SORPTION OF Cu(II), Fe(II), Zn(II), AND Mn(II) FROM AQUEOUS MEDIUM USING LETTUCE ROOTS AND SUGARCANE BAGASSE

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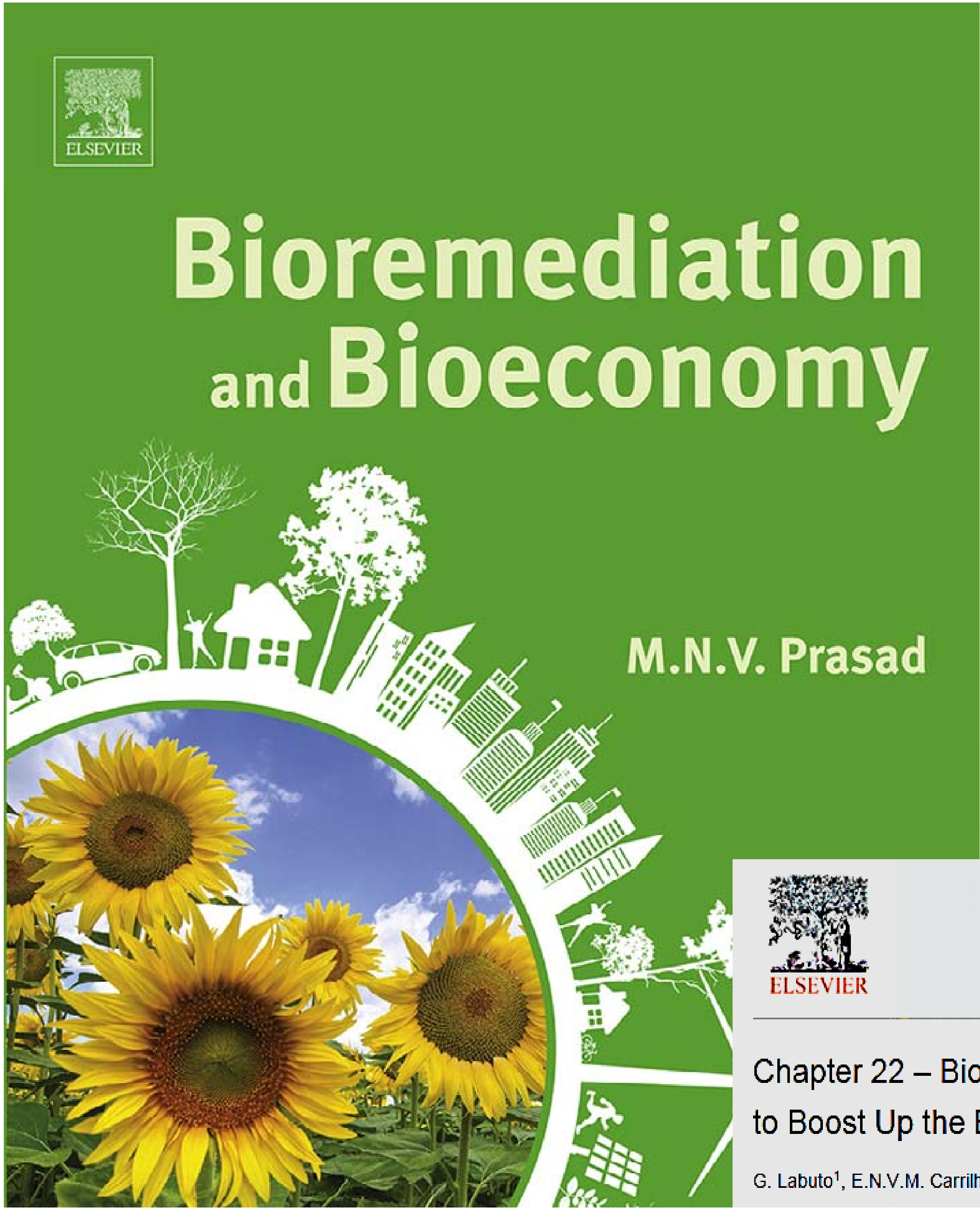
Toxic metals are cumulative, not naturally degraded, either biologically or chemically, and require special treatment as they are harmful to living organisms.



A VERY IMPORTANT FIELD

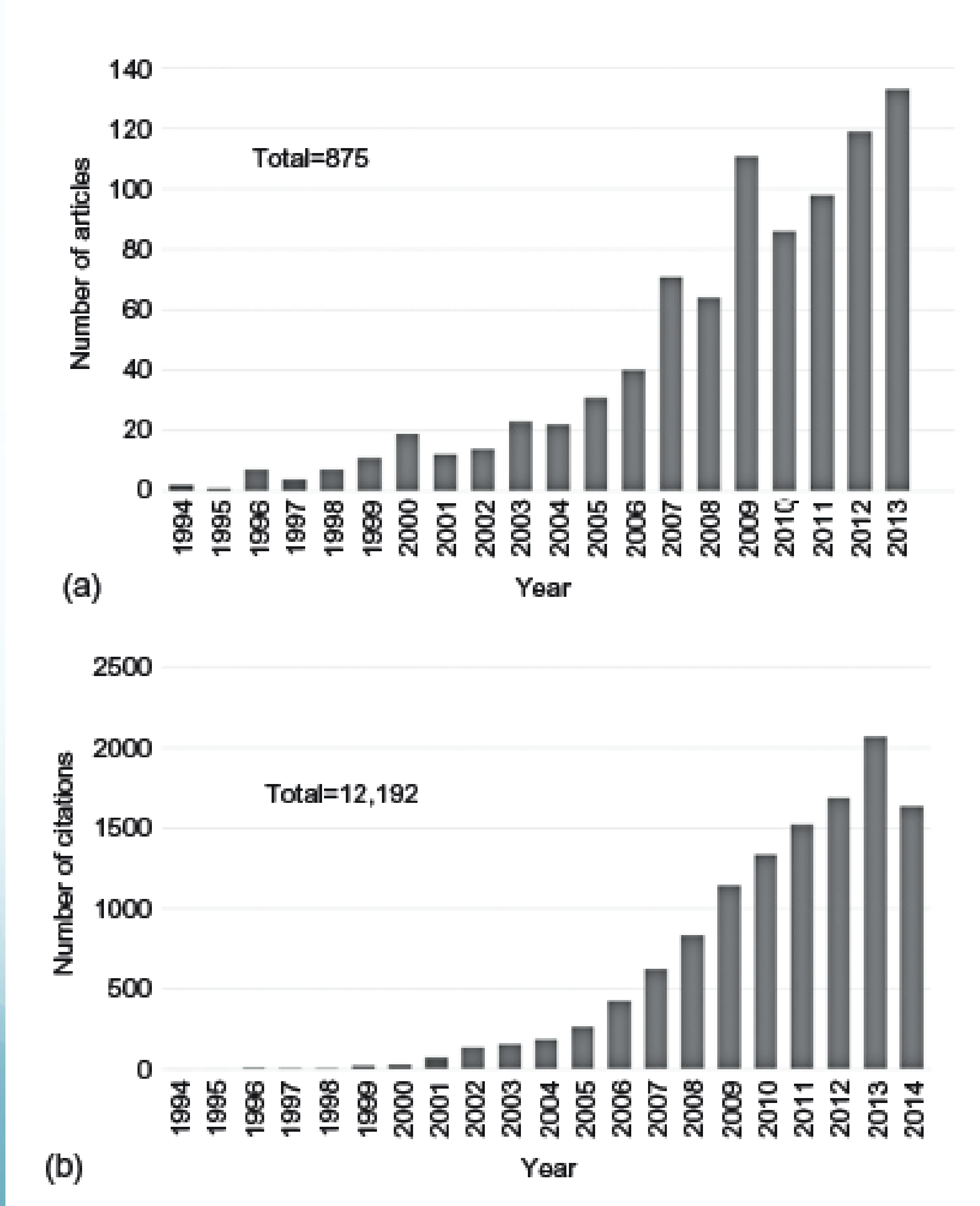
Bioremediation and Bioeconomy

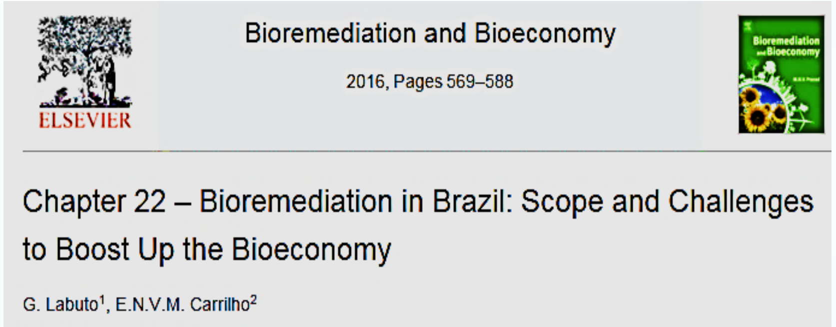
2016, Pages 569–588

Chapter 22 – Bioremediation in Brazil: Scope and Challenges to Boost Up the Bioeconomy

G. Labuto[1], E.N.V.M. Carrilho[2]

RESEARCH ON THE USE OF BIOMASS




ELSEVIER

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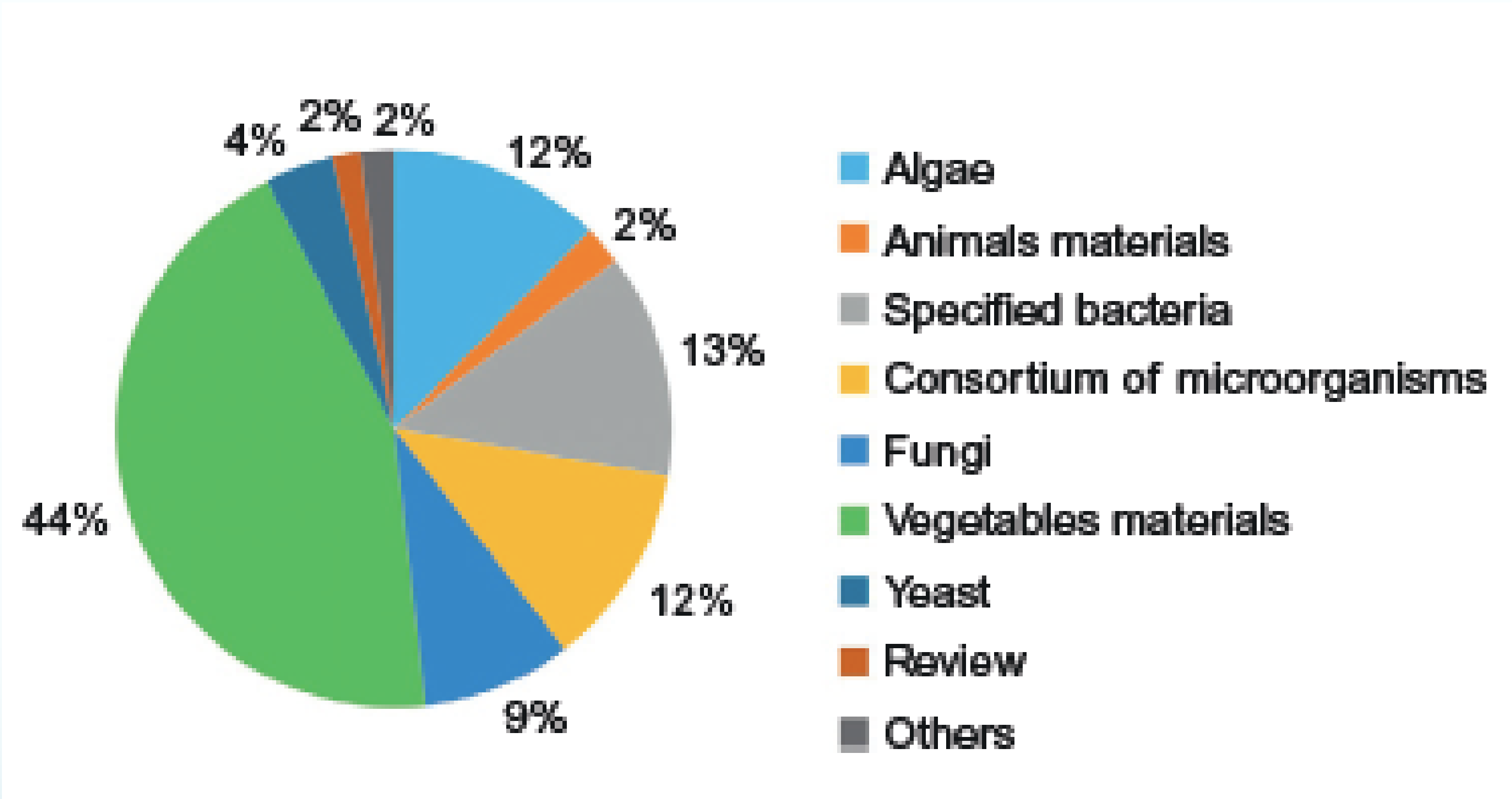
(a) Number of articles published by Brazilian scientists;

(a) Number of citations on articles published by Brazilians over the last 20 years.

Keywords searched: Brazil, biosorption, phytoremediation, and bioremediation.

Source: Web of Science and Scopus websites in 11/30/2014.

Biomasses used as biosorbents in articles published by Brazilians between 1994 and 2014



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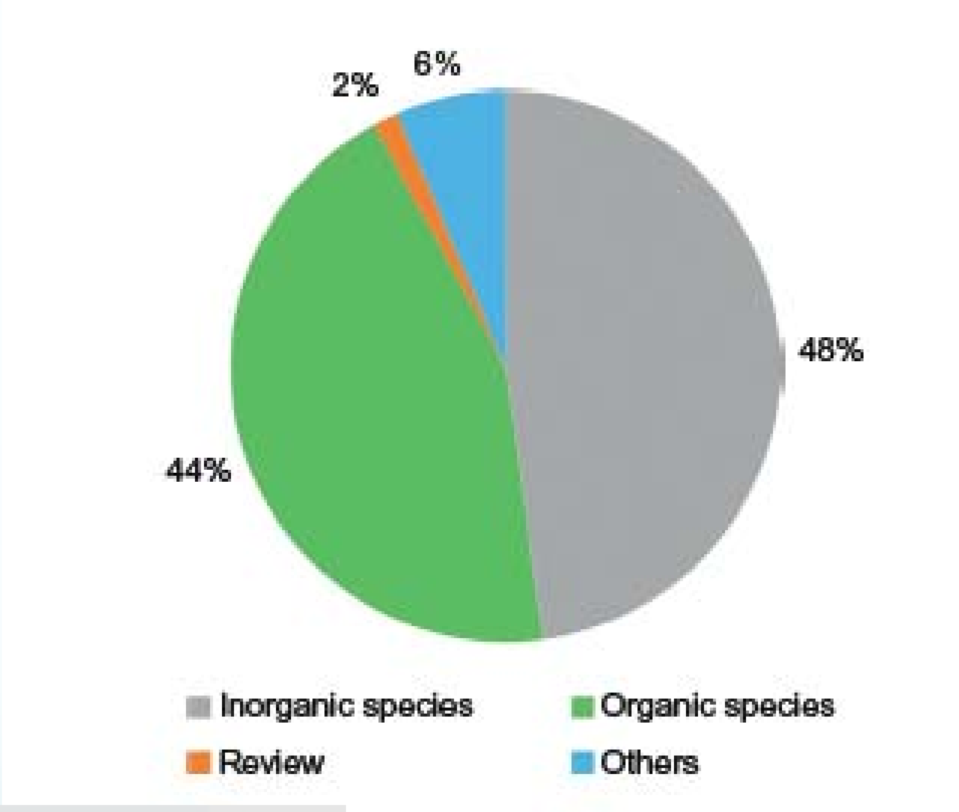
Contaminants or analytes of interest in biosorption studies published by Brazilians between 1994 and 2014

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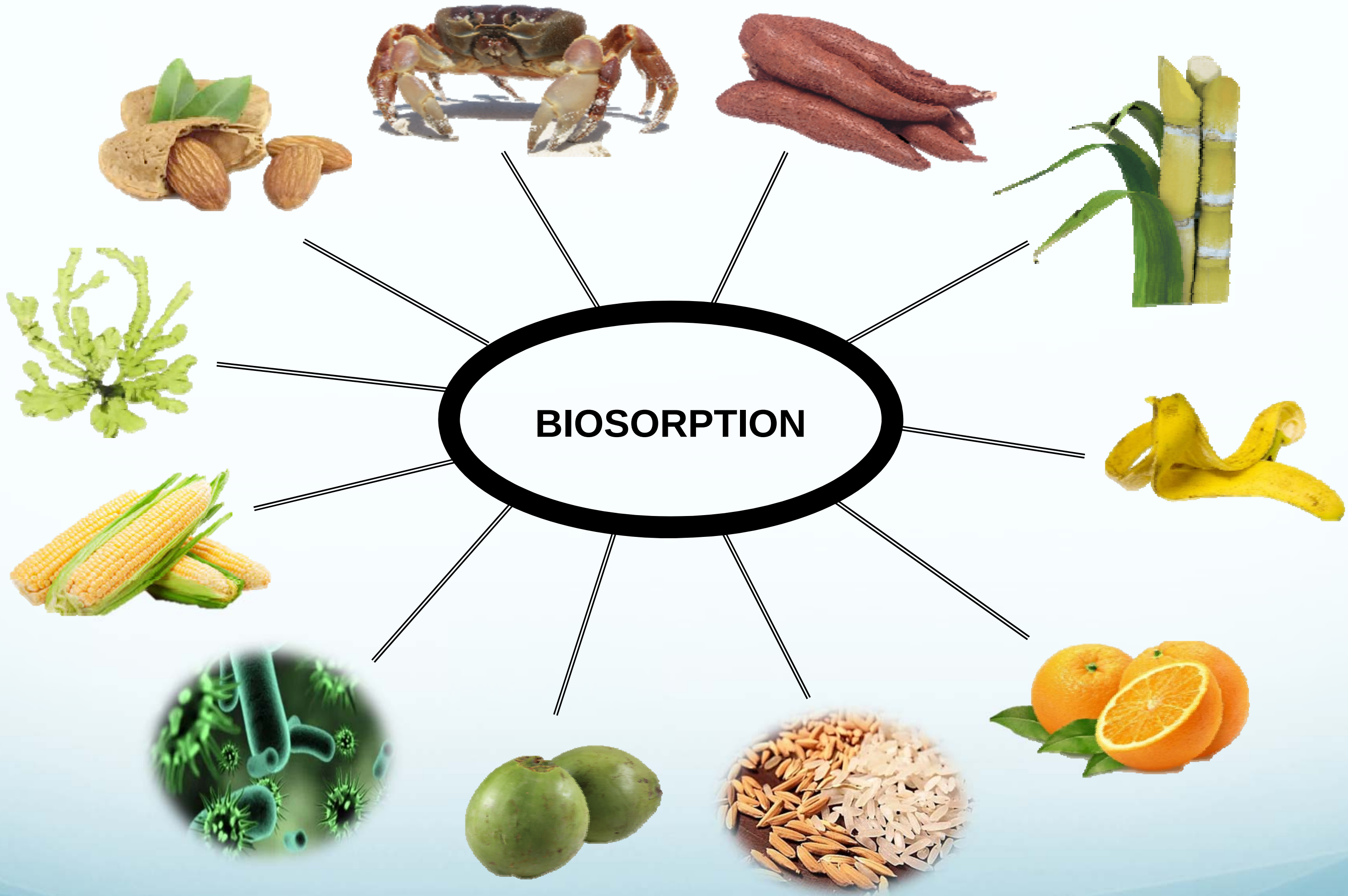
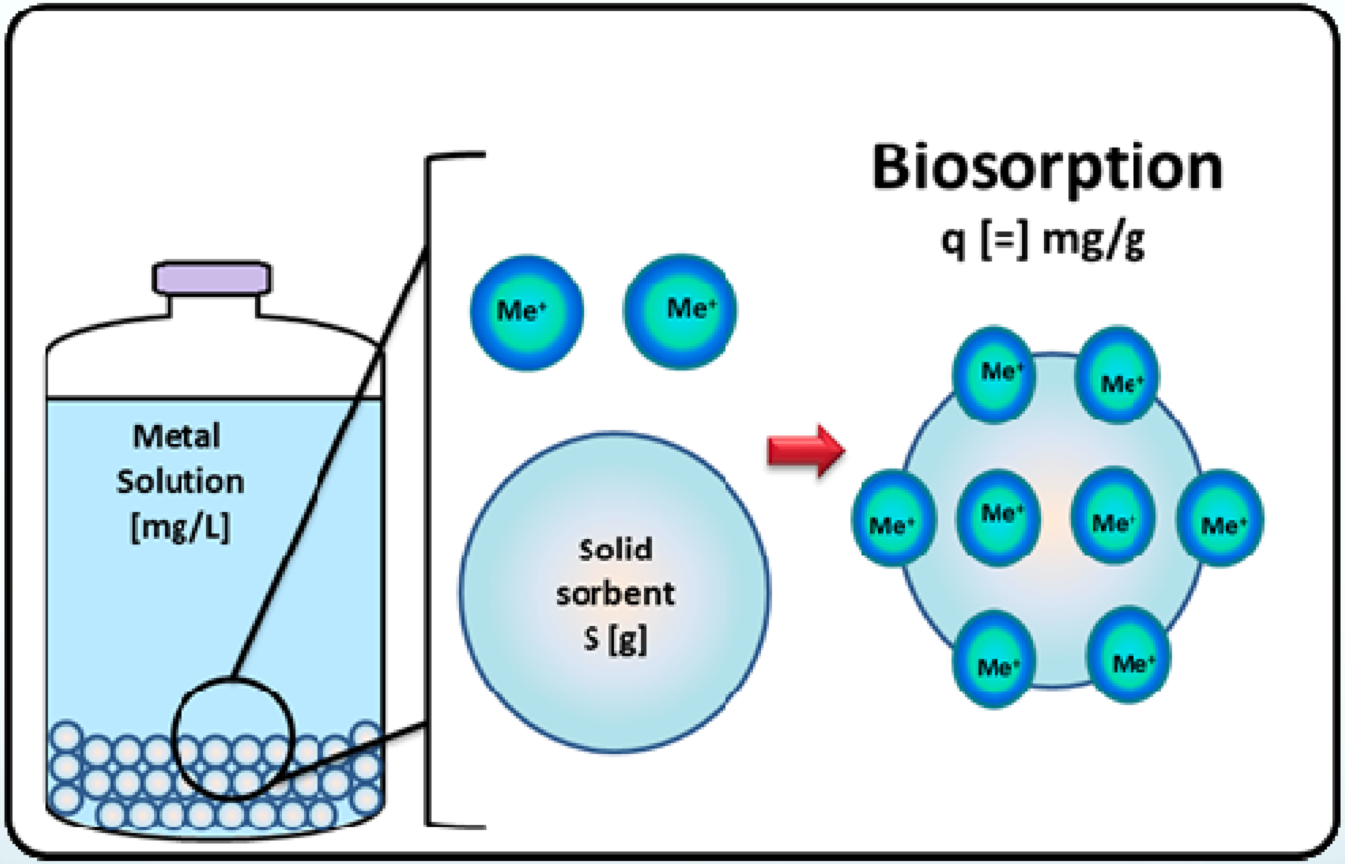
CHOICES OF BIOSORBENTS



METAL BIOSORPTION MECHANISM



Efficient option to remove metals from aqueous medium.

LETTUCE

1.27 million tons/year in 2012/13

SUGARCANE

685 millions of tons 2016/17

Assessment of biomasses in the sorption of Cu(II), Fe(II), Mn(II) and Zn(II) from multielement solution and lake water.

THE UNIVERSITY FARM – SUGARCANE CROP

THE UNIVERSITY FARM – HYDROPONIC LETTUCE

BIOMASSES USED

Sugarcane Bagasse

Lettuce Roots

Cleaning with purified H_2O

Drying at 50 ^{o}C

Ground to 0.5 mm to 1 mm

1.5 g of biomass

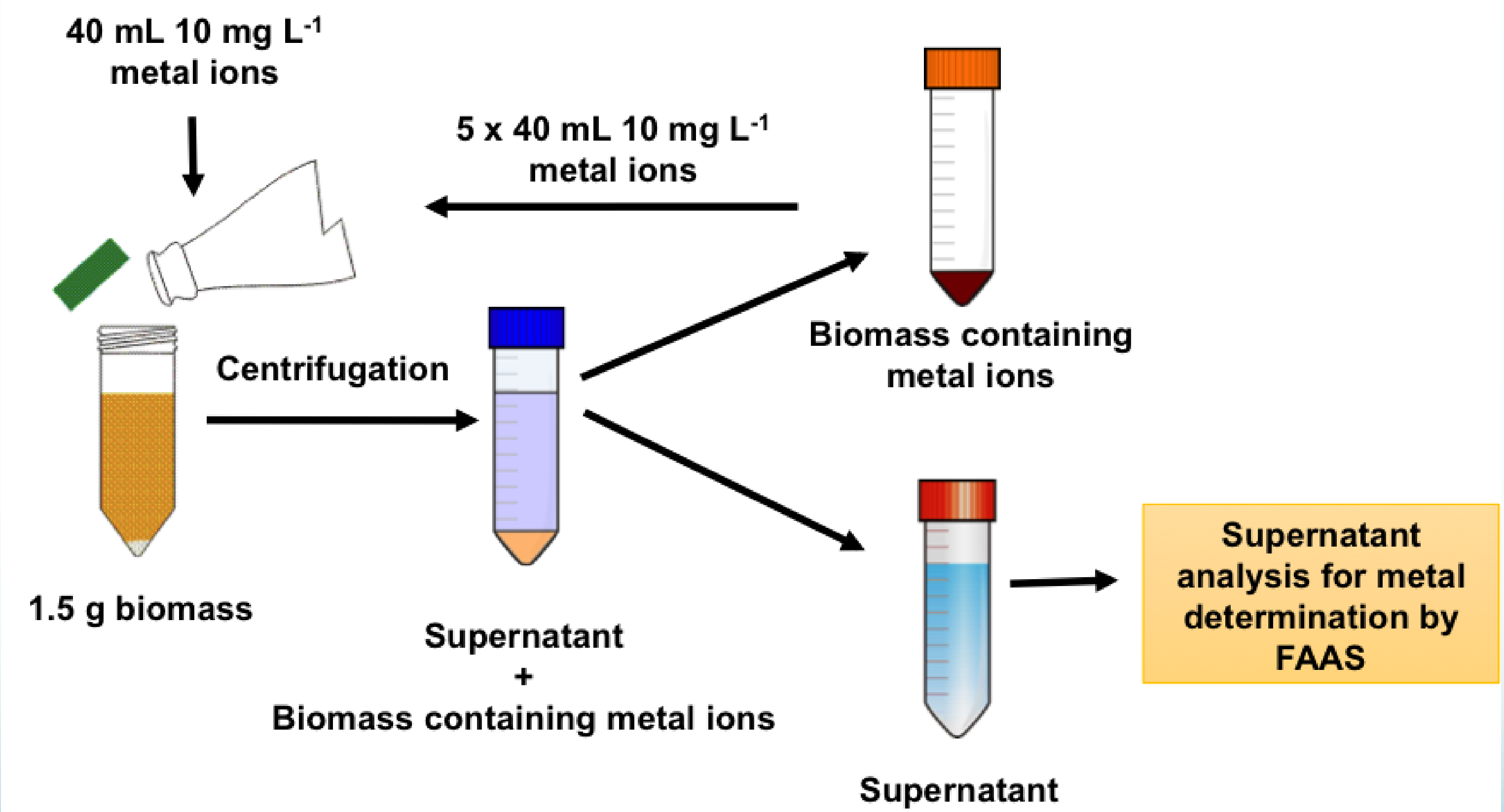
Leaching with HNO_3 1 mol/L

Conditioned with solution KCH_3COO/CH_3COOH 0.005 mol/L at pH 5.5

BIOMASS LEACHING WITH HNO_3

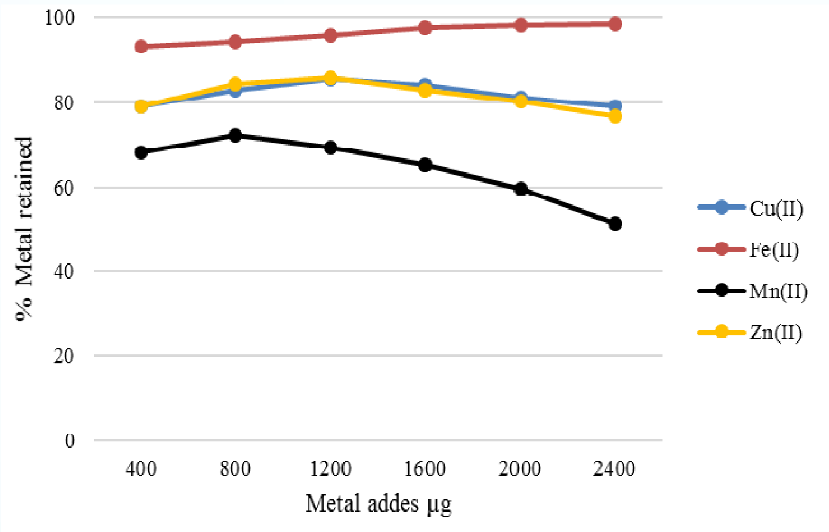
Element	Elements Contents of the Biomasses (mg/g ± SD)			
	NRL	MRL	NSB	MSB
Na	0.45 ± 0.02	0.04 ± 0.01	0.06 ± 0.01	0.04 ± 0.00
Ca	19.99 ± 0.83	0.03 ± 0.01	0.21 ± 0.04	0.002 ± 0.001
Mg	1.91 ± 0.04	0.16 ± 0.00	0.12 ± 0.01	0.004 ± 0.002
P	3.52 ± 0.13	0.81 ± 0.02	0.06 ± 0.01	0.05 ± 0.002
K	0.23 ± 0.01	0.006 ± 0.001	0.04 ± 0.01	0.003 ± 0.001
S	6.58 ± 0.11	5.94 ± 0.22	0.64 ± 0.14	0.58 ± 0.04
Cu	25.68 ± 0.74	0.97 ± 0.02	0.76 ± 0.08	0.15 ± 0.04
Fe	106.74 ± 1.20	115.92 ± 2.44	130.89 ± 3.47	105.53 ± 0.71
Mn	99.94 ± 0.58	0.003 ± 0.001	6.69 ± 0.25	0.05 ± 0.01
Zn	396.15 ± 4.37	3.06 ± 0.49	8.71 ± 0.97	1.56 ± 0.12

