

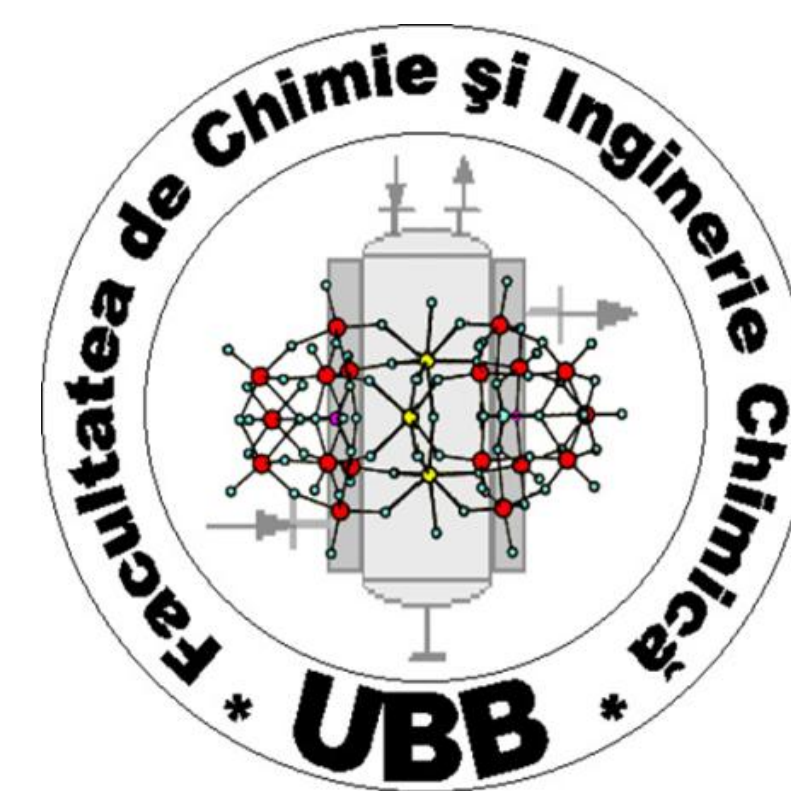


# Electrochemical recovery of metals from WPCBs: Evaluation of direct accessible metals content

Sorin-Aurel Dorneanu<sup>1,\*</sup>, Alexandru-Horațiu Marincăș<sup>1</sup>, Tiberiu Frențiu<sup>2</sup>, Petru Ilea<sup>1</sup>

<sup>1</sup> Department of Chemical Engineering, "Babeș-Bolyai" University, 11 Arany Janos Street,  
RO-400028 Cluj-Napoca, Romania, \*e-mail: dorneanu@chem.ubbcluj.ro

<sup>2</sup> Department of Chemistry, "Babeș-Bolyai" University, 11 Arany Janos Street, RO-400028 Cluj-Napoca, Romania



## INTRODUCTION

Due to the rapid technological development and more demanding customers, the global quantity of waste electrical and electronic equipment (WEEE) was up to 41.8 Mt in 2014 and was forecasted to be 50 Mt in 2018 [1]. The relatively high WEEE metal content imposes to develop new, economical and eco-friendly recycling technologies. The improvement in WEEE's manufacture led to continuously reducing metals consumption, especially noble metals. The printed circuit boards (PCBs) are the most valuable components of WEEE's, concentrating 40% from the value of the recoverable metals [2]. In this context, the content of the exposed metals for 10 different age group PC motherboards (PCMBs) was evaluated by chemical dissolution and ICP-AES analysis of the resulting solutions.

