# TOWARDS SUSTAINABLE MINING: EXPLOITING RAW MATERIALS FROM EXTRACTIVE WASTE FACILITIES

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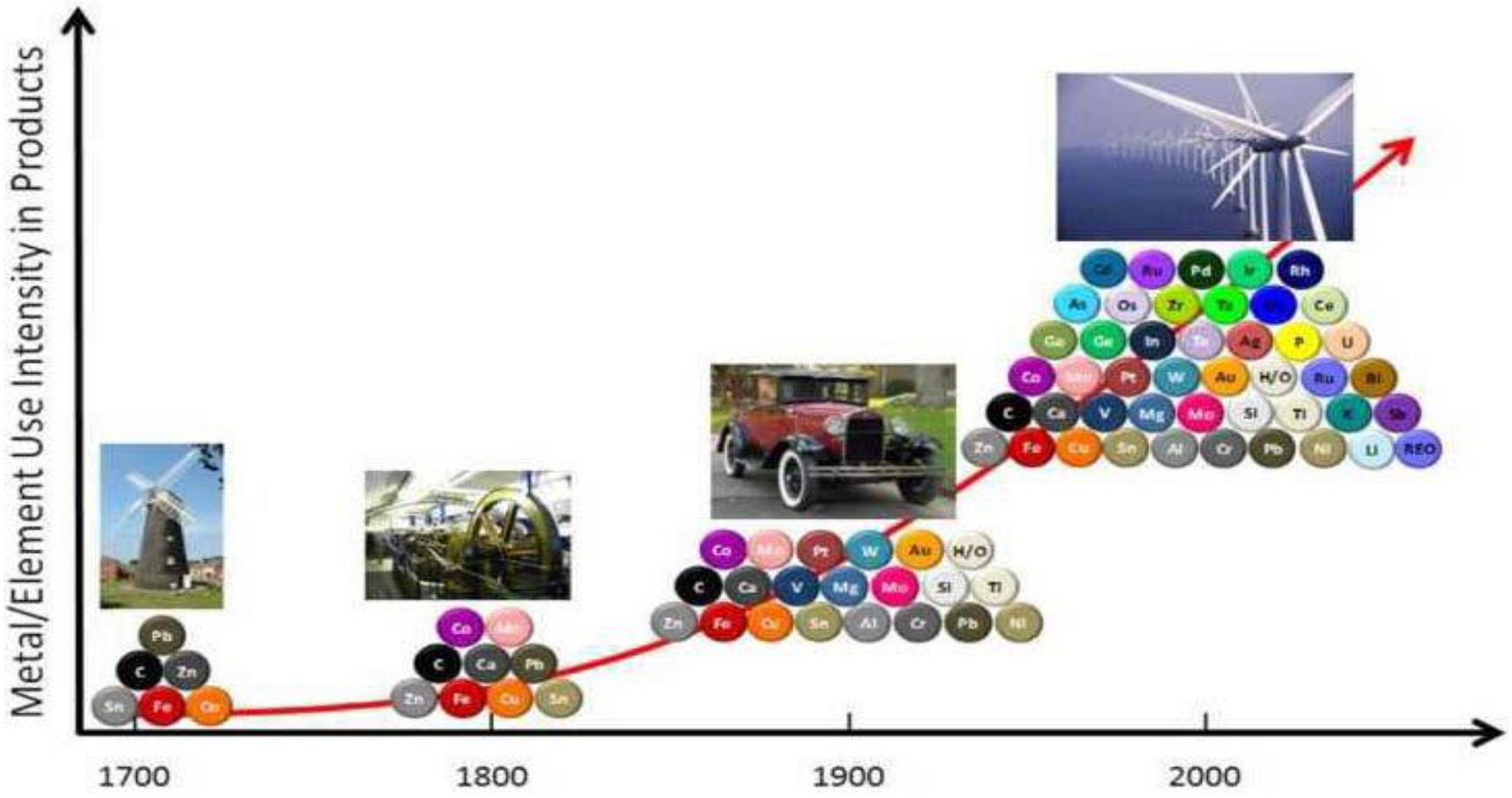
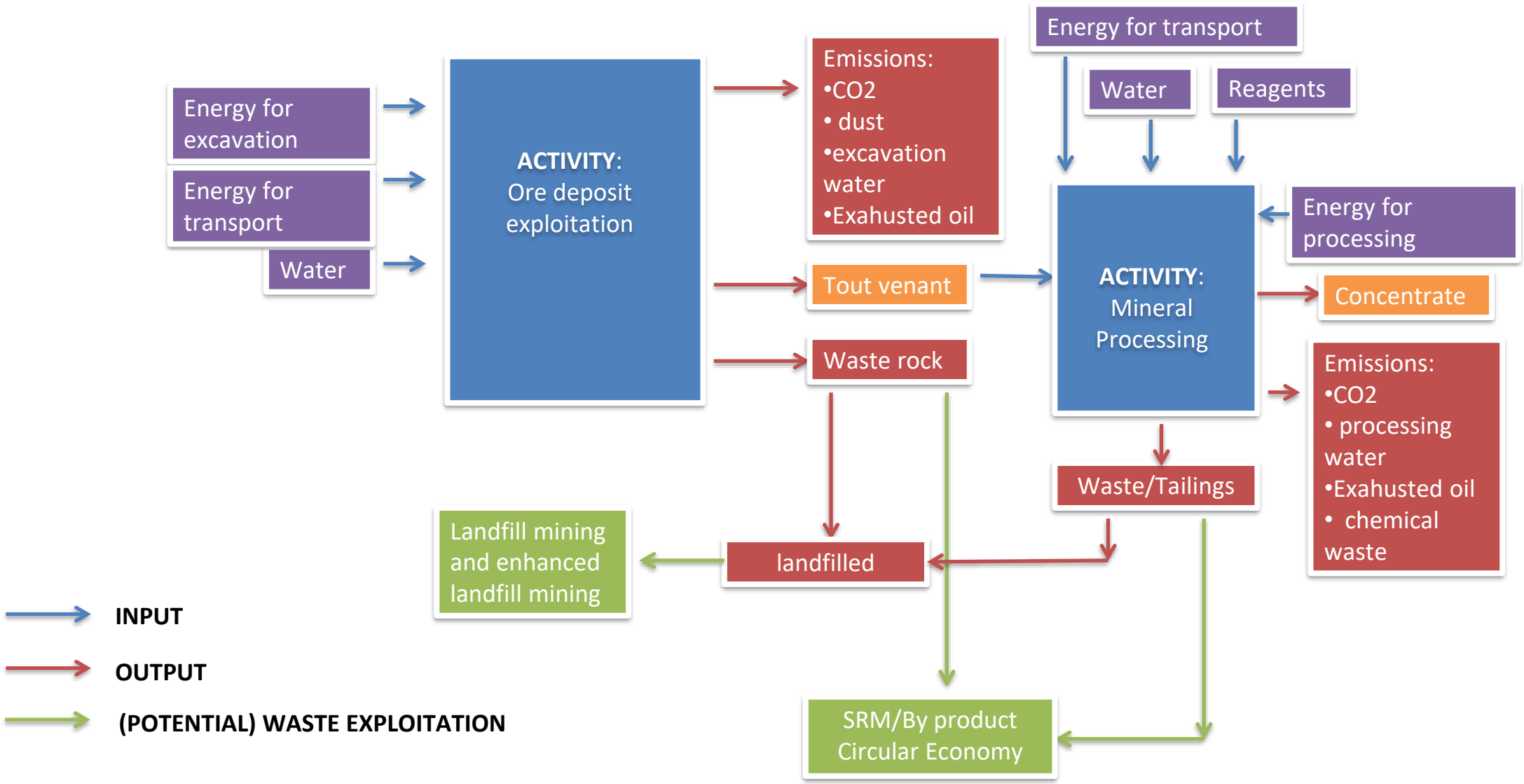
# Resource Security: a key priority




