Journal of Engineering, Electrical and Informatics
Vol.3, No.3 October 2023
e-ISSN: 2809-8706; p-ISSN : 2810-055, page 45-61
DOI: https://doi.org/10.55606/jeei.v3i1.2324

ASSESSING IRRIGATED WATER QUALITY BASED ON PHYSICOCHEMICAL PROPERTIES. CASE STUDY: JENEBERANG RIVER, TAKALAR REGENCY, SOUTH SULAWESI, INDONESIA

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ABSTRACT

In South Sulawesi's Takalar Regency, the Jeneberang River serves as irrigation water for neighboring areas. Several parameters, including electrical conductivity, pH, toxicity, soluble sodium, Sodium Adsorption Ratio (SAR), PI, MH, and Kelly's Ratio, were used to examine the development of water quality. The observation was conducted over three months in 2021: June (5 points), July (5 points), and August (5 points). The method for conducting physiochemical analyses was based on FAO and WHO guidelines. The study results suggest that the research locations' electrical conductivity meets the irrigation water quality standards. The nitrite concentration at the study locations ranged from 0.04 to 10.88 mg/L; thus, it was acceptable and below the standard limit level. The values of calcium and magnesium were 2.54-10.3 and 0.03 mg/L, respectively. The sodium concentration ranged between 4 and 7 mg/L. In addition, the potassium concentration in this study's water samples varied between 0.03 and 0.19 mg/L. Meanwhile, the SAR values range from 0.03 to 0.34 meq/L and are categorized as an excellent class. According Soluble Sodium Percentage standart water sample are categorized as excellent to eligible. KR, PI, and MH also indicate water sample in the suitable conditon for agricultural uses. The lead concentration at all sites was constant, 0.027 mg/L. It also happens for cadmium measurements, which show a value always the same each month, specifically 0.001 mg/L. Eventually, the analysis of cations and anions indicates that the type of water is magnesium bicarbonate. In addition, based on Kelly's Ratio data, the Jeneberang River is suitable for agricultural irrigation.

***Keywords**: water quality index, physicochemical, river, irrigation, agriculture.*

INTRODUCTION

In regions of the world where evapotranspiration exceeds precipitation, irrigation is often used (Bortolini et al., 2018). These waters are often of inferior quality to those in humid regions. In soil formation, the earth's crust's weathering, disintegration, and breakdown lease various soluble salts. This process is greatly aided by the high concentration of carbon dioxide, a weak acid, in the soil atmosphere and solution, as well as acids generated by the decomposition of organic waste. Salts are carried to the ocean via rivers or seepage when sufficient precipitation leaches the soil and provides adequate drainage. However, salts tend to accumulate in dry places with poorly leached soils and inadequate surface drainage (Osman, 2018).

A network of irrigation channels supplies agricultural activities with water, an essential component. Rivers, lakes, and spring water are water supplies that face pollution issues. The low quality of agricultural water sources may result from natural causes, contamination, or both (Zhang et al., 2018). Discharging untreated sewage and industrial effluents have polluted the rivers of Indonesia. The poor water quality of rivers and springs affects irrigation water quality. Surface water supplies have become so contaminated over the past century that they can no longer be used for agricultural irrigation (Marik et al., 2019).

Assessment of river water quality using different (physicochemical and biological) criteria and different methodologies and ways to conserve river water have been reported in the literature (Ustaolu et al., 2010). The water quality index is a valuable and effective analysis tool for water quality. It is one way to determine the quality of river water. This method gave policymakers a sense of the overall water quality (Kaddoura & el Khatib, 2017). Numerous

Received September 20, 2023; Revised October 22, 2023; Accepted November 16, 2023
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physical, chemical, and biological components are included in water quality indices in order to calculate them using formulas (Banda & Kumarasamy, 2020). Horton (1965) was the first to suggest using a WQI (1970). Since then, several WQI calculation methods have been developed. The researcher provided an alternative approach for determining WQI (Mukate et al., 2019). World-wide water quality indices include the US National Sanitation Foundation Water Quality Index (NSFWQI), the Oregon Water Quality Index (OWQI), the British Columbia Water Quality Index (BCWQI), the Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI), and the Weighted Arithmetic Water Quality Index (WAWQI) (Bilgin, 2018; Misaghi et al., 2017; Noori et al., 2019; Tokatli, 2019). Calculating water quality indices typically involves two steps. First, supplied water quality parameters are converted into sub-index values. In the second stage, these data are aggregated to calculate the water quality index. Various researchers have published numerous papers on water quality indices in academic journals.

