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(II)

($R^2 > /$)

%

(II)

(II)

($R^2 > /$)

(II)

(II)

(II) (q_m)

($R^2 > /$)

/ /

(II)

(II) (II)

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Aksu)

(2002; Eckenfelder 2000

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(II)

(Sternberg and Dorn 2002; Volesky 2001)

(II)	(Durvillaea potatorum)	(Ecklonia radiata)	(Biosorption)
/ /			Dönmez et al. 1999; Figueira et al. 2000;)
(II)			(Loukidou et al. 2003
(Streptomyces rimosus)		/	
Selatnia)			()
(II)		(et al. 2004	(...
(II)		(II)	(Davis et al. 2003)
(II)	(II)		
			(Biosorbent)
			Diniz and Volesky)
			(2005; Ma and Tobin 2003
			(II) (II)
/ /			(II)
			% (Aspergillus oryzae)
			Kiff and Little)
/			(;1986
			(II)
			(Rhizopus nigricans)
			(II)
			Benguella and Benaissa)
KCl NaCl Cd(NO ₃) ₂ .2H ₂ O Pb(NO ₃) ₂			(; 2002

) CaCl₂.2H₂O MgCl₂.6H₂O

pH . (Merck

pH

/

(Mixed cellulose ester) / μm

CAMLAB)

pH

(Merck

((II) (II))

(Ltd, Model CG842

FAAS, Chem. Tech Analytical, Model)

)

(ALPHA4

AZTEC ENVIRONMENTAL)

“Standard Methods for B

(CONTROL Ltd

the Examination of Water and Wastewater”

(.APAH, AWWA and WEF 1998)

(II) (II)

(±)

() () (Langergren)

(II) (II)

() (Mixed-order)

$$\ln \frac{(q_e - q)}{q_e} = -k_1 t \quad ()$$

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e} t \quad ()$$

$$\frac{1}{t} \ln \frac{C_0}{C_t} = -\frac{k_0}{K} - \frac{1}{K} \left(\frac{C_0 - C_t}{t} \right) \quad ()$$

$$\frac{1}{(q_e - q_t)} = \frac{1}{q_e} + kt \quad ()$$

:q_e q () :t

pH

) :k₁ (

) :k₂ (

:C_t C₀ (

() k₀ () t

:k () K

(II)

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Azizian 2004; Benguella and)

(.Benaissa 2002; Metcalf and Eddy Inc 2003

pH .

/

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n q_m b : (II) (II)
(Volesky 2003)

q_e = $\frac{K_{RP}C_e}{1+a_{RP}C_e^\beta}$ ()
) a_{RP} () K_{RP}
() β (β)
(Aksu 2002; Volesky 2003)

(II) (II) :

(II) (II)

q_e = $\frac{bq_m C_e}{1+bC_e}$ ()
:C_e
) :q_m ()
() :b ()
Sheng et al. 2004; Yalçınkaya et al.)
(2002

(II) (II)

(II) (II)

q_e = K_FC_e^{1/n} ()
n K_F

(II) (q_m) (II)

Loukidou et al.)
(. 2004, Selatnia et al. 2004b

(II) (II)

q_e = $\frac{bq_m C_e^{1/n}}{1+bC_e^{1/n}}$ ()

% %

(Yan and Viraraghavan 2003)

(k₂)

/ : (II)

/ / /

(k₀)

/ : (II)

/ / /

(Ascophyllum nodosum)

Kuyucak)

(; and Volesky 1989

(II)

(k₂)

(II)

/ /

/

/

% %

(II)

(k₀)

(III)

/

/

/ /

%

(II)

(II)

(II)

(II)

(II)

(II)

Matheickal and)

%

(II)

(Yu 1999

(II)

pH

(R² > /)

(II)

(II)

(II)

(II)

(II)

pH (II)

pH

(II)

pH

Aeromonas)

(VI)

pH / / /

/

(caviae

/ (II)

/ / /

pH

(II)

(II)

(II)

Mucor)

(II)

(rouxii

Diniz and) .

