



Groundwater Quality Assessment for Irrigation Suitability Purpose in the Khelna River Basin of Aurangabad District, Maharashtra, India

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Authors' contributions

This work was carried out in collaboration between both authors. Author SVG did water sample analysis, calculate irrigation parameters, wrote manuscript. Author DSM managed the analyses of the study, literatures survey, improve quality of manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

The present study is based on irrigation suitability for groundwater samples in the Khelna river basin, Chhatrapati Sambhajnagar (Aurangabad), Maharashtra, India. A total 50 groundwater sample were collected, out of 50 groundwater sample 16 groundwater samples were collected from bore well and 34 groundwater samples collected from dug wells in high quality of one liter polyethylene bottles from different locations within the study area. The irrigation water quality parameters like sodium adsorption ratio (SAR), Percent sodium (%Na), Residual sodium carbonate (RSC), Residual Sodium Bicarbonate (RSBC), Kelly's ratio (KR), Magnesium adsorption ratio

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(MAR), and Permeability index (PI) were calculated with the help of physico chemo analysis of groundwater sample using standard formulae was given in Table 1. The irrigation water quality parameters values are measured like SAR (0.63 to 2.89), %Na (1.04 to 6.96), RSC (-6.14 to 0.59), RSBC (-1.54 to 3.91), KR (0.19 to 0.76), MAR (25.78 to 78.78) and PI (36.46 to 72.78). All the irrigation parameters are revealed the value in suitable category for irrigation except MAR (Magnesium hazard). Magnesium hazard water samples that exceed acceptable limits have been recognized in the study area because of different geological and human activities. This study is beneficial for farmers and policymakers in managing and planning groundwater resources.

Keywords: Groundwater quality; irrigation; Kelly's ratio (KR); Permeability index (PI); percent sodium (%Na); Sodium adsorption ratio (SAR); Khelna river; Aurangabad.

1. INTRODUCTION

Groundwater serves as a vital natural resource on Earth and is essential for all living beings to maintain a sustainable environment and ecosystem (Liu et al., 2021; Jabbo et al., 2021; Paneerselvam et al., 2023). Forty-six percent of India's overall national output is derived from the agricultural sector, which plays a significant role in the nation's economic development (Jafar et al., 2013). Half of the irrigated area relies on groundwater extraction through dug and bore wells. Indian agriculture, especially in the Marathwada and Vidarbha areas of Maharashtra state, encounters a scarcity of surface water resources.

In many regions of the nation, the quality of groundwater poses a greater risk to human health, influenced by the swift rise in population, industrial growth, and urban development in developing nations (Adimalla, 2021; Kom et al., 2021). It is a major issue alongside the decreasing water Table (Vasanthavigar et al., 2012; Hossain and Patra, 2021). Groundwater commonly contains certain soluble salts from recharge sources and the surrounding geological layers, which continue to filter through. Consequently, worries regarding the low-quality groundwater for irrigation have increased in recent years. Groundwater contamination arises from both excessive and inadequate use of chemical fertilizers (Ayers and Westcot, 1985; Rowe and Abdel-Magid, 1995; Singh et al., 2015; Rawat et al., 2018). Thus, it is essential to routinely evaluate water quality for sources used in drinking and irrigation (Gupta et al., 2009; Gautam et al., 2015; Jacintha et al., 2017).

Irrigation requires an adequate supply of water that is of usable quality. The index that reflects the concentration and composition of dissolved elements in water can aid in assessing its suitability for irrigation based on the characteristics of the mineral elements present

and their effects on plants and soil (Richards, 1954). Typically, Ca^{2+} , Mg^{2+} , K^{+} , Na^{+} (major cations), SO_4 , NO_3^- , Cl^- , HCO_3^- , CO_3^- , and NO_3^- (major anions), along with heavy metals, serve as indicators of drinking water quality parameters. In contrast, primary water quality parameters such as sodium adsorption ratio (SAR), percent sodium (%Na), residual sodium carbonate (RSC), residual sodium bicarbonate (RSBC), Kelly's ratio (KR), magnesium adsorption ratio (MAR), and permeability index (PI) are commonly utilized to assess the quality of water for irrigation purposes (Singh et al., 2015; Gautam et al., 2015; Singh et al., 2013; Sreedevi et al., 2018). The connection between irrigation and groundwater resources is profoundly intertwined. In the competition to boost agricultural output, irrigation will rely on low-quality water sources.

