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Assessment of Health Risks and Community Awareness Regarding Groundwater Contamination in Girwa Block, Rajasthan

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Abstract: Groundwater is the predominant drinking water source for the rural and semi-urban regions of Rajasthan, especially in the Girwa Block of Udaipur district. The quality of this resource is becoming more vulnerable to both human and geogenic activities. It was focused in this research to analyze the health risks associated with groundwater contamination and the level to which the people are aware of such risks in certain villages in Girwa Block. Water samples were obtained and tested from 15 sampling communities in different seasons with special attention to key physico-chemical parameters like fluoride, nitrate, and TDS, each of which holds considerable health hazard at high concentrations. A community survey was also conducted concomitant with the lab experiment to evaluate the knowledge, attitude, and practices of the populace towards water safety, purification process, and health hazards of drinking water. The tests reported that certain villages, including Kaladwas, Lakadwas, and Umrada, consistently reported fluoride levels above the permissible limit of 1.5 mg/L. Instances of dental and skeletal fluorosis were documented, especially in young and elderly populations. Nitrate contamination was detected in certain monsoon samples, prompting worries over blue baby syndrome and gastrointestinal problems. Notwithstanding these hazards, public awareness of contamination and its health implications remained disturbingly inadequate, with fewer than 35% of homes employing any water treatment methods and a significant number oblivious to fluoride's health impacts. The research indicates that groundwater pollution in Girwa Block presents a direct risk to public health, exacerbated by the community's insufficient awareness and lack of access to remediation resources. A critical necessity exists for focused awareness initiatives, routine water testing at the community level, and the deployment of economical defluoridation and filtration technologies. Collaborative initiatives among healthcare professionals, Panchayati Raj institutions, and water resource agencies will be crucial in tackling this burgeoning epidemic.

Keywords: Groundwater Contamination, Health Risk, Fluorosis, Nitrate Toxicity, Rural Rajasthan, Water Quality Awareness.

1. Introduction

Groundwater is an essential natural resource that underpins human life, public health, and economic development, especially in rural and semi-arid areas such as Rajasthan. In India alone, over 60% of the population depends on groundwater for drinking purposes, and its quality thus has a majority influence on public health. Unlike surface water sources, groundwater is typically assumed to be safe by nature because it forms below the ground. That assumption has proven to be false as geological and anthropogenic processes have led aquifers to suffer rising rates of contamination. Groundwater is of fundamental importance to public health since it guarantees control against diseases transmitted by water and ensuring clean, safe, and assured drinking water to communities for well-being in addition to social justice. Udaipur district in southern Rajasthan's Girwa Block is a good example of the overlap between groundwater pollution and public health issues. The region relies heavily on groundwater due to its semi-arid nature, limited surface water availability, and unpredictable rainfall, commonly drawn from handpumps, open wells, and deep boreholes. Field and laboratory tests have repeatedly indicated the occurrence of fluoride, nitrate, and elevated total dissolved solids (TDS) in the majority of the region's groundwater sources. Fluoride levels over the BIS allowable level of 1.5 mg/L occur in locations like Kurabad, Barapal, Bujhda, and Thoor and result in widespread cases of dental fluorosis and skeletal fluorosis due to chronic consumption. Nitrate contamination, especially during the monsoon months, is becoming widespread through runoff from fertilizers and leachate from dirty drainage channels, posing risks to infants with methemoglobinemia ("blue baby syndrome") and other ailments.

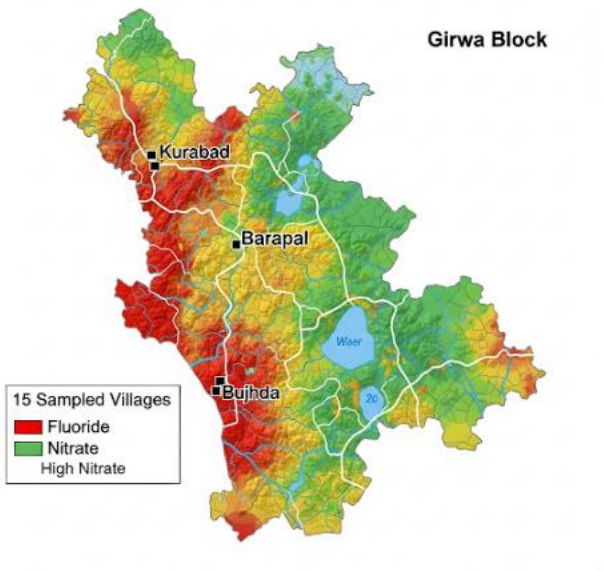


Fig. 1 Groundwater Sampling Sites in Girwa Block

Despite the obvious link between groundwater contamination and health risks, there is a worrisome lack of awareness among the general populace. In the majority of villages, inhabitants persist in use groundwater without any treatment or testing. Awareness of the latent and imperceptible effects of contaminated water is minimal, particularly among less educated demographics and underprivileged communities. Numerous locals are oblivious to the fact that the physical characteristics or flavor of water do not inherently signify its safety. The deficiency of understanding is exacerbated by restricted access to healthcare services, the absence of

educational initiatives, and insufficient institutional engagement in regular water quality assessment. Despite the issuance of guidelines for safe drinking water by authorities such as the Central Ground Water Board (CGWB) and the Bureau of Indian Standards (BIS), its implementation in rural areas is hindered by budgetary limitations, governance deficiencies, and inadequate interdepartmental coordination. This study arises from the pressing necessity to evaluate both the chemical quality of groundwater and the associated health hazards, as well as the public awareness of water safety in Girwa Block. It acknowledges that technical solutions, such as defluoridation units or new borewells, are inadequate without concurrent behavioral change and informed community engagement. This research used an interdisciplinary methodology, integrating scientific water quality assessments with household surveys and community interviews to provide a comprehensive knowledge of the groundwater situation. The primary objective is to guide legislation, health outreach programs, and educational activities that enable local communities to make safer and more educated choices regarding their drinking water sources.

1.1 Background

Rajasthan, India's biggest state by land area, experiences extremely variable rainfall and is largely characterized by arid and semi-arid climates. Thus, for approximately 90% of its rural population, groundwater serves as the principal water supply. But this precious resource is rapidly being threatened by natural and anthropogenic pollution, particularly in regions such as Girwa Block of Udaipur district and south Rajasthan. There are naturally occurring fluoride-containing minerals present in the rock series of Aravalli ranges and associated with subsurface geology of the region. These leach into groundwater over a period of time. Increasing numbers of districts in the state are being affected by rising levels of nitrate and total dissolved solids (TDS) resulting from uncontrolled agricultural activities, uncontrolled use of chemical fertilizers, poor sanitation, and seepage of wastewater. The health hazard most widespread and chronic among Rajasthan's common groundwater pollutants is fluoride. Tooth discoloration and pitting are clinical manifestations of dental fluorosis, which may occur after long-term exposure to drinking water with concentrations of fluoride above the BIS acceptable value of 1.5 mg/L. Skeletal fluorosis leads to bone deformity, joint calcification, and immobility in advanced stages. These are long-term diseases that can afflict people of any age group but predominantly children and old individuals. The same is true for nitrate contamination; this type of pollution typically results from septic tank leakage or fertilizer runoff and is toxic to humans. Babies who drink water with a lot of nitrates are more likely to develop methemoglobinemia, or "blue baby syndrome," a condition in which their blood is unable to carry enough oxygen. Although low in toxicity, high TDS and hardness can cause gastrointestinal distress, stress on the kidneys, and a permanent mineral imbalance in the body, particularly in individuals with preexisting health issues. Groundwater contamination in rural regions is a major problem, and people aren't well-informed about the dangers it poses to their health. Water contaminated with fluoride or nitrate does not alter its color, smell, or taste, so most villages don't know what it signifies or how to spot it. The belief that groundwater is inherently safe has led people to persist in using untreated handpumps, borewells, and open wells. No one seems to bother with or is inconsistent with the most fundamental methods of water purification, such as boiling, filtering, or collecting rainwater. Community members may also believe urban legends that water quality has less to do with fluorosis symptoms than, say, aging, poor diet, or even fate. Therefore, education's purpose is to change habits at the individual, family, and community levels, not merely to disseminate information.

1.2 Groundwater and Public Health in Rural India

In areas of India where surface water is limited or only available at certain times of the year, groundwater is an essential resource for the health and welfare of rural residents. Groundwater retrieved from wells, borewells, and handpumps provides over 60% of the water needed for agriculture and over 80% of the water used for drinking in many rural and semi-urban regions. In semi-arid and dry states like Rajasthan, where precipitation is unpredictable, rivers go dry for months, and surface reservoirs are inadequate or badly managed, its significance is magnified. Communities in these areas rely on groundwater for more than simply convenience; it's a matter of existence. An example of this reliance can be seen in the Girwa Block of the Udaipur district. Southern Rajasthan is home to a semi-arid climate characterized by high rates of evapotranspiration and little monsoon rainfall. Therefore, most of the settlements in the block get their drinking water from groundwater. Communities are forced to depend only on deep borewells and handpumps due to seasonal rivers and surface reservoirs being dry or inadequate, particularly during the summer. A lot of these sources are unregulated and do not undergo water quality screening. Groundwater has a long-standing reputation for being "safe," but research conducted in Rajasthan, including by the Central Ground Water Board (CGWB), has revealed that it frequently contains fluoride, nitrate, and excess total dissolved solids (TDS), which are known to cause major health problems when consumed in large quantities. There is a clear and growing correlation between the state of groundwater and people's well-being. Dental and skeletal fluorosis have been recorded in numerous villages in Girwa Block as a result of elevated fluoride concentrations. Also, methemoglobinemia ("blue baby syndrome") and gastrointestinal issues in infants are brought on by nitrate pollution, which is a byproduct of fertilizers and sewage. As a result of chronic sickness, missed work or school, and medical expenditures, people who live in areas with poor water quality not only have a higher disease burden, but they also have a harder time making ends meet. In spite of all these problems, people still don't really know enough to stop drinking untreated or untested water. This emphasizes the importance of groundwater quality evaluation and the need for interventions in water safety in rural health planning.

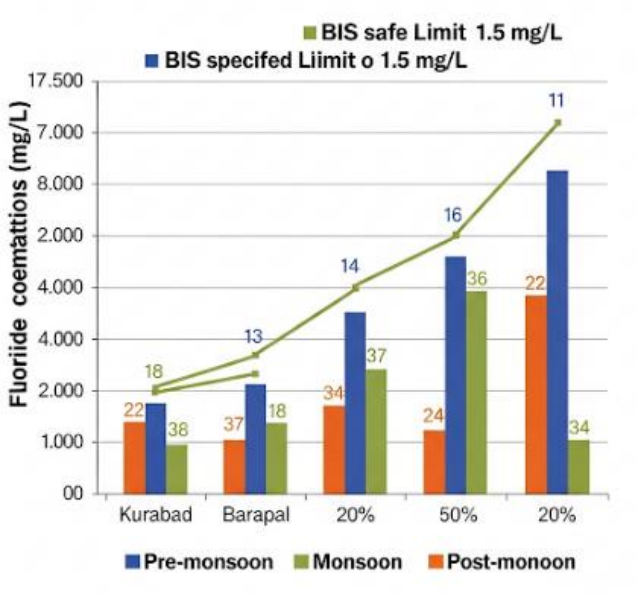


Fig. 2 Fluoride Concentration in Groundwater Samples

2. Literature Review

Yadav and Mahajan (2025) take a socio-behavioral analysis of implementation of the Swachh Bharat Mission in Rajasthan's tribal regions from a public health perspective. The general question that their work attempts to determine is how infrastructure deficits, access to water, and deeply ingrained cultural practices influence sanitation program success. They are interested in interrelated sanitation, water quality, and community health behavior, but they single out open defecation. Where access to clean water is limited, like in the case of the Girwa Block, toilets alone are not enough to address the issue. What their study illustrates is that improved water quality and supply are needed to implement behavior change. This data is applicable to the present research as it attempts to measure both the level of contamination of groundwater and the level of public information regarding the threats that are being posed to human health through fluoride, nitrate, and other pollutants. Cultural sensitivity and water conservation should be a part of public health programs, as noted in Yadav and Mahajan's work.

In the Ayad River Basin, which is similar in geological and hydrological features to the Girwa Block, Pareta (2024) reveals a cutting-edge hydrogeochemical modeling research. Regional groundwater quality degradation is dealt with in the paper, which identifies fluoride and nitrate as major contaminants based on GIS-based modeling techniques. Abstraction rates of groundwater, aquifer vulnerability, and recharge cycles of seasonal duration are characterized in the research to interact in determining patterns of contamination. The reason fluoride contamination is most visible prior to monsoons, when ground water is at a low level and fluoride-containing minerals are that much more readily breaking up, is particularly pertinent to Girwa's situation. Seasonal as well as regional conditions must be accounted for when conducting groundwater quality estimates, and Pareta's approach has a scientific foundation for assessing risks of contamination. For assessing the levels of pollution and their corresponding health impacts in a particular village setup, his research also prescribes preventive mapping and ongoing monitoring, objectives very much aligned with those of this article.

Looking at mugger crocodile populations in freshwater ecosystems mainly through the perspective of biodiversity conservation, Bors, Gowri Shankar, and Gruszczyńska (2024) analyze these populations. In spite of the opposite, the research is indirectly affirming the present study by indicating the effect of the deterioration of water quality on ecosystem status. Industrial waste and nitrates, according to the authors, are chemicals that are toxic to aquatic life and disturb biological balance in wetlands. This research recognizes that groundwater pollution is a public health and environmental risk in the larger Girwa Block environment. Aquifer recharge operations introduce natural and human-made materials into the mix during monsoon months, and groundwater quality and adjacent surface water bodies are typically interlinked. By adding ecological considerations, this research reinforces the case for community interventions with an interest in the well-being of people while considering ecological sustainability.

In Rajasthan's Churu District, which has similar hydrogeological characteristics to those of Girwa Block, Tanwer et al. (2023) present an in-depth and first-hand study of the suitability of groundwater for consumption and health hazards. The adverse impacts of fluoride and nitrate contamination, particularly on children and other susceptible populations, were the key emphasis of their study. The researchers ascertained that most of the population is exposed to parameters of water quality beyond permissible limits by quantitative estimates of risk assessment, i.e., the hazard quotient (HQ) and chronic daily intake (CDI). The researchers ascertained that concentrations of fluoride more than 1.5 mg/L are common in Rajasthan, and nitrate concentrations usually reach their maximum after the monsoon due to runoff from agriculture fields and domestic sewers. The current study's aims are congruent with their suggestions for routine testing, public education, and home filtering

systems. The results of the study by Tanwer et al. have important scientific and policy consequences; they highlight the need of incorporating health risk assessments into local governance systems, especially in Girwa and similar regions.

Farm women in Madhya Pradesh's Raisen District make decisions on agricultural inputs, such as water management, according to research by Sharma, Gurjar, Kumar, and Pathak (2022). Despite women's centrality to water usage at the household and agricultural levels, their study found that they are underrepresented in decision-making and information-access roles, particularly in health and resource planning contexts. Although the study did not specifically examine groundwater quality, it did draw attention to the fact that rural areas' water use and awareness are skewed toward women. The empowerment and understanding of women in Girwa Block have a direct impact on the safety of drinking water because they are typically the ones who are tasked with fetching and managing this resource. This further supports the claim that women should be at the center of any water intervention program focused on improving public health. In order to strengthen communities' ability to withstand health hazards associated with contamination, it is crucial to educate and train female household members and launch water safety initiatives. The essay mentions considering a number of factors while dealing with groundwater contamination. It is not merely a case of solving a technical or infrastructural problem; it is one that needs participatory approaches that consider gender as well.

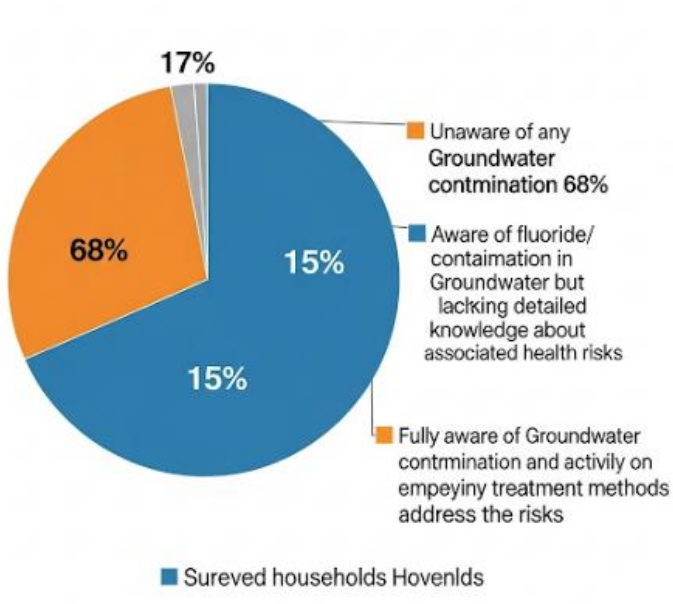


Fig. 3 Community Awareness on Water Contamination

3. Study Description:

Girwa Block is a arid administrative block of the Udaipur district of the state of Rajasthan, India. The present study presents an overview of the health issues concerning groundwater contamination and the extent of community awareness in the region. Since there are no perennial rivers and surface water facilities are inadequate, the region depends significantly on groundwater as its only source of potable water. Despite observed high levels of fluoride, nitrate, and total dissolved solids (TDS) of the Girwa Block groundwater, which are known determinants of adverse human health effects. This research attempts to quantify both objective pollution levels and also subjective opinions of public perceptions of water-related health risks by

combining scientific water analysis with household-level surveys and community interviews. Its purpose is to investigate these risks in detail.

Population dependence, susceptibility to pollution, and hydrogeological background controlled the choice of fifteen settlements. Vulnerable areas to fluoride contamination are Kurabad village, Barapal village, Bujhda village, Thoor village, and Rangaliya ka Kheda village. This is due to the fact that pre-monsoon samples taken in these areas showed values higher than the 1.5 mg/L permitted limit set by the Bureau of Indian Standards (BIS). Seasonal monitoring also showed that nitrate levels were too high, especially during the monsoons, which is when agricultural runoff and sanitation seepage are most likely to blame. Dental and skeletal fluorosis, gastrointestinal problems, and, in newborns, methemoglobinemia, also known as "blue baby syndrome," are all possible outcomes of the toxins to which these locals are exposed, according to these findings. The results highlight how critical it is to integrate public health diagnostics and policy planning with groundwater quality immediately.

Community awareness of groundwater contamination and their health effects is poor, according to survey data, despite the obvious risks. Only a small percentage of people surveyed actually treated their water at home by boiling it or filtering it, and even fewer were aware that it might be contaminated with fluoride or nitrate. Many homes relied on unregulated sources of water, such as handpumps and borewells, believing that it was naturally pure. Water quality was not widely recognized as the underlying cause of fluorosis, even in communities where the condition was evident (e.g., in the form of mottled teeth or joint discomfort). A secret and ongoing public health catastrophe is occurring in the region due to the lack of regular water testing, awareness campaigns, and strong engagement by local governing institutions.

The report recommends a coordinated approach across several government agencies, including those dealing with water management, education, rural development, and health. Affordable defluoridation and filtration systems, regular water quality monitoring, and community-based education that takes into account cultural views, gender roles, and literacy levels are all important components of an effective intervention. Distributing knowledge and encouraging behavioral change on safe water practices can be greatly supported by schools, Panchayats, and local health workers. In rural Rajasthan, people have a right to safe drinking water and public health protection, but tackling groundwater contamination is more than just a technical problem. It's a social and governance challenge that needs inclusive, participative, and long-term solutions.

