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Life cycle assessment analysis for remediation technology choice: a case study

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Abstract

Life Cycle Assessment (LCA) may be helpful in the choice of a remediation technology, because remediation itself entails impacts. Presently, government and public institutions involved in the decisional workflow focused their attention on minimizing risks at site and for the receptors but do not consider environmental effects. The aim of this study was to compare the estimated Global Warming Potential ($kgCO_2eq.$) for dig&dump vs off site soil washing configuration, from a site contaminated by heavy metals. For a significant comparison, all the obtained values were normalized for the m^3 of soil to treat. The analysis, conducted with a *cradle to grave* approach, showed a clear advantage in soil washing technology with an associated GWP of 29,36 $kgCO_2$ eq/m^3 versus 1724 $kgCO_2eq/m^3$ associated to dig & dump.

Keywords: Soil washing, Life Cycle Assessment, Global Warming Potential

1. Introduction

Site remediation activities support the goal of sustainable development, however, the remediation process or technique will introduce new environmental impacts due to the use of energy and materials, which cause emissions throughout their life cycle. These environmental impacts are often referred to as secondary impacts as opposed to the primary environmental impacts, which are related to the site, particularly the ex-situ remediation techniques (ESRTs) (Lemming et al, 2010 a,b,c).

GHG (greenhouse gas) emissions as nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2) are important footprints because of increasing concern over climate change (Kim et al., 2013). The latter is the primary indicator of the greenhouse effect (Kim et al., 2014; IPCC, 2006) and Global warming potential (GWP) is the relative measure to quantify GHG emissions.

In recent years, life cycle assessment (LCA) is gaining consensus in order to support environmental decision-making. LCA may be applied upstream of the reclamation process, in order to choose best available technology to reduce the environmental impact of the remediation service or after, to improve the environmental performance of a specific technology.

However, LCA remains a tolerably new tool; in fact, methodology is in development and still needs to depend on several technical assumptions. (Morais, S.A., Delerue-Matos, C., 2010).

Many researchers have studied the environmental assessment of remediation technologies using life cycle assessment (Cadotte et al. 2007; Toffoletto et al. 2005). In particular, Page et al. (1999) reported an environmental assessment of the excavation and disposal of a Pb-contaminated site using life cycle assessment, where the relative contribution of environmental loads was calculated, including emissions with energy consumption, solid waste generation, and potential toxicity of each unit process in the excavation and disposal processes.

Kim et al. (Kim et al. 2014) reported about an environmental assessment study of a soil washing process of a heavy metal-contaminated shooting range using a green and sustainable remediation tool. They categorized the whole process into four substages, analysing environmental footprints, and calculating the relative contribution of each stage using a case study of a Pb-contaminated shooting range site.

In this work, we performed a life cycle assessment study, comparing the environmental effects caused by a soil washing (SW) remediation process with excavation and disposal of an industrial site in order to define the best environment friendly choice.

2. Materials and Methods

The target site, located in Italy, is contaminated by As and Pb in concentration respectively two and one order of magnitude higher than Italian law limits (Dlgs. 152/06).

For a good comparison of the two technologies, transport of the soil at an existing plant and to the landfill was considered (100 km away). A *cradle to grave* approach was applied, considering the entire life cycle of the process including the entire area of the site to be reclaimed, the excavation, the transport to the SW plant or to the landfill and soil refill. The soil is returned clean to the site of origin in soil washing case and a new one was considered for dig&dump.

As FU was chosen 1 m^3 of contaminated soil to be treated. Energy and material consumption were calculated considering laboratory tests and data from an existing soil washing plant. In detail, a solution of HCl 1M in a 10:1 ratio with contaminated soil was considered as washing solution, and the same was restored and recirculated.

We analyzed the environmental impacts of the remedial activities using GaBi software as LCA tool. Global Warming Potential, in terms of kg of CO_2 eq. was considered. For a good comparison, we used the same process from GaBi database when possible (eg. Transport).

3. Results

Results are reported in terms of kg of CO_2eq/m^3 using the CML2001 - Jan. 2016, Global Warming Potential (GWP 100 years) as method. As represented in Figure 1, excavation and transport are the same for the two processes, so for the comparison of the environmental impact, only the SW phase+refill vs landfill+refill should be considered. The substantial difference is represented by the heart of the two approaches that are included in the soil washing plant (7,8 kg CO_2eq/m^3).

There is also a little difference in the refill phase due to the use of clean soil in case of Dig&Dump (61,1 kgCO_2eq/m^3) versus the treated soil used for SW.

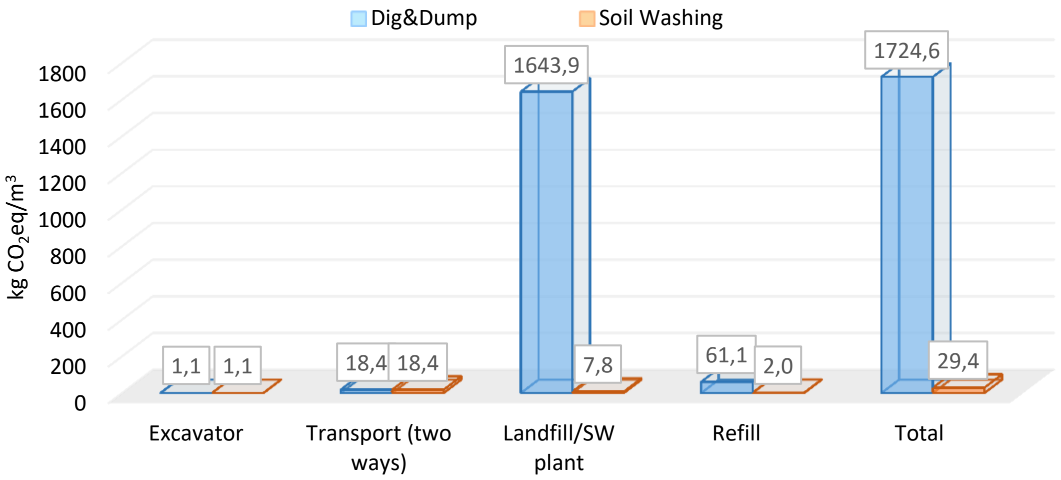

Figure 1. Soil Washing vs Dig&Dump GWP

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