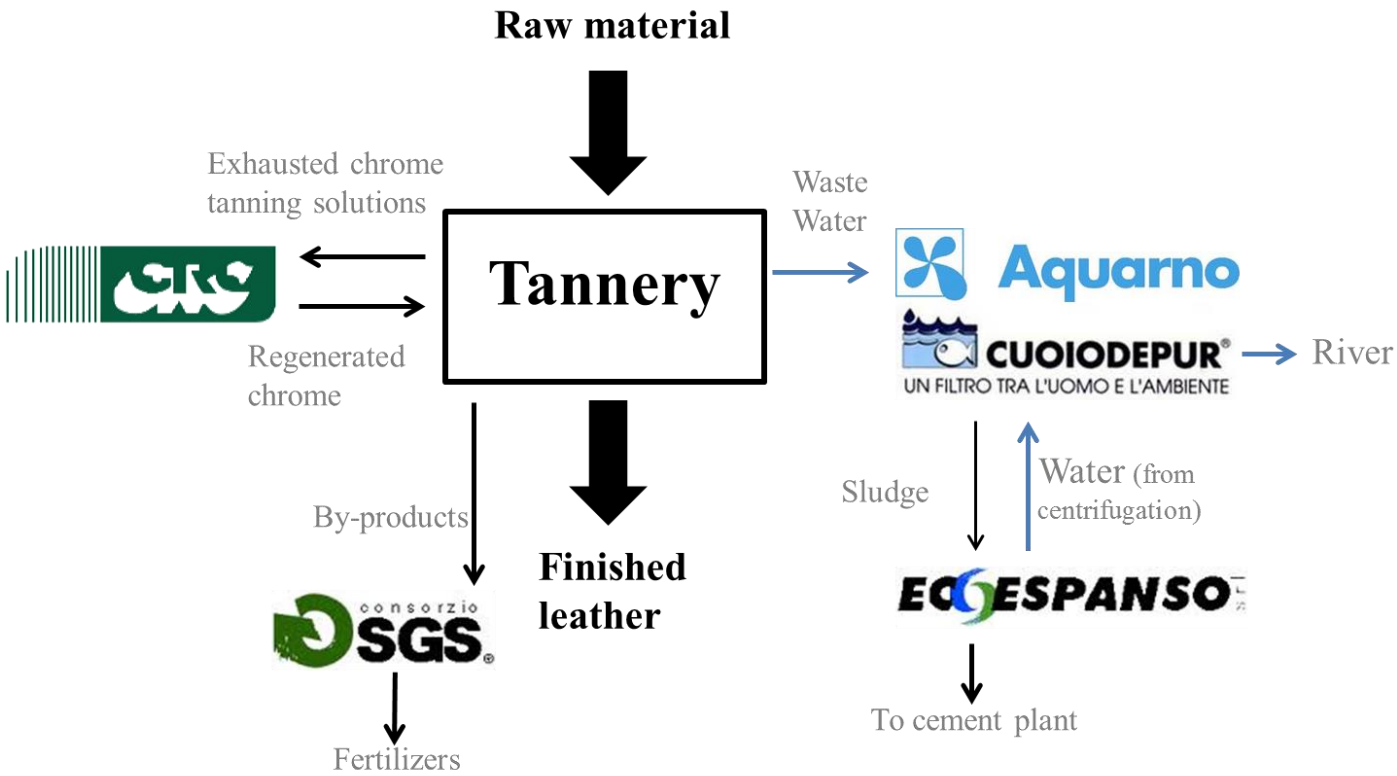
Average LCA: successfull examples

- **Apples** from Trentino Alto Adige – Assomela
- **Kiwi fruits** from Greece – Export company that represents 99 producers
- **Bitumen Roof waterproofing system** – Bitumen Waterproofing association
- **Extra-virgin olive oil** – Assoproli Bari
- **Extra-virgin olive oil** from Greece – 3 farmers organizations
- **Steel for the reinforcement of concrete** – weldable reinforcing steel – PCR developed by SISMIC (5 EPDs)

