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Research Article

Impact assessment of ground water quality at Varanasi, Uttar Pradesh

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A B S T R A C T

The present study was carried out for Varanasi city for assessment of ground water quality with the objectives to assess its ground water quality during pre and post monsoon periods at different locations spread in Industrial zone, Municipal solid waste dumping site and Residential zone. A total of 25 numbers samples during each seasons were collected. The pH is ranging between 7.5-7.7 which is well within the standard limit. The Total Dissolved Solids (TDS) are ranging between 396 to 1682 mg/L and the Conductivity ranges between 116 to 1700 µmhos/cm, which confirms the correlation between the two that the conductivity increases on increase of TDS. The values of Fluoride are ranging between 0.59 to 0.97 mg/L which are within the specified limits at all the locations and Hardness is ranging between 316 to 840 mg/L which are not within the specified limits at all the locations. The cations and anions are within limits at all the locations but Sodium is higher in general at all the locations ranging between 23.5 to 88.2 mg/L. The values of Alkalinity are ranging between 284 to 532 mg/L which are higher than the acceptable limit but within the permissible limit and could be mainly due to the nearby industries. The heavy metals in this area are not very high ranging between ND to 0.31 mg/L indicating the presence of some heavy metals which could be due to industrial activities in this region. The values of Iron are ranging between 0.35 to 1.21 mg/L, which are exceeding the acceptable limit at all the places. The total and fecal coliforms are also absent at all the locations indicating thereby that there is no bacteriological contamination. Analysis results indicate that rapid urbanization and industrialization are major source of inorganic, organic and heavy metals in ground water. The quality of ground water from a few shallow tube wells has been impaired in some of the areas. However, the deep bore tube wells have not yet been affected.

K E Y W O R D S

Water Quality | Groundwater Assessment | Varanasi | Uttarakhand |

C I T A T I O N

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Introduction

Ground Water Pollution is usually traced back to four main origins industrial, domestic, agricultural and over exploitation. Studies carried out in India reveal that one of the most important causes of ground water pollution is unplanned urban development without adequate attention to sewage and waste disposal. Industrialisation without provision of proper treatment and disposal of wastes and effluent is another source of ground water pollution.

In case of industrial units, effluent in some cases are discharged into pits, open ground, or open unlined drains near the factories, thus allowing it to move to low lying depressions resulting ground water pollution. The magnitude of damage caused to our water resources can be estimated from the fact that about 70% of rivers and streams in India contain polluted water.

The incidence of ground water pollution is highest in urban areas where large volumes of waste are concentrated and discharged into relatively small areas. The ground water contamination, however, is detected only some time after the subsurface contamination begins. The present study was carried out for Varanasi city for assessment of ground water quality during pre & post monsoon period in the areas located at Industrial zone, Municipal solid waste dumping site and Residential zone".

Study Area

Varanasi district forms part of central Ganga plain and is situated in the south west part of U.P. State. Physiographically the district can be divided into two physical regions, i.e., the northern alluvial plain and the southern plateau area. The northern alluvial plain is drained by the Ganga and its tributaries namely the Gomti and the Varuna rivers. The southern plateau comprising of extensive hillocks and mesas of Vindhyan sandstone and shales, is deeply dissected by the Karamnasa river and its effluents.

The district of Varanasi is surrounded by Jaunpur and Ghazipur districts in the north, Mirzapur district in the south, Bhadohi district in the west and Sahabad district of Bihar State in the eastern side. The geographical area of the district is 4035 Sq. Km. The holy river Ganga divides the district into almost two equal parts and other rivers flowing through the districts area Gomti, Karamnasa, Chandra Prabha and Varuna. The district is well connected by National and State Highways and also by a network of railways. The National Highway nos. 2 and 7 pass through the district in the east-west and north-south directions, respectively.

The Varanasi city is located in the North Eastern part of the Nation and is one of the biggest cities of Uttar Pradesh and is the district headquarters. It is bounded on north by Jaunpur and Ghazipur, on south east by Mughal Sarai, on east by Bihar State, on west by Bhadohi and on south by Mirzapur. The area of the city is 78.5 Sq. Km. Varanasi is a fast growing commercial, industrial and trading centre of Uttar Pradesh and Central India. It is well connected with all metro cities and other major cities of the country by Railways, National Highways and Airlines.

Varanasi Jal Sansthan provides the water supply in the city. With the development of many new residential areas and increase in population, the water demand has increased. The surface water supply is not adequate to

meet this increased demand. The drinking water supply is drawn from surface and ground water. The city is divided into two parts, Varuna area and trans-Varuna area. The Varuna area has a mixed supply of water, that is, from both surface and ground water, whereas in trans-Varuna area the water supply is exclusively from ground water. The source of surface water for water supply is river Ganga. Deep tube wells, hand pumps and private bore wells are the main sources for extraction of ground water in the city to cater to the water demand of the population. Apart from municipal sources of water supply, a large number of consumers also have shallow hand pumps for augmenting their water requirements.

Geomorphological and Climatic Condition

Physiographically Varanasi district may be divided into two physical regions namely northern alluvial plain and southern hilly regions (plateau).

The plain is devoid of rock and made up entirely of alluvium of two types, the newer alluvium being the base of the flood plain of the Ganga and the older is that of the level upland (locally known as uparwar). The two are separated by clearly defined banks of varying heights which mark the extreme flood limit of the river. Apart from this difference, there are local variations depending upon the slope and height. The northern alluvial plain is generally a flat land with east or north-eastward slopes on a regional scale and forms a part of the central Ganga plain.

The southern hilly region, being a part of Vindhyan plateau is not uniform. It rises abruptly on the southern boundary of the alluvial tract with an escarpment, the average elevation being between 305 metre and 366 metre above mean sea level. The undulating table land extends between parallel ranges of hills and valleys.

The soils in the district are classified into two broad groups, alluvial and residual, representing the different stages of soil development resulting from a sub humid to a humid climate and the physical and chemical weathering of the soils. The alluvial group, comprising the greater and the more important portion of the district - the tehsils of Chandauli and Varanasi, possesses soils developed from the alluviums of the Ganga, while the residual group comprising an area of less importance - tehsil Chakia, primarily possesses residual soils developed insitu from the Vindhyan rocks.

The Varanasi district falls in the subtropical region and its climate is classified as tropical to subtropical type, characterized by hot summer and severe winter. The district experiences three distinct seasons namely, summer, rainy and winter. Winter usually commences from middle of November and extends till end of February whereas summer starts from April and extends upto the middle of June. March is a transitional period. The rainy season starts normally by the third week of June and continues till September or early part of October.

Uses of Ground Water and Surface Water

The population of Varanasi city and in particular of Trans Varuna area is mostly dependent on the ground water for its domestic use. Varanasi Jal Sansthan also draws water from Ganga river for supply to residential colonies after complete treatment. Besides this private boring is also very common.

There are two sources of water available at Varanasi, viz., ground water and river water (surface). Both the sources are utilized for drinking water requirement of the city. These water sources are also used for industrial purposes, irrigation purposes and other domestic usage of the city.

Groundwater availability

Groundwater Depth

Ground water is one of the earth's most widely distributed resource and is most important because of the physiological needs of man, animal and vegetation kingdoms. This valuable resource not only supports life on the earth but also governs the economic, industrial and agricultural growth of human civilization. More than 45% of the total irrigation in our country depends on ground water resource. Nearly 80% of the extracted ground water is being utilized for irrigational purposes in the state of Uttar Pradesh.

Since the monsoon is unpredictable and the deficit causes sometimes drought conditions, it has become imperative for the planners to look forward for a dependable source of water supply, i.e. ground water which is an assured source for agricultural, industrial and domestic requirements.

The depth of water indicates that water level in the alluvial area varies between 1.38 and 11.72 m bgl and in the plateau area it varies from 3.78 to 8.64 m bgl.

