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Assessment of irrigation water quality status among different villages in the Pendhurti block of Visakhapatnam district, Andhra Pradesh

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Abstract
This study aimed to assess the water quality of various villages in the Pendhurti block of Visakhapatnam district, Andhra Pradesh, during 2022-23. Thirty water samples were gathered from tube wells, bore wells and underwent analysis for various physico-chemical parameters, From the analysis it was found that pH ranges from 7.6-8.8, EC ranges from 0.56-2.33 dSm^{-1}, chlorides range from 0.4-1.2 Meq L^{-1}, carbonates and bicarbonates range from 0.4-1.2 Meq L^{-1} and 7.6-18.8 Meq L^{-1}, calcium and magnesium(5.8-75Meq L^{-1}), PI (5.9-53.8)are found more than the permissible limits, Sodium (0.17-0.78 Meq L^{-1}), potassium (0.02-2.89 Meq L^{-1}), SAR(0.03-0.17Meq L^{-1}), SSP (0.53-10 Meq L^{-1}), KR (0.003-0.037), RSC (-60.6 to 4.6 Meq L^{-1}) are found within the permissible limits. According to this water quality index is calculated from these parameters, WQI ranges from (153.43-444.23) and found that water quality is slightly unsustainable. The results obtained from the analysis suggest that proper cultivation and irrigation practices are to be followed and recommended measures need to be taken to improve the water quality status.

Keywords: Water quality, irrigation, physico-chemical parameters, irrigation water quality index

Introduction
Crop sustainability depends on the assessment and monitoring of soil and water quality. The evolution of salinity and alkalinity has been intensively studied throughout the world. Salinity and alkalinity deteriorate 6.73 million hectares of land in India (Singh *et al.* 2009) [22]. Every year, around 10 million hectares of land are lost due to salinity generated by irrigation water. Water quality regarding agricultural usage is assessed by the effect of water on crop quality and yield, as well as the effect on soil characteristics (Food and Agriculture Organization) (FAO, 1985) [3]. A certain amount of water is required for good plant growth, but the water quality used for irrigation should be within the allowable limits; otherwise, the plant growth might be hampered. With the increased strain on businesses and agriculture, as well as an increase in population, water quality is being reduced and its importance has become primary. The quality of water for irrigation is most profoundly influenced by the kind of water, soluble solids and salt concentrations (Arya *et al.* 2021) [1]. The total content of dissolved salts, cations like calcium, magnesium, sodium and potassium, anions like carbonates and bicarbonates sodium absorption ratio, residual sodium carbonate (RSC), Permeability index, soluble sodium percentage, kelly's ratio are essential parameters for determining the water quality. Irrigation water both quantity and quality has an impact on the properties of soil both directly and indirectly (physical, chemical, and biological). The prolonged use of poor-quality water for irrigation is the primary source of salinization and sodification, which inevitably results in salinity and sodium hazards, increased production costs, and crop failures. Irrigation appropriateness was also assessed using several criteria such as salinity and soluble sodium percentage, residual sodium carbonates (RSC), sodium adsorption ratio (SAR), Kelly's ratio (KR), and permeability index (PI). Because groundwater quality criteria are dynamic, they must be examined and monitored in order to provide reliable data and information. The primary goal of this study is to evaluate the water quality status of the Pendhurti block in Visakhapatnam district.

Materials and Methods

Site description

Visakhapatnam appears to be a vase-like in terms of area. It has a geographical area of 681.96 km2 (263.31 square miles) and is positioned between the Eastern Ghats and the Bay of Bengal Coast. Pendhurti is a neighborhood in the city of Visakhapatnam, Andhra Pradesh. It is situated at latitude 17.8333°N and longitude 83.2000°E. It is located on the outskirts of Visakhapatnam City. The mandal headquarters are located 25 kilometers northwest of Visakhapatnam and extend over a maximum extent of 20 kilometers north-south and 12 kilometers east-west. Because of its proximity to the Bay of Bengal, this block has a hot and humid environment with average temperatures ranging from 24.7 to 38.60 °C. The warmest months are April through June. With the commencement of the monsoon in December, the temperature dropped to a low of 21-22 °C, following which a reversal trend was noted, with the temperature reaching a high of 38 °C by the end of May. Pendurthi Block has an annual rainfall of 956.03 mm. The southwest monsoon produces more rainfall than the northeast monsoon. Thirty water samples were collected from different locations of Pendhurti block in Visakhapatnam district, Andhra Pradesh.

