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FEATURED ANALYSIS, September/October 2008

India's New Millennium in Science

by Christopher King, Editor



After several consecutive years of minimal increase through the 1980s and 90s, India's output of scientific papers has risen sharply since 2000. Concurrently, the citation impact of the nation's published research in main fields has been trending upward in recent years.

To assess India-based science, *Science Watch* turned to the Thomson Reuters database *National Science Indicators* and its collection of publication and citation statistics. The first [graph\(1\)](#) records the number of papers indexed by Thomson Reuters for each year between 1985 and 2007 that listed at least one India-based institution among the author addresses. In 1985, the number was approximately 12,500, and for the next 15 years the total never much exceeded 14,000. Around the year 2000, however, the number began to tick upwards, rising to nearly 17,000 in 2001, reaching 20,000-plus in 2003, and winding up at more than 27,000 in 2007.



Currently, India's largest percent share of any main field indexed by Thomson Reuters is in the Multidisciplinary category (comprising papers published in the multidisciplinary journals *Science*, *Nature*, *PNAS*, etc.), with 5.47% of papers in that field indexed in the cumulative five-year period between 2003 and 2007. Close behind is Materials Science, in which India's 9,212 papers in the last five years constitute 5.45% of the field.

Materials Science, in fact, is the field in which India displays the steepest growth in representation during the period covered by *National Science Indicators*. In 1981, only 432 Thomson Reuters-indexed materials papers included an India institutional address—3.68% of the field. In 2007, nearly 2,300 papers with India-based authors were indexed, a share of 6.13%.

India's share of world papers, in the latest five-year period, was also comparatively high in Agricultural Sciences (5.17% of the database), Chemistry (5.04%), and Physics (3.88%).

Physics, as it happens, features prominently in the next set of [graphs\(2\)](#), which plot the nation's relative citation impact (that is, India's citations-per-paper average compared against the world average in each respective field) in 14 main fields in a series of overlapping periods from 1985 through 2007.

In the top [graph\(2\)](#), which covers the physical sciences, India's upward trend in Physics is clearly discernible. For the latest five-year period, ending in 2007, India's relative-impact score stands at 80% of the field average (3.13 cites per paper, versus the world mark of 3.96)—a substantial improvement over the 1985-89 period, when India's relative impact in Physics was at 40%, less than half the world average. In the same graph, India's impact in Engineering and in Chemistry are also trending upward and approaching parity with the world mark.

The other graphs tell a similar story: although the impact of India-based research lags the world average in the fields shown, the nation has been on a discernible upswing since roughly the year 2000, with notable

gains in, for example, [Geosciences](#)(3), [Neurosciences](#)(4), and Biology & Biochemistry.

For another snapshot of India's current concentration in science, *Science Watch* consulted Thomson Reuters' *Essential Science Indicators* web resource and its unique database of Research Fronts—specialty areas defined by a "core" of foundational papers that have been frequently cited together by a group of subsequent reports.



Ashoke Sen

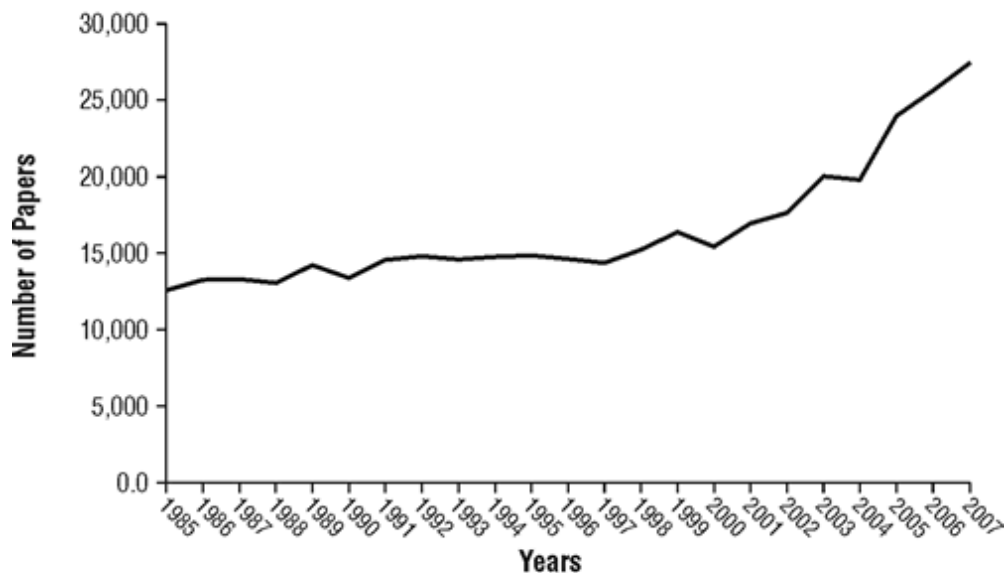
Science Watch identified upwards of 250 Research Fronts in which India-based institutions figured among the core literature. The majority of these fronts, conforming to the trends noted above, fall within the physical sciences. As it happens, the Research Front displaying the highest proportion of Indian institutions among its core papers is devoted to black holes and related aspects involving entropy, supersymmetry, and string theory. An author whose name recurs among the core papers is [Ashoke Sen](#) of the Harish-Chandra Research Institute in Allahabad, who was interviewed in these pages last year (*Science Watch*, 18[3]: 3-4, [May/June 2007](#)). Sen's name also figures among the core authors in another of the most India-centric fronts—this one devoted to tachyon cosmology.

