iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2026 Issue: Conference Month of publication: May 2026

DOI: https://doi.org/10.22214/ijraset.2026.83381

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com
National Conference on Integrated Approaches to Sustainable Innovation 2026 (IASI 2026)

Arsenic Pollution in Gangetic West Bengal: Challenges and Integrated Mitigation Strategies- A Review

Anushka Mukherjee[1], Sukanya Chandra[2]
[1]*Department of Computer Science and Engineering, OmDayal Group of Institutions, Howrah, West Bengal, India*
[2]*Department of Science and Humanities, OmDayal Group of Institutions, Howrah, West Bengal, India*

Abstract: Arsenic (As) contamination in the Ganga–Meghna–Bramhaputra Basin constitutes a catastrophic public health crisis which is predominantly of hydro geochemical and geogenic origin affecting over 100 million inhabitants across India and Bangladesh. The basin supports over 500 million population, a large proportion of whom is heavily dependent on groundwater for drinking and irrigation purposes. In many areas, the arsenic levels in groundwater are highly elevated, often exceeding the permissible limits established by World Health Organization. Long-term ingestion of arsenic contaminated groundwater has resulted in serious health effects, including arsenicosis, skin lesions, and different types of cancer. This paper examines the sources, extent, and impacts of arsenic contamination, and proposes integrated mitigation strategies combining technological innovation, policy frameworks, and community participation. A multidisciplinary approach is essential for achieving sustainable solutions aligned with global development goals.
Keywords: Arsenic contamination, sustainable innovation, integrated remediation, groundwater treatment

I. INTRODUCTION

Arsenic (As) is a highly toxic carcinogen and is considered as a global environmental pollutant. It is a naturally occurring trace element that is widely distributed throughout the earth's crust and is commonly encountered in ground water due to natural processes as well as from anthropogenic activities [1]. It is present everywhere in nature and are usually discharged to soil, water and air during mining and refining activities [2, 3]. It exhibits several different oxidation states of -3 (arsine), 0 (elemental arsenic), +3 (arsenite) and + 5 (arsenate) depending upon environmental conditions or in organic forms such as monomethyl arsonic acid (MMA) and dimethyl arsinic acid (DMA) [4]. Mobility of arsenic compounds in soils depends on soil sorption capacity given by oxides and hydroxides of Fe, Al, Mn, humic substances and clay minerals, on pH and the redox potential [5]. The Ganga River basin is one of the most densely populated and agriculturally productive regions in the world. Groundwater serves as the primary source of drinking water and irrigation for millions of people. However, the use of this arsenic contaminated water for irrigation provides the possibility of arsenic uptake into crops and vegetables. The consumption of such As-contaminated crops and vegetables along with meat from animals ingesting arsenic laden fodder, pose serious threat to humans [6] exposing them to the risk of arsenic poisoning. Studies suggest that As contaminated vegetables affects food quality and, subsequently, human and animal health through contamination of the food chain [7].

Furthermore, the presence of arsenic in agricultural crops may decrease its productivity and disrupt ecosystems sustainability [8]. Chronic ingestion of arsenic-contaminated water can lead to melanosis, characterized by skin lesions, hyperkeratosis, and increased risk of cancers affecting the skin, lungs, and bladder. Despite extensive research over the years, no single remediation technique has achieved applicability universally. Conventional methods often fail to explain the complexity of arsenic speciation, environmental variability, and socio-economic constraints. Therefore, there is an increasing demand for integrated, sustainable, and interdisciplinary strategies that utilize the importance of various techniques. The objectives of this paper are: (i) to review the extent of arsenic pollution in the Gangetic region of West Bengal, arsenic uptake by plants and foodstuffs, and the major pathways of human arsenic exposure; (ii) to summarize the public health impacts of chronic arsenic exposure; (iii) to examine the socio-economic implications and consequences of arsenicosis; and (iv) to evaluate existing mitigation strategies and emerging technologies for arsenic management and remediation.

II. SOURCES AND MECHANISMS OF ARSENIC CONTAMINATION

A. Geogenic Sources

Arsenic contamination in the Ganga basin is primarily of natural origin. It is released from alluvial sediments through geochemical processes such as the dissolution of iron oxides leads to the mobilization of arsenic in water [9]. The reductive dissolution of Fe oxyhydroxides under reducing conditions releases adsorbed arsenic, thereby enhancing its availability to plants [10]. The oxidation of arsenic-bearing sulphide minerals, such as arsenopyrite (FeAsS), releases soluble As(III), sulphate, and Fe^{2+}, and has been widely recognized as a source of arsenic contamination [11]. Furthermore, the decline in the water table due to excessive groundwater withdrawal for irrigation is a major factor contributing to arsenic release. The liberated As(III) is partly oxidized to As(V) through microbially mediated reactions.

B. Anthropogenic Factors

The sources of arsenic which are generated through the human activities are called anthropogenic sources. The anthropogenic sources of arsenic are mining, smelting where, it is found with other metal such as copper, gold, iron etc. Few anthropogenic industrial processes directly release arsenic into the environment such as wood preservatives (Chromated copper Arsenate-CCA), mining of arsenopyrite, electrical waste (semiconductors), insecticides, pesticides, weed controller, disposal of industrial and sewage materials and paint products [12]

C. Hydrogeochemical Processes

Elevated pH and high bicarbonate concentrations play a significant role in the mobilization of arsenic in groundwater. Under alkaline conditions, arsenic that is adsorbed onto mineral surfaces, particularly iron oxyhydroxides, tends to desorb and enter the aqueous phase. Bicarbonate ions further enhance this process by competing with arsenic for adsorption sites, thereby facilitating its release into water. In addition, reducing (anaerobic) conditions in aquifers promote the reductive dissolution of iron oxyhydroxides, which leads to the liberation of previously bound arsenic.

