ISINN-29

Application of the yeast *Saccharomyces cerevisiae* for the removal of heavy metals from industrial wastewater

Yushin N., Zinicovscaia I.

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Relevance of the work

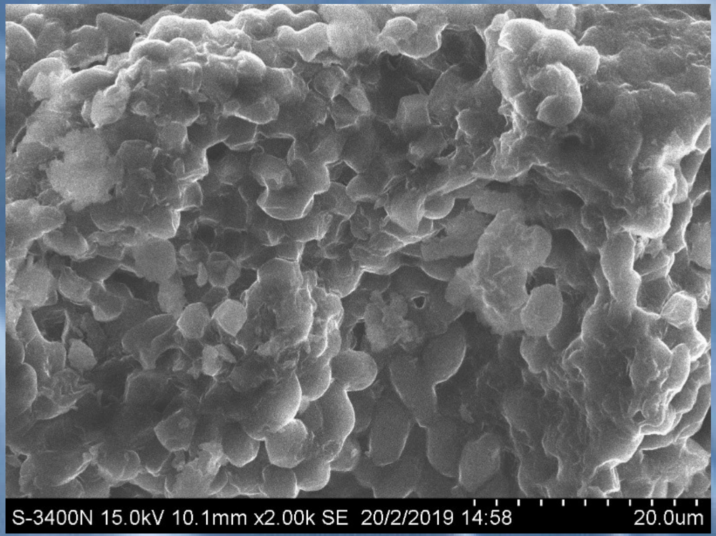
Traditional industrial wastewater treatment methods

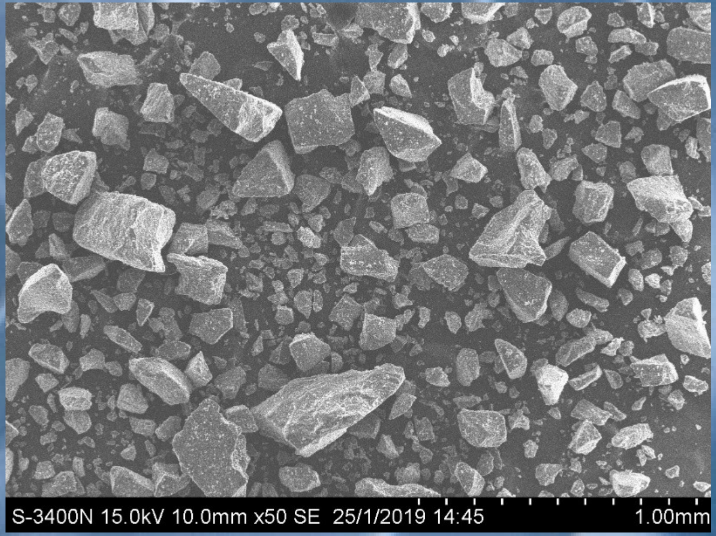
- Mechanical
  Settling, filtration
- Chemical methods
  Complexation, precipitation
- Physical and chemical methods
  Coagulation, extraction, sorption, distillation
- Biochemical methods
  Aeration tanks, filtration fields, biofilters, biological ponds

