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ASSESSMENT OF GROUND WATER QUALITY IN INDUSTRIAL AREA OF ALWAR DISTRICT OF RAJASTHAN, INDIA

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Abstract: Natural resources as well as anthropogenic activities have significant impact on ground-water quality. Point and non-point sources of groundwater contamination are responsible for spreading of health issues. The present study was aimed to assess groundwater quality in industrial areas of Alwar district of Rajasthan and compared with standard limits of WHO. The physico- chemical characteristics of groundwater have been selected for ten different sites in the industrial area of Alwar district namely of RIICO areas of Behror (GWI), Neemrana (GW2), Shahjahanpur (GW3), Sotanala (GW4), and industrial area of Ramgrah (Bager) (GW5), Agyara (GW6), Bagar Rajput (GW7), MACL (GW8), Monto motors (GW9) and in the Agro-food Park (GW10). The physico-chemical parameters *namely* pH, temperature, alkalinity, hardness, calcium, magnesium chloride and fluoride were analyzed by recommended methods. The average values of all physico-chemical parameters were determined to be within the WHO drinking water guidelines permitted limits, although several ground water locations were detected have higher values than the proscribed standard limits. By the results it has been concluded that the industrial waste water has been seen to be accumulate near the ground water tables which is primarily concerned to be source of spreading of dangerous chemicals to surrounding other water bodies also.

Keywords: Anthropogenic activities, Fluoride, Ground-water, Physico-chemical, Water bodies.

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INTRODUCTION

The demand of groundwater for drinking and irrigation rises with expanding population. In the coastal areas, the crisis of groundwater has a substantial impact on the inhabitants of the area (Jena *et al*., 2024). Water is one of our most valuable resources, yet freshwater supplies are rapidly depleting. Water scarcity has emerged as a major worldwide concern for long-term development. This is projected to become increasingly serious as the world's population continues to expand, resulting in an increase in the level of living, changes in nutrition habits, and anthropogenic impact on biodiversity and other things (Zacchaeus *et al.,* 2020; Prakash and Verma, 2022). Natural sources and man-made activities both have an impact on climate change and groundwater quality and sustainable development (Varol and Davraz, 2015; Kumar, 2021). It is essential for domestic, agricultural, and industrial usage (Babiker *et al*., 2007).

Groundwater contamination from point and non-point pollution causes a variety of health problems (Roohul-Amin *et al*., 2012; Nalbantcilar and Pinarkara, 2015). As

a result, constant monitoring of water quality indicators regulates hydrochemical processes, which are essential and sustainable. Because groundwater serves as a universal supply of drinking water, pollution of groundwater by organic and inorganic substances of both human and natural causes is a serious global environmental concern. The groundwater quality is influenced both by natural processes and anthropogenic factors/forces because of complexity of geological environments and variability of human activities. The phenomena i.e. evaporation, precipitation, interaction between water and rocks, recharging and discharging of groundwater and redox reactions results in the dissolution and precipitation of minerals which extensively control the concentrations of chemical components (Wei *et al*., 2025).

Irregular rainfall, excessive evaporation and over exploitation have resulted in decreasing groundwater levels and escalating groundwater pollution in arid and semi arid areas such as Rajasthan of India. The water pollution due to fluoride, nitrate, and chloride are the major issues concerned to groundwater quality in Rajasthan. In addition to that several regions of the state, total dissolved solids concentrations observed exceeding 1000 mg/l as compared to WHO limit of 500 mg/l (Pareta *et al.,* 2024).

The presence of industrial firms is one of the most commonly offered cures for the issues impeding progress in third-world nations (Afolabi *et al*., 2012). However, industrialization, like every other process, has both positive and harmful consequences. The anthropogenic activities including industrial production, waste disposal, indiscriminate release of several heavy metals etc. into the environment are serious concern (Sirajudeen *et al*., 2014; Bhutiani *et al*., 2017; Verma and Prakash, 2020; Singh *et al.,* 2023). Because of the increased densities of industries across a small region, water pollution by industrial operations is a common occurrence in the surrounding communities (Bhutiani *et al.,* 2017). Heavy metals are picked up by percolating wastewater and end up in aquifer systems, contaminating groundwater (Mohankumar *et al.*, 2016; Bhutiani *et al*., 2017). Volcanic eruptions and weathering of metal-bearing rocks are biogenic sources, whereas different industrial, mining and agricultural operations are man-made sources. As a result, a study was conducted to analyze groundwater quality in industrial regions of Rajasthan's Alwar district, and the results were compared to WHO standard limits.

