

[Home](#) > [Journal](#) > [Earth & Environmental Sciences](#) > [JWARP](#)
[Indexing](#) | [View Papers](#) | [Aims & Scope](#) | [Editorial Board](#) | [Guideline](#) | [Article Processing Charges](#)
[JWARP](#) > Vol. 4 No. 4, April 2012



## Zinc and Lead Biosorption by *Delftia tsuruhatensis*: A Bacterial Strain Resistant to Metals Isolated from Mine Tailings

PDF (Size: 381KB) PP. 207-216 DOI: 10.4236/jwarp.2012.44023

### Author(s)

Dorian A. Bautista-Hernández, Landy I. Ramírez-Burgos, Enrique Duran-Páramo, Luis Fernández-Linares

### ABSTRACT

A bacterial strain capable of Zinc and Lead biosorption was isolated from mine tailings. This strain showed the highest minimum inhibitory concentrations (MIC) of metals among other isolates in metal-resistance tests. Sorption tests were conducted placing 0.015 g of dry biomass in 10 ml of metallic solution at fixed pH. Contact was analyzed at different times (kinetics) and different initial concentrations (isotherm). The biomass was separated by centrifugation and the concentration of non-absorbed metal was determined using atomic absorption spectroscopy. The strain was identified by 16S sequencing as *Delftia tsuruhatensis*. The order of toxicity of the metals to the bacterium was Zn > Pb > Se > Ni > Cu = Al. Zinc and Lead absorption kinetics were adjusted to the pseudo second order equation ( $r^2 = 0.99$ ), showing that equilibrium was reached at 40 and 20 min, respectively. Maximal absorption of Pb and Zn was 0.216 and 0.207 mmol·g<sup>-1</sup>, respectively; which can be considered a median magnitude capacity when compared to other biosorbents described in the literature.

### KEYWORDS

 Biosorption; Langmuir and Freundlich Isotherms; *Delftia Tsuruhatensis*; Pb(II); Zn(II)

### Cite this paper

D. Bautista-Hernández, L. Ramírez-Burgos, E. Duran-Páramo and L. Fernández-Linares, "Zinc and Lead Biosorption by *Delftia tsuruhatensis*: A Bacterial Strain Resistant to Metals Isolated from Mine Tailings," *Journal of Water Resource and Protection*, Vol. 4 No. 4, 2012, pp. 207-216. doi: 10.4236/jwarp.2012.44023.

### References

- [1] H. B. Bradl, C. Kim, U. Kramar and D. Stüben, "Inter- actions of Heavy Metals," In: H. B. Bradl, Ed., *Heavy Metals in the Environment: Origin, Interaction and Re- mediation*, Interface Science and Technology, Elsevier Ltd., 2005, Vol. 6, pp. 28-164.
- [2] R. H. Vieira and B. Volesky, "Biosorption: A Solution to pollution?" *International Mycrobiology*, Vol. 3, No. 1, 2000, pp. 17-24.
- [3] K. Vijayaraghavan and Y. S. Yun, "Bacterial Biosorbents and Biosorption," *Biotechnology Advances*, Vol. 26, No. 3, 2008, pp. 266-291. doi:10.1016/j.biotechadv.2008.02.002
- [4] K. Chojnacka, "Biosorption and Bioaccumulation—The Prospects for Practical Applications" *Environment Inter- national*, Vol. 36, No. 3, 2010, 299-307. doi:10.1016/j.envint.2009.12.001
- [5] B. Volesky, "Sorption and Biosorption," BV Sorbex Inc., Montreal-St. Lambert, 2003.
- [6] S. S. Ahluwalia and D. Goyal, "Microbial and Plant De- rived Biomass for Removal of Heavy Metals from Waste- water," *Bioresource Technology*, Vol. 98, No. 12, 2007, pp. 2243-2257.
- [7] M. I. Ansari and A. Malik, "Biosorption of Nickel and Cadmium by Metal Resistant Bacterial Isolates from Ag- ricultural Soil Irrigated with Industrial Wastewater," *Bio- resource Technology*, Vol. 98, No. 16, 2007, pp. 3149- 3153. doi:10.1016/j.biortech.2006.10.008
- [8] A. I. Zouboulis, M. X. Loukidou and K. A. Matis, "Biosorption of Toxic Metals from Aqueous Solutions

- [Open Special Issues](#)
- [Published Special Issues](#)
- [Special Issues Guideline](#)

[JWARP Subscription](#)
[Most popular papers in JWARP](#)
[About JWARP News](#)
[Frequently Asked Questions](#)
[Recommend to Peers](#)
[Recommend to Library](#)
[Contact Us](#)

Downloads:	402,262
------------	---------

Visits:	1,010,644
---------	-----------

[Sponsors, Associates, and Links >>](#)

by Bacteria Strains Isolated from Metal-Polluted Soils," *Process Biochemistry*, Vol. 39, No. 8, 2004, pp. 909-916. doi:10.1016/S0032-9592(03)00200-0

- [9] H.-L. Liu, B.-Y. Chen, Y.-W. Lan and Y.-C. Cheng, "Bio-sorption of Zn(II) and Cu(II) by the indigenous *Thiobacillus thiooxidans*," *Chemical Engineering Journal*, Vol. 97, No. 2-3, 2004, pp. 195-201. doi:10.1016/S1385-8947(03)00210-9
- [10] I. E. Yilmaz, "Metal Tolerance And Biosorption Capacity of *Bacillus circulans* Strain EB1," *Research in Microbiology*, Vol. 154, No. 6, 2003, pp. 409-415. doi:10.1016/S0923-2508(03)00116-5
- [11] Y. S. Ho and G. McKay, "Pseudo-Second Order Model for Sorption Processes," *Process Biochemistry*, Vol. 34, No. 5, 1999, pp. 451-465. doi:10.1016/S0032-9592(98)00112-5
- [12] A. Hiraishi, Y. K. Shin, Y. Ueda and J. Sugiyama, "Automated Sequencing of PCR Amplified 16S rDNA on Hydrogels," *Journal of Microbiology Methods*, Vol. 19, No. 2, 1994, pp. 145-154. doi:10.1016/0167-7012(94)90046-9
- [13] T. Shigematsu, K. Yumihara, Y. Ueda, M. Numaguchi, S. Morimur and K. Kida, "Delftia tsuruhatensis sp. nov., a Terephthalate-Assimilating Bacterium Isolated from Activated Sludge," *International Journal of Systematic and Evolutionary Microbiology*, Vol. 53, 2003, pp. 1479-1483. doi:10.1099/ijs.0.02285-0
- [14] A. Hassen, N. Saidi, Cherif and A. Boudabous, "Effects of Heavy Metals on *Pseudomonas aeruginosa* and *Bacillus thuringiensis*," *Bioresource Technology*, Vol. 65, No. 1-2, 1998, pp. 73-82. doi:10.1016/S0960-8524(98)00011-X
- [15] W. Barabasz, B. Hetmanska and P. Tomasik, "The Metal-Metal Interactions in Biological Systems. Part I. *Escherichia coli*," *Water, Air and Soil Pollution*, Vol. 52, No. 3-4, 1990, pp. 337-375. doi:10.1007/BF00229442
- [16] J. P. Chandy, "Heavy Metal Tolerance in Chromogenic and Non-Chromogenic Marine Bacteria from Arabian Gulf," *Environmental Monitoring and Assessment*, Vol. 59, No. 3, 1999, pp. 321-330. doi:10.1023/A:1006173722510
- [17] G. Haferburg, M. Reinicke, D. Merten, G. Buchel and E. Kothe, "Microbes Adapted to Acidic Mine Drainage as Source for Strain Active in Retention of Aluminum or Uranium," *Journal of Geochemical Exploration*, Vol. 92, No. 2-3, 2007, pp. 196-204. doi:10.1016/j.gexplo.2006.08.011
- [18] A. Hernández, P. R. Mellado and L. J. Martínez, "Metal Accumulation and Vanadium-Induced Multidrug Resistance by Environmental Isolates of *Escherichia harmannii* and *Enterobacter cloacae*," *Applied and Environmental Microbiology*, Vol. 64, No. 11, 1998, pp. 4317-4320.
- [19] M. R. Timberley and L. P. Ian, "Microorganisms and Metal Pollutants," In: R. M. Maier, L. P. Ian, and P. G. Charles, Eds., *Environmental Microbiology*, Academic Press, Cambridge, 2000, pp. 403-423.
- [20] A. S. Luna, A. C. Da Costa, C. A. Henriques and M. H. Herbst, "Electron Paramagnetic Resonance and Atomic Absorption Spectrometry as Tools For the Investigation of Cu (II) Biosorption by *Sargassum filipendula*," *Hydrometallurgy*, Vol. 86, No. 1-2, 2007, pp. 105-113. doi:10.1016/j.hydromet.2006.11.008
- [21] S. Karthikeyan, R. Balasubramanian and C. S. P. Iyer, "Evaluation of the marine Algae *Ulva fasciata* and *Sargassum* sp. for the Biosorption of Cu(II) from Aqueous Solution," *Bioresource Technology*, Vol. 98, No. 2, 2007, pp. 452-455. doi:10.1016/j.biortech.2006.01.010
- [22] P. Puranik and K. M. Paknikar, "Biosorption of Lead and Zinc from solutions Using *Streptovorticillum cinnamomeum* Waste Biomass," *Journal of Biotechnology*, Vol. 55, No. 2, 1997, pp. 113-124. doi:10.1016/S0168-1656(97)00067-9
- [23] P. R. Puranik, J. M. Modak and K. M. Paknikar, "A Comparative Study of Mass Transfer Kinetics of Metal Biosorption by Microbial Biomass," *Hydrometallurgy*, Vol. 52, 1999, pp. 189-197.
- [24] P. Salehi, B. Asghari and F. Mohammadi, "Biosorption of Ni(II), Cu(II) and Pb(II) by *Punica granatum* from Aqueous Solutions," *Journal of Water Resource and Protection*, Vol. 2, No. 8, 2010, pp. 701-705. doi:10.4236/jwarp.2010.28080
- [25] A. H. Hawari and C. N. Mulligan, "Biosorption of Lead(II), Cadmium(II), Copper(II) and Nickel(II) by Anaerobic Granular Biomass," *Bioresource Technology*, Vol. 97, No. 4, 2006, pp. 692-700. doi:10.1016/j.biortech.2005.03.033
- [26] E. Fourest and J. C. Roux, "Heavy Metal Biosorption by fungal Mycelial Byproducts: Mechanism and