These geochemical conditions collectively contribute to increased arsenic concentration in groundwater systems.

III. EXTENT OF ARSENIC POLLUTION IN THE GANGETIC WEST BENGAL

West Bengal is one of the 29 states in India. It extends to the east longitude $85^{o}50^{'}$E and $89^{o}50^{'}$E and north latitude $21^{o}10^{'}$N and $27^{o}38^{'}$N. The area of West Bengal is 89193 sq. km having a population of about 80.1 million. Its administrative structure consists of several districts: each district has several blocks/police stations; each block has several Gram Panchayets (GPs), which are cluster of villages.

There are 19 districts, 341 blocks and 37910 villages in West Bengal. Table 1. shows an overview of arsenic contamination situation of West Bengal up to December 2005 (SOES, Jadavpur University, Kolkata). From the table, it is seen that arsenic contamination in the Bengal Delta Basin is massive in its areal extent and is one of the major arsenic-contaminated hotspots in the world. Nine out of total 19 districts of West Bengal have ground water arsenic contamination [13,14]. The severely arsenic affected districts are Malda, Murshidabad, Nadia, North 24-Parganas, South 24-Parganas, Bardhaman, Howrah, Hooghly and Kolkata. Total number of As affected blocks with As concentration above 50μg/L is 111 and above 10μg/L is 148.The population of severely As affected areas is 50.4 million.

The main source of arsenic in this region is natural and is released during the weathering of sulphide minerals which is then adsorbed on to the surface of oxy-hydroxides that precipitated under oxidizing conditions. Redox processes in the sediments triggered the reductive dissolution of iron oxides that transferred substantial amounts of arsenic in aqueous phases through biogeochemical interactions [1]. Ingestion of As contaminated drinking water is not the only source of As to the diet of Bengal delta [15] but in rural West Bengal, the irrigation system is mostly dependent on ground water.In these areas, farmers are not aware much about the guideline of arsenic (0.10 μg/L) in groundwater (FAO 1985) [16], and they bore the cross-section of lithosphere to lift up arsenic-contaminated groundwater throughout the year through the shallow tubewell for agriculture and allied purpose, leading to entering of arsenic to crops via soil–water system.Irrigation of agricultural fields with arsenic-contaminated ground water has led to arsenic build up in soil with subsequent elevation of arsenic in these crops grown on these soils [17,18], leading to the risk of the arsenic accumulation in soils and subsequently entering into the food chain through plant uptake and animal consumption [19].

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com
National Conference on Integrated Approaches to Sustainable Innovation 2026 (IASI 2026)

Table 1. Present Groundwater Arsenic Contamination Status of West Bengal, India

Physical Parameters	West Bengal
Area in sq. km.	88,750
Population in million	80.2
Total number of districts (no. of district surveyed)	19 (19)
Total number of water samples analyzed	1,40,150
% of samples having arsenic > 10 mg L^{-1}	48.1
% of samples having arsenic > 50 mg L^{-1}	23.8
No. of severely arsenic affected districts	9
No. of mildly arsenic affected districts	5
No. of arsenic safe districts	5
Total population of severely arsenic affected 9 districts in million	50.4
Total area of severely arsenic affected 9 districts in sq. km.	38,861
Total number of blocks/ police station	341
Total number of blocks/ police station surveyed	241
Number of blocks / police station having arsenic >50mgL^{-1}	111
Number of blocks / police station having arsenic >10mgL^{-1}	148
Total number of villages	37910
Total number of villages surveyed	7823
Number of villages/paras having arsenic above 50 mgL^{-1}	3417
People at risk of drinking arsenic contaminated water >10 mgL^{-1} (in million)	9.5
People at risk of drinking arsenic contaminated water >50 mgL^{-1} (in million)	4.6
No. of districts surveyed for arsenic patients	9
No. of districts where arsenic patients found	7
Villages surveyed for arsenic patients	602
Number of villages where we have identified people with arsenical skin lesions	488
People screened for arsenic patients including children (preliminary survey)	96,000
No. of adults screened for arsenic patient	82,000
Number of registered patients with clinical manifestations	9,356 (9.7%)
No. of children screened for arsenic patient	14,000
No. of children showing arsenical manifestation	778 (5.6%)

Source- Reported work done by SOES on Ground water arsenic contamination in West Bengal, India (20 years study)

A. Arsenic in plants and food stuffs

Soils with elevated concentrations (≥ 20 ppm) of arsenic produce plants with increasing As levels. The distribution of As among various parts of the plant varies widely depending upon the availability of As and on the plant physiological properties. Generally, seeds and fruits have low As concentration than leaves, stem or roots. Tuberous vegetables accumulate higher amount of As than leafy vegetables which in turn accumulates more As than fruity vegetables [20].

A number of studies were carried out by various researchers regarding the content of As in various food composites like fruit, grain, vegetable, fish, milk etc from several different countries. Compared with the other countries, Bangladesh and West Bengal show significantly higher concentrations of As in food. The elevated As content of food in Bangladesh and West Bengal may be attributed to irrigation using As contaminated groundwater in the dry season and this can be a significant route for both short and long term As exposure to humans [21, 22]. The concentration of As in five As affected blocks of Malda district of West Bengal was investigated by [23] and it showed that the highest mean As concentration was found in potato (456µg/kg), followed by rice grain (429 µg/kg). The other higher mean arsenic content (micrograms per kilogram dry weight) as measured by them were found in amaranth (411), sweet potato (324), radish (312) and cabbage (311). The reason for this high deposit of As in the tissues is due to its growth in arsenic-rich soil and irrigation with As-contaminated water [24].

Food generally has a maximum contribution to the daily intake of total As. Rice being the staple food of West Bengal and Bangladesh is the major route to As exposure since it is the major crop in As contaminated region of South East Asia [25]. 150 rice samples from different parts of Bangladesh was analyzed by [24] and found that As content in Boro rice, the winter dry season variety was 1.5 times higher than in Aman rice, the summer wet season variety. Based on season, the Boro rice accumulated significantly higher arsenic than the Aman suggesting that irrigation with As contaminated ground water in the dry season contributed higher concentrations of As in the rice. The enhanced risk of consumption of rice containing elevated levels of inorganic As cooked with contaminated water was reported by [26]. In their study they used 12 rice samples and found that at the lowest (3.9%) and highest (17.8%) uptake of total As, consumption of 5.7 and 1.2 kg of rice per day would be required to reach the tolerable daily intake set by the Food and Agriculture Organization (FAO) for inorganic As (150 µg/kg inorganic As per day for a person weighing 70 kg) [26]. Therefore, countries where rice is the major staple food and contains elevated levels of inorganic As are most at risk like Bangladesh where the mean As content in cooked rice as observed by [26] is 260 µg/kg. The total As content in vegetables and pulses of As endemic areas of Nadia was examined by [27] and found that the highest As values were in spinach 910 µg/kg followed by arum tuber (558), tomato (551) and bitter guard (529). Among pulses group, pea showed highest As content of 1300 µg/kg followed by lentil (1120 µg/kg) and Bengal gram (891 µg/kg). The arsenic content in vegetables varies from 70-3990 µg/kg as reported by [11]. The total As concentration ranged from 50-200 µg/kg in onion, 30-200 µg/kg in potato, 9-120 µg/kg in tomato and 50-200 µg/kg in apple as investigated by [28] in Bangladesh. As accumulation of crops of Haringhata block of West Bengal ranged from 84-330 µg/kg [29]. As concentration varied from 70-830 µg/kg in grains and 1-39 µg/kg in pulses. Highest levels of As are found in seafood, meat, fish and poultry as reported by [30].

B. Arsenic in the food chain

The human and environmental implications of this contamination are severe. Millions of residents across thousands of villages are exposed to arsenic through daily groundwater use, leading to widespread health risks. Human beings are exposed to As via different pathways as shown in Figure I [31]. Ingestion of As contaminated drinking water is not the only source of As to humans. Arsenic present in groundwater used for crop irrigation or naturally occurring in the soil can be accessed by plants through their root systems and can be bio accumulated in various parts of the plant.

Subsequently humans can be exposed to As by consumption of these products (fruits, vegetables and grains). Other As transfer pathways include water-soil-plant-animal-human transfer where the exposure can be via consumption of either animal products containing As, such as eggs or milk, or by direct consumption of meat or fish [32]. The combination of geological, hydrological, and human factors makes arsenic pollution in West Bengal a complex and urgent challenge requiring sustained monitoring and effective mitigation strategies.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com
National Conference on Integrated Approaches to Sustainable Innovation 2026 (IASI 2026)

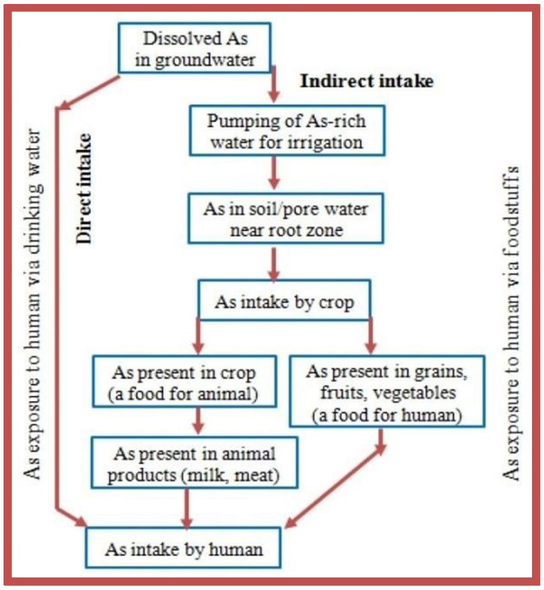


Figure1: Different routes of As exposure to humans

C. Risk of Arsenic Contamination

The bioavailability of As from the contaminated land and water environment is a crucial parameter for estimating exposure risks [33]. Chronic As toxicity in humans has been documented in many countries worldwide. Humans are exposed to many different forms of inorganic and organic arsenic species (arsenicals) in food, water and other environmental media.The adverse health effects of As depend strongly on dose, duration of exposure, and the nutrition status of the exposed population. Chronic As exposure may also cause reproductive, neurological, cardiovascular, respiratory, hepatic, hematological, and diabetic effects in humans [34]. Intake of inorganic As was recognized as a cause of skin, bladder, and lung cancer [34, 35]. Human beings exposed to drinking water ranging from < 3 to 3400 µg/L for a long period of time experience various respiratory problems including cough, chest sound and shortness of breath [36]. Chronic bronchitis was reported in Bangladesh where the concentration of As in drinking water varied from 136 to 1000 µg/L [37]. In a study in Bangladesh high prevalence of breathing problems including chest sound, asthma, bronchitis and cough in patients exposed to As contaminated water of 216 µg/L was found by [37]. Chronic exposure to arsenic has been linked to various vascular diseases affecting both the large (cardiovascular and cerebrovascular diseases) and small (black foot disease) blood vessels with clinical diagnoses such as ischemic heart disease or hypertension [38]. Several cases of myocardial infarction and arterial thickening was reported in children who consumed water containing 0.60 mg As/L [39].

