

ASSESSMENT OF NAGAVALI RIVER WATER QUALITY IN AND AROUND SRIKAKULAM DISTRICT FOR AGRICULTURE AND IRRIGATION

CH.V. Saikrishna¹, L. Vaikunta Rao^{2,✉} and D. Mallikarjuna Rao³

¹Department of Chemistry, Dr. V.S. Krishna GDC(A), Visakhapatnam, 530013, Andhra Pradesh, India.

²Department of Chemistry, GITAM (Deemed to be) University, Visakhapatnam 530045, Andhra Pradesh, India.

³Akshaya Innotech, Visakhapatnam, 530045, Andhra Pradesh, India.

✉Corresponding Author: saisrikar.ch@gmail.com

ABSTRACT

In the Srikakulam district, river water is a crucial supply of irrigation water for agricultural farming operations. Changes in the physicochemical composition of agricultural soil will be influenced by river water quality, and these changes may have a vital impact on crop yields. Water samples were taken from the Nagavali River during the pre and post-monsoon seasons of 2021 to evaluate their appropriateness for irrigation and drinking and using several indices such as SAR, SSP, PI, and MH examined for different criteria. Monitoring river water quality is essential for encouraging sustainable development in agricultural regions and providing critical data for irrigation water management for agricultural production. All sampling stations are of good quality in both seasons according to the WQI values. Piper trilinear diagrams indicate that in two seasons the majority of samples were in the mixed zone (Ca-Mg-So4-Cl), and others were magnesium-bicarbonate type. The Principal Components (PCs) for both seasons were judged to clarify 74.78% of the total change in the pre-season and 81.98 % in the post-season. Both seasons' variables are entirely hydrochemical and are assumed to be the result of geological processes, suggesting geogenic origins. Ca^{2+} and Mg^{2+} do not react similarly in soil systems when used for irrigation, because Mg^{2+} degrades soil structure, particularly in Na-dominated and extremely salty waters. A high Mg concentration in irrigated soils often promotes the development of exchangeable Na. In the Nagavali river, Mg Hazard was found to be less than 50 in 50% of pre-monsoon samples, in post-monsoon 40% were fewer than 50. A magnesium hazard of less than 50 is appropriate in Irrigation waters. Except for the Magnesium hazard, river water quality for irrigation needs varied from acceptable to outstanding in each location.

Keywords: Nagavali River, PCs, MH, Pre-Monsoon, Srikakulam, Piper Diagram, WQI.

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INTRODUCTION

Water is the most essential requirement for existence, water quality and availability have deteriorated significantly due to the unrestrained use of water for agriculture, drinking, and industrial purposes. Rivers provide several functions, including drinking water, irrigation, fisheries, and energy generation¹. Water quality is defined by its physicochemical properties. Various nutrients enter aquatic ecosystems through runoff water and sewage discharge into rivers, resulting in water contamination.² Pollution generally results in a significant decrease or full absence of dissolved oxygen, as well as an increase in organic matter, ammonia, phosphates, chlorides, and solids content, as well as colour and odours in water. However, the number of species will decrease, with the survivors demonstrating prodigious development. It is also obvious that the abundance of species indicates poor water quality and contamination.³ Water quality in agriculture is assessed by its influence on product quality and soil quality. Sewage and agricultural drainage are two ways that pollutants enter rivers, which causes a dramatic drop in the quality of the water. The quantity of soluble salts is a crucial factor in determining the quality of irrigation water. They are created by the disintegration of rocks and soil, which involves the dissolving of lime, gypsum, and other soil minerals. Fertilizers and soil also contribute to this process. Due to evaporation or the use of water byproducts, these salts are transported by water and remain in the earth.⁴ Irrigated agriculture is reliant on a reliable supply of high-quality water. In irrigation water evaluation, the emphasis is on the

physicochemical properties of the water, with additional elements being examined in the basin's agricultural and residential land usage.⁵ Furthermore, the water from this river is used for drinking in the Srikakulam district, in addition to agricultural purposes; thus, this study's objective was to evaluate the water quality of Nagavali for irrigation and drinking. This paper has attempted to evaluate the irrigation water quality by using multivariate analysis in the Srikakulam district.

EXPERIMENTAL

Study Area

Langulya River is the ancient name of the Nagavali River, a significant river in Odissa and North Andhra. It originates in the eastern slopes of the Eastern Ghats of Kalahandi district of Odissa state. The length of the river is about 256 km. of which 95km covers Andhra Pradesh state along the districts of Parvathipuram Manyam and Srikakulam districts flows in the southeastern direction and empties in the Bay of Bengal near Kallepalii village. Nagavali water is a source for irrigation and domestic purposes of the catchment area. Nagavali River is essential for its ecological significance. Nagavali River faces environmental challenges like all other rivers in India due to natural and anthropogenic factors. In the present study, the focus is on quality assessment for irrigation and drinking purposes of Nagavali river in North Andhra Pradesh state at Ten sampling stations extended from 18.86250°N longitude and 83.48083°E latitude to 18.21360°N longitude and 83.93222°E latitude. The map location of the study region is revealed in Fig.-1. Sampling sites of the study region are given in Table-1.

