Corso di Dottorato di Ricerca in Scienze della Vita e dell'Ambiente – Ciclo XXXV

Innovative biotechnology for the recovery of strategic metals from residues

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Electronic waste is one of the fastest growing categories of waste due to technological innovation [1]. Printed circuit boards (PCBs) represent the 5% of this waste and they are of considerable interest due to their metal content. The purity and the amount of precious metals are higher in PCBs compared to the minerals [2]. Therefore, the recycling of PCBs is an increasingly important topic, also in the spirit of circular economy [3]. Metal mobilization can be conducted with hydrometallurgical or bio-hydrometallurgical techniques.

AIM OF MY PhD

Development of sustainable technologies for the recovery of precious metals from PCBs, evaluating the efficiency of thiosulfate as an alternative of chemical cyanide and testing the metal mobilization ability of the cyanogenic bacteria *Pseudomonas aeruginosa*.

MATERIAL AND METHODS

Chemical leaching

LEVELS	-	0	+
Ammonia concentration (M)	0.2	0.6	1
Thiosulfate concentration (M)	0.1	0.55	1
PCBs size (mm)	<0.25	0.25-0.5	0.5-1

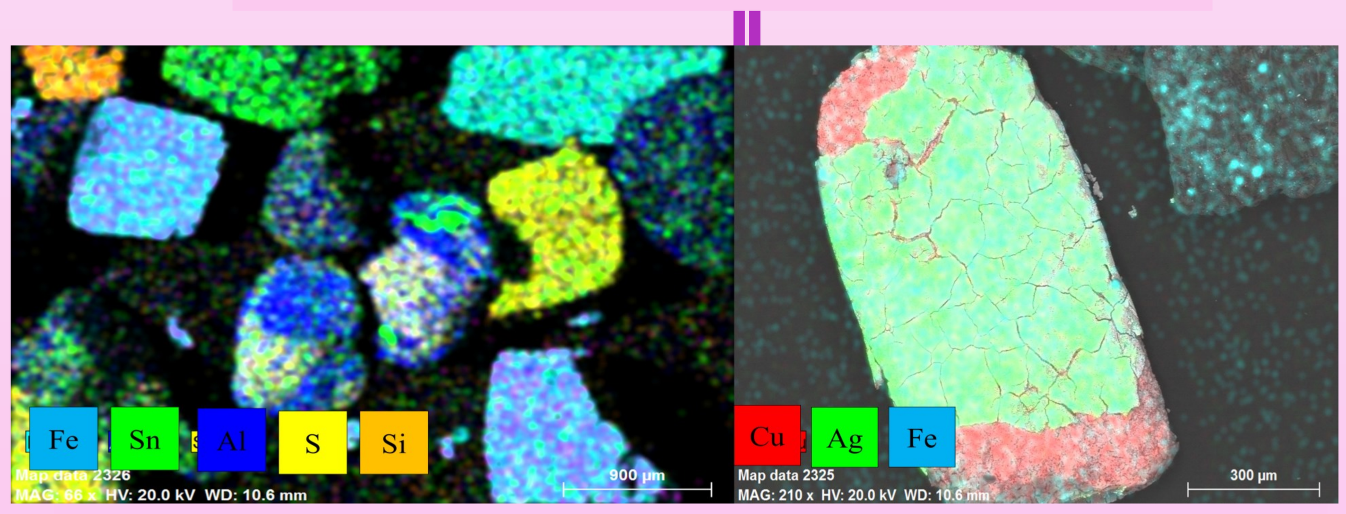


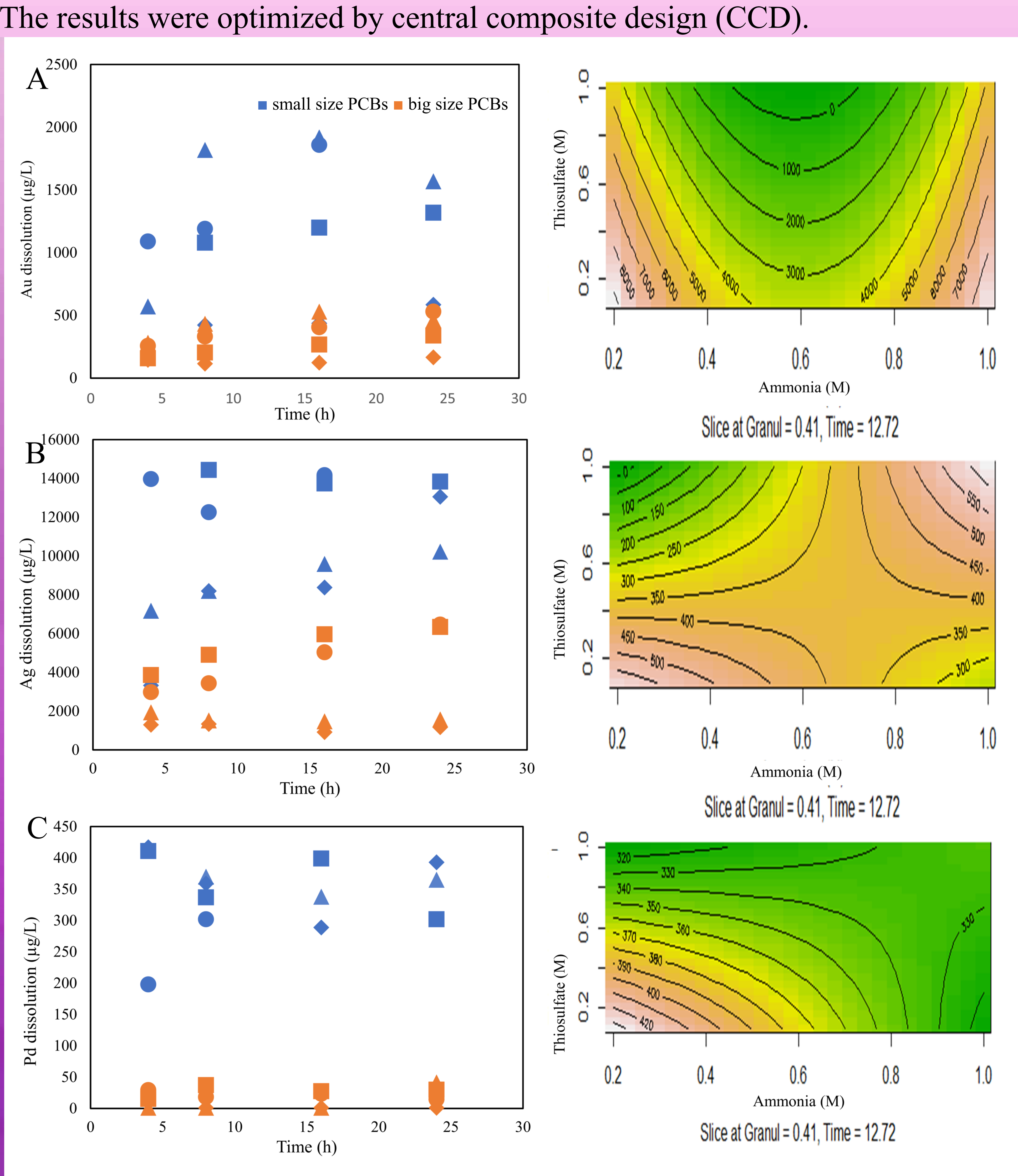
Figure 1. PCBs characterization by SEM analysis

Bioleaching with bacteria

P. aeruginosa was grown at different glycine concentration at pH 8 to optimize cyanide production. The best condition were chosen for the bioleaching test.

RESULTS

The results were optimized by central composite design (CCD).



