

## QUALITY ASSESSMENT AND IMPACT OF INDUSTRIAL POLLUTANTS ON GROUNDWATER OF RIICO INDUSTRIAL AREA OF BHIWADI TOWN OF ALWAR, RAJASTHAN

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### ABSTRACT

Bhiwadi is a small town and rising industrial hub of Tijara tehsil of Alwar district, Rajasthan (India). The needs of drinking, domestic, irrigational and industrial water of Bhiwadi town and surrounding villages are primarily accomplished by the groundwater resources. This study was carried out to investigate the consequence of industrial pollutants on the quality of groundwater of Bhiwadi town and its surrounding areas. The sampling of groundwater was carried out from twelve groundwater sampling sites of Bhiwadi town and its surrounding areas during the period of pre-monsoon season of the year 2019. The groundwater samples were estimated for the various physicochemical parameters such as pH, electrical conductivity (EC), total dissolve solids (TDS), fluoride (F<sup>-</sup>), chloride (Cl<sup>-</sup>), nitrate (NO<sub>3</sub><sup>-</sup>), total hardness (TH), total alkalinity (TA), dissolved oxygen (DO), biochemical oxygen demand (BOD), and toxic industrial constituents following the standard procedures. The results of the study have revealed that the considerable variations in the physicochemical parameters for the groundwater of RIICO industrial area and its surrounding area of Bhiwadi town. All groundwater sampling sites of Bhiwadi town and its surrounding area were found to contaminated due to be industrial activities around the sampling sites. Due to these parameters, the groundwater of Bhiwadi town and its surrounding areas were found to be unsuitable for drinking purpose because all the groundwater samples do not imitate with the acceptable drinking water standards of WHO and BIS.

**KEY WORDS :** RIICO Industrial area, Bhiwadi (Alwar), Groundwater, Physicochemical analysis, Water pollution, Industrial pollutants.

### INTRODUCTION

Water is the greatest appreciated natural constituent of the environment that sustain the life on the earth surface (De, 2000; Kershaw and Cundy, 2000; Valsami-Jones, 2004; Anslyn and Dougherty, 2006). It is most essential element for the growth and nourishment of living beings such as human, animals, plants and microorganisms, and without it, the extensive growth of such living beings are not possible on the earth surface (De, 2000; Kershaw and Cundy, 2000; Valsami-Jones, 2004; Anslyn and Dougherty, 2006). The groundwater is the most significant and esteemed natural renewable resource of freshwater. The purity and composition of groundwater alters with the depth from the earth

surface and high level of pollutions on the earth surface (Yongjin *et al.*, 2015; Frape *et al.*, 2003). Therefore, the groundwater resources are largely contaminated with the dissolved minerals and higher level of pollutants that produced by municipal and industrial activities. The high level of contamination in groundwater is globally considered as a serious water pollution and the polluted water is not safe for human drinking (Sharma and Bhattacharya, 2017). Alwar is a north-east district of Rajasthan and the groundwater resources are the primary resource of water. The groundwater of Alwar district were found to be poor in quality and also contaminated with the industrial toxic contaminants, since Alwar has many growing industrial zones (Kumar and Saini, 1998;

Agrawal and Sharma, 2015). Numerous literature reports have been carried out on the quality and industrial pollution of groundwater. Agarwal and Sharma (2015) have been reported the high level of fluoride contamination and industrial pollution in groundwater in and around the various industrial areas of Alwar district of Rajasthan. Khan (2001) has been reported the industrial effluent contaminated groundwater in arid zone of Rajasthan (Khan, 2001). Meena and Nama (2017) has also been investigated the effect of textile industrial effluents on the Bandi river water of Pali district of Rajasthan and reported as the most affected factor for the Bandi river water pollution (Meena and Nama, 2017). Therefore, the groundwater and surface water resources near industrial areas are highly contaminated with the toxic industrial effluents and is not safe for human consumption.