Limitations

- High cost
- Difficulty in operation
- Exposure to toxic substances

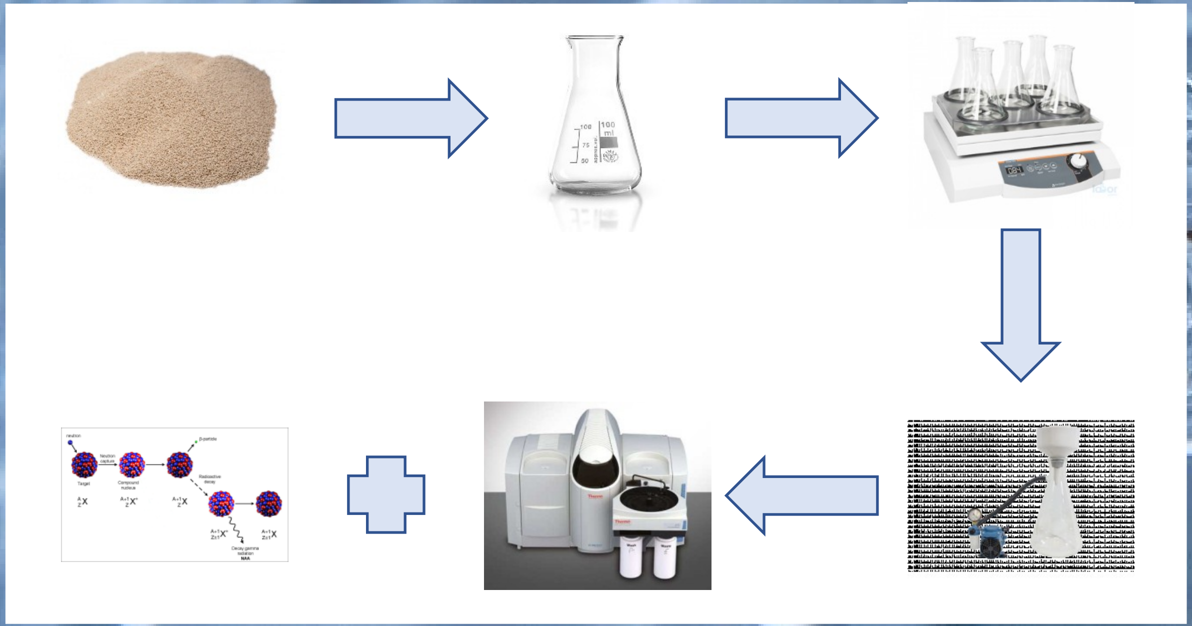
Saccharomyces cerevisiae





Batch experiments

Ni (10 mg/L)
Ni (10 mg /L)-Cr (5 mg/L)-Fe (5 mg /L)
Ni (10 mg /L)-Sr (5 mg /L)-Cu (1 mg /L)-Zn (2 mg /L)
Ni (10 mg /L)-Zn (2 mg /L)-Mo (0.5 mg /L)-Cu (5 mg /L)