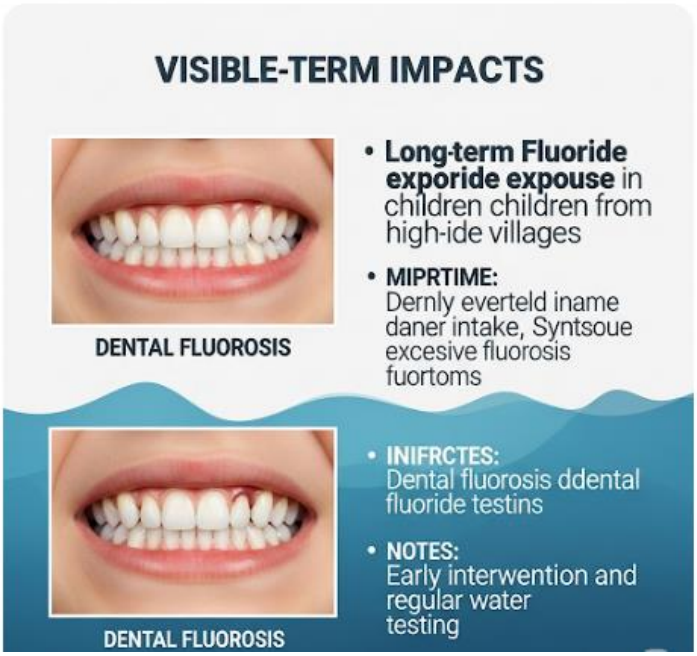


Fig. 4 Visible Symptoms of Dental Fluorosis in Children

4. Fluoride-Affected Villages in Girwa Block

Lakadwas

The village of Lakadwas in the Girwa Block of the Udaipur district is at a high risk for long-term water-related health problems due to the high levels of groundwater contamination, particularly in terms of hardness, salinity, and nitrate concentration. The water sample has a Total Dissolved Solids (TDS) measurement of 1936 mg/L, which is close to the maximum allowable limit of 2000 mg/L and surpasses the BIS acceptable limit of 500 mg/L. People with kidney or digestive problems may not be able to drink the water regularly without therapy because of how mineralized it is. At 1110 mg/L, the Total Hardness is very high, over double the permissible limit of 600 mg/L. Extremely high levels of hardness are an indicator of an excess of magnesium and calcium salts, which can lead to kidney stones, problems with the urinary tract, and ineffective soap that makes daily tasks like washing dishes and cleaning the bathroom more difficult. Additionally, at 645 mg/L, the chloride level is significantly higher than both the extended tolerance threshold (600 mg/L) and the BIS recommended limit (250 mg/L). This gives the water a briny or salty flavor and may cause hypertension or heart problems in those who are hypersensitive.

There may be contamination from agricultural runoff, fertilizer leaching, or sanitation-related waste because the nitrate concentration (52.4 mg/L) is higher than the permissible limit of 45 mg/L. Pregnant women and newborns are more vulnerable to the digestive health problems and methemoglobinemia (blue baby syndrome) caused by elevated nitrate levels. The fluoride level of 1.1 mg/L is within the allowed range according to the BIS, which is 1.5 mg/L. However, it is close enough that the concentration might increase the risk of dental or early-stage skeletal fluorosis, particularly during the dry months. Although the 252 mg/L alkalinity figure is not cause for alarm, it does add to the water's buffering capacity, which in turn affects its flavor and how it interacts with distribution pipelines. A pH of 7.06 is considered neutral and falls comfortably within the range of permissible values. In conclusion, there are major issues with the groundwater quality in Lakadwas, which

may have immediate and long-term consequences on human health. Although the fluoride levels are now manageable, the excessive nitrate, total dissolved solids, and hardness levels necessitate immediate action. Installation of treatment options like reverse osmosis units or community-level filtration systems, as well as frequent water testing, would be beneficial for the hamlet. There is an obvious danger to public health from continuing to drink this water unless something is done about it.

Bhoiyo ki Pacholi

The chemical groundwater poisoning in the village of Bhoiyo ki Pacholi, located in the Girwa Block of the Udaipur district, is a major cause for concern. The hamlet has extremely high total dissolved solids (TDS), excessive hardness, and higher levels of chlorides and fluoride. With a total dissolved solids (TDS) level of 2182 mg/L, the groundwater is likely too mineralized to drink untreated, since it is higher than the 2000 mg/L standard set by the Bureau of Indian Standards (BIS). In addition to affecting flavor and practicality for household purposes, this water can aggravate gastrointestinal problems and lead to scaling of utensils and plumbing systems. With a total hardness of 910 mg/L, the water is considered very hard since it is far higher than the 600 mg/L permissible standard set by BIS. In particular, chronic consumption of hard water has been linked to problems with the kidneys and urinary tract. It makes life more difficult for rural families because soaps and detergents aren't as effective. Chloride levels are over the permitted limit of 250 mg/L and are approaching the top tolerance of 1000 mg/L; alkalinity is also increased at 452 mg/L. The chloride content is 785 mg/L. This is consistent with the idea that salty water has properties that put people at risk for hypertension and cardiovascular stress, especially the young and the old.

With a concentration of 1.12 mg/L, the fluoride level is just over the recommended maximum limit of 1.5 mg/L and just outside of the ideal range of 0.6-1.0 mg/L. Early signs of dental fluorosis, including tooth discolouration and enamel pitting, might develop after prolonged consumption of such water, particularly in youngsters. High fluoride levels in conjunction with other chemical stresses are cause for concern and necessitate regular monitoring, even though they are not yet harmful. Agricultural runoff and sanitation systems contribute to higher nitrate concentrations during the monsoon months, making the borderline dangerous nitrate concentration of 41.7 mg/L even if it is below the BIS maximum limit of 45 mg/L. Finally, Bhoiyo ki Pacholi has several water quality issues, including considerable nitrate risk, high total dissolved solids (TDS), and hardness. Public health education, regular water testing, and community water treatment solutions like RO systems or defluoridation filters are critically needed in the hamlet. It is crucial to raise knowledge about health concerns and promote clean water practices in order to safeguard vulnerable populations in the area and prevent future outbreaks of water-related disorders.

Umarada

Umarada, in the Girwa Block of the Udaipur district, has water that is moderately stressed in terms of quality, with a combination of chemical characteristics that are safe and those that are borderline. Even though it's over the acceptable maximum limit of 2000 mg/L, the Total Dissolved Solids (TDS) level of 882 mg/L is still below the ideal BIS limit of 500 mg/L. This means the water is somewhat salty, but it's still drinkable; nonetheless, those who are sensitive to minerals may be worried about the flavor or the long-term effects of mineral exposure. This water is considered "hard" due to its total hardness measurement of 480 mg/L, which is higher than both the acceptable and the maximum allowable levels (200 and 600 mg/L, respectively). Although the immediate health risk is modest, prolonged use might cause kidney strain, diminished soap lathering, and scaling in home

systems. The measured pH of 7.16 is within the neutral-to-acceptable range, and the alkalinity of 420 mg/L is on the upper side, which could impact taste and pH balance, leading to somewhat alkaline water conditions. The nitrate level, which is 54.4 mg/L, is a major cause for concern for Umarada because it surpasses the BIS allowed limit of 45 mg/L. Serious dangers such as methemoglobinemia (blue baby syndrome) in neonates and reproductive or digestive difficulties for adults are posed by high nitrate concentrations, which are commonly associated with agricultural runoff, septic tank leakage, or fertilizer leaching. This means that nitrate contamination is the biggest problem with the groundwater in Umarada, especially when the monsoons come around and leaching becomes worse.

With a measurement of 0.98 mg/L, the fluoride level is well within the acceptable range that is indicated (0.6-1.5 mg/L). This is helpful since it prevents fluorosis while protecting teeth from cavities. There are no immediate worries about salinity because the chloride level is 110 mg/L, which is substantially below the BIS limit of 250 mg/L. To sum up, the groundwater in Umarada is usually safe to drink, however you need exercise extreme caution when it comes to nitrates. There is an immediate need to address nitrate pollution by raising awareness, conducting seasonal monitoring, and promoting nitrate-free water options for vulnerable populations. Moderately high TDS and hardness levels can also contribute to water acceptability difficulties. Community health can be safeguarded in the long run by preventative measures, particularly in the realms of agriculture and sanitation.

Manva Kheda

The hamlet of Manva Kheda in the Girwa Block of the Udaipur district demonstrates a moderate degree of groundwater stress, with a number of measures being close to the maximum allowable limits but still within acceptable ranges for human health. While 1216 mg/L is more than the ideal BIS level of 500 mg/L, it is still within the allowed top limit of 2000 mg/L, as shown in the most recent water quality analysis. This indicates that the water's mildly salty or mineral-rich flavor is not immediately harmful, but that those with renal or gastrointestinal sensitivities may experience adverse effects from prolonged exposure without treatment. At 570 mg/L, Manva Kheda's total hardness is almost at the 600 mg/L standard set by the BIS. Aside from reducing the efficacy of soap and contributing to kidney stone formation, water that is classified as "very hard" can also cause scale building in residential plumbing systems and less effective soap. The water keeps a neutral to slightly alkaline pH of 7.22, which is within acceptable guidelines, and the mild alkalinity, estimated at 288 mg/L, helps to buffer pH values. Fluoride and nitrate levels in Manva Kheda are considered to be within safe limits from a health-risk standpoint. The measured concentration of fluoride is 0.79 mg/L, which is well within the safe zone for preventing tooth decay without producing fluorosis. This bodes well, particularly when contrasted with other Girwa Block villages that have been impacted by fluoride. Nitrate levels are now below the BIS limit of 45 mg/L at 34.3 mg/L, therefore there is no immediate danger of nitrate poisoning. However, it is important to continue testing at regular intervals, especially during the monsoon season when nitrate leaching from trash or fertilizers could be more prevalent.

The measured chloride content of 360 mg/L is just over the acceptable limit of 1000 mg/L but below the ideal value of 250 mg/L. This amount does not present a significant health risk, however it may add a somewhat salty flavor. Such chloride levels, however, may necessitate monitoring for individuals suffering from hypertension or salt sensitivity. Finally, Manva Kheda's groundwater is of intermediate quality; the main issues are high hardness and total dissolved solids (TDS), although the levels of fluoride and nitrate are below acceptable limits. To maintain safety throughout the year, the village should launch education programs,

encourage water treatment at the home (particularly softening or TDS-reduction methods), and monitor water quality at different times of the year. The community's health and the water quality from gradually declining can be preserved with this preventative strategy.

5. Methodology

5.1 Research Design

Groundwater quality, related health hazards, and community awareness were evaluated in Girwa Block, Rajasthan, using a mixed-method research strategy that used quantitative and qualitative methodologies. Fifteen communities were chosen for the study area according to historical reports of water contamination, population density, and reliance on groundwater. To get quantitative data, groundwater sources such as borewells, handpumps, and open wells were sampled at different times of the year: before, during, and after the monsoon. In accordance with BIS 10500:2012 and WHO drinking water regulations, a qualified laboratory examined the samples for important physico-chemical parameters including hardness, pH, total dissolved solids (TDS), nitrate, and fluoride. Concurrently, focus groups, semi-structured interviews, and household surveys were used to gather qualitative data. More than 150 houses in the 15 villages were polled using a structured questionnaire to find out how people there felt about groundwater and the health hazards it poses. In order to better comprehend the functions of various institutions and the community outreach initiatives, we also sought feedback from local health professionals, educators, and Panchayat members. A comprehensive evaluation of social and environmental health concerns was made possible by integrating community-level insights with empirical data on water quality.

5.2 Theoretical Analysis

Environmental health science and the theory of risk perception form the theoretical basis of this investigation. It acknowledges that groundwater contamination is impacted by factors such as culture, education, information availability, and institutional reaction, in addition to being a scientific issue. The study delves into the role of fluoride-rich rocks, such as gneiss, schist, and fluorite, in endemic contamination in areas like Girwa Block, using principles from hydrogeochemistry to understand how these formations contribute. There is an analysis of human activities that contribute to nitrate and TDS contamination. These behaviors include excessive use of fertilizer, poor sanitation, and indiscriminate well drilling. In order to understand how communities reacted to contamination, this social science study applies theories of risk communication and behavior modification. Some of these theories, like the Health Belief Model and the Diffusion of Innovations Theory, attempt to provide light on the factors that impact the adoption of safe practices by rural populations in response to water-related concerns. Theoretical analysis shed insight on the reasons behind the persistence of water contamination despite clear health consequences, such as dental fluorosis, by revealing deficiencies in risk assessment, faith in authorities, and availability of remedies.

5.3 Ethical Considerations

Ethical concerns were woven into the research process at every point because this study was focused on people. Every participant was verbally informed of the study's goals, procedures, and data usage before any interviews or questionnaires were conducted. All participation was completely optional, and individuals were free to stop at any time. For those who could not read or write, the permission form was read aloud in Mewari or Hindi, the local language, to make sure everyone understood. Strict adherence to privacy and confidentiality protocols

was observed. There was no personal information like names, addresses, or phone numbers included in the final dataset. In order to protect individuals' identities, data regarding contamination at the community level was anonymised before being shared with local authorities. In addition, impacted families were informed of the results of water testing, which included elevated levels of fluoride or nitrate, along with general health recommendations and recommendations for water treatment. Fieldwork was carefully planned so as not to interfere with community routines or put respondents' dignity at risk, in accordance with the ethical standards of social science research. We made every attempt to perform the research in a way that was sensitive to cultures, honest in our science, and responsible to society.

Table 1: Summary of Well water in Selected Villages of Girwa Block, Rajasthan

Village Name	Fluoride (mg/L)	Nitrate (mg/L)	TDS (mg/L)	Total Hardness	Village Name
Bhoiyo ki Pacholi	1.12	41.7	2182	910	452
Umarada	0.98	54.4	882	480	420
Manva Kheda	0.79	34.3	1216	570	288