Ground Water Flow

The master slope of the water table is from South to North. In the central and eastern parts of the district water table contours are widely spaced showing that the aquifer is good in permeability. The western part of the district shows a ground water mound and at places the close spacing of the water table contours reflects moderately poor permeability of the aquifer. In the plateau area in the south of the Ganga, the water table contours are very closely spaced showing poor permeability of the aquifer.

Methodology

The present study has been carried out with the help of following:

a. Collection of information related to physiography, surface and subsurface hydrology, potential of ground water, depth of shallow and deep aquifers, direction of ground water flow.
b. Identification of industrial areas, residential areas, petrol pumps and bulk storage of petroleum products, municipal solid waste disposal (Landfill) area and selection of appropriate sampling location at identified wells (hand pumps, tube wells etc.).
c. Collection of samples from ground water in Pre monsoon (February) and Post monsoon (September) and identified about 25 numbers of locations to cover proportionately in shallow and deep aquifer regions of whole of the city.
d. Analysis of parameters in collected samples as per the Standard Methods for the Examination of Water and Wastewater (APHA), 2000 Edition.
e. Interpretation of analysis data and collected data.

Sampling Locations at Varanasi

Two round of sampling were carried out. The first round of sampling during pre-monsoon season was carried out in February and the second round of sampling during post monsoon season was carried out in September

as per the scope of work. Details of the work done are as under

1) Collection of data related to ground water quality.
2) Selection of water sampling sites.
3) Collected 25 nos. of ground water samples from the hand pumps and tube wells covering shallow and deep aquifer regions around the whole city.
4) The industrial areas, residential areas, municipal solid waste disposal (land fill) area have also been identified and samples collected accordingly.
5) There is no bulk storage depot of Petroleum products in Varanasi city.

Various sites are being used in the city for dumping of municipal solid waste. These sites include Purana Pull, Palang Sahid, Kabir Math and Raj Ghat. The rest comes under residential area out of which many places are very congested. The intensity of sampling locations is more in residential areas because of the intensity of ground water pumping and close variations in ground water withdrawal from place to place. The quality of ground water is also widely variable in different areas which are in turn varying in quality of recharging source water.

Result and Discussion

The ground water samples collected during pre-monsoon and post monsoon seasons from Varanasi city were analyzed for various parameters as per standard procedures. The analytical results of the water quality parameters of the city are compared with the standard for Drinking Water (IS:10500) as the water is being used mostly for drinking purposes. The results are given in Table 1 to 3 respectively.

Discussion on Water Quality Monitoring during Pre Monsoon and Post Monsoon:

The summary of analysis results indicate the following in different areas, viz., Industrial, Residential and Landfill:

The pH at all the locations is almost neutral ranging between 7.5-7.7 which is well within the standard limit. The Total Dissolved Solids (TDS) are ranging between 396 to 1682 mg/L and the Conductivity ranges between 116 to 1700 µmhos/cm, which confirms the correlation between the two that the conductivity increases on increase of TDS. The values of Fluoride are ranging between 0.59 to 0.97 mg/L which are within the specified limits at all the locations and Hardness is ranging between 316 to 840 mg/L which are not within the specified limits at all the locations. The cations and anions are within limits at all the locations but Sodium is higher in general at all the locations ranging between 23.5 to 88.2 mg/L. The values of Alkalinity are ranging between 284 to 532 mg/L which are higher than the acceptable limit but within the permissible limit and could be mainly due to the nearby industries. The heavy metals in this area are not very high ranging between ND to 0.31 mg/L indicating the presence of some heavy metals which could be due to industrial activities in this region. The values of Iron are ranging between 0.35 to 1.21 mg/L, which are exceeding the acceptable limit at all the places. The total and fecal coliforms are also absent at all the locations indicating thereby that there is no bacteriological contamination.

Results indicate that rapid urbanization and industrialization are major source of inorganic, organic & heavy metals in ground water. The quality of ground water from a few

shallow tube wells has been impaired in some of the areas. However, the deep bore tube wells have not yet been affected.