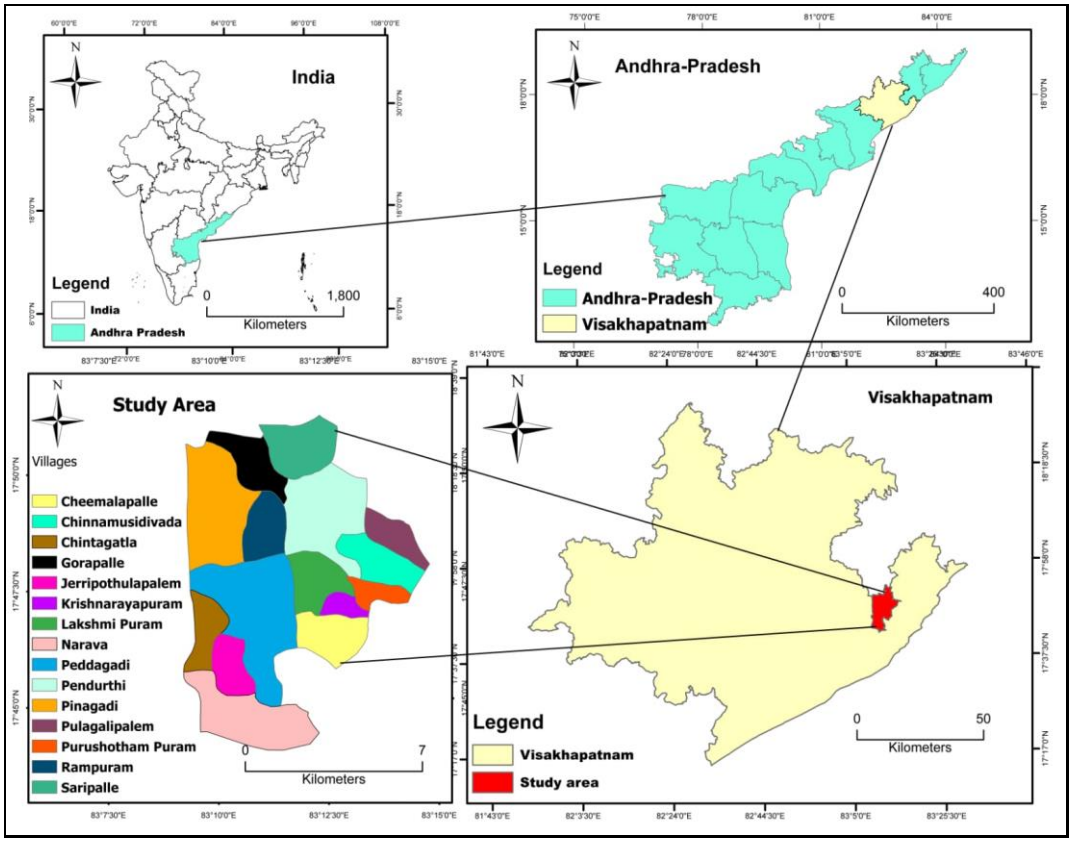

Fig 1: Location of the sampling area

Analysis of physico-chemical properties:

The obtained water samples were analyzed for various Physical and Chemical water quality parameters like pH, Electrical conductivity (EC), potassium, sodium, calcium + magnesium, carbonate, bicarbonate and chloride through standard methods suggested by (APHA, 1992) [2]. The water samples' pH was analyzed by using a Digital pH meter whereas Electrical conductivity was measured by using an EC meter and expressed in terms of units (dSm^{-1}). Potassium and sodium were estimated by using a flame photometer instrument described by (APHA, 1992) [2] which was calibrated by using 1000ppm of potassium chloride (KCl) and sodium chloride solution (NaCl). Calcium+ Magnesium content in water samples was estimated by complexometric titration method using 0.01N EDTA solution and 3-4 drops of Eriochrome Black-T indicator and 0.5ml of ammonium hydroxide-ammonium chloride buffer and titrated until the colour changes from pink to blue. Alkalinity (carbonates and bicarbonates) was estimated by the Acidimetric titration method using 0.02N sulphuric acid solution and indicator of phenolphthalein for carbonates estimation until the pink tint faded and the acid volume was measured if pink colour appeared it indicated the presence of carbonates and in the same solution 2-3 drops of methyl orange was added as an indicator for estimation of bicarbonates and titrated with 0.02N sulphuric acid until yellow colour changes to rose red (P.K. Gupta, 2007) [9]. Calcium in water samples was estimated by using complexometric titration method and an indicator of Murexide or ammonium purpurate was used and titrated with 0.01N EDTA until the colour changed from orange-red to lavender purple. Chlorides in water were estimated by Mohr's titration method using potassium chromate as an indicator and titrated with 0.02N $AgNO_3$ until the colour changed from straw yellow to brick red colour.The secondary water quality parameters which include SAR, SSP, RSC, KR and PI were analyzed by obtained values of primary water parameters like Cl^-, CO_3^{2-}, HCO_3^-, Ca+Mg, Na^+ and K^+.

