Research Centre Rez

Sorption of metals on biological waste material

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Goals

- Low-cost biological material – orange peel;
- Possible replacement for the current expensive adsorbent for a remove of heavy metals;
- Adsorption studies;
- Pb(II), Ni(II) ions from test metallic solutions;
- Investigate the efficiency of adsorption for the removal of heavy metal ions from different concentration of solutions;
- Assess experimental data by several types of adsorption isotherms.

Preparation of biosorbent

- Waste from locally available orange company;
- Grinding in a coffee mill – fraction smaller than ca 0.5 mm;
- Magnetic iron oxide nanoparticles – FERROFLUID;

Orange peel in methanol
+
Ferrofluid

→

mix (one hour)

rinse by methanol

Reagents

- Water-soluble metal salts ($Pb(NO_3)_2$, $NiSO_4 \cdot 7H_2O$ compounds);
- Pb and Ni solutions were prepared at concentrations ranging from 1 to 1000 $mg.L^{-1}$;
- Working solutions – by diluting the stock solutions.

Analytical techniques

- **Surface – SEM with EDX (SEM LYRA3 TESCAN);**
- **Specific surface area – Quadrasorb EVO/S;**
- **Metal concentration – AAS-FA (UNICAM SOLAAR M6).**

Sorption experiments

magnetically modified orange peel

+

stock solution

(with defined initial ion concentration)

↓

stirring and filtration

Isotherm study

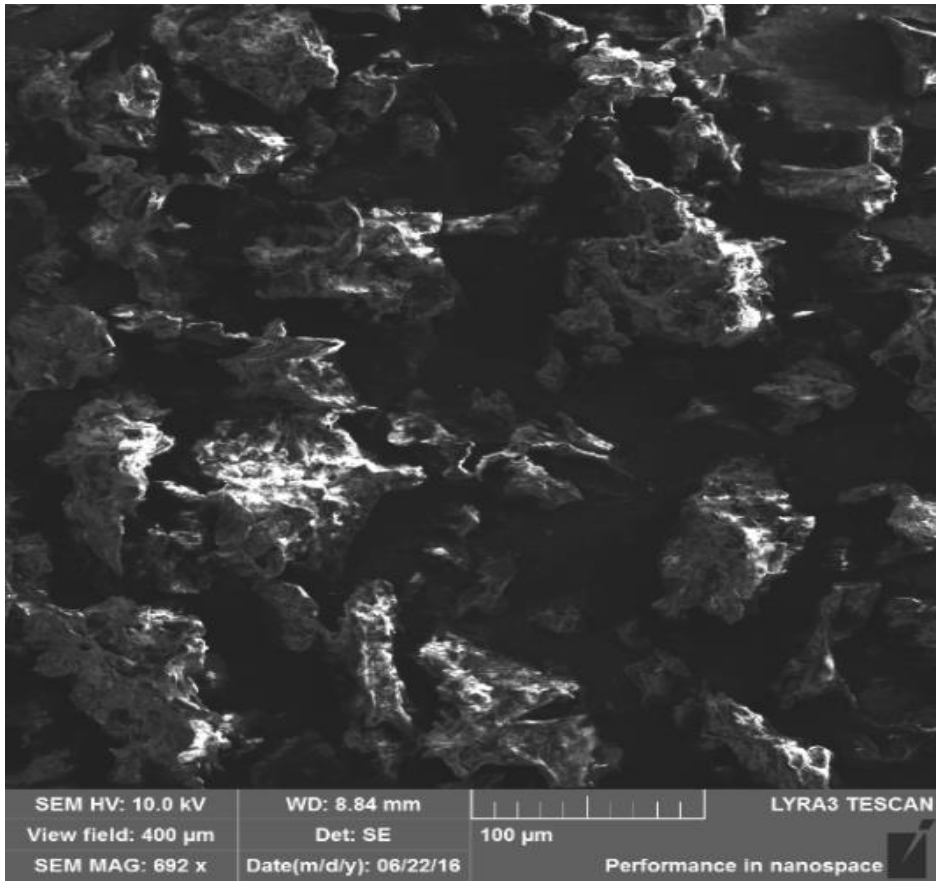
- **Langmuir adsorption isotherm model –** homogenous adsorption surface;
- **Freundlich adsorption isotherm model –** heterogeneous system;
- **Temkin adsorption isotherm model –** the heat of adsorption of all the molecules in the layer decreases linearly with coverage due to adsorbent – adsorbate interactions; uniform distribution of binding energies, up to a maximum binding energy**;**
- **Dubinin-Radushkevich adsorption isotherm model –** adsorption mechanism based on the potential theory assuming a heterogeneous surface.

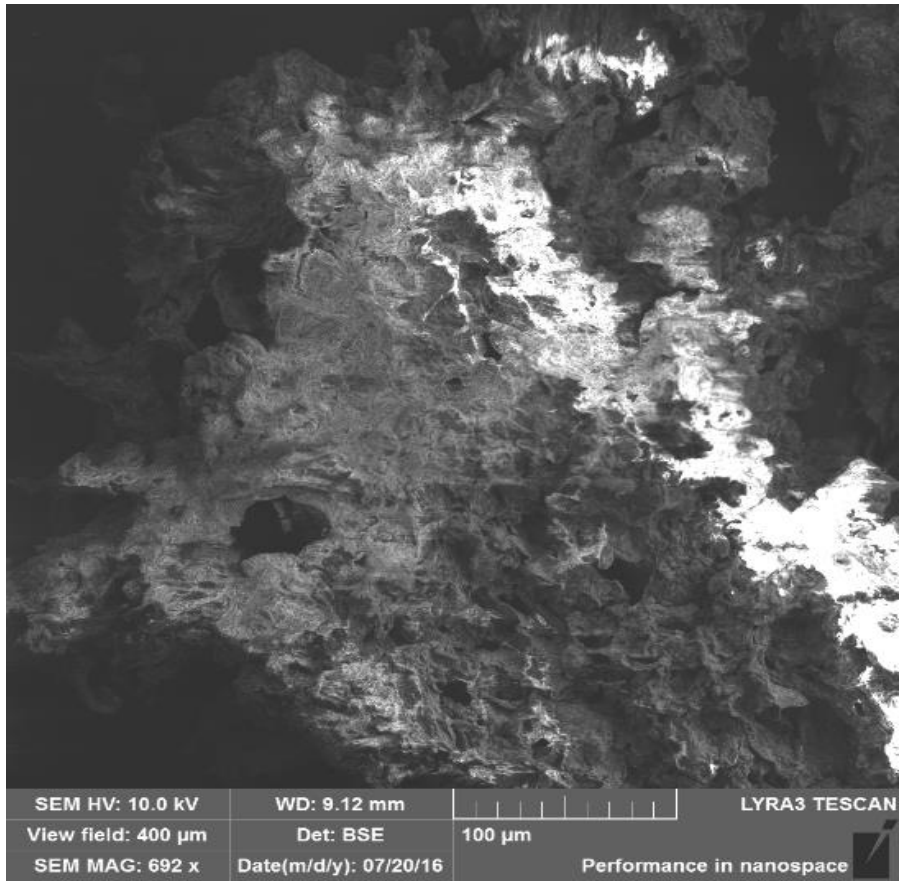
RESULT AND DISCUSIONS

Material characterization

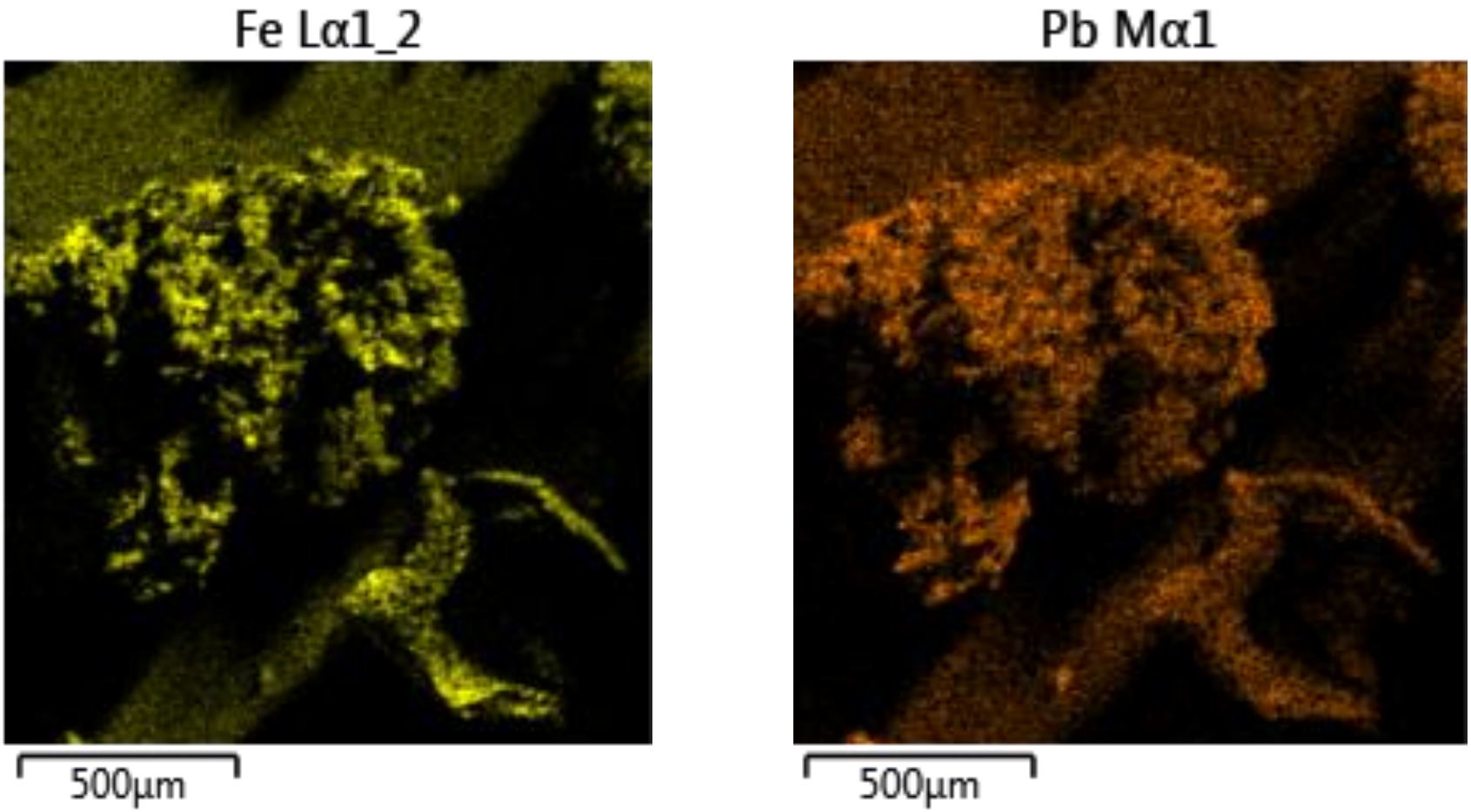
- **Iron in the magnetically modified orange peel took forms:**
  - **magnetite ($FeO.Fe_2O_3$)**
  - **wustite (FeO)**
  - **non-stechiometric iron oxide**
- **Specific surface area before modification – 0.45 $m^2.g^{-1}$**
- **Specific surface area after modification – 1.60 $m^2.g^{-1}$**

Morphological appearance



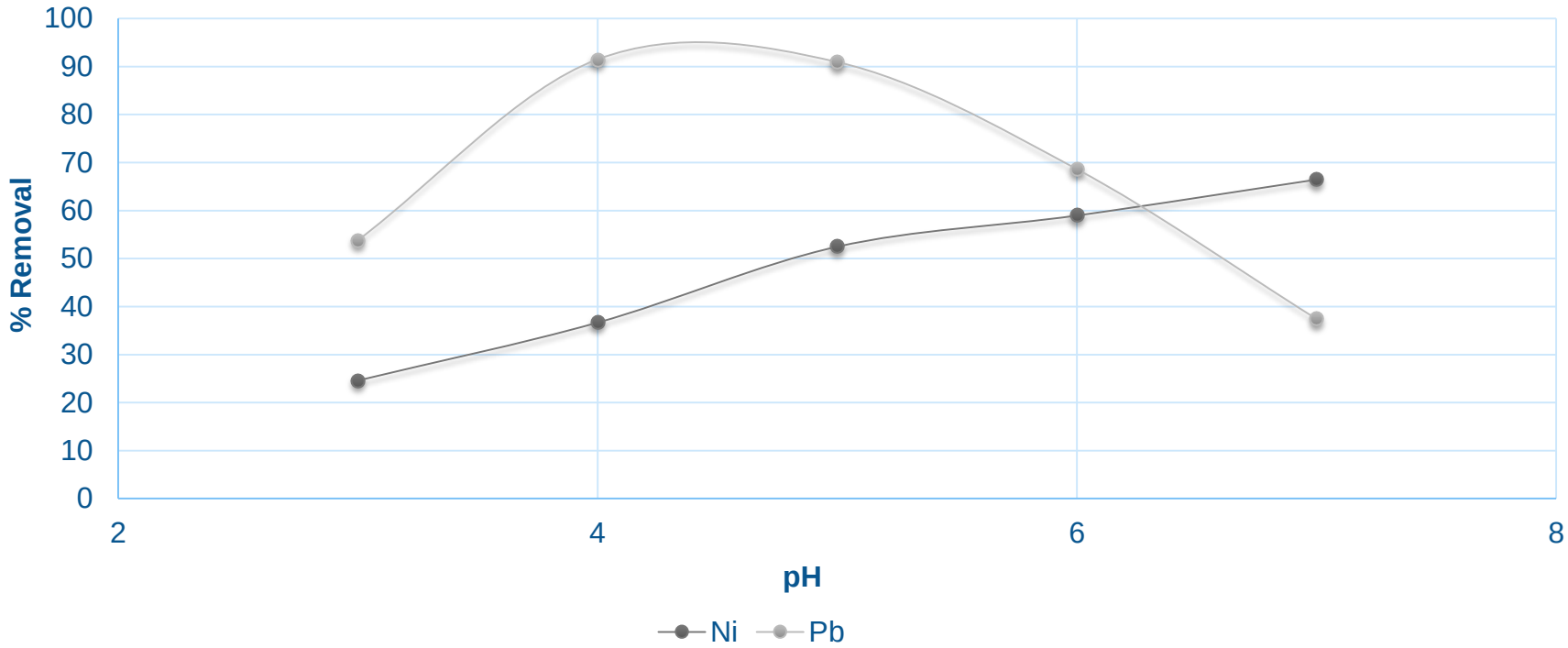


Morphological appearance



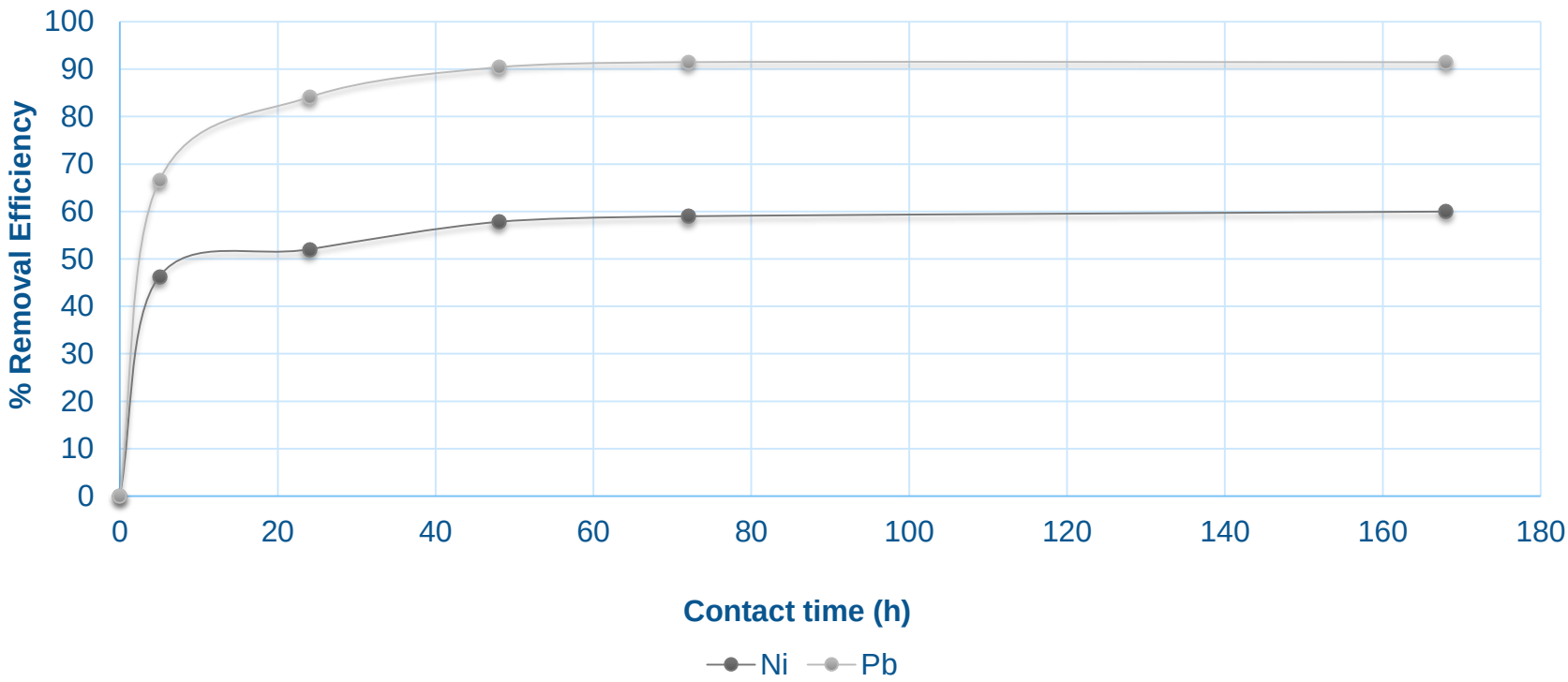
Effect of pH

- metal concentration – 10 $mg.l^{-1}$
- pH range 3 – 7



Effect of contact time

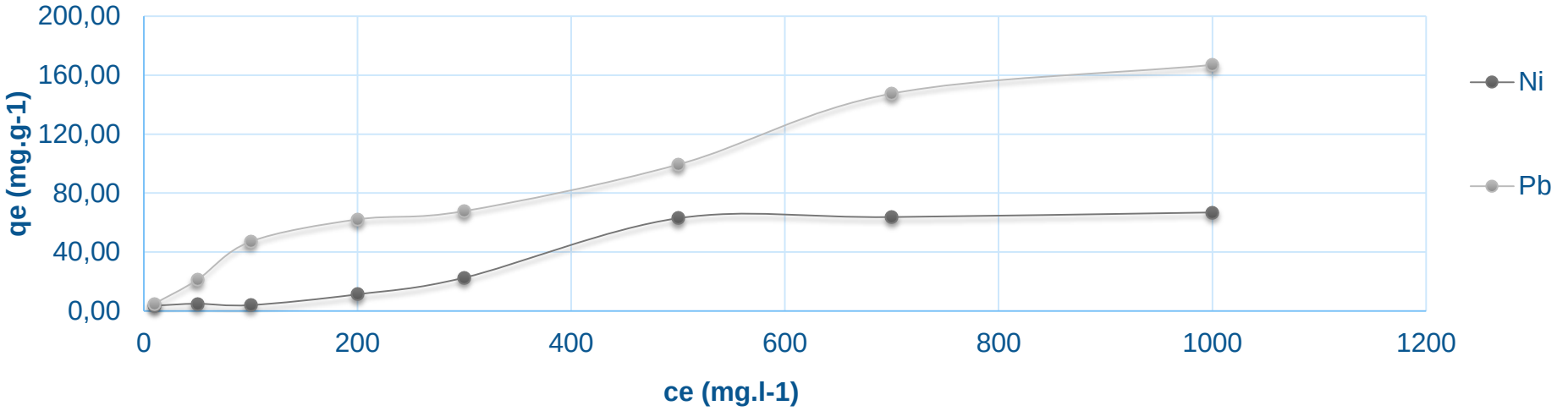
- metal concentration – 10 $mg.l^{-1}$
- time range 5 – 168 hours

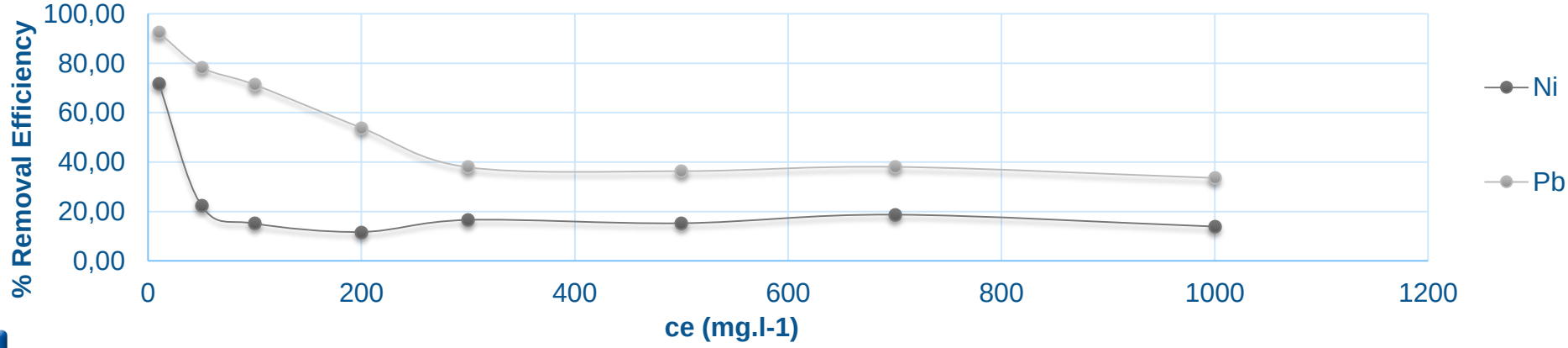


Effect of initial concentration

- metal concentration range – 10 – 1000 mg.l^{-1}

- pH range – (Ni) 6-7 and (Pb) 4-5





Adsorption isotherms

- **The experimental adsorption data were described by the linear form of adsorption isotherms and the linear coefficient of determination (R2);**

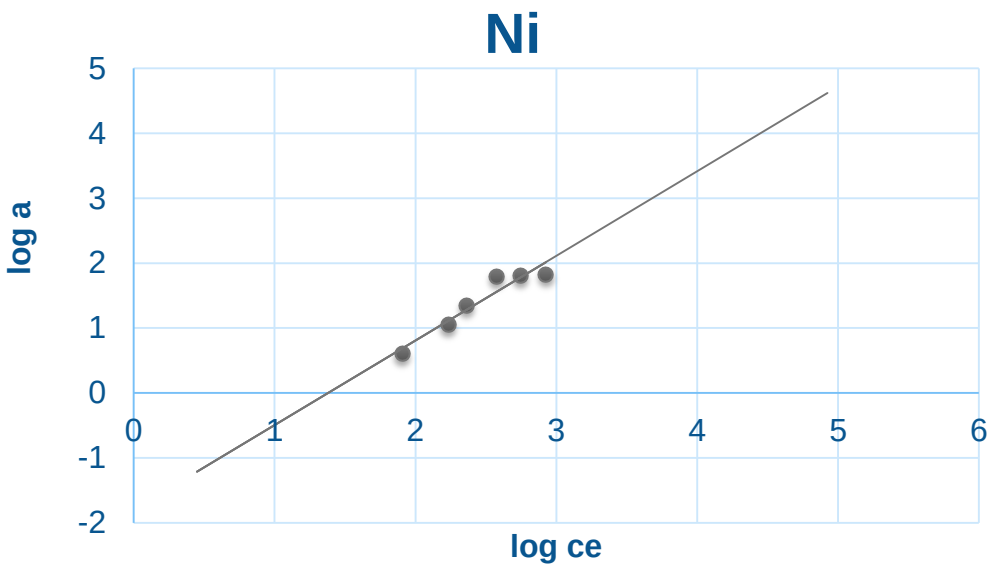
Isotherm models	Isotherm constant	Pb	Ni
Langmuir	q_{max} (mg/g)	181.818	142.857
	K_L	0.010	0.001
	R_L	0.088-0.906	0.478-0.989
	R^2	0.9530	0.1998
Freundlich	K_F (l/g)	2.103	0.166
	n	1.938	0.767
	1/n	0.516	1.303
	R^2	0.9964	0.9134
Temkin	b_T	78	77
	a_T	0.139	0.012
	R^2	0.8757	0.8744
Dubinin-Radushkevich	a_D	88.792	48.429
	b_D	7.301E-07	0.003
	R^2	0.8509	0.8003

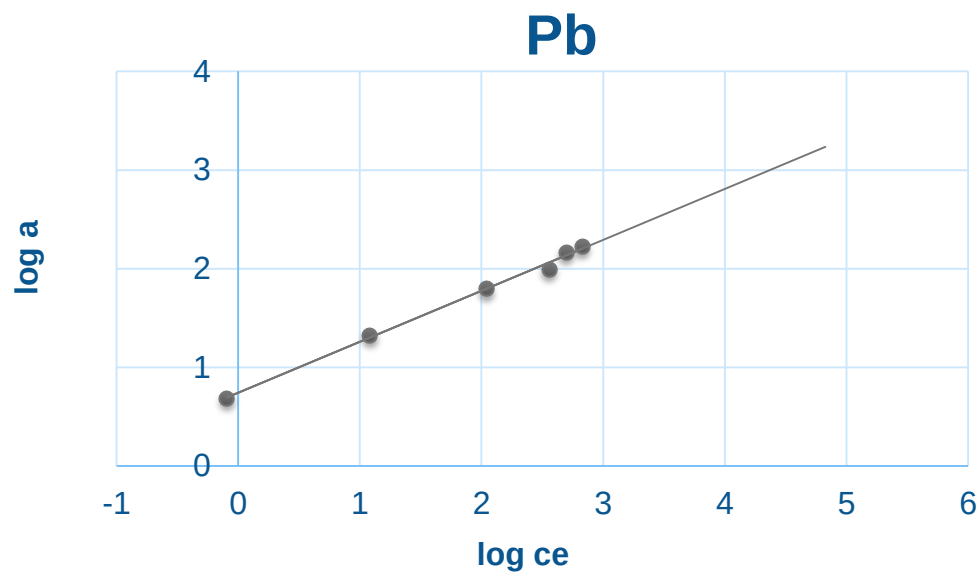
Adsorption isotherms

- **The maximum monolayer coverage capacity:**
  - **181.8 $mg.g^{-1}$ (Pb)**
  - **142.8 $mg.g^{-1}$ (Ni);**
- **The linearized isotherm can be used to interpret the type of adsorption by using the values of R as follows:**
  - **R > 1.0 – not suitable;**
  - **R = 1.0 (0 < R < 1.0) – suitable;**
  - **R = 0 – irreversible;**
- **Sorption is favourable.**

Adsorption isotherms

- K_F and n are parameters characteristic of the sorbent-sorbate system;
- Correlate sorption data – 1/n is a heterogeneity parameter (the greater the expected heterogeneity);
- Value of parameter n indicates – favorable sorption process;





Stability of an adsorbent

- Leaching of iron was observed during sorption experiments;
- The concentration of iron in solution after sorption and desorption was very low;
- The iron oxides are very strongly fixed onto the surface and that the material could be used as Pb and Ni sorbent.

Conclusions

- Magnetically modified orange peel was used to prepare a biological sorbent;
- Suitable material for sorption of metals Pb and Ni from water solution;
- Results indicate that the adsorbate formed a heterogeneous adsorbent surface;
- A better adsorption efficiency was for low concentration of Ni (60%) and Pb (90%);
- The results of this study indicated that magnetically modified orange peels can be used as low cost, eco-friendly adsorbent for Ni and Pb removal with high efficiency.

Acknowledgement

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Thank you for your attention

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