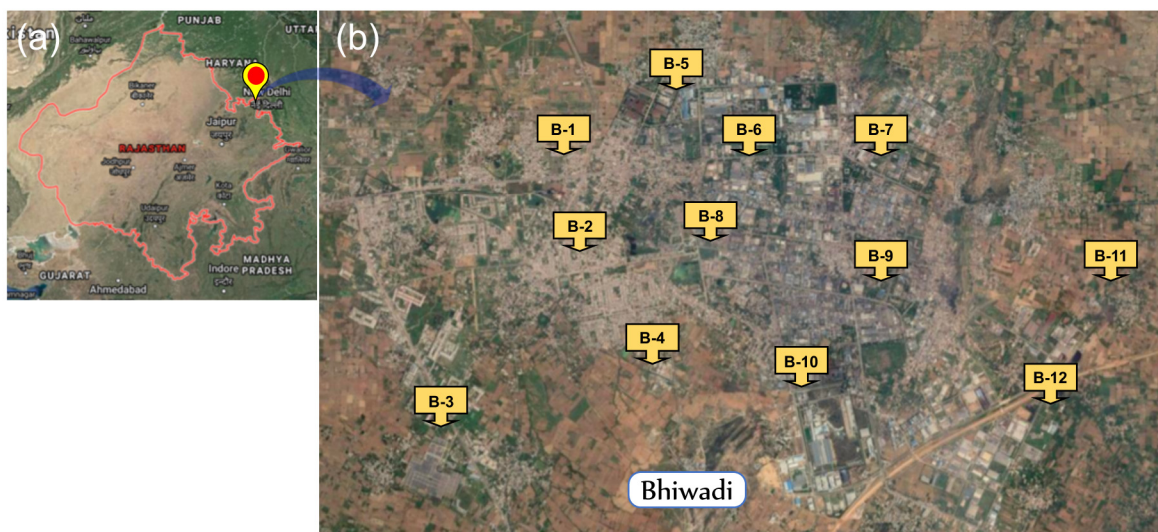
This research work reported the collection of groundwater samples and their physicochemical analysis. For the quality assessment, twelve groundwater samples were collected from RIICO industrial area and its surrounding area of Bhiwadi town during premonsoon season (April-May) of the year 2019. The physicochemical parameters such as pH, electrical conductivity (EC) and total dissolve solids (TDS) of groundwater were taken at the time of sampling. The other physicochemical parameters such as fluoride (F<sup>-</sup>), chloride (Cl<sup>-</sup>), nitrate (NO<sub>3</sub><sup>-</sup>), total hardness (TH), total alkalinity (TA), dissolved oxygen (DO), biological oxygen demand (BOD), and toxic industrial constituents were estimated

following the standard analytical procedures of American Public Health Association (APHA). The study has showed that all groundwater samples of Bhiwadi town and its surrounding area were found to have large concentration of toxic constituents. As per the obtained results, the groundwater of Bhiwadi town and its surrounding area were found to be polluted and highly contaminated with toxic industrial constituents. All the groundwater samples were found to be inappropriate for drinking purposes because all these samples do not imitate with the acceptable drinking water standards of World Health Organization (WHO) and Bureau of Indian Standards (BIS).

## MATERIALS AND METHODS

**Description of the study area:** The present study was conducted for groundwater analysis of RIICO industrial area and its surrounding area of Bhiwadi town of Alwar district, Rajasthan (Fig. 1). Bhiwadi is a north-east town of Tijara tehsil of Alwar district of Rajasthan and geographically coordinated between 28.21° North latitude and 76.87° East longitude. It is a growing industrial hub of Alwar (Rajasthan) and basically located 90 km away from Alwar. Bhiwadi town has the total geographical area of ~8.1 km<sup>2</sup>.

**Description of the groundwater sampling sites:** Groundwater samples were gathered from twelve different sampling sites of RIICO industrial area and its surrounding area of Bhiwadi town of Alwar district, Rajasthan and characterised in laboratory to



**Fig. 1.** (a) Satellite map of Rajasthan showing the exact location of Bhiwadi town (Alwar district) and image (b) demonstrating the satellite view of Bhiwadi town (RIICO industrial area) with highlighted twelve groundwater sampling sites.

obtain the experimental physicochemical characteristics of groundwater and impact of industrial pollutants. See Table 1 for the list of sampling sites and Fig. 1b for the satellite map of Bhiwadi town with highlighted groundwater sampling sites. The highlighted sampling site's code number in Fig. 1b is mentioned in Table 1 along with their sampling site name.