Several gastrointestinal symptoms are observed in humans ingesting heavy doses of As. As poisoning manifests dry mouth and throat, nausea, abdominal pains, diarrhea, gastritis or colitis. Gastrointestinal hemorrhage among the As impacted residents of West Bengal was reported by [40].

Kidneys also accumulate inorganic As since it is the major route of As elimination from the body. Target sites for As damage in the kidney include capillaries, tubules and glomeruli leading to kidney dysfunction [41].

Chronic exposures to As causes varieties of dermal effects such as melanosis, keratosis, hyperkeratosis, dorsum,

Bowen's disease and cancer. Numerous investigators reported the occurrence of skin lesions among the As impacted areas of West Bengal and Bangladesh [42, 43].

Several studies indicate that As toxicity in the population exposed to As contamination can result in neural injury. Peripheral neuropathy is the predominant and common neurological complication of As toxicity [44] which begins as numbness in the hands and feet but later develops in painful 'pins and needles' sensation, loss of reflexes and muscle weakness.

The occurrence of spontaneous abortions in women exposed to As toxicity during pregnancy has been reported by various investigators [45, 46]. Spontaneous abortions, stillbirth's and preterm births in women from As affected village Eruani of Bangladesh where the as level ranged from 201-1200 µg/L were reported by [47]. As exposure enhances the risk of infant death [48].

Longer term effects of As exposure leads to skin, lung, kidney and liver cancers as well as peripheral neuritis and parathesia. The binding with sulphydryl groups by arsenite compounds has the potential to influence varieties of metabolic activities like cellular glucose uptake, gluconeogenesis, fatty acid oxidation and production of glutathione. Arsenite rapidly and extensively accumulate in the liver thereby inhibiting NAD-linked oxidation of pyruvates by complexing with thiols. Arsenic is known to be carcinogenic because of its power to alter DNA repair, acting through a co-carcinogenic mechanism of action, exacerbating the genotoxicity and mutagenicity of other compounds [49].

IV. SOCIO-ECONOMIC IMPACTS OF ARSENIC POLLUTION

Arsenic pollution poses significant socio-economic challenges, particularly in groundwater-dependent regions. Prolonged exposure to arsenic-contaminated water leads to severe health disorders, including skin lesions, cancers, cardiovascular diseases, and neurological impairments, thereby increasing healthcare expenditures and reducing the quality of life of affected populations. The decline in physical health decreases labor productivity and household income, especially among agricultural and daily wage workers. In agriculture, the use of arsenic-contaminated groundwater for irrigation results in the accumulation of arsenic in soil and food crops, adversely affecting crop quality, food safety, and market value. Coping with the economic burden associated with medical treatment, access to safe drinking water, and loss of employment often pushes vulnerable communities into deeper poverty [50]. Furthermore, visible symptoms of arsenicosis frequently lead to social discrimination, psychological stress, and reduced social participation. Arsenic affected people are often abandoned by the society, lose their jobs and get divorced and are forced to live a sub-standard life [51]. Educational attainment is also affected, as children from impacted families may suffer from health complications and school absenteeism. Collectively, these factors hinder sustainable rural development and exacerbate socio-economic inequalities in arsenic-affected regions such as West Bengal and the Ganga Basin.

V. INTEGRATED MITIGATION STRATEGIES

Several arsenic removal technologies have been developed with effective implementation [52-57].

A. Technological Interventions

- Low-cost filtration systems (iron-based adsorbents, activated alumina): In this process, contaminated water passes through a filter column containing the adsorbent media, where arsenic binds to the surface of the material through adsorption. Iron-based media can also oxidize arsenic from As(III) to As(V), which enhances the removal efficiency. As the purified water flows out, arsenic remains trapped within the filter media. After prolonged use, the adsorption sites become saturated, requiring regeneration or replacement of the filter material for continued effectiveness.
- Nanotechnology-based arsenic removal methods: Water is treated with nanomaterials (e.g., iron nanoparticles, graphene-based adsorbents) which attract and bind arsenic readily due to its high surface area. The arsenic-packed particles are removed by filtration or magnetic separation and clear water is collected while nano particles are either reused or safely disposed

B. Sustainable Water Management

- Rainwater harvesting: Rainwater harvesting involves the collection and storage of rainwater from rooftops and other catchment surfaces for future use. It helps reduce dependence on arsenic-contaminated groundwater and supports groundwater recharge and sustainable water management.
- Aquifer recharge: Aquifer recharge is the process of replenishing groundwater through surface water infiltration, which helps dilute arsenic concentrations and improve long-term water availability.

C. Agricultural Practices

- Alternate wetting and drying techniques in rice cultivation: Alternate Wetting and Drying (AWD) is an effective rice cultivation technique that replaces continuous flooding with periodic drying of the paddy field, allowing the water level to fall about 15 cm below the soil surface before re-flooding. This intermittent drying creates aerobic soil conditions by introducing oxygen into the soil. Under these conditions, iron oxides precipitate and strongly bind with arsenic, thereby reducing its bioavailability to rice roots. As a result, the uptake of arsenic by rice plants is significantly minimized. Studies have shown that AWD can reduce total arsenic concentration in rice grains by up to 66%. In addition to lowering arsenic contamination, AWD also decreases irrigation water use by nearly 35% and helps suppress methane emissions, making it an environmentally sustainable agricultural practice.

