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ACADEMIC INFORMATION

Ph.D (Experimental Sciences and Sustainability), 2013

- Department of Chemistry, Universitat de Girona, Spain
  Dissertation title: Arsenic and its speciation analysis in biological and environmental samples using ICP techniques

Post Graduation (MSc in Chemistry), 2008

- Department of Chemistry, University of Kalyani, India

Graduation (BSc in Chemistry), 2006

- Department of Chemistry, Kanchrapara College, University of Kalyani, India

Higher Secondary, 2002

- Julien Day School, Indian Certificate of Secondary Education (ICSE) Board

Secondary, 2000

- Julien Day School, Indian Certificate of Secondary Education (ICSE) Board

RESEARCH EXPERIENCE

- **DST INSPIRE Faculty & Assistant Professor, AcSIR** at CSIR – National Environmental Engineering Research Institute (NEERI) (October, 2020 – continuing)
- **DST INSPIRE Faculty** at CSIR – National Environmental Engineering Research Institute (NEERI) (May, 2016 – October, 2020).
- **Postdoctoral fellow** in Department of Chemistry, University of Kalyani, Kalyani, West Bengal, India (October, 2015 – May, 2016)
- **Research Associate** at Environmental and Chemical Sciences, Qatar Environment and Energy Research Institute (QEERI), QATAR FOUNDATION, Doha, Qatar. (May, 2015 – August, 2015).
- **Consultant** at Environmental and Chemical Sciences, Qatar Environment and Energy Research Institute (QEERI), QATAR FOUNDATION, Doha, Qatar. (March, 2014 – June, 2014).

- **Research Fellow** in Department of Chemistry, University of Kalyani, Kalyani, West Bengal, India (April, 2009 – August, 2010).

RESEARCH INTEREST

- ***Groundwater research:*** Natural contamination of groundwater resources in India and sustainable mitigation measures
- ***Medical Geology:*** Assessment of geogenic contaminant exposure and associated health risk
- ***Environmental Nanotechnology:*** low cost eco-friendly nanoparticles applications for remediation of groundwater contaminants.

RESEARCH / CONSULTANCY PROJECTS

1. "Risk assessment from multi-metal exposure for the population in arsenic affected areas of West Bengal, India and possible mitigation strategy" funded by Department of Biotechnology (DBT), Govt. of India.
   Project Cost: Rs. 45,00,000; Duration: June, 2018 – January, 2022. Role: PI

2. "An investigation of the reduction and abatement of arsenic and other heavy metals (Pb, Cd, Cu, Cr, Ni) from aqueous solution using nano zero-valent iron" funded by Department of Science and Technology (DST), Govt. of India (under INSPIRE Faculty program).
   Project Cost: Rs. 35,00,000; Duration: May, 2016 – March, 2022. Role: PI

3. "Process and Performance Evaluation of Arsenic and Iron Removal Plant of AdEdge India Water Technologies Pvt. Ltd. Installed At Sayestanagar Gram Panchayat-II, North 24 Parganas, West Bengal" funded by AdEdge India Water Technologies Pvt. Ltd
   Project Cost: Rs. 6,49,000 (inclusive of 18% GST); Duration: November, 2017 – December, 2018. Role: PI

4. "Training Programme for Laboratory Personnel & District Consultant on Water Quality Testing and Analysis" funded by PHED, Govt. of West Bengal
   Project cost: Rs. 8,45,824 (inclusive of 18% GST) Duration: March, 2019 – June, 2020. Role: PI

STUDENTS & PhD SUPERVISION

- Ms. Payel Singh

Doctoral Student, Academy of Scientific and Innovative Research (AcSIR) (In progress)
PhD Title: Sulphur amended nano zerovalent iron for groundwater remediation of inorganic aqueous contaminants

- Mr. Arijit Chakraborty

Project Assistant in DBT funded project

- Ms. Bratisha Biswas

Project Assistant in DBT funded project

TEACHING EXPERINCE & COURSES TAUGHT

- Assistant Professor, AcSIR: CSIR- NEERI (PhD course work)

  PHY(NEERI)-1-3801: Analytical & Instrumentation Techniques for Environment

  PHY(NEERI)-2-3802: Environmental Chemistry & Toxicology

- Guest Faculty: University of Kalyani, Department of Chemistry (Analytical Chemistry specialization; Post Graduate level)

  CHEM-SA-42 Unit 1: Basic instrumentation for analytical tools

FACILITIES ESTABLISHED

- Customized Glove-box for controlled air reaction system at CSIR-NEERI
- Coordinated the installation and laboratory set up of ICP-MS and Laser Ablation in Qatar Foundation
- Coordinated the installation of AAS in University of Kalyani