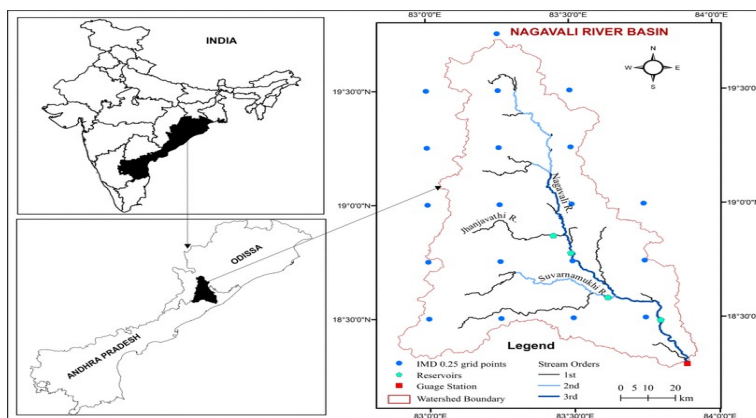


Fig.-1: Location Map of Nagavali River Basin (Sridhara Setti *et al* 2017)

Table-1: Sampling Locations of the Study Area

Nagavali			
S. No.	Location	Longitude	Latitude
1	Dalai Peta	18.86250°N	83.48083°E
2	Gunana Puram	18.81930°N	83.48824°E
3	Vullibhadra	18.76240°N	83.47771°E
4	Bitiwada	18.61339°N	83.63639°E
5	Sankili bridge	18.68408°N	83.74109°E
6	Labham	18.48297°N	83.81428°E
7	Dusi	18.36075°N	83.86535°E
8	Fazulpeta	18.30472°N	83.88637°E
9	Kalinga Peta	18.23069°N	83.91824°E
10	Dibbapalem	18.21360°N	83.93222°E

Methodology

Samples were collected at ten monitoring sites in the Nagavali River in two different seasons of the year 2021. Clean 2-L plastic bottles were used to collect the water samples. During sampling, the bottles were carefully cleaned with distilled water and rinsed with river water. During the sample period, qualitative parameters including pH, EC, TDS, Salinity, Alkalinity, DO, TH, CO_3^{2-} , HCO_3^- , Cl^- , F^- , Phosphates, Sodium, Magnesium, Calcium, Potassium, Sulphates, Nitrates, COD, BOD, and TOC were measured.⁶

Water samples were analyzed by using APHA 2022 procedures.⁷ The methods utilized for water quality analysis are given in Table-2. Irrigation and drinking water were categorized using USSL diagrams, whereas agricultural water was categorized using sodium percent, RSC, KR, SAR, SSP, PI, RSBC, and MH.⁸ These are determined as given in Table-3.

Table-2: Methods and Equipment Used for Water Quality Analysis (APHA)

S. No.	Parameter	Unit	Method/Equipment used
1.	Total Hardness	mg/l	EDTA Titrimetric Method
2.	Chloride	mg/l	Mohr's Method
3.	Dissolve Oxygen	mg/l	Winkler Method
4.	Total Alkalinity	mg/l	Titrimetric method
5.	Sulphates	mg/l	U.V. visible Spectro-photometric method
6.	Nitrate	mg/l	U.V. visible Spectro-photometry
7.	Phosphate	mg/l	U.V. visible Spectro-photometry
8.	TOC	mg/l	carbonaceous analyzer
9.	BOD	mg/l	5-day BOD (Incubator at 28 ⁰ C)
10.	COD	mg/l	Open reflex Method

Table-3: Irrigation Water Quality Parameter (A. K. Haritash *et al* 2016 and Sanjoy Shil *et al* 2019)

Sodium (Na%)	$\frac{Na^+ \times 100}{(Ca^{2+} + Mg^{2+} + Na^+ + K^+)}$
Sodium Absorbtion Ratio(SAR)	$\frac{Na^+}{\sqrt{\frac{Mg^{2+} + Ca^{2+}}{2}}}$
Megnisiium Hazard (MH)	$\frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} \times 100$
Kelly`s Index(KI)	$\frac{Na^+}{Ca^{2+} + Mg^{2+}}$
Residual Sodium Carbonate (RSC)	$(CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$
Residual Sodium Bicarbonate (RSBC)	$(HCO_3^- - Ca^{2+})$
Soluble Sodium Percentage (SSP)	$\frac{Na^+ \times 100}{(Ca^{2+} + Mg^{2+} + Na^+)}$
Permeability Index (PI)	$\frac{(Na^+ + \sqrt{HCO_3^-}) \times 100}{(Ca^{2+} + Mg^{2+} + Na^+)}$

Water Quality Index (WQI)

The WQI efficiently reflects water quality by combining several water quality indicators into a single unitless integer. The different hydrochemical parameters are analyzed by a specific sort of quantitative averaging function that converts diverse values and units into one value.⁹ WQI was estimated using the approach described by Pesce and Wunderlin (2000) and is provided below.¹⁰

$$WQI = K \frac{\sum_{i=1}^n C_i P_i}{\sum_{i=1}^n P_i}$$

C_i is the normalized value allocated to every parameter, whereas P_i represents its comparative weight. k is constant. The range of WQI is shown in Table-4. The Piper-trilinear plot displays the classification of water samples from various lithological conditions. It also exposes the chemical character of the water samples by analyzing the differences and similarities of groundwater samples using the dominant cation and anion.

