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# Heavy metals removal from automobile shredder residues (ASR)

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**Abstract**

The fate of heavy metals during a separation process for automobile shredder residues (ASR) was investigated. A washing method to remove heavy metals from the ASR was also investigated. Although the separation process was not designed for removal of heavy metals, but for the recovery of reusable materials, the heavy metal content in the ASR was efficiently decreased. The concentrations of Pb, Cr and Cd in ASR were effectively reduced by a nonferrous metals removal process, and the As concentration was reduced by the removal of light dusts during the separation process. Five heavy metals (As, Se, Pb, Cr, Cd) remaining in the ASR after the separation process satisfied the content criteria of the Environmental Quality Standards for Soil (EQSS), while the concentrations of As, Se, Pb in the leachate from the remaining ASR did not satisfy the elution criteria of the EQSS. After additional washing of the remaining ASR with a pH 1 acid buffer solution, the As, Se, and Pb concentrations satisfied the EQSS for elution. These results indicate that an ASR residue can be safely recycled after a separation process, followed by washing at acidic pH.


*Keywords:* Automobile shredder residues; Elution; End-of-life-vehicles; Environmental quality standard; Heavy metals

## 1. Introduction

The number of vehicles in Japan has been linearly increasing since 1975 and was approximately 72.5 million in 2002 [1]. Approximately 5 million vehicles are wasted every year. Approximately 9.09 million t of automobile shredder residue (ASR) are produced and disposed of every year after the separation of reusable metals and parts from end-of-life-vehicles (ELV) [2].

Most ASR is directly disposed of in landfill sites. In Japan, the residues area of landfill sites has been reduced every year, so that as of 2004, the landfill capacity for industrial and domestic waste could only be sustained for less than 2 and 8 years, respectively [3]. Therefore, recycling and reuse of ASR is urgently required, and many investigations are being conducted to develop technologies for recycling of plastics [4,5].

There are three methods of plastic recycling that include thermal recycle (energy recycle), chemical recycle (feed stock recycle) and material recycle (mechanical recycle). Material recycling of ASR is generally difficult. One of major reasons for this is the contamination of ASR by heavy metals. The heavy metals in ASR may pose a threat to the environment by leaching from the ASR [6]. The leaching of heavy metals from ASR has become an object of public concern in Japan, so that since 1976, ASR is classified as a hazardous waste and must be disposed of in controlled landfill sites. The heavy metals originate from some residual metal pieces, solder, plasticizers and paints present in ASR [7–9]. The regulations for heavy metals in plastics are not defined in Japan, because the contamination of heavy metals into plastics is not generally assumed, and the recycling and reuse of waste plastics is not yet developed.

Some of the most probable products for material recycle of ASR are equipment used outdoors, e.g. containers, benches, fences and blocks, because the satisfactory production of this type of equipment has been achieved with material recycle of industrial waste plastics. Therefore, in the case of recycled products used outdoors, the elution of heavy metals should be prevented. In Japan, the Environmental Quality Standards for Soil (EQSS) regulate the toxicity and environmental impact of heavy metals eluted from soil. If the toxicities and environmental impact of heavy metals eluted from recycled products are lower

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than the EQSS levels, they can be estimated as being harmless. Therefore, one criterion for the material recycle of ASR is to satisfy the EQSS.

In some commercial plants, the residual reusable materials (e.g. iron and nonferrous metals) are additionally recovered from the ASR by separation processes in order to recycle them. After the recovery of reusable materials, the ASR residue is mainly composed of plastics; therefore, there is a possibility that the heavy metal content has been significantly decreased and will satisfy the EQSS. An evaluation of each separation process for reusable materials is important for the control of heavy metals in ASR for recycle.

In this study, main purpose is to evaluate the possibility of ASR recycling as a resource to remove heavy metals after separation process in comparison with EQSS. EQSS levels for the content in the residue and elution content were used to evaluate the safety of recycling ASR in regard to the effect on soil.

The heavy metal removal was studied in order to promote plastic recycling. An evaluation of heavy metal contamination was performed after each commercial separation process, and the fate of heavy metals in each separation process was investigated.

The performance of several washing methods, used to remove heavy metals from residual ASR after the separation process, was also studied.

