# Nut shells – natural biosorbents for a sustainable water reuse

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## BACKGROUND

Environmental contamination is a worldwide concern due to the high toxicity and persistent character of several trace elements in ecosystems, as well as their bioaccumulation and bioamplification effects along the food chain, affecting human health.

A major issue of concern is undoubtedly the water quality, being amongst the 17 goals of the 2030 Agenda for Sustainable Development [1], as it is an essential good but at high risk, with low availability of potable water on earth.

Elements such as arsenic, lead and mercury are in the top of the lists of hazardous substances that must be reduced and/or eliminated from waters [2,3], but others like cadmium, chromium, cobalt, nickel or zinc also require appropriate awareness.

Thus, it is extremely important to find effective methods capable to remove these contaminants from waters. Also, the possible reuse of treated wastewaters must be a sustainable way to protect the drinking water supply.

Biosorption has been pointed as a promising alternative to the conventional physicochemical methods of water treatment (e.g., chemical precipitation, reverse osmosis, electrolytic processes) and within biosorption, nut shells that are widely available and very low-cost residues, have proved to be potential materials to be applied as biosorbents for water treatment procedures.

## OBJECTIVES

- To develop and validate a low-cost and environmentally friendly water treatment technology:
  - Using almond, hazelnut, pistachio and walnut shells to remove As, Cd, Co, Cr, Hg, Ni, Pb and Zn from contaminated waters.
  - Converting a contaminated water into cleaner water in view of further reuse for agricultural, industrial and urban purposes.

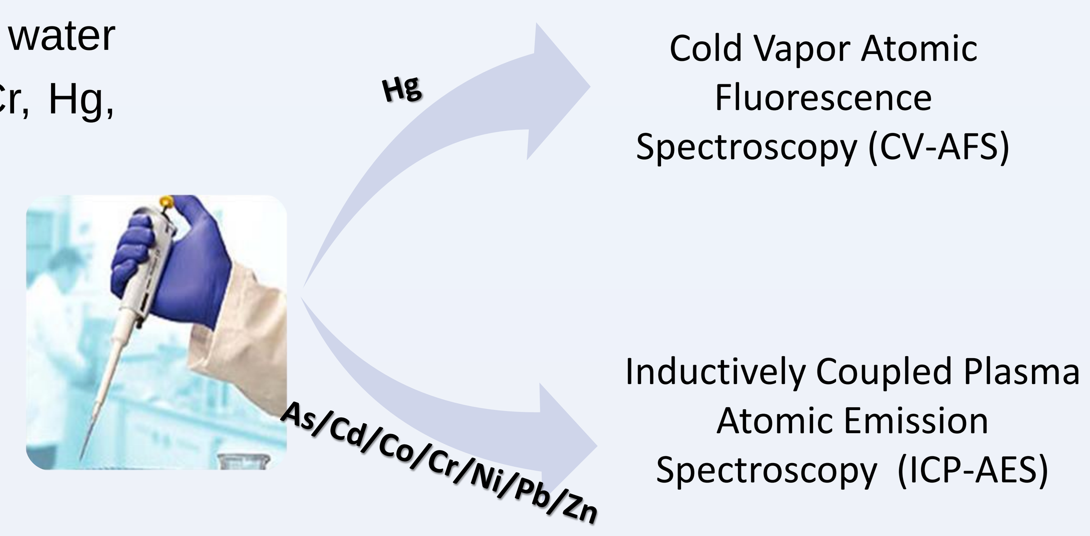
## MATERIALS AND METHODS

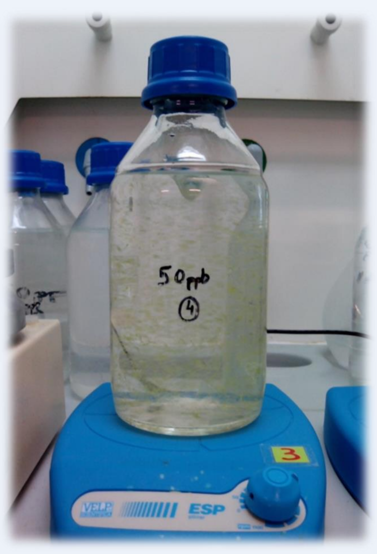
### Pre-treatment of biosorbents

- The shells were collected from domestic consumption and once at the laboratory they were ground and sieved for 1–2 mm, rinsed with deionized water (at 100 ºC) and then oven dried for 48h.

