Journey for Sustainable Development and Peace Journal
Vol 3 Issue 1 February 2025 ISSN:2976-1328(Online)
www.jsdp.org.np, www.nepjol.info/index.php/jsdpj 2976-1360(Print)

Needed Strategies to Negate a Poisoned Challis: Arsenic Mitigation in Bangladesh

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DOI: https://doi.org/10.3126/jsdpj.v3i1.75566

Abstract

The arsenic contamination of groundwater in Bangladesh, first detected in 1993, remains a significant public health crisis, affecting millions of people. Despite decades of mitigation efforts, including interventions from the government, international agencies, and NGOs, arsenic contamination persists, particularly in rural areas. The crisis, which has led to chronic arsenic poisoning and various health issues, calls for more effective, sustainable solutions. This paper reviews the current state of arsenic contamination in Bangladesh, highlighting the complex hydrogeological conditions and the demographic impact of this issue. The approach focuses on the use of accessible arsenic testing kits, responsible utilization of deep arsenic-free aquifers, and affordable, locally manufactured water treatment technologies. This strategy aims to empower local stakeholders and provide self-reliant, scalable solutions to mitigate arsenic exposure, promoting health and sustainability in rural communities. The proposed solutions are designed to be adaptable to other arsenic-affected regions in South Asia, offering a model for addressing the arsenic crisis in resource-constrained environments.

Keywords: Arsenic, Bangladesh, South Asia, potable-water, mitigation

To Cite this article:
Khandaker, N. R., Rahman, M. M., & Rafiq, S. (2025). Needed Strategies to Negate a Poisoned Challis: Arsenic Mitigation in Bangladesh. *Journey for Sustainable Development and Peace Journal*, *3*(1), 22–35. https://doi.org/10.3126/jsdpj.v3i1.75566

Introductory statement: The Arsenic Crisis Today in Contemporary Bangladesh

Alas, it has been many a decade since the arsenic contamination of groundwater came to the forefront in Bangladesh. Though the road to arsenic hell was paved with good intentions by international agencies and the Government Wings of Bangladesh responsible for safe water supply, the poisoned challis is being passed on to the next generation. It is time to take stock and provide solutions that are manageable and sustainable. Donor dependency must be negated and time that Bangladeshi's take stock and ownership of safe water supply in the hands of local stakeholders. After the August revolution when Bangladesh youths threw away the shackles of slavery and foreign dominance, it is high time the water community followed suit and threw away the shekels of water autocracy. Safe water is a right of franchise for every Bangladesh citizen. Self-reliant solutions are the domain of choice fostering sustainable solutions. After three decades of failed policies in the water sector since the advent of the arsenic crisis, we are still reliant on the sixties-era solution of dependency on groundwater for irrigation and potable water. Technology and Bangladesh society have moved on to support fundamentally more appropriate solutions that do not rely solely on the deep aquifer to provide arsenic-safe drinking water.

The economy of the nation has developed along with the growth of the technologies available for treatment or proper hydrogeological databases to make informed technology options to mitigate arsenic contamination and its associated public health crisis. Sadly, as is the case with most international agency-driven initiatives, the arsenic public health crisis is on the back burner as the international focus shifts to more topical issues. Who cares that millions in Bangladesh, Nepal, and India are still consuming arsenic-contaminated water? Time we the people care. This paper gives the background to the arsenic issue in Bangladesh with a focus on updating the real situation at the present time frame and to analyze technical solutions that can easily be implemented that are sustainable and locally reproducible. A solution by the stakeholders for the stakeholders.

Background

The arsenic contamination of groundwater in Bangladesh

The mortality rate from diarrheal diseases and cholera was historically very high in Bangladesh. To reduce the burden of diarrheal diseases and lower mortality, the government installed over 10 million private borehole wells with hand pumps across the country since 1970 (BGS & DPHE, 2001). The initiative to use groundwater as a safe, bacteria-free water source was successful until 1993 when the Department of Public Health and Engineering (DPHE) detected the first case of arsenic contamination in Chapai Nawabganj. A nationwide survey conducted by the British Geological Survey (BGS) and DPHE revealed that over 35 million people in Bangladesh were consuming groundwater with arsenic concentrations exceeding the government's standard of 50 µg/L. This number rose to 57 million when considering the World Health Organization's (WHO) more stringent guideline of 10 µg/L (BGS & DPHE, 2001).