In the present study area of Khelna river basin area of Aurangabad, Maharashtra state, India. Water quality assessment work for drinking purpose was carried out (Deshpande and Sayed, 2021). Since no records are available for water quality assessment work for irrigation, it is decided to take up the same.

2. MATERIALS AND METHODS

2.1 Study Area

The study area falls within the Chhatrapati Sambhajinagar (Aurangabad) district of the Maharashtra state. The study area situated between longitude $75^{\circ} 30' 00''$ to $75^{\circ} 45' 00''$ E and $20^{\circ} 20' 00''$ to $20^{\circ} 30' 00''$ N and shown in Fig. 1. Apart from the south-west monsoon season, the district's climate is characterized by hot summers and generally dry conditions all year long. In Aurangabad, the rainy season lasts from June to September, October to February for the winter season, and March to May for the summer. In Aurangabad district, the average rainfall is 734 mm, with minimum temperatures of 23°C and maximum temperatures of 39°C .

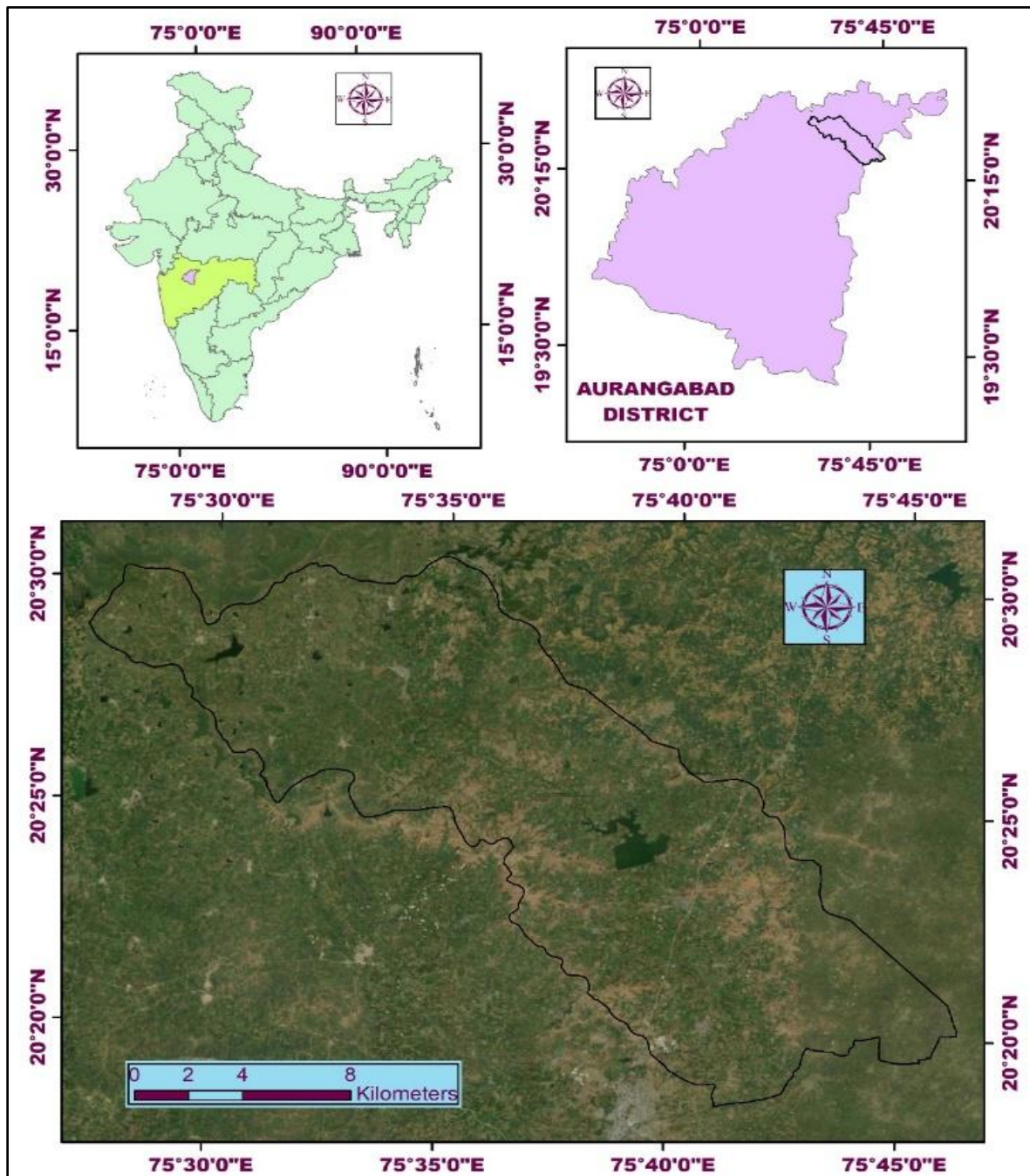


Fig. 1. Location map of the study area.

Geologically, the study area is occupied deccan basaltic lava flows of Upper Cretaceous to Lower Eocene age in Peninsular India. Basaltic lava flows found thick horizontal and flat top hills were observed with the study area. The lava traps of basaltic formations run parallel to the surface and are divided by two layers of lava flow. The top layer of vesicular and amygdaloidal basalt contains cavities filled with secondary minerals, while the lower layer is made up of dense and

solid/ massive basalt (Deshpande et al., 2022; Kadam et al., 2023). Regur type of soils is occurred within the study area, which is formed due to the weathering of basaltic rocks. This type of soil is more fertile for all type of crops.

From an agricultural perspective, soil fertility is influenced by the texture and structure of the soil, which governs its ability to retain and transmit moisture and essential nutrients like nitrogen,

phosphorus, and potassium that originate from the parent rock (CGWB, 2023). It has been determined that geology, topography, climate, and vegetation all influence the soil formation process in the study area. The region of the study is characterized by black cotton soil, also known as regur soil, which is formed through the weathering and erosion of the upper layer of basaltic lava flows. It is rich in plant nutrients like iron, lime, alkalis, and iron, enabling the growth of cotton and dry crops like jowar, pearl millet, wheat, gram, Soyabean and cotton are common practices in the study area.

2.2 Sampling Methods

A 16 groundwater samples were collected from bore well and 34 groundwater samples were collected from dug well locations out of 50 groundwater samples within the study area in high quality of one litter polyethylene bottles.

Sampling and analysis were conducted following the International standard methods. Typically, the quality parameters of water, as well as the presence of anions and heavy metals, indicate the suitability of drinking water, whereas additional water quality parameters include sodium adsorption ratio (SAR), percentage of sodium (% Na), residual sodium carbonate (RSC), residual sodium bicarbonate (RSBC), Kelly's ratio (KR), magnesium adsorption ratio (MAR), and permeability index (PI). This assessment was based on essential water quality parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Chloride (Cl), Total Hardness (TH), Magnesium (Mg), Calcium (Ca), Bicarbonates (HCO₃), and Sodium (Na). Potassium (K) and Sulfate (SO₄) are typically utilized to assess the quality of water for irrigation purposes (Singh et al., 2015; Gautam et al., 2015; Singh et al., 2013). The pH parameter was assessed using a Lapman Model LMHP-12, while EC and TDS were determined with a Cond/TDS meter (Deluxe Model 641E). Cl, Th, Ca, and HCO₃ levels were evaluated through a volumetric titration method. Mg was assessed using the concentrations of Total Hardness (TH) and Calcium (Ca). Potassium (K) and Sodium (Na) were quantified using a flame photometer, while SO₄ was assessed using a spectrophotometer.

2.3 Irrigation Parameter

The irrigation water quality parameters like sodium adsorption ratio (SAR), Percent sodium

(%Na), Residual sodium carbonate (RSC), Residual Sodium Bicarbonate (RSBC), Kelly's ratio (KR), Magnesium adsorption ratio (MAR), and Permeability index (PI) were derived using the standard formulas listed in Table 1.

3. RESULTS AND DISCUSSION

3.1 Sodium Adsorption Ratio (SAR)

The sodium adsorption ratio (SAR) represents the ratio of Na⁺ ions to Ca₂⁺ and Mg₂⁺ ions in a water sample expressed as a percentage. This ratio is employed to forecast the likelihood of Na⁺ accumulation in the soil, primarily at the cost of Ca₂⁺, Mg₂⁺, and K⁺, as a result of frequent usage of sodic water. The SAR is determined using the formula provided in (Table 1). Depending on the quality of irrigation water, SAR values are divided into four categories (Table 2): SAR value 10 (excellent), SAR value from 10 to 18 (Good), SAR value from 18 to 26 (Doubtful), and SAR value above 26 (Unsuitable) (Rawat et al., 2018). Additionally, SAR influences the percolation rate of water through the soil. Consequently, irrigation water that has low SAR values is preferred. The study area shows that SAR values vary from 0.63 to 2.89 during pre-Monsoon season, with the mean SAR level being 1.5 for that season (Table 2), which is classified as excellent, i.e., SAR values < 10 (Richards, 1954). Based on the SAR value, the irrigation classification of water indicates that all thirty water samples are classified as excellent. High-quality categorized samples are utilized for irrigation purposes. Therefore, all water samples are suitable for irrigation and planting.

3.2 Percent Sodium (%Na)

Elevated Na⁺ levels in irrigation water may cause sodium-related risks. The SAR is determined using the formula provided in Table 1. According to % Na values, water is categorized into five classes (Table 2); < 20% is classified as (Excellent), 20-40% as (Good), 40-60% as (Permissible), 60-80% as (Doubtful), and > 80% as (Unsuitable). Excessive Na⁺ levels in irrigation water can negatively impact soil permeability and properties, as well as hinder plant growth. Consequently, the amount of sodium carbonate in irrigation water is an essential element in evaluating its appropriateness for application. The sodium percentage (% Na) in the study area ranges from 1.04 to 6.96 meq/l, with an average of 2.79 meq/l for the pre-monsoon season (Table 2). The

Bureau of Indian Standards (BIS) recommends that the Na^+ content in irrigation water should not exceed 60% (BIS, 2003). An excess of % Na beyond 60% can cause Na^+ accumulation, thereby adversely affecting soil physical properties (Ramesh and Elango, 2012). The % Classification for irrigation suitability percent such as Excellent (< 20 %), Good (20 to 40%), Permissible (40 to 60%) Doubtful (60 to 80%), Unsuitable (> 80%). The (100%) groundwater samples are show values less than the < 20% and as per irrigation parameters standard all the groundwater samples within the study are is excellent in class and it is suitable for irrigation.

3.3 Residual Sodium Carbonate (RSC)

RSC is defined as the surplus of carbonate and bicarbonate levels exceeding those of alkaline earth, mainly the contents of Ca^{2+} and Mg^{2+} beyond permissible thresholds, adversely affecting irrigation (Richards, 1954; Eaton, 1950). The RSC is determined using the formula presented in Table 1. According to RSC ranges, sodium hazards are categorized into three classes: (Table 2) $\text{RSC} < 1.25$ (Good), 1.25-2.5 (doubtful), and > 2.5 (unsuitable), as outlined (Rawat et al., 2018). A high range of RSC in irrigation water suggests an increase in sodium adsorption in the soil. It is generally not recommended to use water with an RSC exceeding 5 for irrigation since it could negatively affect plant growth. Generally, a water source with an RSC exceeding 2.5 is deemed unsuitable for agricultural purposes, while water with an RSC below 1.25 is recommended as safe for irrigation. A low RSC value indicates that the levels of Ca^{2+} and Mg^{2+} are excessively high. A higher RSC suggests that the presence of Na^+ in the soil is possible. The study area groundwater samples show variations in the RSC from -2.73 to -6.14 meq/l, with an average of 0.59 during the pre-monsoon (Table 2). Based on Richards' classification, All the groundwater samples are show values less than < 1.25 it means that the all the groundwater samples within study area is suitable for irrigation. Maximum sample number show negative RSC values (Table 2) because an abundance of Ca^{2+} and Mg^{2+} concentration is shown by a negative RSC value. A positive RSC suggests the potential presence of Na^+ in the soil.

3.4 Residual Sodium Bicarbonate (RSBC)

The levels of carbonate and bicarbonate determine the appropriateness for irrigation.

Elevated pH occurs in water with increased RSBC. RSBC was divided into three categories: < 5 meq/l (satisfactory), 5 to 10 meq/l (marginal), and > 10 meq/l (unsatisfactory) as classified (Gupta and Gupta, 1987). The RSBC is determined using the formula provided in Table 1.

(RSBC) The ranges of residual sodium bicarbonate in water from the study area span from -1.54 to 3.91 meq/l, averaging 0.598 meq/l (Table 2). The RSBC indicates the higher concentration of HCO_3^- compared to Ca^{2+} (Hussain and Hussain, 2004). The water contains excess HCO_3^- , indicated by the negative values (Table 2) for each water category in the study area. The RSBC value for the study area is below 5 meq/l in all water samples, which is deemed safe or satisfactory category for irrigation (Gupta and Gupta, 1987; Kelly, 1940).

3.5 Kelly's Ratio (KR)

To assess and classify water for irrigation, it introduced a novel aspect based on the ratio of Ca^{2+} to Na^+ and Mg^{2+} levels (Kelly, 1940). The formula for calculating the Kelly's ratio (KR) is provided in Table 1. Waters with excessive Na^+ levels are denoted by a $\text{KR} > 1$. Due to the risks associated with alkali, water with a $\text{KR} < 1$ is generally advised for irrigation, while water with a KR of 1 to 2 is considered marginally acceptable, and water with $\text{KR} > 2$ is deemed unsuitable for irrigation (Ramesh and Elango, 2012; Karanth, 1987). To evaluate the suitability of irrigation water quality, Kelly's ratio (KR) serves as an indicator, calculated from the K^+ parameter, which relies solely on Ca^{2+} , Mg^{2+} , and Na^+ . As shown in Table 2, the average KR level throughout the study area is 0.42 meq/l, varying between 0.19 and 0.76 meq/l. It was determined that rainfall had a lesser effect on KR, as the diluting process causes the average KR value to remain within the acceptable range (Table 2). The 100% groundwater samples are classified as suitable for irrigation in the study area.

3.6 Magnesium Adsorption Ratio (MAR)

A surplus of magnesium (Mg) in groundwater alters the soil's pH, increasing its alkalinity and diminishing crop yields (Gautam et al., 2015; Singh et al., 2013; Gowd, 2005). The magnesium adsorption ratio (MAR) is determined using the formula provided in Table 1.

Table 1. Groundwater quality irrigation parameter

Parameter	Formulae	References
Sodium adsorption ratio (SAR)	$SAR = Na^+ / (\sqrt{Ca^{2+} + Mg^{2+}} / 2)$	(Richards, 1954)
Percent sodium (%Na)	$Na\% = (Na^{++}K^+) / (Ca^{2+} + Mg^{2+} + Na^{++}K^+) \times 100$	(Wilcox, 1948)
Residual sodium carbonate (RSC)	$RSC = (CO_3 + HCO_3^-) - (Ca^{2+} + Mg^{2+})$	(Richards, 1954; Eaton, 1950)
Residual Sodium Bicarbonate (RSBC)	$HCO_3 - Ca^{2+}$	(Gupta and Gupta, 1987)
Kelly's ratio (KR)	$Na^+ / Ca^{2+} + Mg^{2+}$	(Kelly, 1940)
Magnesium adsorption ratio (MAR)	$MAR = (Mg^{2+} / Ca^{2+} + Mg^{2+}) \times 100$	(Oladeji et al., 1212)
Permeability index (PI)	$PI = (Na^+ \sqrt{HCO_3} / Ca + Mg + Na) \times 100$	(Doneen, 1964)

Table 2. Irrigation parameter calculated in Khelna river basin, Aurangabad, Maharashtra

Sr. No.	Village	Well Type	SAR	% Na	RSC	KR	RSBC	PI	MAR	Latitude	Longitude
1	Kelgaon	DW	1.41	2.87	-4.69	0.35	-1.49	42.71	38.53	20.475048	75.496313
2	Korhala	BW	1.64	2.7	-1.54	0.5	0.67	57.5	40.88	20.49458	75.488719
3	Sirsala	DW	1.78	3.26	-3.27	0.49	0.01	51.39	49.09	20.486526	75.533192
4	Sirsala Tanda	DW	1.8	4.04	-5.64	0.4	-1.54	43.52	40.58	20.484932	75.531648
5	Pimpalgaon	DW	2.25	4.87	-3.99	0.52	-0.22	50.48	40.24	20.466222	75.520923
6	Dhawada	DW	1.66	3.3	-3.03	0.42	-0.98	49.07	25.78	20.443973	75.476395
7	Jambhai	DW	1.58	2.52	-2.55	0.49	-0.09	54	48.13	20.440243	75.518232
8	Jalkighat	DW	2.02	3.73	-3.16	0.55	-1.28	53.44	27.58	20.418118	75.547677
9	Relgaon	DW	1.61	2.57	-2.82	0.51	-0.77	53.3	40.58	20.437003	75.54505
10	wadala	DW	1.68	4.26	-6.14	0.33	1.24	40.07	57.51	20.419542	75.572342
11	Sasurwada	DW	1.42	2.83	-3.97	0.36	-1.02	44.84	37.35	20.439675	75.595643
12	Bojgaon	BW	0.84	1.65	-4.6	0.21	0.65	36.46	67.72	20.439707	75.571325
13	Bojgaon	DW	1.14	1.78	-2.28	0.36	-0.73	50.85	31.74	20.44236	75.570697
14	Ambhai	BW	0.93	1.65	-2.41	0.26	0.87	45.63	52.22	20.461795	75.566239
15	Ambhai	DW	0.69	1.04	-2.3	0.23	0.08	45.54	52.51	20.466418	75.568304
16	Pangri	BW	1.06	2.09	-3.75	0.27	1.17	41.43	62.91	20.46432	75.589902
17	Pangri	DW	1.2	1.96	-2.84	0.37	-0.46	48.53	44.62	20.463775	75.587785
18	Ghatambri	BW	1.11	1.78	-2.47	0.35	-0.91	49.31	30.2	20.506456	75.595008
19	Ghatambri	DW	1.19	2.39	-4.07	0.29	-1.28	41.87	34.25	20.508403	75.593619
20	Virgaon	BW	1.01	1.83	-2.7	0.28	1.4	45.36	63.07	20.474026	75.607679
21	Hatti	DW	1.43	2.52	-2.18	0.4	1.02	51.75	51.17	20.438342	75.606665

Sr. No.	Village	Well Type	SAR	% Na	RSC	KR	RSBC	PI	MAR	Latitude	Longitude
22	Hatti	DW	2.14	4.91	-5.16	0.47	-0.32	46.81	45.9	20.442501	75.60727
23	Mohal	BW	0.76	1.35	-2.74	0.21	1.36	42.19	64.56	20.435929	75.646372
24	Mohal	DW	1.47	2.22	-1.6	0.49	0.45	58.16	45.05	20.436874	75.645743
25	Bahuli	BW	2.33	5.48	-4.98	0.5	1.08	48.11	55.06	20.412063	75.617104
26	Bahuli	DW	0.86	1.52	-2.16	0.24	1.12	45.65	52.64	20.410131	75.619175
27	Madna	BW	2.89	6.96	-0.19	0.6	3.91	55.7	35.34	20.427466	75.648267
28	Chinchpur	DW	0.88	1.77	-3.75	0.22	2.56	39.17	78.78	20.406527	75.623186
29	Chinchpur	DW	0.63	1.04	-1.62	0.19	1	46.3	48.37	20.405405	75.621754
30	Khedi	BW	1.47	2.48	-1.13	0.43	1.49	56.34	45.83	20.408585	75.675511
31	Khedi	DW	1.27	2.39	-3.93	0.34	0.25	43.98	59.04	20.41354	75.679357
32	Leha	BW	0.95	1.13	-0.52	0.4	0.55	67.04	37.85	20.407491	75.694065
33	Leha	DW	1.81	2.58	-1.64	0.63	0.58	62.27	54.47	20.406711	75.696149
34	Chandapur	BW	1.71	3.26	-3.75	0.45	-0.06	48.75	50.61	20.383894	75.634957
35	Chandapur	DW	1.65	2.17	-0.86	0.62	0.37	67.1	35.34	20.385764	75.632768
36	Palod	BW	0.9	1.46	-1.88	0.28	0.91	49.02	52.71	20.380672	75.668119
37	Palod	BW	1.9	3.04	-2.32	0.59	1.12	57.69	66.94	20.381469	75.664003
38	Mangrul	DW	1.93	4.13	-2.74	0.45	1.53	50.14	46.52	20.371852	75.639801
39	Mangrul	BW	2.25	4.52	-2.37	0.56	3.2	54.86	69.04	20.368106	75.641528
40	Anvi	DW	2.41	4.3	-3.04	0.67	-0.91	57.4	33.4	20.360346	75.685574
41	Anvi	BW	1.84	2.84	-1.23	0.6	1.39	62.04	54.95	20.362502	75.684012
42	Sarola	DW	2.01	4.26	-3.14	0.47	3.59	50.46	74.92	20.393683	75.731192
43	Sarola	DW	1.28	2.3	-3.08	0.36	0.61	47.21	56.85	20.394378	75.731749
44	Rahimabad	BW	0.9	1.22	-1.04	0.33	1.42	58.18	67.2	20.34323	75.725635
45	Rahimabad	DW	1.57	3.04	-3.57	0.41	-0.62	47.68	39.34	20.345473	75.724877
46	Dahigaon	BW	1.63	3.3	-4.69	0.4	-0.42	45.05	52.22	20.358837	75.69329
47	Dahigaon	BW	2.01	2.89	0.59	0.7	2.72	72.11	51.59	20.356967	75.69211
48	Asadi	DW	1.6	2.35	-0.79	0.54	1.42	63.43	51.31	20.343783	75.752916
49	Asadi	BW	2.06	2.78	-0.61	0.76	1.68	70.38	62.96	20.342928	75.750198
50	Jalkighat	DW	1.21	2.28	-2.2	0.32	1.57	47.86	52.95	20.423437	75.530745
	Average	-	1.51	2.79	2.73	0.42	0.598	51.16	49.57	-	-
	Minimum	-	0.63	1.04	-6.14	0.19	-1.54	36.46	25.78	-	-
	Maximum	-	2.89	6.96	0.59	0.76	3.91	72.11	78.78	-	-

Farmers argue that elevated levels of Mg^{2+} ions in water diminish soil quality, resulting in reduced crop yields (Ramesh and Elango, 2012). MAR values below 50% are considered suitable, whereas MAR values above 50% are deemed unsuitable for irrigation (Khodapanah et al., 2009). MAR is based on Mg^{2+} and Ca^{2+} and is represented in percentage, comprising two categories: MAR < 50% (suitable) and > 50% (unsuitable). The MAR values fluctuate between 25.78% to 78.78% with an average of 49.57 % during the study period in the study area (Table 2). During the study duration, groundwater samples number 10, 12, 14, 15, 16, 20, 21, 23, 25, 26, 28, 31, 33, 34, 36, 37, 39, 41, 42, 43, 44, 46, 47, 48, 49 and 50 are exceed the MAR value is > 50%. A MAR values increase due to the geogenic and anthropogenic activates near to groundwater samples location in soil layer and this percolate into rock and groundwater within the study area. Hence, unsuitable for irrigation. A high MAR values influences the long-term impact on soil permeability.

3.7 Permeability Index (PI)

The permeability index (PI) can be used as an indication to determine if water is suitable for irrigation. The permeability, or the capacity of soil to flow water, is impacted by the ions Na^+ , Ca^{2+} , Mg^{2+} and HCO_3^- in the soil and is altered by long-term usage of irrigation water (which has a high concentration of salt). The PI formula to evaluate soil water suitability and water movement capacity of any type of water source for irrigation (Doneen, 1964). The permeability index (PI) is calculated by the equation given in Table 1. The PI values are >75% (suitable), 25 to 75 % (good) and <25% (unsuitable), the value of PI > 75% and between 25 to 75 % is recommended for irrigation purposes, whereas PI values < 25% is not suitable for irrigation (Doneen, 1964). It is influenced by several factors such as the total soluble salt, sodium, calcium, magnesium, and bicarbonate levels present in the water. The PI values in the study area range from 36.46% to 72.11%, with an average of 51.16% (Table 2). According to the PI values, water samples are divided into three categories: > 75% (suitable), 75-25% (good), and < 25% (unsuitable) (Doneen, 1964). The study area is classified within the good class of the PI range for all groundwater samples. Theis class exhibit good soil permeability and are suitable for irrigation.

4. CONCLUSION

The quality of groundwater and its suitability for irrigation purpose in the Khelna river basin of Aurangabad District, Maharashtra, has been measured. The irrigation water quality parameters values are measured like SAR (0.63 to 2.89), %Na (1.04 to 6.96), RSC (-6.14 to 0.59), RSBC (-1.54 to 3.91), KR (0.19 to 0.76), MAR (25.78 to 78.78) and PI (36.46 to 72.78). All the irrigation parameters are reveled the value in suitable category for irrigation except MAR (Magnesium hazard) values for sample number 10, 12, 14, 15, 16, 20, 21, 23, 25, 26, 28, 31, 33, 34, 36, 37, 39, 41, 42, 43, 44, 46, 47, 48, 49 and 50 have observed value is greater than > 50%. These locations are increasing MAR value due to geogenic and anthropogenic activity within the study area. According to this irrigation analysis, the majority of parameters are classified as suitable, indicating their suitability for irrigation use. Magnesium hazard water samples that exceed acceptable limits have been recognized in the study area because of different geological and human activities. Methods for artificial recharge could be implemented to support appropriate crops or reduce chemical levels in groundwater to preserve the current water quality. The findings of this study are beneficial for farmers and policymakers in managing and planning groundwater resources.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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