### Experimental methodology

Nut shells were put into contact with natural mineral water spiked with As, Cd, Co, Cr, Hg, Ni, Pb and Zn



Aliquots were collected at different contact times and element concentration was measured in solution

**Experimental conditions**

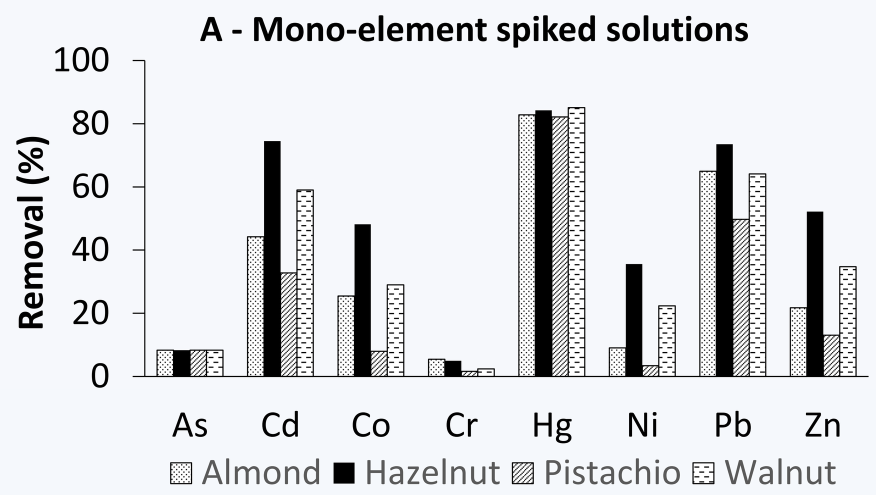
Fixed conditions:
- T=20 ± 1 ºC
- Time of contact: 48h
- pH=7
- Natural mineral water

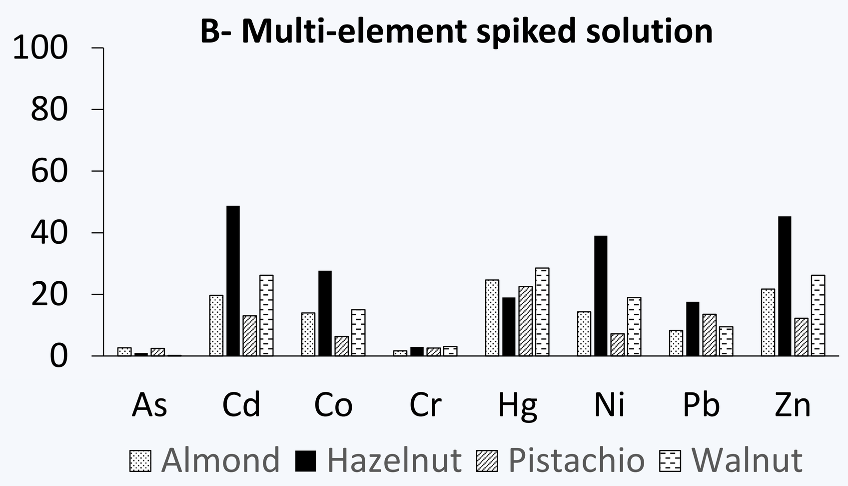
Variable conditions:
- Mono- and multi-element contamination scenario
- Mass of sorbent = 1 and 5 g/L
- [Elem]= Discharge limit value# (DLV) and ten times lower the discharge limit value (0.1 DLV)