More recent estimates indicate that about 30 million people are still exposed to arsenic contamination under the Bangladesh Drinking Water Standard (BDWS), which increases to 50 million when applying the WHO limit. In response, the government, along with local and international NGOs, has introduced various mitigation strategies, including disinfected surface water, rainwater harvesting, deep groundwater sources, and household and community-level arsenic removal filters. However, despite these efforts, the overall situation of groundwater arsenic contamination in Bangladesh has not significantly improved.

Hydrogeology of the arsenic contamination in Bangladesh

Bangladesh's hydrogeology of groundwater arsenic contamination is complex and multifaceted due to its regional geology and hydrology. Bangladesh comprises a large part of the Bengal basin. The Bengal basin accumulated an enormous thickness of sediments (~15 km) originating from the Himalayan and Indo-Burman Mountain ranges (Uddin & Lundberg, 1998). The Ganges-Brahmaputra-Meghna River system gradually developed one of the largest delta complexes commonly known as the Ganges-Brahmaputra-Meghna (GBM) Delta, which makes a significant part of the Bengal Basin. The sediments in the GBM Delta formed the most productive aquifer systems. The aquifers in the GBM delta are the main drinking water source for the people of Bangladesh (Acharyya et al., 1999; BGS & DPHE, 2001; Ravenscroft et al., 2005). The overall pattern of arsenic contamination in Bangladesh is heterogenous in nature even though distinct regional patterns can be seen with the highest number of contaminated wells in the south and south-eastern part and the lowest number of contaminated wells found in the uplifted areas and north-west and north-central part of Bangladesh (BGS & DPHE, 2001). The heterogeneity of groundwater arsenic contamination in Bangladesh comes from the sporadic areas of high arsenic-contaminated wells in the less affected regions and low arsenic-containing wells in the more affected regions.

Also, there is a significant amount of variation in As levels between borehole wells in the affected villages, indicating the heterogeneity of groundwater arsenic contamination in Bangladesh(Ahmed et al., 2004; BGS & DPHE, 2001; Sarkar et al., 2002; Van Geen et al., 2003). The vertical distribution of groundwater arsenic concentrations also shows a heterogenetic pattern (Fig. 1). Arsenic contamination occurs mainly at the depth range between 10 m to 150 m. Arsenic levels at depths greater than 150 m fall within the WHO and Bangladesh guideline values of 10 μg/L and 50 μg/L, respectively (Figure 1). Borehole wells within 150 m depth are generally considered shallow, and wells installed at greater than 150 m depth are considered as deep (Sarkar et al., 2002). However, a recent article suggested that wells at an intermediate depth range of 120 m can be used for arsenic mitigation in Bangladesh, as wells in this depth range contain arsenic and manganese within the WHO and Bangladesh guideline values (Hossain et al., 2023).

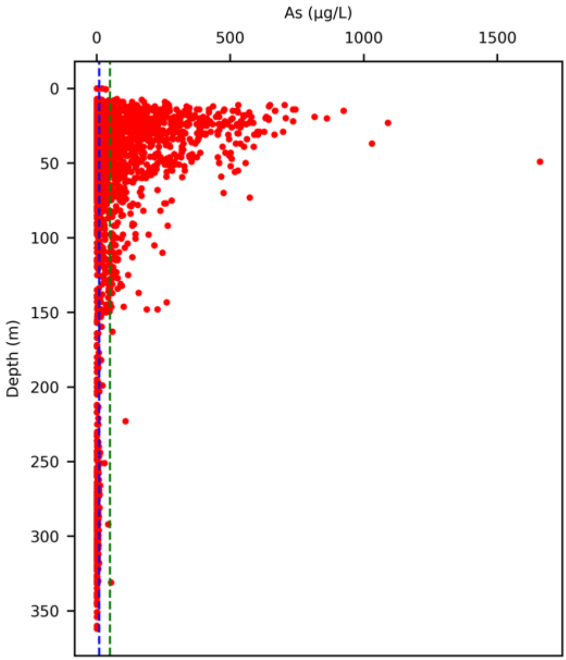

Figure 1: Vertical distribution of groundwater arsenic level in borehole wells in Bangladesh. The blue and green dashed lines represent the WHO and Bangladesh guideline values, respectively. Data source (BGS & DPHE, 2001).