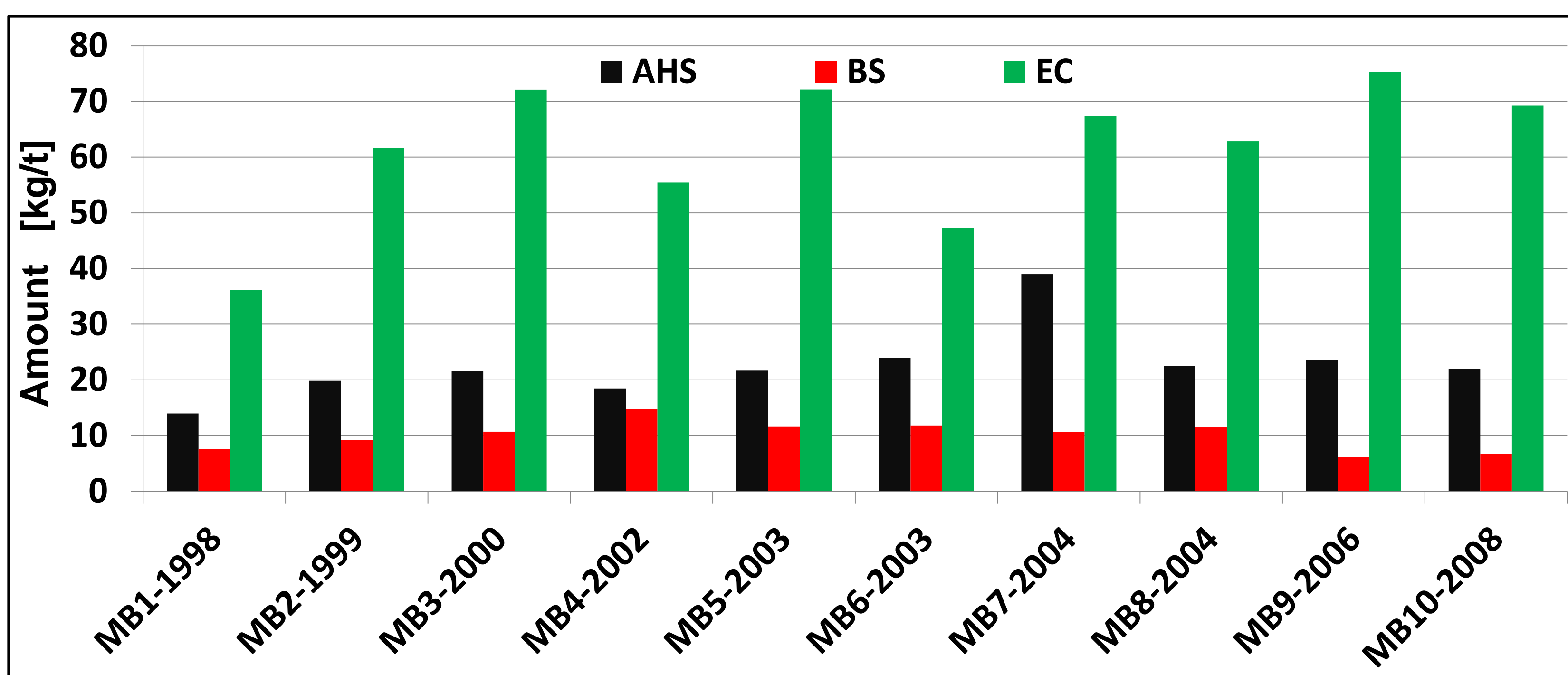
## EXPERIMENTAL CONDITIONS

- 10 PCMBs released between 1998 and 2008 were manually pre-treated in order to remove the Li batteries, aluminium heat sinks (AHS), bronze screws (BS) and the cylindrical aluminium electrolytic capacitors (EC).
- Each board was cut in large pieces and the exposed metals were dissolved in KBr solution containing Br<sub>2</sub> as oxidizing agent.
- The resulting solutions were analyzed by ICP-AES using a SPECTRO CIROS CCD spectrometer (SPECTRO Analytical Instruments, Germany).

## RESULTS AND DISCUSSIONS

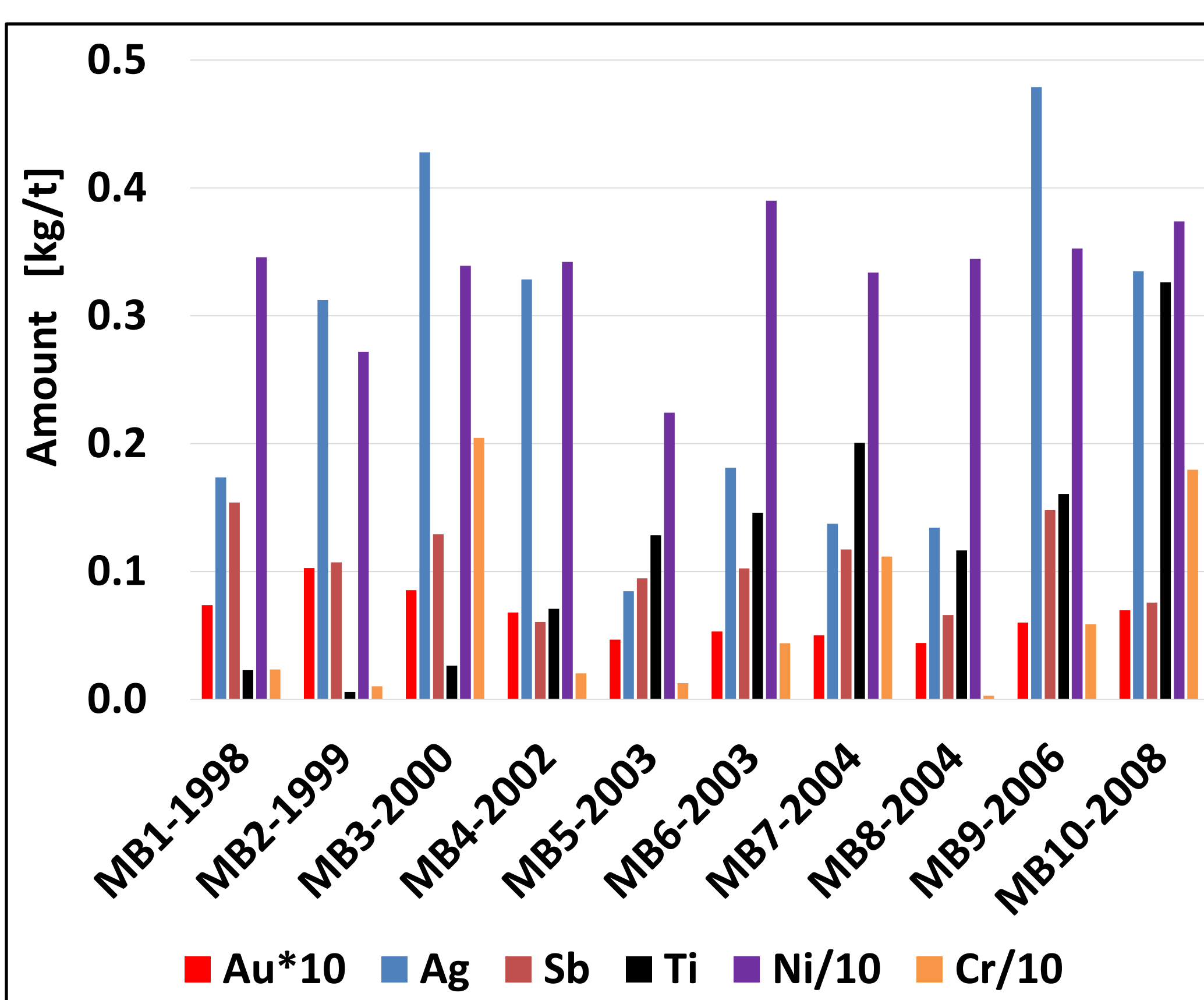