## 2. Experimental

### *2.1. Separation process*

A flow chart of the commercial separation process studied is shown in Fig. 1. Double circles represent reusable commercial materials in Japan. Residue-A, which is ASR in general, is the residue after the removal of iron from the shredded ELV using a permanent magnet. The percentage of ASR is normally 8% of the ELV. Large light plastics (mainly urethanes), large nonferrous metals (aluminum and copper wire) and large light dust (woods, fibers, urethanes and sediments) are removed from residue-A after shredding (particle diameter = 15–20 cm) using an eddy current separator (ECS) and a wind force separator. The light fraction and heavy fraction are separated by a mechanical wind force separator based on the specific gravity of both fractions. The ECS is based on a rotor comprised of magnetic blocks, either standard ferrite ceramic type or the more powerful rare earth magnets, depending on the application. The blocks are spun at high revolution (over 3000 rpm) to produce an ‘eddy current’ that reacts with different metals, according to their specific density and electrical conductivity, creating a repelling force on the charged particle. If a metal is light and conductive, such as aluminum, it is easily levitated and ejected from the normal flow of the product stream, making separation possible. After these

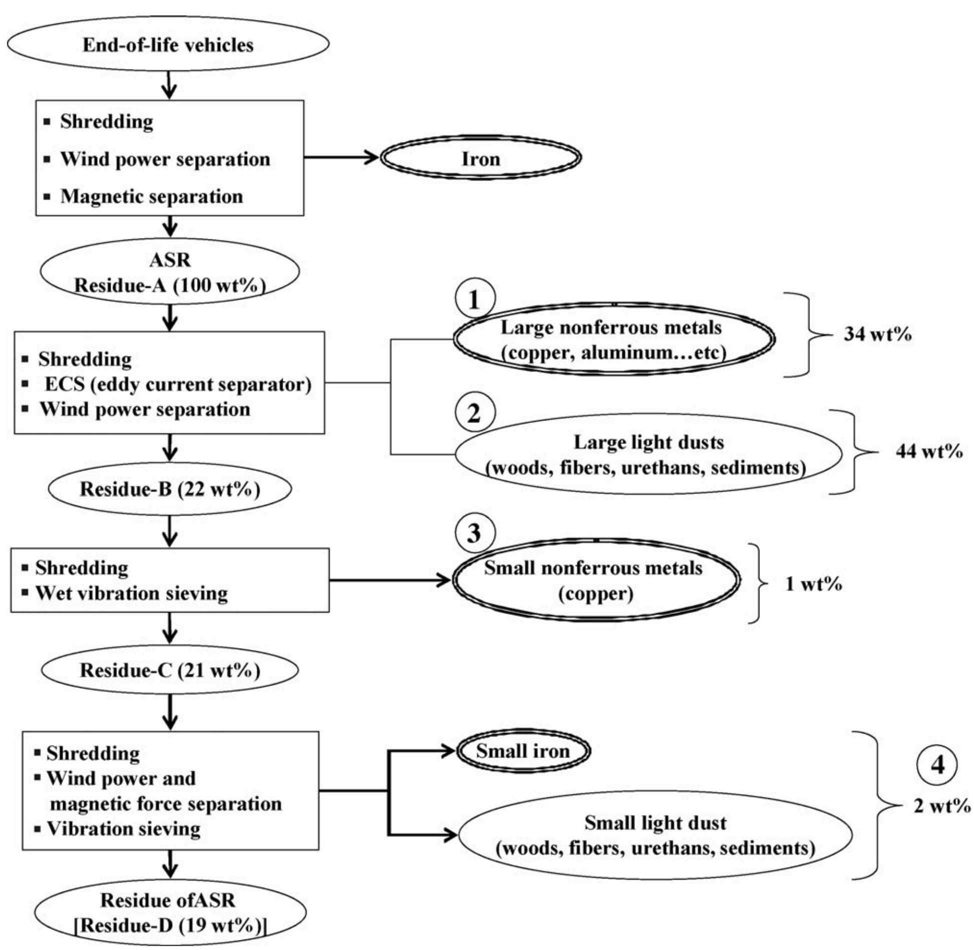


Fig. 1. Flow diagram for the separation process.