- Mines/quarries and working/dressing plants produce **huge amounts of extraction waste (EW)**
- Management is still unsolved issue which involves **stone and mining industries**, **local administration**, and **citizen in general**

# Overview of the mining and processing activities



# Study sites

## MONTORFANO PILOT SITE

1. **Sengio waste facility** - Montorfano massif (investigated in 2009) - blue square in Fig. 2
2. **Ciana Tane-Pilastretto waste facility** - Montorfano massif (investigated in 2009) - red square in Fig.2
3. **Baveno, Braghini waste facility** – Monte Camoscio (investigated in 2009) (not reported in the Fig.2)
4. **Montorfano – Montorfano massif** (investigated in 2016) yellow square in Fig. 2

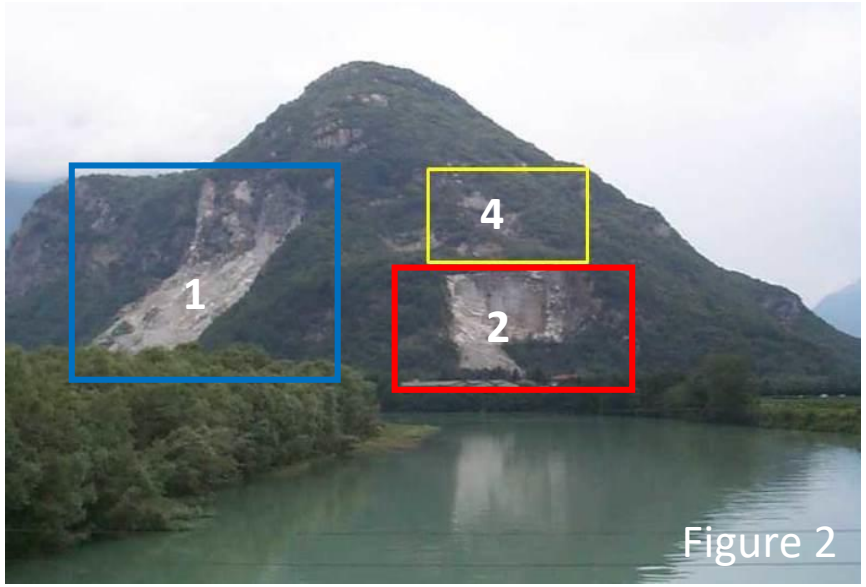


Figure 2

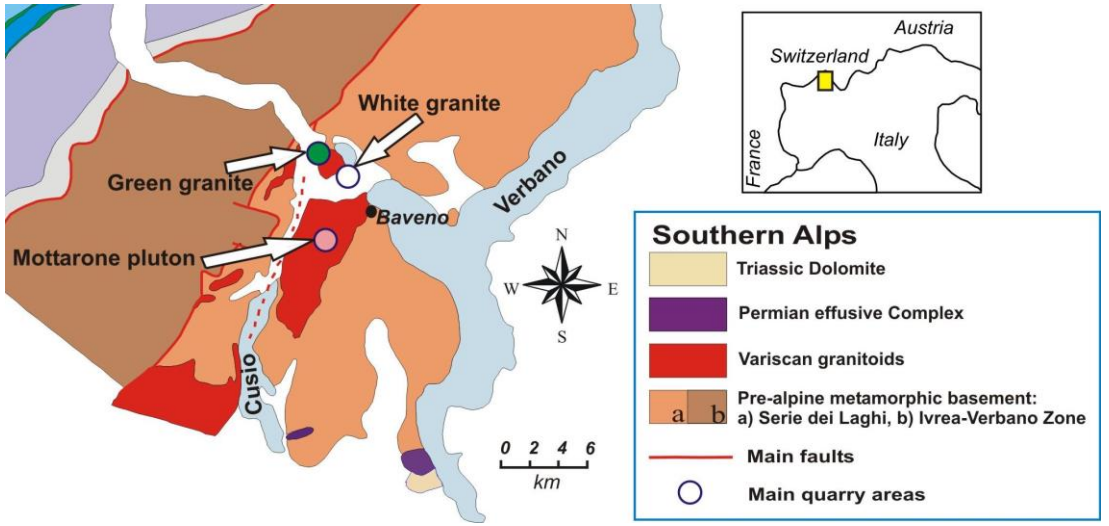



**Figure 1**. Overview of the geological area

## DRESSING ACTIVITY

**FEEDING MATERIAL (granite WR) from EW dumps** → **MINERALI INDUSTRIALI dressing plant (active from 1995)** → **PRODUCTS**

F60P: 110.000 t/Y

(ceramic industry)

**BYPRODUCTS**

SNS, SNG, SF, SF100, SF200: 65.000t/Y

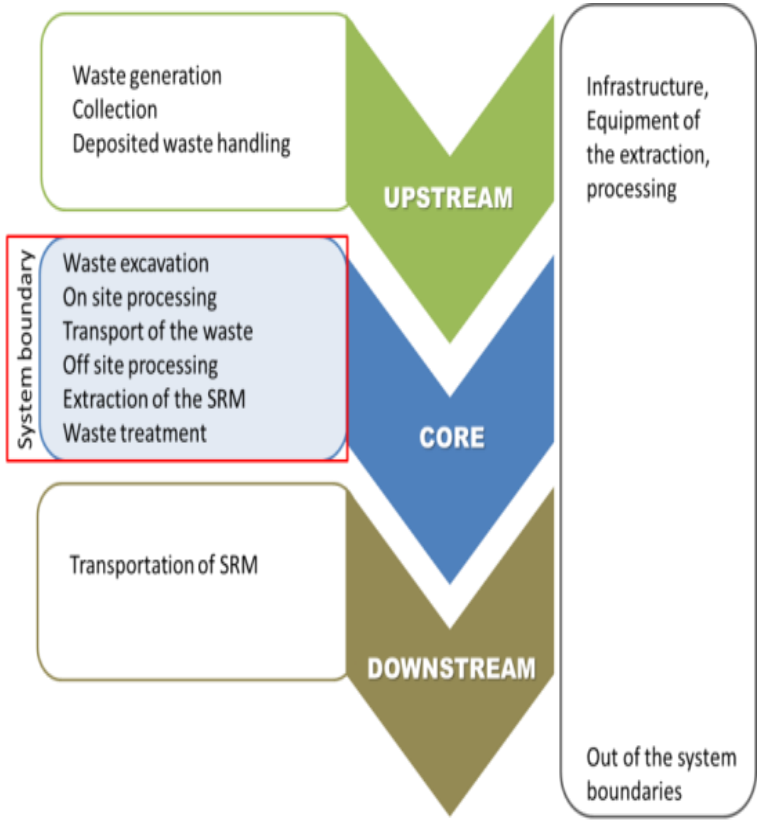
**F60P**: feldspar for ceramic industry; **F60-40**: feldspar for ceramic industry; **Gravel and sands**: for buildings and infrastructures; **SF and SF100**: for bituminous concrete; **SN**: for brick production; **SNG**: for external pavement and industrial surface treatments; **SNS**: for external pavement.