(II) (II) (III) (III) (III) (Volesky 2005)

() (Oscillatoria anguistissima) (Ahuja et al. 1999)

(II) pH (II) Aksu) (II) (II) (2002) (R²> /)

(II) (II) (q_m) (R²> /) / /

(II) (II)

(II) (II)

(II) (II) (q_m) / / (q_m)

(Volesky 2001)

(... pH)

/ ... (II) (II)

Cd ²⁺			Pb ²⁺			Saturation						(Mm)	
R ²	k (gmmol ⁻¹ min ⁻¹)	q _e (mmolg ⁻¹)	R ²	k ₀ (mMmin ⁻¹)	K (Mm)	R ²	k ₂ (gmmol ⁻¹ min ⁻¹)	q _e (mmolg ⁻¹)	R ^{2*}	k ₁ (min ⁻¹)	q _e (mmolg ⁻¹)		
/	/	/	/	/	/	/	/	/	/	/	/		Pb ²⁺
/	/	/	/	/	/	/	/	/	/	/	/		Pb ²⁺
/	/	/	/	/	/	/	/	/	/	/	/	/	Pb ²⁺
/	/	/	/	/	/	/	/	/	/	/	/		Cd ²⁺
/	/	/	/	/	/	/	/	/	/	/	/		Cd ²⁺
/	/	/	/	/	/	/	/	/	/	/	/	/	Cd ²⁺

:R*

(II) (II)

R ²	n	K _F	R ^{2*}	b(Lmmol ⁻¹)	q _m (mmolg ⁻¹)	
/	/	/	/	/	/	(II)
/	/	/	/	/	/	(II)

:R*

(II) (II)

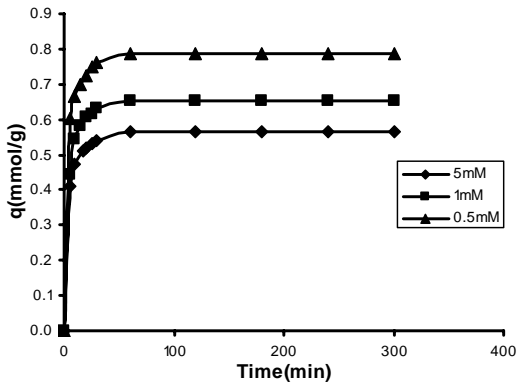
-

R^2	β	K_{RP} (Lg^{-1})	a_{RP} ($Lmmol^{-1}$) $^\beta$	R^{2*}	n	b	q_m	(II)
/	/	/	/	/	/	/	/	(II)
/	/	/	/	/	/	/	/	(II)

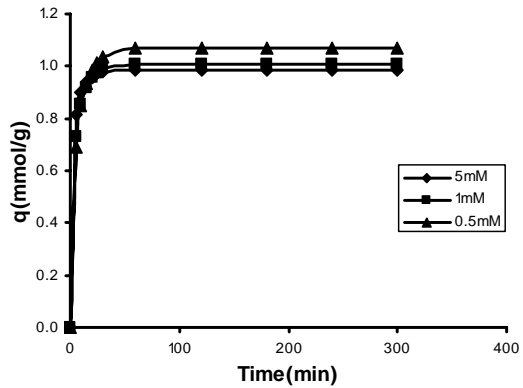
:R*

(II) (II) (q_m)

	(°C)	pH	q_m ($mmolg^{-1}$)		
Matheickal and Yu 1996		/ /	/	Ecklonia)	
Sheng et al. 2004	±		/	(radiata	Pb ²⁺
Sheng et al. 2004	±		/	(Ulva sp.)	
Sheng et al. 2004	±		/	(Padina sp.)	
Jalali et al. 2002		/	/	(Gracillaria sp.)	
Say et al. 2001			/	(Cladophora glomerata)	
Yan and Viraraghavan 2003			/	Phanerochaete)	
Selatnia et al. 2004b			/	(chryso sporium	
Xiangliang et al. 2005		/	/	Mucor)	
Suzuki et al. 2005		/	/	(rouxii	
Sheng et al. 2004	±	/	/	(Streptomyces rimosus)	
Sheng et al. 2004	±	/	/	(Pleurotus ostreatus)	
Sheng et al. 2004	±	/	/	(Ulva onoi)	Cd ²⁺
Yan and Viraraghavan 2003			/	(Ulva sp.)	
Say et al. 2001			/	(Padina sp.)	
Yalçınkaya et al. 2002			/	(Gracillaria sp.)	
Selatnia et al. 2004a			/	Mucor)	
Benguella and Benaissa 2002	/ /		/	(rouxii	
			/	Phanerochaete)	
			/	(chryso sporium	
			/	(Trametes versicolor)	
			/	(Streptomyces rimosus)	
			/	(Chitin)	