**Description of groundwater sample collection:** The groundwater samples were collected from various sampling sites of RIICO industrial area and its surrounding area of Bhiwadi town of Alwar district by applying the previously stated sampling procedures. In this study, the groundwater samples were carefully collected from various sources such as open wells, tube wells and hand pumps of RIICO industrial area and its surrounding area of Bhiwadi town of Alwar district during the pre-monsoon season of the year 2019. The sampling sites were selected carefully, and the sites must be representative of whole geographical location. All the twelve individual groundwater samples were taken in well cleaned and screw capped polyethylene bottles of 2L capacity. The groundwater samples were collected carefully and stored in the refrigerator for physicochemical analysis.

**Physicochemical characterization of groundwater samples:** The groundwater samples were collected by applying the previously stated sampling procedures and were evaluated for various physicochemical parameters and determine the degree of contamination in comparison to standard parameters. The physicochemical parameters of water is important to sustain the quality and potability of water. The collected groundwater samples were preliminarily analysed for various physicochemical parameters such as pH, EC, temperature and TDS at the time of sampling using a pH meter and a portable Water Quality Analyzer kit. For the remaining analysis, the groundwater

samples were brought to the laboratory and stored in freeze at standard temperature and pressure. The physicochemical parameters such as fluoride (F<sup>-</sup>), chloride (Cl<sup>-</sup>), nitrate (NO<sub>3</sub><sup>-</sup>), TH, TA, DO, BOD, and toxic industrial constituents of groundwater samples of Bhiwadi town were tested in laboratory. Fluoride and chloride were analysed by Ion selective method, and nitrate were analysed by spectrophotometric method.

All the physicochemical parameters were analysed as per the WHO and APHA standard methods (1989)

### RESULTS AND DISCUSSION

Bhiwadi is a north-east town of Tijara tehsil of Alwar district (Rajasthan) and it is geographically coordinated between 28.21° north latitude and 76.87° east longitude. The total geographical area of Bhiwadi town is ~8.1 km<sup>2</sup> and the total population is ~1,04,921 peoples including ~59,712 male and ~45,209 female populations. Bhiwadi town is basically covered by a huge number of small, medium and large industrial units. It include all types of industries such as textile, steel, pharmaceuticals, engineering, electronics, food processing, chemicals, etc. There are no major source of surface water and all the basic requirement of water of Bhiwadi town is mainly dependent on the groundwater resources, i.e., open wells, tube wells, and hand pumps.

Bhiwadi is a growing industrial area and due to the large number of industrial units, the Bhiwadi town and its surrounding area are broadly polluted by the untreated and toxic industrial pollutants. The industrial pollution is the major problem for the local populations of Bhiwadi town and its surrounding area, and due to this, the surrounding environment and groundwater resources are broadly contaminated. Therefore, it is necessary to assess the quality of groundwater of Bhiwadi town and its surrounding area with special reference to

**Table 1.** List of groundwater sampling sites of RIICO industrial area and its surrounding area of Bhiwadi town (Alwar, Rajasthan) with their sample code name.

Entry	Code	Name of Sampling Sites	Entry	Code	Name of Sampling Sites
1.	B-1	Vikas Nagar, Bhiwadi	7.	B-7	RIICO Green Park, RIICO, Bhiwadi
2.	B-2	Milakpur, Bhiwadi	8.	B-8	Sector 3, RIICO, Bhiwadi
3.	B-3	Powergrid Road, Bhiwadi	9.	B-9	Harchandpur, RIICO, Bhiwadi
4.	B-4	Sector 24, Bhiwadi	10.	B-10	Khijarpur, RIICO, Bhiwadi
5.	B-5	Jaquar Unit-II, RIICO, Bhiwadi	11.	B-11	Shahdod, Bhiwadi
6.	B-6	RIICO Office, RIICO, Bhiwadi	12.	B-12	Amlaki, Bhiwadi

the impact of industrial pollutants.

