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Waste washing pre-treatment of municipal and special waste

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ABSTRACT

Long-term pollution potential in landfills is mainly related to the quality of leachate. Waste can be conveniently treated prior to landfilling with an aim to minimizing future emissions. Washing of waste represents a feasible pre-treatment method focused on controlling the leachable fraction of residues and relevant impact. In this study, non-recyclable plastics originating from source segregation, mechanical–biological treated municipal solid waste (MSW), bottom ash from MSW incineration and automotive shredder residues (ASR) were treated and the removal efficiency of washing pre-treatment prior to landfilling was evaluated. Column tests were performed to simulate the behaviour of waste in landfill under aerobic and anaerobic conditions. The findings obtained revealed how waste washing treatment (WWT) allowed the leachability of contaminants from waste to be reduced. Removal rates exceeding 65% were obtained for dissolved organic carbon (DOC), chemical oxygen demand (COD) and Total Kjeldahl Nitrogen (TKN). A percentage decrease of approximately 60% was reached for the leachable fraction of chlorides, sulphates, fluoride and metals, as proved by a reduction in electric conductivity values (70%).

1. Introduction

Modern landfill design should aim to adopt the most effective, environmentally sustainable strategy to deal with the leachable fraction of waste that poses a potential threat to the environment in the short and long term. The objective is to achieve an equilibrium with the environment, a final storage quality (FSQ), within the span of one generation [1]. The pre-treatment of waste prior to landfilling plays a fundamental role in achieving this goal [2].

Selected biodegradable waste fractions can be conveniently treated mechanically and biologically before landfilling to minimize future emissions [i.a. 3]. Further to this option and to thermal treatment, other methods of waste pre-treatment may be applied to reduce the leachability of contaminants from waste prior to landfilling. In particular, the washing of waste represents an innovative method.

Several studies have demonstrated the efficacy of the washing of incineration residues in reducing the leachable fraction of metals [4–7]. A recent study on washing of automotive shredder residues (ASR) has demonstrated an efficiency rate of more than 60% in the removal of dissolved organic carbon (DOC), metals, chlorides, sulphates, fluorides [8].

Waste washing treatment (WWT) could likewise be applied prior to landfilling to residues of different waste management processes: non-recyclable plastics originated from source segregation, mechanical–biological treated municipal solid waste (MSW) and ASR [9].

In order to assess the potential of WWT for full scale application, technical washing tests were carried out at the Sanitary Engineering Laboratory of the University of Padua (LISA) and the removal efficiency was evaluated.

Following evaluation of the removal efficiency, column tests were conducted under both aerobic and anaerobic conditions with the aim of assessing the emission potential of washed waste in landfill.

2. Experimental set-up

The general scheme for the research programme is illustrated graphically in Fig. 1.

Samples of different waste were washed on a technical scale. Raw waste samples and washed waste samples were compared to assess landfill acceptability by carrying out standard batch leaching tests. Subsequently, landfill simulation of washed waste was carried out in small lysimeter columns.

2.1. Sample composition and characterization

Technical scale washing tests were performed on five types of waste:

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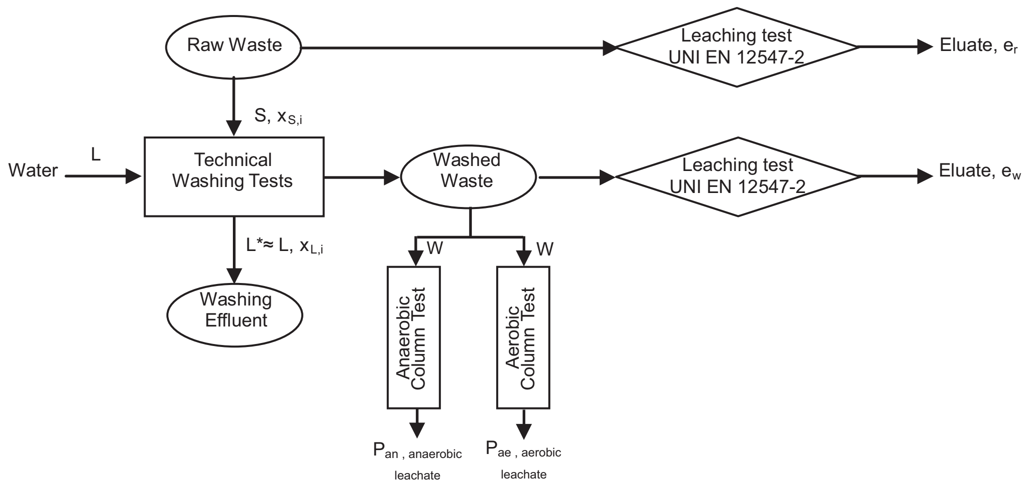

Fig. 1. Scheme of the experimental methodology (L: amount of washing water; S: amount of washed waste; $x_{S,i}$: concentration of i-substance in the raw waste; L^*: amount of washing effluent; $x_{L,i}$: concentration of i-substance in the washing effluent; W: amount of washed waste in column; $e_{r,i}$: concentration of the i-substance in the eluate of batch leaching test for the raw waste samples; and $e_{w,i}$: concentration of the i-substance in the eluate of batch leaching test for the washed waste samples).