COURSES THAT I CAN OFFER:

- Introduction to Environmental Sciences
- Environmental Chemistry & toxicology
- Environmental Pollution
- Advanced Analytical Techniques for Environmental Application
- Environmental Impact Assessment
- Environmental Health & Risk Assessment

AWARDS AND FELLOWSHIP

- **DST-INSPIRE Faculty Award,** awarded by Department of Science and Technology, Govt. of India. February 2016.
- **Erasmus Mundus Doctoral Scholarship**, awarded by European Commission's Erasmus Mundus External Cooperation Window (EMECW- Lot 13) - EURINDIA. 2010-2013
- **Research Fellowship** in a project entitled `` Biomarkers of arsenic exposure and assessment of risks of arsenic in drinking water in Nadia District, India´´ in Department of Chemistry, University of Kalyani funded by Trehan Foundation, University of Michigan. 2008-2010.

PUBLICATIONS

- ***Peer reviewed journal article:***

  - Biswas, B., Chakraborty, A., Chatterjee, D., Pramanik, S., Ganguli, B., Majumdar, K.K., Nriagu, J., Kulkarni, K.Y., Bansiwal, A., Labhasetwar, P., **Bhowmick, S*.** Arsenic exposure from drinking water and staple food (rice): A field scale study in rural Bengal for assessment of human health risk. ***Ecotoxicology and Environmental Safety*** 2021, 228, 113012.

  - Singh P., Pal P., Mondal P., Saravanan G., Nagababu P., Majumdar S., Labhsetwar N., **Bhowmick S*.** Kinetics and mechanism of arsenic removal using sulfide - modified nanoscale zerovalent iron. ***Chemical Engineering Journal,*** 2021, 412 128667.

  - Nagababu, P., Ahmed, S.A.M., Prabhu, Y.T., Kularkar, A., **Bhowmick, S.,** Rayalu, S.S. Synthesis of Ni_2P/CdS and Pt/TiO_2 nanocomposite for photoreduction of CO_2 into methanol. ***Scientific Reports***, 2021, 11, 8084.

  - Roy, S., Bhowmick, K., Singh, P., **Bhowmick, S.,** Mukherjee, M., Majumdar, S., Sahoo, G.C., Mondal, P. Removal of heavy metals by surface tailored copper ion enhanced ceramic-supported-polymeric composite nanofiltration membrane. ***Journal of Environmental Chemical Engineering*** 2021, 9, 106368.

  - Chakraborty, A., Ghosh, S., Biswas, B., Pramanik, S., Nriagu, J., **Bhowmick. S***. Epigenetic modifications from arsenic exposure: A comprehensive review. ***Science of the Total Environment*** 2021, 810, 151218.

  - Moulick D., Samanta S., Sarkar S., Mukherjee A., Pattnaik BK., Saha S., Awashi J.P., **Bhowmick S**., Ghosh D., Samal A.C., Mahanta S., Mazumder M.K., Choudhury S., Bramhachari K., Biswas J.K., Santra S.C. Arsenic contamination, impact and mitigation strategies in rice agro-environment: An inclusive insight. ***Science of the Total Environment***, 2021, 800, 149477.

  - Roy S., Majumdar S., Sahoo G.C., **Bhowmick S.,** Kundu A.K., Mondal P. Removal of As (V), Cr (VI) and Cu (II) using novel amine functionalized composite nanofiltration membranes fabricated on ceramic tubular substrate. ***Journal of Hazardous Materials,*** 2020, 399, 122841.

  - Mandal U., Singh P., Kundu AK., Chatterjee D., Nriagu J., **Bhowmick S*.** Arsenic retention in cooked rice: Effects of rice type, cooking water, and indigenous cooking methods in West Bengal, India. ***Science of the Total Environment*** 2019, 648, 720–727.

  - Kundu AK., Majumder S., Biswas A., **Bhowmick S.,** Pal C., Mukherjee A., Majumder M., Chatterjee D. Optimisation of laboratory arsenic analysis for groundwaters of West Bengal, India and possible water testing strategy. ***International Journal of Environmental Analytical Chemistry*** 2018, 98, 440 – 452.

  - **Bhowmick S*.,** Pramanik S., Singh P., Mondal P., Chatterjee D., Nriagu J. Arsenic in groundwater of West Bengal, India: A review of human health risks and assessment of possible intervention options. ***Science of the Total Environment*** 2018, 612, 148-169.