# Estimation and evaluation of impacts of different scenarios

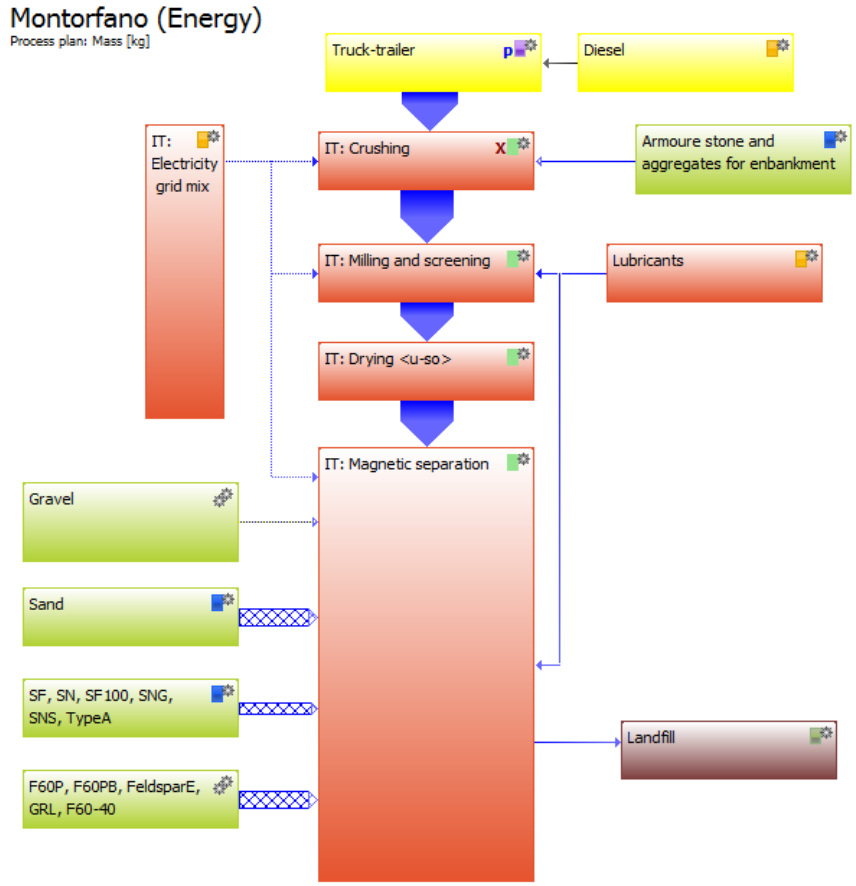
## ORE BODY ESTIMATION

- **SAMPLING ACTIVITY OF EW**
- **PRODUCTION OF SAMPLES AT LAB. STAGE**
- **CHARACTERISATION** (geochemical, petrographycal and mineralogical)
- **EW VOLUME EVALUATION** (geophysical and topographic and morphologic 3D characterisation)
- **EVALUATION OF THE POTENTIAL EXPLOITABLE PRODUCTS, BY PRODUCTS, AND CRM**