The Piper diagram illustrates the findings of the water analysis in the research region. The cations are represented by the left triangle, the anions are represented by the right triangle.

Table-4: WQI Range and Water Quality (Jonnalagadda and Mhere 2001)

S. No.	WQI Range	Water Quality
1	0 – 25	Very Poor
2	26 – 50	Poor
3	51 – 70	Medium
4	71 – 90	Good
5	91 – 100	Very Good

Principal Component Analysis

PCA is a data reduction technique in which a new set of variables known as principal components are obtained from the given dataset, which is a linear combination of the original variables. The basic goal of PCA is to maintain the original variance of the data while creating an uncorrelated dataset.¹¹ It also reveals patterns that standard analytical and visual techniques might overlook.

RESULTS AND DISCUSSION

The summary of the physicochemical characteristics, the average, Standard deviation, minimum, and maximum of physicochemical parameters such as pH, E.C, TDS, Salinity, Total Alkalinity, DO, Hardness, CO_3^{2-} , HCO_3^- , Cl^- , F^- , PO_4^{3-} , Na^+ , Mg^{2+} , Ca^{2+} , TOC, BOD, K^+ , SO_4^{2-} , NO_3^- , COD in Table-5. The pH levels of all samples were confirmed to be within the acceptable range. The average conductivity in both seasons is $305\mu\text{S}/\text{cm}$ and $293\mu\text{S}/\text{cm}$. The ideal EC value for drinking water is 500. Total alkalinity (TA) is a measure of water's resilience to pH fluctuations. TA is the quantity of alkali in the water in the form of bicarbonates, carbonates, and hydroxides. In pre-monsoon water samples, the TA extended from 91 to 166 mg/l, avg. value is 121 mg/l in post-water samples, the TA reached 86 to 175 mg/l, with a mean of 113 mg/l. Our drinking water should have an alkalinity of 20-200 mg/L. Low-alkalinity of River water can be caustic and irritate the eyes. Water with a high alkalinity level has a soda-like taste and can scale plumbing fittings and the water delivery system. Ca and Mg ions, two minerals that are naturally found in water, contribute to water hardness. Hard water is produced when water is coupled with limestone and chalk, which contain significant amounts of calcium magnesium carbonates, and bicarbonates. CaCO_3 hardness in water samples are minimum of 133 ppm and a maximum of 344ppm, an average of 197 ppm prior monsoon and are 138ppm and 366 ppm, average is 195 ppm, in after the monsoon season. Total dissolved solids (TDS) are the inorganic salts and trace amounts of organic materials found in water. As a result of the influence of dissolved ions, it is connected to water conductivity, however, their relationship is not constant. The range of Total dissolved solids in the pre-monsoon season is 134 to 438 ppm and the mean is 204 ppm, in post-monsoon, the range is 140-454 mg/l, and the average is 196 mg/l. Dissolved solids in water may impact its taste according to WHO (1996). Furthermore, the taste of drinking water is outstanding (1200 mg/L). Low TDS values may potentially be unsafe to consume due to its fattiness and bland flavour. In river water, there is a significant fluctuation in salinity distribution. Differences in salinity levels are caused by low and high tide influences. Pre-monsoon salinity readings varied from 0.03 to 0.09 ppm, and the average was 0.06 mg/l; post-monsoon salinity values ranged are 0.02 to 0.08 ppm, and the average was 0.05 ppm. These interactions with river water are supported by hydrochemistry, hydrochemical facies assessment, and salinity distributions. Dissolved oxygen is oxygen that is kept in water and is accessible to aquatic organisms. Water naturally contains dissolved oxygen, which is taken from the air and created by aquatic plants that live in it. DO levels were good at all sampling points in both seasons. Greater HCO_3^- content in the water indicates that mineral dissolution is dominant.¹² Natural water contains chloride in the form of Na, Ca, and Mg ions. Chloride is found in practically all surface water, however, the concentration in river water ranges from¹³ 10 to 20 mg/l. The concentration of chloride is 8 mg/l – 33 mg/l. in the pre season and in the post-monsoon season, ranged from 9 to 41 mg/l. Fluoride is extensively dispersed in nature and is regarded as a required chemical for human health, with a reasonable level of fluoride consumption recommended.¹⁴ Fluorosis is a dangerous condition caused by prolonged exposure to excessive fluoride concentrations. Fluoride levels varied from 0.2 to 0.45 mg/l, and the average was 0.34 in the pre season period. 0.25 to 0.5 in the post-season, and 0.33 mg/l is the mean value. Phosphorus is a nutrient that is

