

Assessment of Water Quality of Surwal Dam Reservoir for Irrigation Suitability During Winter Season Using Hydrochemical Indices

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Abstract

Water is one of the most important elements for sustainability and maintenance of life. Its quality affects living beings both directly and indirectly. Surwal dam reservoir is an earthen type of reservoir situated nearby city of Sawai Madhopur. Main purpose of reservoir is for irrigation. Study on water parameters would help in assessment of water quality which is being used for irrigation in agricultural lands. Assessment of water quality will be helpful in sustainable agriculture practices, ensuring healthy crops and surrounding environment. Study was conducted during winter season when water of the dam was used for irrigational purposes for nearby agricultural lands. Statistical interpretation like Sodium Adsorption Ratio, Kelly's ratio, Percentage sodium, and Chloro-alkaline indices, were used to analyze the water quality. Water quality parameters during the study period (October, 2024 – January, 2025) were within the permissible range, suggesting its suitability for irrigation purposes.

Keywords: Agriculture, Kelly Ratio, Sodium adsorption ratio

INTRODUCTION;

Water is one of the most important abiotic elements for the sustainability of life. The quality of water will ultimately affect the flora and fauna around it. Assessment of water quality used for irrigational purposes is also very important to maintain a healthy agricultural ecosystem. Both qualitative and quantitative aspects will determine water quality together. Availability of good quality water will result in the maximum crop yield under normal soil and water management practices. Availability of ions i.e. cations, anions, and total dissolved solids are important criteria for determination of water quality. Major ions present in water are calcium, magnesium, potassium, carbonates, and bicarbonates (Singh et al., 2017). Poor water quality will cause toxicity, water infiltration, salinity, and hardness. Water quality degrades in response to pollution, chemical, microbial, and organic factors (Merouche et al., 2019). Water quality is highly affected by anthropogenic activities such as organic discharge, agricultural water as well as leachate products (Hadeef et al., 2021). The water quality of dams is also found to be severely affected by rock weathering and leaching (Al taani et al., 2013). Use of unsuitable quality of water will cause damage to crops and reduces its production (Rawat et al., 2018).

In this study, statistical interpretations like Sodium Adsorption Ratio, Kelly's ratio, Percentage sodium,

and Chloro-alkaline indices, were used to analyze water quality for its suitability for irrigational purposes during winter season.

Study site:

The Surwal Dam reservoir (26°.07469701965723' North -76°.335801426538081958' East) is situated near the city of Sawai Madhopur in Rajasthan. It is situated on the River Gambhir and is a part of Chambal river basin. It is an earthen type of dam used for irrigation in nearby 22 villages and its construction was completed in the year 1958. Surwal dam has a catchment area of around 274.19 square km having capacity of 15 Feet.

MATERIALS AND METHODS:

Water samples were collected monthly from 2 different sites for their analysis during the study period (October, 2024 – January, 2025). Analysis of water samples were done using method suggested by APHA (2017).

Water quality parameters for checking suitability for irrigation;**Sodium Adsorption ratio (SAR):**

SAR is used for assessment of the extent of $\text{Na}^+ - \text{Ca}^{+2}/\text{Mg}^{+2}$ exchange reaction between water and soil particles, where Na^+ ions are replaced with the adsorbed Mg^{+2} and Ca^{+2} . Sodium adsorption ratio represents soil alkalinity of water used for irrigation purposes. Cation-exchange reaction between water and soil will lead to decrease in permeability of soil. This results in poor drainage (soil hardening). The SAR is calculated using the formula (Richard, 1954).

$$\text{SAR (Sodium Adsorption Ratio)} = \frac{\text{Na}}{\sqrt{\text{Ca} + \text{Mg}/2}}$$

Where, Ca^{+2} , Mg^{+2} and Na^+ are calculated in mill equivalents/l.

Percentage Sodium (% Na):

Percentage sodium is used to specify irrigation water on the basis of its percentage and electrical conductivity. It is calculated by the given formula (Wilcox, 1955):-

$$\% \text{Na} = \left[\frac{(\text{Na}^+ + \text{K}^+)}{\text{Na}^+ + \text{K}^+ + \text{Mg}^{+2}} \right] \times 100$$

All ionic concentrations are calculated in mill equivalents/l.

Kelly's ratio (KR):

Kelly ratio is used for estimating the suitability of water for agriculture purposes on the basis of alkali hazards. It is calculated by using the following formula (Kelly, 1963):

$$\text{Kelly Ratio (KR)} = \text{Na}^+ (\text{Ca}^{+2} + \text{Mg}^{+2})$$

$\text{KR} \leq 1$: Appropriate for irrigation and shows good quality

$\text{KR} > 1$: Inappropriate for irrigation purposes

All ionic concentrations are calculated in mill equivalents /l.

Chloro Alkaline Indices (CAI):

Chloro alkaline indices are used in calculation of exchange of ions between the water and its surrounding area. It is measured by following formula (Schoeller, 1967).

$$\text{CAI} = \text{Cl} - (\text{Na} + \text{K}) / \text{Cl}$$

All ionic concentrations are calculated in mill equivalents /l.

$\text{CAI} > 0$ represents Base Exchange reaction is absent i.e. there is reverse ion exchange of anion cations.

$\text{CAI} < 0$ represents Base Exchange reaction where Na and K are being exchanged with Mg and Ca present in rocks.

Results:

Figures representing ratios for checking irrigational suitability for both the sites during winter season

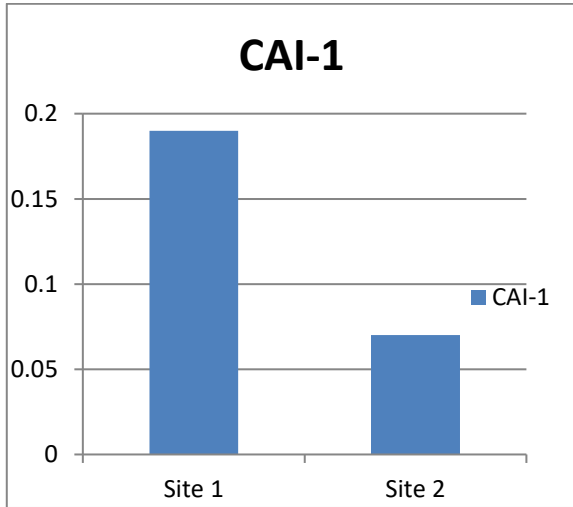


Figure 1. Graph showing CAI for both sites

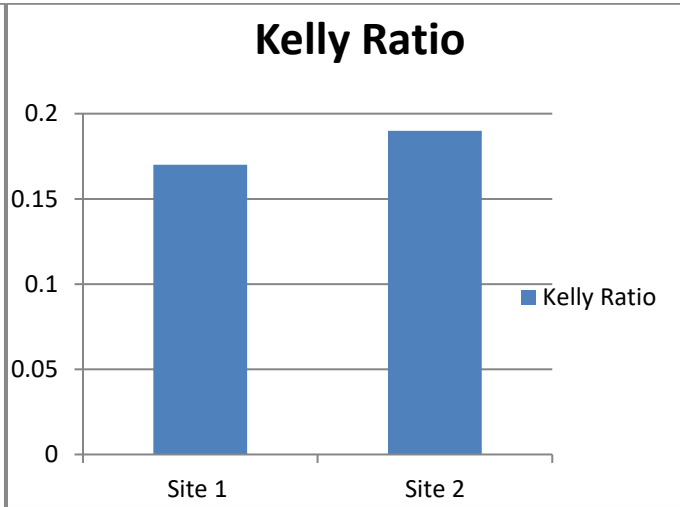


Figure 2. Graph showing Kelly Ratio for both sites

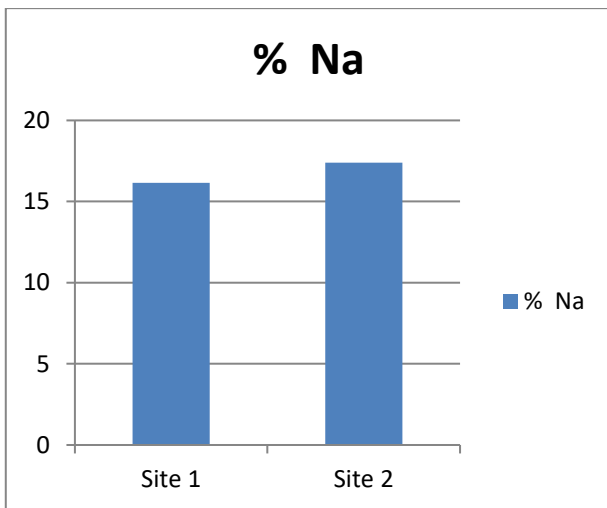


Figure 3. Graph showing % Na for both sites

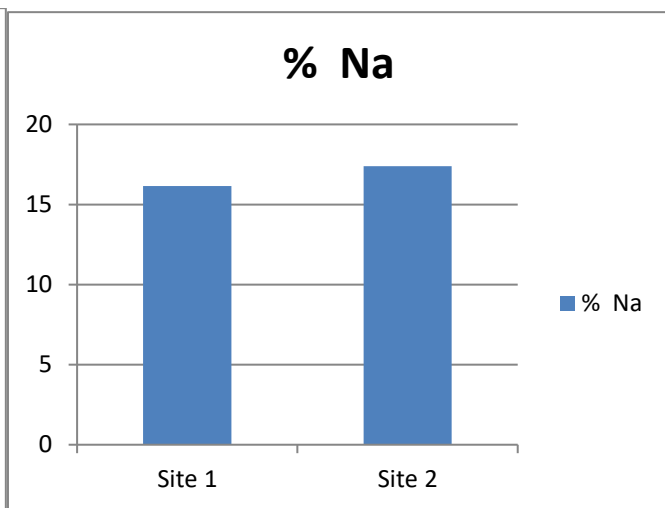


Figure 4. Graph showing SAR for both sites

Table 1: Statistical analysis of water samples of Surwal dam, Sawai Madhopur during winter season

Parameters	Categories	Range	Interpretation for Site 1	Interpretation for Site2
Sodium Adsorption Ratio (SAR)	Excellent	0-10	Excellent	Excellent
	Good	10-18		
	Fair	18-26		
	Poor	>26		
Chloro Alkaline Indices (CAI-1)	Base Exchange Reaction	Negative values	Cation Exchange Reaction occurs	Cation Exchange Reaction occurs
	Cation Exchange Reaction	Positive values		
Percentage	Excellent	0-20	Excellent	Excellent

Sodium(% Na)	Good	20-40		
	Permissible	40-60		
	Doubtful	60-80		
	Unsuitable	>80		
Kelly's Ratio(KR)	Suitable	<1	Suitable	Suitable
	Marginal	1-2		
	Unsuitable	>1		

Discussion:

In the present study, irrigation water quality was evaluated using major cation concentrations to determine the Sodium Adsorption Ratio (SAR), Kelly Ratio (KR), Percentage Sodium (%Na) and Chloro-alkaline Index (CAI-1) for two sampling sites.

SAR values at both sites were found to be low, 0.36 for site 1, 0.40 for site 2 during the winter season. As per FAO irrigation water classification, values of SAR less than 10 represents excellent quality of water, representing absence of sodium hazard in both study sites. Similarly, in studies done on Assabol Dam SAR values were found to be less than 9 and concluded to be excellent for irrigational purposes (Berhe & Leta, 2015). Calculated %Na values were found to be 16.15% for site 1 and 17.54% for site 2, both have values below 60% which is permissible limit for irrigation suitability suggesting that sodium levels have no risk of decrease in soil permeability at both the sites. Usage of water having Na content will cause deterioration in water infiltration and soil quality by increasing sodium exchange in soil (Subramani et al., 2005). Similarly, studies on Guenitra Dam watershed in Algeria found its values between 17.99% and 48.77% (avg. 31.40%) and were concluded to be of Good quality for irrigational purposes (Hadeef et al., 2021). The KR values were 0.17 for site 1 and 0.19 for site 2. KR values less than 1 represents suitability of water for irrigation. This indicates that calcium and magnesium ions are in more concentration than sodium. Similarly, in their studies on the water quality of Vaijapur taluka of Aurangabad, KR values less than 1 were found, and water quality was concluded to be suitable for irrigational purposes, and more than 1 was found concluded to be unsuitable for irrigational purposes (Deshpande & Aher, 2017; Aravinthasamy et al., 2020). The CAI-1 values showed a positive ionic exchange i.e. 0.19 for Site 1, 0.07 for Site 2, indicating that there is an exchange of Na⁺ and K⁺ in the water with Ca²⁺ and Mg²⁺ in the rocks. Similar, studies were performed on River Chambal at Rangpur, Kota District and, River Ujad at Bhimsagar Dam, Jhalawar showed positive values of CAI (Sharma & Singh, 2020). Although water quality analysis suggested suitability of water for irrigational purposes but water sources should be monitor regularly and index-based assessment are recommended for their sustainable management (Singh et al., 2018).

Conclusions;

The following conclusions were drawn from the study performed;

Analysis of samples during winter season shows all the values under the permissible range for irrigational purposes. For checking the suitability of water for irrigational purposes SAR, % Na, Kelly's Ratio, and Chloro-Alkaline indices were used. Water samples from both sites taken during winter season were found to be within permissible range indicating suitability of water for irrigation purposes. Water samples were found to be slightly alkaline during study period. Values of both cation and anion were found to be within permitted limits. Study revealed there were negligible sodium hazard and the

dominance of calcium and magnesium over sodium ions, resulting in good soil permeability which will make water suitable for long term agricultural purposes. This study will be helpful in water management studies around the dams. The positive Chloro-alkaline Index (CAI-1) values were calculated from both sites represented reverse ion exchange processes, suggesting that rock–water interaction are the major factor affecting water quality. Overall, the assessment of ions in water confirms that water from both sites is suitable for irrigation practices and showing no disadvantageous effects on soil structure or crop productivity. However, continuous monitoring is advised to account for any seasonal variations that may influence ion exchange and salinity levels over time. Additionally, this study will also be useful for field engineers, and decision makers in the management, monitoring, evaluation, tracking, and control of the irrigation water of the dam.

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