Agricultural operations in the Takalar Regency are supported by the river that provides irrigation water. One of the rivers used for agricultural irrigation in Takalar Regency is the Jeneberang River. This river is in a wilderness location that is remote from urban and industrial areas. We assume this river's water quality is high due to its position in a conservation area and distance from populated areas. Until recently, we could not locate information regarding the water quality of the river, particularly its suitability for irrigation. According to the preceding, assessing the water quality of surface water in the Takalar Regency is crucial, particularly for irrigation purposes.

RESEARCH METHODS

Water sampling and location

At a depth of 30 centimeters, water samples were taken monthly from May through July at five locations along the river. This research was carried out at Jeneberang River in South Sulawesi Province, Indonesia. The water sample was taken from five different places which site (Fig. 1) as follows:

Site 1: 5°17'27.96"S 119°33'40.53"E; Site 2: 5°18'15.84"S 119°32'7.04"E;
Site 3: 5°18'8.50"S 119°31'42.86"E; Site 4: 5°18'26.53"S 119°31'23.08"E;
Site 5: 5°19'11.08"S 119°30'54.48"E.

Fig. 1. Research sites

Water physicochemical analysis

The physiochemical analysis approach was based on internationally approved FAO (2003) and WHO (2006) guidelines. Sanitized polyethylene terephthalate bottles were used (1 L capacity) to collect water samples. Before collecting water samples, bottles were rinsed at the laboratory with diluted hydrochloric acid and distilled water and then three times with water at the collection site (Boiteux et al., 2016). A portable digital meter was used at each sample point to test the water's temperature, pH, and conductivity. volumetric titration method was used for determinate Bicarbonate (HCO_3), magnesium (Mg^{2+}), calcium (Ca^{2+}), and chloride (Cl), meanwhile spectrophotometric techniques according to American Public Health Association methode ware used to test sodium (Na^+) and potassium (K^+) were measured with a flame photometer, and sulfate (SO_4^{2-}) and nitrate (NO^{3-}) (APHA, 1995). Lead (Pb) and cadmium (Cd) were analyzed by using atomic absorption spectrophotometry. FAO guidelines based on a set of reference values were used to interpret irrigation water quality (Ewaid et al., 2019).

Indices of water quality

Water samples have been using irrigation indicators, such as Electrical Conductivity, Sodium Absorption Ratio, Soluble Sodium Percentage, Residual Sodium Carbonate, Kelly's Ratio, and Potential Salinity. Table 1 provides the criteria for classifying Water sample types.

Table 1. Water quality parameters

Quality Indices (unit)	values	Classes of quality of suitability
EC (mS/cm)	<0.25	C1: Excellent
	0.25-0.75	C2: Good
	0.75-0.225	C3: Eligible
	0.225-5	C4: Not Recommended
	>5	C5: unsuitable (bad)
Soluble Sodium Percentage (%)	<20	Excellent
	20–40	Good
	40–60	Eligible
SAR [meq/L]	<10	Excellent
	10–18	Good
	18–26	Uncertain
	>26	Unsuitable
RSC [meq/L]	<1.25	Suitable
	1.25–2.5	Moderate
	>2.5	Unsuitable
PI [%]	<75	Suitable
	>75	Unsuitable
KR [meq/L]	<1	Suitable
	>1	Unsuitable
MH [%]	<50	Suitable
	>50	Unsuitable

RESULTS AND DISCUSSION

EC and pH values for water samples

The salinity risk of water is the most critical water quality parameter for agricultural yield, as measured by electrical conductivity (EC). The principal effect of high EC water on crop productivity is the incapacity of plants to compete for water with ions in the soil solution. Even though the soil seems wet, the greater the EC, the less water is available for plant development. Since plants can only transpire clean water, as the EC rises, the quantity of plant-usable water in the soil solution decreases drastically (Valdés et al., 2015).

Table 2. Electrical conductivity and pH values in each site

Month	Point	EC	pH
June	1	85.0	6.7
	2	90.0	6.9
	3	70.0	6.6
	4	81.7	6.4
	5	93.0	6.4
July	1	75.0	6.7
	2	80.0	6.5
	3	82.0	6.6
	4	82.0	7.0
	5	82.0	6.9
August	1	101.7	6.7
	2	113.3	6.6
	3	111.7	6.6
	4	113.3	6.9
	5	101.7	6.6

The guideline range of 20 to 300 s/cm for the electrical conductivity of irrigation water is regarded as a suitable category, as shown in Table 1. (Keesari et al., 2016). According to these samples, Water Electrical conductivity (EC) tested at five locations varied from 70 to 101.7, with the most significant value recorded at site point 1 in August (101.7) and the lowest value recorded at site point 3 in June (70.0). Following the classification of irrigation water quality, all samples were categorized as an excellent class with a range of 0-250.