## EVALUATION OF IMPACTS

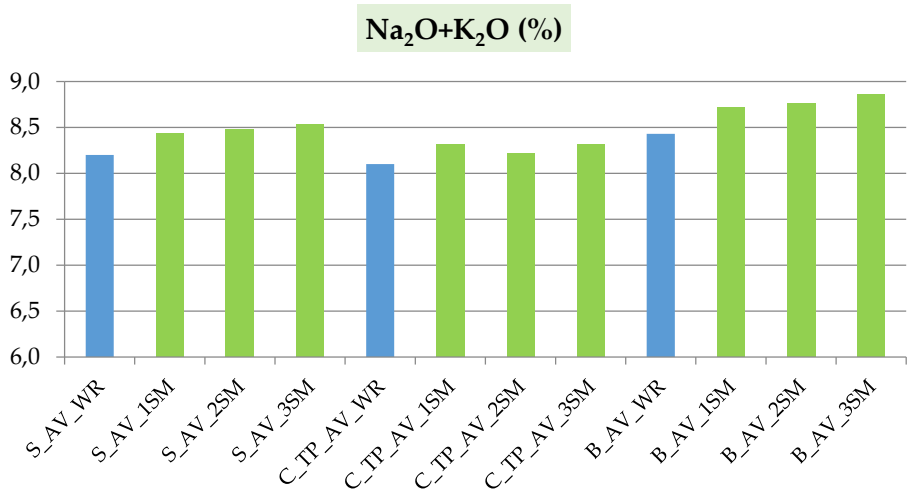



System boundaries

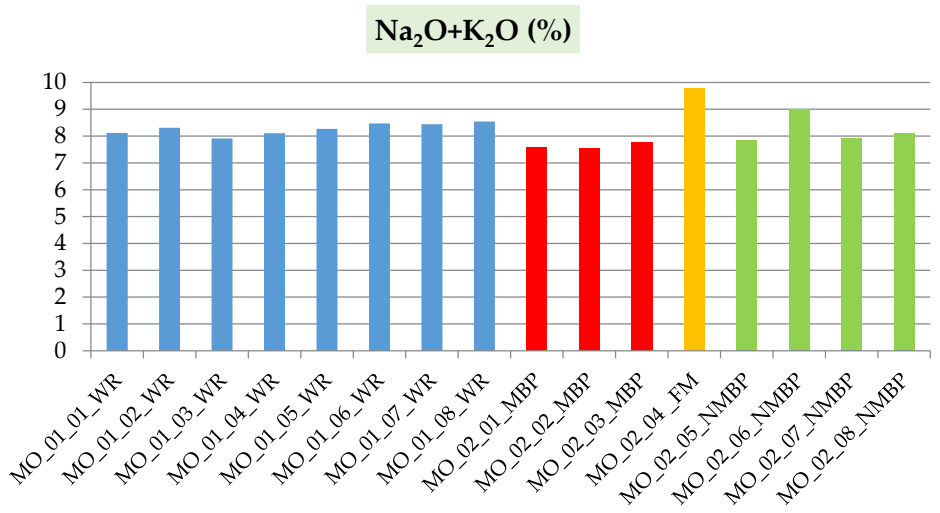



LCA model of the Montorfano scenario

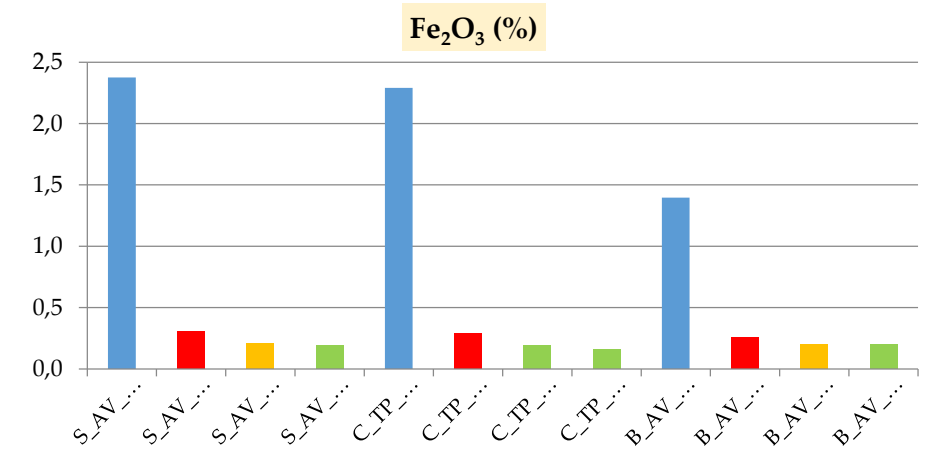
# Ore body concentration estimates



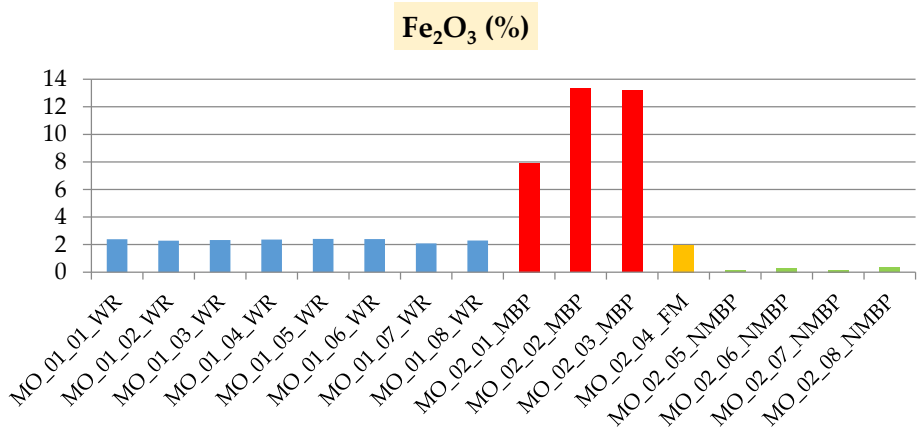

Alkalis in the Sengio, Ciana Tane-Pilastretto and Braghini EW facilities (all samples; values in wt.%). **Waste rock**; **nonmagnetic fraction after each magnetic separation step (1SM, 2SM and 3 SM).**