● 0.1 M thiosulfate 0.2 M ammonia ■ 0.1 M thiosulfate 1 M ammonia ♦ 1 M thiosulfate 0.2 M ammonia ▲ 1 M thiosulfate 1 M ammonia

Figure 2. Metals dissolution in the final liquor with 0.25 mm (blue) and 0.5-1 mm (orange) PCBs size and 2D contour plots for Au (A), Ag (B) and Pd (C).

The optimum conditions for metals dissolution have been found as: ammonia concentration 0.2 M, thiosulfate concentration 0.2 M, PCBs size < 0.25 mm for all the metals.

RESULTS

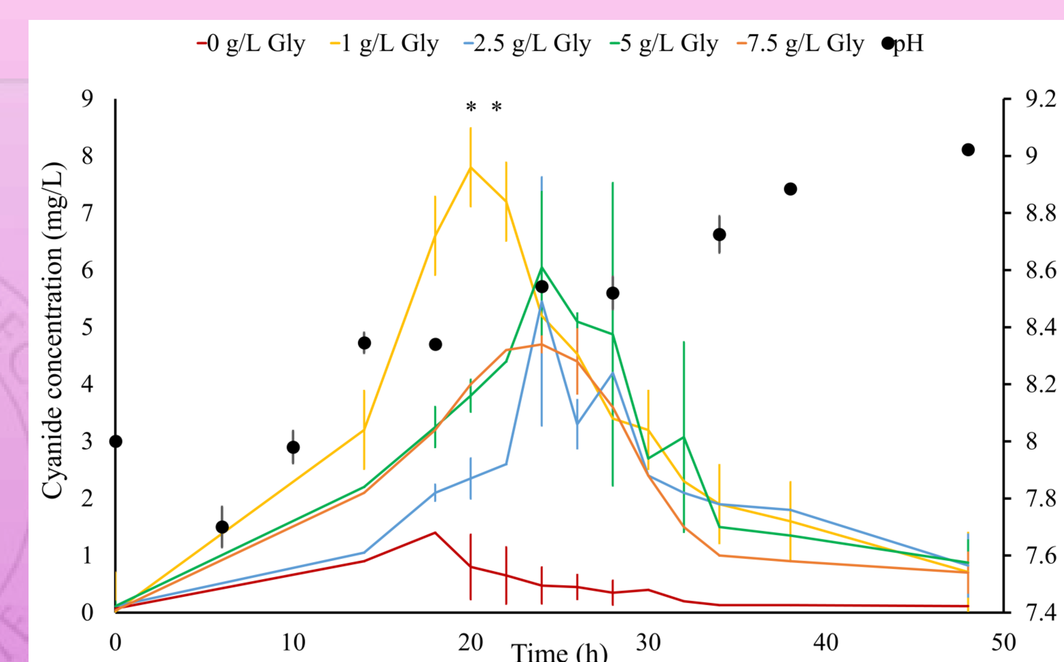
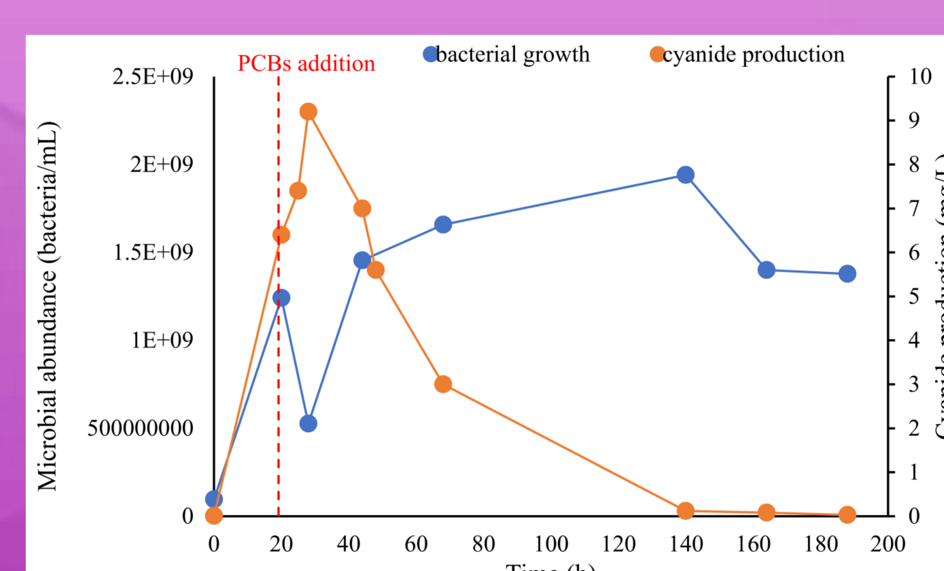