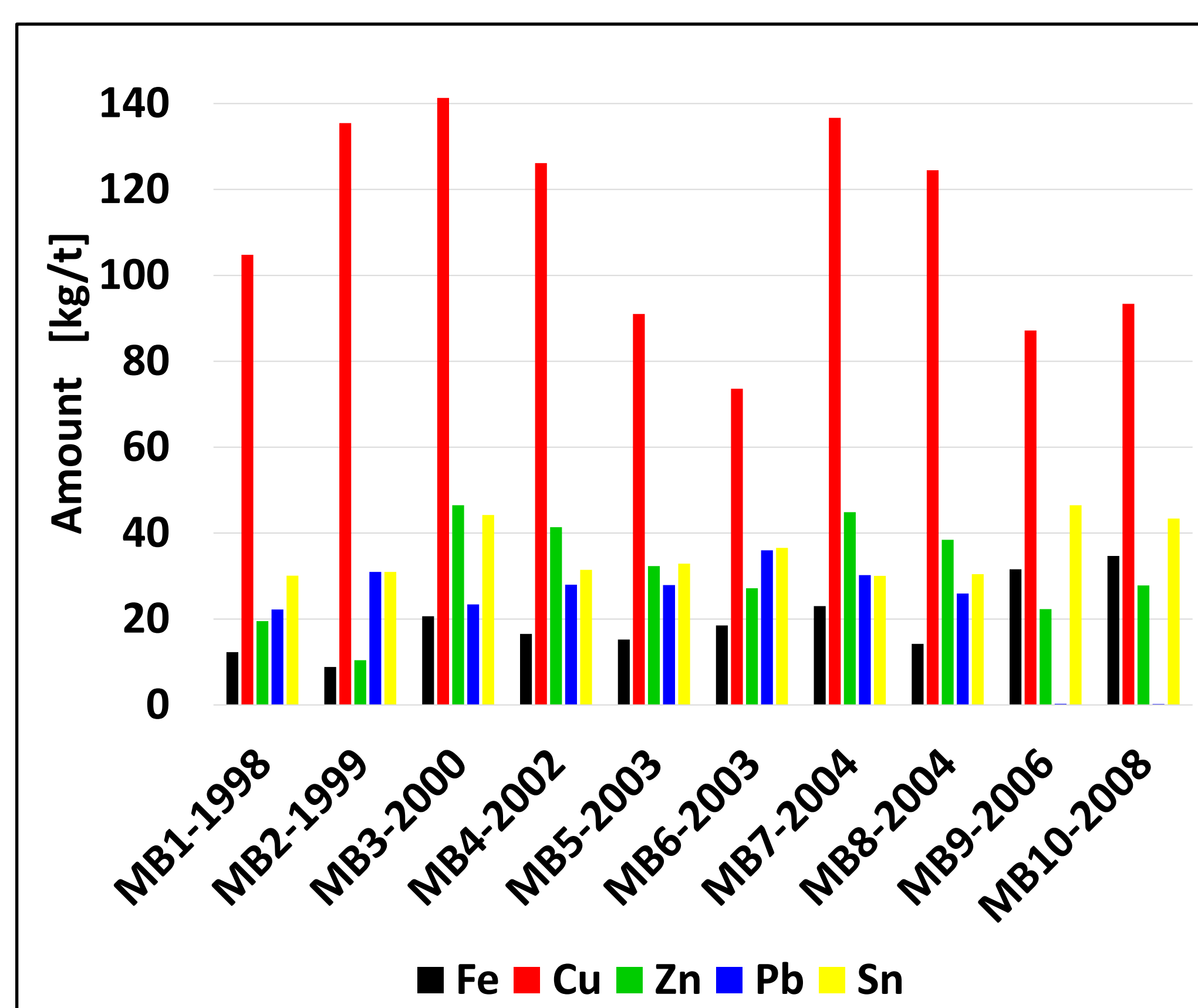
### 1. Amount evolution of the manually removed components

PCMB model	Code	Release
Asus P2B-S	MB1-1998	1998
PRM-00801 E1	MB2-1999	1999
PRM-27IV- DTK Computer	MB3-2000	2000
MSI MS-6378	MB4-2002	2002
Elitegroup K7VTA3/KT333	MB5-2003	2003
Elitegroup P4IBASD (v3.0)	MB6-2003	2003
ASRock P4i45D+	MB7-2004	2004
Mercury KOB KT266a FDSX	MB8-2004	2004
ASRock AliveNF6G-VSTA	MB9-2006	2006
MSI P31 Neo V2	MB10-2008	2008

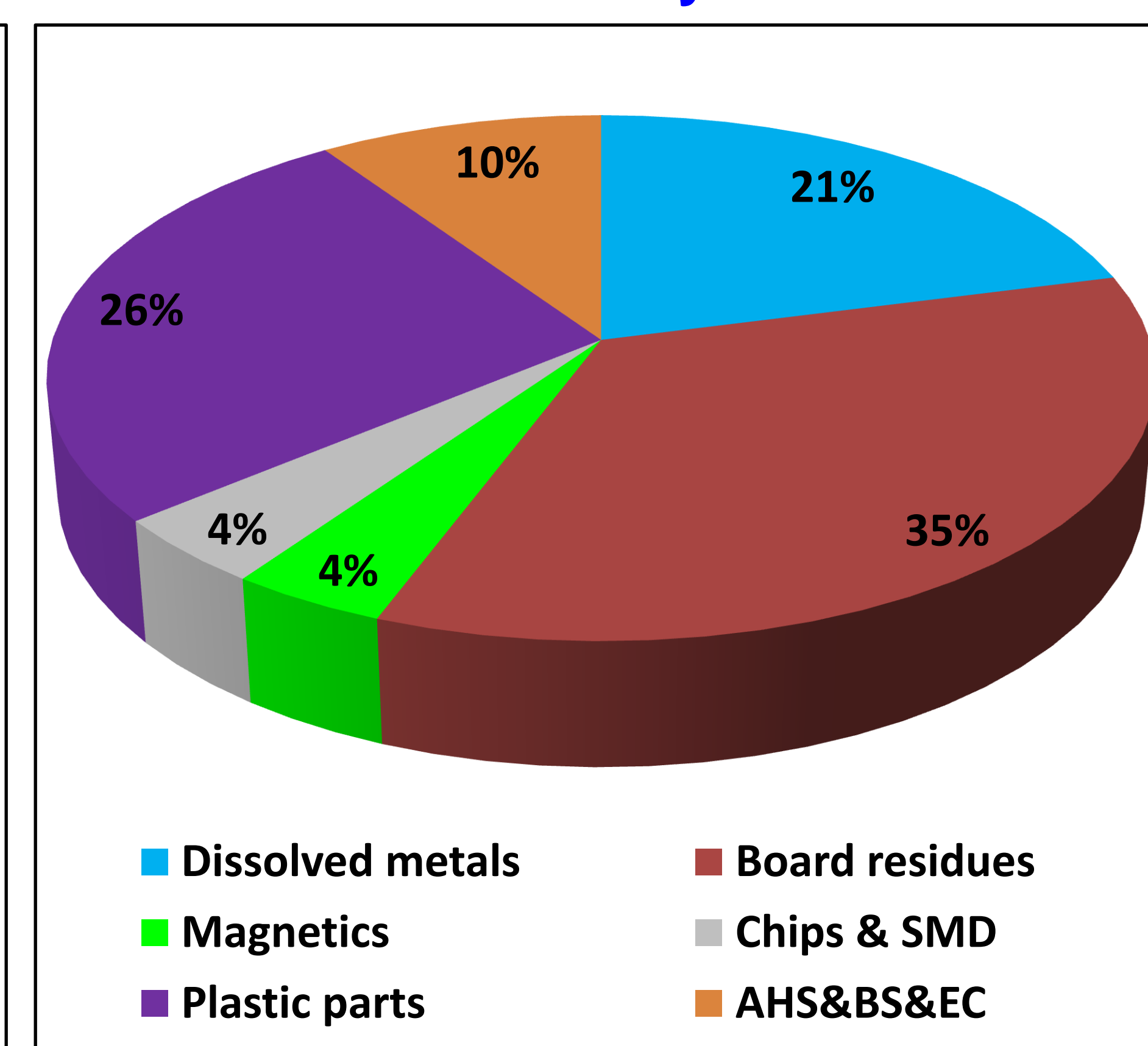


- The amount of the manually removed components slightly increase in the middle of the evaluated period but still remains high.
- Considering only the electric energy consumption for leaching solution regeneration and Al electroextraction, the presence of AHS and EC (~ 85 kg/t) in the leaching step can increase the cost of the PCMBs recycling process with more than 400 €/t.

### 2. Amount evolution of the dissolved metals



### 3. Global amount of recyclable materials



- For the tested PCMBs, mean values of Cu and Sn amounts of 110 and 35 kg/t grant more than 1500 USD/t.
- After RoHS directive took effect in 2006, the Pb content decreased significantly, simultaneous with the increase of the Sn content.
- Concerning the noble and other small quantities metals, the amounts remain quasi-constant, assuring around 500 USD/t revenue.
- The board residues and plastic parts cumulate more than 60% from the global mass of the tested PCMBs.

## CONCLUSIONS

- ✓ The costs for metals recovery from PCBMs can be significantly reduced by a minimal mechanical pre-treatment for removing the Li batteries, AHS, BS and EC.
- ✓ For the tested PCMBs, the content of exposed metals is relatively constant, maintaining a revenue of about 2100 USD/t.
- ✓ The value of metals still remained in chips, SMD and depopulated PCBs, omitted in this study, can also increase the income.
- ✓ Adequate and efficient technologies must be implemented for the board residues and plastic parts recycling.

## ACKNOWLEDGEMENT

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