required by plants, animals, and aquatic creatures. Excess phosphorus in surface water accelerates the growth of aquatic plants and algae and leads to a decrease in DO levels. Because phosphorus is not hazardous to humans until present in extremely high concentrations, it is conceivable to examine its influence on water quality indices, particularly those based on weight.¹⁵ The range of PO_4^{3-} is 1.9 to 8.5 mg/l, with and mean of 3.6 mg/l in the pre-season, and 2.3 to 11.2 in the post-season, mean is 3.94 mg/l. Na is not toxic to humans if it is not more than the typical amounts found in drinking water and meals. Sodium consumption, on the other hand, becomes a source of concern for people suffering from heart and renal disease, as well as sleeplessness. Potassium is an electrolyte that is not freely circulated, stays within the cells, and is a coworker of Sodium. The ability to endure high sodium pressure and pressure brought on by water flow is attributed to the potassium content.¹⁶ The optimum concentrations of Sodium and Potassium was found in the examined area. Surface water naturally contains the elements magnesium and calcium. Their concentrations can be affected by several variables, such as geological structure, soil type, weather conditions, water supply type, and so on.¹⁷ In pre-monsoon, Ca (26 -48 mg/l) averaged 36 mg/l, and Mg (19 -72 mg/l) averaged 29 mg/l. In the post-monsoon, Ca levels varied from (24-45 mg/l) and 34.7 mg/l is average, while Mg is 21-75 mg/l and average is 29.3 mg/l. Furthermore, Mg^{2+} and Ca^{2+} presence in water is frequently linked to the kind of land use in watershed regions.¹⁸ TOC determination has lately been recognized as important, and its measurement has been standard practice in environmental investigations.¹⁹ In the pre-monsoon, TOC readings are 28 to 64, and the mean value is 43 mg/l. 26-55mg/l in post-monsoon, with an average of 39.8 mg/l. Increased NO_3^- and SO_4^{2-} concentrations due to anthropogenic sources in surface water.²⁰ Since both compounds can be harmful to human health.²¹⁻²² They have negative biota effects.²³ It is crucial to design suitable management plans even though it can be challenging to discern between sources of SO_4^{2-} and NO_3^- in coastal environments. Nitrate levels vary from 1.5 to 6.2 mg/l, sulfate values are 11 to 95 mg/l in pre-season, and in post-monsoon Nitrate values vary from 1.4 to 9.8, Sulphates 12 to 99 mg/l. COD and BOD levels are vital in regulating overall pollution levels and maintaining the water environment. COD and BOD are significant in regulating overall pollutant content and managing the water environment because they are the most complete indexes of organic pollution.²⁴ Table-5 provides a summary of water quality statistics. The WQI values are shown in Table-6. All sampling stations are of good quality in both seasons. Variation of the Water Quality Index is shown in Fig.-2.

Table-5: Summary of Descriptive Statistics for Water Quality Parameters of Nagavali River

Parameter	PRE-MONSOON				POST- MONSOON			
	Min	Max	Mean	S. D	Min	Max	Mean	SD
pH	7.40	8.30	7.87	0.32	7.3	8.2	7.81	0.33
E.C	201.00	655.00	305.90	132.87	209.00	678.00	293.60	139.75
TDS	134.67	438.85	204.95	89.02	140.03	454.26	196.71	93.64
Salinity	0.03	0.09	0.05	0.02	0.02	0.08	0.05	0.02
Alkalinity	91.00	166.00	121.70	22.46	86.00	175.00	113.90	26.03
DO	6.10	7.10	6.67	0.28	6.3	7.1	6.64	0.26
TH	133.00	344.00	196.70	63.79	138.00	366.00	195.60	66.43
CO_3^{2-}	6.00	55.00	14.10	14.70	6.00	65.00	14.90	17.80
HCO_3^-	11.00	47.00	31.20	10.17	11.00	55.00	30.10	11.64
Cl^-	8.00	33.00	15.00	7.09	9.00	41.00	17.20	8.97
F^-	0.21	0.50	0.36	0.10	0.25	0.45	0.36	0.07
PO_4^{3-}	1.90	8.50	3.66	1.83	2.30	11.20	3.94	2.59
Na^+	11.00	110.00	29.00	28.83	12.00	115.00	28.80	30.57
Mg^{2+}	19.00	72.00	29.10	15.60	21.00	75.00	29.30	16.21
Ca^{2+}	26.00	48.00	36.40	6.85	24.00	45.00	34.70	6.78
TOC	28.00	64.00	43.00	13.44	26	55	40.20	9.08
BOD	1.80	2.40	2.15	0.22	1.8	2.6	2.11	0.26
K^+	1.80	6.20	3.55	1.38	1.70	8.20	3.51	1.77
SO_4^{2-}	11.00	95.00	32.90	23.00	12.00	99.00	29.10	25.05
NO_3^-	1.50	6.20	3.44	1.58	1.40	9.80	3.55	2.37
COD	33.00	55.00	41.90	7.11	31	45	37.60	5.40

Table-6: Status of Water Quality Index (WQI) at Nagavali River

S. No.	Location	Pre-Monsoon (%)	Post Monsoon (%)
1	Dalaipeta	81.36	82
2	Gunana puram	81.36	80
3	Vullibhadra	80.45	78
4	Bitiwada	80	82
5	Sankili bridge	81	84
6	Labham	77	79
7	Dusi	79	83
8	Fazulpeta	81	78
9	Kalinga peta	78	77
10	Dibbapalem	74	73

