ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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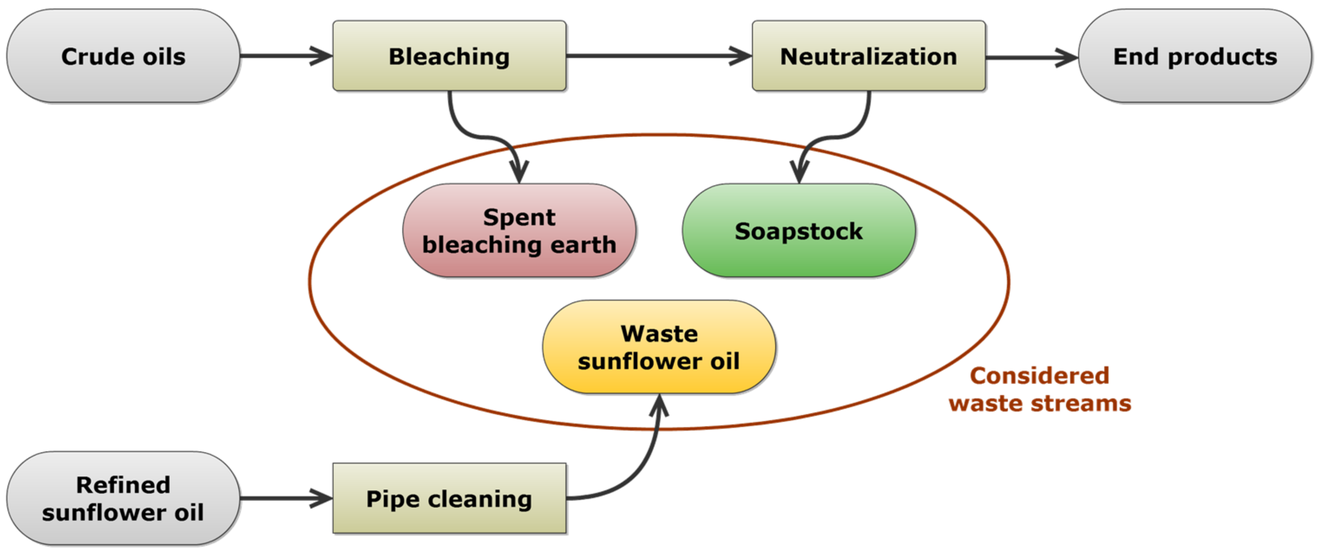
# Design Project – SIE 2013

# Optimal allocation of green industrial waste

## Objectives and methods

- Proposing potential applications for three waste streams of a factory processing edible oils
  - ✓ Detailed composition of each waste
  - ✓ Review of the literature
- Analyzing the legal compliance and the environmental aspects of these applications
  - ✓ Examination of the Swiss waste legislation
  - ✓ Material and energy fluxes analyses
- Finding an environmentally optimal valorization alternative for each of the waste streams
  - ✓ Multi-criteria analyses




*Simplified process scheme and waste streams of the factory*

| | Origin & description | Proposed solutions | Impact | Results of multi-criteria analyses: Material and energy fluxes | Results of multi-criteria analyses: Pros and cons |
|---|---|---|---|---|---|
| **Spent bleaching earth**  Details, flowcharts: | • Clay material used as a filter for bleaching and stabilizing crude oils<br>• Soaked with oils and fats (34%)<br>• High worthless mineral (ashes) content (32%)<br>• High specific surface<br>• Self-ignition hazard<br>• Special waste subject to restrictive laws and requiring specific precautions | **Burning for energy** (fluidized bed combustion) | **2.1** | The ashes serve as the fluidized bed; air emissions | Direct burning: maximal efficiency |
| | | **Filter press extraction** of oils | **1.9** | No material inputs; very low energy inputs | Straightforward method but low recovery yield (50%) |
| | | **Pressure extraction** of oils | **1.8** | Base required; high pressure to maintain (autoclave) | Rather simple method for a high recovery yield (close to 90%) |
| | | **Solvent extraction** of oils (e.g. with hexane) | **2.3** | Solvent handling is complex and possibly dangerous; heating needed to recycle the solvent | High recovery yield (90%) but safe facilities necessary |
| | | **Anaerobic digestion** | **2.1** | Virtually no inputs (except heating); biomass production; air emissions | Simple, but mineral fraction deposits and has to be removed |
| **Soapstock**  Details, flowcharts: | • Resulting from an alkali treatment of crude oils<br>• Mixture of saponified fatty acids, water and impurities<br>• Relatively low mineral content (3%)<br>• Energy-rich compound<br>• Harmless waste | **Oil extraction** (soapstock splitting to recover the free fatty acids) | **2.0** | Strong consumption of base and acid, ending as secondary waste; some energy inputs; biogas as by-product | Good quality of recovered oil, with many applications; high added value |
| | | **Anaerobic digestion** | **1.6** | Virtually no inputs (except heating); biomass production; air emissions | Few residues; expected to increase the overall methane yield of the digester; low added value |
| **Waste sunflower oil**  Details, flowcharts: | • Refined sunflower oil used to clean the pipes<br>• Quality nearly identical to pure oil<br>• Very low levels of impurities (<0.01%) and free fatty acids<br>• Energy-rich compound<br>• Harmless waste | **Burning for energy** (combined heat and power) | **1.6** | Virtually no inputs; air emissions | Direct burning: simplest and most effective way to recover the energy |
| | | **Biodiesel production** (transesterification reaction) | **1.9** | Energy inputs for the processing steps; methanol needed for the reaction; air emissions | Lower efficiency but high added value (favorable policies) |
| | | **Anaerobic digestion** | **1.9** | Virtually no inputs (except heating); biomass production; air emissions | Intermediate steps decrease the recovery yield; no use of the oil specificity; low added value |
| | | **Animal feed** (additive) | **1.6** | Virtually no inputs | Fat-rich compound; high added value but strict requirements |
| | | **Oil chemistry** (e.g. lubricant production) | **-** | Depend on the end application | Biodegradable; growing market |

## Conclusions

- All the waste streams have potential new uses that are both legally compliant and environmentally acceptable, in particular in the bioenergy sector
- Embodied energy (transformation, transportation, etc.) must be considered in the environmental assessment

## Recommended solutions

- Spent bleaching earth: pressure extraction of oils (the mineral fraction is landfilled)
- Soapstock: anaerobic digestion
- Waste sunflower oil: burning for energy

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Full report: