University of Maribor

Faculty of Chemistry and Chemical Engineering

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Heavy metals removal from wastewater by applying natural clay as adsorbent

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Presentation:

- Introduction (motivation)
- Heavy metals in wastewater
- Experiment
- Results
- Conclusion

INTRODUCTION

Water is a good solvent - dissolves beneficial and hazardous compounds.

Quality is decreasing - worldwide pollution, industrial pollution - different heavy metals.

Heavy metals are very long-lived and accumulate in the bodies of humans and animals.

High levels of copper damage the central nervous system.

Nickel slows down the function and operation of enzymes and hormones.
Excessive chromium content causes stomach irritation.

Adsorbents - carbon of various natural origins, zeolite, and clay

Clay is a very efficient adsorbent due to the content of exchangeable ions such as Na^{+}, Ca^{2+} and K^{+}.

Most clay minerals are negatively charged and are used for the removal of metals from wastewater. They also have a large surface area.

Heavy metals in wastewater

Heavy metals are a group of metals with the high density and are harmful to humans

Non-biodegradable and accumulate in human body

The Decree on the emission of substances and heat discharge of wastewater into water and public sewerage determines the limits of selected heavy metals.

Limit values for selected heavy metals

Heavy metal	Limit value (mg/l)	Annual limit value (g/year)
Cu	0.5	500
Ni	0.5	500
Cr	0.1	100
Hg	0.005	20
Al	3.0	3 000
Mn	1.0	1 000

Experiments

- **AIM**

effect of clay mass on removal efficiency

model solutions and from real samples

Absorbent

Natural clay – Celje, Slovenia

Analyses

Zeta potential

The value of potential above 30 V means stable colloid, and below unstable.

Particle size

dynamic light scattering.

Porosity and chemical composition

electron microscope.

A sample of clay

Adsorption efficiency

constant temperature and at atmospheric pressure

Model solutions

$\gamma\,(Cu^{2+})=\gamma\,(Ni^{2+})$=50 mg/l in $\gamma\,(Cr^{6+})$=20 mg/l.

Adsorption efficiency in dependence of clay mass

0.5 g, 1 g, 5 g, 7 g in 10 g of clay was weighted and diluted in 50 ml flask with deionised water. The solution was shake for 24 h.

Adsorption efficiency in dependence of mutual effect of ions

copper-nickel - chromium

Adsorption in wastewater samples at constant mass of clay

Sample A water from wastewater treatment plant

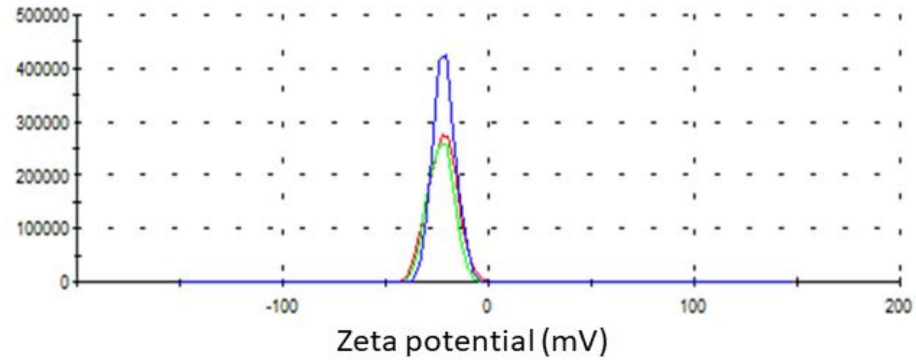
Sample B the effluent from the treatment plant.

The initial concentration were measured after 30, 60, 120, 180, and 1440 min

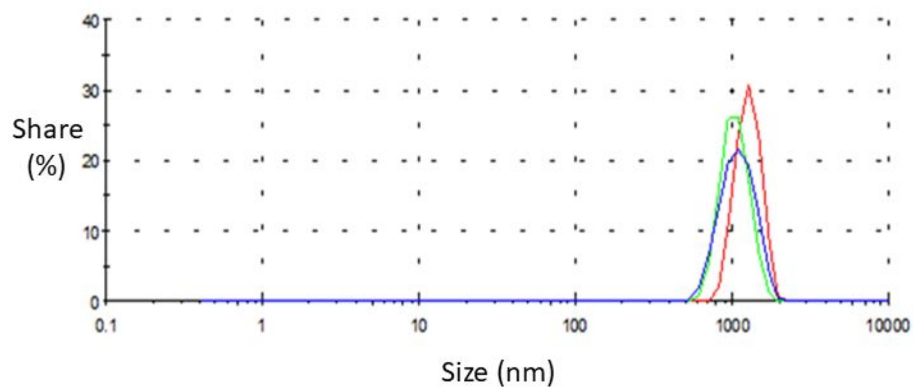
Results

- **Clay characteristics**

The value was -22,2mV. Negative value shows the high probability of attraction of positive ions.



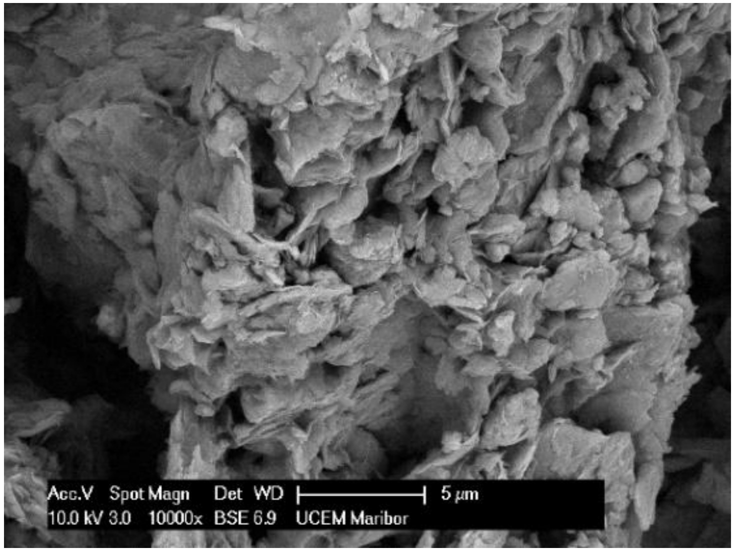
The average value was 1285 nm for clay samples.



The mas and atomic share of elements in clay

Element	Mass share (%)	Atomic share (%)
O	52.77	67.71
Mg	1.15	0.97
Al	13.87	10.55
Si	23.49	17.17
K	2.5	1.31
Fe	6.22	2.29
The Sum	100	100

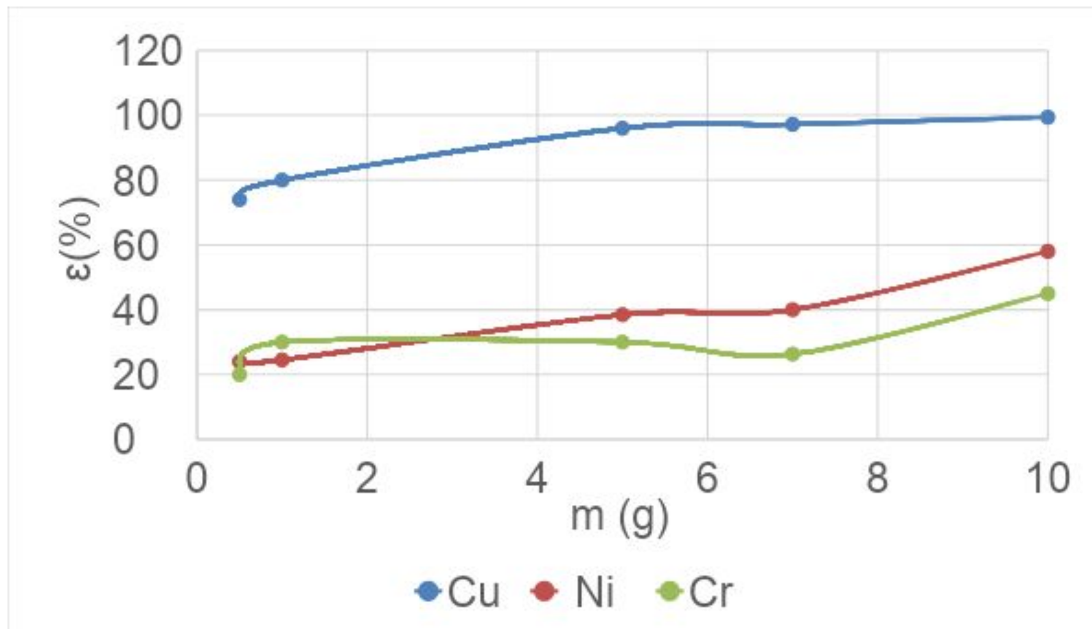
The clay is very porous material with voids between the layers



Results of adsorption efficiency

The removal efficiency improved by higher mass of clay mineral

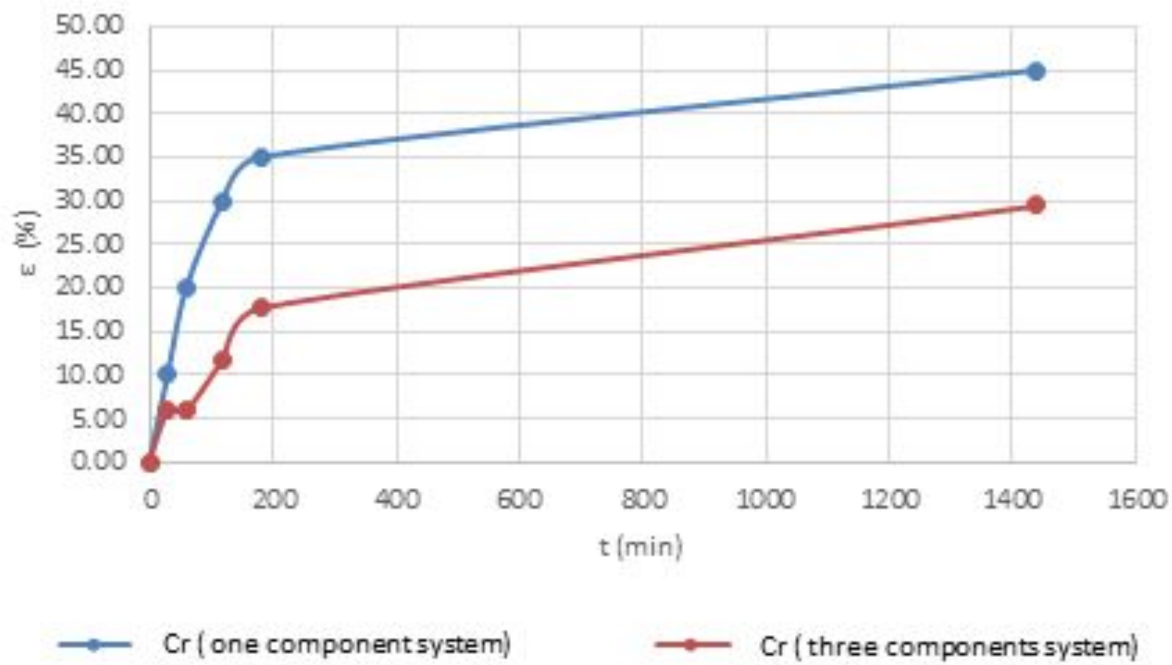
The adsorption rate is the highest in the initial minutes of contact time and then it decreases until stationary phase is reached



Efficiency of adsorbed ions in dependence of adsorbent mass

The comparison of adsorption after 24 hours between one and three component system was made

Adsorption in one component system was more efficient



The comparison of adsorption after 24 hours between one and three component system for chromium

Initial concentrations of individuals ions in samples of wastewater

	γ_0 (Cu^{2+}) (mg/L)	γ_0 (Ni^{2+}) (mg/L)	γ_0 (Cr^{6+}) (mg/L)	pH
Sample A	10	500	4	4,2
Sample B	/	0.5	0,05	8,3

The adsorption efficiency in real samples A and B

Sample A - ε (%) in pH					**Sample B - ε (%) in pH**			
t (min)	Cu^{2+}	Ni^{2+}	Cr^{6+}	pH	Cu^{2+}	Ni^{2+}	Cr^{6+}	pH
0	0	0	0	4.2	/	0	0	8.3
30	50	10	80		/	16	20	
60	70	22	80	4.1	/	20	40	8.1
120	78	24	82.5		/	24	60	
180	82	24	85		/	26	/	
1440	85	32	87.5	4	/	30	/	7.9

Conclusion

- Chemical composition -main share of oxygen, silicious and aluminium.
- SEM analysis - porous material properties.
- Negative zeta potential shows great potential for adsorption.

- The efficiency of adsorption increased with the clay adsorbent mass.
- The highest efficiency was reached with copper ions: on 10 g of clay 99.4 % . High adsorption efficiency was gained with nickel at 58 % and finally chromium ions at 45 %.
- One component system more efficient in comparison with three component system. In three component system 20 % less ions were adsorbed as in one component system, while the competition of ions for free cites in major mechanism.

- The removal from real wastewater comparable with the three-component system.
- The adsorption of chromium in sample A was 87.5 %, followed by copper at 85 % and nickel at 30 %.
- With sample B due to low copper content the concentrations were impossible to determine. Nickel adsorbed at 30 % and chromium at 60 % efficiency.

- Further investigations are going to focus on the influence of temperature, pH, and pressure on adsorption of heavy metal ions.

Questions?

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Maribor city

Thank you !