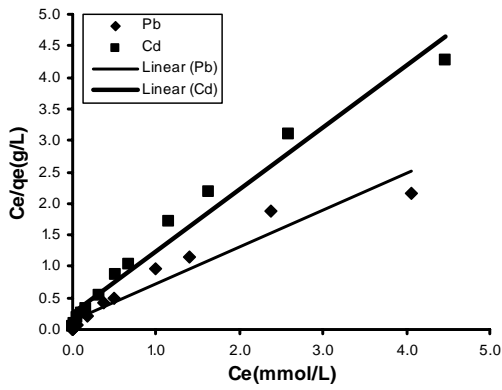
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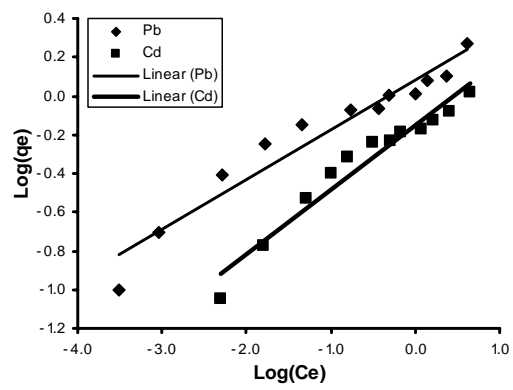
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() (II)

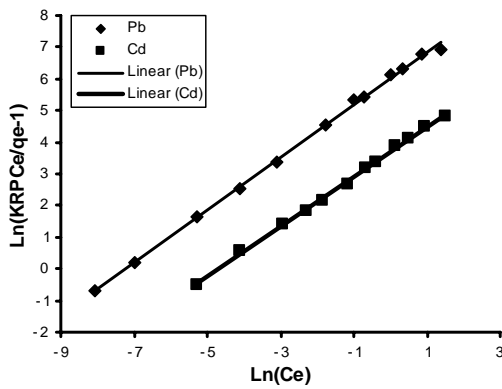
() (II)



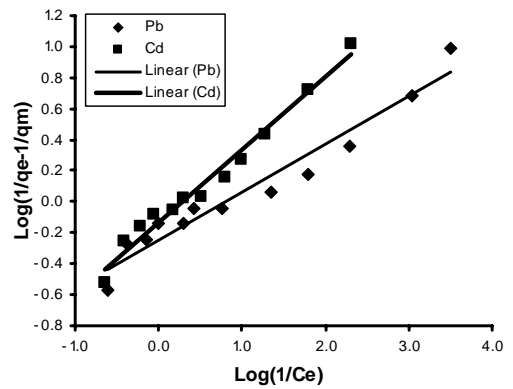
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References