For the quality assessment of groundwater of Bhiwadi town (Alwar, Rajasthan), the twelve groundwater samples were gathered from twelve different sampling sites of Bhiwadi town, RIICO industrial area and its surrounding area during the period of pre-monsoon season (April-May) of the year 2019 (Table 1). The groundwater samples were initially analysed for pH, EC and TDS at the time of sample collection, and later analysed in the research laboratory for the fluoride, chloride, nitrate, TH, TA, DO, BOD, and other toxic elements using standard analytical procedures of APHA. The observed physicochemical parameters of groundwater samples of Bhiwadi town and its surrounding area are illustrated in Table 2 and Table 3. All the observed parameters is compared with the acceptable drinking water standards as recommended by the WHO-2017 and BIS-2012. [13,14] Groundwater quality parameters of Bhiwadi town (Alwar):

**pH of groundwater:** The pH of groundwater resources of Bhiwadi town and its surrounding area were found in the range of pH 7.2 to pH 8.5 (Table 2). The lowest and highest value of pH were recorded for the Shahdod (B-11) and Jaquar unit-II RIICO (B-5) groundwater samples, respectively. All the groundwater samples are alkaline in nature. The pH values of all twelve groundwater resources of

Bhiwadi town and its surrounding area are in the range of acceptable or permissible limit of pH as prescribed by the WHO and BIS.

**Electrical conductivity (EC) of groundwater:** The EC of groundwater resources of Bhiwadi and its surrounding area were found to be in the range of 470  $\mu\text{S}/\text{cm}$  to 1459  $\mu\text{S}/\text{cm}$  (Table 2). The lowest and highest EC were recorded for the Shahdod (B-11) and Jaquar unit-II RIICO (B-5) groundwater resources, respectively. The groundwater of all twelve groundwater sampling sites of Bhiwadi town and its surrounding area exceeds the maximum permissible limit of EC as prescribed by the WHO.

**Total Dissolved Solids (TDS) of groundwater:** The TDS of groundwater resources of Bhiwadi town and its surrounding area were underlying in the range of 722 mg/L to 1877 mg/L (Table 2). The highest TDS (1877 mg/L) was recorded for Jaquar unit-II RIICO (B-5) and lowest TDS (722 mg/L) was recorded for Shahdod (B-11). The groundwater of all twelve sampling sites of Bhiwadi and its surrounding area are not suitable for human drinking because all these samples exceeds the maximum permissible limit of TDS as prescribed by WHO and BIS.

**Fluoride (F<sup>-</sup>) content of groundwater:** The fluoride content in groundwater resources of Bhiwadi town and its surrounding area were underlying in the

**Table 2.** Physicochemical parameters of various groundwater samples of RIICO industrial area and its surrounding area of Bhiwadi town of Alwar district collected during pre-monsoon season of the year 2019 and their comparison with WHO and BIS drinking water standards.

S. No. Water sample/ Name of Sampling sites (Code)	Name of Parameters							
	pH	EC	TDS	F <sup>-</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	TH	TA
1. Water (WHO Standards) *	6.5-8.5	400	600	1.5	250	50	300	300
2. Water (BIS Standards) **	6.5-8.5	-	500	1.0-1.5	250	45	200	200
3. Vikas Nagar (B-1)	7.3	532	898	2.6	464	48	549	675
4. Milakpur (B-2)	7.7	856	1243	2.1	845	45	523	490
5. Powergrid Road (B-3)	7.5	1007	967	3.6	670	36	600	650
6. Sector-24 (B-4)	8.2	1132	1455	4.5	890	62	788	871
7. Jaquar-II, RIICO (B-5)	8.5	1459	1877	6.9	950	81	895	789
8. RIICO Office (B-6)	8.0	1308	1188	5.8	789	56	664	832
9. RIICO Green Park (B-7)	7.9	970	1451	3.4	503	87	556	344
10. Sector-3, RIICO (B-8)	7.9	1049	1643	4.6	555	99	995	818
11. Harchandpur, RIICO (B-9)	7.5	1099	1702	3.7	698	76	655	455
12. Khijarpur, RIICO (B-10)	8.2	1203	1589	2.4	644	78	721	685
13. Shahdod (B-11)	7.2	470	722	6.4	740	53	834	546
14. Amlaki (B-12)	7.6	798	1134	2.9	543	48	383	379