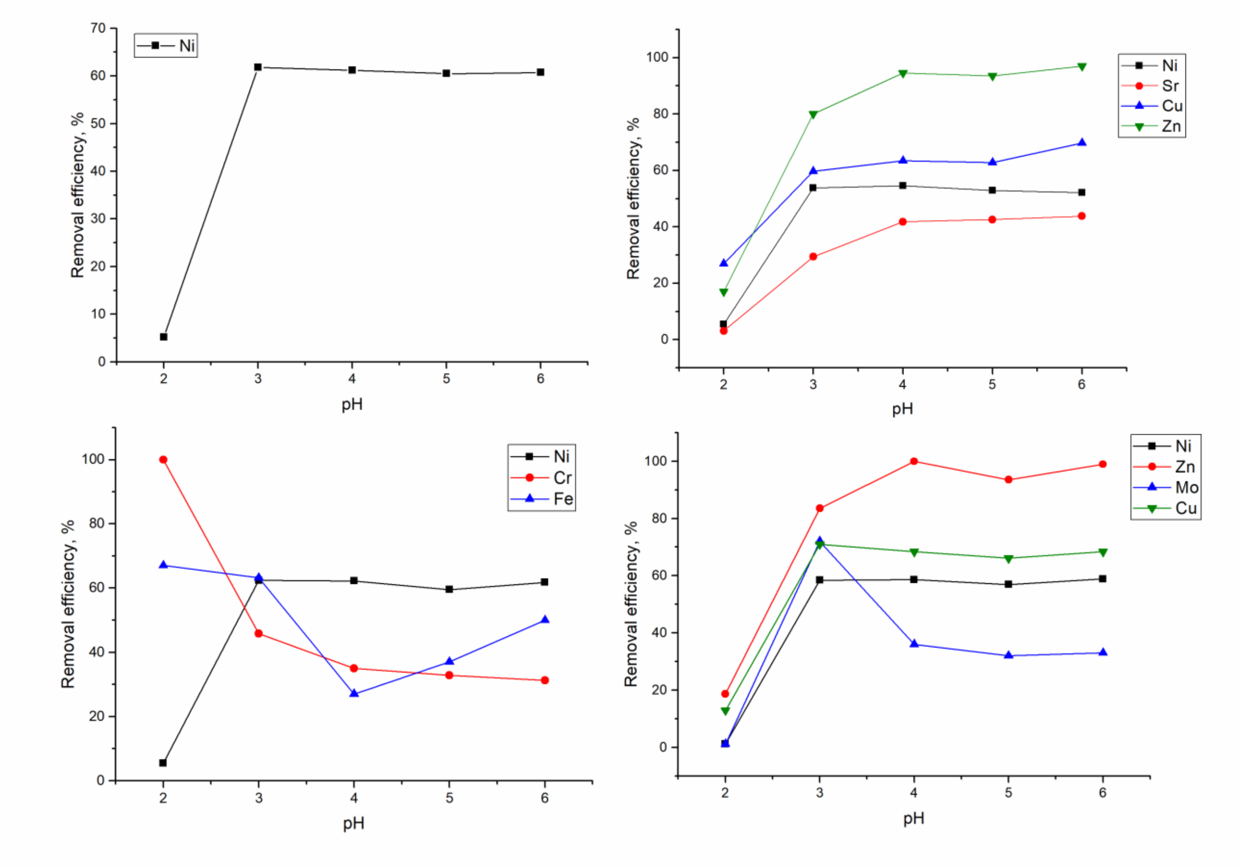
Scheme of the experimental design

Energies used to determine the elements by NAA

Element	Isotope	Energy of γ-line, keV
Ni	^{58}Co	810.57
Cr	^{51}Cr	320
Fe	^{59}Fe	1099.25
Sr	^{85}Sr	514
Mo	^{99}Mo	140.5
Zn	^{65}Zn	1115.54

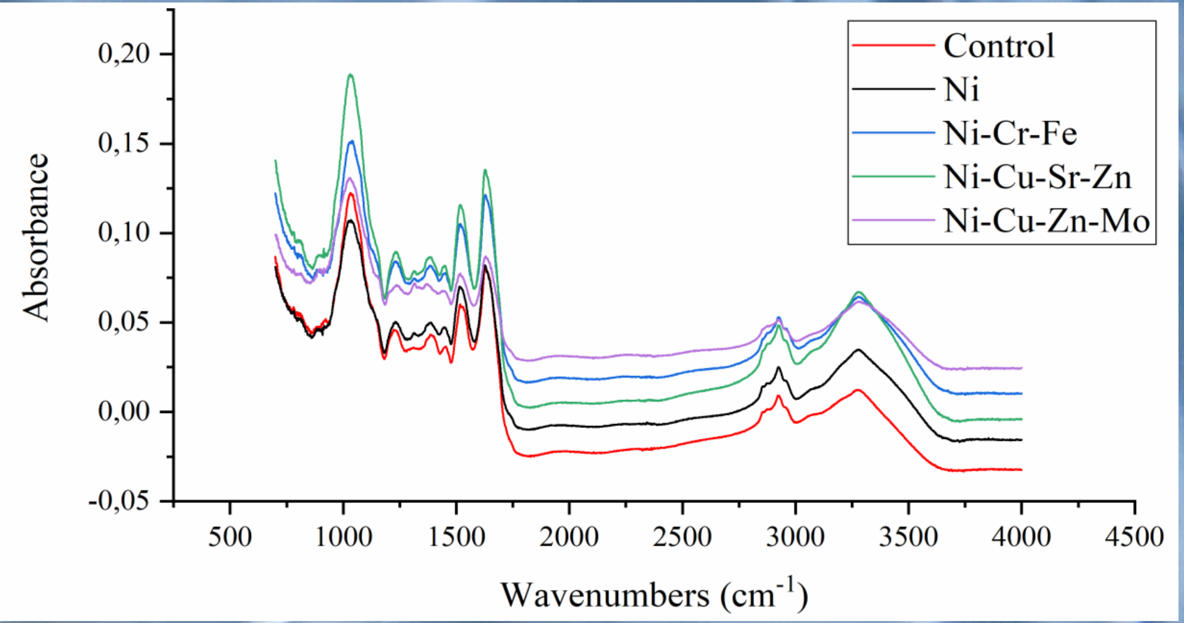
GFAAS — iCE 3400 Thermo Scientific
HRICP-MS — Element 2 Thermo Scientific

