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Original Research Article

Comparative assessment of groundwater quality in different areas of Delhi NCR (Ghaziabad, Noida) and East UP (Varanasi)

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ABSTRACT

Aim: The main aim of this study was to compare the quality of groundwater on the basis of its physical and chemical parameters analyzed. For this purpose, different areas of Varanasi, Ghaziabad and Noida.

Introduction: One the oldest Indian ancient cities, Varanasi, known for the Hindu spiritual practices has now topped the country's list of the most polluted city and Ghaziabad, considered as one of the most developed areas of the state Uttar Pradesh had highest pollution level among the 42 cities of the country in the previous year, 2017. Despite being the developed towns of the state, people have to suffer for basic needs, particularly the water needs. Contamination of underground water is one of the biggest hazards that the world will witness sooner or later. Underground water contamination in the present scenario is done more by the indirect pollution methods which include inadequate treatment of the waste product before their disposal into the water bodies. Ions transported by the rivers are an essential source of almost all the elements found on Earth. The major ions which are responsible to maintain the quality of water, particularly the groundwater includes sundry cations and anions like: carbonate (CO_3^{2-}), Phosphate (PO_4^{3-}), Nitrate (NO_3^-), Bicarbonate (HCO_3^-), Chloride (Cl^-), Sulphate (SO_4^{2-}), Calcium (Ca^{++}), Magnesium (Mg^{++}), Cupper (Cu^{++}), Fluoride (F^-), Sodium (Na^+) and Potassium (K^+). Among the above-listed ions, Calcium (Ca^{++}) and Magnesium (Mg^{++}) are particularly responsible for the hardness of water, intake of this hard water by humans and animals can result in sundry medical complications like diarrhea and Gastrointestinal Disorders.

Materials and Methods: Water samples from nine different areas of Ghaziabad (NCR) and Varanasi (East UP) were collected and analyzed various physical and chemical parameters.

Conclusion: Comparison of groundwater quality showed higher values of observed parameters at Salarpur and Kavi Nagar area of NCR region. This showed that the major contaminants in groundwater of NCR region were mixed pollution sources e.g. effluents from Industries, soil and mineral dust.

1. Introduction

One of the oldest living cities in India is Varanasi which is also known as Kashi or Banaras. The place is very much known for the several spiritual activities and people associate this holy place with Lord Shiva and River Ganga. Varanasi in Hindu Mythology is referred as the hometown of Lord Shiva and so the city witnesses several religious practices done to please Lord Shiva. Ghaziabad, on the other hand, is known for fast industrial and hometown developments in the state Uttar Pradesh. Out of the two Varanasi is a holy place while the Ghaziabad is an attractive site to the emerging Industrialists. Despite being the developed towns of the state, Varanasi tops the country's list of the most polluted city and Ghaziabad was known to have the highest pollution level among the 42 cities of the country in the previous year, 2017. Apart from this, people here have to suffer for basic needs, particularly the water needs. Every other citizen in the two cities faces acute purified water shortage and has to work with unhealthy water to meet their daily needs. With every passing day,

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the two states are witnessing a several-fold increase in the level of pollutants and contaminants which poisoning the water of the cities and making it unfit for consumption by the organisms. The prime requirement for the survival of all the living organisms on the Earth is Water and now the country has arrived at such a stage that people lack or has to adjust with the basic water needs. Due to all the Industrial pollution and activities, the water level in the two cities has lost its purity. The same can be seen by the contamination of one of the Holy Indian River, River Ganga. The river has been contaminated to an extent that now 270 million liters of water from the river cannot meet the daily requirements of the citizens of Varanasi. It is not only about the contamination of the river water but the groundwater which is one of the purest forms of stored water and occurs below the surface of the earth and occupies all or a part of interstitial spaces, also known as the void spaces in the soil witnesses the same fate. Sundry processes taking place at a faster pace are responsible for deriving the composition of groundwater. These processes are dissolution, hydrolysis and precipitation reactions; oxidation, reduction, absorption and ion exchanges taking place between groundwater and the atmosphere is responsible for deriving the composition of groundwater. One of the major reasons for the groundwater contamination is the indirect cause, done particularly by the human activities. Some of the man-made pollutants such as gasoline, road salts, oils, and chemicals when get mixed with groundwater makes it unfit for consumption, especially human consumption and the same is called groundwater contamination. Other than this, chemicals manufactured by the Industries to kill unwanted insects and weeds and to fertilize the crops, fertilizers, and pesticides when move from the surface of the land through the soil into the groundwater it becomes toxic and is then regarded as unfit and unsafe for human use. Diseases like hepatitis, dysentery, gastric disorders, poisoning by toxins and a certain type of deadly cancers are some of the serious medical ailments caused by aster consuming the toxic groundwater.[1] Other diseases like jaundice, cholera, diarrhea, polymavirus infection, amoebiasis, lead poisoning and further still undiscovered disorders are the results of the water contamination, which now has to be taken seriously.[1] Groundwater is a significant source for the provisions of good quality drinking water which requires its judicial use to last long in the future to sustain life on earth. In the developing countries, two million infants deaths are observed yearly due to consumption of unsafe drinking water.[2] The present study assesses the groundwater quality of different areas of Delhi NCR and East UP region.

2. Materials and Methods

2.1. Study area

The different areas of Varanasi (East UP) includes Hariharpur, Bhogabir, Kotwa, Lohta and Dinapurandthe areas of Ghaziabad and Noida (Delhi NCR) includes Raj Nagar, Kavi Nagar, Salarpur and Nehru Nagar were selected for sample collection.

2.2. Collection and analysis of groundwater samples

Groundwater samples were collected from various water sources like River, Hand-pumps in polyethylene bottles from sampling sites of Varanasi and Ghaziabad of Uttar Pradesh during March to May 2019. The bottles were soaked overnight in 15% nitric acid and were later washed with deionized water and were dried at room temperature. Next, rinsing of the containers was done several times with good water source to ensure sufficient flushing before collection and the same was followed by the collection of water samples after pumping the water for 10 mintues. After that, all samples were brought to the laboratory in an ice box jar to avoid unusual changes to take place in water quality and before analysis to take place they were stored in a refrigerator at 4°C. The American Public Health Association (APHA) has listed precise methods of collection, preparation, and preservation which were followed in the experiment.[3–6]

2.3. Experimental work done

The measurement and standardization of the pH value of the river water samples which were to be analyzed were done using Systronic pH meter, type 335 and buffer solution of pH 4 and pH 9.2 respectively. Later on, the total alkalinity and hardness of water samples were respectively determined by titrating with N/50 H_2SO_4 using methyl orange indicator and complexometric titration with EDTA using Eriochrome black T as an external indicator. Complexometric titration with EDTA using ammonium purpurate as an indicator was also carried out to determine cadmium hardness of water samples. While the estimation of chloride ion was made by titrating the water solution against the standard solution of silver nitrate using potassium chromate as an indicator, Na^+ & K^+ were estimated using Flame Photometer (128) and NO_3^-, SO_4^{--}, F^- were estimated using U.V. Spectrophotometer. TDS was measured by gravimetric analysis, one of the famous quantitative titration techniques and EC Value under investigation was measured by Systronic E.C. meter. Various parameters were recorded as per requirements.[4,5] So, Area wise our water analysis and its data recording has been done in the three of the tabular form charts.

3. Results and Discussion

Though theoretically the pH of water is taken as 7 and is considered neutral in science but according to the WHO guidelines, the pH of water which is fit for human consumption ranges around 6.5-8.5. The extent of deterioration and contamination of the water samples collected from the two different cities was studied and compared by pH analysis. The result of the analysis was that the pH value of all the collected water samples ranged from 9.78-11.28, which indicates the presence of highly alkaline nature of the water bodies. Alkaline water is commonly defined as a beverage that has a value greater than 7 on the pH scale and desirable limit for total alkalinity is 200 mg/L. Water samples upon analysis showed a higher pH level than regular drinking water which is definitely accountable to several medical complications and is one of the prime reasons for the gastrointestinal disorders caused by the lowering of natural stomach acidity which is maintained by the level of intestinal acid HCl, which helps to kill bacteria and expel other undesirable pathogens from entering one's bloodstream. Intake of a large amount of alkaline water may agitate the body's normal pH, leading to metabolic alkalosis, a condition that may lead to multiple organ failure if lasted for months. Apart from this contaminated water has been known to cause some of the long-term medical complications like kidney dysfunction, cardiovascular dysfunction, Gut infections and other metabolic abnormalities. Apart from the severe medical disorders caused by the consumption of the unfit and alkaline water, there is an overall excess of alkalinity in the body of several individuals which may cause serious epidermal layer infections and irritations.[7,8]

There are sundry reasons for the increase in the pH of the water samples in the two cities and one of the key causes of the same is the increased concentration of pesticides and fertilizers into the water samples collected from the two cities. The water present over the land surfaces, particularly the agricultural surfaces when unifies with the river and underground water mixes up the harmful pollutants and surface chemicals, increasing the pH of the water bodies and making it unfit for consumption. The desirable limit for hardness in drinking water according to I.S. is 300 mg/L, whereas its value varied strongly from 535 – 570 mg/L. The hardening of water occurs primarily due to the increase in the level of calcium and magnesium ions.

The level of Na^+ in the water samples which is considered apt for drinking should be below 50ppm and if its content in the water bodies exceeds 50 ppm then, the water is considered unsuitable for drinking purposes and can result in certain complications. The current analysis revealed that the level of Na^+ content in the given water samples were more than expected. value of Na^+ in the examined samples was sorted around 425-510 mg/L, which is a major point of concern. Sodium Ion is very much

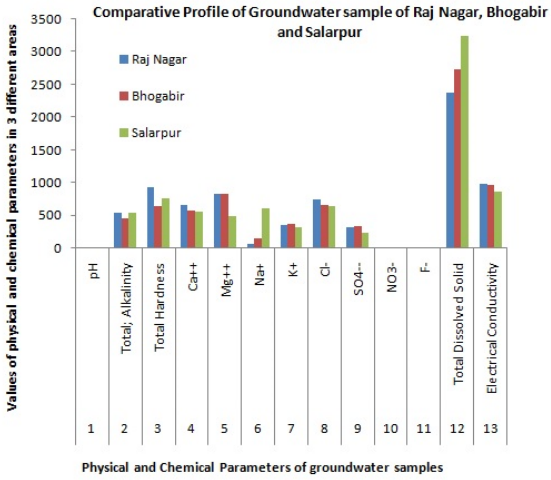

Fig. 1: Comparative profile of groundwater sample of Raj Nagar, Bhogabir and Salarpur

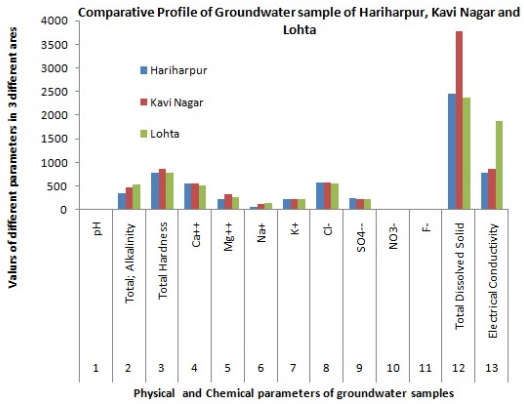

Fig. 2: Comparative profile of groundwater sample of Hariharpur, Kavi Nagar and Lohta

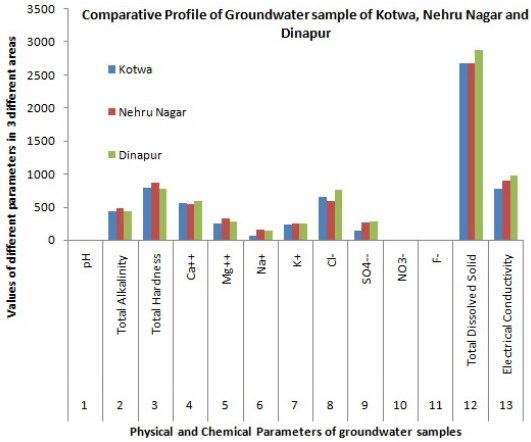

Fig. 3: Comparative profile of groundwater sample of Kotwa, Nehru Nagar and Dinapu

Table 1: Physicaland chemical parameters of groundwater sample from Raj Nagar, Bhogabir and Salarpur

S. No.	Parameter	Raj Nagar	Bhogabir	Salarpur
1	pH	9.95	8.84	10.12
2	Total Alkalinity	548	470	540
3	Total Hardness	940	640	770
4	Ca++	660	580	570
5	Mg++	838	830	490
6	Na+	74.5	164.2	610.6
7	K+	359.5	370.5	330.2
8	Cl-	750.56	660.55	655.85
9	SO4–	324.1	350	238
10	NO3-	1.8	3.6	4.5
11	F-	1.76	3.45	3.1
12	Total Dissolved Solid	2378	2730	3240
13	Electrical Conductivity	980	975	865