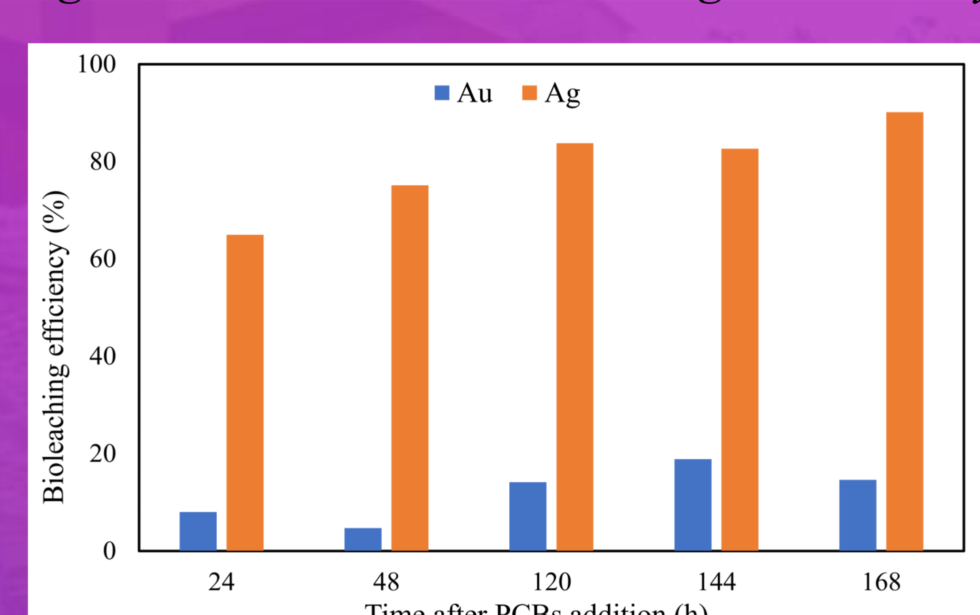
Figure 2. Trend of cyanide production and pH profile at different times and glycine concentration.

The best conditions were 1 g/L glycine and pH of 8.



PCBs (1 g/L) were added after 20 hours of growth and pH was raised to 9 for bioleaching test.

Figure 3. Variation in microbial growth and cyanide production.



Highest Ag mobilization: 90% after 7 days.
Au bioleaching: lower efficiency rate, around 20% after 6 days.

Figure 4. Ag and Au bioleaching efficiencies (%) during time.

CONCLUSIONS

- The processes represent a promising alternative to solve the environmental sustainability issues of chemical cyanide.
- The comparison between the three different PCBs size showed better leaching efficiency (80% Au, 90% Ag, 100% Pd) with the smallest size (<0.25 mm).
- Cyanide biosynthesis optimization followed by bioleaching with *P. aeruginosa* resulted in a high-performance innovative process for Ag mobilization (up to 90%).

REFERENCES

[1] R. Liu, J. Li, Z. Ge, Review on *Chromobacterium Violaceum* for Gold Bioleaching from E-waste, Procedia Environ. Sci. 31 (2016)

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[3] J. Cui, L. Zhang, Metallurgical recovery of metals from electronic waste: A review, J. Hazard. Mater. 158 (2008) 228–256.