Demography of the affected population at present

On the onset of the arsenic mitigation efforts when the crisis came to light national and international agencies reported that around seventy million people were affected with chronic arsenic poisoning at the potable water threshold limit of 50.00 µg/L. Mortality due to arsenic poisoning through the ingestion of arsenic-contaminated water is well documented in Bangladesh (Rashid & Khandaker, 2007) with annual death rates till today over 24, 000 reported in scientific literature (Flanagan et al., 2012). Chronic arsenic consumption through potable water is associated with and forms of skin and organ cancers (Guha Mazumder, 2008). So normal disease mortality may actually be attributed to chronic arsenic consumption and yet not correlated to arsenic poisoning. Thus, the arsenic public health crisis may actually persist in the population.

Although, a recent government estimation report around 20 million people in Bangladesh are using potable water groundwater with over 50 ppb of arsenic, in essence highlighting the mitigation efforts and their successes to date. But if one considers the more stringent and widely accepted limit of 10.00 µg/L it is estimated that upwards of 30 million are affected (Pearshouse, 2016). The WHO limit of 10.00 µg/L for low-concentration arsenic exposure through ingestion is linked to inflammation and DNA damage (Dutta et al., 2015). Addressing this crisis, a burden to our collective societies in resource-challenged regions of the world in particular South Asia requires a comprehensive strategy based on sustainable initiatives that are stakeholder-specific and can easily be implemented within the budget constraint that exists.

Sustainable Mitigation Options

Introduction to Sustainable Mitigation Options

Decades of institutionalized success and failures are more often than not sustainable failures we need to strategies a mitigation strategy that will be sustainable and community-based, more importantly, is a mitigation option that communities can comprehend and sustain. The mitigation strategy at the grassroots level should encompass:

a. Supporting of testing of wells for arsenic and demarcation at the grass roots village level.
b. Identifying arsenic-safe aquifers at every locality based on existing data base generated over the past thirty years.
c. Promotion of simple arsenic filters at the grassroots level with training for fabrication at the village level.
d. Alternate water sources and use of simple microbial filters to be fabricated at the local level.
e. Arsenic network cells at every village level for testing, training, and awareness raising.

The subsequent discussion will elucidate the points put forth above that will foster the development of a self-reliant sustainable community-based arsenic mitigation strategy required for rural Bangladesh. The strategic plan put forth is evidence-based and should be modified based on the norms of the stakeholders in other regions of South Asia suffering from the cure of arsenic poisoning of the groundwater.

Testing as a mitigation option

The first line of defense to tackle the arsine crisis is the identification and demarcation of arsenic-safe wells, noting down the depth of the well. The available instrument that can be used at the rural level is the field test kit. These kits have the ability to simply measure arsenic levels in the well water (Khandaker, 2004; Tonmoy et al., 2016), in average the kits can measure 100 samples at a cost of around US $ 80 per kit. This kit can support the testing of wells in a cluster of villages (a ward's smallest elected administrative administrator), and the village secondary school science teacher can be trained easily to conduct the test. Every well that will be installed would be required to get the well tested for arsenic and designated arsenic safe or not, certification issued to be attested by the local word council, ensuring proper a mandated arsenic-safe water point a simple but effective public health measure.

Safe wells periodically need to be retested to ensure that with time and anthropogenic activities, the wells remain safe. This should be done annually for the arsenic-safe wells. Also, every opportunity should be made to foster the sharing of arsenic-safe well water and the precious resource that arsenic-safe well water is to the community is to be emphasized. The arsenic-safe well waters should be dedicated as potable water drinking points and the stakeholders should be discouraged from using the arsenic-safe well water for other non-critical purposes other than cooking and drinking water. The groundwater strategy as a source of potable water remains the same but with prudence through arsenic testing.