- **Bhowmick S*.,** Kundu A., Adhikari J., Chatterjee D., Iglesias M., Nriagu J., Guha Mazumder D.N., Shomar B., Chatterjee D. Assessment of toxic metals in groundwater and saliva in an arsenic affected area of West Bengal, India: A pilot scale study. ***Environmental Research*** 2015, 142, 328–336.

- Mondal, P., **Bhowmick, S.**, Jullok, N., Ye, W., Van Renterghem, W., Van den Berghe, S., Van der Bruggen, B. Behaviour of As (V) with ZVI-H2O system and the reduction to As (0). ***Journal of Physical Chemistry C*,** 2014, 118, 21614–21621.

- **Bhowmick S.**, Chakraborty S., Mondal P., Van Renterghem W., Van den Berghe S., Roman-Ross G., Chatterjee D., Iglesias M. Montmorillonite-supported nanoscale zero-valent iron for removal of arsenic from aqueous solution: Kinetics and mechanism. ***Chemical Engineering Journal,*** 2014, 243, 14-23.

- **Bhowmick S.,** Halder D., Nriagu J., Guha Mazumder D.N., Roman-Ross G., Chatterjee D., Iglesias M. Speciation of arsenic in saliva samples from a population of West Bengal, India. ***Environmental Science & Technology***, 2014, 48, 6973–6980.

- **Bhowmick S.**, Halder D., Kundu A. K., Saha D., Iglesias M., Nriagu J., Guha Mazumder D. N., Roman-Ross G., Chatterjee D. Is saliva a potential biomarker of arsenic exposure? A case-control study in West Bengal, India. ***Environmental Science & Technology***, 2013, 47, 3326−3332.

- Mondal P., **Bhowmik S.**, Chatterjee D., Figoli A., Van der Bruggen B. Remediation of inorganic arsenic in groundwater for safe water supply: a critical assessment of technological solutions. ***Chemosphere***, 2013, 92, 157–170.

- Halder D., **Bhowmick S.**, Biswas A., Chatterjee D., Nriagu J., Guha Mazumdar D. N., Šlejkovec Z., Jacks G., Bhattacharya P. Risk of arsenic in exposure from drinking water and dietary components: Implications for risk management in rural Bengal. ***Environmental Science & Technology,*** 2013, 47, 1120–1127.

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- Halder D., **Bhowmick S.**, Biswas A., Mandal U., Nriagu J., Guha Mazumdar D. N., Chatterjee D., Bhattacharya P. Consumption of brown rice: A potential pathway for arsenic exposure in rural Bengal. ***Environmental Science & Technology***, 2012, 46, 4142-4148.

- Biswas A., Majumder S., Neidhardt H., Halder D., **Bhowmick S.**, Mukherjee – Goswami A., Kundu A., Saha D., Berner, Z., Chatterjee, D. Groundwater chemistry and redox processes: depth dependent arsenic release mechanism. ***Applied Geochemistry***, 2011, 26, 516-525.

- Chatterjee D., Halder D., Majumder S., Biswas A., Nath B., Bhattacharya P., **Bhowmick S.**, Mukherjee-Goswami A., Saha D., Hazra R., Maity P. B., Chatterjee D., Mukherjee A., Bundschuh J. Assessment of arsenic exposure from groundwater and rice in Bengal Delta region, West Bengal, India. ***Water Research***, 2010, 44, 5803-5812.

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- ***Peer reviewed book chapters:***

1. Majumder S., Biswas A., Neidhardt H., Sarkar S., Berner Z., **Bhowmick S.**, Mukherjee A., Chatterjee D., Chakraborty S., Nath B., Chatterjee D. An insight into the spatio-vertical heterogeneity of dissolved arsenic in part of the Bengal Delta Plain aquifer in West Bengal (India). In ***Safe and Sustainable Use of Arsenic Contaminated Aquifers in the Gangetic Plain: A Multidisciplinary Approach***; Ramanathan, A.L., Eds.; Spinger and Capital Publishing Company: New Delhi; 2015, 161-177.

2. Chatterjee D., Majumder S., Biswas A., Halder D., **Bhowmick S.**, Chatterjee D., Mukherjee- Goswami A., Jana J., Saha D., Kundu A. K., Sarkar S. Arsenic in Grondwater of Young Bengal Delta Plain of India: It's Distribution and Geochemistry. In ***Memoir 1 – Applied Geochemistry: Groundwater Quality Evaluation and Control***; Das, S., Saha D., Eds.; Indian Society of Applied Geochemistry: Hyderabad; 2012, 170-185.

