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EVALUATION OF WATER QUALITY AND IRRIGATION SUITABILITY ACROSS CLIMATIC ZONES IN THE WALAWE RIVER BASIN, SRI LANKA

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The quality of surface water is vital for maintaining sustainable agriculture, particularly in regions that heavily depend on irrigation. The Walawe River Basin, an essential hydrological system in Sri Lanka, spans multiple climatic zones and supports extensive agricultural activities. However, there is a lack of research concerning the spatial variation in irrigation water quality across these zones. This study aims to examine surface water quality and its suitability for irrigation in the intermediate, dry, and arid zones of the Walawe River basin during the dry season. A total of 38 surface water samples were collected in March 2024. In situ measurements included pH, electrical conductivity (EC), and turbidity. At the same time, laboratory analyses determined the concentrations of anions and cations utilizing various spectrophotometric techniques and Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). To assess the suitability of the water for irrigation, several established indices were calculated, including the Irrigation Water Quality Index (IWQI), Sodium Adsorption Ratio (SAR), Per cent Sodium (Na%), Kelly's Ratio (KR), Permeability Index (PI), and Magnesium Hazard (MH). Statistical differences across various climatic zones were evaluated using a General Linear Model. The results revealed significant spatial variability across several parameters, with the arid zone displaying higher pH values, electrical conductivity (EC), alkalinity, chloride, fluoride, and sulfate levels ($p < 0.05$). This variation is likely attributed to limited rainfall and increased evaporation. While most sampling sites fell within acceptable limits for irrigation use, the elevated sodium percentage (Na%) and lower permeability index (PI) values observed in the dry and arid zones indicate potential long-term risks to soil permeability and structure. The Irrigation Water Quality Index (IWQI) categorized all samples from the intermediate and dry zones as highly suitable. In contrast, 10% of the samples from the arid zone were downgraded to medium suitability. Overall, this study highlights the impact of climatic variability on irrigation water quality within the Walawe Basin. The findings advocate for implementing region-specific water management practices and ongoing monitoring programs to support sustainable agricultural development and mitigate potential future degradation of soil and water resources.

Keywords: salinity hazard, sodium adsorption ratio, sodium hazard

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INTRODUCTION

Surface water is the primary source of agriculture, industry, and human consumption across many regions worldwide (Ritter et al., 2002). It has been known that the quality of irrigation water significantly impacts soil health, crop productivity, and the long-term sustainability of agricultural practices. Several water quality indicators are widely used to determine the suitability of water for irrigation, including pH, Irrigation Water Quality Index (IWQI), Sodium Adsorption Ratio (SAR), Per cent Sodium (%Na), Kelly's Index (KI), Permeability Index (PI), and Magnesium Hazard (MH). These parameters collectively influence soil permeability, salinity buildup, and nutrient availability, all of which are critical to plant health and long-term agricultural sustainability (Muhammad et al., 2023). Numerous studies across diverse river basins have highlighted the importance of monitoring these parameters to ensure the viability of agricultural practices. The Walawe River Basin in Sri Lanka, the fourth largest river basin in the country, plays a vital role in providing water for agricultural, domestic, and industrial purposes (Senarathne et al., 2021; Weragala, 2010). This basin encompasses major climatic zones in Sri Lanka, making it an ideal case study for examining how varying climatic conditions affect water quality. However, limited research has been conducted on the water quality of the Walawe River, particularly concerning variations across different climatic zones. This study aims to evaluate water quality and irrigation suitability across different climatic zones within the Walawe River Basin, Sri Lanka, by analyzing key water quality parameters and comparing them to established standards. The findings are intended to provide critical insights for sustainable irrigation practices in the region.