- Ahuja, P., Gupta, R. and Saxena, R.K., 1999. Zn²⁺ biosorption by *Oscillatoria anguistissima*. *Process. Biochem.* **34**, pp.77-85.
- Aksu, Z., 2002. Determination of the equilibrium, kinetic and thermodynamic parameters of the batch biosorption of nickel(II) ions onto *Chlorella vulgaris*. *Process. Biochem.* **38**, pp.89-99.
- APAH, AWWA and WEF, 1998. Standard Methods for the Examination of Water and Wastewater. 20th ed. United Book Press, Baltimore, Maryland.
- Azizian, S., 2004. Kinetic models of sorption: a theoretical analysis. *J. Coll. Interf. Sci.* **276**, pp.47-52.
- Benguella, B. and Benaissa, H., 2002. Cadmium removal from aqueous solutions by chitin: kinetic and equilibrium studies. *Water Res.* **36**, pp.2463-2474.
- Cossich, E.S., Tavares, C.R.G. and Ravagnani, T.M.K., 2002. Biosorption of chromium(III) by *Sargassum* sp. Biomass. *Electronic Journal of Biotechnol.* **5**(2), pp.133-140.
- Davis, T.A., Volesky, B. and Mucci, A., 2003. A review of the biochemistry of heavy metal biosorption by brown algae. *Water Res.* **37**(18), pp.4311-4330.
- Diniz, V. and Volesky, B., 2005. Biosorption of La, Eu and Yb using *Sargassum* biomass. *Water Res.* **39**, pp.239-247.
- Eckenfelder, W.W., Jr., 2000. Industrial Water Pollution Control. 3rd ed. McGraw-Hill Inc., Boston, MA, pp.138-142.
- Jalali, R., Ghafourian, H., Asef, Y., Davarpanah, S.J. and Sepehr, S., 2002. Removal and recovery of lead using nonliving biomass of marine algae. *J. Hazard. Mater.* **B92**, pp.253-262.
- Kiff, R.J. and Little, D.R., 1986. Biosorption of heavy metals by immobilized fungal biomass. In: Hunt E.H., ed, Immobilization of Ions by Biosorption. Ellis Horwood, Chichester, UK. p.219.
- Kuyucak, N. and Volesky, B., 1989. Accumulation of cobalt by marine algae. *Biotechnol. Bioeng.* **33**, pp.809-814.
- Loukidou, M.X., Matis, K.A., Zouboulis, A.I. and Kyriakidou, M.L., 2003. Removal of As(V) from wastewaters by chemically modified fungal biomass. *Water Res.* **37**, pp.4544-4552.
- Loukidou, M.X., Zouboulis, A.I., Karapantsios, T.D. and Matis, K.A., 2004. Equilibrium and kinetic modeling of chromium(VI) biosorption by *Aeromonas caviae*. *Colloids Surf. A: Physicochem. Eng. Aspects.* **242**, pp.93-104.
- Matheickal, J.T. and Yu, Q., 1999. Biosorption of lead(II) and copper(II) from aqueous solutions by pre-treated biomass of Australian marine algae. *Biores. Technol.* **69**(3), pp.223-229.
- Matheickal, J.T. and Yu, Q., 1996. Biosorption of lead from aqueous solutions by marine algae *Ecklonia adiate*. *Water Sci. Technol.* **34**(9), 1-7.
- Metcalf and Eddy Inc., 2003. Wastewater Engineering: Treatment and Reuse. 4th ed. McGraw-Hill Inc., New York. pp.260-265.
- Say, R., Denizli, A. and Arica, M.Y., 2001. Biosorption of cadmium(II), lead(II) and copper(II) with the filamentous fungus *Phanerochaete chrysosporium*. *Biores. Technol.* **76**, pp.67-70.
- Selatnia, A., Bakhti, M.Z., Madani, A., Kertous, L. and Mansouri, Y., 2004a. Biosorption of Cd²⁺ from aqueous solution by a NaOH-treated bacterial dead *Streptomyces rimosus* biomass. *Hydrometallurgy.* **75**, pp.11-24.
- Selatnia, A., Boukazoula, A., Kechid, N., Bakhti, M.Z., Chergui, A. and Kerchich, Y., 2004b. Biosorption of lead(II) from aqueous solution by a bacterial dead *Streptomyces rimosus* biomass. *Biochem. Eng. J.* **19**, pp.127-135.
- Sheng, P.X., Ting, Y.P., Chen, J.P. and Hong, L., 2004. Sorption of lead, copper,

- cadmium, zinc and nickel by marine algal biomass: characterization of biosorptive capacity and investigation of mechanisms. *J. Coll. Interf. Sci.* **275**, pp.131-141.
- Sternberg, S.P.K. and Dorn, R.W., 2002. Cadmium removal using *Cladophora* in batch, semi-batch and flow reactors. *Biores. Technol.* **81**, pp.249-255.
- Suzuki, Y., Kametani, T. and Maruyama, T., 2005. Removal of heavy metals from aqueous solution by nonliving *Ulva* seaweed as biosorbent. *Water Res.* **39**, pp.1803-1808.
- Volesky, B., 2001. Detoxification of metal-bearing effluents: biosorption for the next century. *Hydrometallurgy.* **59**, pp.203-216.
- Volesky, B., 2003. Biosorption process simulation tools. *Hydrometallurgy.* **71**, pp.179-190.
- Xiangliang, P., Jianlong, W. and Daoyong, Z., 2005. Biosorption of Pb(II) by *Pleurotus ostreatus* immobilized in calcium alginate gel. *Process. Biochem.* **40**, pp.2799-2803.
- Yalçinkaya, Y., Soysal, L., Denizli, A., Arica, M.Y., Bektaş, S. and Genç, Ö., 2002. Biosorption of cadmium from aquatic systems by carboxymethylcellulose and immobilized *Trametes versicolor*. *Hydrometallurgy.* **63**, pp.31-40.
- Yan, G. and Viraraghavan, T., 2003. Heavy metal removal from aqueous solution by fungus *Mucor rouxii*. *Water Res.* **37**, pp.4486-4496.
- Zhang, L., Zhao, L., Yu, Y. and Chen, C., 1998. Removal of lead from aqueous solution by non-living *Rhizopus nigricans*. *Water Res.* **32**, pp.1437-1444.