MATERIALS AND METHODS

The water samples were collected in different months of 2021. To assess the qualitative characters 10 different locations are selected for Alwar district of Rajasthan in which 4 sites have been chosen under Rajasthan State Industrial Development and Investment Cooperation Limited (RIICO) area *namely* Behror (GW1), Neemrana (GW2), Shahjahanpur (GW3), Sotanala (GW4), and remaining 6 sites are other industrial sites namely Ramgrah (Bager) (GW5), Agyara (GW6), Bagar Rajput (GW7), MACL (GW8), Monto motors, MIA (GW9) and in the Agro-food Park, MIA (GW10).

To assess the level of groundwater contamination, sampling of groundwater has been collected from hand pumps and bore wells as per the standard procedure. Good quality screw-capped polyethene bottles of one-liter capacity were used to collect the sample. Bottles first washed with distilled water before sample collection bottles were rinsed thrice with water to be sampled and then samples were collected. After sample collection, every sample was marked on sampling bottles by a permanent marker, recorded all the information regarding name of the sampling location, source and date of collection to avoid any confusion and error. The physio-chemicals namely pH, temperature, alkalinity, hardness, calcium, magnesium, chloride and fluoride detected by following APHA (2017) methods.

Table 1: Data processing for statistical analysis.

Sl. No.	Studied parameters	Methods
1.	pH	Specific instrument (pH meter)
2.	Temperature	Specific instrument (Thermometer)
3.	Alkalinity	Titrimetric
4.	Hardness	EDTA titrimetric method
5.	Calcium	EDTA titrimetric method
6.	Magnesium	EDTA titrimetric method
7.	Chloride	Argentometric method
8.	Fluoride	Ion selective electrode method

RESULTS AND DISCUSSION

The physico-chemical characteristics of groundwater quality of Alwar district are presented in Table 2. Details are as under:

1. pH

The pH is a term used universally to express the acid or alkaline condition of a solution. Most of the water samples are slightly alkaline because of existence of carbonates and bicarbonate (Murhekar, 2011). The pH range has been observed in between 6.75 to 7.25 in groundwater of industrial areas, Alwar district. The maximum pH was found in Agyara, Ramgarh (GW6) site while, minimum in MIA Agro Food Park (GW10) as per WHO requirement desirable limit is 6.5 to 8.5.

Table 2: Status of ground water quality in industrial area of Alwar district of Rajasthan.

S. No.	Parameters	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	GW10	Avg.	WHO Desirable Limit
1.	pH	7.03	7.2	6.88	7.1	7.2	7.25	7.07	7.15	6.8	6.75	7.043	6.5-8.5
2.	Temp.	29	30	32	30	30	31	30	31	32	28	30.3	-
3.	Alkalinity (Mg/l)	200	232	240	200	200	235	258	202	180	172	211.9	200
4.	Hardness (Mg/l)	190	285	370	579	420	235	196	459	200	258	319.2	300
5.	Calcium (Mg/l)	44.3	66.9	60.5	98.5	57.5	44.5	60	93	38	62.1	62.53	100
6.	Magnesium (Mg/l)	24.76	33.34	54.65	81.01	66.36	30.25	21.47	53.65	23.45	25.37	41.43	50
7.	Chloride (Mg/l)	289	389	660	900	718	214	135	479	88	87	395.9	500
8.	Fluoride (Mg/l)	0.34	0.42	0.72	0.44	0.62	1.2	0.9	0.3	0.9	0.14	0.598	15

2. Temperature (^{o}C)

The most important environmental element affecting plants and animals is temperature. Water has various distinct thermal qualities that work together to keep temperature changes to a minimum. The temperature of the water is affected by the depth of the water column, as well as climatic and geographical factors (Chapman, 1996). The temperature range of ground water in Alwar district's industrial zones was determined to be between 28^{0} and 32^{0}C. Shahjahanpur-RIICO (GW3) and Monto Moters, MIA-RIICO (GW9) had recorded the highest, while MIA Agro Food Park (GW10) had the lowest temperature.