METHODOLOGY

This study was conducted during the dry season in March 2024, covering thirty-eight sampling locations. At each location, three replicate surface water samples were collected. Surface water samples for analysis were collected into properly labelled 500 mL high-density polyethene bottles. Furthermore, water samples for cation analysis were filtered and collected in 15 mL Falcon tubes, then acidified with a few drops of concentrated HNO_3. The EC, pH, and turbidity were measured in situ using a pre-calibrated Thermo Scientific Orion Star A329™ Multiparameter test kit, MP-103 Handheld pH Meter, and a portable turbidity meter. The alkalinity and chloride content were determined by the Hach™ digital titrator. Other anionic parameters, Nitrate-N (NO_3^-N), sulfate (SO_4^{2-}), Phosphate (PO_4^{3-}), and Fluoride (F^-), were determined using the Hach™ DR 2700 spectrophotometer after transferring the samples to the laboratory. Cation concentrations were measured using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES).

The assessment of surface water quality for irrigation purposes was carried out across different climatic zones of the Walawe River Basin. Key water quality parameters such as pH and electrical conductivity (EC), along with irrigation suitability indices including SAR, Na%, KR, PI, and MH, were calculated following standard methods. In addition, the Irrigation Water Quality Index (IWQI) was computed based on multiple factors such as salinity hazards, permeability risks, ion toxicity, trace element toxicity, and miscellaneous effects, as described by Elsayed et al. (2020).

Data were statistically analyzed using Statistical Package for the Social Sciences (SPSS) version 25 software. A General Linear Model (GLM) was performed to investigate the significant difference in analyzed water quality parameters among climatic zones.

RESULTS AND DISCUSSION

This study underscores the critical importance of considering the diverse climatic zones of the Walawe River Basin in water quality management. Statistical analysis revealed that most parameters, including pH, EC, alkalinity, chloride, fluoride, and sulfate, differed significantly ($p < 0.05$) among climatic zones (**Table 13**), whereas turbidity, nitrate, and phosphate showed no statistically significant variation. The observed high pH, EC, and anion concentrations in the arid zone are consistent with findings by Shaw (1962) who highlight salinity challenges in arid areas due to limited water availability and high evaporation rates. Conversely, the intermediate zone showed relatively lower values, likely due to enhanced rainfall and dilution effects (**Figure 20**).

The assessment of the Irrigation Water Quality (IWQ) index in the Walawe River Basin revealed spatial variation, highlighting its relevance to sustainable agricultural practices. High suitability was observed in 100% of samples from the Intermediate and dry zones and 90% in the arid zone (Table 14). The pH of surface water samples ranged from 6.65 to 8.12, indicating a slightly alkaline trend within the acceptable irrigation range of 6.5–8.5 (Khelif, 2024). High pH levels in irrigation water may reduce crop yield, precipitate salts, and clog soil pores (Dinka, 2016). The irrigation suitability indices, such as the SAR and Na%, were within acceptable ranges for most sites.

However, elevated Na% values in the dry and arid zones suggest potential soil structure risks if irrigation practices are intensified without proper management. As noted by Aragaw & Gnanachandrasamy (2021), high sodium can reduce soil infiltration and impact crop yield. PI evaluates the potential of water infiltration issues. In this study, PI values ranged from 60.36 to 297.82, classifying the water as good and marginal for irrigation (Khelif, 2024). Waters of marginal quality may cause significant water infiltration issues. Using water with high magnesium content for irrigation can lead to increased soil salinity and alteration of its structure (Shyamala et al., 2021). Most samples had suitable MH values, indicating low magnesium hazard and minimal risk for soil degradation. Different studies have noted that higher MH values in irrigation water can have a detrimental effect on soil properties (Alobaidy et al., 2010; Sarker et al., 2000).

Table 13: Water quality variation among climatic zones

Parameter		Climatic Zone			
		Intermediate	Dry	Arid	P value
pH	Mean ± SE	7.08 ± 0.12	7.60 ± 0.09	7.80 ± 0.07	0.00
Turbidity (NTU)	Mean ± SE	4.17 ± 0.85	12.04 ± 3.59	11.00 ± 2.34	0.07
Conductivity (µS/cm)	Mean ± SE	200.70 ± 21.04	373.82 ± 49.94	500.78 ± 58.53	0.00
Alkalinity (mg/L)	Mean ± SE	59.06 ± 12.37	132.28 ± 14.85	141.72 ± 20.04	0.00
Chloride (mg/L)	Mean ± SE	37.21 ± 1.54	42.82 ± 2.42	55.25 ± 4.24	0.00
Fluoride (mg/L)	Mean ± SE	0.11 ± 0.02	0.27 ± 0.05	0.47 ± 0.09	0.00
Nitrates (mg/L)	Mean ± SE	1.02 ± 0.08	1.38 ± 0.16	1.38 ± 0.16	0.35
Phosphates (mg/L)	Mean ± SE	0.08 ± 0.01	0.16 ± 0.03	0.16 ± 0.03	0.11
Sulphates (mg/L)	Mean ± SE	1.71 ± 0.28	6.78 ± 1.53	23.50 ± 4.50	0.00