SORPTION BATCH PROCEDURE OF Cu(II), Fe(II), Zn(II), AND Mn(II) BY *in natura* AND MODIFIED BIOMASS

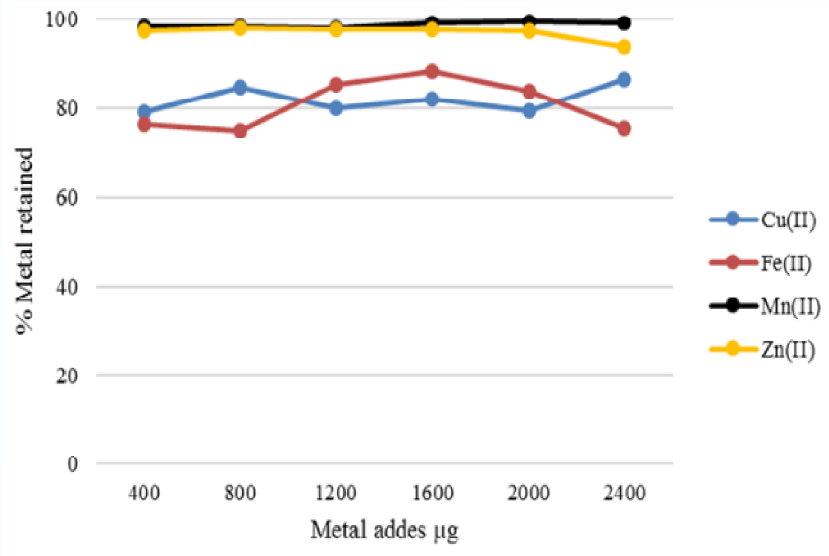


EFFECT OF BIOMASS MODIFICATION

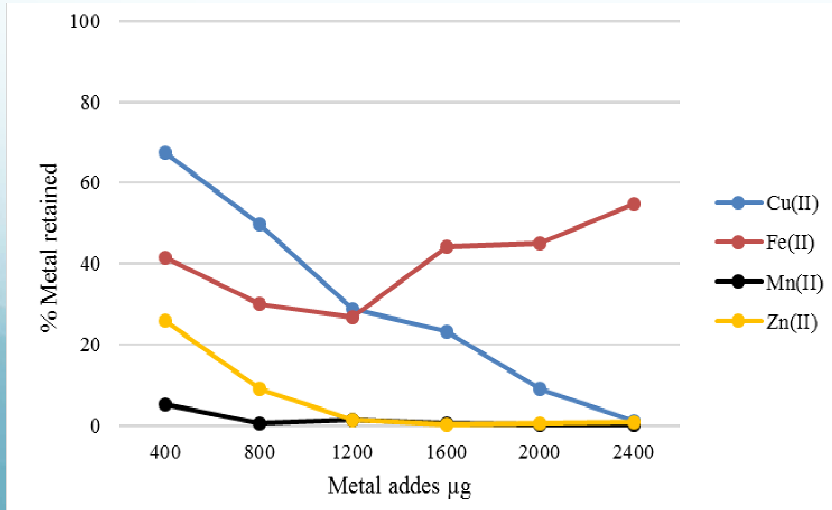
in natura **lettuce roots**



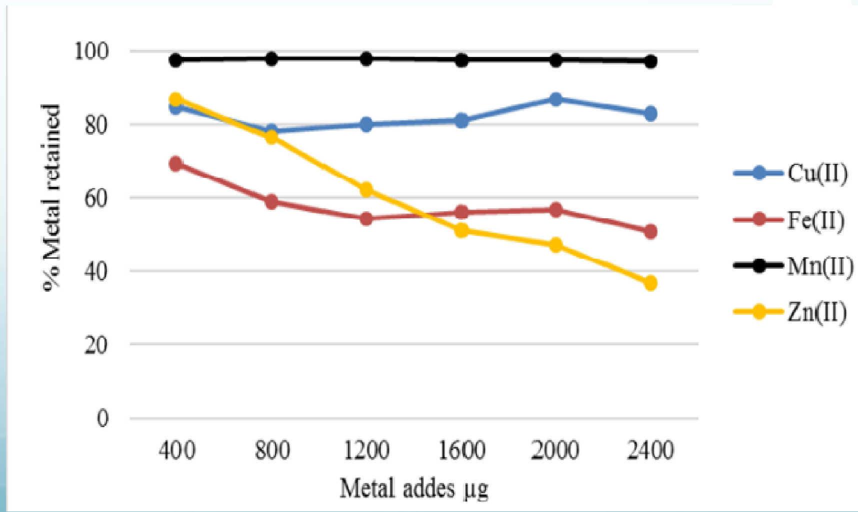
modified lettuce roots



in natura **sugarcane bagasse**



modified sugarcane bagasse



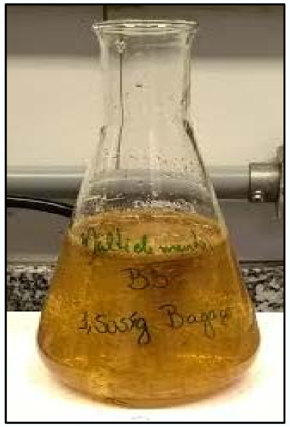
Error analysis and competitive Langmuir calculated sorption isotherm for Cu(II), Fe(II), Zn(II), and Mn(II)

Parameters	NSB				MSB			
	Cu(II)	Fe(II)	Mn(II)	Zn(II)	Cu(II)	Fe(II)	Mn(II)	Zn(II)
q_{max}(mg/g)	0.92	3.94	0.03	0.18	54.11	6.52	16.7	1.26
b (L/mg)	0.1414	0.02	0.16	0.3271	0.0022	0.009	0.075	0.153
χ^2	*0.0024*	*0.400*	*0.0001*	*0.0002*	*0.0100*	*0.0030*	*0.0200*	*0.0090*