The pH indicates whether irrigation water is acidic or basic (less than 7.0 acidic; more than 7.0 basic). The optimal pH range for irrigation water is between 6.5 and 8.4. From June to August, the water pH measured in this study fluctuated between 6.4 (the highest) and 7.0 (the lowest). Even though each site point had a different pH value, it was determined that the pH was within the normal range and adequate for irrigation purposes. In regions with low pH levels, irrigation system corrosion may be accelerated. Alkalinity or high bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) concentrations often cause more than 8.5. Due to high carbonates, calcium and magnesium ions form insoluble minerals, leaving sodium as the predominant ion in the solution (Li et al., 2016). This alkaline water could intensify sodic soil conditions.

Temperature, pH, and some cations and anions may influence carbonate concentration. The high chloride concentration in the water may be the consequence of interactions between water, soil, and rock, as well as weathering and human activities like wastewater discharge. The chloride concentration varied between 2.39 and 7.1 mg/L in the present study, suggesting that it is below the WHO standard limit (250 mg/L). A high quantity of sulfate and magnesium may have adverse effects on people, such as a laxative impact. The concentration of sulfate remained consistent at all study locations, ranging from 4 mg/L to 400 mg/L, which is below the WHO guideline threshold. High chlorine and sulfate levels in groundwater may impact corrosion processes and network systems (Abbasnia et al., 2019). Due to excessive fertilizer usage in agricultural operations and nonpoint sources, nitrate may enter water sources. Nitrogen molecules may have detrimental impacts on human health and impair the quality of groundwater. Due to the human body's creation of nitrosamide and nitrosamine, high nitrate levels may induce blue baby syndrome, thyroid disease, hypertension, diabetes, and carcinogenic consequences. The acceptable limit for nitrate in drinking water, according to WHO recommendations, is 50 mg/L as NO_3. The results indicated that the nitrate concentration ranged from 0.04 to 10.88 mg/L, regarded as the standard level over the whole study region. The nitrite level in the Jeneberang River was acceptable and below the standard limit level (Yusal et al., 2019).

Table 3. Chemical parameters in research sites

Parameters	Sample Points	Month			Statistical Parameter	
		June	July	August		
Bicarbonate (mg/L)	1	44.2	29.4	40.9	min	29.4
	2	32.6	31.4	37.29	max	48.12
	3	41	31.4	36.09	Average	36.554
	4	40	30.9	42.11	SD	5.650988
	5	32	30.9	48.12		
Magnesium (mg/L)	1	0.03	0.03	0.03	min	0.03
	2	0.03	0.03	0.03	max	0.03
	3	0.03	0.03	0.03	Average	0.03
	4	0.03	0.03	0.03	SD	0.00
	5	0.03	0.03	0.03		
Calcium (mg/L)	1	5.11	11.31	2.73	min	2.54
	2	5.11	11.31	2.8	max	11.31
	3	5.25	4.83	2.95	Average	5.13
	4	5.15	4.81	2.54	SD	2.64
	5	5.33	4.91	2.78		
Chloride (mg/L)	1	3.18	3.18	5.3	min	2.39
	2	3.98	3.98	3.6	max	7.10
	3	2.39	2.39	3.6	Average	3.78
	4	3.98	3.98	5.3	SD	1.27
	5	2.39	2.39	7.1		
Natrium (mg/L)	1	2.06	1.25	0.67	min	0.16
	2	2.54	1.56	0.16	max	2.58
	3	1.56	0.94	0.16	Average	1.43
	4	2.58	1.56	1.99	SD	0.73
	5	1.55	0.94	1.97		
Potassium (mg/L)	1	0.09	0.15	0.03	min	0.03
	2	0.09	0.19	0.03	max	0.19

	3	0.10	0.14	0.03	Average	0.09
	4	0.09	0.14	0.03	SD	0.05
	5	0.09	0.14	0.03		
Sulfate (mg/L)	1	4	4	4	min	4
	2	4	4	4	max	4
	3	4	4	4	Average	4
	4	4	4	4	SD	0
	5	4	4	4		
Nitrate (mg/L)	1	0.45	0.04	10.88	min	0.04
	2	0.49	0.13	10.76	max	10.88
	3	0.51	0.2	10.79	Average	3.75
	4	0.49	0.05	10.7	SD	4.89
	5	0.49	0.06	10.17		
Lead (mg/L)	1	0.027	0.027	0.027	min	0.03
	2	0.027	0.027	0.027	max	0.03
	3	0.027	0.027	0.027	Average	0.03
	4	0.027	0.027	0.027	SD	0.00
	5	0.027	0.027	0.027		
Cadmium (mg/L)	1	0.001	0.001	0.001	min	0.001
	2	0.001	0.001	0.001	max	0.001
	3	0.001	0.001	0.001	Average	0.001
	4	0.001	0.001	0.001	SD	0.000
	5	0.001	0.001	0.001		
Temperature (°C)	1	26.6	27.0	28.5	min	26.6
	2	27.0	27.3	28.8	max	29.0
	3	26.8	27.1	29.0	Average	27.4
	4	27.1	27.2	27.7	SD	0.7
	5	26.6	27.1	27.7		