Table 2: Physical and chemical parameters of groundwater from Hariharpur, Kavi Nagar and Lohta

S. No.	Parameter	Hariharpur	Kavi Nagar	Lohta
1	pH	8.82	8.69	8.1
2	Total; Alkalinity	346	476	530
3	Total Hardness	785	876	786
4	Ca++	550	560	510
5	Mg++	231	328	279
6	Na+	66.8	120.8	138.8
7	K+	230.4	240.5	230.8
8	Cl-	575.46	580.75	556.25
9	SO4–	242.1	235	231
10	NO3-	2.9	5.7	6.5
11	F-	1.88	3.8	4.2
12	Total Dissolved Solid	2458	3780	2380
13	Electrical Conductivity	778	870	1875

Table 3: Physical and chemical parameters of groundwater from Kotwa, Nehru Nagar and Dinapur

S. No	Parameter	Kotwa	Nehru Nagar	Dinapur
1	pH	7.82	8.58	8.9
2	Total Alkalinity	436	486	430
3	Total Hardness	794	864	776
4	Ca++	556	542	595
5	Mg++	242	332	282
6	Na+	67.8	153.8	148.8
7	K+	238.5	260.5	250.8
8	Cl-	655.97	590.58	756.86
9	SO4–	142.1	275	284
10	NO3-	2.6	5.8	8.5
11	F-	1.89	7.9	4.2
12	Total Dissolved Solid	2678	2680	2880
13	Electrical Conductivity	774	895	975

Table 4: Physical and chemical properties of groundwater and list of substances found in the groundwater along with their effects [9]

S.No.	Physical and Chemical Parameters	Unit	Acceptable Limit	Permissible Limit	Types of Problem
1	Colour	Hazen unit	5	15	-
2	Odor	-	Agreeable	Agreeable	-
3	pH	-	6.5-8.5	No relaxation	-
4	Turbidity	ntu	1	5	-
5	Total dissolved material	mg/l	500	2000	-
6	Ammonia	mg/l	0.5	0.5	Portability, Corrosiveness
7	Boron	mg/l	0.5	1	Corrosiveness
8	Calcium	mg/l	75	200	Encrustation
9	Chloride	mg/l	250	1000	Portability, Corrosiveness
10	Fluoride	mg/l	1	1.5	Fluorosis
11	Magnesium	mg/l	30	100	Encrustation
12	Nitrate	mg/l	45	45	Methemoglobinemia
13	Total alkalinity	mg/l	200	600	Portability, Health aspects
14	Sulphate	mg/l	200	400	Portability
15	Total Hardness	mg/l	200	600	-
16	Temperature	0C	-	-	
17	Sodium	mg/l	-	-	Hypertension
18	Iron	mg/l	0.3	0.3	Encrustation, staining of laundry and toilet fixtures
19	Cadmium	mg/l	0.003	-	Portability, Corrosiveness
20	Chromium	mg/l	0.05	0.05	Portability, Corrosiveness
21	Zinc	mg/l	5	15	Portability, Corrosiveness
22	Manganese	mg/l	0.1	0.3	Encrustation, staining of laundry and toilet fixtures
23	Nickel	mg/l	0.02	0.02	Portability, Health aspects
24	Silica	-	-	-	Encrustation

required to regulate body activities and being easily soluble in water it cannot be removed from water bodies, making increased sodium content in the water sample one of the alarming issues. [8,10,11] Any increase or decrease in its level can lead to several medical issues, like nausea, muscular twitching, arterial hypertension, convulsions, teratogenicity, embryotoxicity, the problem of dismaintenance of osmotic pressure, reproductive toxicity and others, thereby causing hypermatracemia within the body. [8,12,13]