3. Bhattacharya P., Jacks G., Nath B., Chatterjee D., Biswas A., Halder D., Majumder S., **Bhowmick S.**, Ramanathan A. L. Natural arsenic in coastal groundwaters in the Bengal Delta region in West Bengal, India. In ***Management and Sustainable Development of Coastal Zone Environment;*** Ramanathan, A.L., Bhattacharya, P., Dittmar, T., Prasad, M.B.K. Neupane, B.R. Eds.; Spinger and Capital Publishing Company: New Delhi; 2010, 146-160.

- ***Article in Conference Proceedings:***

1. **Bhowmick S**., Chatterjee, D., Mondal, P., Chakraborty, S., Iglesias, M. (2016) Montmorillonite supported nZVI: A novel adsorbent for arsenic removal from aqueous solution. In: P. Bhattacharya, M. Vahter, J. Jarsjo, J. Kumpiene, A. Ahmad, C. Sparrenbom, G. Jacks, M.E. Donselaar, J. Bundschuh, R. Naidu (eds.) "Arsenic Research and Global Sustainability, As 2016". Interdisciplinary Book Series: "Arsenic in the Environment-Proceedings". Series Editors: J. Bundschuh and P. Bhattacharya, Publisher: CRC Press/Balkema, Taylor and Francis (ISBN 978-1-138-02941-5), p. 510-511.

2. Kundu A. K., Biswas A., **Bhowmick S.,** Chatterjee D., Mukherjee A., Neidhardt H., Berner Z., Bhattacharya P. (2016) Variation of arsenic in shallow aquifers of the Bengal Basin: Controlling geochemical processes. In: P. Bhattacharya, M. Vahter, J. Jarsjo, J. Kumpiene, A. Ahmad, C. Sparrenbom, G. Jacks, M.E. Donselaar, J. Bundschuh, R. Naidu (eds.) "Arsenic Research and Global Sustainability, As 2016". Interdisciplinary Book Series: "Arsenic in the Environment-Proceedings".

Series Editors: J. Bundschuh and P. Bhattacharya, Publisher: CRC Press/Balkema, Taylor and Francis (ISBN: 978-1-138-02941-5), p. 52-53.

3. **Bhowmick S.**, Halder D., Chatterjee D., Nriagu J., Guha Mazumder DN., Bhattacharya P., Iglesias M. (2014). Saliva as a biomarker of arsenic exposure. In: M I. Litter, H B. Nicolli, M Meichtry, N Quici, J Bundschuh, P Bhattacharya, R Naidu (eds.) *"One Century of the Discovery of Arsenicosis in Latin America (1914-2014) As 2014". Interdisciplinary Book Series: "Arsenic in the Environment—Proceedings"*. Series Editors: Jochen Bundschuh and Prosun Bhattacharya, CRC Press/Taylor and Francis (ISBN-13: 9781138372634), pp. 540-542.

4. Chatterjee D., Nath B., Chakraborty S., Majumder S., Biswas A., **Bhowmick S.,** Halder D., Mondal P., Kundu A., Saha D., Barman S., Biswas U., Saha I., Das A., Sarkar S., Chatterjee D. (2013). Groundwater arsenic in the fluvial Bengal plains: geochemistry and mitigation. Procedia Earth and Planetary Science, 7, 143-146.

5. Chatterjee D., Majumder S., Biswas A., Sarkar S., Kundu A. K., Mukherjee A., **Bhowmick S**., Roman-Ross G., Chatterjee D., Neidhardt H., Berner Z. (2012). Spatial heterogeneity of arsenic in a deltaic groundwater environment of West Bengal, India. In: J.C. Ng, B. N. Noller, R. Naidu, J. Bundschuh & P. Bhattacharya (eds.) "Understanding the Geological and Medical Interface of Arsenic, As 2012". Interdisciplinary Book Series: "Arsenic in the Environment-Proceedings". Series Editors: J. Bundschuh and P. Bhattacharya, CRC Press/Balkema, Taylor and Francis (ISBN-13: 978-0-415-63763-3), p. 65-66.

6. **Bhowmick S.**, Nath B., Halder D., Chakraborty S., Chatterjee D. (2012). Groundwater arsenic chemistry and redox process comparison in three physiographic settings of deltaic West Bengal, India. In: J.C. Ng, B. N. Noller, R. Naidu, J. Bundschuh & P. Bhattacharya (eds.) *"Understanding the Geological and Medical Interface of Arsenic, As 2012". Interdisciplinary Book Series: "Arsenic in the Environment—Proceedings"*. Series Editors: Jochen Bundschuh and Prosun Bhattacharya, CRC Press/Taylor and Francis (ISBN-13: 978-0-415-63763-3), pp. 54-56.