Batch experiments



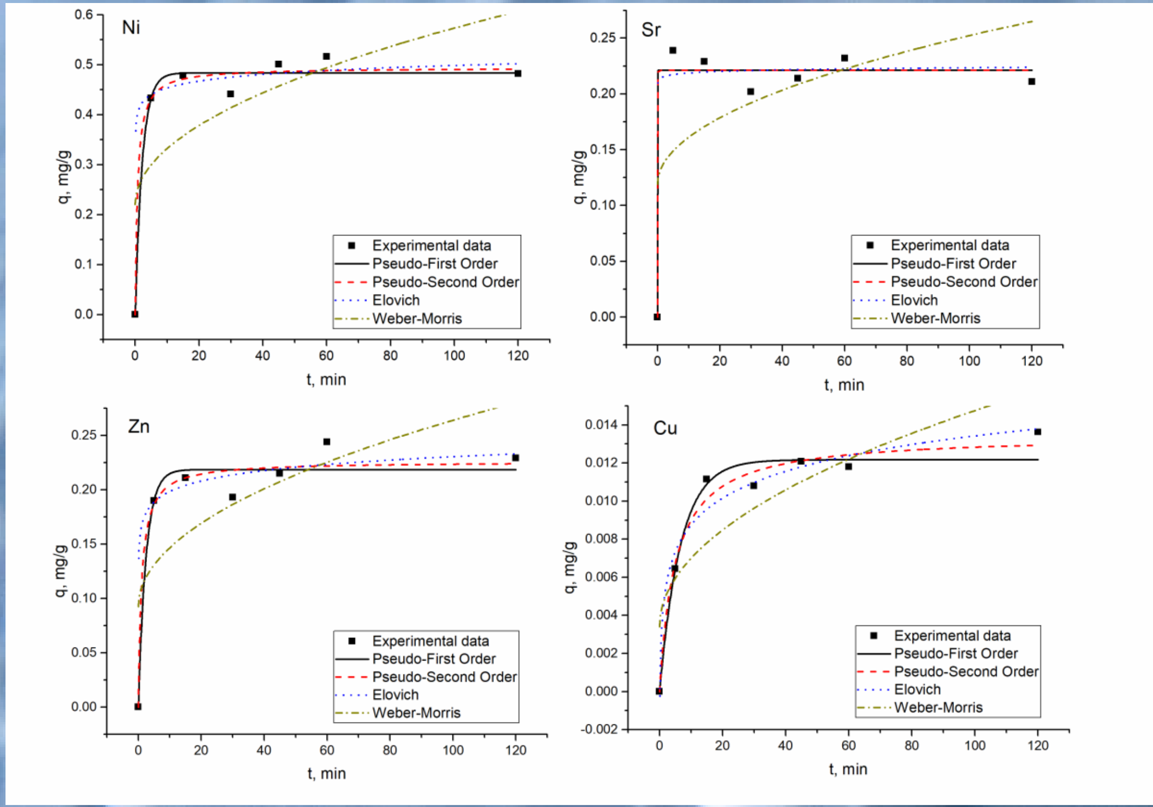
Removal of metal ions at different initial pH