#DLV: Hg=50 µg/L; Cd=200 µg/L; As, Co, Pb= 1000 µg/L; Cr, Ni, Zn= 2000 µg/L, according to Decree-Law 236/98, establishing limit values on wastewater discharges

## RESULTS

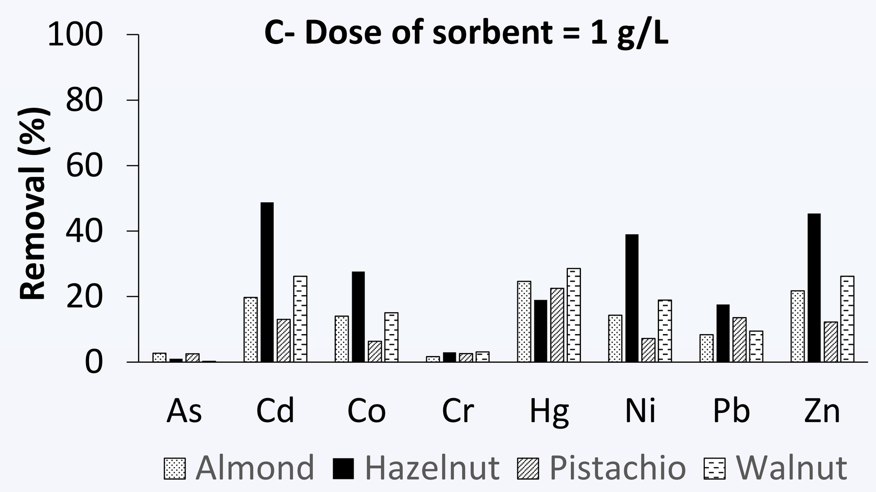
### Mono- vs. multi-element solution

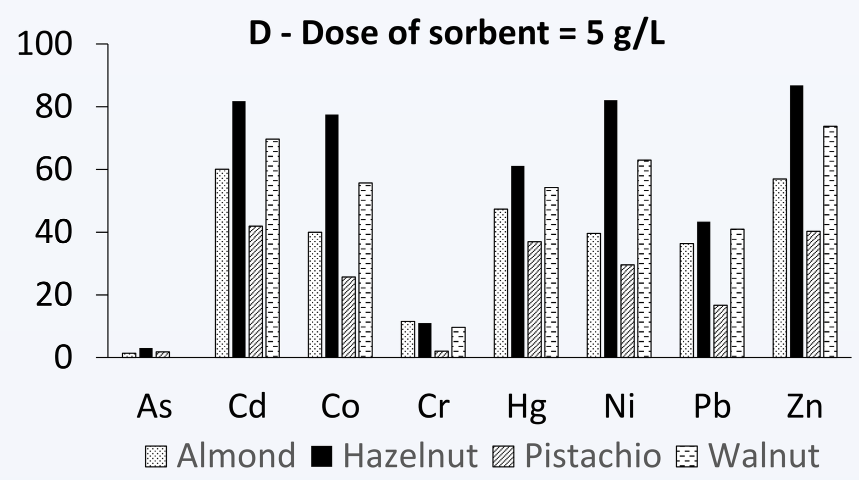



- Element removal decreased when competing with other elements in solution
- Hg and Pb highly affected by other elements, decreasing from 82-85% to 19-29% and from 60-74% to 8-18%, respectively
- Hazelnut with the highest percentages of removal for almost all the elements

