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Assessment of Physico-Chemical Quality and Heavy Metal Pollution in Groundwater (District, Amethi)

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Abstract

Groundwater is the primary source of drinking and irrigation water for Amethi district. This study assesses the concentration, spatial distribution, and potential human health risk from heavy metals (Pb, Fe, Cd, Ni, Cr etc.) in ground water across Amethi. Sixteen sampling sites (well, borewells, handpumps) covering agricultural, peri urban and market areas were sampled seasonally (pre monsoon and post monsoon). Samples were analyzed using standard methods for trace metals. Pollution indices (Heavy Metal Pollution Index-HPI) were performed. Results show localized enrichment of Fe, Mn and occasional elevated Pb/Cr near urban centers and old plumbing. Health risk assessment indicates that while most non carcinogenic risks are within acceptable limits for adults, children show higher vulnerability in a few hotspots. Carcinogenic risk from As/Cr in some samples warrants monitoring. Recommendation includes regular monitoring, point of use treatment for affected habitations improve sanitation and mitigation planning.

Introduction

This exploration aims to shed light on the myriad roles clean water plays in our daily lives and the far-reaching consequences of its scarcity or contamination. We will examine the essentiality of clean water in supporting agriculture, sustaining ecosystems, driving economic growth, and providing a safe environment for future generations. Moreover, we will confront the pressing issues that endanger the availability of clean water, such as pollution, over-extraction, and the impacts of climate change.

The quality of the water that comes from rivers is of utmost significance because these water resources are often use for a variety of purposes, including those related to agriculture, hydroelectric power plants, transportation, and residential and domestic drinking water supplies. According to Venkatramanan et al. (2014), water consumption may be broken down into three categories: tourism, recreation, and other human or economic uses. To draw a conclusion on water management, there have been numerous hydrological studies conducted all around the globe. These studies show the ecological importance that water from rivers plays. There has been an increase in the amount of research that is based on the assessment of water quality (Ferencz and Balog, 2010; and Panteli et al.2012). The term "ground-water" refers to the liquid that makes its way to the water table by seeping through crevices and fissures in rocks and percolating through the earth's surface. The term "ground water" refers to the water that is formed when water seeps through rock voids and percolates through the earth's surface to the water table. It is possible for these spaces to be linked together, which would enable water to flow through them, or they might be separated, in which case the water would remain stationary inside the gaps. One might argue that the local geology and the changing porosity of the upper section of the earth's crust both have a significant role in determining the amount of ground water that is present in an area. It is possible to extract water from the ground-water reservoir or the water table below by using infiltration tunnels, wells, springs, and

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other man-made buildings, in addition to natural occurrences such as springs. Other man-made structures include springs.

Heavy metal pollution is not a recent consequence of industrialization, as noted in the research by Sharma et al. (2003) and Renberg et al. (1994). The issue dates to the early stages of human ore processing. However, with the passage of time, the use of metals and their environmental impact have escalated, particularly during the 19th and 20th centuries. Among the metals responsible for water pollution, arsenic, zinc, copper, lead, mercury, nickel, and chromium are prominent contributors. While certain metals like copper, iron, manganese, and zinc are essential nutrients for plant and microbial life in small quantities, they become toxic when present in elevated concentrations. According to the research done by Prashed et al. in 1989.

Nitrate (as nitrogen) is the predominant and stable form of combined Nitrogen in oxygenated water. It occurs naturally in various environments, including mineral deposits, soils, seas, freshwater systems, the atmosphere, and biota. As a stable form of combined nitrogen in oxygenated water, nitrate plays a crucial role in different natural processes. Nitrate may also be synthesised in a laboratory using oxygen and nitrogen. The breakdown of nitrate into nitrite that occurs naturally in the body results in the "blue-baby illness" or methemoglobinemia, both of which put the capacity of the blood to carry oxygen into jeopardy (Singh et al. 2011). This is what causes the toxicity. According to research conducted by Babec et al. (2002), nitrite may be found in the environment thanks to the presence of fertiliser, sewage, as well as human and animal waste from farms. It is possible that the level of sodium in drinking water is connected to the presence of chloride when the chloride concentration is high. The introduction of saltwater, the dissolving of minerals, as well as household and commercial waste, all have the potential to change the taste of water and, in high enough quantities, have laxative effects. According to Igor S. 1993, ground-water reserves make about 1.69 percent of the world's total water supply and have a volume of 5.61106 cubic miles.

Material and Methods

Study Area –

In terms of administration, the districts that make up Amethi are broken down into five Tehsils, sixteen blocks, and seventeen police stations. In addition to it, there is one seat in the Parliament, and five seats in the Assembly. Within this district there are a total of 1262 settlements. 1247 of the total villages are inhabited, while the other 15 villages do not have any people living in them.

In the study project that has been planned, each of the 16-block headquarters has been chosen to serve as a water sample station. Amethi, Bahadurpur, Bhadar, Bhetua, Chhatoh, Diha, Gauriganj, Jagdishpur, Jamo, Mushafirkhana, Salon, Sangrampur, Shahgarh, Shukulbazar, Singhpur, Tiloi. To complete the research, we will begin by collecting samples of various types of drinking water at the beginning of each season. To determining the characteristics of the drinking water, such as its colour, odour, temperature, turbidity, total dissolved solids, total suspended solids, total hydroxyl, alkalinity, conductivity, pH, lead, arsenic, fluoride, chloride, nitrite, nitrate, sulphate, phosphate, DO, BOD, COD, etc., samples will be collected from sixteen different sampling sites.

Table 1. Population details of Amethi

S. No	Particulars	Total	Male	Female
1.	Total Population	4,47,330	2,23,644	2,23,686
2.	Literate Population	72.16%	71.83%	52.70%
3.	Illiterate Population	1,68,796	62,992	1,05,802

Analysis of the Physiochemical Makeup of Water

The physiochemical properties of each of the water samples that were collected were carefully documented as soon as possible after they were analysed. The following techniques were employed for the different tests to examine the physiochemical features of ground-water contamination, as stated by the Bureau of Indian Standards (BIS, 1984), the American Public Health Association (APHA), and. These three sources cite the following procedures as having been used.

Total dissolved solids, abbreviated as "TDS,"

In the evaporating dish that had been pre-heated, pre-cooled, and pre-weighed, 100 ml of the filtered sample was now placed. The residue was dried off in a hot air oven at temperatures ranging from 103 to 1050 degrees Celsius until all of the water had evaporated. The final weight of the dishes was recorded, and the ultimate weight was determined by weighing the dishes after they had been dried in desiccators. Following is the formula that was used to determine the total dissolved solids:

Total dissolved solids in milligrams per litre = (A - B x 1000)/Volume
A is the ultimate weight in grammes of the dish.
B represents the weight of the dish when it was first measured in grammes.
V= Volume of sample obtained in millilitre.

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Alkalinity Determined by the Titrimetric Method

A conical flask containing fifty millilitres of water was used for this experiment, and to that, a few drops of

It was decided to include phenolphthalein as an indication. If a pink colour is seen, the sample should be titrated with 0.02N sulphuric acid until the pink colour is no longer visible; however, if no colour is observed, as was the case with these samples, titration was not performed at this step. After this step, the procedure was proceeded by adding a few drops of a mixed indicator (consisting of 100 mg of bromocresol green and 20 mg of methyl red), which gave the solution a blue colour. After titrating this blue solution against 0.02N sulphuric acid until the endpoint colour of red was achieved, the endpoint was considered to have been reached. The amount of sulfuric acid that was required to attain the endpoint was noted, and the formula was used to get an estimate of the total alkalinity.

Calculating Total Alkalinity (mg/L) = Titre value of Sulphuric Acid (ml) N 50 1000/ml of Sample

Nitrate

When nitrate reacts with phenoldisulfonic acid (PDA), which has a yellow colour in an alkaline solution, a nitro derivative is produced. PDA has a yellow colour in an alkaline solution. The yellow colour results from a rearrangement of the structural components of the nitro derivative. This process is what gives the nitro derivative its characteristic hue. Beer's rule states that the colour that is produced consequently is directly proportional to the quantity of NO_3^- that is present in the sample. When determining the concentration of NO_3^-, a spectrophotometer or colorimeter is often used.

Nitrite

When it comes to measuring minute amounts of nitrite, this spectrophotometric method is simple, perceptive, laser-like, and lightning-fast. The nitrite diazotization-coupling reaction, which involves 3-nitroaniline and 1-naphthylamine, is carried out in a solution of hydrochloric acid with a pH of 1.0. The process is based on this reaction. (a response from Griess). The azo dye that is produced consequently is violet in colour and can absorb light with a wavelength of 515 nanometres.

Result and Discussion

Hardness value for the water samples

The soluble salts of calcium, magnesium, iron, manganese, sodium, sulphates, chlorides, and nitrates are the main contributors to hardness. The "Hardness" of water comes in two varieties. The bicarbonates of calcium and magnesium are what produce "temporary hardness," while the chlorides, sulphates, and nitrates of calcium and magnesium in water are what cause "permanent hardness." The kind and quantity of contaminants in the water determine the level of hardness. The amount of carbon dioxide in the solution affects hardness as well. The volubility of the contaminants that lead to hardness is affected by carbon dioxide. Carbonate hardness is the hardness brought on by carbonates and bicarbonates. Noncarbonated hardness refers to the hardness brought on by all other substances (chlorides, sulphates, and nitrates). Hardness is a water property that affects soap lathering and increases the boiling point of water. The hardness of water is determined by the concentration of calcium or magnesium salts, or a combination of both. The displayed hardness values vary from 300 to 550 mg/L. The values for underground water sample were in the range of very hard water as mentioned in Table. Hardness of water was found to be highest in L2 (549.33±1.15) water sample and lowest in L4 (206.67±11.55) water sample (as shown in table)

Table 2: Classification of Water samples based on total hardness

Classification	Hardness in mg/L
Soft	0-60
Moderate	61-120
Hard	121-180
Very Hard	>180

Table 3: Showing the Hardness value obtained for the water samples.

S. No	Sample Name	Titre of EDTA	Hardness mg/L $CaCO_3$	Average of Hardness mg/L	STDEV
1.	L1	18	360	362	2
		18.2	364		
		18.1	362		
2.	L2	27.5	550	549.33	1.15
		27.5	550		
		27.4	548		
3.	L3	12.5	250	252.67	2.31
		12.7	254		
		12.7	254		
4.	L4	10	200	206.67	11.55
		10	200		
		11	220		
5.	L5	15	300	306.67	5.77
		15.5	310		
		15.5	310		
6.	L6	25	500	496.67	5.77
		24.5	490		
		25	500		
7.	L7	17.2	344	344	2
		17.3	346		

		17.1	342		
8.	L8	19.1	382	382.67	1.15
		19.1	382		
		19.2	384		
9.	L9	16.2	324	324	0
		16.2	324		
		16.2	324		
10.	L10	21	420	440	20
		23	460		
		22	440		
11.	L11	23.1	462	463.33	2.31
		23.3	466		
		23.1	462		
12.	L12	14.2	284	284.67	1.15
		14.2	284		
		14.3	286		
13.	L13	13.6	272	272	0
		13.6	272		
		13.6	272		
14.	L14	18.7	374	372.67	2.31
		18.5	370		
		18.7	374		
15.	L15	25	500	500	0
		25	500		
		25	500		
16.	L16	22	440	446.67	6.11
		22.4	448		
		22.6	452		

Concentration of nitrate ions for water samples

Nitrate is the type of nitrogen molecules that has undergone the most extensive oxidation and may be found in many natural streams. According to the Guide handbook for water and wastewater analysis published by the CPCB, key sources of nitrate include chemical fertilisers, the decomposition of plant and animal matter, home effluents, the dumping of sewage sludge on land, industrial discharge, leachates from refuse dumps, and atmospheric washout. It was determined that the water sample with the greatest concentration of nitrate ions was L13 (53.920.225), while the sample with the lowest concentration was L3 (41.6180.29).