$r^{2(*)}$	0.9964	0.1485	0.9999	0.9987	0.9895	0.9982	0.9973	0.9921
	NLR				MLR			
	Cu(II)	Fe(II)	Mn(II)	Zn(II)	Cu(II)	Fe(II)	Mn(II)	Zn(II)
q_{max}(mg/g)	35.86	31.42	3.33	24.07	25.36	27.95	14.06	6.43
b (L/mg)	0.0194	0.0801	0.1111	0.0063	0.0047	0.0041	0.1390	0.2060
χ^2	*0.60*	*1.37*	*0.65*	*0.03*	*0.01*	*0.06*	*0.15*	*0.03*
$r^{2(*)}$	0.9323	0.0242	0.9737	0.9953	0.9959	0.9789	0.9354	0.9998

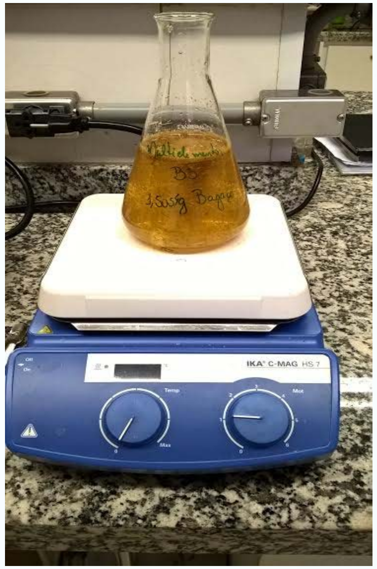
(*) corresponds to the linear fitting by plotting $q_{exp} \times q_{calc}$ obtained from the model adjustment.

KINETIC STUDIES

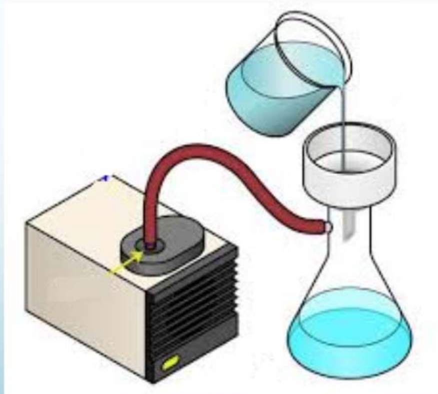
1.5g de biomass



500 mL de Multielement solution



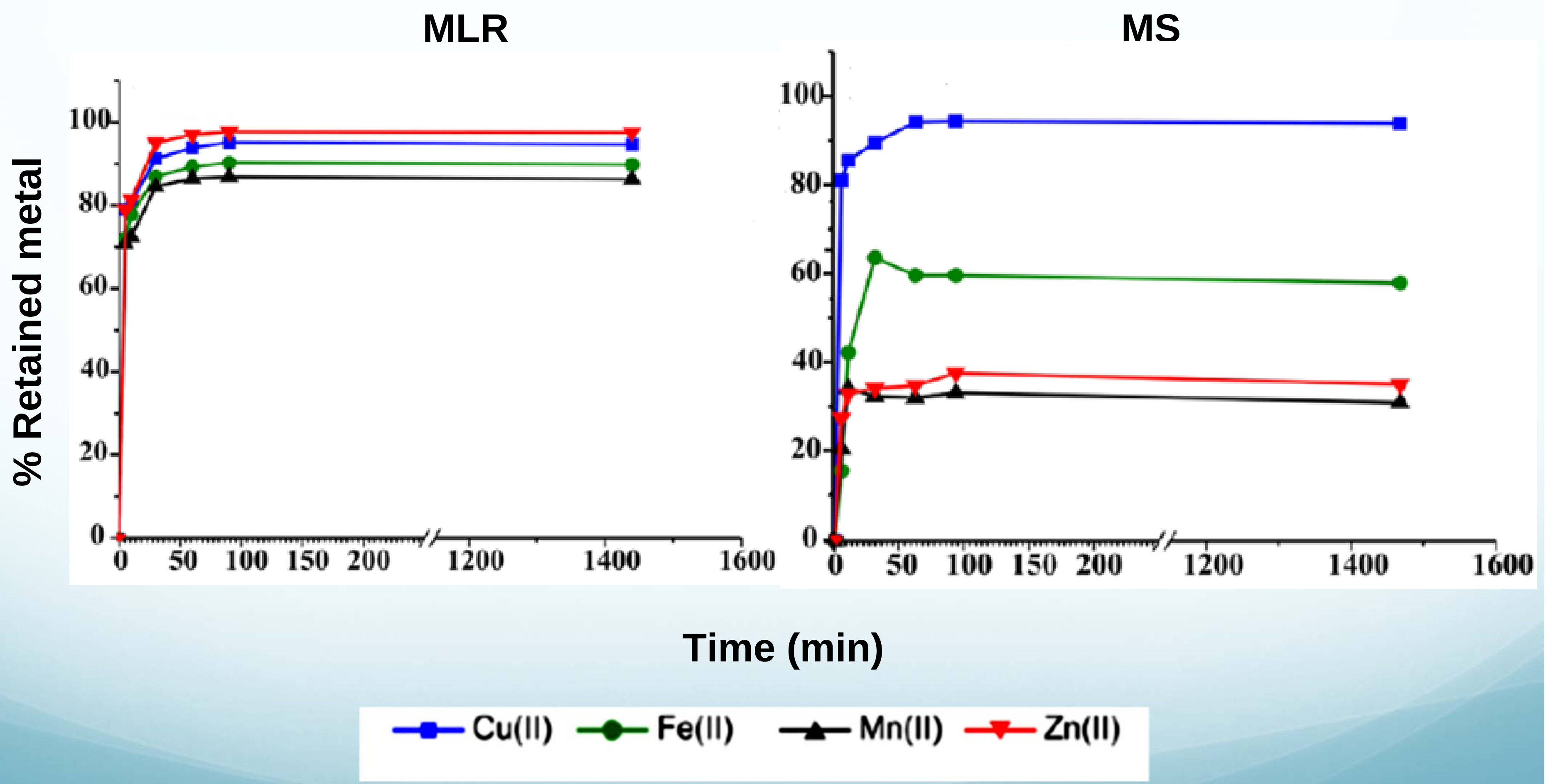
20 mL aliquots at 5, 10, 30, 60, 90, and 1440 min