- USP: under-sieve residues from plastics sorting process;
- ESP: end residues from plastics sorting process;
- MBT: mechanical–biological treated waste;
- BA: bottom ash from MSW incineration; and
- ASR: automotive shredder residues.

The first two residues were sampled in a sorting plant for source segregated plastics (Fig. 2).

The USP residue is generated from the ballistic sorting unit and is mainly made up of non-recyclable fine fraction, representing 20% of total input material. The ESP residue is constituted by the non-recyclable portion of the heavy fraction, representing 15% of total input material.

All samples from MSW management were collected in treatment plants located in the Veneto Region, Italy. The production of waste in the area is 1.3 kg/cap/d. The average composition is reported in Table 1. Source segregation rates are among the highest in Italy, reaching mean values of 43% [10].

The ASR sample was collected at a plant for the mechanical treatment (shredding and sorting) of end-of-life vehicles (ELV). Whilst metals and other components are forwarded to recovery the residual light fraction (ASR), representing approximately 30% of total weight of ELV, is landfilled. The plant, located in Northern Italy, produces approximately 6000 tons of ASR per year (2008).

All residues were sampled according to the Italian reference method UNI 10802 [11], collecting a minimum quantity of 50 kg for each material.

Table 1
Average composition of municipal solid waste in the Veneto Region, Italy [10].

Putrescible fraction	20.0%
Garden waste	15.0%
Paper and paperboard	20.6%
Plastics	11.7%
Glass	7.0%
Textiles	2.5%
Aluminium, ferrous and non-ferrous materials	2.3%
Wood	0.9%
Other (fine fraction, tetra pak, inert materials, napkins, hazardous waste . . .)	20.0%

First all samples were classified in terms of fine fraction (<20 mm and <10 mm for the bottom ash) and other material fractions that differed according to each individual type of waste. The samples were then ground to a size <4 mm using a laboratory cutting mill (model Retsch SM 2000) and analysed.

Analyses were carried out on both the solid and the leachable fraction using the equipment and methods reported in Table 2.

The solid fractions were analysed for the following parameters: total solids (TS), volatile solids (VS), respirometric index (RI_7), Total Kjeldahl Nitrogen (TKN), total organic carbon (TOC) and metals (Ba, Cd, Cr, Cu, Mo, Ni, Pb, Zn). Analyses were performed in triplicate.

Batch leaching tests were performed as established by UNI EN 12547-2. Eluates, filtered at 0.45 μm, were analysed for the following parameters: chemical oxygen demand (COD), DOC, TKN, metals (Ba, Cd, Cr, Cu, Mo, Ni, Pb, Zn), electric conductivity (EC), chlorides,

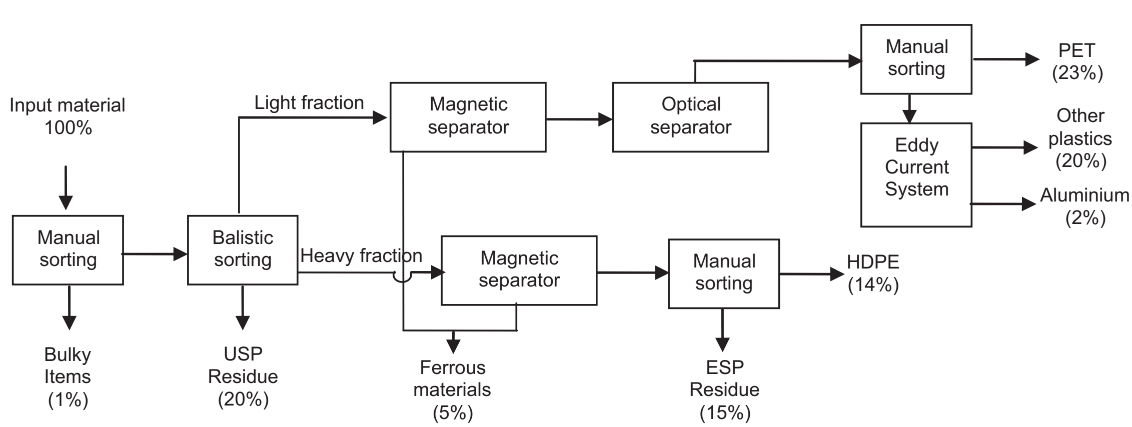

Fig. 2. Scheme of the sorting plant for source segregated plastics where USP and ESP residues were sampled [9].