Calcium and magnesium cations are abundant near the surface of the water and are directly responsible for their hardness. The calcium and magnesium values were between 2.54 and 11.31 mg/L and 0.03 mg/L, respectively. A high calcium and magnesium content may have adverse health, economic, and hydrological effects, such as gastrointestinal problems. The water may be complex due to the presence of calcium and magnesium cations. The sodium content fluctuated between 4 and 7 mg/L. In water, sodium ions arise naturally via evaporation, agricultural and human activities, and clay weathering.

Moreover, ion exchange between sodium, calcium, and other cations may have contributed to the high sodium concentration of the water. The potassium value ranged from 0.03-0.19 mg/L in the water samples examined for this study. In this study, potassium concentration was lower than other cations (Lukatskaya et al., 2018).

Soluble Sodium Percentage

One measure for determining water quality for irrigation is the soluble sodium percentage. The water sample in the Jeneberang river shows variable content at each site and time, according to the sample test results. Water samples are taken at five locations each month (June-August). The calculating results show that the na % value for each point ranges from 4.92 (August) to 40.37 (August). According to the 2003 Fao standard, samples with a value of less than 20 are categorized as excellent, while samples with a value of 20-40 are categorized as good. As shown in table 1 and figure 1, the soluble sodium percentage in the Jenneberang river water sample was classified as excellent and sound, as shown in table 1. Meanwhile, only one point in the observation sample is considered permissible, namely in August, with a value of 40.37. Figure 4 shows the detail of soluble sodium percentage in the diagram.

