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Removal of metal ions from a petrochemical wastewater using brown macro-algae as natural cation-exchangers

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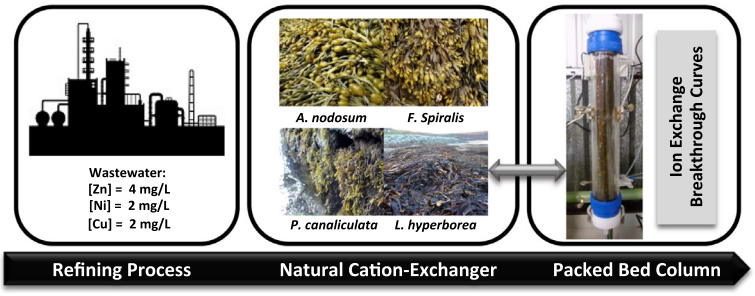
HIGHLIGHTS

- Heavy metals removal from petrochemical wastewater (PW) by ion-exchange.
- Brown marine macro-algae as natural cation exchanger for PW treatment.
- Trapping of heavy metals by raw biomass occurs by the release of light metals.
- *L. hyperborea* showed an useful capacity of 1558, 515 and 528 BV for Cu, Zn and Ni.
- Desorption using 1.2% HCl eluent (11 BV) was fast and near 100% effective.

GRAPHICAL ABSTRACT



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ABSTRACT

Four brown macro-algae, *Ascophyllum nodosum*, *Fucus spiralis*, *Laminaria hyperborea* and *Pelvetia canaliculata*, were investigated as natural cation exchangers for the removal of transition metals from a petrochemical wastewater. The wastewater presents a high conductivity due to chloride, sulfate, sodium, calcium and residual concentrations of copper, zinc and nickel species. According to all-inorganic species evaluated, the molar fraction of Zn^{2+}, Cu^{2+} and Ni^{2+} is near 92% and the remaining species are $ZnCl^{+}$, $ZnSO_4$, $CuSO_4$, $NiCl^{+}$ and $NiSO_4$. A Langmuir multicomponent model was able to predict the ion-exchange equilibrium data for Cu, Ni, Zn and Ca species present in the petrochemical wastewater. *L. hyperborea* showed a higher uptake capacity than the other brown algae tested. The equilibrium affinity constants for the functional groups decreased in the following order: Cu > Zn > Ni ≈ Ca, except for *L. hyperborea*, which presents a lesser affinity for Ca. Ion-exchange breakthrough curves obtained from a fixed-bed column packed with raw *L. hyperborea*, led to an operating capacity of 0.22, 0.10 and 0.05 mEq/g for Cu, Zn and Ni, corresponding to 1558, 515, 528 BV (7.2 BV/h), respectively. The treatment strategy consisted in the operation of two consecutive columns, the first one for copper ions removal (operating capacity of 1558 BV – 7.2 BV/h) and the second one for zinc and nickel removal (operating capacity of 163 BV–7.3 BV/h). The elution of Cu, Zn and Ni from the natural resin was achieved with 10 and 6 BV of HCl (0.4 M, 1.2%) (150 and 90 g HCl/L of resin), using a flow rate of 3.6 BV/h, respectively for the first and second columns.

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