7. Halder, D., Biswas, A., Bhattacharya, P., **Bhowmick, S.**, Mandal, U., Chatterjee, D., Nriagu, J. (2012). Arsenic exposure and non-cancer health risk from consumption of brown rice in rural Bengal, India. In: J.C. Ng, B. N. Noller, R. Naidu, J. Bundschuh & P. Bhattacharya (eds.) *"Understanding the Geological and Medical Interface of Arsenic, As 2012"*. Interdisciplinary Book Series: *"Arsenic in the Environment—Proceedings"*. Series Editors: Jochen Bundschuh and Prosun Bhattacharya, CRC Press/Taylor and Francis (ISBN-13: 978-0-415-63763-3), pp. 505-507.

8. Chatterjee D., Biswas A., **Bhowmick S.**, Halder D., Hazra R., Majumder S., Mukherjee-Goswami A., Saha D., Nath B. (2010) Geochemistry of arsenic in Bengal Delta Plain (West Bengal, India). In: J.-S. Jean, J. Bundschuh & P. Bhattacharya (eds.) *"Arsenic in Geosphere and Human Diseases, As 2010"*. Interdisciplinary Book Series: *"Arsenic in the Environment—Proceedings"*. Series Editors: Jochen Bundschuh and Prosun Bhattacharya, CRC Press/Taylor and Francis (ISBN-13: 978-0-415-57898-1), pp. 125-126.

REFERENCES

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Ecotoxicology and Environmental Safety 228 (2021) 113012

Contents lists available at ScienceDirect

Ecotoxicology and Environmental Safety

journal homepage: www.elsevier.com/locate/ecoenv

Arsenic exposure from drinking water and staple food (rice): A field scale study in rural Bengal for assessment of human health risk

Bratisha Biswas [a], Arijit Chakraborty [a], Debashis Chatterjee [b], Sreemanta Pramanik [a], Bhaswati Ganguli [c], Kunal Kanti Majumdar [d], Jerome Nriagu [e], Ketki Y. Kulkarni [f], Amit Bansiwal [f,h], Pawan Labhasetwar [g,h], Subhamoy Bhowmick [a,h,*]

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A R T I C L E I N F O

Edited by Richard Handy

Keywords:
Arsenic
Rice
Drinking water
Exposure assessment
Cancer risk

A B S T R A C T

Arsenic is a well-known carcinogen with emerging reports showing a range of health outcomes even for low to moderate levels of exposure. This study deals with arsenic exposure and associated increased lifetime cancer risk for populations in arsenic-endemic regions of rural Bengal, where arsenic-safe drinking water is being supplied at present. We found a median total exposure of inorganic arsenic to be 2. 9 μg/Kg BW/day (5th and 95th percentiles were 1.1 μg/Kg BW/day and 7.9 μg/Kg BW/day); with major contribution from cooked rice intake (2.4 μg/Kg BW/day). A significant number of households drank arsenic safe water but used arsenic-rich water for rice cooking. As a result, 67% participants had inorganic arsenic intake above the JEFCA threshold value of 3 μg/Kg BW/day for cancer risk from only rice consumption when arsenic contaminated water was used for cooking (median: 3.5 μg/Kg BW/day) compared to 29% participants that relied on arsenic-free cooking water (median: 1.0 μg/kg BW/day). Arsenic in urine samples of study participants ranged from 31.7 to 520 μg/L and was significantly associated with the arsenic intake ($r = 0.76$); confirming the preponderance of arsenic exposure from cooked rice. The median arsenic attributable cancer risks from drinking water and cooked rice were estimated to be 2.4×10^{-5} and 2.7×10^{-4} respectively, which further emphasized the importance of arsenic exposure from staple diet. Our results show that any mitigation strategy should include both drinking water and local staple foods in order to minimize the potential health risks of arsenic exposure.

1. Introduction

The notion that arsenic-contaminated water is the primary source of arsenic exposure is being continuously challenged by new reports which document high levels of arsenic exposure from foodstuff (Signes-Pastor et al., 2016; Islam et al., 2017; Cubadda et al., 2017; Upadhyay et al., 2019; Menon et al., 2020). In fact, arsenic exposure from food can be an important source even when arsenic content in drinking water is minimal (Halder et al., 2013; Kurzius-Spencer et al., 2014; Mondal et al., 2021). Due to global food trade, the accumulation of arsenic in agricultural crops produced in arsenic contaminated areas represents a significant health risk to the importing countries (Shraim, 2017; Menon et al., 2020). To safeguard the security of the global food chain, new guidelines on arsenic content of food are now being set-up by regulatory authorities (FAO Food and Agriculture Organization, 2014). For example, the European Commission has now set a maximum permissible limit for inorganic arsenic of 200 μg/Kg for polished rice, 250 μg/Kg for parboiled or husked rice and 100 μg/Kg for rice intended to produce infant or baby foods (European Commission (EC), 2015).

In India, naturally occurring arsenic in alluvial sediments and

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https://doi.org/10.1016/j.ecoenv.2021.113012
Received 16 May 2021; Received in revised form 2 October 2021; Accepted 17 November 2021
Available online 24 November 2021

Chemical Engineering Journal 412 (2021) 128667

Contents lists available at ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Kinetics and mechanism of arsenic removal using sulfide-modified nanoscale zerovalent iron

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ARTICLE INFO

Keywords:
Sulfidation
Nano zerovalent iron
Arsenic
Kinetics
Removal mechanism

ABSTRACT

Sulphur modified nano zerovalent iron (S–nZVI) has shown considerable promise for removal of various aqueous contaminants. However studies utilizing S–nZVI for removal of aqueous inorganic arsenic (As) is relatively rare, which was studied in this work. Characterization of the synthesized S–nZVI showed typical core-shelled structure with distorted outer shell consisting of iron oxide and FeS. The removal rate of both As(III) and As(V) by S–nZVI was considerably enhanced compared to nZVI and highest As removal was observed at S/Fe ratio of 0.1 under acidic condition. Results showed slight decrease in As removal efficiencies for S–nZVI aged upto 48 h, with obvious drop in As removal efficiencies for longer aging time which although still exhibited higher reactivity than bare nZVI. Spectroscopic investigation showed sulphur amendment of nZVI completely altered the As sequestration mechanism compared to nZVI. While reduction of the adsorbed As(III) and As(V) was observed for bare nZVI, in contrast, uptake of As(III) and As(V) by S–nZVI involves adsorption as As(III) and As(V) oxyanion respectively with additional precipitation of As_2S_3. Overall, the study shows that incorporation of FeS on the surface of nZVI can be an effective modification strategy for efficient sequestration of As from contaminated water.

1. Introduction

Arsenic (As) is a naturally occurring metalloid that is omnipresent in the nature [1,2]. The geogenic contamination of As in groundwater have severely compromised the quality of water thereby endangering the lives of millions of people who are being exposed so such poison [2,3]. This is of particular concern for the rural populations of developing countries such as India, Bangladesh, Vietnam, Cambodia etc where the populations are severely dependent upon groundwater for drinking and cooking purposes [2,4]. Long term intake of As via drinking water results in severe health implications including cancers [5,6]. As a result, WHO and various environmental protection agencies have imposed a stringent maximum permissible limit of 10 μgL^{-1} in drinking water [7].

Several technologies are being used for As removal from water and includes coagulation-filtration, membrane separation, ion-exchange and adsorption [8; references therein]. Among these various technologies, adsorption is widely preferred for its simplicity and stable operations, compactness, lack of added reagents, and cost effectiveness [9]. In the last two decades, nanoscale zerovalent iron (nZVI) has received great attention owing to its high reactivity to effectively remove a wide spectrum of water contaminants, including As [10]. Arsenic is removed from aqueous solution by adsorption onto the outer iron oxide layer of nZVI by forming a strong surface complex [11,12] and/or by co-precipitation with iron hydroxide formed in-situ from iron corrosion [13,14]. However, although effective in contaminant removal, nZVI has several limitations, particularly particle agglomeration due to inherent magnetism and high surface energy, and surface passivation owing to formation of thick surface oxide layer by reaction with water [15]. As a result, a number of countermeasures are being researched to overcome these limitations, which includes a range of physical and chemical

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https://doi.org/10.1016/j.cej.2021.128667
Received 21 October 2020; Received in revised form 18 January 2021; Accepted 20 January 2021
Available online 26 January 2021
1385-8947/

scientific reports

OPEN

Synthesis of Ni_2P/CdS and Pt/TiO_2 nanocomposite for photoreduction of CO_2 into methanol

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It is a great challenge to convert thermochemically stable CO_2 into value-added products such as CH_4, CH_3OH, CO via utilizing solar energy. It is also a difficult task to develop an efficient catalyst for the reduction of CO_2. We have designed and synthesized noble metal-free photocatalytic nanostructure Ni_2P/CdS and Pt/TiO_2 for conversion of CO_2 to methanol in the presence of sacrificial donor triethylamine (TEA) and hydrogen peroxide. The synthesised catalysts physicochemical properties were studied by using several spectroscopic techniques like; XRD, UV-DRS, XPS, TEM, SEM and PL. Quantification of methanol by GC–MS showed encouraging results of 1424.8 and 2843 µmol g^{-1} of catalyst for Pt/TiO_2 and 5 wt% Ni_2P/CdS composites, respectively. Thus, Ni_2P/CdS is a promising catalyst with higher productivity and significant selectivity than in-vogue catalysts.

From the past few decades, substantial changes have been witnessed in the atmosphere due to the burning of fossil fuels[1] leading to an increase in the demand for renewable energy[2]. Also, the natural resources of fossil fuels are decreasing day by day, thus increasing the demand for an alternate source of energy[3,4]. At present, much of our energy demands are met by fossil fuel, but this resource is not a renewable source and is associated with contemporary environmental issues. Thus, renewable sources of energy shall play a critical role in fulfilling the requirement of energy demand[5]. More efforts have been focused on substituting renewable biomass sources for chemicals and fuels, which possess high energy density and environmentally friendly properties[6]. Mixing alcohol with petroleum products increases the fuel's combustion efficiency due to oxygen and reduces the emission of pollutants into the atmosphere[7,8]. The regular trend for methanol synthesis uses syngas conversion with high pressure and high thermal energy with heterogeneous catalytic reaction over alumina supported Cu/ZnO catalyst[9]. In the petrochemical industry, the production of methanol from CO_2 reduction an important achievement. In this research area, efforts are continuing to increase the selectivity for methanol by reverse-water–gas-shift (RWGS) reaction in thermal catalytic CO_2 hydrogenation via Cu/ZnO-based catalyst. The great challenge in this reaction is to maintain the operating temperature and pressure. Due to the competing RWGS reaction, the exothermic nature of methanol synthesis, equilibrium-limited conversion, and the very high activation energy barrier of the CO_2 hydrogenation to methanol reaction, the process must balance operation temperature megapascal pressures to achieve high selectivity and production rate[10,11]. Fujishima first reported the photocatalysis study in 1972; in recent years, it's become a common word in chemistry and also various technology products[12]. The theoretical target is to get chemical energy by using light energy with semiconductor materials. The electron present on the conduction band gets activated and migrates to the valance band of the semiconductor with the holes in the conduction band. Thus, the charge carriers facilitate the reaction wherein the electrons react with dissolved CO_2 present in the reactant stream[13]. The reduction of CO_2 is mainly depending on the highly reducing electron, which has a high reduction ability to convert CO_2 into useful methanol[14]. As per Gibb's free energy values, the CO_2 and methanol having − 394.4 and − 166.4 kJ/mol energy indicating that the reduction of CO_2 is an exothermic reaction[15]. Many processes are used for the conversion of CO_2 into methanol such as (1) chemical conversion method, (2) electrochemical conversion method, (3) photochemical reduction method and (4) photoelectrochemical reduction method (Eq. 1).

$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O \quad \Delta H_{298} = -49.51 \text{ kJ/mol} \tag{1}$$

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Science of the Total Environment 648 (2019) 720–727

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Arsenic retention in cooked rice: Effects of rice type, cooking water, and indigenous cooking methods in West Bengal, India

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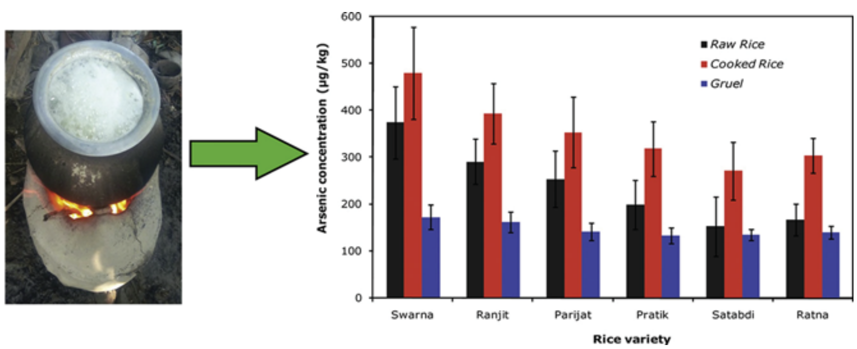
HIGHLIGHTS