Source: www.environdec.com

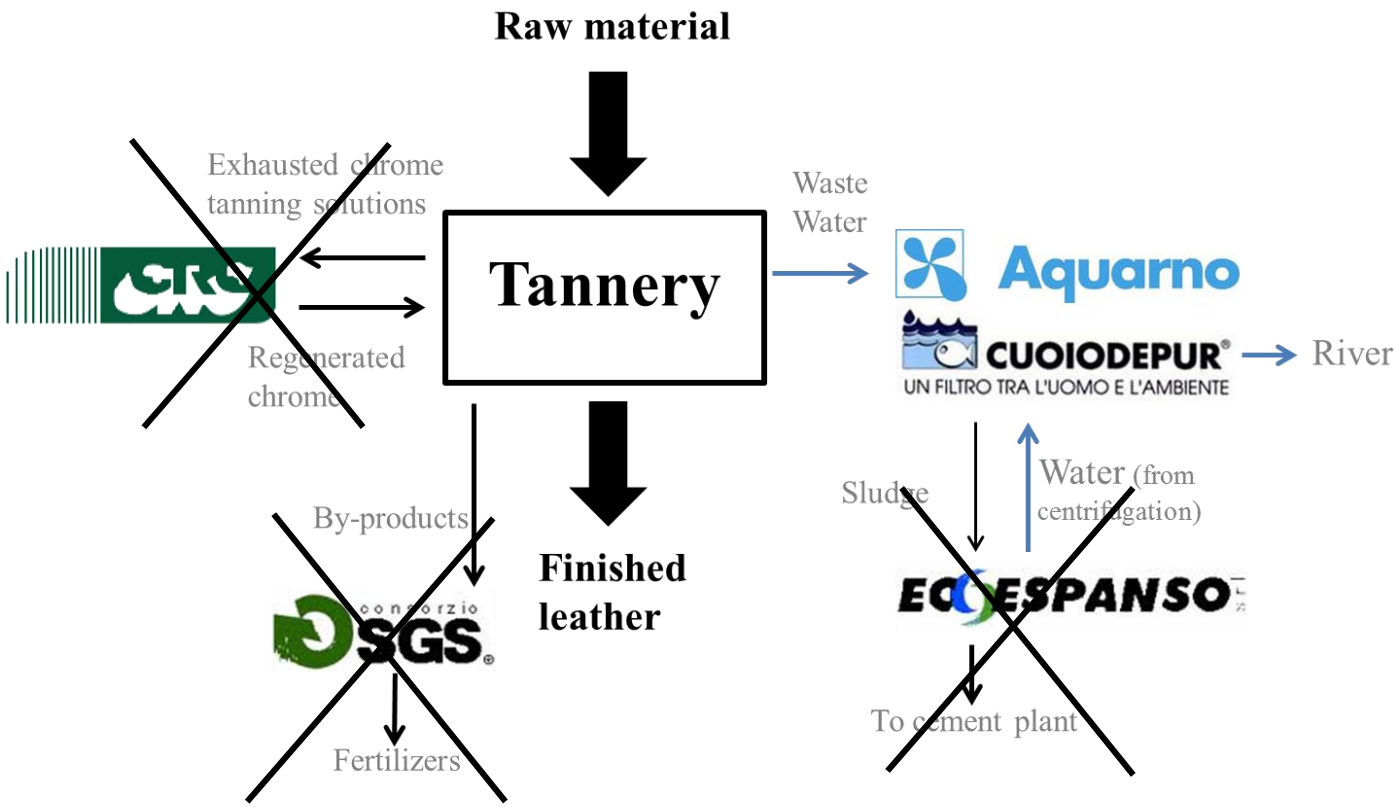
Method: graphical representation

Sectoral LCA of the current scenario (SCENARIO 1)



Method graphical representation

Sectoral LCA of SCENARIO 2 (identified according to the features of other Italian tannery industrial areas)



Methodological aspects

- ISO 14040 – 44, PCR: «Finished bovine leather»
- Functional unit: 1 m^2 of finished leather for chrome and vegetable tanned leather
- System boundaries: from cradle to gate
- Method: PEF (Product Environmental Footprint), UE Recommendation 179/2013
- Data collected referred to the years 2012-2013

Sample description

22 tanneries representing 6.300.104 m^2 of finished leather

(*14% of the total cluster production and around 5% of Italian production*)

Results

Results of average LCAs

Impact category	Unit	1 m2 of finished leather		Difference
		SCENARIO 1 (with ind. symbiosis)	*SCENARIO 2* (no ind symbiosis)	
Climate change	*kg CO2 eq*	*12,120*	*16,419*	**-22%**
Ozone depletion	*kg CFC-11 eq*	*9,19E-06*	*9,321E-06*	**-1%**
Particulate matter	*kg PM2.5 eq*	*0,00967*	*0,0118*	**-15%**
Photochemical ozone formation	*kg NMVOC eq*	*0,0537*	*0,0636*	**-14%**
Acidification	*molc H+ eq*	*0,1164*	*0,1416*	**-11%**
Terrestrial eutrophication	*molc N eq*	*0,0780*	*0,1651*	**-18%**
Freshwater eutrophication	*kg P eq*	*0,001109*	*0,001333*	**-12%**
Marine eutrophication	*kg N eq*	*317,92*	*601,265*	**-7%**

Conclusions

Findings

✓ the study confirm that the average LCA can be considered a good tool to assess industrial symbiosis benefits at the territorial level;

✓ while some LCA impact categories has been strongly improved by the industrial symbiosis initiatives implemented in the cluster, others are less influenced;

✓ the method could support the policies of local policy makers that could aim to plan the territorial environmental improvement following a LCA perspective;

Thank you!

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