- Use of arsenic-resistant crop varieties: The cultivation of arsenic-tolerant plant varieties is an essential approach for maintaining crop quality and sustainable farming in areas affected by elevated arsenic levels in soil and irrigation water, particularly in regions of India, Bangladesh, and China. These specially developed cultivars are capable of minimizing arsenic absorption into consumable plant tissues or enduring arsenic-induced stress while sustaining normal growth and productivity.

VI. EMERGING TECHNOLOGICAL INTERVENTIONS IN ARSENIC MITIGATION

Conventional remediation approaches for arsenic contamination, including deep groundwater extraction and chemical precipitation methods, often encounter limitations related to cost, maintenance, and long-term effectiveness in the Ganga Basin region. However, the integration of Industry 4.0 technologies has transformed arsenic management into a more efficient and data-driven process. Modern mitigation technologies like the Internet of Things (IoT), Artificial Intelligence (AI), and mobile-based community reporting systems enable real-time groundwater monitoring, contamination prediction, and greater public participation. These smart approaches improve early detection, support informed decision-making, and strengthen community awareness for sustainable arsenic mitigation [58, 59].

A. *Real-Time IoT-Based Arsenic Monitoring*

The implementation of IoT-based arsenic monitoring systems using electrochemical or optical sensors in wells enables continuous and real-time measurement of arsenic levels. The collected data is transferred through low-power communication networks to cloud-based monitoring platforms for analysis and visualization. This advanced system helps scientists, authorities, and local stakeholders track sudden variations in arsenic concentration caused by seasonal rainfall, groundwater recharge, and excessive water extraction. As a result, real-time monitoring improves early detection, rapid response, and effective management of arsenic contamination.

B. *Predictive AI-Driven Risk Mapping*

Machine Learning (ML) techniques are now widely applied to forecast arsenic contamination zones and future risk patterns. These intelligent models combine historical arsenic concentration records with Geographic Information System (GIS) data and environmental factors such as sediment composition, organic carbon content, groundwater withdrawal intensity, and local hydrogeological characteristics. Using this integrated dataset, AI-based systems produce detailed predictive risk maps that help identify areas vulnerable to arsenic pollution. This approach transforms arsenic management from a reactive monitoring system to a proactive mitigation strategy. As a result, high-risk regions can be recognized before severe exposure occurs, allowing authorities to implement early interventions, design safer groundwater extraction strategies, and better safeguard public health against prolonged arsenic contamination.

C. *Mobile-Enabled Community Crowd sourcing and Alerts*

Mobile applications help spread awareness about arsenic-contaminated water in affected regions. They provide realtime water quality updates and contamination alerts to local communities. Through color-coded alerts and notifications, residents can quickly identify unsafe water sources and take preventive measures. The applications also enable citizens to report contaminated wells, water supply failures, and health-related concerns directly to local authorities. Such digital tools improve communication, community participation, and efficient water management in the Ganga Basin.

VII. CONCLUSION

Arsenic pollution in the Ganga Basin is a multifaceted crisis impacting health, agriculture, and socio-economic stability. Adopting sustainable technologies, such as low-cost filtration systems and rainwater harvesting, is crucial for long-term mitigation of arsenic contamination in affected areas. Key strategies include enhancing community awareness, improving monitoring systems, training local stakeholders and implementing sustainable agricultural practices. Collaboration among governments, NGOs, and local communities essential for effective policy enforcement and technological innovation.