Sodium adsorption ratio (SAR): SAR is a measurement of alkali/sodium crop hazard. The following formula is used to determine SAR suggested by (Richards, 1954) [20], where all ion concentrations are measured in Meq L^{-1}.

$$SAR = \frac{Na}{\sqrt{Ca+Mg/2}}$$

Residual sodium carbonate (RSC): Residual sodium carbonate is an index that measures the hazard of alkalinity in water. The RSC is calculated by using the following formula suggested by (Raghunath, 1987) [19] where the concentrations of all ions are in Meq L^{-1}.

$$RSC\ (Meq\ L^{-1}) = (CO_3^{2-} + HCO3^{-}) - (Ca^{2+} + Mg^{2+})$$

Soluble sodium percentage (SSP): Soluble sodium percentage is used to study the hazard of sodium in water. The SSP is calculated by using the formula suggested by (Todd, 1980) where the concentrations of all ions are in Meq L^{-1}.

$$SSP = \frac{(Na+K)\times 100}{Ca+Mg+Na+K}$$

If SSP value is less than 50 it indicates that the quality of water is good and decent for irrigation purposes. If the values of SSP are higher than 50 indicates that unsafe for irrigation purposes (USDA, 1954) [20].

Kelly's ratio (KR): Water suitability for irrigation use is also assessed based on Kelly's ratio (Kelly, 1951) [15]. Kelly's ratio was calculated by using the following formula. Where concentrations are expressed in Meq L^{-1}.

$$KR = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}}$$

Kelly's ratio value with more than one is considered as unsuitable for irrigation use due to alkali hazards and values of Kelly's ratio less than one is considered as suitable for irrigation use (Karanth, 1987) [14].

Permeability index (PI): The permeability index (PI) is used to indicate the water's suitability for irrigation use. The water's capability to move within soil i.e. (Permeability) is greatly affected by long-term use of irrigation water with more amounts of Ca, Mg, Na and bicarbonates. PI was calculated by using the formula suggested by (Doneen, 1964) [6] in Meq L^{-1}.

$$PI = \frac{Na+\sqrt{HCO3}}{Ca+Mg+Na} \times 100$$

Irrigation Water Quality Index (IWQI): The kind and amount of salts dissolved in irrigation water greatly influence its quality. The irrigation water quality index is used to calculate the basic water quality characteristics. The quality of irrigation water varies by location, area, country, and so on depending on soils, cropping pattern, etc (Babiker *et al.,* 2007) [4]. The salinity and alkalinity of the irrigated region are important factors influencing water quality. Water quality is the most important aspect in guaranteeing long-term water use for irrigated agriculture. The various indices of water quality are used to evaluate the Water quality index. The IWQI model was applied to the data. This model was developed by (Meireles *et al.* 2010) [16].

Computation of WQI: The WQI is computed following the three steps

First step: Assigning weight (w_i) to the selected water parameters like pH, HCO_3, Cl, EC, Na, K, etc. According to their relative importance in the overall quality of water, rating was given.

Second step: Computation of relative weight (W_i) of the chemical parameter using the following equation

$$W_i = w_i / \Sigma\, w_i\ (i = 1 to\ n)$$

Where,
W_i = is the relative weight
w_i = Weight of each parameter
n = Number of parameters

Third step: Assigning a quality rating scale (q_i) for each parameter, as below:

$$q_i = (C_i / S_i) \times 100$$

Where,
q_i = quality rating
C_i = Concentration of each chemical parameter in each water sample in mg/l
S_i = value of parameter given by (BIS 1991) [5].

For the computation of WQI, the sub-index (SI) is first determined for each chemical parameter, given below:

$$Sl_i = W_i \times q_i$$

WQI = ($\Sigma\, Sl_i$)-no of parameters (Σw_i)
Where, Sl_i = sub-index of i^{th} parameter
W_i = Relative weight of the parameter
q_i = Rating based on the concentration of the i^{th} parameter
n = Number of chemical parameters
(Σw_i) is obtained by adding no of parameters.

Results and Discussions

The results of the physico-chemical properties of irrigation water samples from different villages of Pendhurti block in Visakhapatnam district are given in Table 1.The values of different parameters of water samples were analyzed and correlated. The pH of the water samples ranges from 7.6 to 8.8 with an average value of 7.87. From the results it shows that93.3% of samples are moderately suitable for irrigation and 6.6% of samples are not suitable for irrigation purpose. Higher pH is server to crops (Ayers and Westcot, 1985) [3] and reduces the effectiveness of some nitrogenous fertilizers through irrigation (Hopkins *et al.* 2007) [10]. Similar results were reported by (Naidu *et al.* 2020) [17] in various mandals of Nellore district in Andhra Pradesh. The electrical conductivity of the water samples ranges between 0.56 to 2.33dSm^{-1} with a mean value of 1.23 dSm^{-1}.93.3% of samples are in the moderately suitable range for irrigation and 6.6% of samples are in the suitable range for irrigation purposes. From obtained results, it show that watersamples of Pendhurti block are in a moderately suitable range for irrigation use in terms of electrical conductivity. Higher EC concentration indicates more amounts of total dissolved salts which affect the mobility and solubility of oxygen in water (Kumar *et al.* 2011) [13]. The concentration of carbonates in water samples ranges between 0.4-1.2 meq L^{-1} with a mean value of 0.67 meq L^{-1}.

100% of samples are more than the permissible limits and not suitable for irrigation and concentration of bicarbonates ranges between 7.6-18.8 meq L^{-1} with an average of 12.47 meq L^{-1}. 93.3% of samples are not suitable and 6.6% of samples are moderately suitable in range and found that water samples from different villages of Pendhurti block are not suitable for irrigation purposes in terms of alkalinity. The content of chlorides in groundwater samples ranges between5.2-13.6meq L^{-1} with an average value of 7.39meq L^{-1}. 90% of the samples are in a moderately suitable range and 10% of the samples are not in a suitable range for irrigation. The calcium plus magnesium content in groundwater samples ranges from 5.8 to 75Meq L^{-1} with an average of 38.85Meq L^{-1}. The maximum permissible limit for total hardness is 6.0 Meq L^{-1} as per the guidelines of ICMR, 1975.From the obtained data it was found that only 3.3% of samples are within the permissible limits (<6 Meq L^{-1}) and the remaining 96.6% of samples are more than the permissible limits and not suitable for irrigation in terms of hardness. Similar findings were observed by (Srinidhi *et al.* 2020) [21] in Madanapalle block, Chittoor district. The potassium content of groundwater samples ranges between 0.02 to 2.89Meq L^{-1} with a mean value of 0.38 Meq L^{-1}. The maximum permissible range for potassium in water is 0 to 2 Meq L^{-1} (FAO, 1994) [3]. Data shows that 93.3% of samples are within permissible range and suitable for irrigation purposes. The sodium content in groundwater samples ranges from 0.17 to 0.78 Meq $L^{-1}$with a mean value of 0.37 Meq L^{-1}. From the obtained data it was found that 100% of samples are within the permissible limits and suitable for irrigation purposes. The irrigation water quality index of samples ranges from 153.43 to 444.23 with a mean value of 258.67. The water quality index data depicted in Table.2 was found that 46.6% of samples are very poor in water quality and 33.3% of samples are found unsuitable and 20% of samples are poor in water quality. The high water quality index in water samples is due to high calcium and magnesium content. The sodium adsorption ratio (SAR) ranges between 0.03 to 0.17 Meq L^{-1} with a mean value of 0.09 Meq L^{-1}. From the data, it was found that 100% of samples fall within the S1 class *i.e.* very low sodium hazard. The soluble sodium percentage of samples ranges between 0.53 to 10 Meq L^{-1} with an average of 2.32 Meq L^{-1}. From results, shows that 100% of samples are in excellent range and suitable for irrigation. Kelly's ratio ranges from 0.003 to 0.037 with a mean value of 0.01 and found that 100% of samples are within permissible limits and good for irrigation purposes. A Kelly's ratio of unity or less suggests good water quality for irrigation, while a ratio above one indicates unsuitability for agricultural purposes due to alkali hazards (Karanth, 1987) [14]. The permeability index ranges from 5.9 to 53.8 with an average of 13.42 and found that 90% of samples are not suitable for irrigation and 10% of samples are moderately suitable for irrigation. The residual sodium carbonate (RSC) of samples ranges from-60.6 to 4.6 Meq L^{-1} with an average of-25.71 Meq L^{-1}. From the data, it was found that 93.3% of samples fall within the class of low hazard and 6.6% of samples fall within the class of high hazard. The RSC values of groundwater samples were found negative due to offsetting calcium and magnesium levels which indicates less chance of sodium accumulation. Similar findings were reported by (Kant *et al*, 2015) [12] inlahar Pradesh. block of Bhind district, Madhya Pradesh and (Raju, 2007) [18] in Cuddapah district, Andhra Pradesh.

Table 1: Physico-chemical properties of Pendhurti block of Visakhapatnam district

Sl. No.	pH	EC (dS m^{-1})	Ca+Mg (Meq L^{-1})	Ca (Meq L^{-1})	K^+ (Meq L^{-1})	Na^+ (Meq L^{-1})	Cl^- (Meq L^{-1})	CO_3^{2-} (Meq L^{-1})	HCO_3 (Meq L^{-1})	SAR	PI	KR	SSP	RSC	IWQI
W1	7.6	1.711	47.8	12.6	0.077	0.522	13.6	1.2	18.8	0.107	10.11	0.011	1.24	-27.8	333.97
W2	7.6	1.727	72.2	14.2	0.051	0.565	10.8	0.8	18.4	0.094	7.07	0.008	0.85	-53	353.30
W3	7.6	1.728	75	8.6	0.051	0.522	9.6	0.8	13.6	0.085	5.96	0.007	0.76	-60.6	357.36
W4	7.7	1.722	41	14	0.077	0.739	8.8	0.4	14.8	0.163	10.86	0.018	1.95	-25.8	329.71
W5	7.7	1.523	54	8.2	0.051	0.435	7.2	0.4	14.8	0.084	7.99	0.008	0.89	-38.8	312.25
W6	7.7	1.527	17.4	6	0.051	0.435	8	0.4	16	0.147	23.86	0.025	2.72	-1	286.93
W7	7.8	0.789	5.8	10.6	0.128	0.217	5.2	0.8	9.6	0.128	53.86	0.037	5.62	4.6	171.88
W8	7.8	1.527	47.4	7.8	0.051	0.478	6.8	0.4	14.4	0.098	8.96	0.01	1.11	-32.6	308.80
W9	7.7	1.532	62	12.4	0.026	0.609	8	0.8	13.6	0.109	7.17	0.01	1.01	-47.6	317.63
W10	7.8	0.803	56	17.8	0.128	0.174	5.6	0.8	10.8	0.033	6.22	0.003	0.54	-44.4	203.18
W11	7.8	2.336	70.8	13.8	0.231	0.783	12.8	0.8	16.4	0.132	7.29	0.011	1.41	-53.6	444.23
W12	7.7	1.86	34.8	10	2.897	0.652	8.4	0.8	12.8	0.156	11.59	0.019	9.26	-21.2	350.25
W13	7.8	1.372	48.6	8.8	1.282	0.391	7.6	0.4	10.8	0.079	7.54	0.008	3.33	-37.4	287.33
W14	7.7	1.014	8.8	9.6	0.128	0.261	6.4	0.8	12.4	0.124	40.54	0.03	4.23	4.4	204.12
W15	7.8	0.966	37.8	11.8	0.359	0.217	6	0.8	10.8	0.050	9.13	0.006	1.5	-26.2	216.80
W16	7.8	0.97	17.8	11.6	0.359	0.217	5.2	0.4	10.8	0.073	18.90	0.012	3.14	-6.6	202.54
W17	7.8	0.952	45.4	20.4	0.359	0.217	6.8	0.4	12.4	0.046	8.19	0.005	1.25	-32.6	216.72
W18	7.7	0.921	41.4	9.6	0.385	0.217	5.6	0.4	9.2	0.048	7.76	0.005	1.43	-31.8	212.79
W19	7.9	1.308	27.8	10.8	0.154	0.348	7.2	0.4	12	0.093	13.16	0.013	1.77	-15.4	261.16
W20	8	0.888	10.4	8.2	0.410	0.217	6	0.8	9.2	0.095	29.60	0.021	5.69	-0.4	187.94
W21	7.9	0.887	41.8	7	0.410	0.217	6	0.8	9.6	0.048	7.85	0.005	1.48	-31.4	210.87
W22	7.8	1.314	38.6	12.4	0.128	0.348	6.4	0.8	12.8	0.079	9.96	0.009	1.22	-25	268.64
W23	8.7	0.593	22.8	9.2	0.103	0.174	5.2	0.4	7.6	0.052	12.44	0.008	1.2	-14.8	157.54
W24	8.8	0.562	23	10.8	0.103	0.217	6.8	0.8	8.4	0.064	13.04	0.009	1.37	-13.8	153.44
W25	8	0.798	35.4	6.8	0.103	0.217	6.4	0.8	10.4	0.052	9.54	0.006	0.9	-24.2	193.57
W26	7.8	1.013	44.4	9.6	0.128	0.304	6	0.8	12.8	0.065	8.67	0.007	0.97	-30.8	229.59
W27	7.9	1.01	41.2	9.8	0.128	0.261	6.8	0.8	12.4	0.057	9.07	0.006	0.94	-28	227.45
W28	8.3	0.997	37.2	9.6	0.103	0.217	7.6	0.8	12.4	0.050	9.90	0.006	0.85	-24	225.66
W29	7.8	0.811	27.2	12.4	0.128	0.174	6.4	0.4	12.8	0.047	13.50	0.006	1.1	-14	185.68
W30	8.1	1.877	31.6	20.2	2.821	0.696	8.4	0.8	13.2	0.175	12.89	0.022	10.01	-17.6	348.80
Mean	7.87	1.23	38.85	11.15	0.38	0.37	7.39	0.67	12.47	0.09	13.42	0.01	2.32	-25.71	258.67
Range	7.6-8.8	0.56-2.33	5.8-75	6.0-20.4	0.02-2.89	0.17-0.78	5.2-13.6	0.4-1.2	7.6-18.8	0.03-0.17	5.9-53.8	0.003-0.03	0.53-10.0	-60.6-4.6	153.43-444.23
SD	0.28	0.44	18.01	3.54	0.71	0.19	2.06	0.22	2.72	0.04	10.65	0.01	2.40	16.73	72.96
CV (%)	3.58	35.99	46.36	31.76	187.73	51.22	27.89	32.8	21.84	44.86	79.39	69.74	103.13	-65.05	28.20

Note: SAR = Sodium adsorption ratio, RSC = Residual sodium carbonate, KR = Kelly's ratio SSP = Soluble sodium percentage, PI = Permeability index, WQI = Water quality index

Table 2: Water Quality Classification Based on WQI Value

WQI	Water quality status	No. of samples (IWQI)	% of the samples	Sustainable state
<50	Excellent	0	0	Sustainable
51-100	Good	0	0	Sustainable
101-200	Poor	6	20	Slightly Unsustainable
201-300	Very poor	14	46.6	Unsustainable
>301	Unsuitable	10	33.3	Highly Unsustainable

Network analysis

The colour band (based on 'r' values) in the network among different water hydro properties depicts the strength of association. The broader lines indicate a strong correlation (both positive and negative) and narrow lines suggest a weak correlation (Fig. 2).

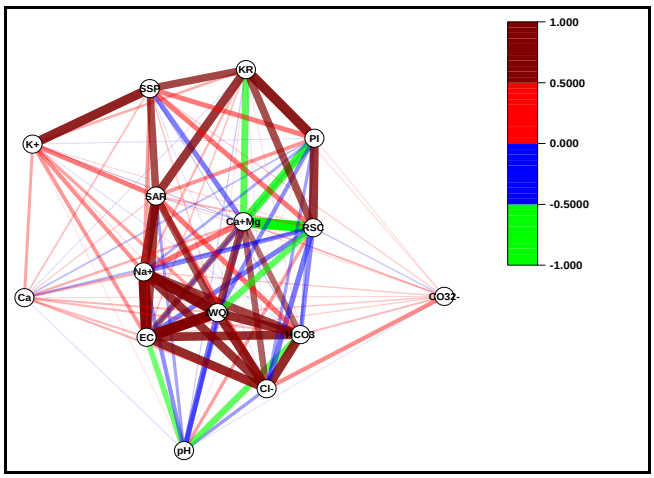

Fig 2: Network analysis showing the relation between hydro chemical parameters

Correlation between water quality parameters

The correlation between the water qualities parameters were given in the Fig.3. The pH of the water samples are negatively non-significantly correlated with Chlorides (r =-0.313), Carbonates (r =-0.022), Calcium (r =-0.062), SAR (r =-0.271), KR (r =-0.115). pH is negatively significantly correlated with EC (r =-0.501), Bicarbonates (r =-0.583), Magnesium (r =-0.386), Sodium and Water quality index (r =-0.369,-0.494). It is positively non-significantly correlated with Potassium (r = 0.012), SSP (r = 0.001), PI and RSC (r = 0.001 and r = 0.305).EC in water is negatively non-significantly correlated with PI (r =-0.268). EC is negatively significantly correlated with RSC (r =-0.462). EC is positively non-significantly correlated with carbonates (r = 0.118), Calcium (r = 0.192), Potassium (r = 0.337), SSP (r = 0.230) and KI (0.152). EC is positively significantly correlated with chlorides (r = 0.805), Bicarbonates (r = 0.788), Mg (r = 0.526), Na (r = 0.951), SAR (r = 0.709) and WQI (r = 0.99).Chlorides in water is negatively non-significantly correlated with SSP (r =-0.027), KI (r =-0.006) and PI (r =-0.290). Chlorides negatively significantly correlated with RSC (r =-0.470). Chlorides positively non-significantly correlated with Calcium and Potassium (r = 0.212, 0.078) and positively significantly correlated with carbonates, bicarbonates, magnesium, sodium, SAR, WQI (r = 0.388, 0.814, 0.536, 0.760, 0.467, 0.820). Carbonates in water are negatively non-significantly correlated with RSC (r =-0.129). Carbonates are positively non-significantly correlated with bicarbonates (r = 0.182), Ca, Mg, K, Na, SAR, SSP, KI, PI and WQI (r = 0.095, 0.159, 0.078, 0.126, 0.088, 0.121, 0.077, 0.066 and 0.138). Bicarbonates in water are negatively non-significantly correlated with Potassium (r =-0.061), SSP and PI (r = 0.117, 0.230). Bicarbonates positively non-significantly correlated with Calcium (r = 0.203), KR (r = 0.042) and positively significantly correlated with Mg (r = 0.493), Na, SAR and WQI (r = 0.704, 0.470 and 0.788).Calcium in water is negatively non-significantly correlated with KI, PI and RSC (r =-0.064, r =-0.175 and r =-0.212). Ca is positively non-significantly correlated with Mg, K, Na, SAR, SSP and WQI (r = 0.030, 0.265, 0.236, 0.115, 0.158 and 0.195).Magnesium in water is negatively non-significantly correlated with K and SAR (r =-0.158 and r =-0.122). Mg is negatively significantly correlated with SSP, KR, PI and RSC (r =-0.485,-0.576,-0.691 and 0.97). Mg in water is positively significantly correlated with Na and WQI (r = 0.466 and r = 0.638). Potassium in water is negatively non-significantly correlated with PI (r =-0.051). K is positively significantly correlated with Na, SAR and SSP (r = 0.366, 0.453 and 0.845) and positively non-significantly correlated with KR, RSC and WQI (r = 0.238, 0.09 and 0.291).Sodium in water is negatively non-significantly correlated with PI (r =-0.248) and negatively significantly correlated with RSC (r =-0.421). Na is positively non-significantly correlated with SSP and KR (r = 0.278 and r = 0.205) and positively significantly correlated with WQI (r = 0.94).(SAR) Sodium adsorption ratio in water is positively significantly correlated with SSP, KR and WQI (r = 0.654, 0.753 and 0.62) and positively non-significantly correlated with PI and RSC (r = 0.35 and r = 0.195).(SSP) Soluble sodium percentage in water is positively non-significantly correlated with WQI (r = 0.134) and positively significantly correlated with KR, PI and RSC (r = 0.685, 0.457 and 0.465).(KR) Kelly's ratio in water is positively non-significantly correlated with WQI (r = 0.036) and positively significantly correlated with PI and RSC (r = 0.872 and r = 0.659). (PI) Permeability index in water is negatively significantly correlated with WQI (r =-0.366) and positively significantly correlated with RSC (r = 0.767) and (RSC) Residual sodium carbonate in water is negatively significantly correlated with WQI (r =-0.581).