Alkalis in the Montorfano pilot (all samples; values in wt.%). **waste rock**; **treatment plant, magnetic fraction**; **treatment plant, amagnetic fraction**, **feeding material**.



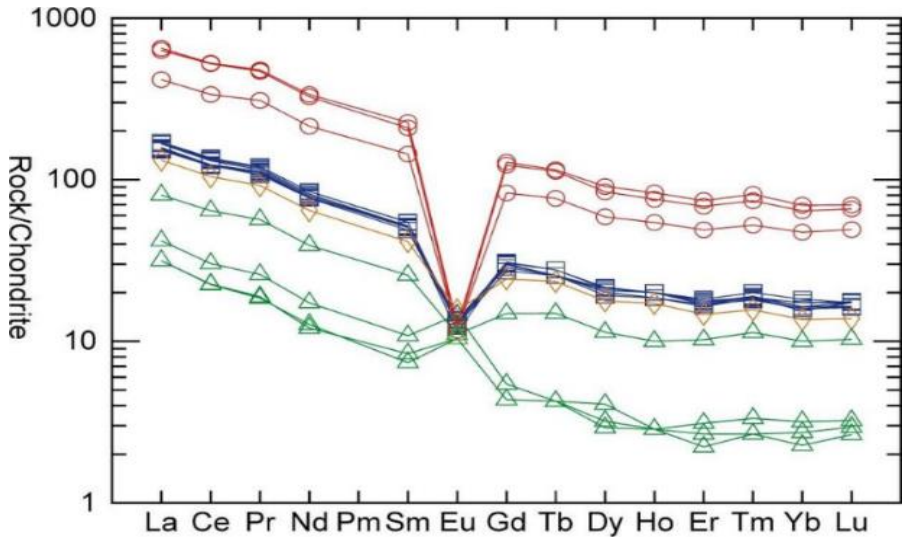

$Fe_2O_{3tot}$ in the the Sengio, Ciana Tane-Pilastretto and Braghini EW facilities (all samples; values in wt.%). **Waste rock**; **nonmagnetic fraction >0.2%; nonmagnetic fraction just above 0.2%; nonmagnetic fraction <0.2%.**