Responsible utilization of the deep arsenic-free aquifer

In Bangladesh, borehole wells serve as the primary means of accessing drinking water (Hossain et al., 2023). The withdrawal of water from shallow aquifers for irrigation purposes played a pivotal role in driving Bangladesh's green revolution. However, extensive irrigation relying on these aquifers has disrupted the natural flow patterns (Michael & Voss, 2008) and introduced organic material from agricultural lands into the groundwater. This process facilitates the breakdown of iron oxides under reducing conditions, leading to the release of arsenic into shallow aquifer systems (Harvey et al., 2002). Deep aquifers (greater than 150 m depth) are generally free from arsenic contamination due to protective clay layers. However, these confining layers are not uniformly distributed across the region. As a result, over-extraction of water from deep aquifers could cause arsenic migration from contaminated shallow layers to deeper, previously uncontaminated zones (Mihajlov et al., 2020). To prevent such cross-contamination and promote sustainable use, the extraction of water from deep aquifers should be restricted to drinking purposes only.

Sustainable treatment options

Over the years, various technologies have been developed to remove arsenic and provide safe drinking water in regions affected by arsenic contamination, particularly in areas where surface water is either unavailable or polluted. The technology is based on adsorption, coagulation, ion exchange, and membrane filtration (Rafiq et al., 2024a, Khandaker et al., 2020). They could be a singular mechanism or in combination of multiple mechanisms. The challenge is to provide a technology that is viable, sustainable, and cost-effective keeping in mind a particular stakeholder group. Both the water quality matrix and the affordability of a particular population are paramount.

It is essential to take into account the financial and social conditions of the rural communities in Bangladesh and the broader South Asian region. The technology can be off the shelf with an ideal situation of local manufacture with a locally supported material supply chain. Keeping in mind local sustainability metal oxide and mixed metal oxide technologies fit the form. Adsorption-based technologies can easily be applied in rural settings and can be supported by locally available materials. Metal oxides of iron, aluminum, and even calcium can serve as sites for arsenic adsorption and hence metal oxide and mixed metal oxide-based filer media applications in rural settings are ideal (Khandaker, 2004; Khandaker & Seto, 2010; Sahil Rafiq et al., 2024). Ferric and aluminum-based metal salts can be crystalized and sun-dried and then used as adsorption media for arsenic filters. Even better is the use of mixed metal oxides such as calcium and iron oxide-based coagulation filtration systems, where the filter media can be cores or fine sand. Similarly, when groundwater contains dissolved iron, simple air oxidation followed by sand filtration can remove arsenic and provide drinking water free from arsenic contamination (Neidel et al., 2006; Rafiq et al., 2024b).

Vermiculite-based surface-coated media can also serve as arsenic and other contaminant removal filters. Even a common ceramic filter can be combined with a coagulating agent to make an effective arsenic removal filter. Sustainable technology is available for the rural people affected by arsenic in Bangladesh, what is required is initiative, interjection of technology and evaluation of the efficacy of the arsenic removal systems based on field trials in arsenic-affected areas of Bangladesh.

Sustaining local initiatives through micro-financing or social business format

No more is the reliance on international donor-dependent projects. Projects die when donors lose interest and the rural marginalized people of Bangladesh and other South Asian countries suffer. In the new model of existence, we need to sustain water initiatives through self-reliant financing. An excellent model would be the micro-financing of rural stakeholders to set up small water companies to provide safe water or to manufacture and sell arsenic filters that are home-based. Micro-financing organizations such as German Bank or other microfinancing Banks can be enticed to foster rural mum-and-pop water companies. Moreover, major business organizations could be encouraged to back social business initiatives aimed at delivering safe water to rural areas affected by arsenic contamination in Bangladesh. What could be more fitting than a solution crafted for rural communities by national enterprises?