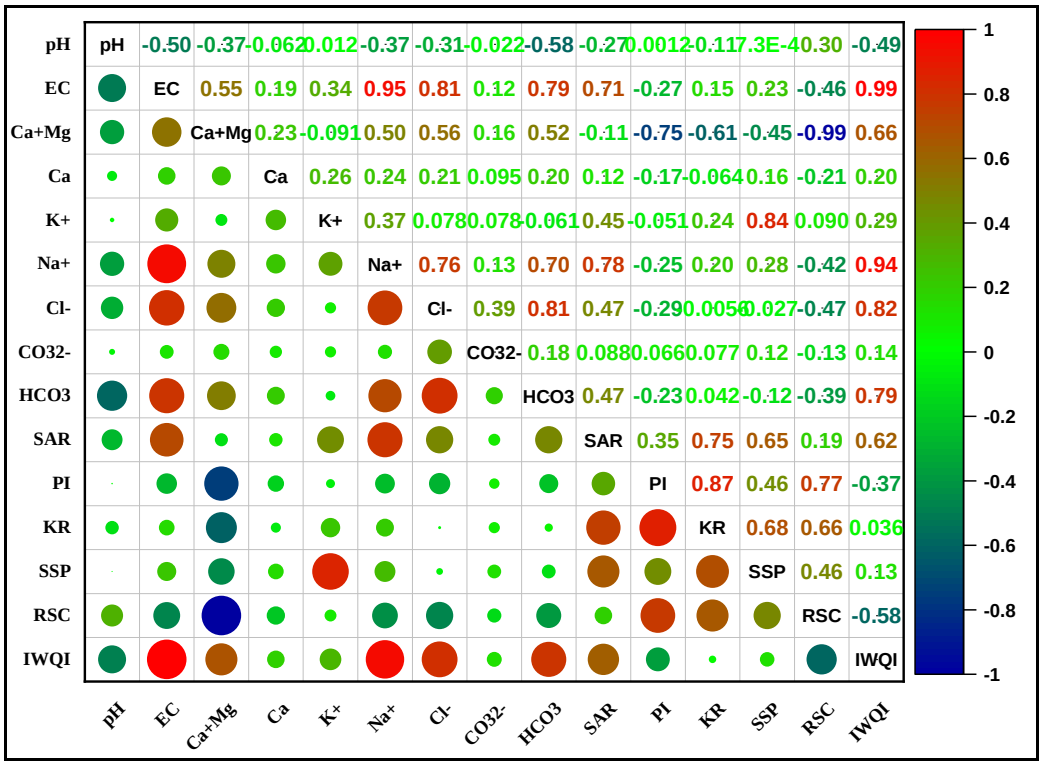

Fig 2: Correlation between water quality parameters of Pendhurti block of Visakhapatnam district in Andhra Pradesh.

Conclusion

Due to usage of high pesticides and fertilizers by the farmers and also due to inappropriate cultivation practices there was accumulation of soluble salts which resulted moderate range of EC concentration in the samples. The pH was found to be acidic to neutral and all the water samples have shown low sodium hazard and alkalinity of all the water samples has shown moderately suitable for irrigation. The permeability index of water showed that 66.66% of samples are not suitable for irrigation purposes and 33.33% of samples are moderately suitable. The calcium and magnesium concentrations of the samples were quite high. Due high concentration of calcium and magnesium and moderate range of soluble salts in water samples indicated poor quality irrigation water index where 62.50% of the samples were in the poor range. From this analysis it was found that water quality for irrigation needs to be improved and recommended measures, proper irrigation management, soil and water conservation practices should be followed to achieve good water quality, this improves crop yields in the future without having much impact on the environment

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