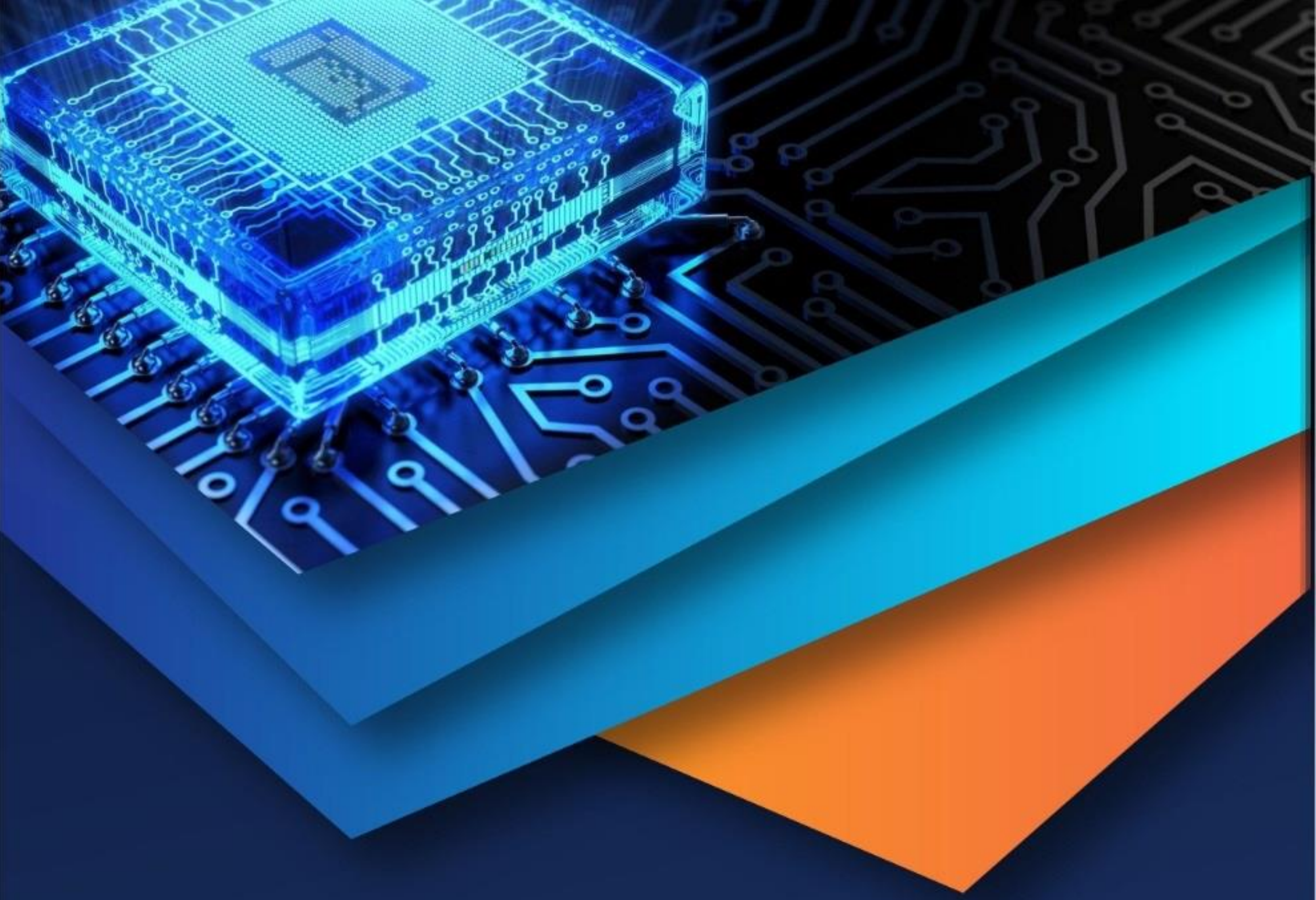
REFERENCES

[1] P. L. Smedley and D. Kinniburgh, “A review of the source, behavior and distribution of arsenic in natural waters,” Applied Geochemistry, vol. 17, pp. 517–568, 2002.

[2] H. J. Wei and B. X. Li, “Characteristics of geological structures in Zhangye-Minle Basin and feasibility study of geothermal resources in Zhangye City,” Gansu Geology, vol. 16, pp. 74–76, 2007.