Influence of pH," Applied Microbiology and Biotechnology, Vol. 37, No. 3, 1992, pp. 399-403. doi:10.1007/BF00211001

- [27] S. Tunali, A. Cabuk and T. Akar, " Removal of Lead and Copper Ions from Aqueous Solutions by Bacterial Strain Isolated from Soil," Chemical Engineering Journal, Vol. 115, No. 3, 2006, pp. 203-211. doi:10.1016/j.cej.2005.09.023
- [28] S. Mustafiz, A. Basu and M. R. Islam, " A Novel Method for Heavy Metals Removal," Energy Resources, Vol. 24, No. 11, 2002, pp. 1043-1050. doi:10.1080/00908310290086905
- [29] G. Ozdemir, N. Ceyhan, T. Ozturk, F. Akirmak and T. Cosar, " Biosorption of Chromium(VI), Cadmium (II) and Copper(II) by *Pantoea* sp. TEM 18," Chemical Engineering Journal, Vol. 102, No. 3, 2004, pp. 249-253. doi:10.1016/j.cej.2004.01.032
- [30] G. Ozdemir and S. H. Baysal, " Chromium and Aluminum Biosorption on *Chryseomonas luteola* TEM 05," Applied Microbiology and Biotechnology, Vol. 64, No. 4, 2004, pp. 599-603. doi:10.1007/s00253-003-1479-0
- [31] M. Tsezos, E. Remoudaki and Angelatau, " A Systematic Study on Equilibrium and Kinetics of Biosorptive Accumulation: The Case of Ag and Ni," International Biodegradation and Biodegradation, Vol. 35, No. 1-3, 1995, 129-153. doi:10.1016/0964-8305(95)00049-B
- [32] Y. Liu, H. Xu, S. F. Yang and J. H. Tay, " A general Model for Biosorption of Cd<sup>2+</sup>, Cu<sup>2+</sup>, and Zn<sup>2+</sup> by Aerobic Granules," Journal of Biotechnology, Vol. 102, No. 3, 2003, pp. 233-239. doi:10.1016/S0168-1656(03)00030-0
- [33] A. Esposito, F. Pagnanelli, A. Lodi, C. Solisio and F. Veglió, " Biosorption of Heavy Metals by *Sphaerotilus natans*: An Equilibrium Study at Different pH and Biomass Concentrations," Hydrometallurgy, Vol. 60, No. 2, 2001, pp. 129-141.
- [34] C. Can and W. Jianlong, " Influence of Metal Ionic Characteristic on Their Biosorption Capacity by *Saccharomyces cerevisiae*," Applied Microbiology and Biotechnology, Vol. 74, No. 4, 2007, 911-917. doi:10.1007/s00253-006-0739-1
- [35] K. Chandrasekhar, C. T. Kamala, N. S. Chary and Y. Anjanayuku, " Removal of Heavy Metal Using Plant Biomass with Reference To Environmental Control," International Journal of Mineral Process, 2003, Vol. 68, No. 1-2, pp. 37-45. doi:10.1016/S0301-7516(02)00047-9
- [36] J. M. Brady and J. M. Tobin, " Binding of Hard and Soft Metals Ions to *Rhizopus arrhizus* Biomass," Enzyme and Microbial Technology, Vol. 17, No. 9, 1995, pp. 791-796. doi:10.1016/0141-0229(95)00142-R
- [37] J. T. Matheikal and Q. Yu, " Biosorption of Lead(II) and Copper(II) from Aqueous Solutions by Pre-Treated Biomass of Australian Marine Algae," Bioresource Technology, Vol. 69, No. 3, 1999, pp. 223-229. doi:10.1016/S0960-8524(98)00196-5
- [38] W. Lo, H. Chua, K. H. Lam and S. P. Bi, " A Comparative Investigation on the Biosorption of Lead by Filamentous Fungal Biomass," Chemosphere, Vol. 39, No. 15, 1999, pp. 2723-2736. doi:10.1016/S0045-6535(99)00206-4
- [39] S. B. Choi and Y.-S. Yun, " Lead Biosorption by Waste Biomass of *Corynebacterium glutamicum* Generated from Lysine Fermentation Process," Biotechnology Letters, Vol. 26, No. 4, 2004, pp. 331-336. doi:10.1023/B:BILE.0000015453.20708.fc
- [40] H. Salehizadeh and S. A. Shojaosadati, " Removal of Metal Ions from Aqueous Solutions by Polysaccharide Produced from *Bacillus firmus*," Water Research, Vol. 37, No. 17, 2003, 4231-4235. doi:10.1016/S0043-1354(03)00418-4
- [41] Z. R. Holan and B. Volesky, " Biosorption of Lead and Nickel by Biomass of Marine Algae," Biotechnology and Bioengineering, Vol. 43, No. 11, 1994, pp. 819-825. doi:10.1002/bit.260431102
- [42] B. Volesky, " Removal of Heavy Metals by Biosorption," In: M. R. Ladisch and A. Bose, Eds., Harnessing Biotechnology for the 21st Century, American Chemical Society, Washington DC, 1992, pp. 462-466.
- [43] B. Wehrem and M. Wetter, " Biosorption of Cadmium, Copper and Lead by Isolated Mother Cell Wall and Whole Cells of *Chlorella fusca*," Applied Microbiology and Biotechnology, Vol. 41, No. 6, 1994, pp. 331-343. doi:10.1007/BF00167291
- [44] A. Selatnia, A. Boukazoula, N. Kechid, M. Z. Bakhti, A. Chergi and Y. Kerchich, " Biosorption of Lead(II)

from Aqueous Solution by a Bacterial Dead Streptomyces rimosus biomass," *Biochemical Engineering Journal*, Vol. 19, No. 2, 2004, pp. 127-135. doi:10.1016/j.bej.2003.12.007