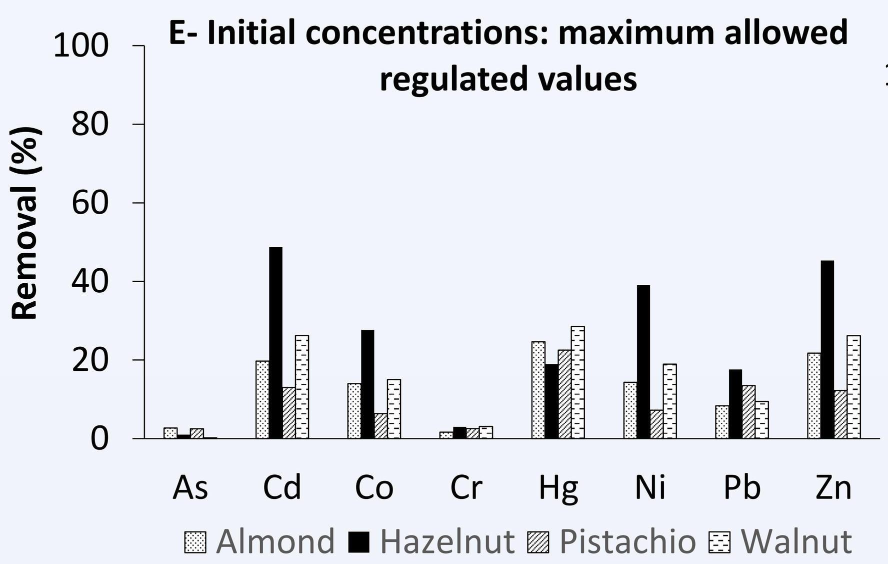
### Effect of sorbent dose

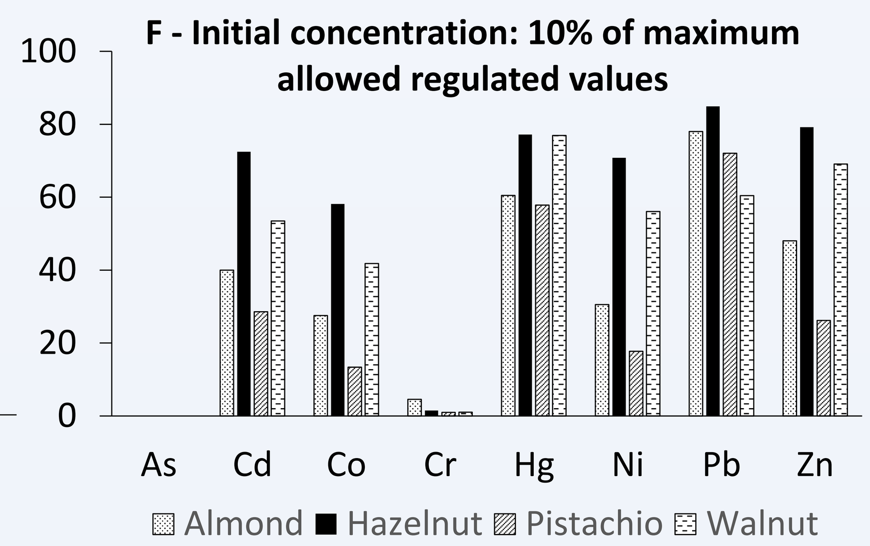



- Higher mass, higher removal of all the elements by all the nut shells
- Globally, an increase between 16 and 77% was observed, depending on element and nut shell
- Hazelnut is the material with higher percentages of removal in both doses of sorbent, up to 87% of removal

### Effect of initial element concentration




- Lower initial element concentration leads to higher removals
- Effect of initial concentration more pronounced for Hg and Pb, increasing from 23-29% to 58-77% and from 8-18% to 60-85%, respectively

## CONCLUSIONS

- ✓ Nut shells are effective materials for the removal of inorganic contaminants from waters
- ✓ Possible to achieve high removal efficiencies, up to ≈90%
- ✓ Arsenic and chromium not efficiently removed
- ✓ Hazelnut stood out as the overall best biosorbent
- ✓ Improvement of water quality through a low cost and environmentally friendly technology

## REFERENCES

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[3] Directive 2013/39/EU, 2013. Directive 2013/39/EU of the000/60/EC and 2008/105/EC as regards priority substances in the field of water policy. Off. J. Eur. Union.

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