Vacuum filter

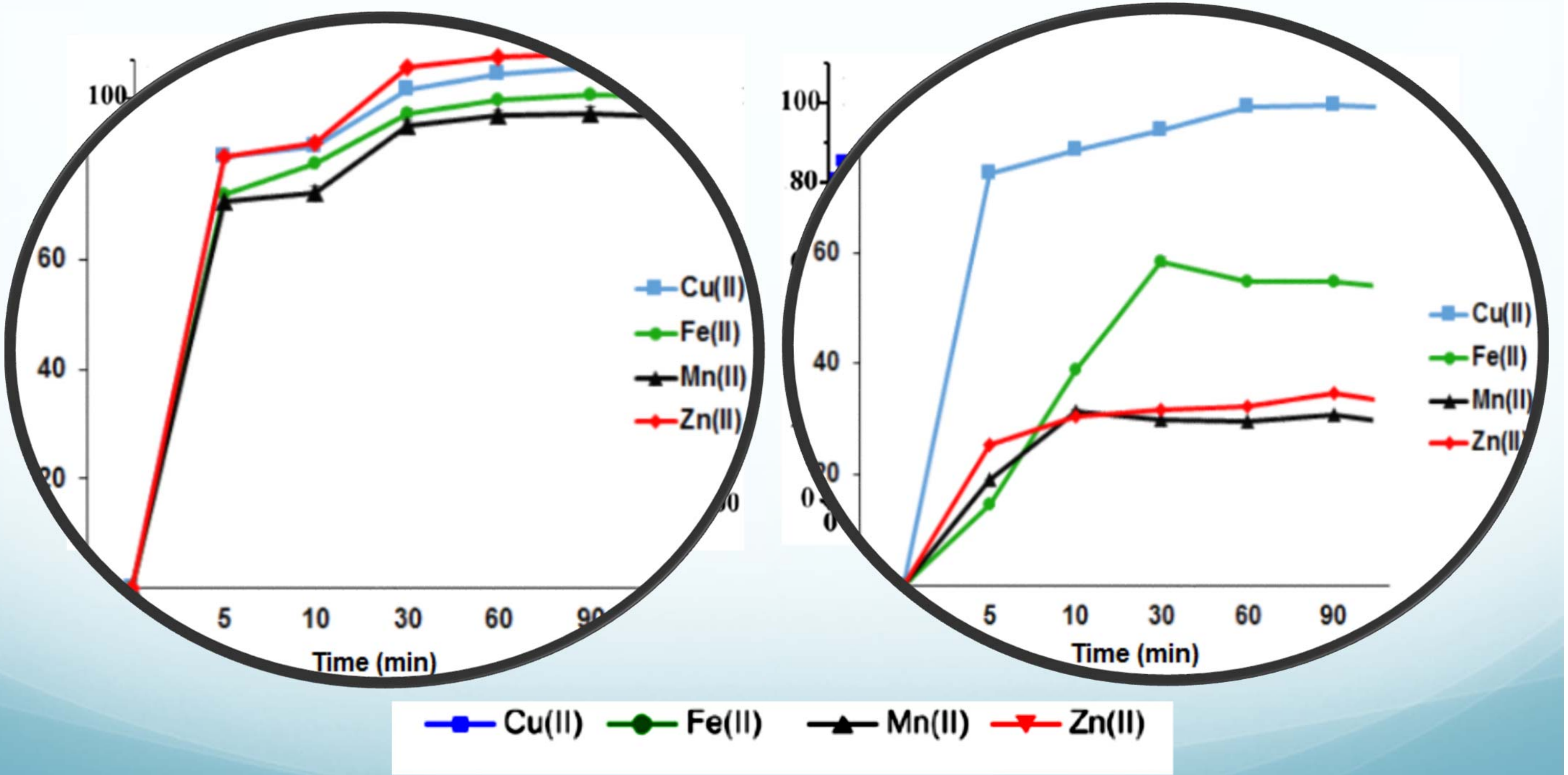
Flame Atomic Absorption Spectrometry

SORPTION KINETICS OF Cu(II), Fe(II), Mn(II), AND Zn(II) USING MODIFIED LETTUCE ROOTS (MLR) AND SUGARCANE BAGASSE (MSB)