Challenges and future insights on arsenic mitigation

The primary challenge lies in developing and sustaining rural-based projects over the long term, particularly in resource-constrained environments. This research aims to offer practical, evidence-based solutions tailored to these challenges (Rafiq et al., 2024c, Rafiq et al., 2024e; Rafiq & Khandaker, 2024). Future efforts must prioritize sustainable mitigation techniques that address critical environmental and public health issues, such as arsenic contamination in groundwater. Identifying geologically favorable formations with arsenic-free water is essential for ensuring safe and reliable water supplies in rural areas.

Further research should focus on leveraging locally available materials to design cost-effective, sustainable technologies. For instance, utilizing indigenous resources in filtration and treatment systems can reduce costs and enhance community acceptance. Exploring innovative techniques for arsenic removal, wastewater treatment, and water reuse can create integrated solutions that align with local needs.

Sustainability also depends on fostering community participation, establishing effective policies, and strengthening supply chains for local materials (Haque et al., 2024). This holistic approach will bridge the gap between research innovation and practical application, ensuring long-term success. Future research must expand beyond technical solutions to incorporate socio-economic and policy frameworks, enabling resource-efficient and scalable interventions for arsenic-free and sustainable water systems in rural settings.

Conclusion

Arsenic contamination in drinking water remains a critical issue in Bangladesh, Nepal, and West Bengal, India, despite decades of mitigation efforts. Chronic exposure to arsenic has severe health consequences, including cancer and DNA damage. First identified in 1993, surveys revealed over 35 million people in Bangladesh consume water exceeding the national arsenic limit of 50 µg/L, with this number rising to 57 million under the stricter WHO guideline of 10 µg/L. Efforts like surface water use, rainwater harvesting, deep aquifers, and filtration systems have had limited impact. The hydrogeology of Bangladesh complicates mitigation. Shallow aquifers (10–150 m) are most affected, while deeper aquifers (>150 m) generally meet safety standards. Intermediate-depth wells (around 120 m) offer a promising solution, with manageable levels of arsenic and manganese. While the number of affected people has dropped significantly—from 70 million to 20–30 million—the crisis persists, causing over 24,000 deaths annually and contributing to widespread, underdiagnosed health issues.

The paper advocates for a sustainable, grassroots-driven solution. Key strategies include testing wells, identifying safe aquifers using existing data, promoting simple arsenic filters, and training communities in filter fabrication and water treatment. Establishing arsenic network cells at the village level for testing, awareness, and training is also recommended. These community-focused measures aim to empower local populations to tackle the crisis effectively. By building on past experiences, this approach seeks to address arsenic contamination sustainably, saving lives and ensuring long-term water safety. The three zeroes of zero carbon emission, zero poverty, and zero unemployment, to that, add zero people drinking arsenic-contaminated water thereby decreasing poverty and also fostering employment through social business fostering local water companies. This goal is not only apropos to Bangladesh but applies to all other South Asian Countries.

Conflict of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Acharyya, S. K., Chakraborty, P., Lahiri, S., Raymahashay, B. C., Guha, S., & Bhowmik, A. (1999). Arsenic poisoning in the Ganges delta. *Nature*, *401*(6753), 545–545. https://doi.org/10.1038/44052

Ahmed, K. M., Bhattacharya, P., Hasan, M. A., Akhter, S. H., Alam, S. M. M., Bhuyian, M. A. H., Imam, M. B., Khan, A. A., & Sracek, O. (2004). Arsenic enrichment in groundwater of the alluvial aquifers in Bangladesh: An overview. *Applied Geochemistry*, *19*(2), 181–200. https://doi.org/10.1016/j.apgeochem.2003.09.006

BGS & DPHE. (2001). Final Report. Arsenic contamination of groundwater in Bangladesh, vol. 2. In: Kinniburgh, D.G., Smedley, P.L. (Eds.), Brit. Geol. Surv. (BGS) Technical Report WC/00/19. British Geological Survey, Keyworth.