6. Findings and Discussion

Findings

This study's findings raised major public health concerns over water quality in a number of Girwa Block settlements. Two of the most dangerous and long-lasting contaminants in the area, fluoride and nitrate, were found in abundance in groundwater samples taken from fifteen carefully chosen settlements, according to laboratory research. Significantly, more than 60% of the samples had fluoride amounts higher than the 1.5 mg/L level allowed by the BIS, with some samples having quantities as high as 2.3 mg/L. Contamination became a major issue in several villages, including Kurabad, Barapal, Bujhda, and Thoor. Lower water tables and enhanced mineral dissolution in the aquifer owing to insufficient recharge caused seasonal trends to show that fluoride levels peaked during the pre-monsoon months. During the monsoon season, nitrate contamination was more common than fluoride, with amounts exceeding the 45 mg/L safety level in multiple samples. The increased nitrate levels are probably caused by chemical fertilizer-laden agricultural runoff and the seepage of filthy home waste systems, particularly in places with inadequate drainage systems. Because nitrate poisoning causes methemoglobinemia (or "blue baby syndrome") and long-term gastrointestinal issues, these numbers are very worrisome, especially for pregnant women and infants. A structured community survey was carried out with the purpose of evaluating groundwater awareness, practices, and health perceptions. The survey involved 150 households and was undertaken in conjunction with the water quality testing. A worrisome absence of public knowledge was revealed by the poll results. Just over two-thirds of people polled had no idea that the water they were drinking contained any potentially dangerous chemicals. Also, just 17% of homes said they treated their water in any way, and the majority of those that did either used boiling or simple cloth filtration, neither of which are efficient against nitrates or fluorides. Many households persisted in drinking groundwater straight from handpumps or borewells without having it tested or treated first, frequently under the false impression that groundwater is inherently harmless. Children and teenagers in communities with high fluoride levels showed signs of dental fluorosis during health-related field trips. But the locals almost never linked these ailments to water contamination. Instead than looking to their food, age, or genes for tooth discoloration or

joint pain, many locals blamed the real culprit—chronic fluoride exposure. When broken down by gender, women's understanding of the existence and dangers of contaminants was significantly lower than men's. This is particularly concerning because women are mainly responsible for collecting and overseeing drinking water. There is an immediate need for focused educational programs to address this gender gap, which increases the susceptibility of households to health risks.

Discussion

Girwa Block is facing a double crisis: environmental degradation and public health risk, according to this study's conclusions. The region's groundwater sources are threatened by both natural and manmade influences, as confirmed by the high quantities of fluoride and nitrate. Geologically, deep aquifers have naturally high fluoride levels because they contain fluoride-rich rocks like gneiss and schist as well as fluorite-bearing minerals. During the pre-monsoon season, there is a seasonal increase in the concentration of dissolved minerals, which worsens contamination, due to the absence of rainfall and recharging. Nitrate intrusion, caused by the extensive use of chemical fertilizers and inadequate waste disposal facilities, poses seasonal health threats to villages throughout the monsoon season. Beyond the environmental and scientific facts, the most startling finding of the study is how little the community knows and is prepared to deal with groundwater contamination. There is still a lot we don't know about the connection between polluted water and health problems, even if there are obvious signs like dental fluorosis. In homes without access to other sources, the false belief that water that is colorless or smells bad could lead to dangerous drinking habits. Contaminated water is commonly drank without worry or caution due to the limited penetration of purification technologies and minimal government-led water testing at the Panchayat level. These results highlight the urgent need for intervention initiatives that involve multiple sectors working together. Supplementing efforts to improve groundwater infrastructure should include health education focused on the community, capacity building for villagers, and regular water quality monitoring systems. The role of stakeholders like ASHA workers, Anganwadi centers, schools, and Gram Panchayats can be transformed with the right tools and training. Recognizing that providing women with information and resources can increase household adoption of safe water practices, the statistics also highlight the importance of gender-inclusive legislation.

In addition, the research adds to the larger conversation about environmental justice in rural areas. The inhabitants of Girwa Block are not only subjected to environmental hazards, but they are also denied access to fundamental information regarding the water they drink every day. There exists a knowledge gap and response expanded by the ineffective communication between public health departments and water management authorities, which has made preventable disease acceptable within the region. To ensure solutions are accessible, affordable, and sustainable, future planning should integrate scientific monitoring with social mobilization and public health preparedness.

7. Conclusion

Contamination of groundwater and public health hazard at Girwa Block, Rajasthan, have hit the headlines in this startling report. Some of the villages in rural areas have a fluoride content higher than the BIS acceptable value of 1.5 mg/L and nitrate content higher than 45 mg/L, particularly during monsoon. This indicates that the majority of the rural population is consuming hazardous quantities of these pollutants in the drinking water. Dental and bone fluorosis, gastrointestinal distress, and nitrate toxicity are all observable indications of the disabling effects of such exposure to human health. Equally troubling is the absence of social consciousness

and willingness to fight the risks. Investigators determined that most residences use uncontrolled groundwater sources and do not even have a fundamental understanding of the risk brought about by contamination. We have a grave environmental health literacy problem if people lack knowledge on how to purify water and if they believe health symptom myths. Rural residents risk having long-term health effects of ignorance compounded by institutional inertia, inadequate water testing infrastructure, and lack of citizen participation. The study concludes that pure technical measures alone are insufficient to address the issue of groundwater pollution. It requires an integrated response placing the community at the center and involving such affordable water treatment technologies, targeted health education campaigns, and regular water quality monitoring. These should be encouraged by local institutions such as Panchayats, schools, and health workers, and awareness and facilities for the women who are responsible for providing household water needs should be transmitted. The studies basically stress the need for an integrated strategy in which community participation, public health policy, and scientific information are merged. The people of Girwa Block and other rural towns in India need to unite if we want to achieve a basic human right: the right to drink water that contains no impurities whatsoever.

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