OH, CH=CH, C=O and HN = O groups participated in metal binding



FTIR-spectra of *S. cerevisiae* biomass

Kinetics of sorption

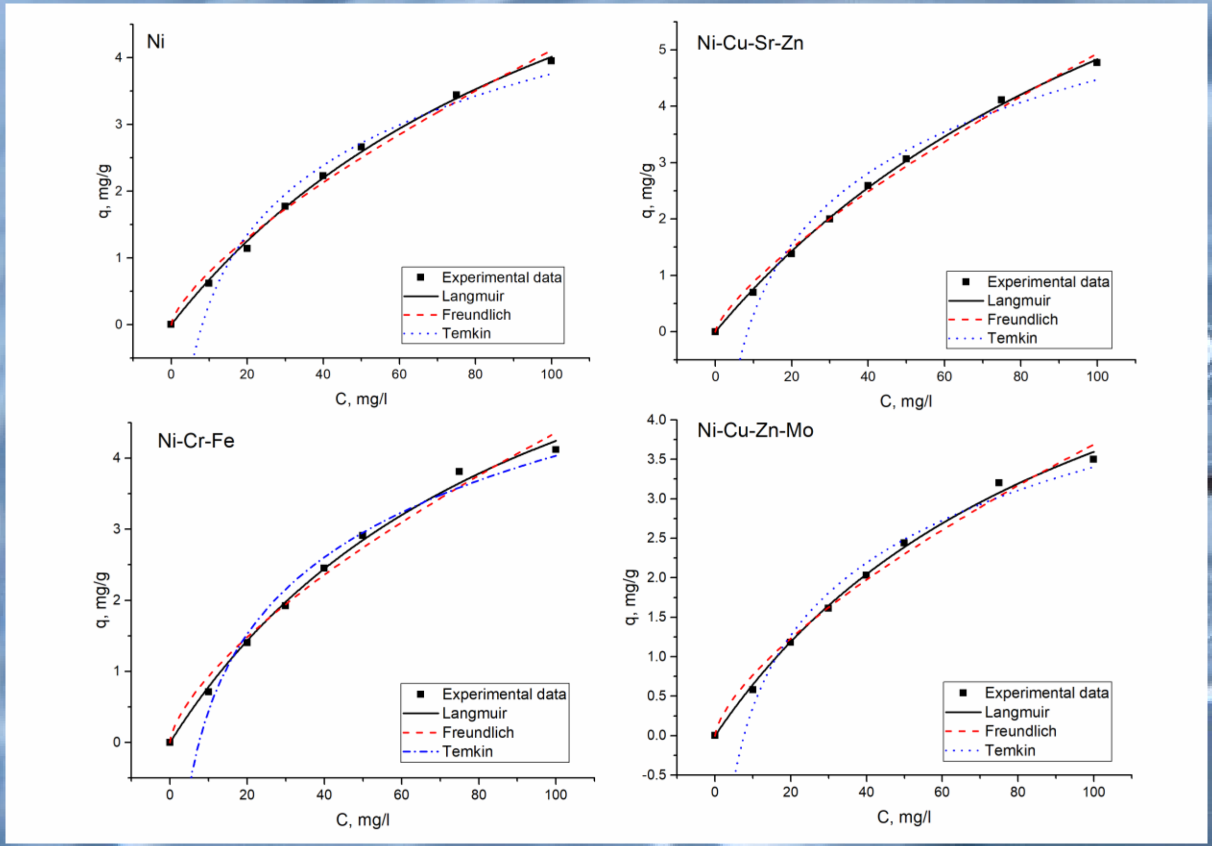


Kinetics of the metal adsorption using *S. cerevisiae* in Ni(II)–Sr(II)–Zn(II)–Cu(II).

The constants and determination coefficients (R^2) of the kinetic models

			Model											
			PFO			PSO			EM			IPM		
	Metal	q_{exp}, mg/g	q_e, mg/g	k_1, min^{-1}	R^2	q_e, mg/g	k_2, g/mg·min	R^2	α, mg/g·min	β, g/min	R^2	k_{diff}	C_i	R^2
Ni(II)	Ni	0.52	0.51	0.89	**0.98**	0.51	2.3	**0.98**	n.a.	n.a.	n.a.	0.03	0.3	0.21
Ni(II)-Cr(VI)-Fe(III)	Ni	0.52	0.51	0.64	**0.99**	0.51	6.4	**0.99**	n.a.	n.a.	n.a.	0.03	0.3	0.34
	Cr	0.22	0.22	0.05	0.93	0.26	0.28	0.97	0.05	20.4	**0.99**	0.03	0.03	0.91
	Fe	-	0.07	29.2	0.36	0.07	3.7	0.37	0.2	90.7	0.46	0.008	0.02	0.5
Ni(II)-Zn(II)-Sr(II)-Cu(II)	Ni	0.5	0.48	0.45	**0.98**	0.49	2.8	**0.98**	n.a.	n.a.	n.a.	0.03	0.2	0.38
	Zn	0.22	0.23	0.4	0.96	0.22	4.2	0.96	216	72	**0.97**	0.02	0.09	0.48
	Sr	0.22	0.22	45.4	0.97	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.02	0.1	0.19
	Cu	0.01	0.01	0.15	0.96	0.01	1.5	**0.98**	n.a.	n.a.	n.a.	0.001	0.003	0.7