In sum, all but three of the top ten Research Fronts with the highest representation of India institutions concern high-energy or theoretical physics. The exceptions are one front dealing with the adsorptive removal of dyes and other hazardous materials from aqueous solutions (see Research Front [Map 1](#)), another devoted to the study of stress caused by water deficit and salinity in *Catharanthus roseus* and other plants (see Research Front [Map 2](#)), and a third centering on conducting polymers and their use in biosensors.

Still another aspect of India's progression since the early 1980s involves the nation's increasing presence in international science. In 1981, more than 95% of Thomson Reuters-indexed papers from India featured authors exclusively at India-based institutions, with no other nations listed. By 2007, the percentage of "India only" papers had fallen to 80%, indicating that, albeit gradually thus far, the nation is moving toward greater participation in world science. ■

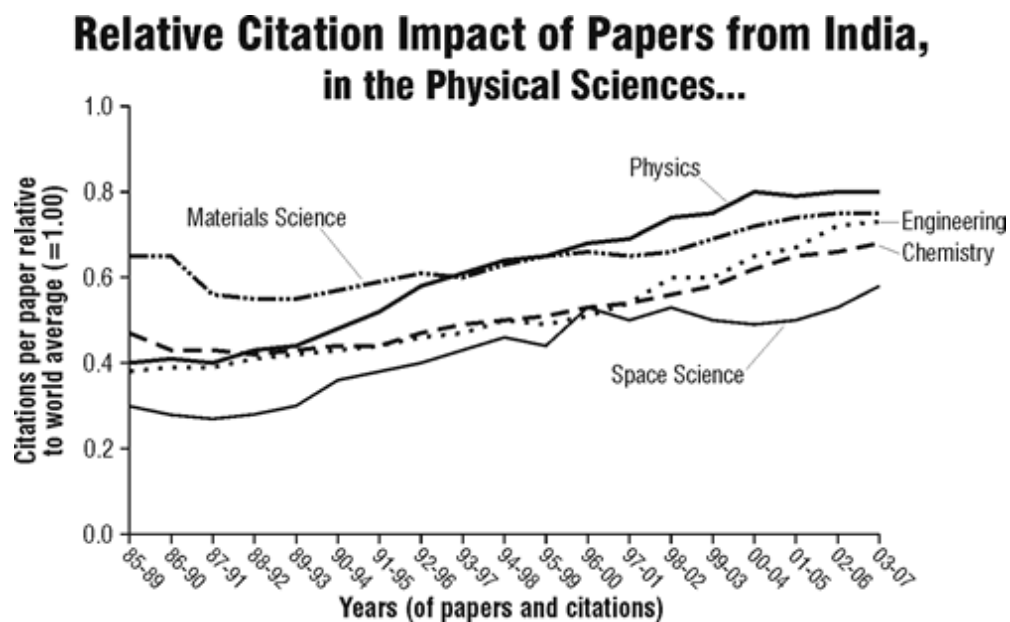
Graph 1 [[back](#)]

Annual Paper Output Since 1985

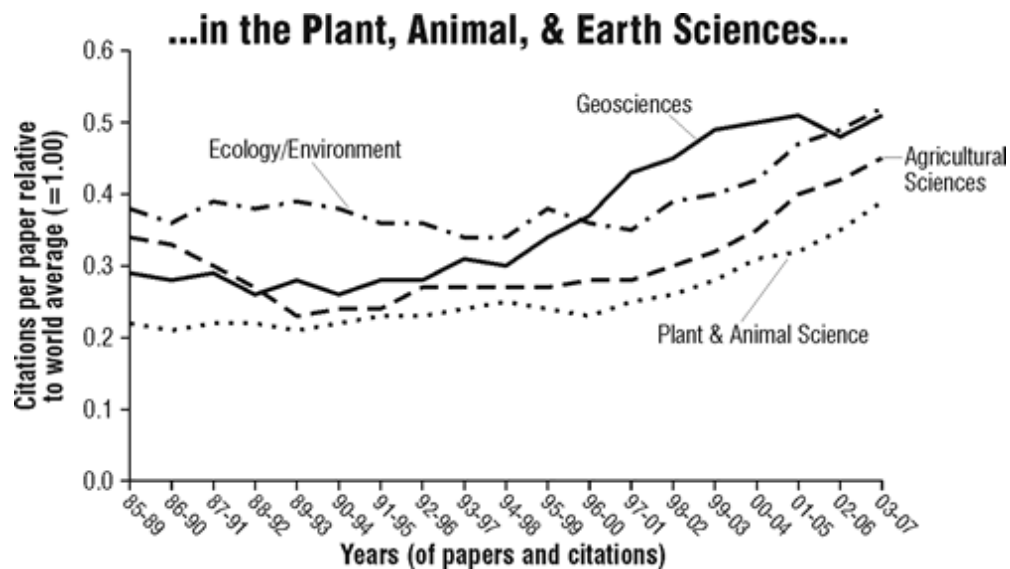


SOURCE: Thomson Reuters National Science Indicators

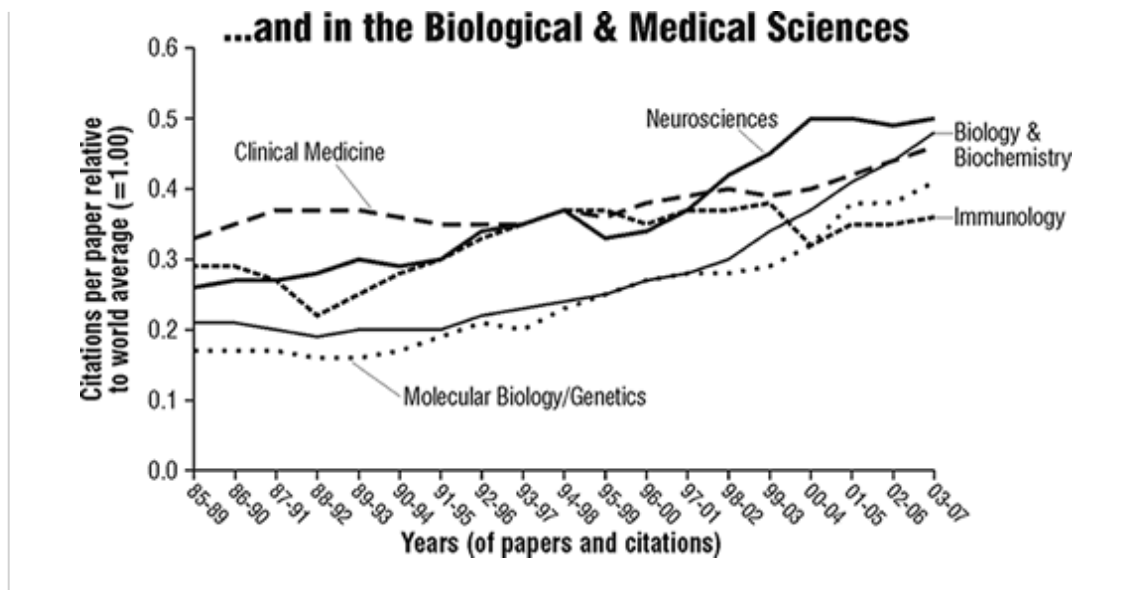
Graph 2 [back]



Graph 3 [back]



Graph 4 [back]



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Keywords: India, science in India, research in India, Indian science, Ashoke Sen.

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[Interviews](#)[Analyses](#)[Data & Rankings](#)Analyses : [Featured Analyses](#) : [India's New Millennium in Science - Research Front Map 1](#)**RESEARCH FRONT MAP****India's New Millennium in Science**

Research front maps are diagrammatic representations of the core papers comprising each front. They are selected from the current Research Front set that are relevant to the featured topic. Each circle represents a highly cited paper whose bibliographic information is displayed when the user clicks on the circle. The solid lines between circles represent the strongest co-citation links for each paper (that is, indicating that the papers are frequently cited together); weaker links are indicated by dashed lines. Papers close to each other on the map are generally more highly co-cited. The most recent paper(s) are indicated in pink.

This Research Front contains 25 core papers based on the keywords:

AQUEOUS SOLUTIONS USING CARBON AEROGEL; AQUEOUS SOLUTION USING SYZYGIUM CUMINI L; CADMIUM REMOVAL; ADSORPTION KINETICS; ADSORPTIVE REMOVAL.

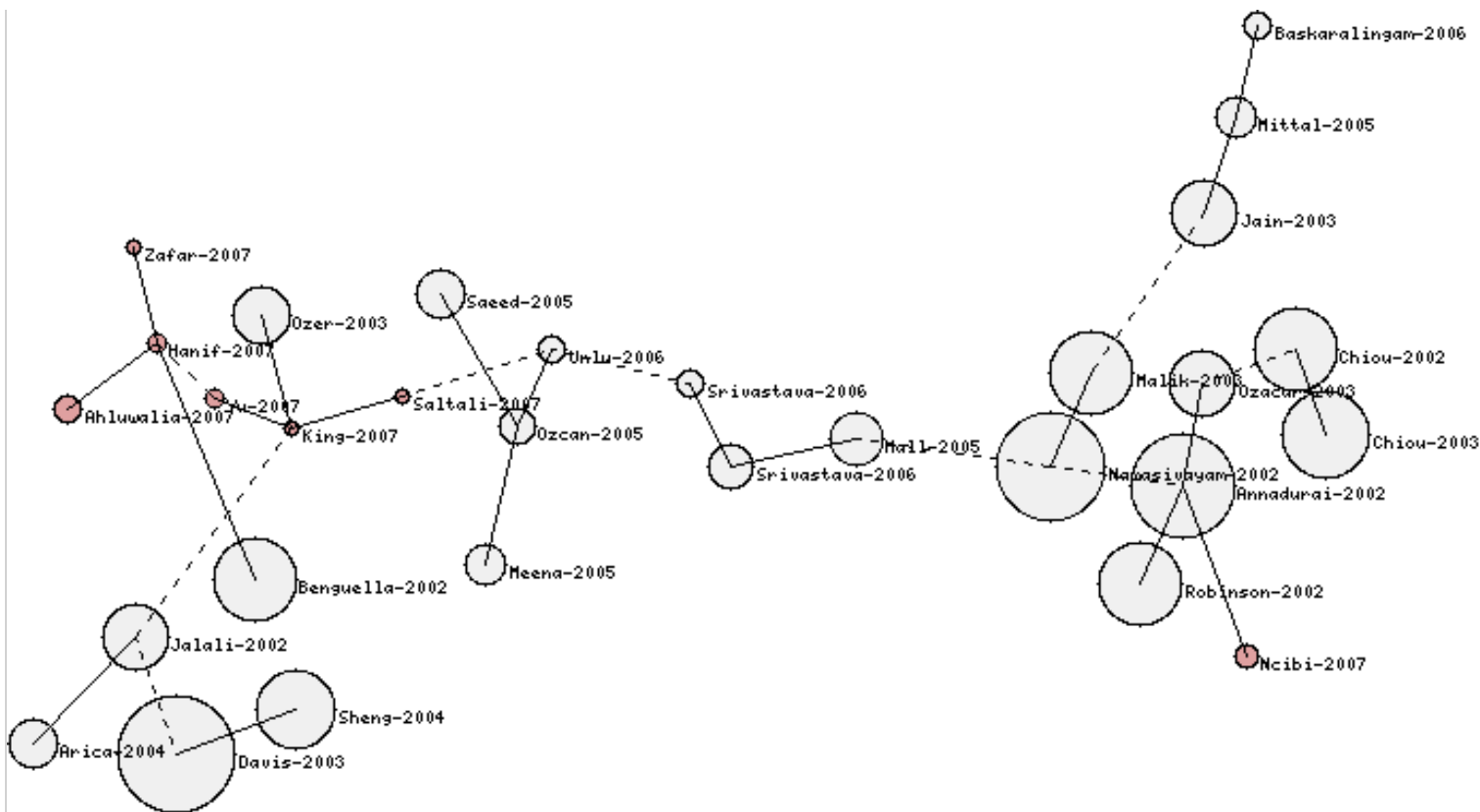
The papers were from the fields of Biology & Biochemistry, Chemistry, Engineering, and Environment/Ecology. Source dates: 1998-April 30, 2008 (second bimonthly period 2008).

Note: For best results use the "landscape orientation" option when printing this page.

Research Front Map 1

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Core Papers

Label: Davis-2003

Title: A review of the biochemistry of heavy metal biosorption by brown algae

Journal: WATER RES, 37 (18): 4311-4330 NOV 2003

Citations: 168

Authors: Davis, TA;Volesky, B;Mucci, A

Addresses:

McGill Univ, Dept Earth & Planetary Sci, 3450 Univ St, Montreal, PQ H3A 2A7, Canada

McGill Univ, Dept Earth & Planetary Sci, Montreal, PQ H3A 2A7, Canada

McGill Univ, Dept Chem Engr, Montreal, PQ H3A 2B2, Canada

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Label: Namasivayam-2002

Title: Removal of Congo Red from water by adsorption onto activated carbon prepared from coir pith, an agricultural solid waste

Journal: DYE PIGMENT, 54 (1): 47-58 JUL 2002

Citations: 147

Authors: Namasivayam, C;Kavitha, D

Addresses:

Bharathiar Univ, Dept Environm Sci, Environm Chem Lab, Coimbatore 641046, Tamil Nadu, India

Bharathiar Univ, Dept Environm Sci, Environm Chem Lab, Coimbatore 641046, Tamil Nadu, India

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Label: Annadurai-2002

Title: Use of cellulose-based wastes for adsorption of dyes from aqueous solutions

Journal: J HAZARD MATER, 92 (3): 263-274 JUN 10 2002

Citations: 135

Authors: Annadurai, G;Juang, RS;Lee, DJ

Addresses:

Yuan Ze Univ, Dept Chem Engr, Chungli 320, Taiwan

Yuan Ze Univ, Dept Chem Engr, Chungli 320, Taiwan

Natl Taiwan Univ, Dept Chem Engr, Taipei 106, Taiwan

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Label: Chiou-2003

Title: Adsorption behavior of reactive dye in aqueous solution on chemical cross-linked chitosan beads

Journal: CHEMOSPHERE, 50 (8): 1095-1105 MAR 2003

Citations: 101

Authors: Chiou, MS;Li, HY

Addresses:

Natl Lien Ho Inst Technol, Dept Chem Engr, Miaoli 36003, Taiwan

Natl Lien Ho Inst Technol, Dept Chem Engr, Miaoli 36003, Taiwan

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Label: Malik-2003

Title: Use of activated carbons prepared from sawdust and rice-husk for adsorption of acid dyes: a case study of Acid Yellow 36

Journal: DYE PIGMENT, 56 (3): 239-249 MAR 2003

Citations: 93

Authors: Malik, PK

Addresses:

Jadavpur Univ, Dept Chem, Ctr Surface Sci, Calcutta, W Bengal, India
Jadavpur Univ, Dept Chem, Ctr Surface Sci, Calcutta, W Bengal, India

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Label: Benguella-2002

Title: Cadmium removal from aqueous solutions by chitin: kinetic and equilibrium studies

Journal: WATER RES, 36 (10): 2463-2474 MAY 2002

Citations: 89

Authors: Benguella, B;Benaissa, H

Addresses:

Univ Tlemcen, Lab Mat Sorbants & Traitement Eaux, Fac Sci, Dept Chim, BP 119, Tilimsen 13000, Algeria

Univ Tlemcen, Lab Mat Sorbants & Traitement Eaux, Fac Sci, Dept Chim, Tilimsen 13000, Algeria

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Label: Robinson-2002

Title: Removal of dyes from a synthetic textile dye effluent by biosorption on apple pomace and wheat straw

Journal: WATER RES, 36 (11): 2824-2830 JUN 2002

Citations: 86

Authors: Robinson, T;Chandran, B;Nigam, P

Addresses:

Univ Ulster, Sch Biomed Sci, Coleraine BT52 1SA, Londonderry, North Ireland

Univ Ulster, Sch Biomed Sci, Coleraine BT52 1SA, Londonderry, North Ireland

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Label: Chiou-2002

Title: Equilibrium and kinetic modeling of adsorption of reactive dye on cross-linked chitosan beads