3. Alkalinity (mg/l)

The cause of alkalinity is the minerals which dissolve in water originating from the soil. The various ionic species which add to alkalinity include bicarbonate, hydroxide, phosphate, borate and organic acids (Shyamala *et al.,* 2008; Bhagde *et al.*, 2020). The range of alkalinity was detected between 172 to 258 mg/l in groundwater in industrial areas of Alwar district. The maximum concentration of alkalinity was found in Bager Rajput (Site-GW7) whereas minimum in MIA Agro food park (Site-GW10) according to WHO standards desirable limit is 200 mg/l.

4. Hardness (mg/l)

Hardness is the property of water which prevents the lather formation with soap and increases the boiling point of water (Patil and Patil, 2010). Hardness was found in the range of 190 to 579 mg/ in ground water of industrial areas in Alwar district. The maximum hardness was found in Rajasthan State Industrial Development and Investment Cooperation Limited (RIICO) area Sotanala (Site-GW4) while, minimum in RIICO area of Behror (Site-GW1) as per WHO requirement desirable limit is 300 mg/l.

5. Calcium

Calcium ions are important components of plant tissues and participate in various cellular functions. It is also required as a nutrient for various metabolic processes i.e. translocation of carbohydrates that facilitate the availability of other ions (Wetzel, 1975). The range of calcium was observed within 38.0 to 98.5 mg/l in groundwater of industrial areas in Alwar district. The maximum calcium was found in RIICO area Sotanala (Site-GW4) site while, minimum in industrial site Monto Moters, MIA (Site-GW9) as per WHO requirement desirable limit is 100 mg/l.

6. Magnesium (mg/l)

Mg2+ is in a condition of balance in almost all waterways, but when the salinity of the water rises, the quantity of magnesium in the water rises as well, affecting crop productivity (Joshi *et al.,* 2009; Singaraja *et al.,* 2014). Magnesium concentrations in groundwater in Alwar district industrial zones vary from 21.47 to 81.01 mg/l. The highest concentration of magnesium was detected at the Sotanala (RIICO)/GW4 site, while the lowest concentration was recorded at the Bager Rajput/GW7 site. The WHO recommends a concentration of 50 mg/l.

7. Chloride (mg/l)

Chloride is a widely dispersed element that may be found in various forms in all sorts of rocks. It has a

strong affinity for salt. As a result, it has a high concentration in groundwater, where temperatures are high and rainfall is low. The porosity and permeability of the soil also have a role in increasing the chloride content (Ashok, 2019). In the Alwar district's industrial districts, chloride levels in groundwater ranged from 87 to 900 mg/l. As per W.H.O. requirements, the greatest chloride was detected in Sotanala (RIICO)/GW4 site, whereas the least was found in MIA Agro Food Park/GW10.

8. Fluoride (mg/l)

Probable source of high fluoride in Indian waters seems to be that during weathering and circulation of water in rocks and soils, fluorine is leached out and dissolved in groundwater (Arya *et. al.,* 2012). The range of fluoride has been found between 0.14 to 1.20 mg/l in groundwater in industrial areas of Alwar district. The maximum fluoride was found in Agyara, Ramgarh (GW6) site while, minimum in MIA Agro Food Park (Site-GW10) as per WHO desirable limit is 15 mg/l.

This study provides an informative primary data on water quality parameters and helps to understand the contamination of ground water and its possible influence on the ecological system. In the present study, an effort has been made to evaluate many physico-chemical parameters and its characteristic behavior of ground water samples at different sampling sites in industrial areas of Alwar district. This may be due to heavy discharge of effluent, domestic sewage and other anthropogenic activities. The study suggest immediate need to take extensive water quality monitoring studies and to find the remedial measures to protect this important natural water sources in the study area.

CONCLUSION

Assessment of the groundwater quality in industrial area is done by collecting water samples and analysis of physico-chemical characteristics of water samples at different locations of district Alwar. As per WHO guidelines for drinking water higher values of parameters recorded in various sites of ground water i.e. alkalinity (GW2, GW3, GW6, GW7 and GW8, hardness (GW3, GW4, GW5 and GW8), magnesium (GW3, GW4, GW5 and GW8) and chloride (GW3, GW4 and GW5).The average values of all physiochemical parameters were determined to be within the WHO drinking water guideline's permitted limits, although several groundwater locations had values that were significantly higher than the standard limit. During the examination of sample locations, it was discovered that there was a buildup of industrial wastewater near the water sources. Groundwater quality is also impacted by industrial waste. As a result, industrial waste management is required in significant human settlements to prevent dangerous chemicals from contaminating water bodies.

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