**Note:** EC measure in  $\mu\text{S}/\text{cm}$ ; and TDS, F<sup>-</sup>, Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>, TH, and TA measures in mg/L; EC = Electrical Conductivity; TDS = Total dissolve solids; TH = Total Hardness; TA = Total Alkalinity; and \* BIS-2012 (IS 10500 : 2012) drinking water standards [13] & \*\* WHO-2017 drinking water standards. [14]

range of 2.1 mg/l to 6.9 mg/l (Table 2). The highest fluoride content (6.9 mg/l) was obtained for Jaquar unit-II RIICO (B-5) and lowest fluoride content (2.1 mg/l) was obtained for Milakpur (B-2). The acceptable or permissible limit of fluoride should be in the range of 1.0-1.5 mg/l as prescribed by the WHO and BIS. The groundwater samples of all twelve sampling sites of Bhiwadi town and its surrounding area exceeds the maximum acceptable or permissible limit of fluoride. Therefore, the groundwater of Bhiwadi and its surrounding area is not safe for human drinking.

**Chloride (Cl<sup>-</sup>) content of groundwater:** The chloride content of groundwater resources of the Bhiwadi town and its surrounding area were underlying in the range of 950 mg/l to 464 mg/l (Table 2). The highest chloride content (950 mg/l) was obtained for Jaquar unit-II RIICO (B-5) and lowest chloride content (464 mg/l) was obtained for Vikas Nagar (B-1). The groundwater of all twelve sampling sites of Bhiwadi town and its surrounding area exceeds the maximum permissible limit of chloride as prescribed by the WHO and BIS.

**Nitrate (NO<sub>3</sub><sup>-</sup>) content of groundwater:** The nitrate concentration of groundwater resources of the Bhiwadi town and its surrounding area were underlying in the range of 36 mg/l to 99 mg/l (Table 2). The highest nitrate concentration (99 mg/l) was obtained for Sector-3 RIICO (B-8) and lowest nitrate

concentration (36 mg/l) was obtained for Powergrid Road (B-3). The permissible limit of nitrate for drinking water is specified as 45-50 mg/l as prescribed by WHO and BIS. The nitrate in ten groundwater samples of Bhiwadi town and its surrounding area exceeds the maximum permissible limit, while two samples such as Milakpur (B-2) and Powergrid Road (B-3) found under the permissible limit.

**Total hardness (TH) of groundwater:** The TH of the groundwater resources of Bhiwadi and its surrounding area were underlying in the range of 383 mg/l CaCO<sub>3</sub> to 995 mg/l CaCO<sub>3</sub> (Table 2). The higher and lower hardness was observed for the groundwater sample of Sector-3 RIICO (B-8) and Amlaki (B-12), respectively. The TH of all twelve groundwater samples of Bhiwadi town and its surrounding area exceeds the maximum permissible limit of TH as prescribed by the WHO and BIS. The higher value of hardness could possibly be due to the overexploitation of groundwater and large number of industrial activities around the sampling sites.

**Total alkalinity (TA) of groundwater:** The alkalinity of the groundwater resources of Bhiwadi town and its surrounding area were underlying in the range of 344 mg/l to 871 mg/l (Table 2). The higher and lower alkalinity was observed for the groundwater sample of Sector-24 (B-4) and RIICO Green Park (B-

**Table 3.** General parameters of various groundwater samples of RIICO industrial area and its surrounding area of Bhiwadi town of Alwar district collected during pre-monsoon season of the year 2019 and their comparison with WHO and BIS drinking water standards.