Isotherm studies

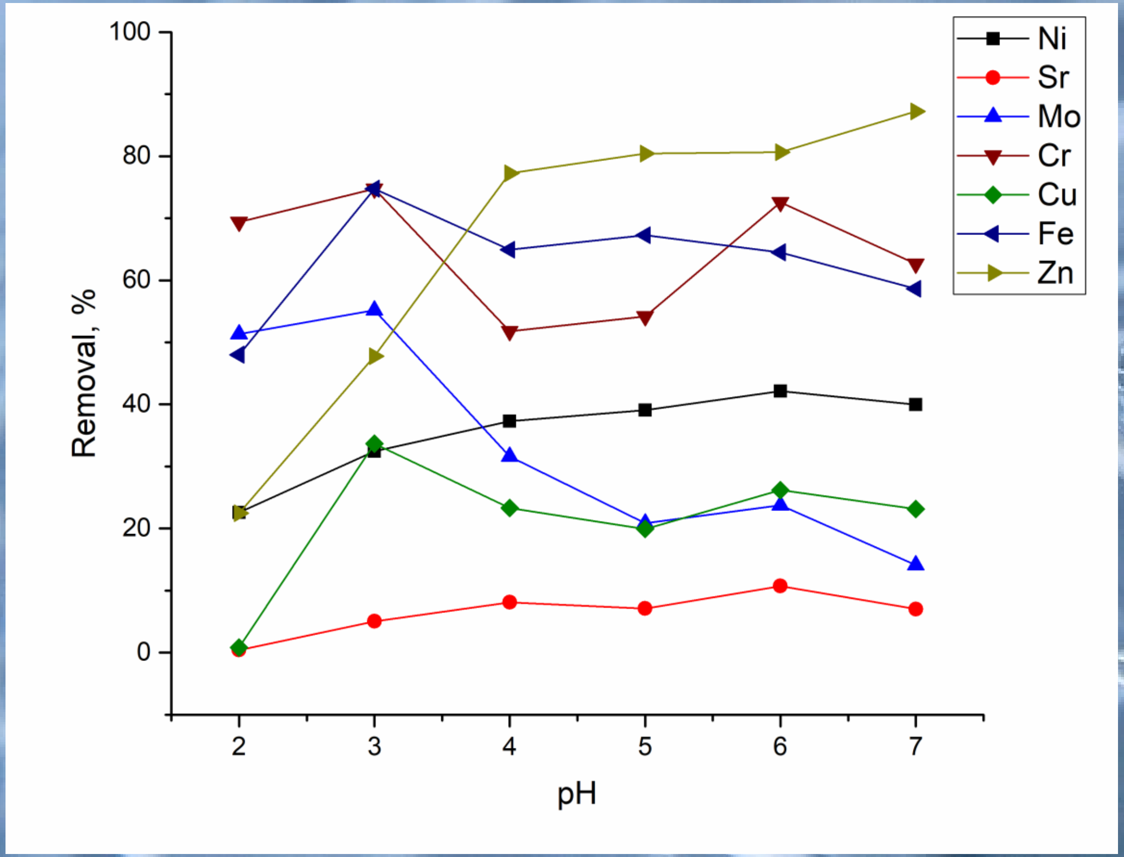


The adsorption isotherms

The constants and correlation coefficients, R^2 of the adsorption isotherms

Model	Parameters	System			
		Ni(II)	Ni(II)-Cr(VI)-Fe(III)	Ni(II)-Zn(II)-Sr(II)-Cu(II)	Ni(II)-Zn(II)-Cu(II)-Mo(VI)
Langmiur	q_{m}, mg/g	8.9	8.3	11.9	7.3
	b, L/mg	0.008	0.01	0.007	0.01
	R^2	0.99	0.99	0.99	0.99
Freundlich	K_F, mg/g	0.15	0.2	0.15	0.16
	1/n	0.71	0.67	0.77	0.67
	R^2	0.988	0.98	0.99	0.99
Temkin	a_T, L/g	0.12	0.13	0.12	0.13
	B, J/mol	13.5	13	11.2	15
	R^2	0.98	0.98	0.97	0.98

