Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 8 ~ Issue 4 (April 2022) pp: 73-79
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Study of sources and consequences of groundwater pollution in some villages of Diphu, Karbi Anglong district, Assam, India from various point sources

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Abstract
Geogenic sources such as Fluoride and Arsenic, which are mostly dissolved from rocks and soil, are contaminating groundwater in Karbi Anglong, specially in the plain parts of Diphu. Leachate from septic tank, landfills and industrial activities can seep into the groundwater, contaminating aquifers with pathogens like bacteria , viruses, nitrates and heavy metals., potentially impacting the quality of drinking water sources. There is typically very little turbulence and very slow movement of groundwater. Therefore, there is little dilution or dispersion after a contaminant enters the groundwater. Rather, the concentration plume can follow the same course as groundwater. Deeper aquifers beyond 10 meters have high levels of iron above the allowable limit, the pediment zone on the northern foothill zone in the Diphu Subdivision have high levels of fluoride up to 16 parts per million. In contrast, the shallow zones are free of both fluoride and iron.In such areas leakage from septic tanks introduces pathogens and viruses causing diseases such as diarrhea, cholera, hepatitis A and E, Typhoid. Nitrate poisoning interferes with oxygen transport in the blood. Heavy metals from landfills cause cancer, liver and kidney damage etc. Industrial groundwater pollution causes aquifer degradation, loss of biodiversity and reduce fertility and forest regeneration capacity.

Key Words: *Groundwater, pollution, geogenic, anthropogenic sources, diseases.*

I. Introduction

When natural pollutants (fluoride, arsenic) or man-made products (oil, gasoline, road salts, chemicals) seep into the earth and contaminate aquifers, the result is groundwater contamination. Surface spills, leaking subterranean storage tanks, malfunctioning septic systems, or inappropriate disposal of hazardous waste are the causes of this. These sources introduce a variety of contaminants, including nitrates, bacteria, heavy metals, and harmful chemicals, which can infiltrate groundwater supplies through leaching and runoff. The resulting contamination can lead to waterborne illnesses, ecological damage, and potential economic consequences. This region, being ecologically sensitive with tribal populations depending heavily on natural water sources, is particularly vulnerable. The world's population relies heavily on groundwater for industrial, agricultural, and residential purposes. Groundwater provides drinking water for almost one-third of the world's population . In arid and semi-arid areas with little precipitation and surface water, groundwater is an especially valuable resource. *(Peiyue Li, 2021)*

One recurring issue found in groundwater research is chemical pollution. Although groundwater contamination poses a significant threat to human populations, it also offers researchers a chance to learn more about the evolution of our subsurface aquifers and decision-makers a way to preserve the quantity and quality of these resources.

Weathering of rocks releases naturally occuring arsenic, fluoride, iron, and manganese into aquifers. These minerals dissolve in groundwater, especially under certain pH or redox conditions. Karbi Anglong district has hilly terrain and mineral-rich formations that may release iron and manganese, and possibly fluoride. The region’s granitic and sedimentary rocks in fractured hilly formations, naturally release high levels of fluoride ranging from 0.15-17 mg/L in several blocks of Karbi Anglong district. This leads to dental and skeletal fluorosis, affecting around 10% of the population, with children at higher risk. The BIS permissible limit of fluoride is 1.5 mg/L.

Iron contamination is also present due to natural weathering of minerals, contributing to poor water quality. The BIS permissible limit of iron is 0.3 mg/L.

In Karbi Anglong district, the groundwater pollution by manganese is primarily caused by geogenic and anthropogenic factors. These include the weathering of mangnese bearing minerals in the local geology, agricultural practices, and potentially mining activities. The BIS permissible limit of manganese is 0.3 mg/L.

If there is no transport mechanism in place, the pollutant that has been added to the soil rock groundwater system will not travel throughout the system. For instance, a liquid that flows. Numerous physical, geochemical and biological processes affect the destiny of the contamination as soon as it enters the saturated or unsaturated zone of subterranean water.

Many of the contaminants in groundwater are of geogenic origin as a result of dissolution of the natural mineral deposits within the Earth's crust. Both organic and inorganic forms of arsenic are naturally occurring elements in the environment. Trivalent arsenite (AsIII) and pentavalent arsenate (AsV) are two examples of the more common and hazardous inorganic forms of As found in terrestrial environments compared to the organic forms. By interacting with the sulfhydryl groups found in cysteine residues, it has a highly deleterious effect on overall protein metabolism.When people contract arsenicosis, it has a devastating effect on their capacity to earn a living, maintain a family, and support themselves. Women become socially outcast when their physical beauty deteriorates. Larger viewpoints are raised because contamination of an area can lead to poverty, stress on society, disability in individuals, and a drop in the market value of potentially polluted agricultural products, which lowers the income of the impacted farmers. It is impossible for a layperson to notice and avoid due to the lack of taste, odor, color, and exposure. *(Shiv Shankar et.al., 2014).*

The inorganic version, which is present in many foods and surface and ground water, is far more dangerous. Numerous detrimental health effects, including cancer of the skin, lungs, liver, kidney, and bladder, as well as neurological and cardiovascular problems, are caused by this type. Water passing through rocks rich in arsenic may contain arsenic. The sources are varied. These include fossil fuel burning, industrial effluents released into water, the dissociation of minerals and ores, and the introduction of the earth's crust into water. *(Basu et al. 2014)*

Septic systems and pit latrines without proper design or contaminant is widespread in rural areas-this leads to pathogens, nitrates, and organic pollutants infiltrating groundwater which is unsafe for consumption and other uses. When rainwater or other liquids enter a landfill, they percolate through the layers of waste. As these water passes through the garbage, it picks up a variety of contaminants including lead, mercury, arsenic, some organic pollutants from decomposing food and plastics, pathogens from medical or organic waste, chemicals from batteries, paints, electronics etc. All these contaminated liquid is known as leachate. If the landfill is not properly sealed, the leachate can seep into the soil and from there it can migrate downward and reach the groundwater table. Once leachate reaches the groundwater, it pollutes drinking water sources, harm ecosystems that rely on clean groundwater, cause long-term health effects for humans and wildlife. Karbi Anglong faces landfill pollution due to its geography and socio-economic conditions. Due to hilly terrain and high rainfall leachate runoff very fast into streams and aquifers, during monsoons there is more possibility of spreading of pollutants. Many dumpsites in rural and semi-urban areas are unlined open dumps. In Karbi Anglong district, there are many villages which depend on shallow wells or springs which are in close proximity of landfills. where groundwater tables are more vulnerable. Mixed waste dumping and burning of waste also contributes to air pollution, which later settles on land and leaches into water. Groundwater contamination can have a significant impact on human health, economic development, and social well-being. In the Northeast, as in other parts of India, anthropogenic activities can negatively impact groundwater quality. To effectively manage groundwater, it is necessary to have comprehensive data on its current and potential quality. Therefore, a thorough understanding of water resource quality in the state of Assam is paramount for prudent groundwater management. Government should take initiative for installation of leachate collection systems and regular monitoring of groundwater pollution every year. Municipal infrastructure should be strengthened. Public awareness programme should be arranged there to encourage people about proper disposal and reduce open dumping.

Although Karbi Anglong is primarily a tribal, forested and agricultural district with relatively limited industry, certain localized industrial and mining activities-especially limestone mining and cement manufacturing which has measurable environmental impacts. This district has substantial limestone reserves. The Cement Corporation of India (CCI), a Government of India enterprise, Bokajan Cement Plant is located near Diphu in the Karbi Anglong District of Assam. Mining is done for cement factories. Mining exposes sulfide minerals that react with water and air to form sulfuric acid, lowering the pH for groundwater. Dust and sedimentation from mining pits seep into water channels and aquifers.Small scale industries in the region like sawmills, food processing units, brick kilns often lack proper waste treatment. Wastewater and effluents containing oil, grease, chemicals, and organic matter percolate into the soil and contaminate aquifers. Excessive use of chemical fertilizers and pesticides also leaches into the groundwater and disturbs the natural water filtration cycles. Environmental regulations are not strictly enforced in many parts of Karbi Anglong due to administrative challenges in remote tribal areas. Contaminated groundwater leads to reduced agricultural productivity due to toxic water used in irrigation and also effects publuc health which causes gastrointestinal disorders, skin diseases and neurological problems. Contaminated groundwater used for irrigation can effect crop yield and food safety, impacting the livelihoods of local farmers. Toxic contamination may lead to loss of biodiversity, these may harm aquatic flora and fauna in connected water bodies. Industrial pollutants and seepage from septic tanks can lead to soil contamination, affecting agriculture and forested areas of Karbi Anglong.

II. Aim of the study:

The aim of this study is to examine the primary anthropogenic and naturalsources of groundwater pollution in the KarbiAnglong district and evaluate the effects that these sources have on local ecosystems, public health, and livelihoods.

III. Literature Review:

Fluoride contamination is the dominant water-quality concern in central Assam particularly in Golaghat,Assam, often exceeding WHO limits and posing serious health risks. Karbi Anglong's groundwater faces challenges related to fluoride and iron contamination, with geological factors and human activities contributing to the problem. Addressing these issues requires a multi-faceted approach, including monitoring, source identification, and public awareness campaigns.

Long-term rock-water interaction is thought to be the cause of the fluoride enrichment in groundwater. Significant amounts of fluoride are present in the crystal structures of hydrous silicate minerals as biotite, muscovite, hornblende, and tourmaline. This is because the hydroxide ion (OH-) and fluoride have almost the same ionic radius (0.136 nm), which causes the two ions to frequently replace one another in the crystal structure of minerals. Fluorapatite $[Ca_3 (PO_4)_2(F,Cl)_2]$ and fluorite (CaF2) are other minerals that include fluoride. However, at typical temperature and pressure settings, fluorite is not very soluble in fresh water and dissolves at a very sluggish rate. Consequently, the breakdown of silicate minerals and fluorapatite in the rocks is more likely to be the cause of a high fluoride concentration in groundwater. *(Dr. Duryadhan Behera, 2020).*

In general, groundwater contains more fluoride than surface water due to greater contact and residence times with fluoride-bearing minerals in rock-water interactions *(Edmunds and Smedley, 2012*). About 70 million people in 20 states and union territories are at danger of developing fluorosis, and it is estimated that 14.1% of the fluoride deposited on the earth's crust is found in India. Andhra Pradesh, Rajasthan, Haryana, Tamil Nadu, Gujarat, Uttar Pradesh, Punjab, Madhya Pradesh, and Bihar are among the regions of India that are negatively impacted. Humans can be exposed to fluoride through five main sources, including industrial processes, food, medicine, cosmetics, and dental items. However, drinking water contributes significantly—up to 75–90%. Since fluoride is extremely electronegative and does not exist in the free state, it combines with a variety of substances to generate ionic compounds in water, such as HF and NaF, which dissolve to form fluoride ions with a negative charge. Numerous studies demonstrate that moderate fluoride intake can reduce dental cavities and, in certain cases, improve the development of strong bones. The mineral hydroxyapatite $(Ca_{10} (PO_4)_6 (OH)_2)$ is collected in and around the collagen fibrils of skeletal tissues in order to produce bone. Fluoride can create fluorapatite $(Ca_{10} (PO_4)_6F_2)$ by replacing a column hydroxyl in the hydroxyapatite structure. This substitution results in a decrease in mineral solubility, an increase in structural stability, and a decrease in crystal volume. The driving force behind the formation of apatite minerals may also be enhanced by free fluoride ions in the fluid phase. Since fluoride is important for the development of strong bones, several medical professionals have looked into the possibility that consuming fluoride could help prevent osteoporosis. Clinical and epidemiological studies have demonstrated that fluoride supplementation with adequate calcium and vitamin D levels can aid in bone calcification. The incidence of fractures may rise when the fluoride content of drinking water is more than or equal to 4 parts per million. Skeletal fluorosis results from prolonged consumption of water with more than 8 mg/l of fluoride. The accumulation of fluoride ions in the pelvis, neck, knee, and shoulder joints results in issues with walking and movement. *(Preeti Gahlot et.al.,2020).*

High levels of iron are also commonly found in Assam's groundwater, often imparting an unpleasant taste and discoloration to the water. Studies have shown iron concentrations exceeding the permissible limit in Greater Guwahati and other regions. The Brahmaputra River basin, a major source of water for Assam, is significantly impacted by groundwater contamination, particularly with arsenic.In India, arsenic contamination in groundwater is becoming an emerging issue in the water supply and health sectors. Its abundance has been primarily reported from the Bengal Delta of West Bengal. According to Singh (2004), high concentration of arsenic in groundwater of North eastern states of India viz. Assam, Manipur, Mizoram etc. has become a major cause of concern in recent years. The problem of arsenic in groundwater in Assam is also a matter of great concerned. The presence of groundwater arsenic in the state of Assam was first reported by Singh (2004), NERIWALM. His study revealed that 20 of the 30 districts of Assam have arsenic concentration exceeding 0.050 mg/l. Another study revealed that several underground water sources in India's northeast are unfit for consumption due to highly toxic contamination of arsenic. *(Chakraborty et al. 2004)* . In 2005, Public Health

Engineering Department (PHED), Assam carried out a state wide blanket survey for arsenic contamination in drinking water. In total 5729 water samples collected from 22 of the 30 districts in Assam, where the water samples collected from 18 districts had arsenic concentration greater than 0.05 mg/l. Groundwater arsenic contamination in Brahmaputra River basin of Golaghat district (Assam) imposes serious health hazards. There is a very significant correlation between arsenic and iron and suggested that the mobilisation of arsenic in the groundwater of that region may have been caused by the reductive breakdown of arsenic-iron featuring minerals. *(Chetia et al. (2010).* Arsenic and iron contamination of ground water in three development blocks of Lakhimpur district, Assam was (*Bhuyan et al.*.2010). It is recommended to take precautions against the harmful elements since Assamese ground water contains arsenic, which has been confirmed and tested by national and international bodies. However, because the concentration is significantly lower than the WHO and BIS-recommended tolerance threshold, the distribution of fluoride has shown less concern for the environment and human health. Furthermore, maintaining environmental sustainability in Assam may benefit from raising knowledge of community sanitation. Furthermore, research has shown that arsenic may harm genetic structure and contribute to metabolic disorders. Exposure to arsenic may cause Alzheimer's disease, inflammatory brain disorders, and cardiovascular problems. In addition to harming DNA, arsenic ingestion results in additional associated neurological issues. The state of Assam's groundwater is unimaginable, and both directly and indirectly, Assamese people drink it. In addition, rice absorbs more water and minerals, which are then immediately absorbed by the body and mind. (*Ananta Kumar Jena et.al., 2020). River Kopili, regarded as one of the most important Southern bank tributaries of the mighty river Brahmaputra, is facing a tremendous pollution threat from its riparian areas, especially in its upper stretches due to anthropogenic activities. The Central Pollution Control Board (CPCB) in one of its report has placed the Kopili river in 4th rank among the 56 most polluted river of North-East region. The water quality index of the river ranges from poor to unsuitable quality of water for drinking in almost all the five sampling stations. The water quality found to be deteriorated during winter season .(D.Nath et.al., 2020).*

The Study Area:

The various sources contaminates water in Diphu. The contaminated water leads to severe health issues, including respiratory problems from air pollution and potential fluoride-related illness, while also damaging agricultural lands. Some villages from Diphu in Karbi Anglong district is selected for study about the pollution level of groundwater and surface water.

Sl.No.	Sample No,	Location of station	Nature of source
1	A_1	Dekachang Adivashi Gaon	Tube well (TW)
2	A_2	Bagsamari	Tube well (TW), Dug Well (DW)
3	A_3	Dokmoka	Tube well (TW),River Water(RW)
4	A_4	Horkati Boro Gaon	Tube well(TW) ,River Water(RW)
5	A_5	Langhin	Tube well(TW), Dug Well(DW)

Sources of water sample:

TW_1=Tube well of sample no. A_1
TW_2=Tube well of sample no. A_2
TW_3=Tube well of sample no. A_3
TW_4=Tube well of sample no. A_4
TW_5=Tube well of sample no. A_5
DW_2=Dug well of sample no. A_2
DW_5=Dug well of sample no. A_5
RW_3=River Water of sample A_3
RW_4=River Water of sample A_4

IV. MATERIALS AND METHODS:

The whole year is divided into three seasons, viz. Pre-monsoon season (February-May), Monsoon season (June-September) and Winter (October-January) starting from Feb, 2021 to Jan,2021. But here the groundwater samples were collected in winter season, i.e., from October, 2021 to January,2022. Water samples were collected in pre-cleaned polythene containers of 5 liters capacity from different sources in 5 locations. The sources includes tube wells (from TW_1 to TW_5), dug wells (from RW_2 and RW_5) and river water(from RW_5). Random selection was used to choose individual water samples, which were then combined in sterile, clean 5-litre polythene cans, rinsed with diluted HCl to create a representative sample, and kept in an ice box. During transit to the lab, samples were shielded from the sun, and metals were examined in accordance with standard protocol.

Nitrate content was measured by using a UV-VIS spectrometric technique (Hitachi 3210) by measuring the absorbance of the phenol-disulphonic acid nitrate complex at 410 nm. The process typically involves a colorimetric analysis using chemical reagents that form a colored complex with nitrate ions specifically using the Phenol Disulphonic acid (PDSA] method. The methodology involves a series of precise chemical reactions and measurements. Initially, a water sample is mixed with a known amount of KNO_3 to introduce a nitrate standard for calibration. The sample is then treated with PDSA reagent, which reacts with nitrate ions to form a yellow-colored complex. To ensure complete reaction and accurate measurement, potassium hydroxide is added to adjust the pH, and silver sulfate is introduced to remove any interfering substances by precipitating them. Following this, the sample is subjected to a color evelopment phase, and EDTA is used to complex any residual metal ions that might interfere with the colorimetric analysis. After colour development, the intensity of the yellow colour is measured using a spectrophotometer of approximately 410 nm. The concentration of nitrate nitrogen and nitrite in the sample is determined by comparing the absorbance of the sample to a calibration curve prepared from standard nitrate solution.***[** APHA-American Public Health Association, (2017),**]***

Iron in water samples were estimated estimated by phenanthroline method. Ferrous iron chelates with 1,10- Phenanthroline at 3.2 to 3.3 to form an orange-red complex. The intensity of this colour is proportional to the iron content in the sample and the later was read on a UV- spectrophotometer (Hitachi 3210) operating the instrument at 510 nm in photometry mode calibrating against a standard and a blank.

Fluoride was measured spectrophotometrically by the SPADNS method at 570 nm. The process involves a colorimetric analysis that provides a quantitative measurement of fluoride ions. Initially, a water sample is treated with SPANDS (Sodium Phenolphtalein Phthalein) reagent, which reacts with fluoride ions to form a colored complex. The sample is first adjusted to a appropriate pH using a buffer solution to ensure optima conditions for the reaction. The addition of SPANDS reagent to the sample produces a blue-colored complex in the presence of fluoride ions. The intensity of the blue color, which is directly proportional to the fluoride concentration, is measured using spectrophotometer at a specific wavelength typically around 570 nm. The concentration of fluoride in the sample is then determined by comparing the absorbance of the sample to a calibration curve prepared using known fluoride standards. ***[**APHA-American Public Health Association, (2017), 23^{rd} Edition**]***

Atomic absorption spectroscopy (AAS) with hydride generation is a widely used method for determining arsenic levels in groundwater. This technique involves converting arsenic in the sample to gaseous arsine (AsH_3), which is then introduced into an atomic absorption spectrophotometer. The absorbance of light at a specific wavelength by the arsine molecules is measured, and this absorbance is directly proportional to the arsenic concentration in the sample.

Sample Preparation:

Groundwater samples may contain arsenic in different chemical forms (e.g., As(III) and As(V). Some AAS methods require pre-reduction of As(V) to As(III) for accurate total arsenic determination. The sample is acidified, often with hydrochloric acid (HCI), to optimize hydride generation. A reducing agent, like sodium borohydride ($NaBH_4$), is added to convert arsenic to arsine gas.

Hydride Generation:

The acidified sample, containing arsenic, is mixed with a reducing agent, typically sodium borohydride. Arsenic compounds in the sample are reduced to arsine gas (AsH_3). An inert gas, such as argon, is used to carry the arsine gas into the AAS instrument.

Atomic Absorption Measurement:

A light source emits light at a specific wavelength known to be absorbed by arsenic atoms.The arsine gas is passed through a flame or a heated quartz cell (depending on the AAS configuration.The amount of light absorbed by the arsenic atoms is measured by a detector. The absorbance reading is compared to a calibration curve created using standard arsenic solutions to determine the concentration of arsenic in the original sample.

Microbiological examination of water enjoy a special status in studying the water quality. In this examination the Most Probable Number (MPN) indices of total coliform organisms as well as faecal coliforms were determined using the multiple tube fermentation technique (Greenberg et. al, 1985). The method is based on the ability of coliform organisms to ferment lactose sugar producing an aldehyde and carbon dioxide gas. The fermentation was carried out in an incubator (SICO India). at 35 (+/-)0.5°C for total coliform and at 44(+/-) 0.5^0C for faecal coliforms.These presumptive tests were confirmed following standard procedure. The presence of E. coli was tested by the indole formation test and was confirmed by differential test . Free-living amoebae (FLA) are common unicellular organisms that can be found in samples of dust, water, soil, and air. Certain FLA are thermophilic, meaning they can endure and/or proliferate at temperatures of 37 °C or higher. Primary amoebic meningoencephalitis (PAM), a rare but usually fatal disease of the central nervous system, can be brought on by the thermophilic FLA Naegleria fowleri, which is commonly found in freshwater and soil. In freshwater lakes, it is typically acquired while swimming or engaging in other leisure activities. (The Most Probable number method is commonly used to quantify free-living amoebae(FLA), including pathogenic species. The MPN values were calculated on the basis of number of positive and negative presumptive tests *.(Mirna Moussa et.al., r2020).*An optimized most probable number method PCR(Polymerase chain reaction) technique amplifies specific DNA sequences, allowing for the detection and quantification of viruses and bacteris. It is highly sensitive and can fetect even low concentrations of microorganisms.

Culture based technique is also used which involves growing microorganisms on specific types of media that favor the growth of certain bacteria or viruses.

V. Results and Discussion:

The following table shows the average values of nitrate, iron, fluoride, arsenic, manganese and Escherichia coli bacteria.. Here results of one season is presented, i.e., from October, 2021 to January,2022

Sl.no.	Sampling sources	Nitrate(mg/L)	Iron (mg/L)	Fluoride (mg/L)	Arsenic (mg/L)	Manganese(mg/L)	E.coli MPN/100ml
1	TW_1	7.73	12	16.13	ND	2.9	0.3
2	TW_2 DW_2	7.69 8.00	7.85 6,81	17.00 16.99	ND 0.01	2.05 ND	0.001 0.002
3	$TW_{3,}$ RW_3	7.89 6.16	9.01 8.54	13.00 12.01	0.01 0.002	2.00 2.89	3.22 4.19
4	TW_4	8.1	8.92	15.00	0.1	3.01	1.23
5	$TW_{5,}$ DW_5	9.79 7.2	9.12 8.03	17,16 16.99	6.3 6.01	3.00 3.34	2.24 3.37

Samples collected near agricultural fields shows elevated nitrate concentration exceeding the BIS permissible limit (45 mg/L.). This suggests excessive use of fertilizers and inadequate waste disposal practice Dokmoka is affected by fluoride and arsenic from the waters of Dikrut river. Some places Bokajan subdivision are also known to be affected by arsenic contamination in groundwater, additionally other areas like Diphu which is situated on a hilly plateau within the Karbi Anglong district of Assam is also susceptible to arsenic contamination due to its location within the South and Southeast Asian Arsenic belt. In Diphu both the pollutants As and F^-, were found to be predominant in shallow aquifers(<20m). The fluoride content in groundwater varies from place to place differences in geographical, chemical and physical characteristics of water bearing aquifers, the porosity of rocks, the pH and temperature of water. When Fluoride containing minerals in the rocks and soils come in contact with groundwater, they release fluoride into water by the process of hydrolysis. Many people in this district are affected by dental fluorosis and skeletal fluorosis. BIS permissible limit of E.coli in drinking water is zero. E.coli pollution is found in Dokmoka, Langhin and Bagsamari in Diphu. The value of E,coli bacteria is considerably high in river wells.The presence of coliform bacteria in the water sources from sewage and faeces of animals from various sources, which is undesirable for human consumption. Their presence also indicate the possibilities of occurance of pathogenic organisms in the water.

VI. Conclusion:

The world's population relies heavily on groundwater for industrial, agricultural, and residential purposes. One of the key components of a country's sustainable development is ensuring a clean, renewable supply of drinking groundwater. Groundwater pollution in Karbi Anglong district is a growing concern, driven by both geogenic and anthropogenic factors such as improper waste disposal, agricultural runoff, and lack of adequate sanitation infrastructure. It presents a significant environmental and public health challenge. Of this type of pollution is left unaddressed, this could impact not only human health but also agricultural productivity and ecosystem stability. Fluoride contamination is a burning problem in this district. Dental fluorosis, joint pain, waist bend,bent of boners of legs as well as hands etc.,affects a significant portion of the population in this research area.In addition of this outbreak of water-borne diseases such as dysentery, typhoid, infections.,hepatitis, malaria etc., are commom among the people of Karbi Anglong district. Mitigation strategies must focus on the implementation of integrated water resource management (IWRM), improved waste treatment infrastructure, and adoption of best agricultural practices. Urgent intervention is critical to prevent irreversible damage to the district's groundwater reserves.

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