Bhattacharya, P., Chatterjee, D., & Jacks, G. (1997). Occurrence of arsenic-contaminated groundwater in alluvial aquifers from delta plains, eastern India: Options for safe drinking water supply. Water Resources Development,13(1),79–92.Scopus. https://doi.org/10.1080/07900629749944

Dutta, K., Prasad, P., & Sinha, D. (2015). Chronic low level arsenic exposure evokes inflammatory responses and DNA damage. *International Journal of Hygiene and Environmental Health*, *218*(6), 564–574. https://doi.org/10.1016/j.ijheh.2015.06.003

Flanagan, S., Johnston, R., & Zheng, Y. (2012). Arsenic in tube well water in Bangladesh: Health and economic impacts and implications for arsenic mitigation. *Bulletin of the World Health Organization*, *90*(11), 839–846. https://doi.org/10.2471/BLT.11.101253

Guha Mazumder, D. N. (2008). Chronic arsenic toxicity & human health. *The Indian Journal of Medical Research*, *128*(4), 436–447.

Haque, I. S., Rahman, M. M., Rafiq, Md. S., Apurba, M. S. H., & Khandaker, N. R. (2024). Energy recovery potential in Bangladesh from elevated temperature textile processing wastewater: An analysis of energy recovery, energy economics and reduction in carbon dioxide emission. *Modeling Earth Systems and Environment*. https://doi.org/10.1007/s40808-023-01933-w

Hossain, M., Bhattacharya, P., Frape, S. K., Ahmed, K. M., Jacks, G., Hasan, M. A., Von Brömssen, M., Shahiruzzaman, M., & Mörth, C.-M. (2023). A potential source of low-manganese, arsenic-safe drinking water from Intermediate Deep Aquifers (IDA), Bangladesh. *Groundwater for Sustainable Development*, *21*, 100906. https://doi.org/10.1016/j.gsd.2023.100906

Khandaker, N. R. (2004). Letter: Limited accuracy of arsenic field test kit. *Environmental Science & Technology*, *38*(24), 479A-479A. https://doi.org/10.1021/es040687d

Khandaker, N., & Seto, P. (2010). Novel Application of Vermiculite for Siloxane Removal from Biogas. *International Journal of Green Energy*, *7*(1), 38–42. https://doi.org/10.1080/15435070903501217

Khandaker, N. R., Afreen, I., Diba, D. S., Huq, F. B., & Akter, T. (2020). Treatment of textile wastewater using calcium hypochlorite oxidation followed by waste iron rust aided rapid filtration for color and COD removal for application in resources challenged Bangladesh. *Groundwater for Sustainable Development*, *10*, 100342. https://doi.org/10.1016/j.gsd.2020.100342

McArthur, J. M., Ravenscroft, P., Safiulla, S., & Thirlwall, M. F. (2001). Arsenic in groundwater: Testing pollution mechanisms for sedimentary aquifers in Bangladesh. *Water Resources Research*, *37*(1), 109–117. https://doi.org/10.1029/2000WR900270

Neidel, L., Krumhansl, J., Siegel, M., & Khandaker, N. (2006). *Performance evaluation of ALCAN-AASF50-ferric coated activated alumina and granular ferric hydroxide (GFH) for arsenic removal in the presence of competitive ions in an active well :Kirtland field trial—Initial studies.* (SAND2005-7693, 883491; pp. SAND2005-7693, 883491). https://doi.org/10.2172/883491

Nickson, R., McArthur, J., Burgess, W., Ahmed, K. M., Ravenscroft, P., & Rahmanñ, M. (1998). Arsenic poisoning of Bangladesh groundwater. *Nature*, *395*(6700), 338–338. https://doi.org/10.1038/26387

Pearshouse, R. (2016). Nepotism and Neglect. *Human Rights Watch*. https://www.hrw.org/report/2016/04/06/nepotism-and-neglect/failing-response-arsenic-drinking-water-bangladeshs-rural

Rafiq, M. S., Apurba, M. S. H., & Khandaker, N. R. (2024a). Enhancing textile wastewater sustainability through calcium hypochlorite oxidation and subsequent filtration with assistance from waste blast furnace iron slag. Water and Environment Journal, 38(4), 602–612. https://doi.org/10.1111/wej.12948