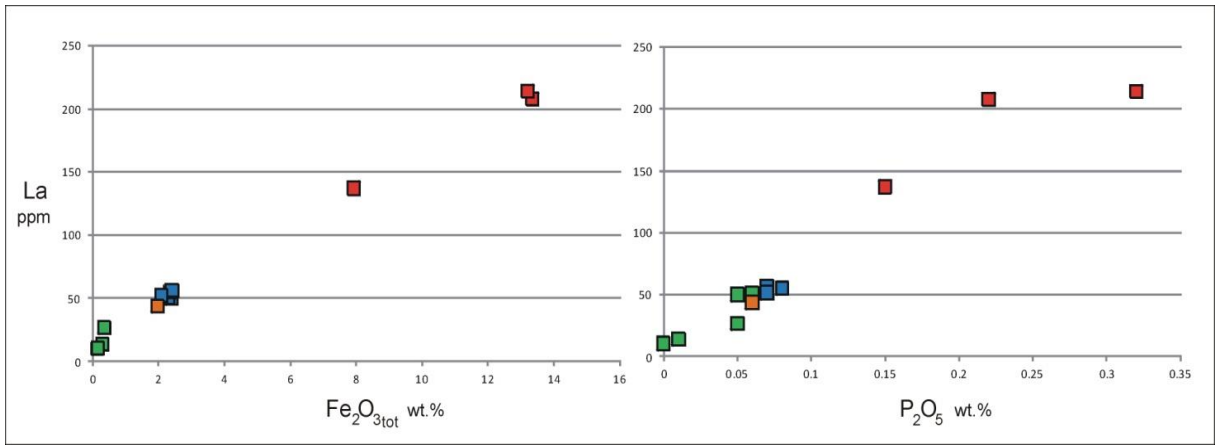

$Fe_2O_{3tot}$ in the Montorfano pilot (all samples; values in wt.%) **waste rock**; **treatment plant, magnetic fraction**; **treatment plant, amagnetic fraction**, **feeding material**.

# Ore body concentration estimates

The **total volume of EW facilities** was estimated at **about 2.1 Mm³.**




REE pattern for all samples, normalized to chondrite, logarithmic scale (chondrite values from Nakamura, 1974). **waste rock**; **treatment plant, magnetic fraction**; **treatment plant, amagnetic fraction**, **feeding material**.




La-$Fe_2O_3$ and La-$P_2O_5$ correlations. La as ppm, $Fe_2O_3$ and $P_2O_5$ as wt.%. **waste rock**; **treatment plant, magnetic fraction**; **treatment plant, amagnetic fraction**, **feeding material**.

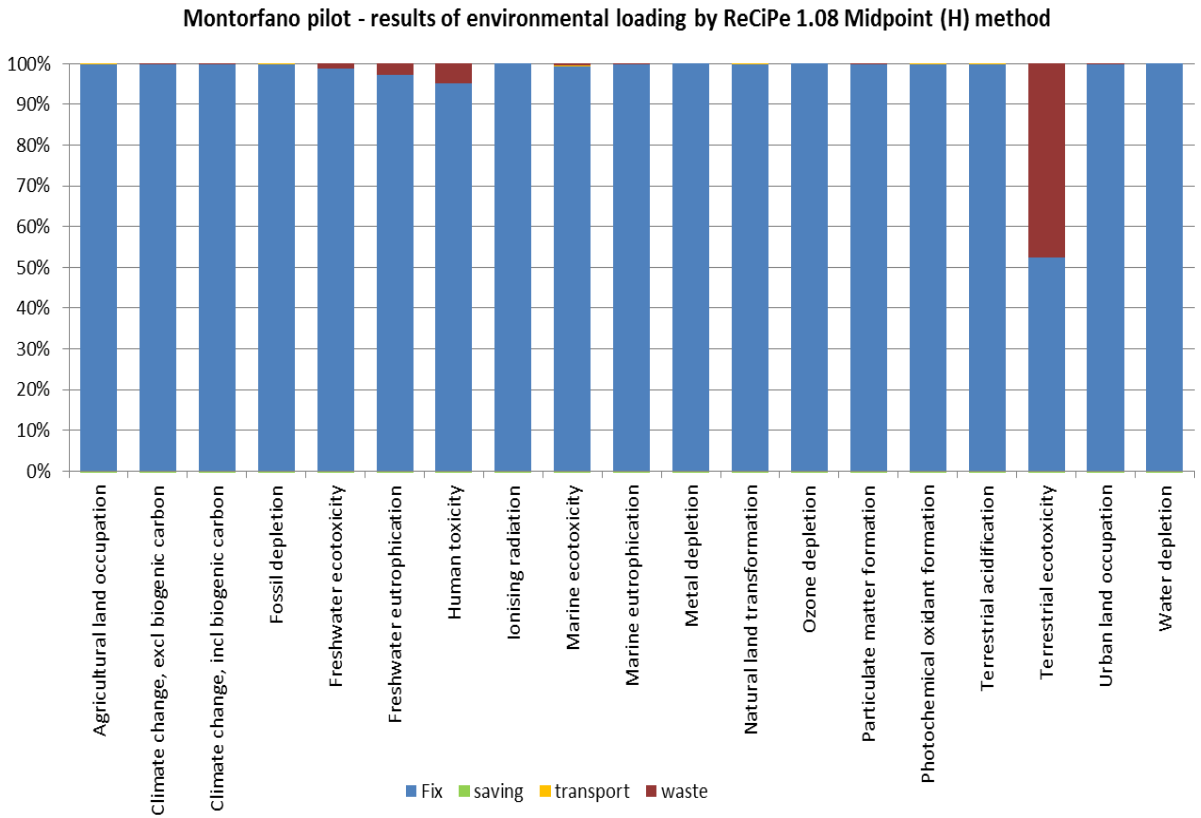
**Montorfano area (2016 field activity):** significant differences in **LREE enrichments**