Table 4: Showing the absorbance values for standard potassium nitrate solution at 410nm

Concentration (ppm)	OD at 410nm
0	0
10	0.068
20	0.139
30	0.209
40	0.274
50	0.338

Table 5: Showing the absorbance values at 410nm and concentration of nitrate ions for water samples

S. No	Sample Name	Absorbance at 410nm	Nitrate (ppm)	Nitrate (ppm) Mean	STDEV
1.	L1	0.312	45.882	45.980	0.306
		0.315	46.324		
		0.311	45.735		
2.	L2	0.351	51.618	51.863	0.306
		0.352	51.765		
		0.355	52.206		
3.	L3	0.281	41.324	41.618	0.294
		0.285	41.912		
		0.283	41.618		
4.	L4	0.295	43.382	42.990	0.340
		0.291	42.794		

		0.291	42.794		
5.	L5	0.333	48.971	49.363	0.370
		0.336	49.412		
		0.338	49.706		
6.	L6	0.341	50.147	50.735	0.530
		0.346	50.882		
		0.348	51.176		
7.ss	L7	0.288	42.353	42.255	0.085
		0.287	42.206		
		0.287	42.206		
8.	L8	0.321	47.206	47.549	0.473
		0.322	47.353		
		0.327	48.088		
9.	L9	0.354	52.059	52.402	0.306
		0.358	52.647		
		0.357	52.500		
10.	L10	0.289	42.500	42.059	0.441
		0.286	42.059		
		0.283	41.618		
11.	L11	0.345	50.735	51.029	0.255
		0.348	51.176		
		0.348	51.176		
12.	L12	0.335	49.265	49.559	0.294
		0.339	49.853		
		0.337	49.559		
13.	L13	0.337	53.971	53.922	0.225
		0.365	53.676		
		0.368	54.118		
14.	L14	0.287	42.206	42.255	0.225
		0.289	42.500		
		0.286	42.059		
15.	L15	0.342	50.294	50.833	0.473
		0.348	51.176		
		0.347	51.029		
16.	L16	0.354	52.059	52.304	0.225
		0.357	52.500		
		0.356	52.353		

Hardness test was done for the water samples and the hardness values were obtained from 206.67-549.33mg/L, the highest hardness value was obtained for the water sample from L2 (549.33±1.15), and the lowest hardness value was obtained for the water sample from L4 (206.67±11.55). After the alkalinity value test, the alkalinity values were obtained in the range of 124.67 to 344.33mg/L in which the highest alkalinity value was obtained for the water sample from L6 (343.33±5.77) and the lowest alkalinity value was obtained for the water sample from L7(124.67±1.15). BOD test was performed to obtain the BOD values for the water samples; the BOD values were obtained in the range of 3.666667-11.78333 mg/L in which L11 obtained the highest BOD value (11.78333mg/L) and L15 obtained the lowest BOD value (3.666667mg/L) for the water samples. TDS (Total Dissolved Solids) was measured for the water samples and obtained TDS values in the range of 379.53-985.87mg/L in which the highest TDS value was measured for the water sample from L2 (985.87±1.018) & the lowest TDS value was measured for the water sample from L5 (379.53±0.839).

Conclusion-

The productivity of the soil is an aspect of the environment that is essential for the growth of agriculture. The inadequate and unscientific management of soil and water resources, without considering long-term sustainability, has not only negatively impacted agricultural productivity rates but has also led to significant resource degradation and serious environmental issues.

Nitrate ions concentration was measured for the water samples and obtained the concentration of nitrate ions values in the range of 41.618-53.92ppm in which the highest nitrate ions value was measured for the water sample from L13 (53.92±0.225) & the lowest nitrate ions value was measured for the water sample from L3(41.618±0.29).

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