Conclusion

Based on the observation and assessment made during pre and post monsoon monitoring of Ground Water Quality of Metro City of Varanasi, the findings are following:

1. Variation in water quality was observed during both the periods of the study.
2. Ground water quality varies from place to place with the depth of water table.
3. The Alkalinity and Hardness are exceeding the acceptable limits at most of the places in Varanasi. It is a natural cause for ground water in tropical alluvial basin. Varanasi being a city in Ganga basin, these high alkalinity and hardness values are common.
4. With respect to the other physico-chemical properties of the samples collected, it is either conforming to acceptable or permissible limits.
5. The Iron content was found to be exceeding the permissible limit at some of the locations.
6. The presence of Boron, Chromium and Arsenic were not observed.
7. The samples in respect of concentration of Copper, Lead, Manganese and Zinc were conforming to the acceptable limits.
8. The Aluminium was found to be within either the acceptable or permissible limit.
9. Bacteriological contamination was observed at one location in the residential area.
10. The quality of ground water from a few shallow hand pumps or tube wells has been impaired in some of the areas. However, the deep bore hand pumps or tube wells have not yet been affected.

Recommendations

Based on the observation and assessment made during pre and post monsoon monitoring of Ground Water Quality of Metro City of Varanasi, the following recommendations are made:

1. Water source should be thoroughly investigated before recommending it for use, whether it is private or government boring.
2. Periodical investigation should be conducted every two to three years on quarterly basis to evaluate the level of ground water contamination in the study area.
3. Alternative drinking water source may be provided along the river bank because people residing nearby are using hand pump water for drinking and other domestic purposes.
4. Public awareness should be created among the masses particularly for the people residing along the bank of the river Ganga for consumption of safe drinking water.
5. It is suggested that some low cost and easy to implement technique may be provided to the consumers for removing hardness, total dissolved solids and chloride in water where the values exceed the permissible limit.
6. A thorough examination of water supply pipelines should be conducted by Jal Sansthan to check the infiltration of sewage or other kinds of pollutants into pipeline.

7. The doses of chlorine should be adjusted in such a way, so as to maintain a minimum concentration of residual chlorine, in the range of 0.2 mg/L at the consumer's end.
8. The abandoned existing dug wells should be closed up to the land surface to avoid dumping refuge and in turn causing pollution to the ground water.
9. Regular monitoring of water level should be practiced.
10. The water management practices should be utilized, such as sprinkler irrigation should be encouraged.
11. The pollution of ground water in the affected areas with respect to various bacteriological, health related and aesthetic parameters and over dependency on ground water should be viewed seriously.
12. Efforts should also be made for water harvesting wherever necessary.

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Monitoring Stations	pH	TDS (mg/L)	Conductivity (µmhos/cm)	BOD (mg/L)	COD (mg/L)	Hardness (mg/L)	Phosphate (mg/L)	Fluoride (mg/L)
Industrial Area								
(Ram Nagar, Munduadih, Chandpur)	7.1 – 7.7	282 - 1682	43 - 1700	0.2 – 0.9	1.0 – 3.0	188 - 840	0.15 – 1.43	0.28 – 0.97
Residential Area								
North (Nadesar, Khajuri)	7.4 – 7.7	304 - 444	681 - 1120	0.1 – 0.5	2.0 – 3.0	198 - 380	0.18 – 0.33	0.06 – 1.48
East – NE (Sonarpura, Benia, Ram katora, Nati Imli, Bari Bazar, Peeli Kothi, Paharia, Sarnath, Kotwa, Kamaoli)	7.2 – 7.7	212 - 998	498 - 3240	0.1 – 1.0	1.0 – 14.0	146 - 871	0.08 – 3.30	ND – 1.48
West – NW (Bhojubir, Shivpur, Basai, Cantt. Rly. Stn.)	7.2 -7.6	273 - 861	694 - 1360	0.1 – 0.6	1.0 – 4.0	186 - 771	0.19 – 0.52	0.11 – 0.96
South – SE – SW (BHU Lanka, Gadauliya, Bhelupur, Sigra, Lahartara)	7.1 – 7.8	205 - 353	343 - 861	0.1 – 0.8	1.0 – 8.0	124 - 283	0.18 – 1.41	0.15 – 2.05
Landfill Area								
Tubewell, Raj Ghat	7.2 – 7.4	375 - 452	1320 - 1370	0.1 – 0.2	3.0 – 6.0	274 - 401	0.22 – 0.38	ND – 0.48