up to 1000 time more chondrite,

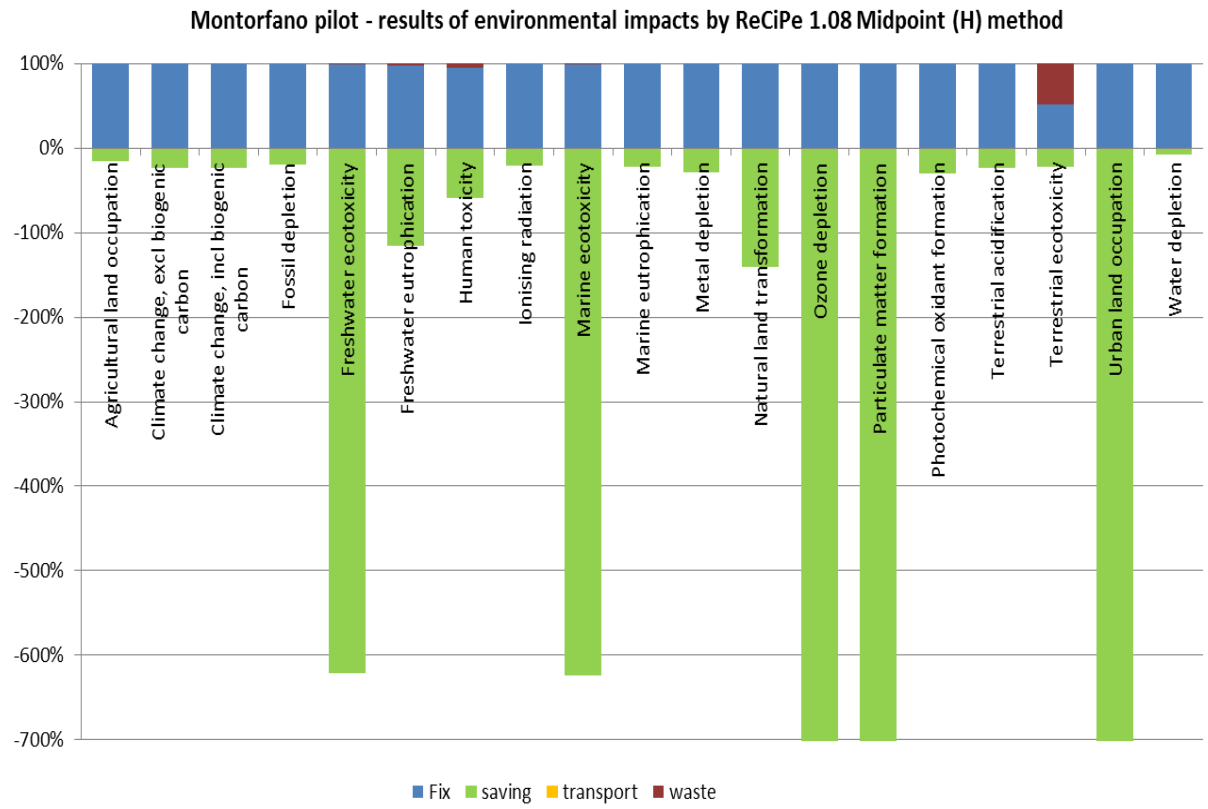
**La+Ce average concentration 164 ppm (waste rock) to 585 ppm (magnetic fraction)**

**Y and Sc enriched in the magnetic fraction**.

# Environmental Impact Assessment



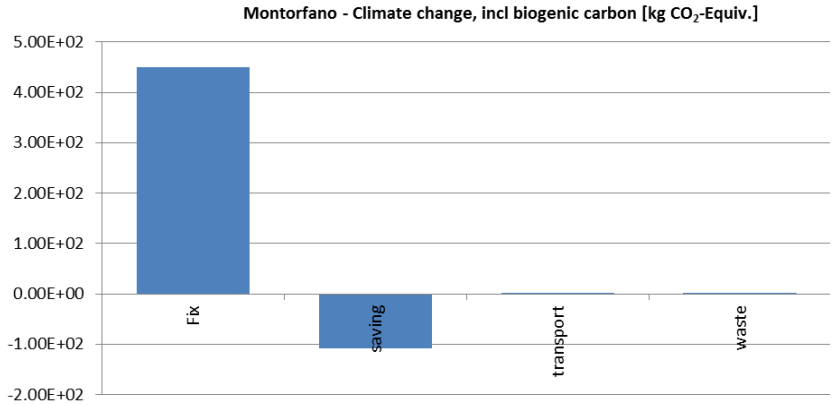

Ratio of environmental loads in impact indicators.