[3] C. N. Cheng and D. D. Focht, "Production of arsine and methylarsines in soil and in culture," Applied and Environmental Microbiology, vol. 38, pp. 494–498, 1979.
[4] S. Tu and L. Q. Ma, "Effects of arsenate and phosphate on their accumulation by an arsenic-hyperaccumulator Pteris vittata L.," Plant and Soil, vol. 249, pp. 373–382, 2003.
[5] M. Bissen and F. H. Frimmel, "Arsenic: A review. Part I: Occurrence, toxicity, speciation and mobility," Acta Hydrochimica et Hydrobiologica, vol. 31, pp. 9–18, 2003.
[6] Biswas, S. Biswas, and S. C. Santra, "Risk from winter vegetables and pulses produced in arsenic endemic areas of Nadia District: Field study comparison with market basket survey," Bulletin of Environmental Contamination and Toxicology, vol. 88, pp. 909–914, 2012.
[7] J. A. Baig and T. G. Kazi, "Translocation of arsenic contents in vegetables from growing media of contaminated areas," Ecotoxicology and Environmental Safety, vol. 75, pp. 27–32, 2012.
[8] E. E. C. Melo, E. T. S. Costa, L. R. G. Guilherme, V. Faquin, and C. W. A. Nascimento, "Accumulation of arsenic and nutrients by castor bean plants grown on an As-enriched nutrient solution," Journal of Hazardous Materials, vol. 168, pp. 479–483, 2009.
[9] P. L. Smedley and D. G. Kinniburgh, "Arsenic in groundwater and sediments—Distribution, geochemistry and human impact," in Arsenic in Groundwater: A Multi-Disciplinary Overview, pp. 1–155, 2004.
[10] A. van Geen, J. Rose, S. Thoral, J. M. Garnier, Y. Zheng, and J. Y. Bottero, "Decoupling of As and Fe release to Bangladesh groundwater under reducing conditions. Part II: Evidence from sediment incubations," Geochimica et Cosmochimica Acta, vol. 68, no. 17, pp. 3475– 3486, 2004.
[11] P. K. Das, A. K. Mitra, P. K. Sengupta, A. Hossain, F. Islam, and G. H. Rabbani, "Arsenic concentration in rice, vegetables, and fish in Bangladesh: A preliminary study," Environment International, vol. 30, no. 3, pp. 383–387, 2004.
[12] P. Bhattacharya, A. H. Welch, K. G. Stollenwerk, M. J. McLaughlin, J. Bundschuh, and G. Panaullah, "Arsenic in the environment: Biology and chemistry," Science of the Total Environment, vol. 379, no. 2, pp. 109–120, 2007.
[13] R. T. Nickson, J. M. McArthur, P. Ravenscroft, W. G. Burgess, and K. M. Ahmed, "Mechanism of arsenic release to groundwater, Bangladesh and West Bengal," Applied Geochemistry, vol. 15, pp. 403–413, 2000.
[14] D. Chakraborty, M. M. Rahman, K. Paul, U. K. Chowdhury, M. K. Sengupta, D. Lodh et al., "Arsenic calamity in the Indian subcontinent: What lessons have been learnt?" Talanta, vol. 58, pp. 3–22, 2002.
[15] T. Roychowdhury, "Groundwater arsenic contamination in one of the 107 arsenic-affected blocks in West Bengal, India: Status, distribution, health effects and factors responsible for arsenic poisoning," International Journal of Hygiene and Environmental Health, vol. 213, pp. 414–427, 2010.
[16] FAO, Water Quality Guidelines for Maximum Crop Production. Rome, Italy: Food and Agriculture Organization of the United Nations, 1985. [Online]. Available: www.fao.org/docrep/T0551E
[17] A. Meharg and M. M. Rahman, "Arsenic contamination of Bangladesh paddy field soils: Implications for rice contribution to arsenic consumption," Environmental Science & Technology, vol. 37, no. 2, pp. 229–234, 2003.
[18] P. N. Williams, A. H. Price, A. Raab, S. A. Hossain, J. Feldmann, and A. A. Meharg, "Variation in arsenic speciation and concentration in paddy rice related to dietary exposure," Environmental Science & Technology, vol. 39, pp. 5531–5540, 2005.
[19] S. M. Imamul Huq and R. Naidu, "Arsenic in ground water and contamination of the food chain: Bangladesh scenario," in Natural Arsenic in Groundwater: Occurrence, Remediation and Management, J. Bundschuh, P. Bhattacharya, and D. Chandrasekharam, Eds. New York, NY, USA: Balkema, 2005, pp. 95–101.
[20] A. C. Samal, S. Kar, P. Bhattacharya, and S. C. Santra, "Human exposure to arsenic through foodstuffs cultivated using arsenic contaminated groundwater in areas of West Bengal, India," Journal of Environmental Science and Health, Part A, vol. 46, no. 11, pp. 1259–1265, 2011.
[21] R. Naidu and H. Skinner, "Arsenic contamination of rural ground water supplies in Bangladesh and India: Implications for soil quality, animal and human health," in Proceedings of the International Conference on Diffuse Pollution, C. Barber, B. Humphries, and J. Dixon, Eds. Perth, Australia: CSIRO, 1999, pp. 407–417.
[22] P. K. Das, A. K. Mitra, P. K. Sengupta, A. Hossain, F. Islam, and G. H. Rabbani, "Arsenic concentration in rice, vegetables, and fish in Bangladesh: A preliminary study," Environment International, vol. 30, no. 3, pp. 383–387, 2004.
[23] S. Rahaman, A. C. Sinha, R. Pati, and D. Mukhopadhyay, "Arsenic contamination: A potential hazard to the affected areas of West Bengal, India," Environmental Geochemistry and Health, vol. 34, pp. 1–4, 2012.
[24] J. M. Duxbury, A. B. Mayer, J. G. Lauren, and N. Hassan, "Food chain aspects of arsenic contamination in Bangladesh: Effects on quality and productivity of rice," Journal of Environmental Science and Health, Part A, vol. 38, no. 1, pp. 61–69, 2003.
[25] A. A. Meharg and L. Jardine, "Arsenite transport into paddy rice (Oryza sativa) roots," New Phytologist, vol. 157, pp. 39–44, 2003.
[26] J. M. Laparra, D. Velez, R. Barbera, R. Farre, and R. Montoro, "Bioavailability of inorganic arsenic in cooked rice: Practical aspects for human risk assessment," Journal of Agricultural and Food Chemistry, vol. 53, no. 22, pp. 8829–8833, 2005.
[27] A. Biswas, S. Biswas, and S. C. Santra, "Risk from winter vegetables and pulses produced in arsenic endemic areas of Nadia District: Field study comparison with market basket survey," Bulletin of Environmental Contamination and Toxicology, vol. 88, pp. 909–914, 2012.
[28] Kabata-Pendias and H. Pendias, Trace Elements in Soils and Plants, 2nd ed. Boca Raton, FL, USA: CRC Press, 1992.
[29] C. Samal, "An investigation on accumulation of arsenic in ecosystem of Gangetic West Bengal and assessment of potential health risk," Ph.D. dissertation, Univ. of Kalyani, Kalyani, India, 2005.
[30] H. J. Wei and B. X. Li, "Characteristics of geological structures in Zhangye-Minle Basin and feasibility study of geothermal resources in Zhangye City," Gansu Geology, vol. 16, pp. 74–76, 2007.
[31] J. Q. Jiang, S. M. Ashekuzzaman, A. Jiang, S. M. Sharifuzzaman, and S. R. Chowdhury, "Arsenic contaminated groundwater and its treatment options in Bangladesh," International Journal of Environmental Research and Public Health, vol. 10, pp. 18–46, 2013.
[32] N. I. Khan, G. Owens, D. Bruce, and R. Naidu, "Human arsenic exposure and risk assessment at the landscape level: A review," Environmental Geochemistry and Health, vol. 31, pp. 143–166, 2009.
[33] R. Naidu, E. Smith, G. Owens, P. Bhattacharya, and P. Nadebaum, Managing Arsenic in the Environment: From Soil to Human Health. Collingwood, Melbourne, Australia: CSIRO Publications, 2006, p. 747.