Journal: J HAZARD MATER, 93 (2): 233-248 JUL 22 2002

Citations: 85

Authors: Chiou, MS;Li, HY

Addresses:

Natl Lien Ho Inst Technol, Dept Chem Engn, Miaoli 36003, Taiwan

Natl Lien Ho Inst Technol, Dept Chem Engn, Miaoli 36003, Taiwan

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Label: Sheng-2004

Title: Sorption of lead, copper, cadmium, zinc, and nickel by marine algal biomass: characterization of biosorptive capacity and investigation of mechanisms

Journal: J COLLOID INTERFACE SCI, 275 (1): 131-141 JUL 1 2004

Citations: 82

Authors: Sheng, PX;Ting, YP;Chen, JP;Hong, L

Addresses:

Natl Univ Singapore, Dept Chem & Biomol Engrn, 10 Kent Ridge Crescent, Singapore 119260, Singapore

Natl Univ Singapore, Dept Chem & Biomol Engrn, Singapore 119260, Singapore

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Label: Ozacar-2003

Title: Adsorption of reactive dyes on calcined alunite from aqueous solutions

Journal: J HAZARD MATER, 98 (1-3): 211-224 MAR 17 2003

Citations: 61

Authors: Ozacar, M;Sengil, IA

Addresses:

Sakarya Univ, Sci & Arts Fac, Dept Chem, TR-54100 Sakarya, Turkey

Sakarya Univ, Sci & Arts Fac, Dept Chem, TR-54100 Sakarya, Turkey

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Label: Jain-2003

Title: Utilization of industrial waste products as adsorbents for the removal of dyes

Journal: J HAZARD MATER, 101 (1): 31-42 JUL 4 2003

Citations: 57

Authors: Jain, AK;Gupta, VK;Bhatnagar, A;Suhas

Addresses:

Indian Inst Technol, Dept Chem, Roorkee 247667, Uttar Pradesh, India

Indian Inst Technol, Dept Chem, Roorkee 247667, Uttar Pradesh, India

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Label: Jalali-2002

Title: Removal and recovery of lead using nonliving biomass of marine algae

Journal: J HAZARD MATER, 92 (3): 253-262 JUN 10 2002

Citations: 55

Authors: Jalali, R;Ghafourian, H;Asef, Y;Davaranpanah, SJ;Seppehr, S

Addresses:

Atom Energy Org Iran, Nucl Res Ctr, Dept Biotechnol, Tehran, Iran

Atom Energy Org Iran, Nucl Res Ctr, Dept Biotechnol, Tehran, Iran
Univ Alzahra, Dept Biol, Tehran, Iran

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Label: Ozer-2003

Title: Comparative study of the biosorption of Pb(II), Ni(II) and Cr(VI) ions onto S-cerevisiae: determination of biosorption heats

Journal: J HAZARD MATER, 100 (1-3): 219-229 JUN 27 2003

Citations: 43

Authors: Ozer, A;Ozer, D

Addresses:

Univ Mersin, Dept Chem Engn, TR-33343 Ciftlikkoy, Mersin, Turkey

Univ Mersin, Dept Chem Engn, TR-33343 Ciftlikkoy, Mersin, Turkey

Firat Univ, Dept Chem Engn, Elazig, Turkey

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Label: Mall-2005

Title: Removal of congo red from aqueous solution by bagasse fly ash and activated carbon: Kinetic study and equilibrium isotherm analyses

Journal: CHEMOSPHERE, 61 (4): 492-501 OCT 2005

Citations: 38

Authors: Mall, ID;Srivastava, VC;Agarwal, NK;Mishra, IM

Addresses:

Indian Inst Technol, Dept Chem Engn, Roorkee 247667, Uttar Pradesh, India

Indian Inst Technol, Dept Chem Engn, Roorkee 247667, Uttar Pradesh, India

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Label: Saeed-2005

Title: Removal and recovery of lead(II) from single and multimetal (Cd, Cu, Ni, Zn) solutions by crop milling waste (black gram husk)

Journal: J HAZARD MATER, 117 (1): 65-73 JAN 14 2005

Citations: 32

Authors: Saeed, A;Iqbal, M;Akhtar, MW

Addresses:

Biotechnol & Food Res Ctr, Environm Biotechnol Grp, PCSIR Labs Complex, Lahore 54600, Pakistan

Biotechnol & Food Res Ctr, Environm Biotechnol Grp, Lahore 54600, Pakistan

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