SORPTION KINETICS OF Cu(II), Fe(II), Mn(II), AND Zn(II) IN MRL AND MSB

% Retained metal by MLR **% Retained metal by MSB**

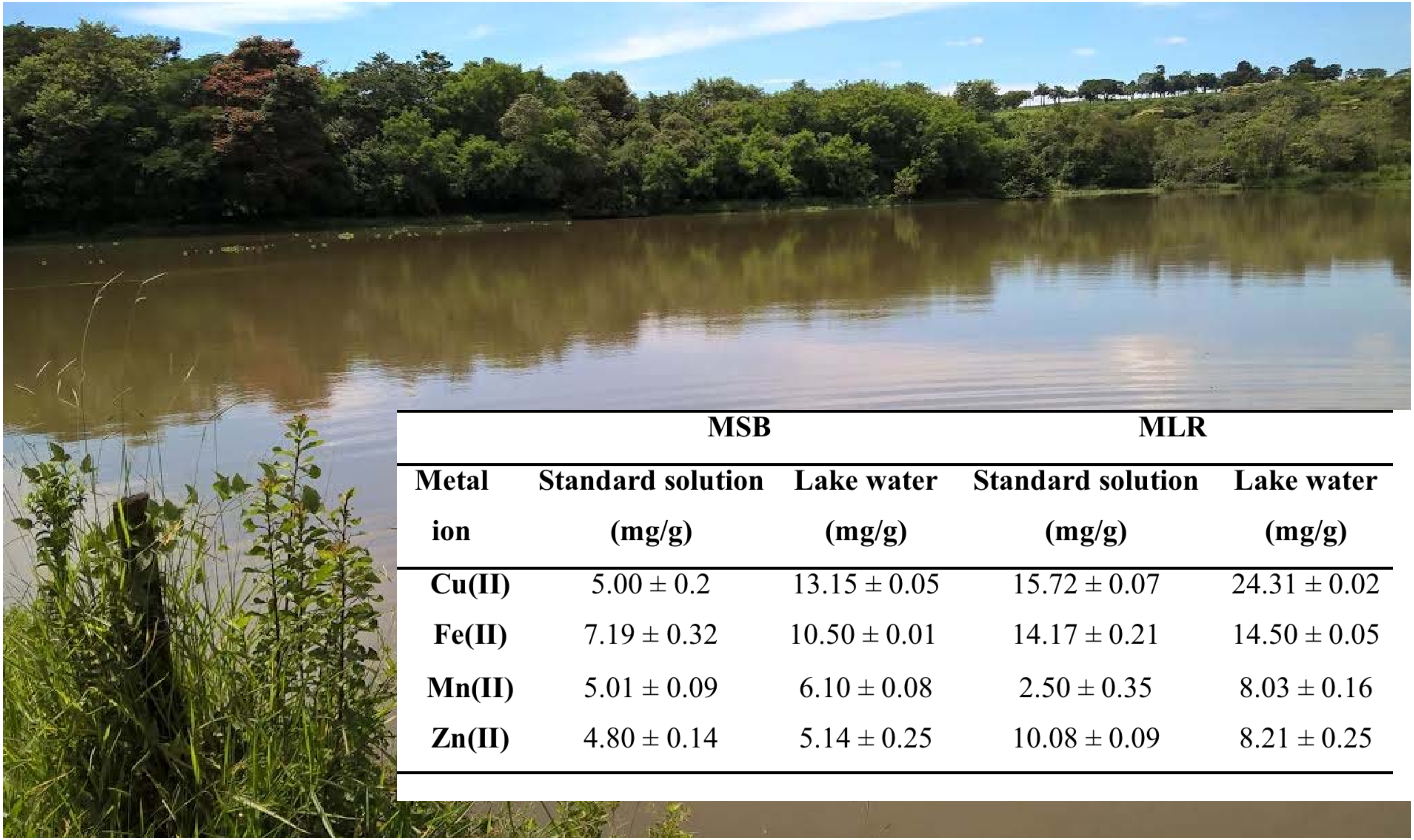


EQUATIONS AND THEIR CORRELATION COEFFICIENTS FOR KINETICS SORPTION OF MULTILEMENTAL SOLUTIONS BY MODIFIED BIOMASSES

	MSB		MLR	
	pseudo 1st order	**pseudo 2nd order**	**pseudo 1st order**	**pseudo 2nd order**
Cu(II)	y = -1.6132x + 2.4689	y = 0.1426x + 0.1796	y = -0.0502x + 0.5011	y = 0.1292x + 0.2108
	$r^2 = 0.8936$	$r^2 = 0.9998$	$r^2 = 0.9850$	$r^2 = 0.9999$
	$k_1 = 0.16$	$k_2 = 1.56$	$k_1 = 0.006$	$k_1 = 0.98$
Fe(II)	y = -2.6053x + 5.0601	y = 0.1814x + 1.5368	y = -0.0774x + 0.8406	y = 0.1219x + 0.1977
	$r^2 = 0.8227$	$r^2 = 0.9971$	$r^2 = 0.9999$	$r^2 = 1.000$
	$k_1 = 0.08$	$k_2 = 1.02$	$k_1 = 0.60$	$k_2 = 0.41$
Zn(II)	y = -0.7672x - 0.02	y = 0.3922x + 0.9451	y = -0.0917x + 0.8823	y = 0.1374x + 0.2284
	$r^2 = 0.9703$	$r^2 = 0.9975$	$r^2 = 0.9965$	$r^2 = 0.9999$
	$k_1 = 0.07$	$k_2 = 1.51$	$k_1 = 0.01$	$k_2 = 0.83$
Mn(II)	y = 0.0279x - 0.1184	y = 0.4092x + 0.3917	y = -0.9895x + 1.5884	y = 0.1409x + 0.2304
	$r^2 = 0.5333$	$r^2 = 0.9985$	$r^2 = 0.9485$	$r^2 = 0.9999$
	$k_1 = 0.32$	$k_2 = 1.41$	$k_1 = 0.005$	$k_2 = 1.12$

MSB: Modified Sugarcane Bagasse; MLR: Modified lettuce roots; For pseudo 1st order the slope = k_1 (min^{-1}). For pseudo 2nd order the angular parameter = k_2 ($g\ mg^{-1}\ min^{-1}$), n = 3.

EFFECT OF WATER MATRIX ON METAL IONS SORPTION BY MODIFIED BIOMASSES



	MSB		MLR	
Metal ion	**Standard solution (mg/g)**	**Lake water (mg/g)**	**Standard solution (mg/g)**	**Lake water (mg/g)**
Cu(II)	5.00 ± 0.2	13.15 ± 0.05	15.72 ± 0.07	24.31 ± 0.02
Fe(II)	7.19 ± 0.32	10.50 ± 0.01	14.17 ± 0.21	14.50 ± 0.05
Mn(II)	5.01 ± 0.09	6.10 ± 0.08	2.50 ± 0.35	8.03 ± 0.16
Zn(II)	4.80 ± 0.14	5.14 ± 0.25	10.08 ± 0.09	8.21 ± 0.25

CONCLUSIONS

Biomasses

- ✓ Lettuce roots and sugarcane bagasse have great potential in the sorption of Cu(II), Fe(II), Mn(II), and Zn(II) in aqueous solutions and lake water.
- ✓ Lettuce roots presented higher adsorption capacity for the investigated metals.

Chemical Modification

- ✓ The chemical modification of the biomass was efficient to increase the maximum capacity of multielementar adsorption of all elements for sugarcane bagasse.

Adsorption Capacity

- ✓ High adsorption capacity was found for both biomasses using the Langmuir isothermal model.

Industrial Application

- ✓ Due to the high sorption capacity in both *in natura* and modified lettuce roots this is expected to be a promising biosorbent.

THE BIOSORPTION GROUP

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Efharistó

Thank You

Obrigada