S. No. Water sample/ Name of Sampling sites (Code)	Name of Parameters						
	DO	BOD	Cd	Hg	Pb	As	Cr
1. Water (WHO Standards) *	-	-	0.003	0.006	0.01	0.01	0.05
2. Water (BIS Standards) **	-	-0.003	0.001	0.01	0.01	-0.05	0.05
3. Vikas Nagar (B-1)	5.5	14.0	ND	ND	ND	ND	ND
4. Milakpur (B-2)	3.7	19.2	ND	ND	0.01	ND	ND
5. Powergrid Road (B-3)	5.1	6.4	ND	ND	ND	ND	ND
6. Sector-24 (B-4)	3.2	20.9	ND	ND	ND	ND	0.02
7. Jaquar-II, RIICO (B-5)	1.4	48.6	0.011	ND	0.02	ND	0.05
8. RIICO Office (B-6)	1.0	42.0	0.027	ND	0.01	ND	0.05
9. RIICO Green Park (B-7)	3.1	24.1	ND	ND	ND	ND	ND
10. Sector-3, RIICO (B-8)	1.8	33.5	0.001	ND	0.01	ND	0.01
11. Harchandpur, RIICO (B-9)	3.0	28.7	0.002	ND	0.01	ND	0.01
12. Khijarpur, RIICO (B-10)	2.3	44.0	0.002	ND	0.01	ND	0.02
13. Shahdod (B-11)	4.7	16.4	ND	ND	ND	ND	ND
14. Amlaki (B-12)	6.2	7.8	ND	ND	ND	ND	ND

**Note:** All parameters measures in mg/L; DO = Dissolved oxygen; BOD = Biological oxygen demand; ND = Not detected; and \* BIS-2012 (IS 10500 : 2012) drinking water standards [13] & \*\* WHO-2017 drinking water standards. [14]

7), respectively. The alkalinity of all twelve groundwater samples of Bhiwadi town and its surrounding area exceeds the maximum permissible limit of TA as prescribed by the WHO and BIS.

**Dissolved oxygen (DO) of groundwater:** The DO values of groundwater resources of Bhiwadi and its surrounding area were underlying in the range of 1.0 mg/l to 6.2 mg/l (Table 3). The results indicated that the groundwater samples were found to be contaminated and has very less concentration of DO except three groundwater samples. For drinking water, the DO should be more than 5 - 6 mg/l in normal water (WHO, 2017). Therefore, most of the groundwater samples of Bhiwadi and its surrounding area are not suitable for human drinking.

**Biochemical oxygen demand (BOD) of groundwater:** The BOD values of groundwater resources of Bhiwadi and its surrounding area were underlying in the range of 6.5 mg/l to 48.6 mg/l (Table 3). For drinking water, the satisfactory limit of BOD should be 0 - 4 mg/l at room temperature and the higher values of BOD indicates the presence of large number of organic matters and pollutants in water (Yongjin *et al.*, 2015). The groundwater of all twelve sampling sites of Bhiwadi town and its surrounding area has higher values of BOD and therefore, it is not suitable for drinking and for any other purposes.

**Cadmium (Cd) in groundwater:** The concentration of Cd in groundwater resources of Bhiwadi and its surrounding area were underlying in few samples in the range of 0.001 mg/l to 0.027 mg/l (Table 3). The groundwater samples of Jaquar unit-II RIICO (B-5) and RIICO office (B-6) has the higher concentration of Cd which is above the maximum acceptable limit for drinking water and it is due to the industrial pollutants that has large concentration of Cd containing pollutants. Therefore, the groundwater of these sampling sites is not suitable for human drinking.

**Mercury (Hg) in groundwater:** Mercury (Hg) was not detected in the groundwater resources of Bhiwadi and its surrounding area (Table 3).

**Lead (Pb) in groundwater:** The concentration of Pb in groundwater resources of Bhiwadi and its surrounding area were underlying in few samples in the range of 0.01 mg/l to 0.02 mg/l (Table 3). The groundwater samples of Jaquar unit-II RIICO (B-5) has the higher concentration of Pb which is above the maximum acceptable limit for drinking water and it is due to the industrial pollutants that has

large concentration of Pb containing pollutants. Therefore, the groundwater of these sampling sites is not suitable for human drinking.

**Arsenic (As) in groundwater:** Arsenic (As) was not detected in the groundwater resources of Bhiwadi and its surrounding area (Table 3).