Rafiq, Md. S., Apurba, M. S. H., & Khandaker, N. R. (2024d). Harnessing Untapped Resources for Sustainable Energy Production from Municipal Solid Waste in Recourse Challenged Economies: A Case Study of Rajshahi City Corporation, Bangladesh. *Journey for Sustainable Development and Peace Journal*, *2*(1), 35–57. https://doi.org/10.3126/jsdpj.v2i1.63240

Rafiq, Md. S., Apurba, M. S. H., Rahman, M. M., Mirdha, Z., & Khandaker, N. R. (2024b). Application of Anaerobic Process and Energy, Materials Recovery for Textile Processing Wastewater. In S. Yadav, M. M. Ghangrekar, & R. N. Yadava (Eds.), *Emerging Technologies in Biological and Hybrid Wastewater Treatment: Lessons from Developed to Enhancing Practices in Developing Countries* (pp. 233–261). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-74515-7_13

Rafiq, Md. S., & Khandaker, N. R. (2024). *Sustainable Management of Construction and Demolition Waste in Bangladesh: Advancing a Greener Industry through Resource Recovery and Recycling*. https://doi.org/10.21203/rs.3.rs-3954758/v1

Rafiq, Md. S., Sultana, R., Apurba, M. S. H., & Khandaker, N. R. (2024c). Sustainable management of construction and demolition waste in Bangladesh to promote resource recycling. *Sustainable and Resilient Infrastructure*, 1–15. https://doi.org/10.1080/23789689.2024.2413339

Rashid, S., & Khandaker, N. (2007). Risk Factors for Early Myocardial Infarction in South Asians. *JAMA*, *297*(17), 1880. https://doi.org/10.1001/jama.297.17.1880-b

Ravenscroft, P., Burgess, W. G., Ahmed, K. M., Burren, M., & Perrin, J. (2005). Arsenic in groundwater of the Bengal Basin, Bangladesh: Distribution, field relations, and hydrogeological setting. *Hydrogeology Journal*, *13*(5–6), 727–751. https://doi.org/10.1007/s10040-003-0314-0

Sahil Rafiq, Md., Apurba, M. S. H., Rahman, M. M., & Khandaker, N. R. (2024). Sustainable Operation of Textile Wastewater Using Calcium Hypochlorite Oxidation Followed by Waste Iron Slag-Aided Micro-filtration. In S. Yadav, M. M. Ghangrekar, & R. N. Yadava (Eds.), *Emerging Technologies in Biological and Hybrid Wastewater Treatment: Lessons from Developed to Enhancing Practices in Developing Countries* (pp. 211–231). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-74515-7_12

Sarkar, B., Bhattacharya, P., Jacks, G., & Frisbie, S. (2002). *Arsenic in the environment: A global perspective* (pp. 147–215).

Tonmoy, T. H., Hanif, Md. A., Rahman, H. A., Khandaker, N., & Hossain, I. (2016). Error reduction in arsenic detection through color spectrum analysis. *2016 19th International Conference on Computer and Information Technology (ICCIT)*, 343–350. https://doi.org/10.1109/ICCITECHN.2016.7860221

Uddin, A., & Lundberg, N. (1998). Cenozoic history of the Himalayan-Bengal system: Sand composition in the Bengal basin, Bangladesh. *Geological Society of America Bulletin*, *110*(4), 497–511. https://doi.org/10.1130/0016-7606(1998)110<0497:CHOTHB>2.3.CO;2

Van Geen, A., Zheng, Y., Versteeg, R., Stute, M., Horneman, A., Dhar, R., Steckler, M., Gelman, A., Small, C., Ahsan, H., Graziano, J. H., Hussain, I., & Ahmed, K. M. (2003). Spatial variability of arsenic in 6000 tube wells in a 25 km^2 area of Bangladesh. *Water Resources Research*, *39*(5), 2002WR001617. https://doi.org/10.1029/2002WR001617

Zheng, Y., Stute, M., Van Geen, A., Gavrieli, I., Dhar, R., Simpson, H. J., Schlosser, P., & Ahmed, K. M. (2004). Redox control of arsenic mobilization in Bangladesh groundwater. *Applied Geochemistry*, *19*(2), 201–214. https://doi.org/10.1016/j.apgeochem.2003.09.007