- [45] F. Veglio, F. Beolchini and A. Gasbarro, " Biosorption of Toxic Metals: An Equilibrium Study Using Free Cells of *Arthrobacter* sp.," *Process Biochemistry*, Vol. 32, No. 2, 1997, pp. 99-105. doi:10.1016/S0032-9592(96)00047-7
- [46] A. B. Ariff, M. Mel, M. A. Hasan and M. I. A. Karim, " The Kinetics and Mechanism of Lead(II) Biosorption by Powderized *Rhizopus oligosporum*," *World Journal of Microbiology and Biotechnology*, Vol. 15, No. 2, 1999, pp. 291-298. doi:10.1023/A:1008995026987
- [47] H. Niu, X. S. Xiu, J. H. Wang and B. Volesky, " Removal of Lead from Aqueous Solution by *Penicillium* Biomass," *Biotechnology and Bioengineering*, Vol. 42, No. 6, 1993, pp. 785-787. doi:10.1002/bit.260420615
- [48] A. Kapoor and T. Viraraghavan, " Fungal Biosorption— An Alternative Treatment Option for Heavy Metal Bearing Wastewater: A Review," *Bioresource Technology*, Vol. 53, No. 3, 1995, pp. 195-206. doi:10.1016/0960-8524(95)00072-M
- [49] N. Friis and P. Myers-Keith, " Biosorption of Uranium and Lead by *Streptomyces longwoodensis*," *Biotechnology and Bioengineering*, Vol. 28, No. 1, 1986, pp. 21-28. doi:10.1002/bit.260280105
- [50] D. Sanyahumbi, J. R. Duncan, M. Zhao and R. Vanhile, " Removal of Lead from Solutions by the Non-Viable Biomass of the Water Fern *Azolla filiculoides*," *Biotechnology Letters*, Vol. 20, No. 8, 1998, pp. 745-747. doi:10.1023/A:1005386703592
- [51] Y. Sag and T. Kutsal, " Fully Competitive Biosorption of Chromium (VI) Iron (III) Ions from Binary Metal Mixtures by *Rhizopus arrhizus*: Use of the Competitive Langmuir Model," *Process Biochemistry*, Vol. 31, No. 6, 1996, pp. 573-585. doi:10.1016/S0032-9592(96)00003-9
- [52] J. S. Chang, R. Law and C. Chang, " Biosorption of Lead, Copper and Cadmium by Biomass of *Pseudomonas aeruginosa* PU21," *Water Research*, Vol. 31, No. 7 1997, pp. 1651-1658. doi:10.1016/S0043-1354(97)00008-0
- [53] A. Vecchio, C. Finoli, D. Di Simone and V. Andreoni, " Heavy Metal Biosorption by Bacterial Cells *Fresenius*," *Journal of Analytical Chemistry*, Vol. 361, No. 4, 1998, pp. 338-342. doi:10.1007/s002160050899
- [54] D. H. Cho and E. Y. Kim, " Characterization of Pb<sup>2+</sup> Biosorption from Aqueous Solution by *Rhodotorula glutinis*," *Bioprocess Biosystem Engineering*, Vol. 25, No. 5, 2003, pp. 271-277. doi:10.1007/s00449-002-0315-8
- [55] J. H. Suh, J. W. Yun and D. S. Kim, " Comparison of Pb<sup>2+</sup> Accumulation Characteristics between Live And Dead Cells of *Saccharomyces cerevisiae* and *Aurebasidium pullulans*," *Biotechnology Letters*, Vol. 20, No. 3, 1998, pp. 247-251. doi:10.1023/A:1005373718222
- [56] R. Pardo, M. Herguedas, E. Barrado and M. Veja, " Biosorption of Cadmium, Copper, Lead and Zinc by Inactive Biomass of *Pseudomonas putida*," *Analytical Bioanalytical Chemistry*, Vol. 376, No. 1, 2003, pp. 26-32. doi:10.1007/s00216-003-1843-z
- [57] W. B. Lu, J. J. Shi, C. H. Wang and J. S. Chang, " Biosorption of Lead, Copper and Cadmium by an Indigenous Isolate *Enterobacter* sp. J1 Possessing High Heavy Metal Resistance," *Journal of Hazardous Materials*, Vol. 134, No. 1-3, 2006, pp. 80-86. doi:10.1016/j.jhazmat.2005.10.036
- [58] L. Zhang, L. Zhao, Y. Yu and C. Chen, " Removal of Lead from Aqueous Solution by Nonliving *Rhizopus nigricans*," *Water Research*, Vol. 32, No. 5, 1998, pp. 1437- 1444. doi:10.1016/S0043-1354(97)00348-5
- [59] S. Y. Quek, D. A. J. Wase and C. F. Forster, " The Use of Sago Waste for the Sorption of Lead and Copper," *Water S.A.*, Vol. 24, No. 3, 1998, pp. 251-256.
- [60] O. Keskinan, M. Z. L. Goksu, M. Basibuyuk and C. F. Forster, " Heavy Metal Adsorption Properties of a Submerged Aquatic Plant *Ceratophyllum demersum*," *Bioresource Technology*, Vol. 92, No. 2, 2004, pp. 197-200. doi:10.1016/j.biortech.2003.07.011
- [61] K. J. Tiemann, J. L. Gardea-Torresdey, G. Gamez, K. Dokken and S. Sias, " Use of X-Ray Adsorption Spectroscopy and Esterification to Investigate Chromium(III) and Nickel(II) Ligand in Alfalfa Biomass," *Environmental Science and Technology*, Vol. 33, No. 1, 1999, pp. 150-154. doi:10.1021/es9804722