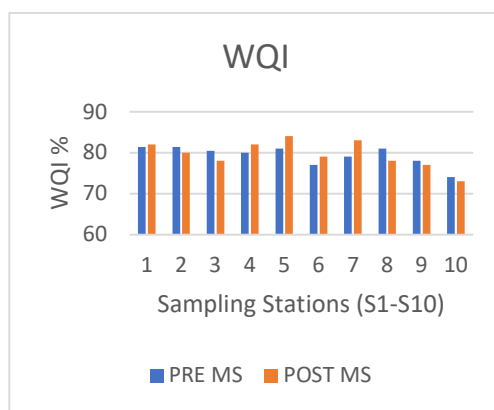


Fig.-2: Variation of WQI in Both Seasons

Piper trilinear diagrams are plotted using Aquachem 4.0 scientific software. The process indicates that in pre-monsoon, 85% of Samples were in the Mixed Zone (Ca-Mg-So₄-Cl) and 15% of the samples (Mg-HCO₃) type. In Cations, 10% of the samples are Mg type, and 90 % have no dominant type. In anions, 25% Bicarbonate type, 75% No dominant type. In post-monsoon, 60% were in the Mixed Zone, and 40% of the samples (Mg-HCO₃ type). In Cations, 10% of the samples are Mg type, and 90 % have no dominant type. In anions, 40% Bicarbonate type, 60% no dominant type. They are shown in Fig.-3 a and b.

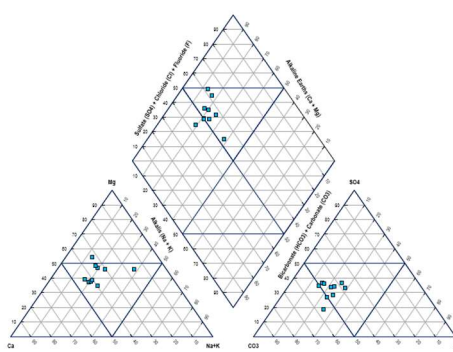


Fig.-3a: Piper Diagram Pre-Monsoon

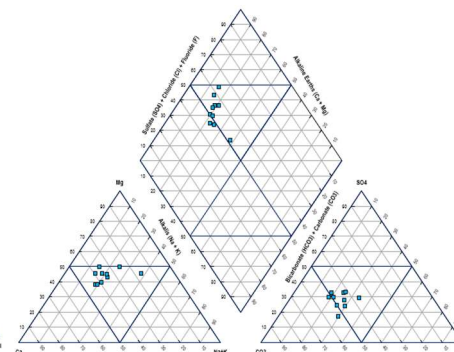


Fig.-3b: Piper Diagram Post Monsoon

The correlation coefficient is a helpful statistical measure for indicating the degree to which one variable is dependent on another. In general, Pearson's correlation has efficient values. Strong correlations have r values more than 0.7, whereas moderate correlations have r values between 0.5 and 0.7. It vividly illustrates the link between two variables. r values greater than 0.7. This indicates that the parameters change in a straight proportionate manner. The correlation values ($r > 0.7$) are shown in Table-7.

Table-7: Correlation Coefficient ($r > 0.7$) in Pre-Monsoon

EC	TDS	TA	TH	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	PO ₄ ³⁻	Na ⁺	K ⁺
TDS, TH, CO ₃ ²⁻ Cl, SO ₄ ²⁻ , PO ₄ ³⁻ , Na ⁺ K ⁺ , Mg ²⁺	TH, CO ₃ ²⁻ , Cl, SO ₄ ²⁻ , PO ₄ ³⁻ , Na ⁺ K ⁺ , Mg ²⁺	Salinity, SO ₄ , Na ⁺	HCO ₃ ⁻ , CO ₃ ²⁻ , Cl, SO ₄ ²⁻ , PO ₄ ³⁻ , Na ⁺ Mg ²⁺	Cl ⁻ , SO ₄ ²⁻ , PO ₄ ³⁻ , Na ⁺ Mg ²⁺	Cl ⁻	SO ₄ ²⁻ , PO ₄ ³⁻ , Na ⁺ Mg ²⁺	PO ₄ ³⁻ , Na ⁺ Mg ²⁺	Mg ²⁺ , Na ⁺	Mg ²⁺	Mg ²⁺

Correlation coefficient ($r > 0.7$) in post monsoon

EC	TDS	TA	TH	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	PO ₄ ³⁻	Na ⁺	K ⁺
TDS, TA, salinity TH, CO ₃ ²⁻ HCO ₃ , Cl, NO ₃ SO ₄ ²⁻ , PO ₄ ³⁻ , Na ⁺ K, Mg ²⁺	TA, Salinity, TH, HCO ₃ , CO ₃ ²⁻ Cl, NO ₃ , SO ₄ , PO ₄ , Na ⁺ ,K ⁺ Mg ²⁺	Salinity, TH, CO ₃ ²⁻ HCO ₃ , Cl, SO ₄ ²⁻ PO ₄ ³⁻ , Na ⁺ K ⁺ Mg ²⁺	CO ₃ ²⁻ , HCO ₃ , Cl, NO ₃ , SO ₄ ²⁻ , PO ₄ ³⁻ , Na ⁺ K ⁺ Mg ²⁺	HCO ₃ , Cl, NO ₃ , SO ₄ ²⁻ , PO ₄ ³⁻ , Na ⁺ K ⁺ Mg ²⁺	Cl, SO ₄ ²⁻ , PO ₄ ³⁻ , Na ⁺ Mg ²⁺	NO ₃ , SO ₄ ²⁻ , PO ₄ ³⁻ , Na ⁺ K ⁺ Mg ²⁺	PO ₄ , Na ⁺ K ⁺ Mg ²⁺	Na ⁺ , K ⁺ Mg ²⁺	K ⁺ Mg ²⁺	Mg ²⁺

The principal component analysis examines the variables' compositional structure throughout the complete dataset and limits the dataset to specific prompting components by excluding some data of little importance²⁵. PCA is then applied to the 21 parameters. PCA was used since analyzing 21 parameters in pre- and post-monsoon seasons would still be time-consuming and expensive. Furthermore, the final index values will be biased because multiple characteristics are connected. PCA uses a statistical method to conduct parameter reduction. Data is projected in PCs, which are separate axes. Out of these PCs, the first three are chosen to proceed with. Table-8 shows the rotating factor loadings of these three principal components, the three principal components (PCs) for both seasons were judged to clarify 74.78% of the total change of the pre-season and 81.98 % of the total variance of the post-season. In the pre-monsoon dataset, PC₁ explains 53.27 % of the variations, PC₂ explains 11.9% of the variances, and PC₃ explains 9.57 % of the variances, whereas in post-monsoon PC₁ explains 64%, PC₂ explains 10.2%, PC₃ explains 7.77 % of the variances. Factor loading values of more than 0.75 are classified as strong, the value is 0.75-0.50 is considered moderate, and it's weak if the value is ²⁶ 0.50-0.30. In the pre-monsoon season, in F₁ (Chloride, Carbonate, EC, K, Mg, Na, Phosphate, Sulphate, TDS) in F₂ (BOD), and F₃ (TOC), In post monsoon F₁ (Chloride, Carbonate, EC, Bicarbonate, Potassium, Magnesium, Sodium, Nitrate Phosphate, Salinity, Sulphate, TA, TDS, pH, TH) are dominating factors. The variables in pre and post-monsoon seasons are solely hydrochemical and are thought to arise by geological processes, indicating geogenic causes. Figure-4and5 shows the variation of Eigenvalues with components.

Table-8: Variations of Principal Component Values

Parameter	Pre-Monsoon			Post-Monsoon		
	PC ₁	PC ₂	PC ₃	PC ₁	PC ₂	PC ₃
BOD	0.27	0.789	-0.28	0.479	-0.465	0.587
Ca ²⁺	0.131	0.391	0.022	0.499	0.561	0.16
Cl ⁻	0.804	0.403	0.062	0.925	0.0243	0.159
CO ₃ ²⁻	0.944	0.259	0.058	0.957	0.238	-0.079
COD	-0.171	-0.88	-0.149	-0.428	-0.269	-0.764
DO	0.08	0.093	-0.051	0.08	0.566	0.163
E.C	0.939	0.112	-0.055	0.974	0.159	0.023

F ⁻	0.126	-0.097	-0.194	0.283	0.026	-0.531
HCO ₃ ⁻	0.427	0.659	0.261	0.749	0.42	0.389
K ⁺	0.749	0.091	-0.261	0.945	0.082	-0.269
Mg ²⁺	0.908	0.305	0.054	0.973	0.089	-0.113
Na ⁺	0.925	0.253	0.187	0.959	0.198	-0.013
NO ₃ ⁻	0.698	-0.204	-0.347	0.863	0.246	-0.227
pH	-0.427	-0.048	-0.095	-0.423	-0.744	0.203
PO ₄ ³⁻	0.852	0.395	0.139	0.979	0.135	-0.003
SALINITY	0.576	0.42	0.48	0.809	-0.177	0.036
SO ₄ ²⁻	0.941	0.168	0.117	0.937	0.294	-0.096
TA	0.604	0.244	0.743	0.844	0.082	0.372
TDS	0.939	0.112	-0.055	0.974	0.159	0.023
TH	0.692	0.667	0.074	0.931	0.169	0.213
TOC	-0.136	-0.098	0.963	-0.293	0.423	0.545
Eigen Value	11.187	2.507	2.012	13.441	2.144	1.632
Variability (%)	53.271	11.939	9.579	64.003	10.211	7.773
Cumulative (%)	53.271	65.21	74.788	64.003	74.214	81.987

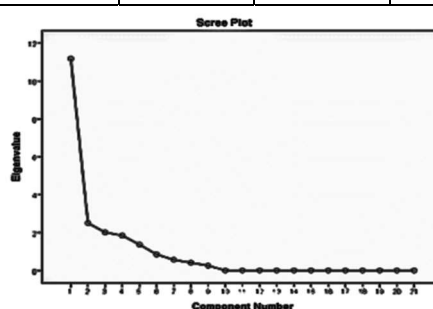
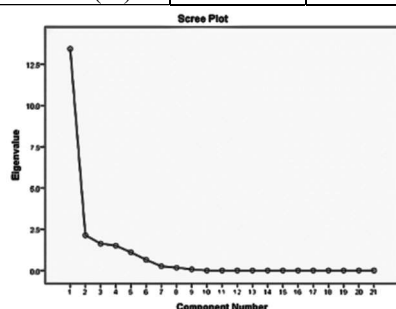


Fig.-4: Scree Plots of Post-Monsoon Season Fig.-5: Scree Plot of Pre-Monsoon Season

Water quality parameters for irrigation in both seasons are given Table-9, and classification is given in Table-10. It is appropriate to use irrigation water with a magnesium hazard of under 50. In the Nagavali river, magnesium hazard was found to be less than 50 in 50% of pre-monsoon samples. 40% of samples during the postseason contained fewer than 50. High concentrations of Mg ions in water lead to altered soil alkalinity, and reduced yields. Except for Magnesium risks, the irrigation quality of river water varied from satisfactory to outstanding in all locations.

Table-9: Water Quality Parameters for Irrigation in Both Seasons

Na%	PRE MS	25.06	23.76	20.93	25.27	24.62	29.41	31.36	15.58	18.80	47.99
	POST MS	28.50	22.19	21.98	23.61	25.61	31.75	25.86	17.94	17.77	47.29
RSBC	PRE MS	-1.14	-1.66	-1.24	-1.76	-1.03	-0.87	-1.26	-1.07	-1.77	-1.28
	POST MS	-1.06	-1.44	-1.19	-1.64	-0.88	-0.81	-1.32	-1.10	-1.62	-1.35
RSC	PRE MS	-3.28	-3.21	-3.53	-3.43	-2.14	-2.54	-2.58	-3.21	-3.29	-5.45
	POST MS	-2.83	-2.86	-3.09	-3.18	-2.36	-2.86	-2.92	-2.90	-3.44	-5.43
SSP	PRE MS	18.65	18.85	15.86	19.84	19.49	22.47	25.04	11.36	14.99	37.27
	POST MS	21.74	17.46	16.83	18.55	19.70	23.81	20.08	13.30	13.55	37.04
PI	PRE MS	33.21	33.35	30.19	33.88	39.14	37.81	41.34	24.95	24.74	44.11
	POST MS	37.73	33.36	32.17	33.03	37.77	37.03	35.25	27.16	23.00	44.07
KR	PRE MS	0.23	0.23	0.19	0.25	0.24	0.29	0.33	0.13	0.18	0.59
	POST MS	0.28	0.21	0.20	0.23	0.25	0.31	0.25	0.15	0.16	0.59
MH	PRE MS	58.58	46.56	58.94	47.45	48.97	60.61	46.80	62.50	47.30	74.53
	POST MS	55.56	47.30	56.03	47.62	56.93	66.82	50.46	58.82	53.65	73.53

The relevance of water for irrigation use is resolute by using USSL diagrams. USSL diagrams are generated by Richards (1954) by comparing salt absorption ratio (SAR) measurements to the electrical conductivity data given in Fig.-6 and Fig.-7. The SAR indicates the degree to which irrigation water engages cation exchange reactions in the soil. Excess sodium fixes to soil particles, altering soil characteristics and

reducing permeability. This investigation determined that SAR was 0.35 to 2.38 in the pre-season and 0.4 to 2.43 in the post-season. Water with sodium absorption ratio S10 is the highest range in both seasons. The above figures illustrate the extent to which the water might influence the land regarding salt danger. 90% of samples in the C1S1 class, and 10% of samples were found in C2S1 in both seasons, water having less salinity and and sodium hazard class, is good for irrigation purposes in most soils.

Table-10: Classification of Water Quality for Irrigation

E.C. Range	R.S.C	K. R	S. A. R	M.H	Quality
250	< 0	< 1%	0 -10	< 50%	Very Good
250-750	0 – 2.5		10 -18		Good
750-2000	2.5 – 5.0	1 -2 %	18 – 26		Marginal
2000-3000	5.0 - 7.5	> 2		> 50%	Poor
3000 ABOVE	> 7.5		> 26		Harmful

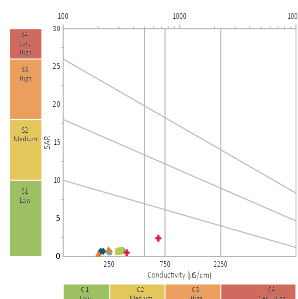


Fig.-6

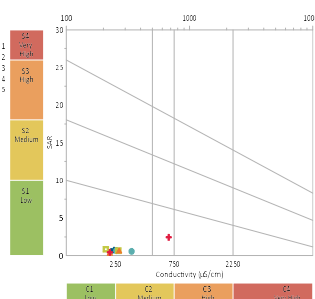


Fig.-7

(SAR and EC of water samples for classification of irrigation water)

CONCLUSION

Nagavali River water quality was found to be satisfactory in most areas in the Srikakulam district during the research. The water quality in the Nagavali River stretch was excellent enough to consume with minor disinfection treatment. The river water in the study region during the period of study for irrigation was found to be of good to exceptional quality. Irrigation water with a Mg hazard of less than 50 is appropriate. In the Nagavali river, magnesium hazard was found to be less than 50 in 50% of pre-season samples. During the post-season, 40% were fewer than 50. Except for the Magnesium threat, the irrigation quality of river water varied from satisfactory to outstanding in all locations. Based on the present state of river water quality, the responsible agency shall offer the appropriate education and training to water users. To preserve the quality of river water for irrigation purposes, efficient sewage water treatment facilities are emphasized before to release into the river to avoid water contamination by certain ions. Finally, it is advised that complete research with seasonal fluctuation be conducted to thoroughly assess the degree of contamination.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

All the authors contributed significantly to this manuscript, participated in reviewing/editing and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

CH.V. Saikrishna  <http://orchid.org/0009-0004-1179-0519>

L. Vaikunta Rao  <http://orchid.org/0000-0001-8360-7067>

D. Mallikarjuna Rao  <http://orchid.org/0000-0002-5207-1228>

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REFERENCES

1. D. Tickner, et al., *Frontiers in Environmental Science*, **5**, (2017), <https://doi.org/10.3389/fenvs.2017.00004>
2. N. Hassan Omer, *Intech Open*, Jul. 29, (2020), <https://doi.org/10.5772/intechopen.89657>
3. S. M. Bassem, *Biodiversity International Journal*, **4(1)**, 10(2020), <https://doi.org/10.15406/bij.2020.04.00159>
4. R. Bhateria, D. Jain, *Sustainable Water Resources Management*, **2**, 161(2016), <https://doi.org/10.1007/s40899-015-0014-7>
5. M. Masoud, et al., *Applied Water Science*, **12**, 244(2022), <https://doi.org/10.1007/s13201-022-01770-9>
6. Ma J, Wu S, et al., *Bioinorganic Chemistry Applications*, **2020**, Article 8886093(2020), <https://doi.org/10.1155/2020/8886093>
7. A. K. Haritash, Shalini Gaur, Sakshi Garg, *Applied Water Science*, **6**, 383(2016), <https://doi.org/10.1007/s13201-014-0235-1>
8. M. Hosseininia, et al., *Applied Water Science*, **13**, 84(2023), <https://doi.org/10.1007/s13201-023-01891-9>
9. S. Shil, et al., *Applied Water Science*, **9**, 168(2019), <https://doi.org/10.1007/s13201-019-1045-2>
10. S. F. Pesce, *Water Research*, **34(11)**, 2915(2000), [https://doi.org/10.1016/S0043-1354\(00\)00036-1](https://doi.org/10.1016/S0043-1354(00)00036-1)
11. B. Everitt, et al., *An Introduction to Applied Multivariate Analysis with R*, pp. 61-103, (2011)
12. W. Stumm, J. J. Morgan, (1996), *Aquatic Chemistry*, Wiley, New York, p 1022(1996)
13. Y. Hong Y, et al., *International Journal Environmental Research and Public Health*, **20(4)**, 2875(2023), <https://doi.org/10.3390/ijerph20042875>
14. S. Ayoob S, Gupta A, *Critical Reviews in Environmental Science and Technology*, **36(6)**, 433(2006)
15. L. Sabreen, et al., *Groundwater for Sustainable Development*, **14**, 100630(2021), <https://doi.org/10.1016/j.gsd.2021.100630>
16. P. Banerjee, B. Prasad, *Applied Water Science*, **10**, 113(2020), <https://doi.org/10.1007/s13201-020-01188-1>
17. A. Potasznik, et al., *Journal of Elementology*, **20**, 677(2015), <http://dx.doi.org/10.5601/jelem.2015.20.1.788>
18. M. Wons, et al., *International Journal of Ecology*, **31**, 137(2012).
19. J. Siepak, *Acta Hdrochemical et Hydrobiological*, **27(5)**, 5282(1999),
20. Juan Antonio Torres-Martínez, et al., *Journal of Hazardous Materials*, **417**, 126103(2021), <https://doi.org/10.1016/j.jhazmat.2021.126103>
21. J. Blaisdell, M.E. Turyk, K.S. Almberg, R.M. Jones, L.T. Stayner Prenatal, *Environmental Research*, **176**, Article 108553(2019), <https://doi.org/10.1016/j.envres.2019.108553>
22. M.K. Sharma, M. Kumar, *Environmental Monitoring and Assessment*, **192**, 74(2020), <https://doi.org/10.1007/s10661-019-8051-6>
23. D.F. Gomez Isaza, et al., *Environmental Pollution*, **261**, Article 114091(2020). <https://doi.org/10.1016/j.envpol.2020.114091>
24. Y. Qiong, et al., *Journal of Water Resource and Protection*, **1(4)**, 286(2009)
25. J. Wang, et al., *Science of the Total Environment*, **583**, 421(2017), <https://doi.org/10.1016/j.scitotenv.2017.01.088>
26. CW. Liu, *Science of the Total Environment*, **313**, 77(2003), [https://doi.org/10.1016/S0048-9697\(02\)00683](https://doi.org/10.1016/S0048-9697(02)00683)

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