Another vital extracellular ion required for the proper and healthy functioning of the living organism is potassium. The level of K+ which is considered essential for the survival of the living organisms varies from 210 – 220.3 mg/L. [8] Any change in the level of potassium ions can lead to medical ailments like Hyperkalemia and Hypokalemia. There are chances that some serious issues involving nerve impulse conduction persist if recurrent and prolonged hyperkalemia occurs. The adequate potassium intake for adults (19–>70 years of age) is 4.7 g/day (IOM, 2004). The same is equivalent to 78 mg/kg body weight per day for a 60 kg adult. Individuals may suffer from tremendous complications probably due to increase in the level of potassium ions like arterial disorders, immature kidney function, diabetes, adrenal insufficiency, hypertension, and coronary artery disease and other. The same is also found to affectinfants which have underdeveloped organs and immature liver, limited renal reserve, and kidney function and can affect the processes like metabolism and excretion. Accordingly, ingestion of potassium supplements of up to 3700 mg/day is likely to be without overt effects. [10,13–15]

As prescribed by WHO the chloride value was found to be more than the permissible limit i.e. greater than 5800

mg/L. And this increase in the level of chlorine may lead to dysfunction of the urinary bladder and increased chances of cancer, rectal bladder cancer, and heart diseases. It also has a negative effect on the body, especially on the skin and that too facial skin as it robs our skin, robs our moisture and the elasticity of the hair.[9,16] When the concentration of chlorine is more than 200 mg/L the water is considered impermissible for human consumption and needs immediate attention by the authorities.[17,18]

The increased level of calcium ions may result in hypercalcemia and cause sundry medical complications including problems in the muscular activity. Calcium is one of the elements responsible for hardening of water making it unfit for consumption. Along with the excessive consumption of hardened water over a period of time people can have an acute effect on iron absorption. The level of calcium ion in the water samples was found to exceed the range given by the WHO, which makes the water unfit for human consumption.[12,13,17]

Not only these elements but also the SO_4^{--}value was found to be more than the permissible limit in the samples collected from the two cities. Upon analysis, its level was reported to be around 280mg/L, which is a significant increase from the normal WHO prescribed range. Excess of consumption of water having increased sulphate content by the humans is not considered healthy, and there are chances that it would lead to the cathartic effect on the human body and result in laxative effect, dehydration and other medical ailments.[18–20]

Fluoride is another important element essential for human life but only if the same is in the WHO prescribed permissible limit. According to WHO 1984 and Indian standard drinking water specification 1991 the maximum permissible limit of fluoride in drinking water is 1.5 ppm and its highest desirable limit is 1.0 ppm. Fluoride's low concentration (approximately 0.5 ppm) is very much needed for healthy teeth as it helps in preventing conditions like dental caries. Fluoride for teeth acts like an anti-oxidant and forms a hard and tough layer over teeth, preventing the microbial degradation of the teeth. Also, where its low concentration is considered useful its higher concentration i.e. above 1.5 ppm in drinking water is harmful as it can cause dental fluorosis and its prolonged much higher concentration over a long period of time can result in skeletal fluorosis, another medical ailment. Another danger that the analysis revealed was that the quantity of fluoride in the water sample of the given areas was also found to be in excess. The analysis revealed that the Fluoride in water samples is in a very strong concentration as 1.89-3.5 mg.[13,19] The total solid in the bodies is determined by the sum of dissolved solids and suspended solids in the water body which consists of inorganic salts and a small amount of organic matter. Increase in suspended solids contains much of the organic matter and tends to increase the pollution. An upper limit of these solid particles 500 ppm has been set in order to control undesirable taste and diarrhoea.[19,20]

Various physical and chemical parameters of groundwater samples of nine different areas of NCR region and East UP were studied and list of substances found in the groundwater along with their effects are shown in Tables 1, 2, 3 and 4 respectively. And comparative profiles of groundwater samples are represented in Figures 1, 2 and 3.

4. Conclusion

After studying Physical and chemical parameters of ground water and comparing the groundwater quality of different areas of Ghaziabad (NCR) and Varanasi (East UP), showed higher values of observed parameters at Salarpur and Kavi Nagar area of NCR region. This showed that the major contaminants in groundwater of NCR region were mixed pollution sources e.g. effluents from Industries, soil and mineral dust. It was concluded that water of these areas are unfit for human consumption and will soon harm a large population with multiple organ failures and other severe medical complications. Thus everyone should support and strictly follow the governmental norms of pollution to at least control the level of pollutants which later should immediately be followed by steps to reduce the level and effect of these pollutants. It should not deny the fact that pure water is an anticipated need for all life forms. Thorough treatment is required for groundwater samples from these areas before it could be certified fit for human consumption.

5. Source of Funding

None.

6. Conflict of Interest

None.

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