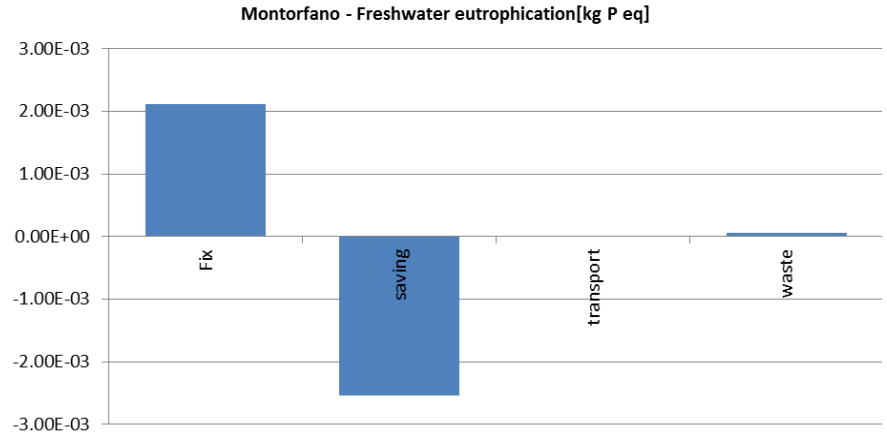

Environmental loads versus savings

(Note: Due to the high saving values in several indicators, the chart has been cut to show other indicators).

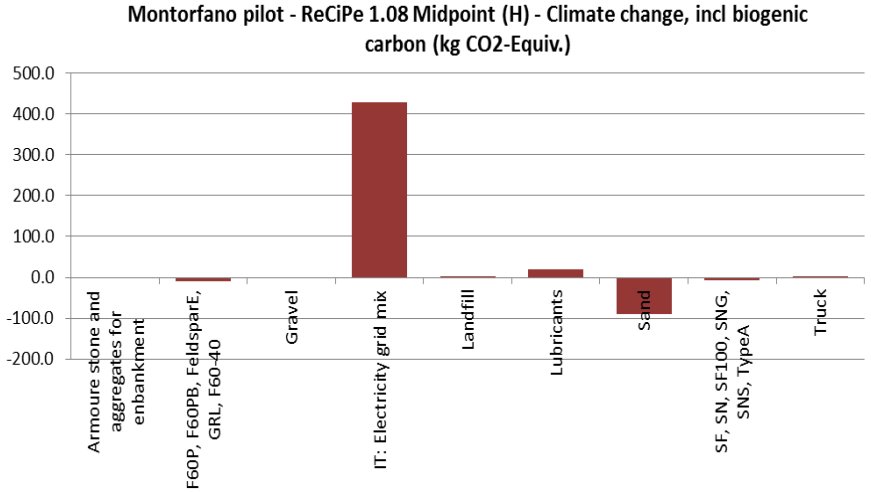
# Environmental Impact Assessment



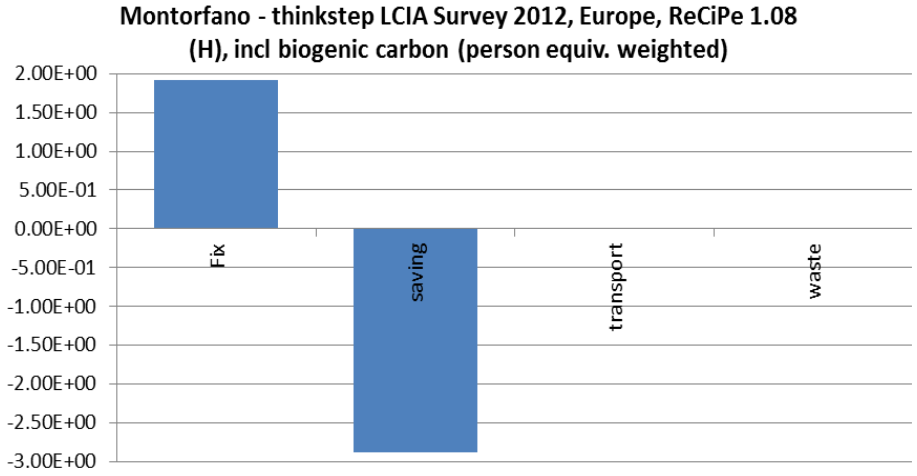

Loads versus savings in climate change impact indicator.




Loads versus savings in freshwater eutrophication impact indicator.




Loads versus savings in climate change impact indicator based on specific processes.




Weighted loads versus savings.

# Conclusion

- Materials of the EW facilities highly **homogeneous geochemical features** for **major elements**.
- Alkalis ($K_2O$ + $Na_2O$) and $Fe_2O_3$tot content extremely important for the feldspar industry (l.s.)
- Samples obtained after magnetic separation showed lower $Fe_2O_3$ passing from >1.4% (not good for ceramic industry) to <0.2% (good for ceramic industry).
- Magnetic fraction are much more concentrated in REE than feeding material
- SRM recovery activities more environmental friendly than primary sources extraction activity.
- Study can help guide best practice for granite EW exploitation to produce the main products for the ceramic industry and several by-products for building and civil applications
- The systematic recovery of RM from EW (from ongoing quarrying activity) can help create a supply from unexploited ore bodies and contributes to the Circular Economy

**For details, please read :** Dino, G.A.; Cavallo, A.; Rossetti, P.; Garamvölgyi, E.; Sándor, R.; Coulon, F. Towards Sustainable Mining: Exploiting Raw Materials from Extractive Waste Facilities. ***Sustainability*** 2020, *12*, 2383**.**