Table – 1: Range of physico-chemical parameters during post and pre-monsoon period respectively in ground water at Varanasi

Monitoring Stations	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Alkalinity (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)
Industrial Area								
(Ram Nagar, Munduadih, Chandpur)	18.3 – 88.2	1.6 – 6.5	17.1 – 36.0	19.0 – 33.0	244 - 532	19.0 – 37.6	2.11 – 37.06	18.0 – 48.6
Residential Area								
North (Nadesar, Khajuri)	30.5 – 71.1	3.7 – 4.9	16.1 – 43.0	19.0 – 30.2	304 - 336	32.0 – 66.0	0.19 – 15.39	25.1 – 38.1
East – NE (Sonarpura, Benia, Ram katora, Nati Imli, Bari Bazar, Peeli Kothi, Paharia, Sarnath, Kotwa, Kamaoli)	20.1 – 150.8	2.5 – 10.2	16.0 – 51.0	15.0 – 137.5	248 - 514	6.8 – 81.0	0.30 – 39.25	11.5 – 64.2
West – NW (Bhojubir, Shivpur, Basai, Cantt. Rly. Stn.)	24.0 – 77.7	4.1 – 7.6	14.6 – 39.0	21.5 – 55.0	263 - 365	24.0 – 52.4	0.17 – 1.75	16.0 – 56.4
South – SE – SW (BHU Lanka, Gadauliya, Bhelupur, Sigra, Lahartara)	24.6 – 46.0	2.3 – 5.7	17.0 – 36.8	16.0 – 43.5	136 - 405	10.0 – 61.9	0.31 – 2.88	16.2 – 50.0
Landfill Area								
Tubewell, Raj Ghat	39.5 – 47.5	3.6 – 3.7	21.5 – 40.1	27.0 – 29.0	312 - 450	38.0 – 47.6	ND – 1.08	18.4 – 28.0

Table – 2: Range of ionic distribution during post and pre-monsoon period respectively in ground water at Varanasi

Monitoring Stations	Boron (mg/L)	Chromium Total (mg/L)	Copper (mg/L)	Iron (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Lead (mg/L)	Manganese (mg/L)	Zinc (mg/L)
Industrial Area									
(Ram Nagar, Munduadih, Chandpur)	ND	ND	ND – 0.02	0.27 – 1.21	ND – 0.04	ND	ND – 0.01	ND – 0.02	ND – 0.31
Residential Area									
North (Nadesar, Khajuri)	ND	ND	ND – 0.03	0.15 – 1.08	ND – 0.03	ND	ND – 0.01	ND – 0.04	ND – 0.13
East – NE (Sonarpura, Benia, Ram katora, Nati Imli, Bari Bazar, Peeli Kothi, Paharia, Sarnath, Kotwa, Kamaoli)	ND	ND	ND – 0.04	0.08 – 2.14	ND – 0.06	ND	ND – 0.01	ND – 0.05	ND – 0.36
West – NW (Bhojubir, Shivpur, Basai, Cantt. Rly. Stn.)	ND	ND	ND – 0.03	0.09 – 0.41	ND – 0.05	ND	ND – 0.01	ND – 0.02	ND – 0.19
South – SE – SW (BHU Lanka, Gadauliya, Bhelupur, Sigra, Lahartara)	ND	ND	ND – 0.04	0.08 – 0.78	ND – 0.04	ND	ND – 0.01	ND – 0.03	ND – 0.17
Landfill Area									
Tubewell, Raj Ghat	ND	ND	ND – 0.01	0.37 – 1.00	ND – 0.02	ND	ND – 0.01	ND – 0.01	0.01– 0.22

ND – Not Detectable **Table – 3:** Range of trace metals distribution during post and pre-monsoon period respectively in ground water at Varanasi

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