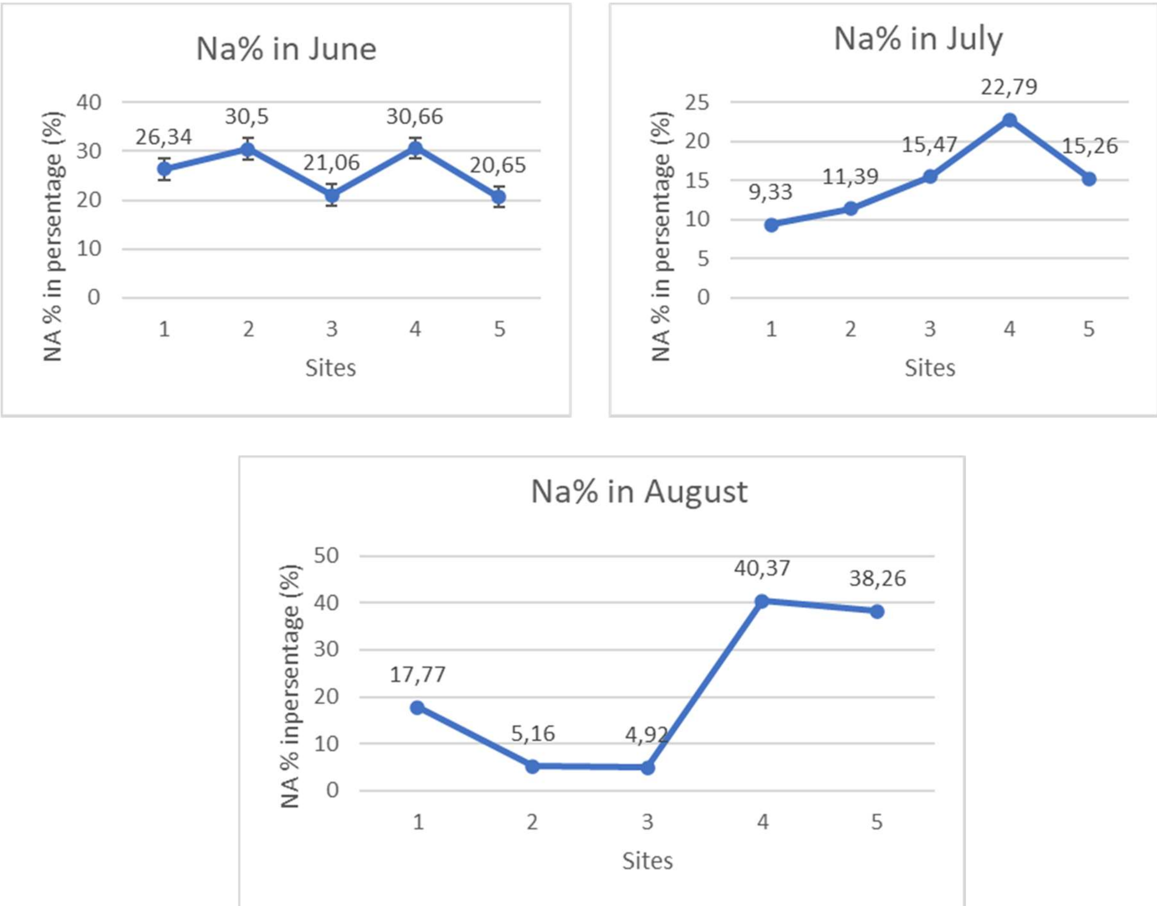

Fig. 4. Soluble Sodium Percentage (Na%) （a）in June, (b) in July, (c) in August

When irrigation water has a high salt content compared to calcium and magnesium, water penetration may be inhibited. This condition, known as "sodicity," is caused by the excessive accumulation of salt in the soil. Sodic water is dissimilar to saline water. Sodicity causes soil clays to expand and disperse, as well as surface crusting and pore obstruction. This deteriorated soil structure inhibits infiltration and may increase runoff. Despite water pooling on the soil's top during irrigation, sodicity delays the downward flow of water into and through the soil. Thus, actively developing plant roots may not get sufficient water. (Patra et al., 2016).

Water Quality Index

Table 4. Water quality Parameters from five sites and time (June-August)

Parameters	Sample Points	Month 1	2	3	Statistical Parameter	
SAR	1	0.25	0.1	0.11	min	0.03
	2	0.31	0.13	0.03	max	0.34
	3	0.19	0.12	0.03	Average	0.18
	4	0.31	0.2	0.34	SD	0.10
	5	0.18	0.12	0.33		
Soluble Sodium Persentage	1	26.34	9.33	17.77	min	4.92
	2	30.50	11.39	5.16	max	40.37
	3	21.06	15.47	4.92	Average	20.66
	4	30.66	22.79	40.37	SD	10.64
	5	20.65	15.26	38.26		
MH	1	0.96	0.43	1.78	min	0.43
	2	0.96	0.43	1.73	max	1.91
	3	0.93	1.01	1.65	Average	1.16
	4	0.95	1.02	1.91	SD	0.46
	5	0.92	1.00	1.75		
PI	1	270.5	120.3	504.1	min	120.27
	2	228.2	123.5	527.7	max	527.74
	3	266.5	266.1	494.4	Average	309.75
	4	247.5	250.7	424.1	SD	127.57
	5	235.2	260.4	426.9		
KR	1	0.12	0.11	0.04	min	0.01
	2	0.21	0.13	0.01	max	0.21
	3	0.10	0.08	0.01	Average	0.10
	4	0.17	0.13	0.13	SD	0.05
	5	0.13	0.08	0.11		

Sodium Adsorption Ratio (SAR)

The Sodium Adsorption Ratio is the most systematic way to test sodicity in water and soil (SAR). Sodicity is defined by the relative concentration of sodium (Na) in a sample compared to the total of calcium (Ca) and magnesium (Mg) ions. The SAR evaluates the possibility of infiltration issues as a result of a salt imbalance in irrigation water. Table 3 shows a sodium adsorption ratio water sample from June to August at five different sites. The value of its site fluctuates, and it is shown that the value of the sodium adsorption ratio every month also fluctuation. From all the samples, according to calculation, the sodium adsorption ratio range from 0.03 to 0.34. According to Table 1, the range value of SAR less than 10 meq/L is categorized as an excellent class and between 10 to 18 meq/L as a good class.

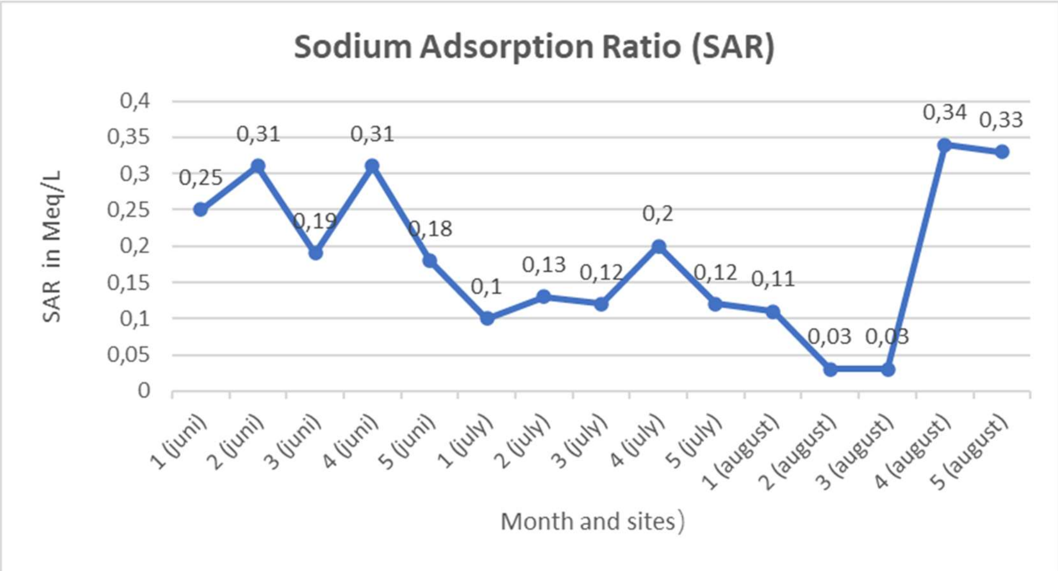

Fig. 5 Sodium Adsorption Ratio (SAR)

Figure 5 shows the detail of the Jeneberang River water sample of sodium absorption ration value in every site and month. As seen in Figure 5, all the water samples from every place and month are categorized as excellent because their value is less than 10 meq/L. It means that the water sample from the Jeneberang River is suitable for irrigated agricultural land. The sodium adsorption ratio determines the sodium risk of irrigation water (SAR). Although salt contributes directly to total salinity and may be harmful to sensitive crops such as fruit trees, the primary concern with high sodium levels is their effect on soil physical properties (soil structure degradation). To prevent long-term soil degradation, irrigation with water with a high sodium adsorption ratio may need soil amendments. If soil is frequently watered with water with a high SAR, salt may displace calcium and magnesium. It will result in a reduction in the soil's capacity to produce stable aggregates, as well as a loss of soil structure and tilth. It will also reduce the soil's penetration and permeability to water, producing problems for agricultural productivity (Rogger et al., 2017).

Magnesium Hazard and Permeability Index

Magnesium hazard and permeability index concentration can be seen in table 3. It shows that present water sample of magnesium hazard value throughout all site and month during June to august. Magnesium Hazard concentration on this study reported in range between 0.43 % (lowest) – 1.91 % (highest) with an average value of 1.16 %. this mean that all samples categorized as suitable for irrigation purpose. Magnesium hazard value more than 50 % means water not suitable for irrigation. Meanwhile the value of permeability index that can be shown in table 3 are exceeded form recommendation limit where Permeability index concentration less that 75 %.

The permeability index (PI) is a critical metric for evaluating the quality of irrigation water in relation to the soil in order to improve agricultural productivity (Thilagavathi et al. 2012; Thivya et al. 2013a). Long-term irrigation water use can have an effect on soil permeability, which is regulated by the soil's Na^+, $Ca^{2+,}$ $Mg^{2+,}$ and HCO3 concentrations. Based on the PI values, irrigated water can be classed as Class I (> 75%), Class II (25–75%), or Class III (25%). The permeability index indicates that the water analyzed in this study does not satisfy the standard recommended for irrigation. The study area's samples fall under the class 1 category.

Kelly's ratio

Kelly ratio (KR) is an additional important indicator of irrigation water quality (Towfiqul Islam et al., 2017). It was determined by comparing the sodium ion concentration to the calcium and magnesium ion concentrations. A KR greater than 1 indicates that there is an excess of sodium in the water, making it unsuitable for irrigation. In contrast, a KR of 1 indicates that the water is suitable for irrigation. Figure 6 indicate that 100% of the total water sample from 5 sites and different time (June to August) are categorized as suitable. The most significant value of Kelly's Ratio in Figure 6 is 0.21, while the lowest is 0.01. Based on Kelly's Ratio, this suggests that the Jeneberang River's irrigated water is acceptable for agricultural irrigation.

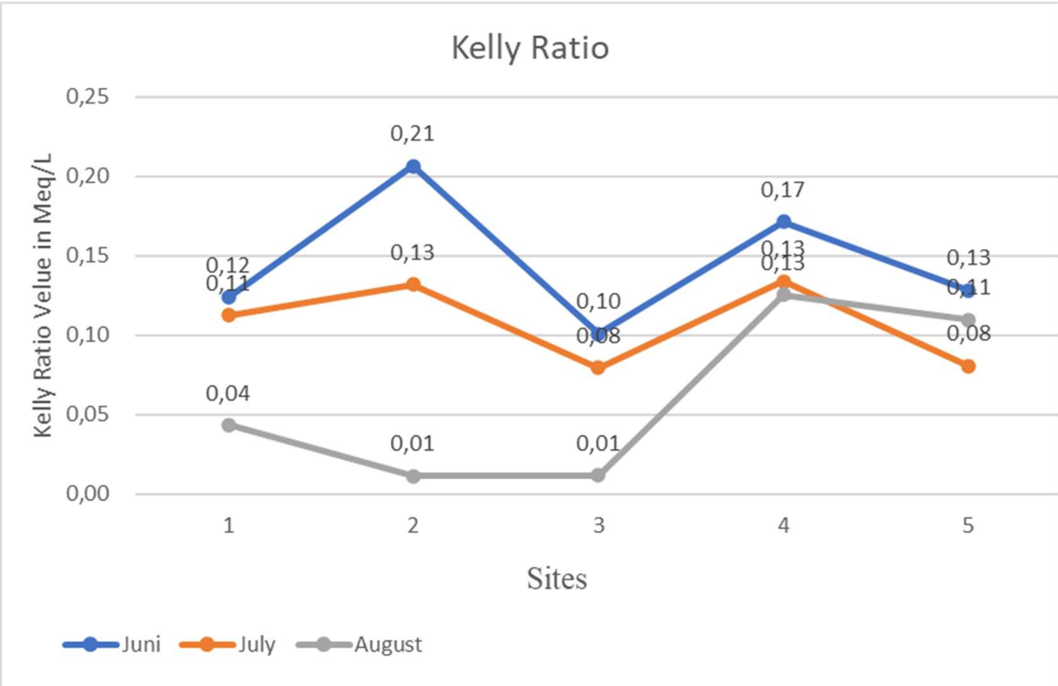

Fig. 6 Kelly's Ratio

Toxic heavy metal in a water sample

Heavy metal is any relatively thick metal or metalloid that is notable for its potential toxicity, especially in environmental circumstances. The phrase mainly pertains to cadmium, mercury, and lead, all of which are on the World Health Organization's list of 10 substances of grave public concern. Additional examples include manganese, chromium, cobalt, nickel, copper, zinc, silver, antimony, and thallium (Kumar & Bharadvaja, 2020).

Heavy metals are naturally occurring on earth. They may enter plant and animal (including human) tissues by inhalation, ingestion, and direct contact due to human activities. Then, they might attach to important biological components and interfere with their function. The ancients were aware of the danger of arsenic, mercury, and lead. However, it does not seem that systematic research on particular heavy metals began until 1868. Chelating agents are often used to address the toxicity of heavy metals in humans. Some elements that are generally considered to be harmful heavy metals are required for human health at trim levels (Alengebawy et al., 2021).

Based on the results of measuring lead content for three measurements between June-August, it was found that the lead concentration at all sites was constantly the same, namely 0.027 mg/L. It also happens in cadmium measurements. The cadmium concentration value in the Jeneberang River water sample showed a value that was always the same in the month, and the observation site was 0.001 mg / L.

Physicochemical correlation matrix

Statistical analysis can be used to understand the relationship and variation between physicochemical parameters and ion concentrations in water samples, as well as to interpret the data and their interactions. A correlation matrix is a statistical technique used to assess the relationship between two variables in a data set. The matrix is a table in which each cell contains a correlation coefficient, where 1 indicates a strong relationship between variables, 0 indicates a neutral relationship, and -1 indicates a weak relationship. The correlation matrix between ion concentration and physical and chemical properties in this study is shown in Table 5.4. The psychochemical parameters and water quality parameters of the water samples were compared to find correlations between them. The results of the statistical analysis showed that several parameters were significantly/strongly correlated, namely, pH- Na^{+2}, pH-SAR, ph-KR, Ec-KR, Ca^{+2}- K^{+}, Ca^{+2}-MH, Na^{+2}-SAR, Na^{+2}-Na%, Cl^{-}-SAR, Cl^{-}-Na% , SAR-Na%, SAR-KR , Na%-KR

Table 5. Physicochemical parameters correlation matrix for the analyzed factors

Temp	pH	EC	Ca^{+2}	Mg^{+2}	Na^{+2}	K^{+}	Cl^{-}	HCO^{-}_{3}	SO_4^{-}	SAR	Na%	Pi	KR	MH
pH	1.00													
EC	0.22	1.00												
Ca^{+2}	0.08	-0.01	1.00											

Mg^{+2}	0	0	0	1										
Na^{+2}	0.87	0.57	-0.18	0	1.00									
K^{+}	-0.15	0.45	0.71	0	-0.21	1.00								
Cl^{-}	0.83	0.54	0.09	0	0.94	-0.11	1.00							
HCO^{-}_{3}	0.40	-0.58	-0.33	0	0.27	0.42	0.28	1.00						
SO_4^{-}	0	0	0	0	0	0	0	0	1					
SAR	0.76	0.50	-0.44	0	0.96	-0.43	0.84	0.39	0	1.00				
Na%	0.69	0.38	-0.54	0	0.90	-0.58	0.79	0.39	0	0.98	1.00			
Pi	-0.55	-0.50	-0.64	0	-0.56	-0.39	-0.79	0.09	0	-0.35	-0.25	1.00		
KR	0.82	0.72	-0.04	0	0.97	0.03	0.93	0.04	0	0.88	0.79	-0.66	1.00	
MH	0.19	0.09	-0.96	0	0.42	-0.74	0.15	0.43	0	0.65	0.72	0.47	0.27	1

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Piper's Diagram

A Piper diagram is a graphical illustration of water chemistry data developed by Arthur M (Sarikhani et al., 2015). Piper in 1944 to assist in interpreting the sources of dissolved component salts in water. This technique is predicated on the premise that there are sufficient cations and anions in water to maintain the electroneutrality of dissolved salts or that the algebraic sum of the cation and anion electric charges is zero. In this study, piper diagrams are used to determine the characteristics of water samples. Water samples use the average value of chemical properties of samples in June-August. Then the data is converted from mg/L to meq/L. Piper-based water characteristic analysis of the diagram should use meq/L units.

The piper diagram was created using the Grapher 13 software. The required parameters are inputted into the Grapher 13 software. Then, the application plots to determine the class of the water sample at each observation point. Based on the plotting results, the water samples at sites 1-5 are classified as calcium type in the cation triangle, and the anion triangle shows that at the five observation sites, water samples are classified as bicarbonate type. The analysis of cations and anions indicates that the kind of water is magnesium bicarbonate, which type of water is weak acid exceeds strong acid and alkaline earth exceeds alkalies.

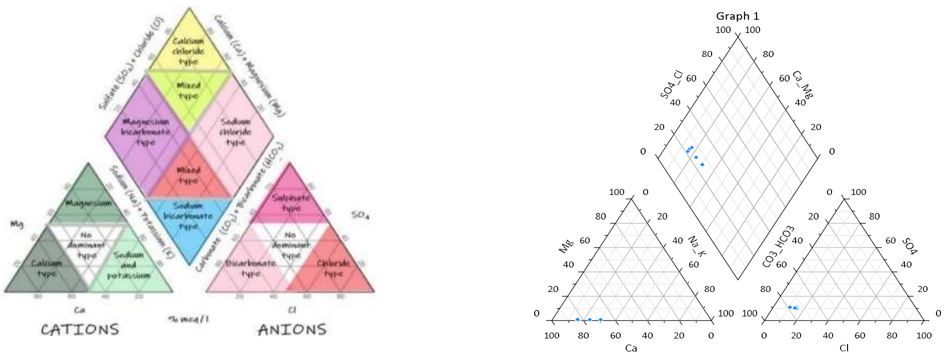

Fig. 7 Piper's Diagram

CONCLUSION

This study's results revealed different water qualities of the Jeneberang River. The electrical conductivity of the study location suggests the highest in August and the lowest in June 2021, with values of 101.7 (on point 1) and 70.0 (on point 3), respectively. These results satisfy the irrigation water quality. In addition, the nitrate concentration of the study locations was in the range of 0.04-10.88 mg/L. Therefore, the nitrite level in the Jeneberang River was adequate and lower than the standard limit.

Meanwhile, the concentration of calcium and magnesium were between 2.54-11.31 and 0.03 mg/L, respectively. In addition, sodium concentration was in the range of 4-7 mg/L. Moreover, the potassium concentration in this study's water samples was 0.03-0.19 mg/L. Regarding the soluble sodium in the research sites, the study results indicate that the soluble sodium percentage in the Jeneberang River water sample was classified as excellent and reasonable. Meanwhile, based on SAR analyses, the values range between 0.03 meq/L to 0.34 meq/L and are categorized as an excellent class. In addition, the highest number of Kelly's Ratio in this study is 0.21 meq/L and the lowest is 0.01 meq/L. It shows that the irrigated water from the Jeneberang River is suitable for agricultural irrigation. Based on the results of measuring lead content for three measurements between June-August, it was found that the lead concentration at all sites was constantly the same, namely 0.027 mg/L. It also happens for cadmium measurements, which show a value always the same each month, specifically 0.001 mg/L. The statistical analysis results show that several parameters significantly correlate: pH-Na^{+2}, pH-SAR, ph-KR, Ec-KR, Ca^{+2}- K^{+}, Ca^{+2}-MH, Na^{+2}-SAR, Na^{+2}-Na%, Cl^{-}-SAR, Cl^{-}-Na% , SAR-Na%, SAR-KR， Na%-KR. Eventually, the analysis of cations and anions indicates that the type of water is magnesium bicarbonate. This weak acid exceeds strong acid, and alkaline earth exceeds alkalies.

ACKNOWLEDGMENTS

The authors are grateful for the financial support from the National Natural Science Foundation of China (NSFC) (No. 11972311) and the Innovation Research 2035 Pilot Plan of Southwest University (SWU-XDPY22003).

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