- [62] B. Mattuschka and G. Straube, " Biosorption of Metals by a Waste Biomass," *Journal of Chemical Technology and Biotechnology*, Vol. 58, No. 1, 1993, pp. 57-63. doi:10.1002/jctb.280580108
- [63] T. J. Beveridge and S. F. Koval, " Binding of Metals to Cell Envelopes of *Escherichia coli* K-12," *Applied Environmental Microbiology*, Vol. 42, No. 2, 1981, pp. 876- 887.
- [64] Y. H. Kim, Y. J. Yoo and H. Y. Lee, " Characteristic of Lead Adsorption by *Undaria pinnatifida*," *Biotechnology Letters*, Vol. 17, No. 3, 1995, pp. 354-350. doi:10.1007/BF01190651
- [65] G. Yan and T. Viraraghavan, " Heavy-Metal Removal from Aqueous Solution by Fungus *Mucor rouxii*," *Water Research*, Vol. 37, No. 18, 2003, pp. 4486-4496. doi:10.1016/S0043-1354(03)00409-3
- [66] Q. Li, S. Wu, G. Liu, X. Liao, X. Deng, D. Sun, Y. Hu and Y. Huang, " Simultaneous Biosorption of Cadmium(II) and Lead(II) Ions by Pretreated Biomass of *Phanerochaete chrysosporium*," *Separation and Purification Technology*, Vol. 34, No. 1-3, 2004, pp. 135-142. doi:10.1016/S1383-5866(03)00187-4
- [67] B. D. Hoyle and T. J. Beveridge, " Metal Binding by the Peptidoglycan Sacculus of *Escherichia coli* K-12," *Canadian Journal of Microbiology*, Vol. 30, No. 2, 1984, pp. 204-211. doi:10.1139/m84-031
- [68] U. Soltmann, S. Matys, G. Kieszig, W. Pompe and H. Böttcher, " Algae-Silica Hybrid Materials for Biosorption of Heavy Metals," *Journal of Water Resource and Protection*, Vol. 2, No. 2, 2010, pp. 115-122. doi:10.4236/jwarp.2010.22013
- [69] M. Galun, E. Galun, B. Z. Siegel, P. Keller, H. Lehr and S. M. Siegel, " Removal of Metal Ions from Aqueous Solution by *Penicillium* Biomass: Kinetics and Uptake Parameters," *Water Air Soil Pollution*, Vol. 33, No. 3-4, 1987, pp. 359-371. doi:10.1007/BF00294204
- [70] C. P. Huang, C. P. Huang and A. L. Morehart, " The Removal of Cu(II) from Dilute Aqueous Solution by *Saccharomyces cerevisiae*," *Water Research*, Vol. 24, No. 4, 1990, pp. 433-439. doi:10.1016/0043-1354(90)90225-U
- [71] R. Say, A. Denizli and M. Y. Arica, " Biosorption of Cadmium(II), Lead(II) and Copper(II) with the Filamentous fungus *Phanerochaete chrysosporium*," *Bioresource Technology*, Vol. 76, No. 1, 2001, pp. 67-70. doi:10.1016/S0960-8524(00)00071-7
- [72] P. Ahuja, R. Gupta and R. K. Saxena, " Zn<sup>2+</sup> Biosorption of *Oscillatoria angustissima*," *Process*