Table 14: Classification of irrigation suitability

Parameter	Range	Suitability for Irrigation	Number of samples in each zone (%)		
			Intermediate	Dry	Arid
IWQI	>37	High	100	100	90
	22-37	Medium			10
	<22	Low			
pH	6.5-8.4	Optimum range	100	100	100
SAR	0–10	Excellent	100	100	100
	10-18	Good			
	18-26	Doubtful			
	>26	Unsuitable			
KR	<1	Suitable	100	100	90
	1>	Unsuitable			10

Na%	<20	Excellent	50	14	
	20–40	Good	50	72	70
	40–60	Permissible		14	30
	60–80	Doubtful			
	>80	Unsuitable			
PI	>75%	Suitable	86	71	40
	25–75%	Marginal	14	29	60
	<25%	Unsuitable			
MH	<50	Suitable	93	86	80
	>50	Unsuitable	7	14	20

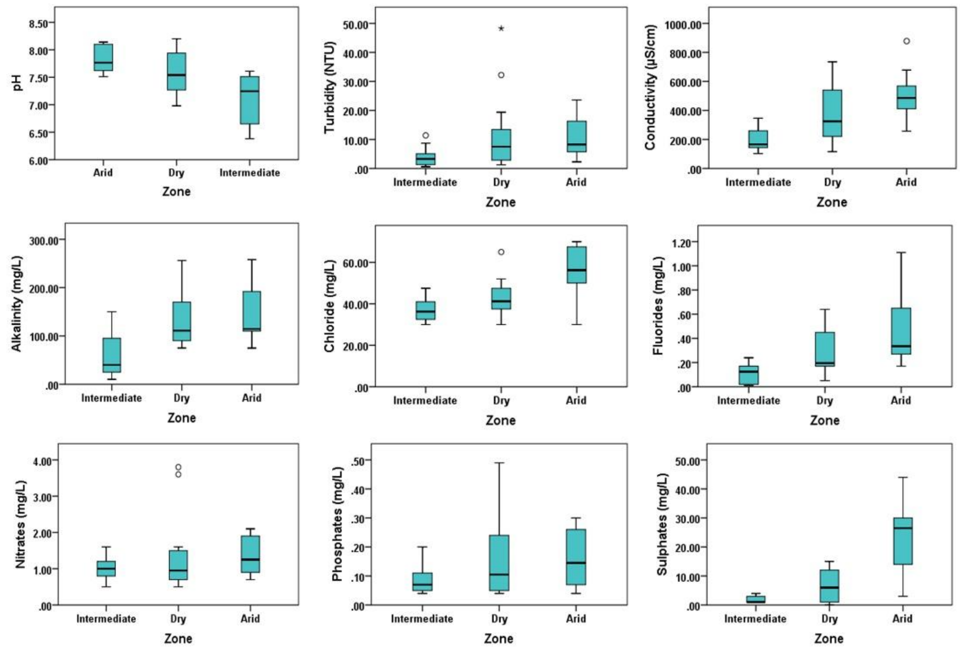

Figure 20: Graphical illustration of zonal variations of water quality parameters in the Walawe River basin

CONCLUSIONS/RECOMMENDATIONS

In conclusion, the study reveals that the arid zone of the Walawe River Basin generally has lower water quality than the intermediate and dry zones. Climatic variation significantly influences irrigation suitability, as evidenced by the arid zone's marginal suitability in several parameters, which may lead to infiltration challenges and soil structure issues over time. These findings underscore the importance of tailored water management practices across different climatic zones to sustain agricultural productivity in the basin.

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