- Paired raw and cooked rice prepared by individual households was assessed.
- Cooking with arsenic-rich groundwater elevated cooked rice arsenic concentration.
- The habit of drinking gruel heightened the arsenic risk for the local communities.
- Arsenic in raw rice and cooking water influence arsenic accumulation in cooked form.
- Use of low-arsenic water for cooking alleviates arsenic exposure from cooked rice.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 11 April 2018
Received in revised form 10 August 2018
Accepted 13 August 2018
Available online 15 August 2018

Editor: Xinbin Feng

Keywords:
Arsenic
Raw rice
Cooking practice
Cooked rice
Safe water

ABSTRACT

This study evaluated the concentration of arsenic in paired raw and cooked rice prepared by individual households in arsenic-endemic rural area of West Bengal. The aim was to investigate how the cooking habits of rural villagers of West Bengal might influence the arsenic content of rice meals. It was found that the use of arsenic-rich groundwater for cooking could elevate the arsenic concentration in cooked rice (up to 129% above the raw sample), thereby enhancing the vulnerability of the rural population of West Bengal to arsenic exposure through rice consumption. The risk is heightened by the habit of drinking the stewed rice water (gruel) in the local communities. The cooking method employed, rice variety, background arsenic concentration in raw rice and cooking water arsenic concentration were found to be important predisposing factors that could affect the accumulation of arsenic in cooked form. The fundamental indigenous cooking practice followed by the villagers requires use of low-arsenic water for cooking as a necessary strategy to alleviate arsenic exposure in their staple food.

1. Introduction

Human civilization has encountered the poisonous effect of arsenic for thousands of years (Nriagu, 2002; Cullen, 2008). Arsenic exposure above certain dosage can result in a wide array of health conditions which includes hematological, endocrine, cardiovascular, renal, hepatic,

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https://doi.org/10.1016/j.scitotenv.2018.08.172
0048-9697/

Science of the Total Environment 612 (2018) 148–169

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Review

Arsenic in groundwater of West Bengal, India: A review of human health risks and assessment of possible intervention options

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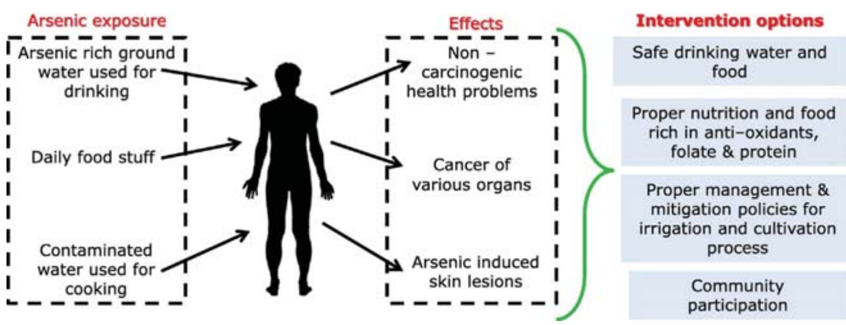
HIGHLIGHTS

- Arsenic poisoning is wide spread in West Bengal and millions of people are at risk.
- Exposure routes are many and are intertwined with the lifestyle of the people.
- Various intervention options to address the arsenic crisis are critically discussed.
- Universal mitigation model may not suite the vast area contaminated with arsenic.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 15 May 2017
Received in revised form 15 August 2017
Accepted 20 August 2017
Available online xxxx

Editor: D. Barcelo

Keywords:
Sustainable management
Groundwater
Rice
Biomarkers
Mitigation

ABSTRACT

This paper reviews how active research in West Bengal has unmasked the endemic arsenism that has detrimental effects on the health of millions of people and their offspring. It documents how the pathways of exposure to this toxin/poison have been greatly expanded through intensive application of groundwater in agriculture in the region within the Green Revolution framework. A goal of this paper is to compare and contrast the similarities and differences in arsenic occurrence in West Bengal with those of other parts of the world and assess the unique socio-cultural factors that determine the risks of exposure to arsenic in local groundwater. Successful intervention options are also critically reviewed with emphasis on integrative strategies that ensure safe water to the population, proper nutrition, and effective ways to reduce the transfer of arsenic from soil to crops. While no universal model may be suited for the vast areas of the world affected with by natural contamination of groundwater with arsenic, we have emphasized community-specific sustainable options that can be adapted. Disseminating scientifically correct information among the population coupled with increased community level participation and education are recognized as necessary adjuncts for an engineering intervention to be successful and sustainable.

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http://dx.doi.org/10.1016/j.scitotenv.2017.08.216
0048-9697/