**Chromium (Cr) in groundwater:** The concentration of Cr in groundwater resources of Bhiwadi and its surrounding area were found in few samples in the range of 0.01 mg/l to 0.05 mg/l (Table 3). The concentration of Cr in all twelve groundwater samples were found under the maximum permissible limit as prescribed by the WHO and BIS.

## CONCLUSION

Bhiwadi (Alwar) is a north-east town of Tijara tehsil and a rapidly growing industrial hub in Alwar district of Rajasthan. The rapid industrialization and industrial pollutions are the major and drastic problem that further contaminated the essential traditional resources, i.e., drinking water resources, soil and air. In the present study, the groundwater samples were gathered from RIICO industrial area and its surrounding area of Bhiwadi town during the pre-monsoon season of the year 2019 and investigated for the water quality parameters. On the basis of present study, it is concluded that the groundwater resources of Bhiwadi town and its surrounding area are not consistent with the drinking water standards of WHO and BIS. The water quality parameters such as electrical conductivity, total dissolve solids, fluoride, chloride, nitrate, hardness, alkalinity, dissolved oxygen, biological oxygen demand, cadmium and lead were found above the maximum acceptable or permissible drinking water standards. The parameters such as pH, arsenic and chromium fall under the prescribed limit or not detected in few samples. The study has revealed that the groundwater of Bhiwadi and its surrounding area is contaminated due to the industrial pollution around the sampling sites and found unsafe for human drinking purposes.

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### REFERENCES

- Agrawal, M. and Sharma, K. C. 2015. Physico-Chemical Contamination of Groundwater in and Around Industrial Areas of District Alwar, Rajasthan. *Current World Environment*. 10 (2) : 676-682.
- Anslyn, E. V. and Dougherty, A. D. 2006. *Modern Physical Organic Chemistry*. University Science Books, USA.
- BIS, 2012. Indian Standard, Drinking Water-Specification (Second Revision). Bureau of Indian Standards, IS 10500: 2012.
- De, A. K. 2000. *Environmental Chemistry*. (4th Edition). New Age International (P) Ltd., New Delhi, India.
- Frape, S. K., Blyth, A., Blomqvist, R., McNutt, R. H. and Gascoyne, M. 2003. 17 - Deep Fluids in the Continents: II. Crystalline Rocks. *Treatise on Geochemistry*. 5 : 541-580.
- Kershaw, S. and Cundy, A. 2000. *Oceanography: An Earth Science Perspective*. 2000. Stanley Thornes (Publishers) Ltd., United Kingdom.
- Khan, M. A. 2001. Pollution of water resources due to industrialization in arid zone of Rajasthan, India. *J. Environ. Sci. (China)*. 13 (2) : 218-23.
- Kibria, G. 2017. Dissolved oxygen: The facts. DOI: 10.13140/RG.2.2.24591.28320.
- Kumar, S. and Saini, D. K. 1998. Status of fluoride in ground water of Alwar District in Rajasthan. *Journal of Environment and Pollution*. 5(4) : 299-305.
- Meena, L. R. and Nama, P. 2017. Effect of Textile Industrial Effluents on Bandi River (Pali) Rajasthan, India. *Journal of Global Biosciences*. 6(2) : 4784-4789.
- Parameters of Water Quality: Interpretation and Standards. Environmental Protection Agency (EPA), Ireland (2001).
- Sharma, S. and Bhattacharya, A. 2017. Drinking water contamination and treatment techniques. *Applied Water Science*. 7 : 1043-1067.
- Standard Methods for the Examination of Water and Waste water* (17th Edition). American Public Health Association (APHA), 1989, New York, USA.
- Valsami-Jones, E. 2004. *Phosphorus in Environmental Technologies: Principles and Applications* (Editor: Valsami-Jones, E.). IWA Publishing, UK (2004).
- WHO, 2017. Guidelines for Drinking Water Quality (Fourth Edition). World Health Organization, ISBN: 978-92-4-154995-0.
- Yongjin, C., Weihong, L., Jiazhen, L., Ming, L., Mengchen, X. and Shengliang, L. 2015. Variations in Depth and Chemical Composition of Groundwater During an Interval in Intermittent Water Delivery. *Water Environment Research*. 87 (8) : 712-720.