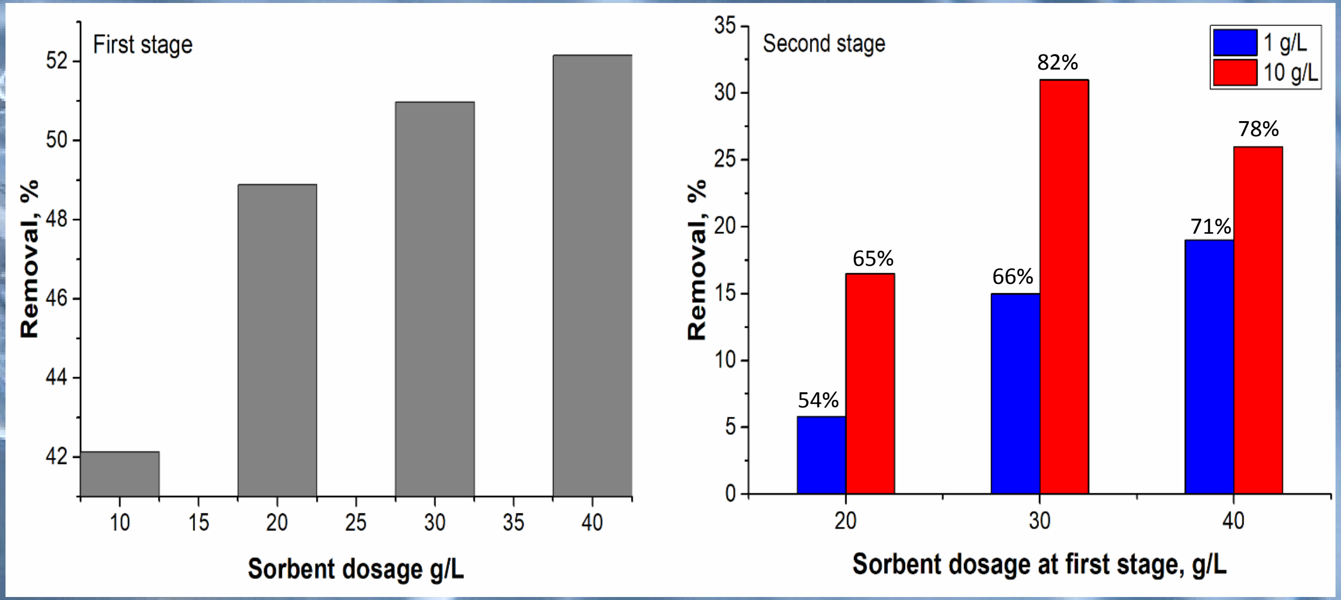
Wastewater treatment



Efficiency of removal of metal ions from wastewater at different pH

Chemical composition of the effluent

Element	Sr	Mo	Cr	Ni	Cu	Zn	Fe	pH
Concentration, mg/l	0.31	0.002	0.005	143.1	0.03	0.5	0.69	7.0



Efficiency of removal of Ni ions from wastewater at different sorbent dosage

Conclusions

- The process of metal removal showed to be pH dependent, maximum Ni(II) removal from synthetic and real effluent was achieved at pH 6.0.
- The OH, CH=CH, C=O and HN = O groups were mainly involved in metal ion binding.
- Biosorption equilibrium data fit well the Langmuir and Freundlich models
- Kinetic studies reveal that nickel biosorption by *Saccharomyces cerevisiae* could be described more favourably by the pseudo-first and pseudo-second-order kinetic models.
- Application of two-stage process with 30 g/L of biomass on the first stage and 10 g/L of biomass on the second stage allowed to remove up to 82% of Ni(II) ions from industrial effluent.
- *Saccharomyces cerevisiae* can be considered as cheap and efficient sorbent for complex effluents treatment and especially Ni(II) ion removal.


Thank you for your attention!