[34] WHO, IPCS Environmental Health Criteria 224: Arsenic and Arsenic Compounds. Geneva, Switzerland: International Programme on Chemical Safety, World Health Organization, 2001.
[35] IARC, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 84: Some Drinking Water Disinfectants and Contaminants, Including Arsenic. Lyon, France: International Agency for Research on Cancer, 2004.
[36] D. N. Guha Mazumder, R. Haque, N. Ghosh et al., "Arsenic in drinking water and the prevalence of respiratory effects in West Bengal, India," International Journal of Epidemiology, vol. 29, pp. 1047–1052, 2000.
[37] L. N. Islam, A. H. M. N. Nabi, M. M. Rahman et al., "Association of respiratory complications and elevated serum immunoglobulin with drinking water arsenic toxicity in human," Journal of Environmental Science and Health, vol. 42, pp. 1807–1811, 2007.
[38] R. K. Kwok, "A review and rationale for studying the cardiovascular effects of drinking water arsenic in women of reproductive age," Toxicology and Applied Pharmacology, vol. 222, pp. 344–350, 2007. doi:10.1016/j.taap.2007.02.016.
[39] R. Zaldivar, "Beitr. Pathol.," vol. 151, p. 384, 1974.
[40] D. N. Guha Mazumder, J. Das Gupta, and A. Santra, "Arsenic exposure and health effects," in Non-cancer Effects of Chronic Arsenicosis with Special Reference to Liver Damage, C. O. Abernathy, R. L. Calderon, and W. R. Chappell, Eds. London, U.K.: Chapman and Hall, 1997, pp. 112–123.
[41] K. Mandal and K. T. Suzuki, "Arsenic round the world: A review," Talanta, vol. 58, pp. 201–235, 2002.
[42] N. Guha Mazumder, R. Haque, N. Ghosh et al., "Arsenic levels in drinking water and the prevalence of skin lesions in West Bengal, India," International Journal of Epidemiology, vol. 27, pp. 871–877, 1998.
[43] Chakraborti, M. K. Sengupta, M. M. Rahman et al., "Groundwater arsenic contamination and its health effects in the Ganga–Meghna– Brahmaputra plain," Journal of Environmental Monitoring, vol. 6, pp. 74–83, 2004.
[44] S. C. Mukherjee, M. M. Rahman, U. K. Chowdhury et al., "Neuropathy in arsenic toxicity from groundwater," Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering, vol. 38, no. 1, pp. 165–183, 2003.
[45] A. Aschengrau, S. Zeiler, and A. Cohen, "Quality of community drinking water and the occurrence of spontaneous abortion," Archives of Environmental Health, vol. 44, pp. 283–289, 1989.
[46] S. A. Ahmad, M. H. S. U. Sayed, S. Barua et al., "Arsenic in drinking water and pregnancy outcomes," Environmental Health Perspectives, vol. 109, pp. 629–631, 2001.
[47] S. Ahamed, M. K. Sengupta, S. C. Mukherjee et al., "An eight year study report on arsenic contamination in groundwater and health effects in Eruani village, Bangladesh and an approach for its mitigation," Journal of Health, Population and Nutrition, vol. 24, pp. 129– 141, 2006.
[48] A. Rahman, M. Vahter, E. C. Ekstrom et al., "Association of arsenic exposure during pregnancy with fetal loss and infant death: A cohort study from Bangladesh," American Journal of Epidemiology, vol. 165, pp. 1389–1396, 2007.
[49] S. Andrew, J. L. Burgess, M. M. Meza, E. Demidenko, M. G. Waugh, J. W. Hamilton et al., "Arsenic exposure is associated with decreased DNA repair in vitro and in individuals exposed to drinking water arsenic," Environmental Health Perspectives, vol. 114, pp. 1193–1198, 2006.
[50] S. A. I. Mahmood and A. K. Halder, "The socioeconomic impact of arsenic poisoning in Bangladesh," Journal of Toxicology and Environmental Health Sciences, vol. 3, no. 3, pp. 65–73, 2011.
[51] M. A. Rahman, A. Rahman, M. Z. K. Khan, and A. M. N. Renzaho, "Human health risks and socio-economic perspectives of arsenic exposure in Bangladesh: A scoping review," Ecotoxicology and Environmental Safety, vol. 150, pp. 335–343, 2018.
[52] S. Guha and M. Chaudhuri, "Removal of As (III) from ground water by low cost material," Asian Environment, vol. 12, no. 1, pp. 42– 50, 1990.
[53] G. S. Longsdon, T. J. Sorg, and J. M. Symons, "Removal of heavy metals by conventional treatment," in Proceedings of the 16th Water Quality Conference on Trace Metals in Water Supplies: Occurrence, Significance and Control, Urbana Champaign, IL, USA: University of Illinois, 1992, pp. 111–113.
[54] J. G. Hering, P. Chen, J. A. Wilkie, and M. Elimelech, "Arsenic removal from drinking water during coagulation," Journal of Environmental Engineering, ASCE, vol. 123, no. 8, pp. 800–807, 1997.
[55] O. Kartinen and C. J. Martin, "An overview of arsenic removal processes," Desalination, vol. 103, pp. 79–88, 1995.
[56] Y. S. Shen, "Study of arsenic removal from drinking water," Journal of the American Water Works Association, vol. 65, no. 8, pp. 543– 548, 1973.
[57] D. Bhattacharya, P. K. Mukherjee, A. K. Ray, and S. Sengupta, "Arsenic-polluted ground water in West Bengal: A cost-effective remedy," Current Science, vol. 86, no. 9, pp. 1206–1209, 2004.
[58] M. U. Mahmud, M. A. Hossain, and M. M. Rahman, "Internet of Things (IoT)-based smart water quality monitoring system for realtime assessment of drinking water safety," Environmental Monitoring and Assessment, vol. 194, no. 3, pp. 1–15, 2022.
[59] A. Mukherjee, B. Scanlon, A. Fryar, D. Saha, and A. Ghosh, "Artificial intelligence and geospatial technologies for groundwater quality assessment and arsenic risk prediction in South Asia," Science of the Total Environment, vol. 857, p. 159451, 2023.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY